PULSE AND RHYTHM

Exploring the Value of Repetitive Motion as an Element of Design

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PhD Thesis (2015)
Royal College of Art

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Exploring the Value of Repetitive Motion as an Element of Design

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Declaration

During the period of registered study in which this thesis was prepared the author has not been registered for any other academic award or qualification. The material included in this thesis has not been submitted wholly or in part for any academic award or qualification other than that for which it is now submitted.

Hideki Yoshimoto

Date : 21 May 2015

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ABSTRACT

With this thesis I want to share my exploration of pulse and rhythm as elements of design. I locate my research on the meeting point of two different contexts: one is the expansion of kinetic art into design projects, resulting in aesthetic use of motion playing wider roles in design, and the other is the expansion, in relation to technological development, of the value of pulse as a design element. My hypothesis is that the value of pulse as an element of design can be heightened by acquiring the aesthetic use of repetitive motion seen in kinetic art, forging emotional communication with viewers/users. The mission of this research is to demonstrate this argument through practice, collecting working ideas and methods. I propose a model of pulse which can be used as a tool to reflect on projects from a new perspective. To forge a workable focus for the research, I articulate a definition of Japanese aesthetics and deploy related criteria of design.

My exploration covers three topics — single pulse, pulse synchronisation, and pulse interference. Several ideas and methods were tested across eight projects in total, related to theories from various fields including biology, physiology, psychology, philosophy, mathematics and physics, and inspired by art and design practice. The insights gained from the projects allowed me to expand the scope of the exploration from pulse to rhythm, and I also reflect on my work from this perspective, distinguishing rhythm from pulse. Furthermore, I conducted an interview-based study to look into rhythm inferred from non-pulsing motions, and the insights from the interviews are presented in the thesis with an additional discussion.

The output of the research takes two forms: recommendations, as a simplified and generalised summary of my findings, and case studies (projects), as a concrete source of inspiration for the reader's own creations. By thus interweaving the practical and theoretical knowledge gained in the research, I believe this work provides a useful contribution to the field of design.

THESIS STRUCTURE

The context of this research and the way I explore pulse and rhythm are rather complicated. Therefore, before beginning to describe the content of the research, I want to explain the structure of this thesis and the role of each chapter (diagrams follow). Readers are recommended to refer back to this as they read through the thesis.

Chapter 1 gives one of the contexts behind this research — the historical movement where kinetic motion has been used in creative activities, starting from kinetic art and now expanding into design. At the same time, my early work which was inspired by this movement is introduced, including the project that eventually helped me start looking into the particular theme of pulse.

Following the choice of this theme, Chapter 2 introduces the other context of the research — pulse as an element of design. I review the historical process where pulse has expanded its role in design, mainly from the era of the Industrial Revolution up to the present day. In conclusion, I locate my research on the meeting point of the two contexts described in Chapters 1 and 2, and articulate a mission statement in relation to the future of pulse in design.

Chapter 3 provides a definition of Japanese aesthetics in order to enable its particular criteria of design to be used in the research. Aesthetics, the focus of the research areas set out in Chapters 1 and 2, can be evaluated differently depending on the personal and cultural context; therefore, the aim of this chapter is to frame the criteria using my own cultural background, so that all the work carried out in the research is evaluated from the same point of view.

Chapter 4 is about the methodology I adopt. As I place myself always in the centre of activity, this is what is called 'action research'. This chapter details how I will weave theoretical and practical studies into the research. In addition, I propose a model of pulse that I will use to reflect on my own practice.

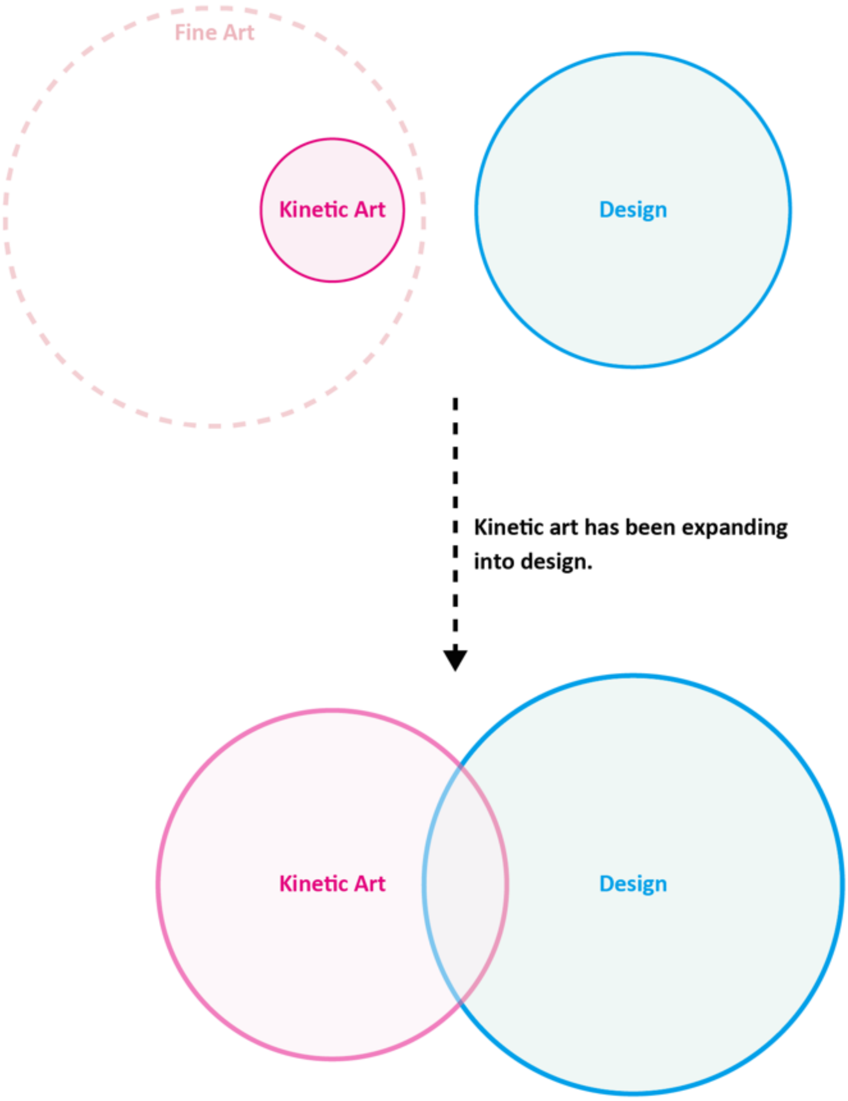
Chapter 5, the main chapter, describes my exploration of pulse. This chapter is long, and consists of three sections, focusing respectively on single pulse, pulse synchronisation, and pulse interference. Each section has subsections, which correspond to the eight major projects I conducted. These eight projects are not presented in parallel but in sequence; you are recommended to read 'through' them so that you can track the path by which I expanded the scope of the research. References are interweaved into this sequence in order to reveal my inspirations and the basis of my thinking for each project.

The insights I gain from this exploration lead me to a further discussion about rhythm, which is presented in Chapter 6. This section expands my argument from the previous chapter by reflecting on the projects from the perspective of rhythm as distinguished from pulse.

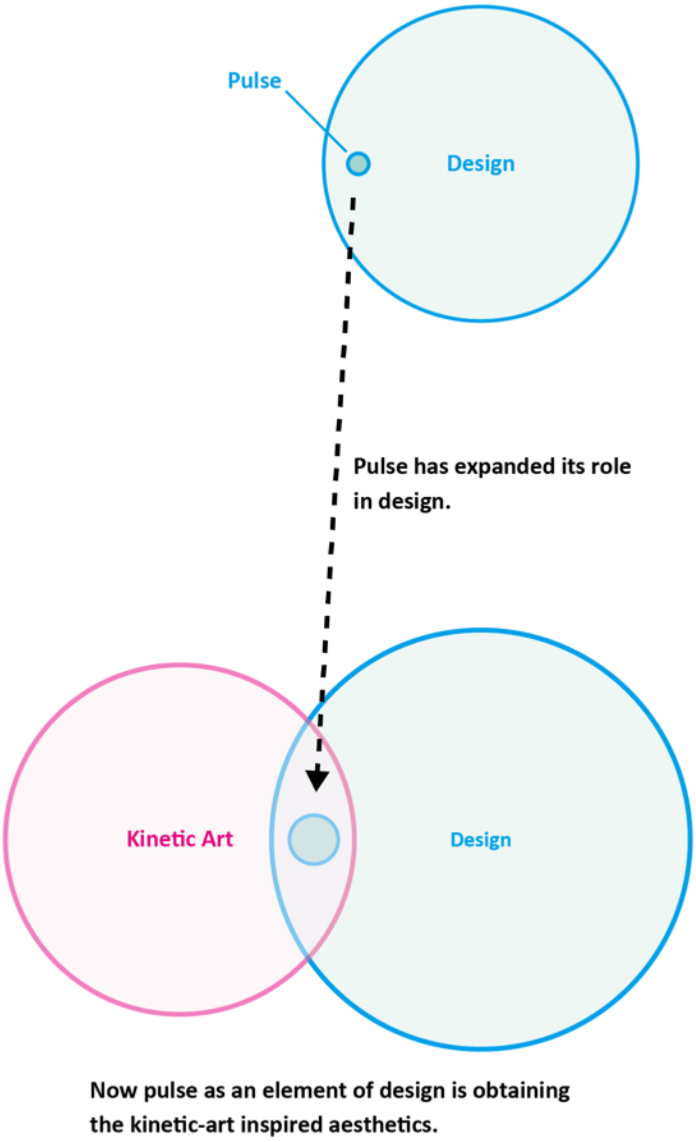
Chapter 7 presents an additional discussion on rhythm inferred from non-pulsing motions. This was a new interest, which emerged in me during my study of rhythm. To look into this issue, I conducted an interview-based study; my insights are presented in this chapter.

Chapter 8 is the concluding chapter. It summarises my study and provides recommendations, simplified and generalised from my exploration. It also discusses the significance and limitations of this research, and potential future research directions.

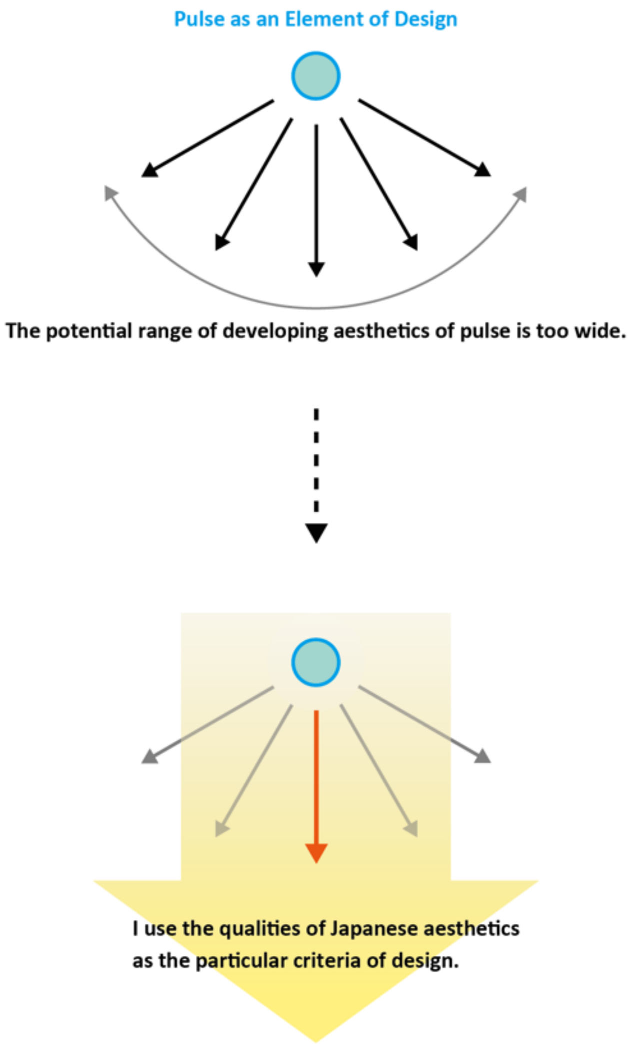
Chapter 1


Fine Art
Kinetic Art
Design
Kinetic art has been expanding
into design.
Kinetic Art
Design

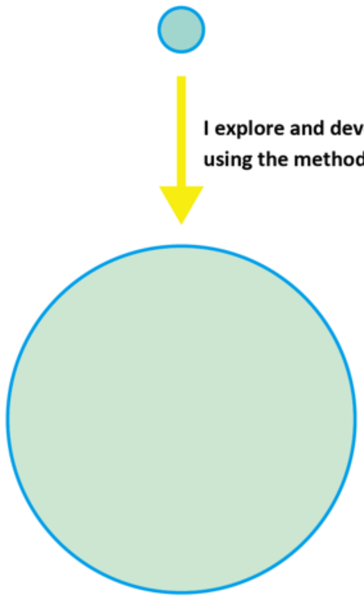
Chapter 2


Pulse
Design
Pulse has expanded its role in design.
Kinetic Art
Design
Now pulse as an element of design is obtaining the kinetic-art inspired aesthetics.

Chapter 3

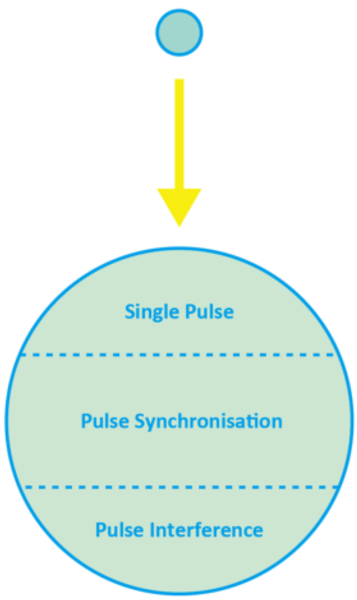

Pulse as an Element of Design
The potential range of developing aesthetics of pulse is too wide.
I use the qualities of Japanese aesthetics
as the particular criteria of design.

Chapter 4



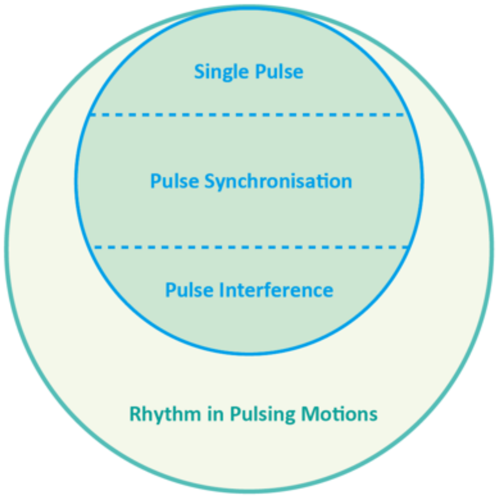
I explore and develop pulse as an element of design using the methodologies of practice-led research.

Chapter 5



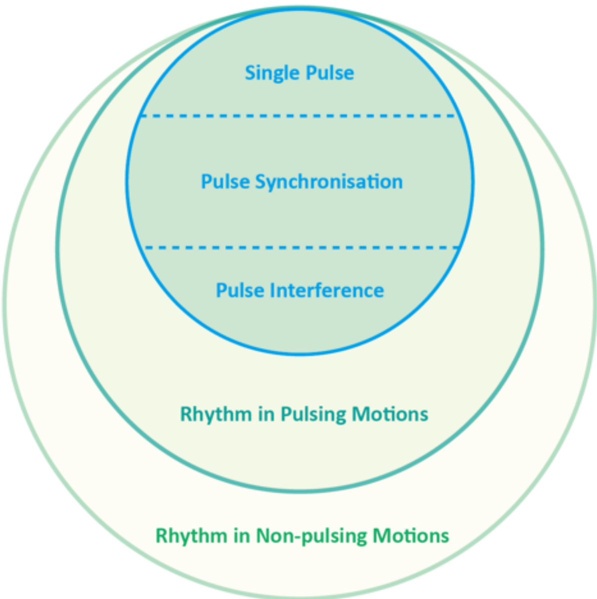
My exploration consists of three sections — single pulse, pulse synchronisation, and pulse intereference — and eight projcts.

Chapter 6



The scope of my exploration is expanded with the focus on rhythm as distinguished from pulse.

Chapter 7



The scope of the research is further expanded with additional discussions on rhythm in non-pulsing motions.

CHAPTER 1

SEEKING MOTION

1.1 MOTION AS AN ELEMENT OF DESIGN

My Bachelor's and Master's degrees at the University of Tokyo were awarded by the Department of Aeronautics and Astronautics, where I belonged to the Artificial Intelligence Laboratory. The Master's research, which continued from the Bachelor's dissertation, was about how the latest AI (Artificial Intelligence) and HCI (Human-Computer Interaction) technology can expand applications of aircraft in the field of entertainment. I chose the airship as my particular focus and proposed the concept 'airships as performance media', arguing that airships can play more varied roles as media for artistic performance, going beyond advertising blimps, for example. I demonstrated the concept through a couple of projects: one was an art installation of luminous airships (Yoshimoto 2009), and the other was a hobby kit where users could control the light and movement of a small luminous airship with multiple interfaces such as digital music instruments, multi-touch smart phones, telephone, online graphical interface, and computer keyboard (Yoshimoto 2010). This research was presented at several domestic and international conferences including ACM Siggraph Asia, ACM Creativity and Cognition and ACM Advances in Computer Entertainment Technology, and won the Annual Conference Award of the Japanese Society of Artificial Intelligence. This three-year experience as a young researcher and the success I achieved helped me develop a solid base of interests, which has actually stayed unchanged: these include computer-related technology, physical objects, kinetic motion, and artistic expression. I decided to sign up to the Innovation Design Engineering programme at the Royal College of Art (RCA) to enable me to keep working in these areas while developing a designer's perspective.

The topic of computer-controlled motion as an aesthetic element of design does not only respond to my personal interests; it is also a recent trend in design. Today, many design schools, including the RCA, teach computer programming

Figure 1.1 Four Squares in a Square (1969) by George Rickey

and robotics (actually I spent some time working as a tutor in this area for the MA students in my department), and many students are seeking to use such technology in their projects. This is reflected in the high number of such projects that go on show at graduation shows, for example at the RCA, Central Saint Martin's, or the Architecture Association School of Architecture.

Where is the origin of this theme? Ever since fine artists in the early 1900s, particularly sculptors, started to use 'movement itself (which combines space and time), to make art, as the painter uses colour, or the composer the notes of the scale' (Selz 1919, p.13), this sort of creation has been called 'kinetic art'. The pioneers of the field included Marcel Duchamp, (whose Bicycle Wheel (1913) is widely recognised as the first work of kinetic art), Man Ray and Alexander Calder (who invented and established mobiles as a form of art), George Rickey (who created a series of metal sculptures moving in the wind), Pol Bury (who made several sculptural water fountains), and Fletcher Benton (one of the earliest to utilise electric and mechanical components to move sculptures).

The evolution of computers expanded the world of kinetic art from the middle of the 20th century. One of the most historic moments was the exhibition 'Cybernetic Serendipity', put on at the Institute of Contemporary Arts (ICA), London, in 1968. It was the first international exhibition in the UK devoted to the relationship between the arts and new technology (Usselman 2003). The

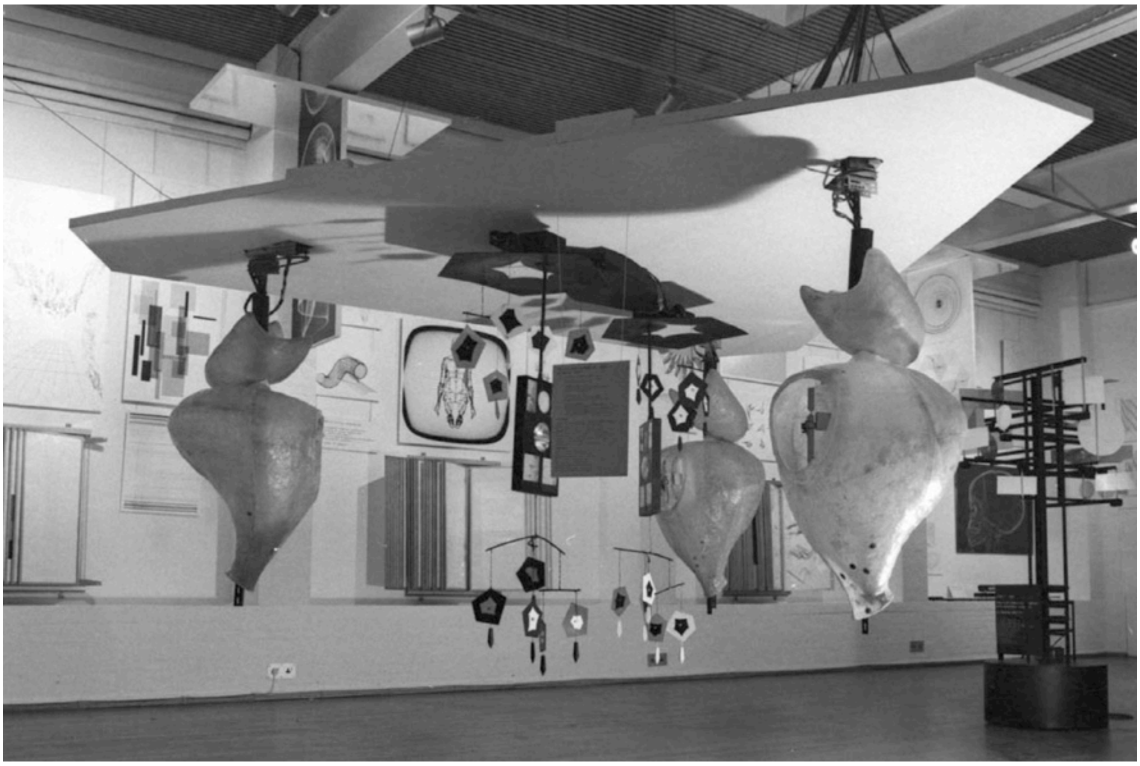


Figure 1.2 Colloquy of Mobiles (1968) by Gordon Pask

exhibition press release stated: 'exhibits in the show are either produced with a cybernetic device (computer) or are cybernetic devices in themselves. They react to something in the environment, either human or machine, and in response produce either sound, light or movement.' One exhibit for example was Gordon Pask's Colloquy of Mobiles (1968), where five individual mobiles suspended from the ceiling moved and rotated, communicating with each other as well as the audience using beams of light reflected by moving mirrors (Reichardt 1968; Haque 2007). Wen Ying Tsai also exhibited his Cybernetic Sculpture (1968), which was composed of vibrating stainless-steel rods surmounted by polished metal plates, in constant harmonic motion under electronically activated lighting. The lighting changed in response to the environment — including the viewers — and the motion changed accordingly from gentle undulations to rapid vibrations (Reichardt 1968). Although the main focus of these works of cybernetic art was not their movement in itself but rather their exchanges with

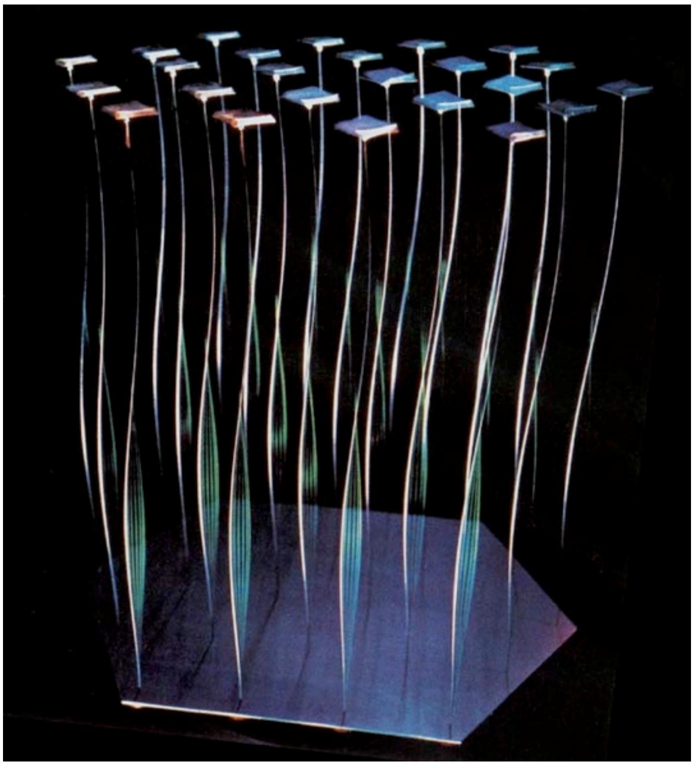


Figure 1.3 Square Tops (1969) by Wen-Ying Tsai

the environment, motion was one of the key elements from this earliest stage of marriage of computer and arts.

A lot of work since this era has applied computational controls to kinetic art (see Chapter 5 in Wilson 2002). For example, Milton Komisar was one of the first kinetic light artists to apply computers to control. His light sculptures achieved elegant movement that progressed over time, created by computer programs. Komisar describes his approach as follows: 'Developing a system to work with Light in this particular way has led me to the idea of composition in time. (...) I believe it is possible to "mould" Light through time in such a way that a coherent composition is experienced by the viewer. The physical structure and the electronics are simply necessary tools to this end' (cited in Wilson 2002, p.389). Paul Friedlander constructed kinetic light sculptures by rapidly rotating a rope stretched between two holding units. The vibrating string itself became invisible as the rotation was very fast, but the light being reflected off the rope

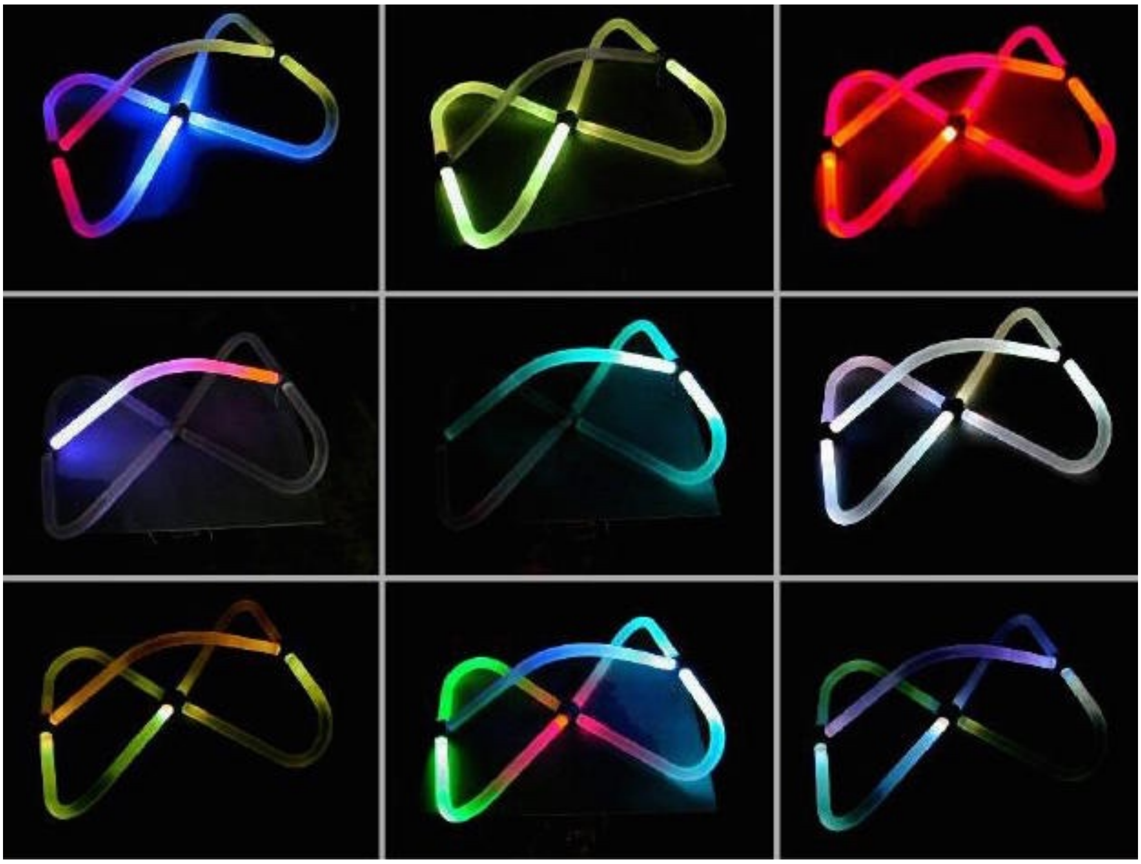


Figure 1.4 Light Sculpture (2000) by Milton Komisar

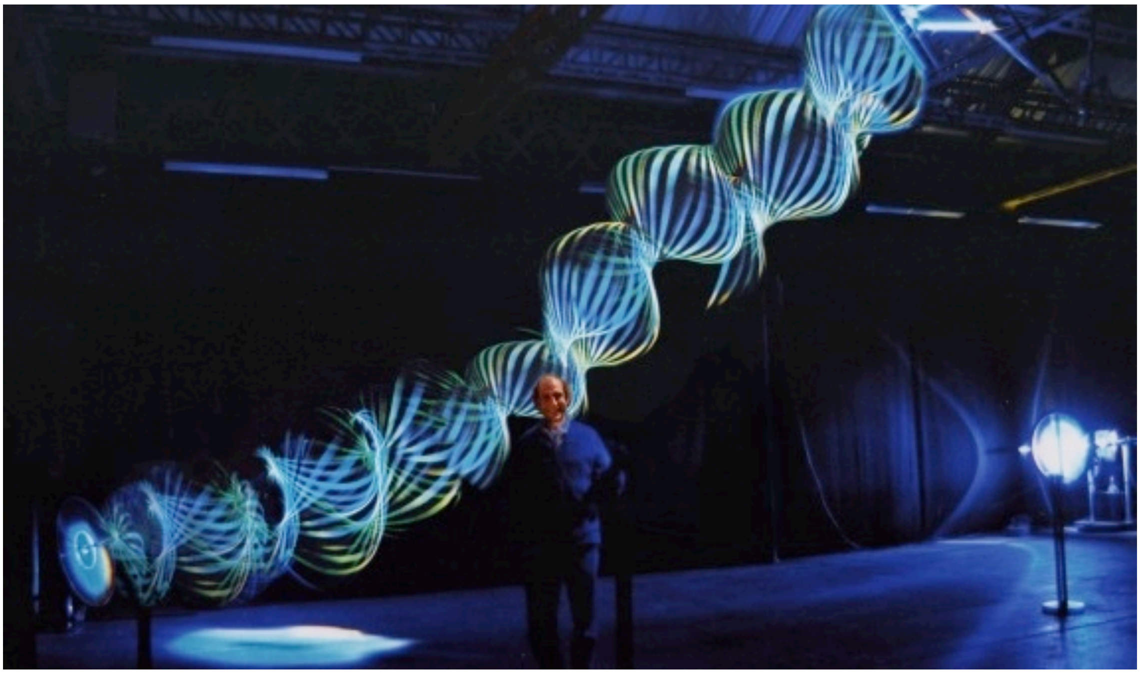


Figure 1.5 Light Sculpture (2001) by Paul Friedlander

Figure 1.6 Tree Time (1998) by Bruce Cannon

generated a beautiful effect in exchange. The colours of the light changed, illuminating the double-helix shape emerging in the traced movement of the swinging rope. Later, Friedlander made larger examples of this kind of sculpture, which he hung from the ceiling, and allowing viewers to participate in the work by adjusting the beams. Bruce Cannon created the kinetic art piece Tree Time (1998) in collaboration with Paul Stout, an installation that reanimates a lightning-struck tree transported from a forest. He added robotic elements to the tree so that the branches moved at an almost imperceptible speed — the motion was perceptible only over many days. This work successfully delivered a concept about life and death ('the obvious reference to Mary Shelley's Frankenstein' (ibid., p.398), as Cannon wrote) in the motion.

The last decade has seen successors in this field beginning to install their work in commercial space as permanent décor, as well as exhibiting it in art galleries. ART+COM's Kinetic Sculpture (2008, see Sauter et al. 2011) and Troika's


Figure 1.7 Kinetic Rain (2012) at the Changi Airport by ART+COM

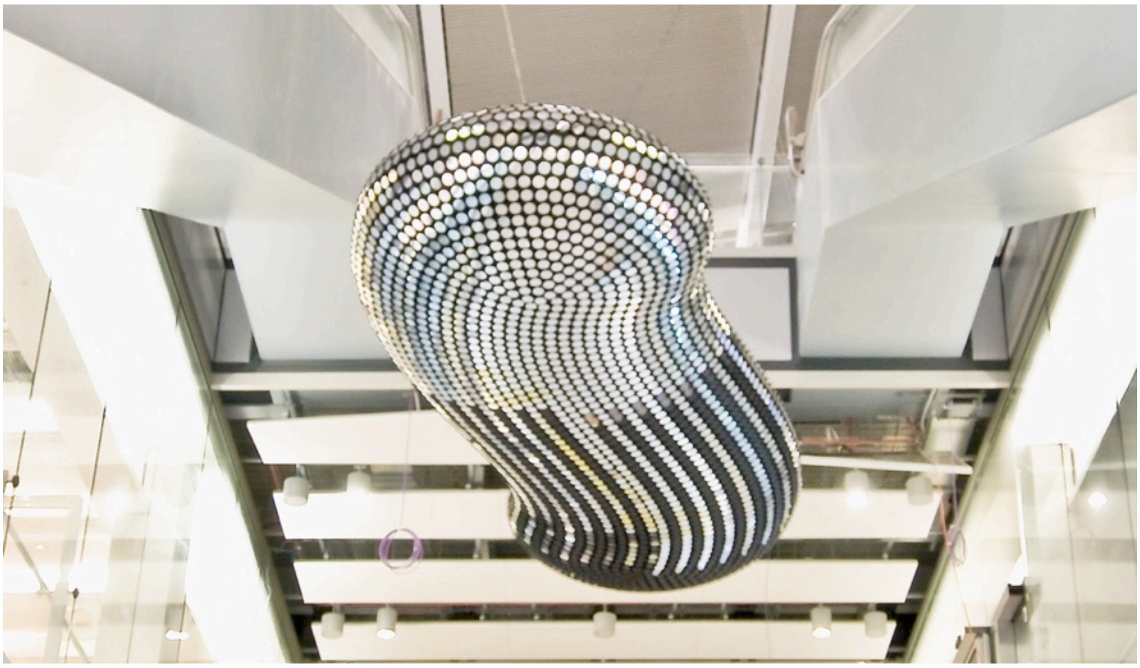


Figure 1.8 Cloud (2008) at the Heathrow Airport by Troika

Figure 1.9 Flare (2008) by WHITEvoid Interactive

Cloud (2008, see Troika 2010) were both installed in airports. Troika also made a kinetic sign for the Victoria and Albert Museum. Daniel Rozin's series of works Mechanical Mirrors (1999, see Cameron 2005) can be seen at various venues, such as the W Hotel in Seoul. This expansion of contemporary kinetic art has begun to cross the boundary into architecture and interior design, for example in the façades of buildings. A business that emerged from the Massachusetts Institute of Technology led by Mark Goulthorpe is selling a programmable kinetic display called HypoSurface (2001, see Goulthorpe et al. 2001) to be used as a building façade; WHITEvoid Interactive, meanwhile, proposed a building façade called Flare (2008, see Fox and Kemp 2009), where modular moving metal flakes create programmable animations. Many such kinetic façades are still in the prototype or demonstration phase, but animating façades with programmable lighting is becoming popular. Leading architects in the field such as Jason Bruges, Realities United (Jan and Tim Edler), and UN Studio have created artistic animating façades for stores, stations, hotels, museums, hospitals, stadiums, etc. (Griffiths 2014; Bullivant 2006).

Figure 1.10 Memory Wall (2005) at the Hotel Puerta America by Jason Bruges Studio

This trend in architecture is just one aspect of a broader movement in which designers as well as artists have begun to use technology in what they produce. The fashion designer Hussein Chalayan for example unveiled the Mechanical Dress, which used motors to change its appearance, and the Video Dress in 2007, in which a flexible LED display was embedded behind the fabric to show the moving images in the same collection (Violette 2011). A number of fashion designers are currently following Chalayan's pioneering work in 'e-textiles' movement (Clarke 2012). The design duo Poetic Lab, founded by recent RCA graduates Hanhsi Chen and Shikai Tseng, released Ripple (2013) with the glass brand J & L Lobmeyr, a floor lamp in which a beam of light is projected through gently rotating mouth-blown glass to create an ever-changing texture of light on the wall. Lasvit, a Czech Republic-based lighting furniture brand, exhibited a collection of chandeliers at the Milan Design Fair 2014, in which glass objects kinetically move and change the texture of reflected light[1]. At the same fair, the Japanese design collective Kappes exhibited the coffee table

[1] See a report at www.designboom.com/design/lasvit-kinetic-programmable-glass-lighting-systems-05-16-2014/


Figure 1.11 Video Dress (2007) by Hussein Chalayan


Figure 1.12 Ripple (2013) by Poetic Lab

Figure 1.13 Magnetic (2014) by Libor Sošťák for Lasvit

Momentum (2014), in which water drops move on the water-repellent surface as if dancing under the glass tabletop. We can see in these examples the technology and aesthetic expressions developed in the field of kinetic art now expanding into design.

It is necessary to mention some key technical inventions which have enabled this trend to develop. Progress in computers and software engineering has always provided a foundation, but some of the most important developments in this context have come from researchers who have sought to bridge computer science and art and design. Researchers such as Mark Weiser, Nicholas Negroponte, John Maeda, and Hiroshi Ishii once predicted a future where computational technology would be used widely by artists and designers, playing important roles in forming our living space (Weiser 1991; Negroponte 1995; Ishii 1997; Maeda 2001); people influenced by these ideas went on to develop tools which eventually helped realise this prediction. Maeda's students Casey Reas and Benjamin Fry invented Processing (Reas and Fry 2007), a Java-based programming language simple enough for artists and designers to use for

Figure 1.14 Momentum (2014) by Kappes

their creations. Since its release in 2001, it has become one of the standard software platforms for students and professionals in the field, along with its descendants, such as openFrameworks and Cinder. In hardware, the concept of Physical Computing, proposed by Tom Igoe (2004), caused a sensation, which resulted in the birth of Arduino, a hardware toolkit that provides easy usage of micro-controllers, sensors and actuators for artists and designers — often quite a similar group to users of Processing. Arduino has also become a 'must-have' for creators in this field.

And here we are. A number of young designers, including myself and many of my fellow students, are sensing this trend and reacting to it to help create the future. Paola Antonelli, the senior curator of design at the Museum of Modern Art (MoMA) in New York, contributed a short text to Troika's book Digital by Design (2010), in which she wrote: 'there is a touch of wide-eyed wonderment in every project [curated in the book] along with a friendly competitive feeling and the desire to share in the joy of discovery that is typical of communities of ninja-geek tinkerers who share unrequited passions'. This community is not as matured as other well-explored areas of design but is still growing, and its members are searching for new expressions and new tools to expand the possibilities together.

1.2 SEEKING MOTION

Though my area of interest was clear from the start, this area was broad and seemed to offer a number of possible directions for my research. It actually took me a long time to choose one of these directions. Briefly described in this section is this earliest phase of the research, during which I spent most of my time making things more or less at random, changing my focus and bringing my interests into greater and greater clarity.

Experiment Series 1

I started to create my first set of works not knowing exactly what I wanted to achieve with them, and motivated purely by my fundamental interest in physical motion and controls. Figure 1.15 shows images from these experimental works. From top left to bottom right:

Experiment 1-1) A glass sphere of 20 cm diameter equipped with light, servo motor, ballast, and human detection sensor, which began to roll when people walked past.

Experiment 1-2) A wooden board (0.7 m x 1.2 m) with multiple projections; the surface was painted with super-water-repellent paint. I put some water on it and placed the board on a cushioned floor. When someone walked on it the board bent and the water behaved unexpectedly. The idea was to bring unpredictability into the response of the object through human input.

Experiment 1-3) A computer program which generated a number of tiny moving dots emulating flocking birds; a person captured by the computer's camera could interfere with these dots. Again, the idea was to have

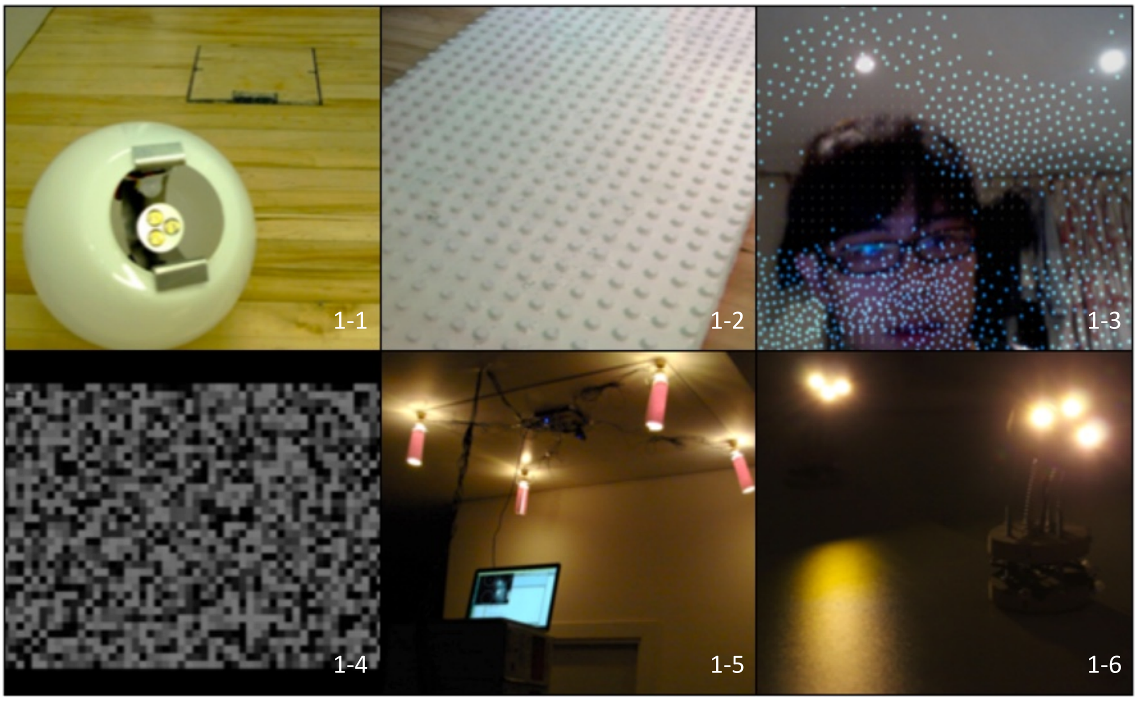


Figure 1.15 Experiment Series 1

unpredictability in the movement of the dots, which behaved according to a distinct set of rules but at the same time responded to external influences.

Experiment 1-4) A black-and-white geometrical animation, which changed its visual pattern corresponding to the sound level in the environment — but when someone was captured by the computer's camera it also responded to their movement. It responded to two different elements simultaneously, so the person in front of the camera knew the animation was responding to him or her, but at the same time also knew it was not fully under their control.

Experiment 1-5) An experimental installation that was composed of four spot-lights, the directions of which could be changed with mechanical actuators, and one camera in the middle that fed data to a computer program to observe the light and shadow on the floor. Each spot-light moved to light up the darkest point in the field. This actually led to chaotic behaviour because the spotlights affected each other in a rather complicated and undetermined way — if one light lit up one position the others avoided this bright spot, and this process was repeated. Human presence (shadow) and environmental light also affected the system.

Experiment 1-6) I found the idea of Experiment 1-5 interesting, but the setting of the spot-lights was a hard task and the calibration of the program made a lot of noise. Therefore, I changed the design to make a floor-light version. I also changed the actuators from servo motors to artificial muscle fibre (memory alloy); by coupling these actuators with a spring I achieved a very smooth motion with an almost organic quality.

As seen in the sequence of these experiments, my interests gradually crystallised around interactive communication between humans and objects, particularly where unpredictability or chaos was introduced into the communication. This led to my first major project, Yuen.

Yuen

Yuen, developed in collaboration with my colleague Moto Takabatake, was an installation composed of several floor lamps, each of which was equipped with a lighting 'head', artificial muscle fibre and spring, a circuit-board (also functioning as the base), and light sensors around this base. Each lamp organically moved its head, seeking the darkest area around it. One lamp's movement affected another's by changing the light and shadow field in the environment, which resulted in the indirectly connecting of all lamps, creating of a system. People who came into the space could also affect the system with their shadows. The installation obviously inherited the key concept of Experiments 1-5 and 1-6, which was to introduce unpredictability and chaos into the communication between the lamps and humans. I expected the work to be something people wanted to explore because of its strangeness, which they

Figure 1.16 Yuen, Experimental Installation at the RCA

would find more interesting than a machine that responded to stimuli in simple ways.

My field experiments were carried out in the RCA's buildings, entrance hall, and courtyard, and in Hyde Park; I set up the installation in these locations and observed how passers-by reacted to it. A few groups of people showed an interesting reaction: their attention was first caught by the work's appearance and motion; then, they seemed to be trying to understand whether/how the lamps were reacting to them. It seemed that they were exploring their relationship with the objects — which is what I was aiming for in the project. Quick chats with the passers-by after the observation, however, told me something else. They had been trying to understand what was going on because the installation was strange to them — but this did not necessarily mean they encountered their communication with the lamps as pleasant. Some of them even felt they had to walk away because they felt uneasy they could not establish what was happening.

Figure 1.17 Yuen, Installation at the Milan Design Fair 2012

There was another insight I gained from this work. Yuen won some international design awards, and I was given opportunities to exhibit it in other countries, including at the Milan Design Fair and the Reddot Design Museum in Singapore, as well as at the RCA's interim show. In observing and talking with visitors at these exhibitions, a thought occurred to me — what was really powerful and impressive to people might be the lamp's smooth and organic motion and the sequence of those motions spread over the group of lamps, rather than the unpredictability in the communication. The turning point was when I exhibited the installation in Milan. In all the observations made at the RCA and in Hyde Park, I had always placed the lamps such that they were scattered over the space, so that people could walk in between them. In Milan, I chose to make a baseboard and arranged the lamps on it like flowers in a bed, intending to hide the messy cables. However, in this set-up the installation actually seemed to be more impressive to visitors than it had been originally. At this exhibition in Milan, the installation was set up in a very small room, which did not allow enough space for people to move around the baseboard, so most visitors looked in at the installation from the entrance of the room. The distance allowed the visitors to appreciate the lamps as something untouchable, and simply to enjoy watching the lights moving, like little exotic animals in a zoo. In fact, many visitors with whom I chatted talked about the cuteness, beauty, and poetry of the lamps' motion and behaviour, using metaphors of plants blown by the wind, or of animals relaxing or seeking food. I carried out no organised survey and no rigorous research interviews, so I do not intend to dwell on these experiences in Milan; however, at least to me, people seemed to enjoy the work more in this exhibition than in the original 'walk-through' set-up, where I had expected people to explore the ambiguous and obscure communication with the lamps, and from which some visitors seemed to take a sense of unease. From this moment, my interest began to shift from the mechanism of communication between people and moving objects to the aesthetics of the motion of those objects.

Experiment Series 2

Back in London, I started another set of experiments focusing on this new interest. This time I intended to carry out many primitive experiments in parallel rather than spending time in developing one complicated project after another. This would allow me to explore the basic ideas of the theme and compare those ideas from the same point of view more easily.

Figure 1.18 shows images captured in 30 experiments (See Appendix A for details). They included inflating and deflating balloons, shining light through foam, oil floating on coloured water, shining light through oil, beads and other liquids, small metal plates with magnets, lots of salt sinking in water, honey flowing along thin string, rusting metal, wax, etc., etc. The criteria were simple — any project had to have motion which was beautiful, interesting, unique, or worth exploring to me personally. Finally, one experiment caught my eye: a bubble I blew with a straw inside a can of thick paint.

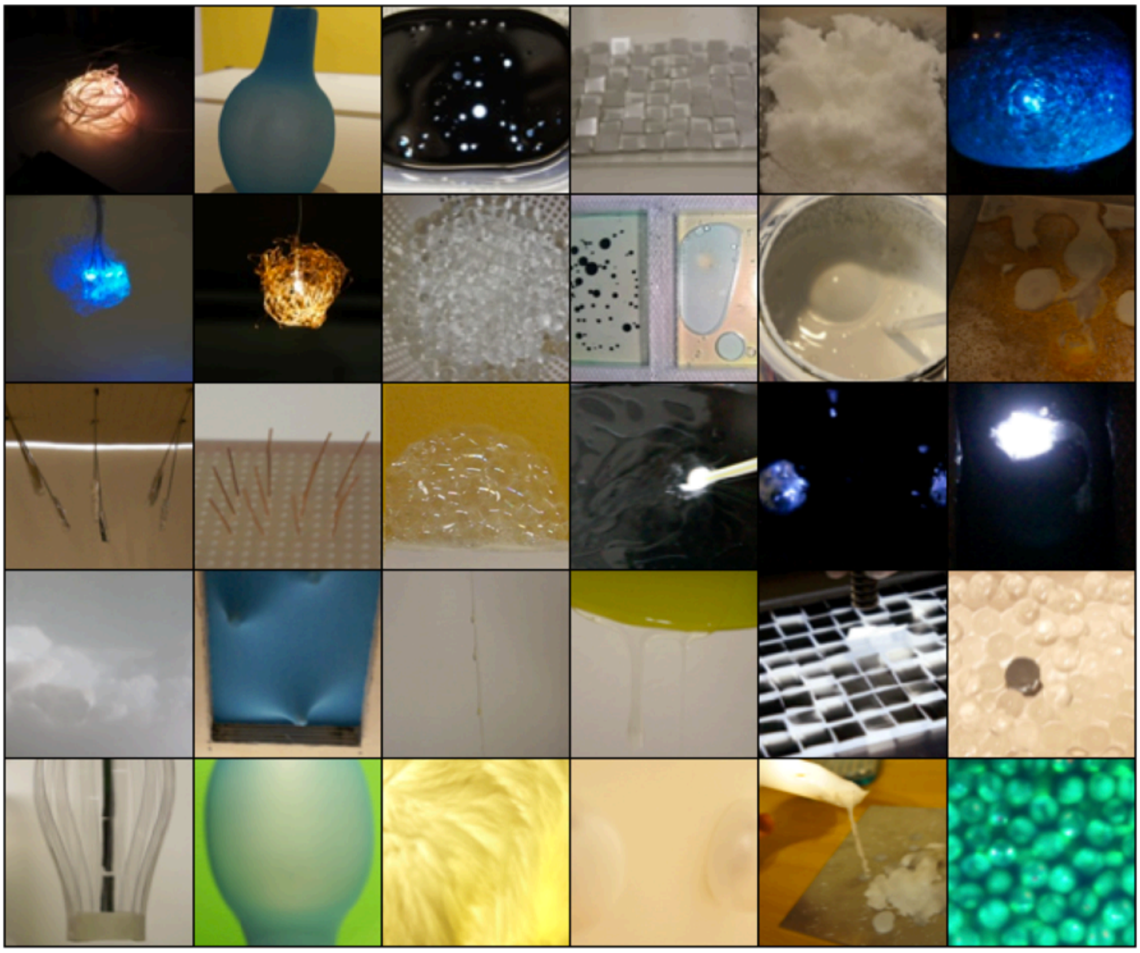


Figure 1.18 Experiment Series 2

1.3 THE KEYWORD IS PULSE

The motion of a bubble gradually appearing out of thick liquid paint, getting larger, stretching and then popping somehow fascinated me. Looking closely at the liquid on the bubble's surface, it got thinner and thinner until the surface tension became weaker than the air pressure, at which point it would break. This felt dramatic, as if one were looking at a fight between liquid and air.

I started to explore this further. I spent a few days continuously blowing bubbles into various kinds of liquid such as water, sparkling water, wine, chocolate, vegetable oil, silicone oil, resin, and glycerin, and combinations of some of them, too. I also tested different sizes and shapes of outlet of the air tube to see the variation in the form of the bubbles. A big round opening made a slowly growing bubble. A small and sharp opening made many small bubbles appear successively. A sponge made tiny bubbles, all created at the same time.

Whilst carrying out these tests, what I found particularly interesting was when I blew air into a bottle of glycerine with opaque black oil on top — transparent bubbles emerged from the black surface. It felt like something beautiful or even 'sacred' was being born from the darkness, and then lost again after its transient life. Another striking moment during these experiments was when the bubble was pulsing — appearing successively at a regular interval. This pulse of the bubbles reminded me of life's breathing or heartbeat. From this moment I began to narrow my research interest to pulsing motion and its aesthetics.

Further tests were carried out to maximise the value of these insights and I finally came upon a particular mix of materials: honey, silicone oil dyed black, a light source and an air pump that could be accurately controlled by a program. The contrast between the illuminated golden honey and the deep black oil, the thickness of the honey and the lightness of the oil, successfully expanded the dramatic effect I found in the experiment. I discovered that the Japanese

Figure 1.19 Kihou, Experiment Process
1 - Blowing a bubble in a paint can; 2 - Blowing bubbles in soap solution; 3 - Testing various kinds of liquid;
4 - Thick liquid, black oil, and light source; 5/6/7 - Testing different types of nozzle.

Figure 1.20 Kihou, Prototype with Wood

manufacturer Murata produces a pump that was originally developed for cooling ICs on computer circuit boards, and I used this device together with a micro-controller to blow pulsing air bubbles. I also built my own software to control the timing of its operation. Finally, these components and the liquids were all placed into a small ceramic cube. The work had acquired qualities which were enough for me to sigh, 'This is beautiful!' I named the project 'Kihou', which means 'bubble' in Japanese.

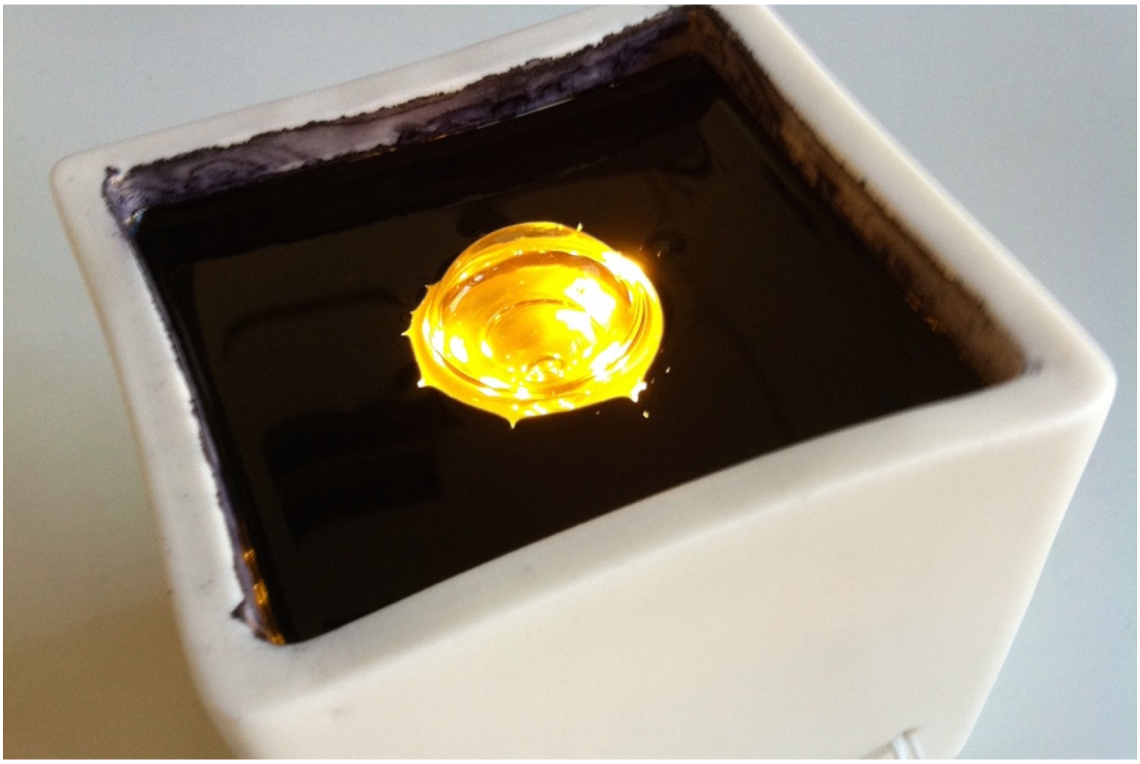


Figure 1.21 Kihou, Prototype with Ceramics

Figure 1.22 Kihou


Figure 1.23 Kihou, Overview of the Bubbling Motion

CHAPTER 2

PULSE AS AN ELEMENT OF DESIGN

2.1 DEFINING 'PULSE'

My first crucial step towards deciding the direction my research would take was made during the development of Kihou — I wanted to explore further the idea of pulse as an element of design. Before continuing to describe Kihou and other projects in greater detail, I want to devote Chapters 2, 3 and 4 to developing this 'seed' of the research idea, reviewing the context around the theme, defining my research question, and outlining the methodologies I decided to take. To begin with, I want to set out my definition of 'pulse'.

According to the Oxford Dictionary of English, pulse (noun) has the following meanings:

1) a rhythmical throbbing of the arteries as blood is propelled through them, typically as felt in the wrists or neck / each successive throb of the arteries or heart;
2) a single vibration or short burst of sound, electric current, light, or other wave / a musical beat or other regular rhythm;
3) the central point of energy and organisation in an area or activity;
4) (Biochemistry) a measured amount of an isotopic label given to a culture of cells.

The meanings in 1) and 2) are particularly relevant to what I deal with in this research. These definitions suggest that pulse means a successive motion when it deals with throbbing of the arteries, and a single vibration or short burst in other cases.

However, the same dictionary also defines pulse (verb) as:

1) throb rhythmically;
2) modulate (a wave or beam) so that it becomes a series of pulses.

It is noticeable that the throbbing motion is not limited to the case of the arteries here. In this thesis I will be using the definition of pulse (verb) rather than that of pulse (noun); I will regard pulse as that which it produces, by which I mean 'a rhythmical throbbing' or 'a series of single vibrations'. The word 'rhythmical' perhaps poses difficulties here, as the word 'rhythm' is the other keyword of my research which I will discuss later on; for now I will adopt the same dictionary's definition of this word, which is 'occurring regularly'. With all of these premises, I define 'pulse' simply as 'regular repetition' (noun) or 'repeat regularly' (verb).

2.2 PULSE AS AN ELEMENT OF DESIGN

In what ways has this 'regular repetition' been used in design? The history is different to what we saw in relation to kinetic art, which I discussed in the previous chapter.

One of the earliest examples would be the clock. The modern mechanical clock existed already in the 1300s, for example the 'Astrarium' designed by Giovanni Dondi dell'Orologio. Clocks in that era were developed for religious purposes, and regularity seemed to play an important role. Matthews (2000) explains: 'In theology, the clock was appealed to in the very influential argument of design for God's existence — if the world functions regularly like a clock, then there must be, as Newton insisted, a cosmic clockmaker' (p.41). In the 1600s the first pendulum clock, introduced as a concept by Galileo Galilei and then actually designed and built by Christiaan Huygens in 1656, also appeared. The pendulum clock is particularly interesting because its pulse is visible, with more dynamics in the movement of the pendulum than other types of clock. That this type of clock has been being designed and produced for nearly 400 years, even after other kinds of technology were established, shows that the pulsing motion of a pendulum can be loved, for its cultural and emotional attraction as well as its technical function. Even in the contemporary art and design scene, works which feature a pendulum are seen frequently, for example United Visual Artists' Chorus (2009), Michael Anastassiades's Kinetic Light 2: Golden Pendulum (2010), ART+COM's Grasp Pendulum (2010), and Formafantasma's Fighting Time (2014).

A rocking chair is another classic example of design that features pulse. Rocking is one of the most primitive human motions, which we experience from the earliest stages of life. It can be seen in infants even a few months after birth, who often beat their feet while lying on their backs. As soon as a child can sit up, rocking of the trunk is often seen. Fraisse (1982) explains the psychological

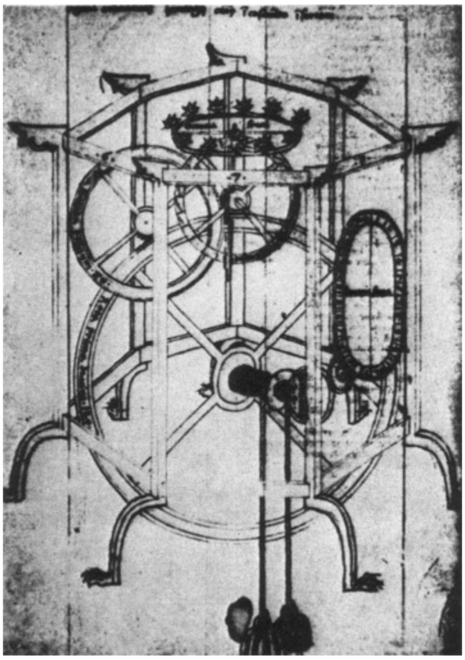
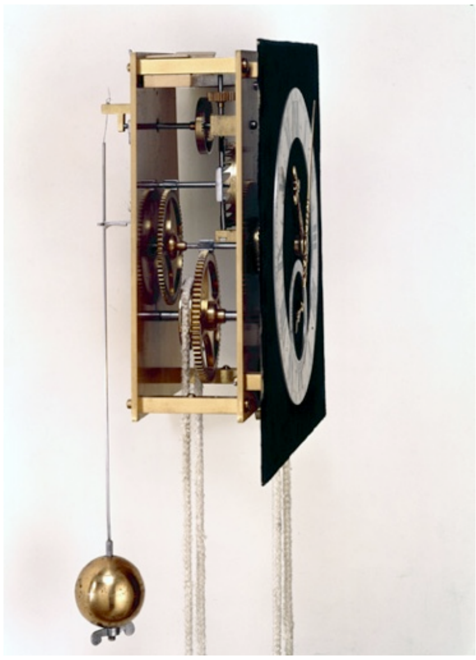



Figure 2.1 (left) Astrarium (1364) by Giovanni Dondi dell'Orologio
Figure 2.2 (right) Pendulum Clock by Christiaan Huygens (Replica)

Figure 2.3 No.21 Thonet Rocking Chair by Michael Thonet

effect of the motion as follows: '[rocking] appears when the child is idle or at the moment of falling asleep. In the adult it also translates into an absence of voluntary control or a state of distraction. (...) In any of these cases, rocking seems to aim at the maintenance of a state of excitation, and it has a heavy affective connotation.' Researchers at the University of Geneva studied the effects of rocking on sleep in a dozen adult men (Bayer et al. 2011). The subjects took naps on a special rocking bed and researchers measured their brain activity during their sleep. The result showed that all of the sleepers had deeper and more restful sleep on the rocking bed than a normal one. The rocking chair is an example of an invention that utilises this psychological effect in design. Its origin can be found in the early 1700s; Michael Thonet, who was the first to mass produce rocking chairs using the bentwood process, would be the most well-known designer of this kind of furniture.

Various kinds of automated machines appeared and spread in the late 18th century, driving the Industrial Revolution. These machines, epitomised by the famous steam engine of James Watt and Matthew Boulton, with its huge metal rods moving up and down, were the embodiment of regularly repeated motion. However, I would not say that these pulses were 'designed'; rather, they were like a 'side-effect' of the main function — though still interesting as another early example of artificial pulse being brought into people's lives.

From the late 19th century, when steam power began to be replaced by electricity, pulse with more controls started to appear widely as an independent function of industrial products. The flashing light adopted by the automotive industry is a good example. To remove the necessity for the driver of a motor vehicle to extend his hand or arm outside the car to indicate an intended change of direction or a stop, and to improve the visibility of the sign for pedestrians and other drivers, flashing turn signals were invented. The idea to equip vehicles with electric lighting devices on the left and right sides was patented in 1907 (Douglas-Hamilton 1907); the modern idea of having dynamic electrical controls was invented in 1938 (Bell 1938). The first flashing

Figure 2.4 Flash-Way Directional Signal of Buick Model 41-C (1939)

turn signal was adopted by the American automotive brand Buick in 1939, and advertised as a 'flash-way directional signal'. But from the viewpoint of pulse in design, the turn signal adopted by the fourth generation of the Ford Thunderbird from 1965 is particularly interesting. These lights were called 'sequential turn signals'; multiple lit elements cast light sequentially outward to more dynamically indicate the direction in which the vehicle was turning. This pulse was obviously integral to the aesthetic design of the vehicle. Recent luxury vehicles equipped with LED , such as the Audi A8, still use the same principle.

Another example in the automotive industry is the use of strobe lights for emergency vehicles. The design (e.g., colour or lighting pattern) of beacons on emergency vehicles varies between countries, but a flashing light is very common all over the world. According to Cook et al. (2000), 'a flashing daytime

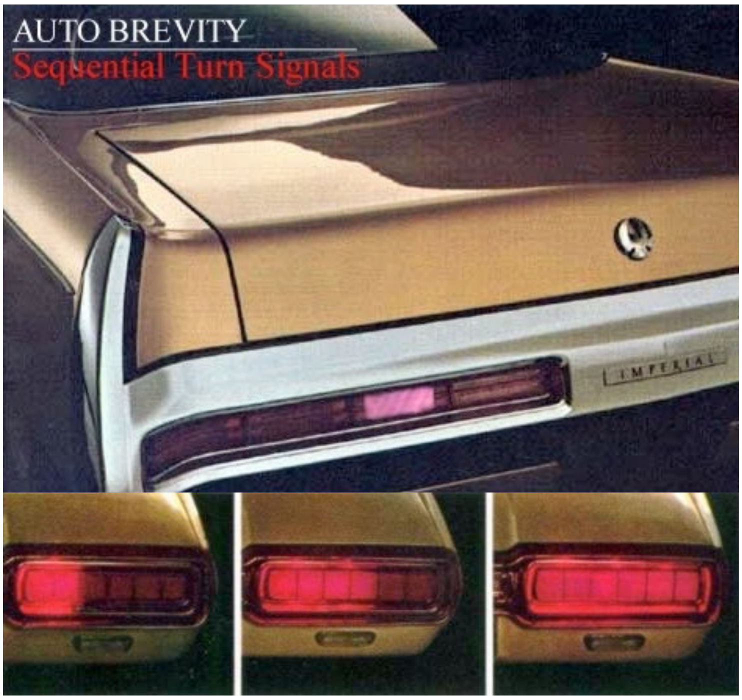


Figure 2.5 (left) Sequential Turn Signals of the Ford Thunderbird (1965)
Figure 2.6 (right) Sequential Turn Signals of the Audi A8 (2010)

running lamp in addition to a 40 W headlamp increases mean peripheral detection of a motorcycle by 20% over a headlamp alone' (p.3).

Telephone ringtones would be another example of pulse becoming an essential part of industrial products. The earliest dial telephone, introduced by Bell in the early 20th century, had some variations of sound indicating the condition of the network: a continuous buzzer sound when ready to call, a rapidly oscillating sound when someone was actually calling, and a slowly pulsating buzzer sound when the network was busy[1]. The first telephone that combined ringer and handset, the Western Electric Model 500, was introduced in 1949 in the United States and made the 'bell ringing sound' popular to the public. This pulsing sound became a cultural icon, thought by many people to be synonymous with 'ringtone' even today — Apple's iPhone also has it as one of the preset options.

[1] A video is available from the AT&T archives: www.youtube.com/watch?v=uaQm30DDHL8

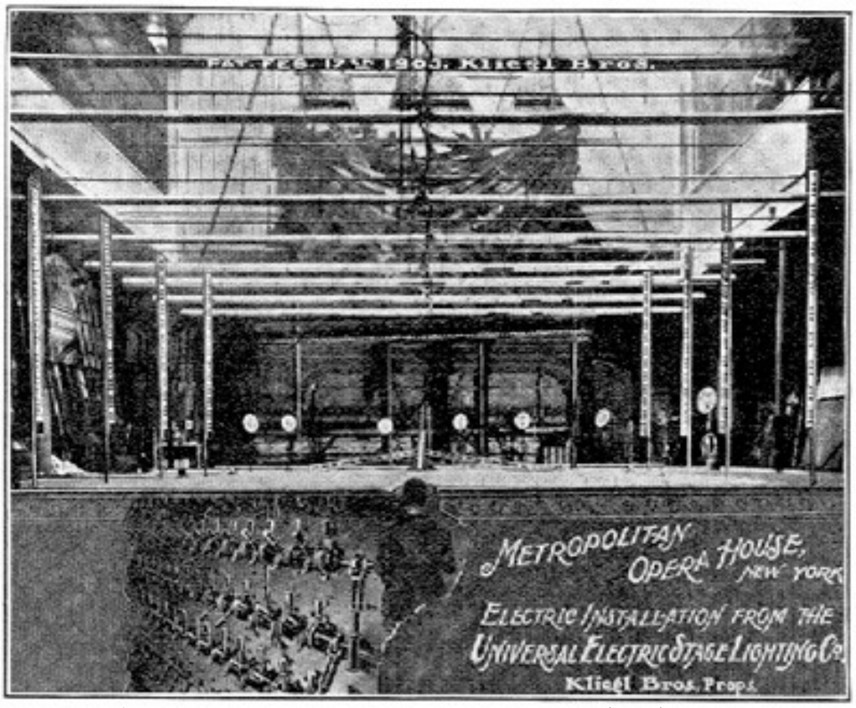


Figure 2.7 Advertisement for the Metropolitan Opera House (1903)

As electronic controls became more affordable and accessible, pulsing light and sound began to be seen on the interfaces of various home appliances, from washing machines to personal computers, typically used to notify the user of the condition of the machine. Taking Dyson's Animal series of vacuum cleaners as an example: the fast-flashing green light indicates that the battery is operating outside of its optimum temperature range; the slow-flashing green light indicates that the battery is fully discharged; the red flashing light indicates that the pre-filter is not fitted correctly; and the solid green light indicates that the battery is charged and the cleaner is operating correctly. In this way, pulsing light and/or sound is often used for alerting, as it attracts users' attention better, in general, than static effects.

One of the earliest uses of pulse for entertainment was in the theatre (George, 1997). The Kliegl Brothers installed the first electrical lighting system with resistance dimmers at the Metropolitan Opera House in New York City in 1903, which were controlled from the switch board by an electrician. Later, flashing lights using dimmers and strobe lights came to play an important role in discos too: 1968 was the year that saw the first example of a dedicated disco light (Dimond 2013). Electronic components such as transistors and thyristors were used to make the lamps flash according to their different frequencies. For example, one lamp would flash in sync with the bass frequency, one with the treble and one with the middle. Such flashing lights and 'sound-to-light' technology have become an essential element in music performances, theatre dramas, fashion and sports events, as well as being applied in urban illuminations, including festive decorations. Philips launched a product called 'Hue' in 2013[2], a full-colour LED light bulb equipped with a wireless modem that allows the user to control the colour, brightness and dynamic effects, such as strobe or oscillation, wirelessly from his or her smart-phone. Third parties and end users can program their original lighting patterns, called 'scenes', and share them online. People can thus download and enjoy disco lighting effects, for example, at home. The project is interesting in that it provides a platform on which dynamic lighting effects for the domestic environment can be developed further.

Some toys, particularly primitive ones designed for infants such as so-called 'balance toys', bobbing-head dolls and cymbal-banging monkeys, also have regular repetitions. A part of the reason why pulsing motion is so popular in these classic toys would be that it is the simplest kind of motion which can be generated by gravity alone — but there seems to be a psychological effect too. Psychologists have argued that when there are regularities in auditory or visual input, infants pick them up effortlessly (Saffran et al. 1996; Brand et al. 2009).

In the design scene of the 2000s, we can find some examples of design where pulse functions more for aesthetic ends. One well known product element is the Apple Macbook's sleep indicator (2002). When the computer is in the sleep mode, the indicator LED begins to oscillate slowly in a way reminiscent of a human's breathing. Apple's patent explains that the pattern used for this sleep

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[2] www.meethue.com

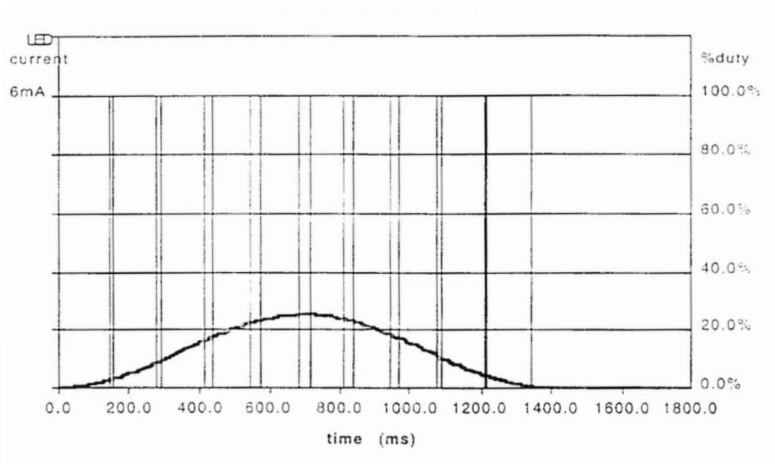

Figure 2.8 (left) Apple Macbook's Sleep Indicator (2002)
Figure 2.9 (right) Diagram for the Intensity of the LED from Apple's Patent (2002)

indicator simulates a typical human's respiration (Apple 2002). The information it conveys is small — only whether the computer is in sleep mode or not — but this feature works well to lend an element of humanity to the computer. 'Glow' headphones (2015) are another product which features pulse for its aesthetic function: the headphones have illuminating cables, whose light pulsates either to the music the wearer is listening to or to their heartbeat. This pulsing visual effect expands the experience of listening to music to a multi-sensory one, and also enhances the experience emotionally.

There are more examples among contemporary artistic installations and conceptual design projects. For example, Nils Voelker designed Thirty Six (2011), a chandelier-like site-specific installation which is composed of arrays of plastic bags attached to fans and light. The plastic bags are inflated and deflated repeatedly, 'shifting shape and light, creating a rhythm not unlike our own breathing'[3]. U-Ram Choe's Una Lumino (2008) is another chandelier-like kinetic sculpture with controls such that many flower-like modules open and close repeatedly. Its creator explained the concept as follows: 'communities of these species [the flower-like modules] gather and collect to form a giant mass

[3] www.artlabgnesta.se/en/2011/10/02/rhythm-2/

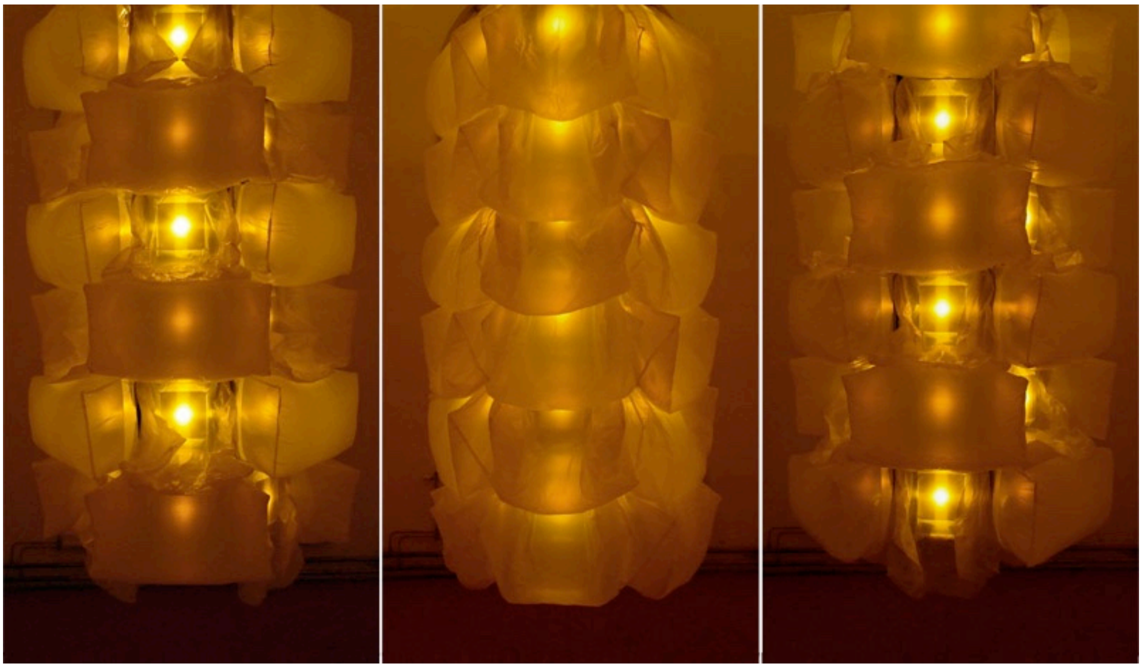

Figure 2.10 Thirty Six (2011) by Nils Voelker

Figure 2.11 Una Lumino (2008) by U-Ram Choe

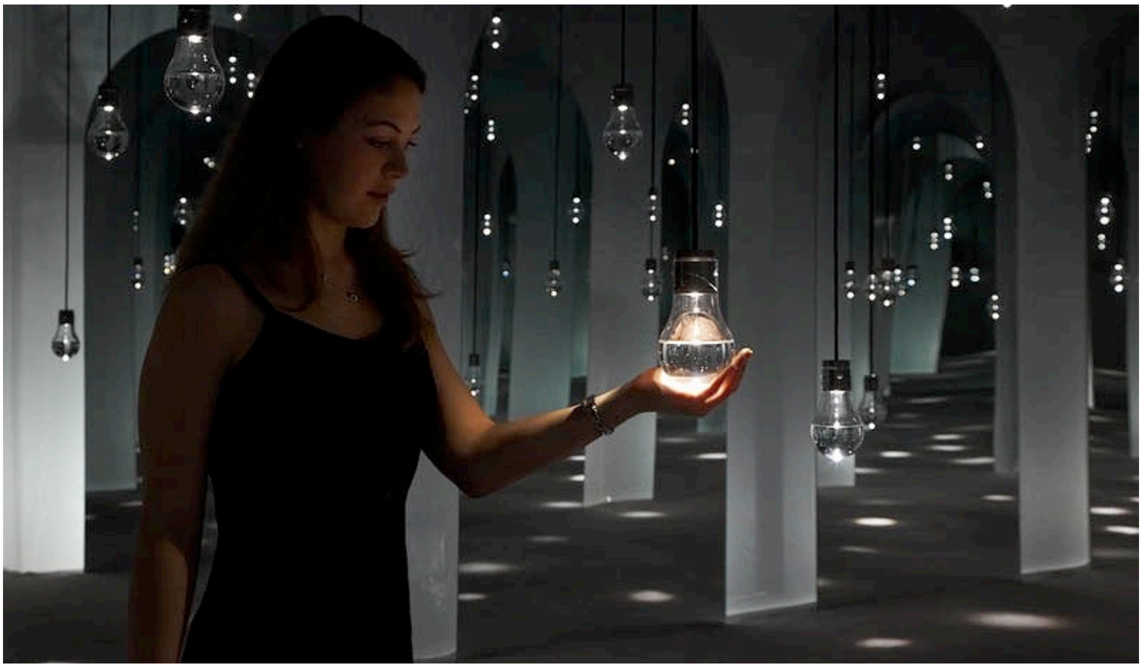

Figure 2.12 Overture (2009) by Takram Design Engineering

of pulsing, breathing light, where they exchange information about where to find city energy, their main source of sustenance'[4], in the imaginary context that this is 'a brand new species of mechanised sentient creatures'.

Takram Design Engineering designed an installation for Toshiba, the Japanese electronics company, to express the brand's 'paradigm shift' from classic incandescent lamps to new LEDs. The work, named Overture (2009), was composed of about 100 light-bulb-shaped objects suspended from the ceiling, each containing water and an LED. When a visitor touched one of the bulbs, it started to make a pulsating tactile vibration analogous to the human heartbeat, with an accompanying oscillation of light. The subtle vibration on your palm would remind you of the heartbeat of an infant rather than of an adult. By featuring the pulse analogy in this way, the designer expressed the dawn of the era of the 'newborn' LED.

[4] www.uram.net/eng_new/intro_en.html


Figure 2.13 Pulse Room (2006) by Rafael Lozano-Hemmer

The Mexican artist Rafael Lozano-Hemmer created an installation entitled Pulse Room (2006). Borrowing the artist's own description, 'bulbs are uniformly distributed over the exhibition room, filling it completely. An interface placed on a side of the room has a sensor that detects the heart rate of participants. When someone holds the interface, a computer detects his or her pulse and immediately sets off the closest bulb to flash at the exact rhythm of his or her heart. The moment the interface is released all the lights turn off briefly and the flashing sequence advances by one position down the queue, to the next bulb in the grid. Each time someone touches the interface a heart pattern is recorded and this is sent to the first bulb in the grid, pushing ahead all the existing recordings. At any given time the installation shows the recordings from the most recent participants.'[5] Thus, the pulse in the flashing light is a reflection of the participants' heartbeats. Lozano-Hemmer has expanded the concept in

[5] www.lozano-hemmer.com/pulse_room.php

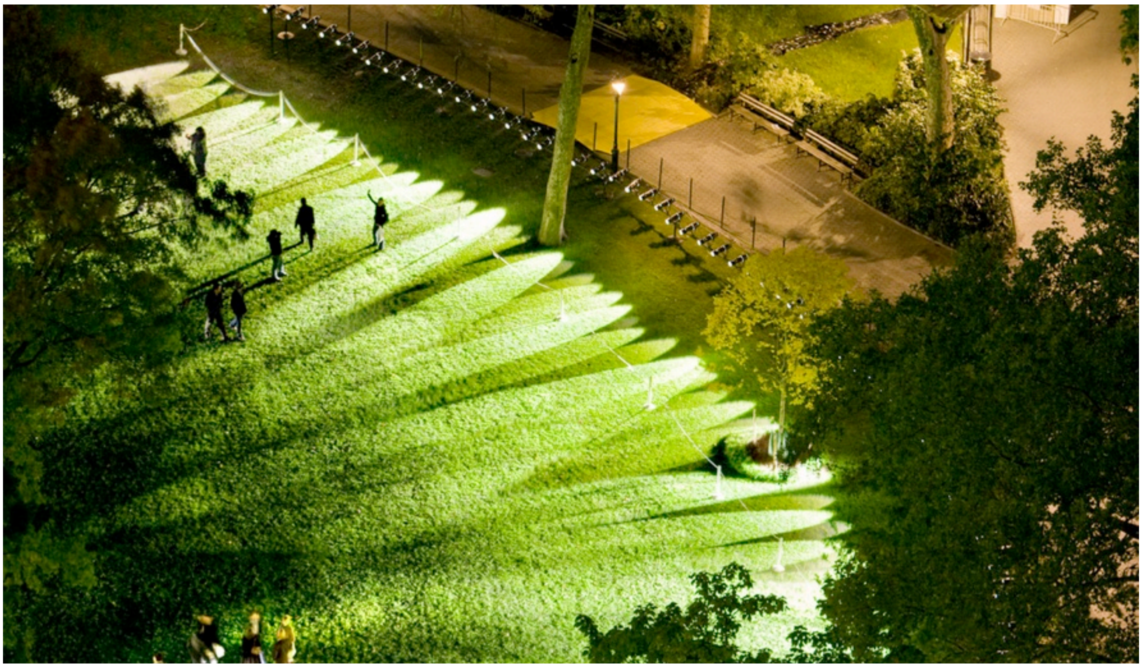

Figure 2.14 Pulse Park (2008) by Rafael Lozano-Hemmer

several projects such as Pulse Tank, Pulse Front, Pulse Spiral, Pulse Park and Pulse Index[6], using various media and choosing different kinds of site.

In this review of examples from history, we can see pulse has been expanding its value as an element of design. To summarise in broad terms: pulse originally appeared as a 'side-effect' or accompaniment to other functioning elements of machines in the 19th century; it acquired more controls and became a 'designed element' of products in the 20th century, with particular functions such as alerting, exciting or meditating, utilising humans' psychological reactions; most recently, the 21st century has seen attempts to use metaphors or narratives in pulse, so that objects can communicate with customers or audiences not just psychologically but emotionally or semantically. What is happening in this century could be understood as the meeting of pulse as an element of design with the complementary stream of expanding kinetic art. We are at a point where designers are beginning to apply artistic ideas to pulse in order to

[6] www.lozano-hemmer.com/projects.php

augment its effects beyond psychological reactions. Sometimes examples of this undertaking are hard to distinguish either as design or as art; however, I believe this area of design will develop further from this point.

2.3 THE MISSION STATEMENT

The question is, how? At present pulse is still only beginning to play a role in design for artistic and emotional communication. The number of works embracing the concept is still small; indeed, even these works, including the examples I introduced above, tend to use limited methods such as blinking lights, opening and closing mechanical components, or inflating and deflating balloons. The majority of these pulses deliver a metaphor of a heartbeat or breathing; it seems, at least to me, that at present few of them appreciate the more subtle qualities of irregularity, unpredictability, contingency, etc., of life — the outputs of most works are still fully controlled and allow little room for noise. I perceived a definite opening for someone who not only makes and exhibits individual works, but also explores new, useful methods and working ideas to present a wider range of qualities that can be appreciated with greater 'sophistication' in the sequence of his or her works, contributing to the development of a broad picture of how 'pulse as an element of design' can develop in the future. This became the mission of my PhD.

However, my problem at the outset was that the possible space to explore is huge, probably too huge for one PhD. If I wanted to explore useful methods or ideas for good, sophisticated design, what should be considered 'good', 'sophisticated', or 'useful'? Some people find shiny gold design objects beautiful, while others may think them too showy or even gaudy; some people appreciate antique objects, while others may not understand their value and think they are just old and dirty — these issues are highly dependent on cultural context. I needed to develop some criteria. My criteria also needed to work for me, to help me self-evaluate my exploration. Because I intended to position myself in my thesis not only as a critic, but more importantly as a creator, I needed to be able to naturally sympathise with my criteria when making things. I decided to seek these criteria in my cultural DNA — in the culture of Japan.

CHAPTER 3

JAPANESE AESTHETICS

3.1 DEFINING 'JAPANESE AESTHETICS'

My sense of beauty, particularly during creative activities, is certainly affected by the particular kind of aesthetics I have inherited through Japanese culture — I will call it 'Japanese aesthetics' in this thesis. This influence is unavoidable for me, as someone born and raised in this country, living there for 25 years. In this chapter I define my concept of Japanese aesthetics to allow me to use its criteria for my research.

It is not easy to define aesthetics, as its concepts are 'alive and often unfriendly to interpretation' (Richie 2007, p.12). Defining traditional Asian aesthetics, however, is perhaps particularly hard. As Richie writes, 'the conventions of a Western disclosure — order, logical progression, symmetry — impose upon the subject an aspect that does not belong to it' (ibid.); the Japanese writer and architectural critic Teiji Itoh states, 'The dilemma we face is that our grasp is intuitive and perceptual rather than rational and logical' (Itoh et al. 1992).

Richie, Itoh and others have attempted to find ways to resolve the problem. According to Richie, 'most likely to succeed in defining Japanese aesthetics is a net of associations composed of listings or jottings, connected intuitively, that fills in a background and renders the subject visible' (Richie 2007, p.11). The word 'characterising' might be better to express this approach, in which different writers have adopted different language. For example, Richie (ibid.) categorised the vast concept of Japanese aesthetics into the following central 'tastes': *fūryū* (elegance), *shibui* (unobtrusive), *wabi* (poverty), *sabi* (antiqueness), *aware* (pathos of things), and *yūgen* (suggested deepness of feelings). Dunn (2001) adopted a similar approach but chose different central tastes: *kodai* (ancientness), *soboku* (simplicity and pureness), *wabi* (poverty), *iki* (chic), and *karei* (elegance). Teiji Itoh, an architectural critic, adopted very different categories when isolating Japanese design techniques (Itoh 1966): curved line, pivot space, pattern of change, status symbolic planning, function symbolic planning, formal-informal, aesthetic triangle, trump element, activity space, and visualisation of activities. Donald Keene, who contributed greatly to introducing Japanese culture to the West, particularly literature, used the terms 'suggestion', 'irregularity', 'simplicity', and 'perishability' (Keene 1988) to understand the aesthetics in the writing of the Buddhist monk Kenkō. The terms chosen by each writer may read differently, but what they are trying to grasp is similar. The differences emerge from differences in the authors' purpose, which ranges from literary criticism to framing design methods. What I want to set out in this section is my own definition, or characterisation, of Japanese aesthetics, to help ensure that the reader and I share the same image.

Suggestion

After spending two years in the UK, I returned to Japan for a holiday at the beginning of 2013 and had a chance once again to visit the Tokyo National Museum. I cannot forget the experience I had in front of the piece *Shōrin-zu Byōbu* (Pine-trees Screen) by the famous *suibokuga* (ink-wash painting) artist Tōhaku Hasegawa. It was a kind of rediscovery of my mother nation's traditional beauty. What I saw in the work was not a reproduction of the landscape of pine trees but the aura or impression that the painter experienced within the landscape. Historically, reproduction or realistic illustration was never the purpose of Japanese *suibokuga* painters: 'Eschewing realistic depiction for symbolic expression, they transformed their depictions of mountains and rivers, rocks and bamboo, into extensions of themselves, into spontaneously executed mirrors of the soul. Ink painting had become a spiritual exercise, and this is the quality that sets it apart from other types of painting' (Kanazawa 1979, p.16). This non-illustrative form of expression gives us the room to imagine what is not drawn in the work. In Tōhaku Hasegawa's piece, I could 'see' the haze floating between the pine trees. I could see the seashore far behind the trees. I could also imagine deep cloud covering the sky and dusk shrouding the scenery, or night-time with the vague shapes of the trees in the moonlight.

Figure 3.1 Shōrin-zu Byōbu by Tōhaku Hasegawa

It could be autumn or winter. I could smell the sea but just faintly. Maybe the scene was completely silent, or maybe I could hear the sound of wind. Such scenes are completely in the viewer's imagination but the painting does not refuse them. It leaves room for us to participate, through the imaginary eyes of the painter.

This kind of expression is universal throughout many forms of Japanese culture. I use the term 'suggestion' to explain this quality. The central taste included in this quality is what has been called *yūgen* ('suggested deepness of feelings'). Zeami Motokiyo, the pioneer of Japanese Noh theatre performance in the early 15th century, left this famous passage explaining the essence of *yūgen* in his treatise *Fūshikaden* (known in English as *Flowering Spirit*): 'If hidden — a flower; unless hidden, no flower at all' (Zeami and Wilson 2006). We should note that 'flower' here does not literally mean 'flower' but 'beauty'. Being 'hidden' does not literally mean being out from sight but being presented vaguely, subtly and implicitly, without being explanatory or illustrative. It is not the object itself but the substance of it that is hidden in the vagueness (Shigemori 2008). Makoto Ueda has written that, 'a distinctive feature of traditional aesthetic thought in Japan was a tendency to value symbolic representation over realistic delineation. Mimesis in its sense of an imitation of outward appearance was never an aim of traditional Japanese aesthetics' (Ueda 1991, as cited by Richie 2007, p.23). Richie (ibid.) supported this view: 'Realism in the Western sense of the word played a small part in the realities of life as experienced by the traditional Japanese artist. The expectations of the artist's cultivated sensibilities did not demand mimesis. Rather, indication, suggestion, simplicity took the place of any fidelity to outward appearance' (p.24).

Let us stay with this idea of 'suggestion' with a couple more examples. Here is the famous *haiku* poem by Matsuo Bashō:

The ancient pond.
A frog leaps in.
The sound of the water. (Trans. Donald Keene)

Bashō was writing about a scene in this short poem, but the quintessence was never capturing the scenery, as it would be with the Western tradition of realism. He would never have thought of describing how the frog leaped or what the water sounded like. The restricted use of words can be seen as presenting a portal into the realm of the imagination — though I would note that what we imagine within Bashō's poem is not a fictional fantasy but the realities which Bashō did experience more than 300 years ago. In this sense, suggestion is different from illusion. The other example I want to advance is the Japanese garden of *Ryoan-ji* Temple, which is probably the most well-known *kare-san-sui* garden (rock garden, Zen garden). The 15 rocks, varying in size and shape, and the painstakingly maintained white gravel are enough for the visitor to see the 'hidden' vast scenery of a calm sea and small islands in his or her mind's eye. Kakuzo Okakura phrased it thus: 'leaving the imagination to suggest to itself the completion of an idea' (Okakura 1904, p.178).

It may seem somewhat reckless to some readers but I would like to include the quality of simplicity within this quality of suggestion. As is often said (see, e.g., Keene 1988), simplicity is one of the most notable tastes in Japanese aesthetics.


Figure 3.2 Ryoan-ji Temple Zen Garden

However, it is important to understand that it is not making things simple as a goal in itself that we Japanese have been aiming for. The simplicity of Japanese aesthetic tastes connotes intangibility and richness (Fukasawa 2005). It 'hides' the 'substance' inside. In contemporary design practice, this philosophy of simplicity is often represented by the minimalism style.

Emptiness

The quality of 'emptiness' very often coexists with the quality of suggestion. By this term I mean perceptible emptiness, such as the emptiness of visible and/or tangible space (called 'negative space'), emptiness of sound (i.e., silence), or emptiness of colour (i.e., transparency or plain colour); the 'suggestion' I wrote about above accompanies the intangible space for the imagination to access. If we take the *Ryoan-ji* Temple garden as an example again, we can see the apparent emptiness in the vast plane of white gravel. Mirei Shigemori, a pioneer Zen gardener of the modern age, argued that *kare-san-sui* is the art of emptiness as well as the art of suggestion (Shigemori 2008). According to his study, as the inhabitants of a small island nation that has relied so much on the fruits of the seas, it is natural that Japanese gardeners should feature empty space as the essential structural element as a way to express the vast expanse of the ocean. Furthermore, the emptiness in Zen gardens works not only as a metaphor for the ocean but also as a contrast with the other elements — 15 rocks in the case of the *Ryoan-ji* Temple gardens. Shigemori stressed this point by writing that the beauty of the arrangement of rocks only works due to the contrast of the emptiness of the ground (ibid.).

An example of emptiness in time can be found in the haiku poem form. When a poet or reader reads a haiku poem aloud, the poem is always, even necessarily, read slowly, with intervals between phrases. This interval, the emptiness in *haiku*, is called *ma*. The *ma* releases the reader from the formal constraint of having only 17 characters (Hidaka 2013), giving him or her the space to imagine the realities within. This is why Kai Hasegawa, a researcher in Japanese classical literature, including *haiku*, wrote, '*ma* is more eloquent than words'(Hasegawa 2012, p.132).

The graphic designer Kenya Hara, in an essay on the aesthetics of the colour white, explained this power of emptiness as follows: 'emptiness doesn't mean "nothingness" or "energy-less"; rather, in many cases, it indicates a condition, or *kizen* (in Japanese), which will likely be filled with content in the future. (...) A creative mind, in short, does not see an empty bowl as valueless, but perceives it as existing in a transitional state, waiting for the content that will eventually fill it; and this creative perspective instils power in the emptiness' (Hara 2009, p. 28). Therefore, the emptiness is waiting. In the case of works of art, it is waiting for the viewer to participate. Donald Keene contrasted the aesthetics of the East and the West from this perspective: 'the Sistine Chapel is magnificent, but it asks our admiration rather than our participation; the 15 stones of the Ryoan-ji, irregular in shape and position, allow us to participate in the creation of the garden' (Keene 1988, p.20).

Transience

The last quality I distinguish in Japanese aesthetics is transience. This is what we call *mujō* ('impermanence'; Keene (1988) uses the term 'perishability'). Kamo-no-Chomei's essay *Hōjōki* (*Ten Foot Square House*) begins with this famous passage, which captures the spirit of transience:

'Though the river's current never fails, the water passing, moment by moment, is never the same. Where the current pools, bubbles form on the surface, bursting and disappearing as others rise to replace them, none lasting long. In this world, people and their dwelling places are like that, always changing.' (Trans. Muro 1997)

In the passages that followed, Chomei wrote about a conflagration, tornadoes, famines and earthquakes — all of which he experienced in only eight years. Such frequent disasters and the weakness and frailty of humans in the face of them formed a view of the world as transient or impermanent, not only in Chomei but also in most people of the era (Takeuchi 2007). The notable thing, however, is that in the Kamakura period, when the *Hōjōki* was written, people began to change this view in two ways (ibid.). Firstly, transience began to apply not only to human life but to literally everything in the world. Secondly, and more importantly, such transience came to be accepted as part of the nature of the world instead of being something to be rejected as pitiful, and people eventually even found a sense of beauty in it. Kenkō Yoshida's *Tsurezuregusa* (*The Harvest of Leisure*) from the Kamakura period asked: 'Is it only when the flowers are in full bloom and when the moon is shining in spotless perfection that we ought to gaze at them?' This question is designed not only to ask us to appreciate cherry trees in winter or the darkened moon in the rain — the point is that we should appreciate the beauty in the transience of nature.

How has this approach to aesthetics been expressed in design? Itoh (1966) took a Japanese hill-and-pond garden as an example. Gardens in this style, which have an even longer history than *kare-san-sui* rock gardens, have various trees and a pond, suggesting the mountains and the sea. Gardeners do not complete the design to claim an ideal landscape; they take the growth of trees or any sort of natural change into account and design the gardens to flower naturally ten years from 'completion'. What to do after the ten years? Maintaining the trees and pond as they are could be an option, but the attitude is mostly a different one. Gardeners rather try to minimise such maintenance, leaving old trees to die and embracing the growth of new ones: 'the transience is real nature and it is what the designers long for' (ibid.). This spirit has been inherited in today's Japanese design. For example, Naoto Fukasawa, one of the most famous Japanese product designers in 2000s, explained his view on designing industrial products by saying that he appreciates changes over years of use, 'always considering such beauty of perishing' (Fukasawa 2005, p.110).

I want to stress that, although the quality of transience is almost always associated to change, change does not necessarily bring this quality by itself. The essence of being transient is not being eternal — like the lives of living things. Repeating the same process eternally will not augment the quality of transience. Change needs to be as irreversible, unpredictable, and contingent as change in nature. Conversely, fragile and delicate things, which can be expected to be easily changed, can have the quality of transience even though they are static.

Nature as the Source of Inspiration

The Japanese national religion Shinto worships deities within nature. Terada (1948) saw the origin of this in the Japanese climate and geographical conditions. The continental climate from Eurasia and the oceanic climate from the Pacific Ocean together brought the Japanese islands ample water and soil for cultivation. Rich vegetation and marine resources sustained the people's diet. At the same time, the frequent typhoons, earthquakes and tsunamis have meant that the environment inspires awe or even fear of nature. Such feelings of gratitude, awe and fear contributed to the growth of the worship and animistic view of nature in this country.

In fact, the word *shizen*, the Japanese translation of 'nature', did not exist in any Japanese dictionary until the mid-19th century (Ueda 1991). The concept of distinguishing trees, waters, animals and all such things as 'nature' and contrasting it to humans was introduced from the West. For the Japanese, the human being was inseparable from what we now call nature. In Kenya Hara's words: 'Since ancient times, the Japanese have believed that wisdom resides in nature and human beings live by basking in the wisdom of nature. This differs from the Western conceptual climate, which posits wisdom on the part of human beings and states that nature, an undomesticated wilderness, should be controlled by human intellect' (Hara 2007, p.330).

This philosophy has shaped the nation's culture too, and nature has very often been the theme or source of inspiration for all types of creative activities. We have already seen in some of the above examples how poets, painters, gardeners, and designers have appreciated nature in their work. The contrast to Western landscape paintings, for example, in which nature is an object, is clear. For Japanese artists, nature has traditionally been more than an object — it is the world itself, which the artist is also a part of. In short, 'the distance between arts and nature [in Japan] was considerably shorter than in its Western counterparts' (Ueda 1991, p.24). As a Japanese designer myself, I believe using inspiration from nature is one of the most effective ways to heighten the qualities of Japanese aesthetics.

Summary

Figure 3.3 summarises my definition of Japanese aesthetics with some keywords I have used. This definition is composed of three qualities — suggestion, emptiness, and transience — and nature is placed in the background as the source of inspiration to heighten these qualities. As stressed in Donald Richie's expression 'a net of associations', these qualities are inseparable and overlapping. Of course I would not argue that this definition can cover the whole possible spectrum of Japanese aesthetics — for example, we do also appreciate gorgeous decorations or realistic expression, too, occasionally — but this is 'my edition' of Japanese aesthetics, which I believe represents its most important aspects and will aid my research.

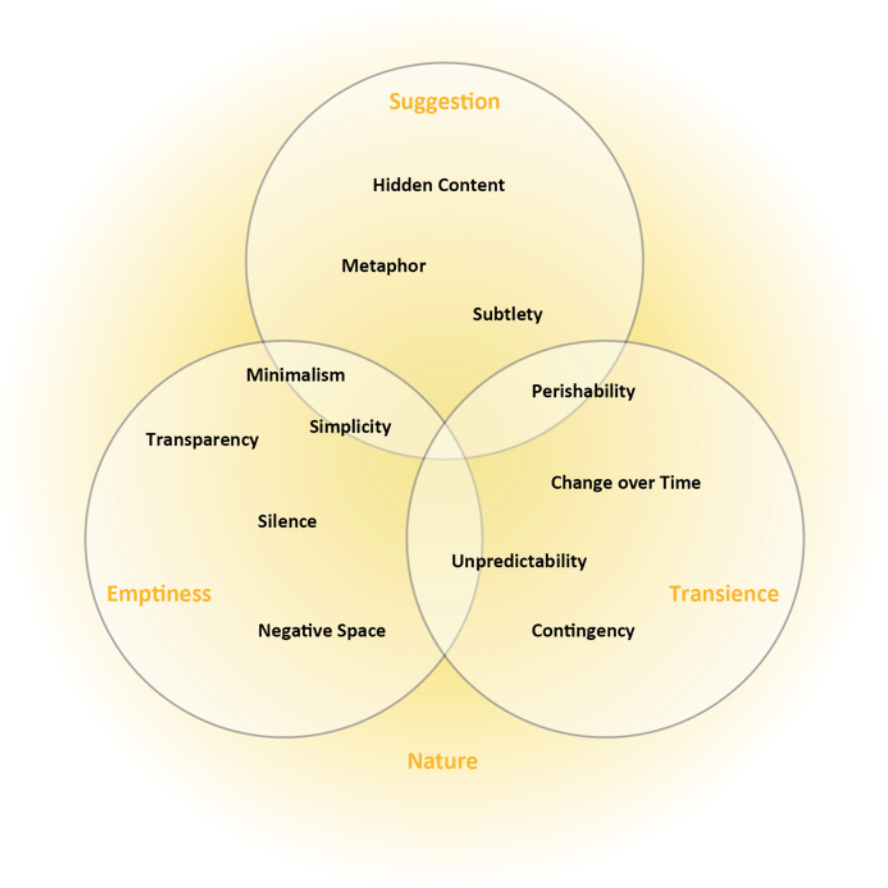

Figure 3.3 Definition of Japanese Aesthetics

3.2 QUALITIES OF JAPANESE AESTHETICS AS CRITERIA

My intention is to use this definition of Japanese aesthetics to provide the specific criteria for my research in order to clarify its focus. Namely, I will explore pulse such that being suggestive, empty, and transient is preferred to being illustrative, filled, and eternal. A work will be better evaluated when it better achieves the qualities of Japanese aesthetics.

Let me introduce a few examples of works of contemporary Japanese design which I believe embody these qualities to a high standard. First, Tokujin Yoshioka's Venus Chair (2008). This chair literally 'grows' in a tank filled with chemical solution as crystals form on a sponge-like substrate until they achieve a strength that is great enough for people to actually sit on the structure. Although the use of minerals as the material brings a certain 'naturalness' to the work, there is no hint of life visible in the overall shape of the chair. However, the process of the chair growing in a tank is more than enough for the viewers to understand the concept of birth and growth of life behind this chair. This is a highly suggestive way to communicate the concept of design. The process of growth also draws attention to the quality of transience in itself. In addition, the use of pure transparent crystals could be understood as a result of the designer's appreciation of emptiness.

Shivering Bowls (2012) by nendo is another example. This set of thin, elastic silicone bowls was designed for the KAMA: Sex & Design exhibition at the Triennale Design Museum in Milan. Borrowing the designer's own words: 'The bowl changes shape as easily as liquid when it is touched, and continues to quiver momentarily in response to the outside force. We wanted to express eros through a design that invokes desire — a design that viewers simply can't bear

Figure 3.4 Venus Chair (2008) by Tokujin Yoshioka

Figure 3.5 Shivering Bowls (2012) by nendo

not to touch'[1]. Most of the works by other designers curated in the same exhibition featured sex organs or the sex act directly in shape or graphics. The uniqueness of nendo's approach is that they avoided such direct expressions and tried to let the subtle materiality suggest the theme of eros. We also see the philosophy of emptiness in the choice of the plain white colour. On top of that, the delicateness of the thin material reminds us of the perishability of things, and thus their transience.

The last example I will introduce here is Tadao Andō's Church of Light (1989). When asked to design the Ibaraki Kasugaoka Christian Church in Osaka, Japan, Tadao Andō designed a building of reinforced concrete featuring a cross cut in the wall, extending vertically from floor to ceiling and horizontally from wall to wall. The cross lets in the natural light, whose texture is always changing hour by hour, day by day. Andō was thus successful in borrowing the transience of nature, as this 'cross of light' suggested divinity (there is no other cross or statue in the church). Another feature of the interior is the profound emptiness that sits inside this cube of concrete. The architect meant this emptiness as a space for the occupant to fill with spirituality (Drew and Andō 1996). His work has always featured this emptiness within the solid materiality — it has been his philosophy that 'architecture should exhibit both qualities of substance and abstraction simultaneously', as he said in an interview (Brownell 2011).

Keeping in mind this understanding of how Japanese aesthetics can be embodied in design, I want to frame my research question as follows: 'How can I develop the value of pulse further as an element of design, with the qualities of suggestion, emptiness, and transience?' I want to answer this 'how' question in two steps — finding the concrete ideas and methods by which I can heighten these qualities, and generalising those concrete ideas and methods to construct accessible knowledge for other designers.

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[1] www.nendo.jp/en/works/shivering-bowls-2/


Figure 3.6 Church of Light (1989) by Tadao Andō

CHAPTER 4

METHODOLOGY

4.1 PRACTICE-LED RESEARCH

Through Chapters 2 and 3 I have narrowed my research area and set up the research question. In this chapter, as the last preparation before describing my own investigation, I want to write about the methodology I adopt in the research.

The research for my Master's degree in the University of Tokyo began with a survey of journal and conference papers around my own and my lab's areas of interest in order to find what had been done to date in the field, and what was still left to do. It was one of my supervisor's major roles to look into this with me to help me choose the right theme, which needed to sustain interest and be feasible within the given period of time. We set the goals of the research together and planned a 'road map' towards the target. Only when this road map had been proposed with a certain level of concretion was the research considered ready to get underway, and I began to try various ideas through experiments, improving these ideas as I went along.

The approach to researching I encountered at the RCA was different. Every proposal of mine was rejected by my supervisors in the first term, again and again,. They would never allow me to set my goals. Instead, they asked me to stay in the studio, play with materials, do experiments — essentially, to make things. My heart said, 'How can I begin a research study without setting the target!?' That was the only approach to research that I knew at that time.

After spending some time in this environment, I began to understand the message behind the supervisors' advice, which I believe was 'learn through acting'. Ranulph Glanville, one of my supervisors, highlighted two kinds of knowledge, which Aristotle distinguished in his Nicomachean Ethics: 'sophia' and 'phronesis', where sophia is 'theoretical knowledge' while phronesis is 'practical knowledge'[1], for instance the knowledge of a highly skilled potter acquired through his experience of making things with his hands (Glanville 2014). Barrett (2010) called it 'experiential learning and knowledge'. No practice-led design research could be carried out without appreciation of the phronesis gained through the act of designing — this may seem natural, but for a person trained in a traditional way as an engineer or engineering researcher it is not. However, by experiencing the moment in which random experiments in the studio gave me the seed of my argument (as I have described in Chapter 1), and the process in which I kept refining and expanding this seed with knowledge I gained from practice and theory, I came to realise the power of phronesis and the nature of practice-led design research. (This realisation itself would be another phronesis, gained through the act of design-researching.) The rest of this section details this methodology, which I learned from and used in my research.

Action Research

Frayling (1993) categorised research in art and design into three types: research *into* art and design (such as research of art or design history, analysis of art or design output), research *for* art and design (such as research of materials for the activity and output of art or design), and research *through* art and design (where the researcher is inside the activity of art and design). Archer (1995) used the terms 'research about practice', 'research for the purpose of practice', and 'research through practice', which could be understood to correspond to the types Frayling distinguished.

My research is undoubtedly research through design. This is also broadly known as action research. In action research the researcher sets himself inside the practice and is actively involved in it. The position of the researcher in action

[1] Glanville emphasises that these interpretations are oversimplifications, but I use them for their clarity and their direct connection to two common terms we use in the context of research: theory and practice.

research can be first person or second person (Reason 2001). In first-person action research the researcher is the practitioner. In second-person action research the researcher engages with others face-to-face to enhance his first-person inquiries. In the case of my research, I positioned myself as the practitioner all the time, except when conducting interviews (in Chapter 7) to expand and support my first-person argument. In addition, I was also the main evaluator of all of my own projects. Because I am dealing with such a highly qualitative matter as aesthetics and emotion, it is very difficult to establish a definitive standard for evaluation. The only possible method, I believed, was to compare two or more works from the same person's point of view. Evaluating by myself, I could keep the standard for evaluation throughout all the projects and easily make use of the outcomes of my reflections in my next work.

Archer (1995) stressed that action research is almost always 'situation-specific', i.e., 'its findings only reliably apply to the place, time, persons and circumstances in which that action took place' (p.12). Bearing this in mind, my research does not aim to prove anything as general truth. Instead, my intention is to demonstrate my findings through my works and this thesis. My argument concerns how the world can be looked at rather than what the world is, and I accept the freedom of my readers and audience to agree or disagree with my view; however, I do expect most readers will find this view valuable and 'good enough' (Glanville 2014).

Reflection in/on Action

Schön (1983) described the concepts of 'reflection-in-action' and 'reflection-on-action' based on his interviews with professionals in various fields such as architecture, medicine, natural science, and urban planning. Applied to practice-led research based on making things, such as my own, reflection-in-action refers to a mode of study where the researcher analyses his observations while making and changes his method of making based on this analysis. Schön wrote that design is a reflective conversation with a situation. Conversely, reflection-on-action refers to a mode of research where the researcher steps back from the situation and looks back at what has occurred. I think both these terms well articulate how I conducted my action research.

I would say that I carried out reflective practice on multiple levels throughout this PhD. Reflection-in-action was present in every practical element of my research, including the quick and small tests I carried out in the early stages of each project, where day-by-day or even minute-by-minute reflective iterations contributed to achieving a higher quality of work. On completion of each project I looked back at what I had made and reflected on my learning for the next project; for example, I worked out new ideas to improve the original concept, or developed a new understanding of it. This could be regarded as reflection-in-action in the layer of the sequence of projects. At some key stages, I compared multiple projects from the same point of view and obtained generalised knowledge in finding the commonalities and differentials among them; this was the reflection-on-action mode. The most critical reflection-on-action would be writing this thesis. Actually I changed the structure of the whole thesis three times, looking back at all the practical and theoretical studies, and in this reflective writing my argument became visible.

Theories for Inspiration and Reflection

As far as I know, there is no existing theoretical work that adopts the same standpoint as I do here, that is, arguing for the value of pulse in emotional communication in design. Therefore, my research is not something that extends a particular existing theory. Instead, because pulse is widely dealt with in various academic fields such as medicine, physiology, psychology, biology, physics, mathematics and music, I referred to theories in some of these fields. These theories tended to fulfil one of two different functions. In some cases, they became a source of inspiration for my projects; for example, I was interested by pulse synchronisation as it is discussed in biology, and utilised in my own work some of the mathematical models I saw proposed in biological studies (see Section 5.2). In other cases, such theories helped me to interpret and understand my own projects; for example, psychology, particularly perceptional psychology, and the theory of Gestalt helped me to understand what I was perceiving in looking at the random yet rhythmic bubbling of my piece Kihou Foam (see Section 5.1), and I was able to better explain the way I experienced the work Inaho by using image processing technology and a principle of physics (see Section 5.3). Sometimes such reflections on the projects deepened my understanding of theories as well; an example is presented in Section 5.2, which deepened my understanding of a biological theory about the synchronisation of fireflies after I had first drawn inspiration through comparing results from four different projects of mine.

As seen here, the relationship between theory and practice in my research was not as linear as a simple application of theory to practice, but complicated and interactive. Linking my practice with various theories to expand its scope was part of the methodology of my investigation. In his writing on Aristotle's sophia and phronesis, Glanville (2014) adds that sophia is based on and must refer back to phronesis; 'the relationship is thus circular'. The way I learned from my research could definitely be understood in terms of this circular relationship. What was characteristic in my case was that the relationship was not between a particular theory and a particular practice (project), but moved from one theory to another, from one project to another, expanding the scope of knowledge.

4.2 STRATEGY AND TOOL

In this section I want to propose a model of pulse as an element of design, based on the insights from the contextual review of pulse given in Chapter 2. I will utilise this as a tool to reflect on and evaluate my projects, keeping the same standpoint throughout the whole research.

Figure 4.1 shows this model. It is composed of three layers: object layer, motion layer and content layer. The object layer refers to physical objects that work as the medium of the motion. It forms part of the physical body of the designed piece. The motion layer refers to the repetitive motion. The content layer includes elements that communicate with people not only psychologically but also emotionally or semantically, such as metaphors, messages, artistic performances, etc.

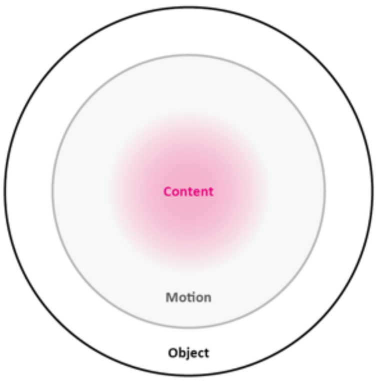


Figure 4.1 Model of Pulse (Three Layers)

In Chapter 2, I concluded that pulse became a designed element of products in the 20th century with particular functions that utilised humans' psychological reaction; the 21st century has since seen creators attempting to use metaphors or narratives in pulse such that design objects can communicate with customers or audiences not just psychologically but emotionally or semantically. In other words, moving from the 20th century to the 21st, the content layer began to play an increasingly important role in design. Therefore, my approach is to make this content layer even stronger, for example with more variations, more layers, more conviction in the content, as the key to increasing the value of pulse as an element of design. This is the strategy of this research.

However, we have to note that content does not actually 'exist' in the pulse itself, but only in a person's interpretation of it. Therefore, a designer's role is to prepare a guide to the content he or she expects people to find (Figure 4.2). Some elements of the guide, for example tempo, regularity or waveform, would be in the motion layer, and others, for example material, colour, form or graphics, in the object layer. At least some of these elements are dependent on each other; for example, the material that constitutes a physical object can have a strong influence on the characteristics of its motion.

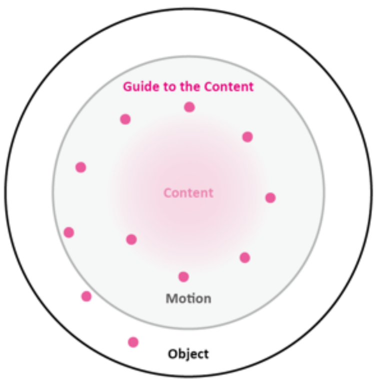


Figure 4.2 Model of Pulse (Guide to the Content)

The three qualities of Japanese aesthetics — suggestion, emptiness, and transience — are taken as the criteria that determine the approach to designing the elements in these layers. Suggestion relates to the preparation of the guide to the content. This content should be not too obvious but rather 'hidden'; the use of subtle and minimalistic elements is recommended to achieve this.

Emptiness and transience do not necessarily relate to the guide to the content. Japanese aesthetics generally recommends establishing emptiness in the arrangement of physical and temporal elements (e.g., silence), and establishing transience by using perishable or temporary-changeable elements. If these elements contribute to suggestion in the content — for example, if silence in the intervals between pulses or the decline of pulse amplitude over time enhance the metaphor of a dying heartbeat — then these elements contribute to the guide to the content. If emptiness and transience do not contribute to the content, they are still appreciated in Japanese aesthetics.

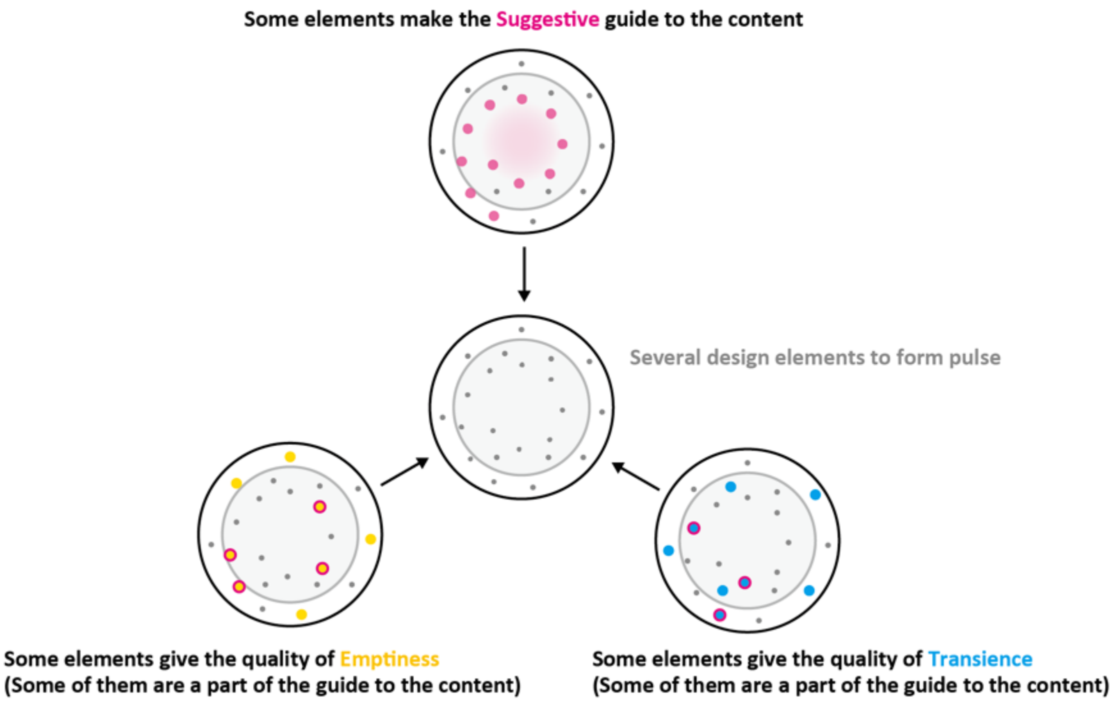
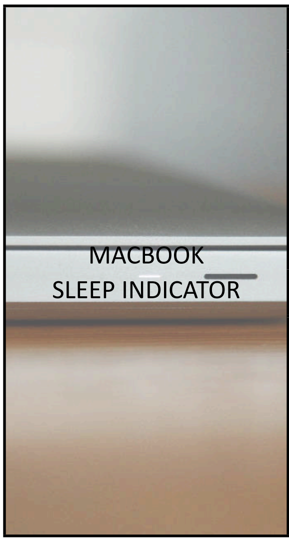


Figure 4.3 Model of Pulse and Japanese Aesthetics



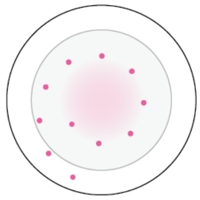
Model	Content	Guide to the Content
	Metaphor of human respiration.	Tempo mimicking human breathing.
Suggestion in:	Emptiness in:	Transience in:
No illustrative hint of life in form or graphical elements.	Minimal shape and plain whiteness of the light.	

Table 4.1 Reflections Summary on Apple's Macbook Sleep Indicator

To see how this tool functions in reflections on a design work, I want to apply it to two existing works, which I introduced in Chapter 2. I gave the examples of the Apple Macbook's sleep indicator and Nils Voelker's Thirty Six, which share the same content — a metaphor of human respiration. It is interesting to compare their approaches to this content.

As stated in its patent, the Macbook sleep indicator is intended as a metaphor of human respiration during sleep. The guide to this content is the change of intensity of the light with its particular tempo, which mimics average human breathing. The quality of suggestion is in the designer's avoidance of any graphical or sculptural illustration; instead, only the subtle moving light communicates the content. Emptiness is seen in the use of the minimal shape and plain whiteness of the light. It is, however, hard to find transience in the design. The light is fully programmed at a fixed rate of pulse and does not allow any change over time. The quality of transience would be heightened if the light changed its behaviour in reaction to environmental noise, or according to the time since the computer was made, and so on, whether Apple wanted it to or not.

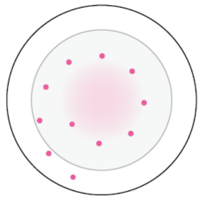
	Model	Content	Guide to the Content
		Metaphor of human respiration.	Tempo mimicking human breathing, inflation/ deflation of the bags with an analogy to lungs.
	Suggestion in:	Emptiness in:	Transience in:
	No illustrative hint of life in form or graphical elements.	Minimal structure, plain colour.	Unpredictability in the motion of the physical objects (bags).

Table 4.2 Reflections Summary on Thirty Six by Nils Voelker

As mentioned, the other example, Nils Voelker's Thirty Six, also contains a metaphor of human respiration. The guide to this content is the change in the intensity of the light and the inflation/deflation of the bags (which may remind the viewers of lungs), both at a tempo that mimics human breathing. Suggestion is in the absence of graphical elements; only motion is used to communicate the content, as in the case of the Macbook. The inflatable bags may be reminiscent of lungs, but only in a suggestive manner because the shape and arrangement of the bags are minimalistic, rather than explicitly representing actual lungs. Emptiness is in this minimalism of the structure and the choice of plain colour. For me, there is also a certain level of transience in the work: through the use of physical materials, i.e., air and plastic bags, a certain unpredictability is introduced in the motion of the bags. There is no guarantee that the same motion is repeated eternally with the same intensity. Wear and tear may change the motion over time.

From the comparison of these two works, we can see they have many qualities in common — except that of transience. According to criteria of practicality as an industrial product, for example, Apple's design would certainly be considered superior. According to my criteria, however, I would regard Voelker's work more highly.

Having thus collected all the necessary context, criteria, and methodology to actually explore pulse through my own practice, the next chapter, comprising the main part of this thesis, describes my exploration.

CHAPTER 5

EXPLORATION INTO PULSE

5.1 SINGLE PULSE

This main chapter of the thesis describes my exploration into pulse, according to the framework I have laid out in Chapters 2, 3, and 4. It comprises three topics: single pulse, pulse synchronisation, and pulse interference. For each topic I tried out some ideas in different projects, being inspired by other practitioners' works and theories, and reflecting on them using the tool proposed in Section 4.2. To begin with, I revisit the Kihou project, which I described in the last part of Chapter 1.

5.1.1 Kihou

As described in Chapter 1, I came across pulsing bubbles appearing from thick liquid and developed the work Kihou featuring this phenomenon with honey, silicone oil dyed black, a light source and a programmatically controlled air pump. Looking at the pulsing motion by myself, what I imagined intuitively was human breathing. I decided to work on Kihou further to make this 'content' stronger.

Metaphor of Breathing in Pulse

Studies on biology and physiology gave me some interesting ideas. While fish, crustaceans, and the larvae of amphibians use a water stream that flows from mouth to gill to breathe, the lungs of mammals, reptiles, birds and adult amphibians have only one opening, and thus they need to repeat inhalation and exhalation for breathing. As we all know, this ventilation is controlled both voluntarily and involuntarily. Voluntary control of respiration varies from taking deep breaths to holding the breath — but involuntary control is more interesting for me in this context. It is exerted by the respiratory neural network in the reticular formation and brainstem through a process in which inspiratory muscles such as the diaphragm and intercostal muscles are moved for inhalation and then exhalation follows silently through the relaxing of those muscles. This process is repeated regularly without sudden change at rest; therefore, we could call it a pulse. It is known that the tempo of this pulse is predominantly controlled by blood levels of carbon dioxide. The average frequency of respiration in human adults is about 14 times per minute, while an infant takes 33 breaths per minute[1]. It has also been revealed that the human respiratory rate can be affected by emotions. Respiration tends to become faster when a person is aroused (Boiten 1998), and faster and shallower in response to natural noises or unpleasant sounds (Masaoka and Homma 1997; Gomez and Danuser 2004). Unpleasant odours increase respiratory rate and induce rapid shallow breathing, and pleasant odours induce deep breathing, even before subjects discern whether the smell is pleasant or not (Masaoka et al. 2005). Another study analysed breathing of three-month-old infants in a bed with their mothers and reported a spectrum showing the induction of children's breathing to their mothers (Watanabe and Okubo 1998).

For me, the fundamental yet most interesting insight to be gained from these studies is that regularity of breathing can be easily affected by internal or environmental conditions. It is something much more sensitive and delicate than mere LEDs blinking on a programmed loop. These were the qualities I wanted to aim for in Kihou.

Designing the Pulse

The timing of the pulse of the bubbles was the first thing to think about. In the case of Kihou, it was controlled by two parameters: the length of time for the pump to blow the bubble (we can call this the 'On' time) and the interval

[1] Encyclopaedia Britannica, article on Human Respiratory System.

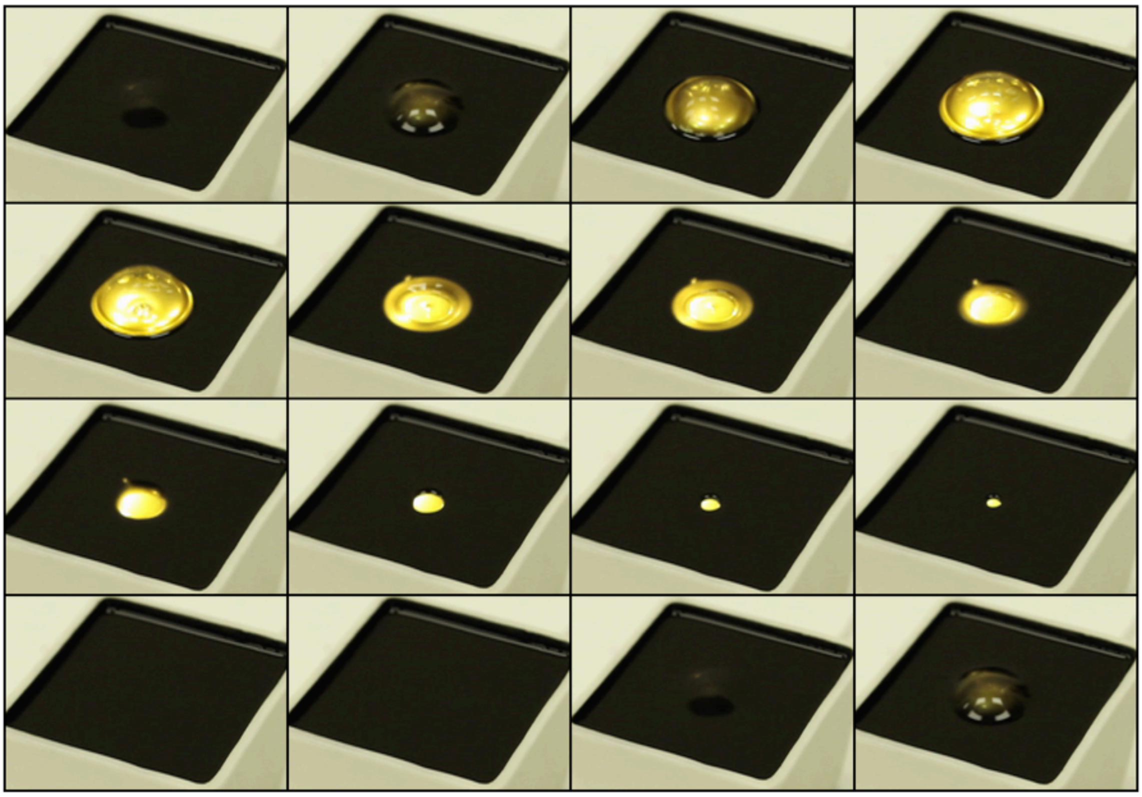


Figure 5.1 Kihou, Sequence of a Bubble Appearing, Popping and Appearing Again

between blows ('Off' time). The On + Off set is repeated. I chose to use the typical rate of respiration of a human adult, which is 14 breaths per minute — I therefore made the On + Off time 4.3 seconds. The ratio of On time against Off time within the 4.3-second cycle radically changed how the bubbles appeared. Because the surface tension of the honey limits the size of the bubble, if the On time is longer than a particular time (here 1.5 seconds), i.e., the volume of air in one blow is larger than a certain volume, the bubble splits into two. 100% On time (i.e., continuous blowing) led to a rapid succession of bubbles; 35% (1.5 seconds) On time led to one big bubble followed by another; less than 35% On time simply resulted in smaller bubbles. It was my personal impression that the 35% On time gave the most impactful and dramatic effect because of the greater dynamics. I then floated the black-dyed oil on the surface so that the speed of the 'luminous hole' closing after the bubble popped would be harmonised with the tempo of the bubbling. The ideal motion for me was where, after the one big bubble popped, the hole would close smoothly, giving a short moment of complete darkness before the new bubble appeared. There were thus various parts to this short animation: darkness, bubble appears, bubble grows, bubble pops, no bubbles but luminous hole, hole closes, darkness again.

I also conducted a series of short interviews with five RCA students in relation to the Kihou with different tunings. The aim was to help me get more insights about the pulse timing from the participants. Although the number and variety of the participants were very limited and not nearly adequate to assess the phenomenon completely, I actually gained valuable hints.

For the interview, five different modes were prepared: (a) 100% On time ratio; (b) 50% On time ratio; (c) 35% On time ratio; (d) 25% On time ratio; and (e) completely random timing. The participants observed these three modes and were asked to describe how they felt about each of them.

With the setting (a), some subjects saw a relaxing rhythm:

'I feel a rest. The speed is fast but not too fast.'

'Feel relieved because bubbles do not stop.'

'Sexual in rhythm. Meditational.'

I could not find an apparent tendency to differentiate the settings (b), (c), and (d) in the participants' comments, but it was notable that all of them commented that the pulse reminded them of life with these settings:

'Feels like something is born.'

'I feel a heartbeat. Very slow feeling. Birth. Growth.'

'This is the most peaceful for me. There was a feeling of life but at the same time I feel the pattern is nice and smooth.'

'The movement of the black surface is like a sea or breathing.'

'Now the tempo is really close to human respiration.'

‘It looks like it’s alive and calm — particularly its rhythm.’

‘Sleep. Feels like a slow deep bass-drum kick. You want to wait for the next to come up.’

‘Rhythm is gentle, almost ballerina-like. Very relaxing.’

Finally, with the setting (e), where bubbles were blown at random, most participants had negative impressions, such as:

‘I do not know what is happening — can’t catch the pattern. Feels a little uneasy.’

‘Frustrating.’

However, one participant said:

‘It is more complicated than others and feels random — I feel it dramatic.’

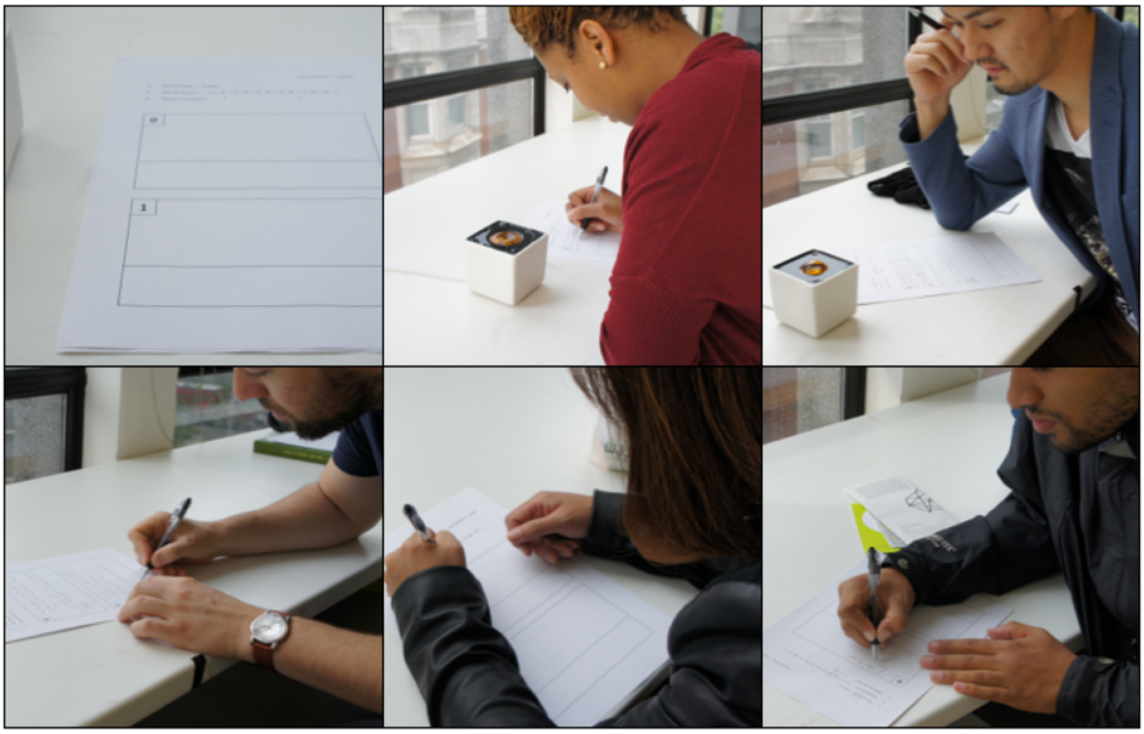


Figure 5.2 Interview on Kihou’s Pulse

The comments about mode (b), (c), and (d) supported my own impression of the work in their comparisons to life, but what was more interesting for me was that some of the interviewees talked about heartbeat, some talked about breathing, and some mentioned birth and growth. This demonstrated that the way the work communicated its content was highly suggestive. As there was no hint of life in the form or material other than the pulse of the bubbles, the analogy to life was successfully stimulating the participants' imagination rather than imposing an illustration of breathing upon them. It was also interesting that the interviewees made different kinds of comments on modes (a) and (b/c/d): they talked about relaxation and meditation for (a) and about life for (b/c/d). The only positive comment, 'dramatic', given about mode (e) inspired me to think about the appreciation of obstacles to pulse in design. This idea will be revisited later in Subsection 5.1.3.

It is noteworthy that most of the interviewees used the word 'rhythm' rather than 'pulse' to describe what they experienced. Later I formed an understanding whereby the perception of pulse is the same as rhythm, but at the time of this interview I could not clearly distinguish the difference between these two terms. Again, this point will be revisited later in Chapter 6.

Another interesting finding in tuning the parameters was that the bubble sometimes behaved in an unpredictable way. Sometimes a bubble split into two, probably because of air friction at the valve. Sometimes the smaller bubble from the split remained on the surface and the next bubble 'swallowed' it. Sometimes the big bubble 'popped' quickly and there was a longer period of darkness before the next bubble. Sometimes the big bubble popped late and one ended up with two bubbles in layers. All these things happened with the same tuning. The materials I used — honey, oil and air — and their combination were greatly affected by friction, air pressure, surface tension, and all such physical forces. This unpredictability could be one advantage of using liquid or gas to approach the reflection of life's sensitivity and delicateness in design. It significantly differentiates the pulse from that in machines whose behaviour is completely dominated by a fixed program.

Engaged in this discussion, I was reminded of the cybernetics theory of Heinz von Foerster (2003) regarding trivial and non-trivial machines. A trivial machine, as he called it, always does the same thing (i.e., delivers the same output from the same input). A non-trivial machine has inner states that change at every operation, and thus the result of the operation is unpredictable. The behaviour of the machine is dependent on the past and its system can be only synthetically and analytically determined. If we regard Kihou as a machine that takes the On/Off electrical signal from the software program as input and delivers the combination of liquid and air bubble as output, it has at least some of the qualities of a non-trivial machine. An LED circuit that merely repeats a pre-programmed sequence does not.

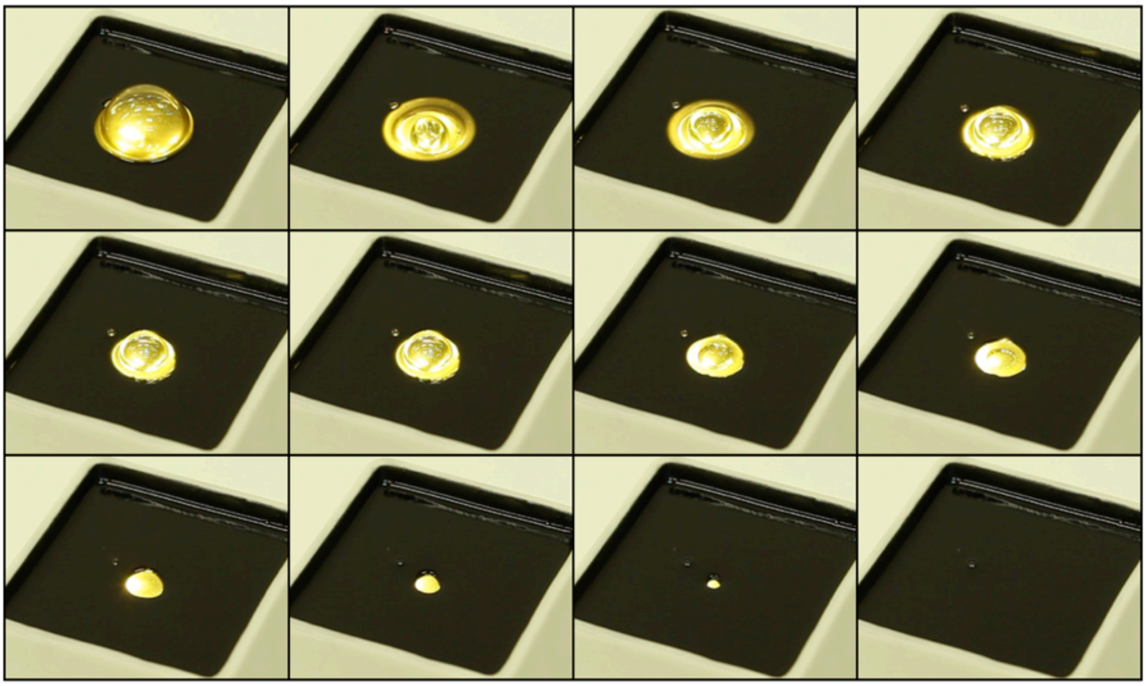


Figure 5.3 Kihou, an Unexpected Small Bubble Appears after a Big Bubble Pops

Other Elements of Kihou

The electrical pump I used in Kihou was piezoelectric-ceramic driven, whereby a thin ceramic sheet is vibrated by electricity very fast. This pump does not make the typical motor noise you hear from a pump attached to a fish tank. Instead, when operating it makes a subtle noise caused by air friction, close to the sound 'sss'. In addition, when the bubble popped, I could hear a very small noise of popping. The combination of these two kinds of sound — 'Sssssss...... pop!' — repeated in synchronisation with the bubble growing and popping even reinforced my impression of breathing. The sound was very small and easily overwhelmed by environmental noise, thus encouraging viewers, including myself, to be quiet; this also worked well to enhance the experience of viewing/hearing the work.

The colours in Kihou are the gold of the lit honey, the black of the oil, and the white of the ceramic bowl. The reason for choosing white for the colour of the bowl was simply that I wanted to highlight the contrast of the golden bubble on the black oil, and so the bowl needed to be a neutral background. The reason for the black oil was thus to make a background that contrasted with the illumination in the centre as much as possible. I once tried white oil, thinking about making an all-white cube with a golden bubble on top, but the contrast was weaker than with black. The gold colour was chosen for two reasons. One was simply that it is the colour of honey. Using the material 'as is' ensured less 'intended preparation'; it was more natural. The other reason was the special nature of the gold colour, which is associated with preciousness, nobleness, and magnificence. The shiny gold thing gradually appearing from the darkness was intended to give an impression of something precious — like life being 'born', as one of the interviewees commented.

As I remarked above, the ceramic bowl was chosen because I wanted a neutral background; this was also the biggest reason to make it a cube. If the opening had been circular, people might have imagined a relationship between the circular bubble and the circular bowl. My choice was to give more focus to the bubble by having the rectangular bowl acting like a frame. In addition, I intended the frame to somehow make a natural and friendly impression. The phenomenon of the illuminated bubble appearing on the black surface is not like anything we see in daily life — it is extraordinary. I wanted to bring this extraordinary phenomenon into an ordinary setting, rather than keeping it at a distance like a treasure. By using ceramic as the material of the bowl and making it in a 'handy' size like a food bowl, I believe it became something not be shown in a glass case in a museum but which people can approach with shorter emotional distance. The size also made a good combination with the bubble. The biggest bubble size, with 35% On time, was approximately 40 mm in diameter; the opening of the bowl was a square with 75 mm side — visually, these were pleasing proportions.

Summary of Reflection (with the Criteria of Japanese Aesthetics)

I have already described all the elements of Kihou in which we can find suggestion, emptiness, and transience. Here I present a summary of these elements. Firstly, a pulse with dedicated tuning of temporal parameters was enough to suggest to viewers a connoted concept without other illustrative elements such as relevant graphics or sculptural forms. Secondly, this minimalistic approach allowed viewers to freely use their imaginations in interpreting the work. Thirdly, complex physical forces (e.g., friction and tension) differentiated the pulse from that of a 'trivial' machine with complete control, and augmented the quality of transience by introducing contingency and unpredictability into the motion. Lastly, by highlighting the silent interval of pulse — the moment the bubble disappears into the black surface in this case — and using the white plain bowl, it was possible to celebrate the quality of emptiness.

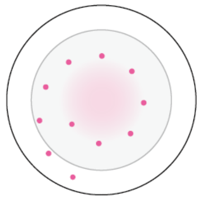
 KIHOU	Model	Content	Guide to the Content
		Metaphor of a repetitive motion of life, such as breathing.	Tempo mimicking human breathing, use of air (link to breathing), mucus-like stickiness of liquid, exhalation-like air sound.
	Suggestion in:	Emptiness in:	Transience in:
	No illustrative hint of life in form or graphical elements.	Interval of pulse enhanced by black colour, subtle sound and complete silence in between, white plain bowl.	Unpredictability and contingency in motion caused by complex forces.

Table 5.1 Reflections Summary on Kihou

5.1.2 Kihou Foam — Complex Texture

Kihou gave me a lot of insights to drive my further work — but I was actually stuck at this point for a while. The pulse in Kihou was rather simple and the metaphor behind it was straightforward. I believe there was power in this simplicity and purity, which is why many people who saw the work greatly appreciated it and could spend a long time in front of it (some people more than 15 minutes) — but I needed other ideas to move forward.

Development of Kihou Foam

I returned to the studio and began further tests, exploring other ideas to move forward from Kihou. I remembered that bath soap had also made an interesting effect during my first tests. I had left it aside when I chose the combination of honey and oil, but I decided to focus on this material again. I diluted the bath

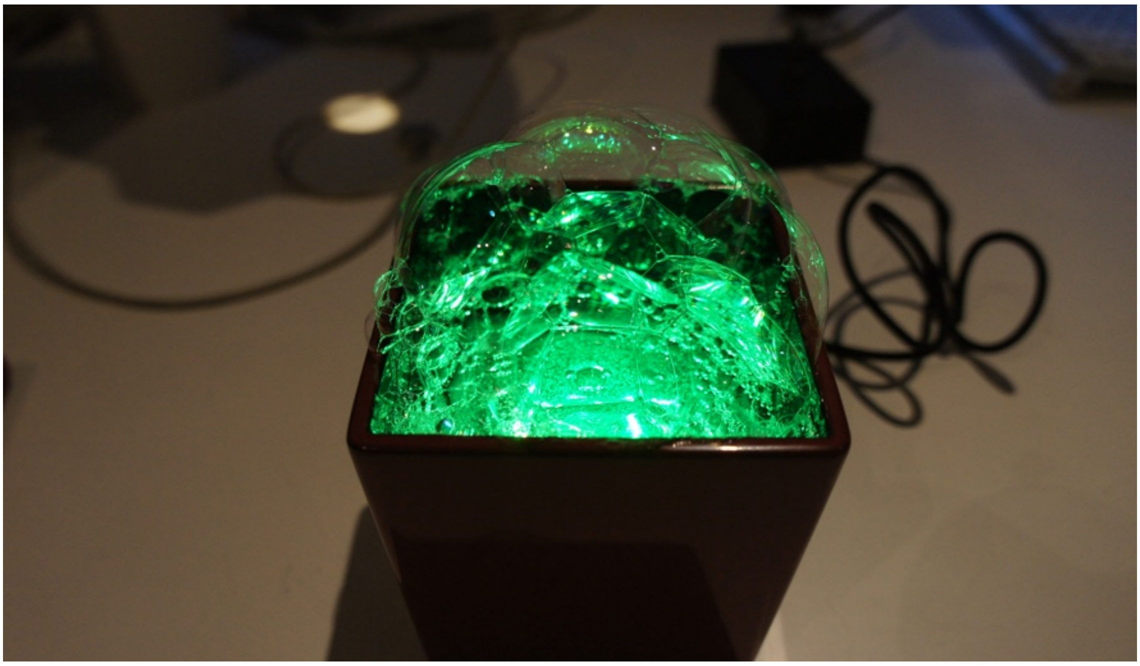


Figure 5.4 Testing Bath Soap with Kihou Apparatus

soap with glycerine to achieve a foam of a certain thickness so it was not destroyed too quickly, and tested the liquid in the Kihou apparatus. The best dilution created new big bubbles growing in the centre, while much smaller and older bubbles still remained around the corners.

The pulse's analogy to breathing, aimed at in the original Kihou, was still there. The point where the bubble appears was covered by thick foam this time, but the steady pulse was still clearly visible and audible, reminding me of something like, but not necessarily limited to, breathing. Because this new version did not have the black oil on top, each bubble and the silence between the bubbles were not as clearly highlighted as in the original. The foam, however, gave a different effect instead: the naturally formed structure of the foam was very complicated and made the reflection of light chaotic. Every time the pump pulsed, the motion spread to the whole foam and the shape and structure changed slightly. The steady pulse was still in the centre, but this work had a richer texture. I made a simple white box to house this experiment, featuring slightly inclined sides towards the bottom and a curved inner surface, which was inspired by a bathtub.

Comparing Kihou Foam with Kihou

I want to look into the elements of Kihou Foam in detail here in comparison with the original Kihou. The tempo of the pulse was similar. I started tuning with the same setting as Kihou — a 4.3-second cycle with 35% On time — then made it slightly faster so that a good body of foam would develop in 10 minutes or so. Electrical components including the pump were common to both works, so they both had the same kind of air friction noise and bubble 'pop' sound. The concept of making the bowl white and of a neutral shape was also common, except that I designed details of the Kihou Foam bowl with a bathtub inspiration, as mentioned. I chose clear soap, simply because there was no particular reason for any colour.

Figure 5.5 Kihou Foam

The differences were interesting. Firstly, a big difference was that foam developed gradually over a period. Kihou had one timeline, where pulses kept repeating in a 4.3-second cycle. Kihou Foam had another timeline on top of that, which started when I turned the pump on and continued as the foam grew until I turned it off. The foam would overflow from the bowl at some point, so I added a code to gradually reduce the pulse rate after 10 minutes to avoid this — but the foam still kept 'refreshing', with old tiny bubbles disappearing and new bubbles appearing, like a metaphor of the metabolism of life.

Secondly, the tiny bubbles in the foam that were generated by the central bubble brought the work greater unpredictability. I did not know which small bubble would disappear when and how this 'metabolism-like' appearance and disappearance of bubbles would change the overall form of the foam. It seemed that the central pulse had some level of influence on the timing of the small bubbles disappearing, but at the same time the thickness and surface tension of the soap and the actually very complex structure of the bubbles gave it a chaotic randomness.

Figure 5.6 Kihou Foam, Top View

Gazing at these bubbles, interestingly I found myself somehow sensing something like a musical rhythm in the timing of appearing and disappearing. At first it felt like a steady regular pulse in the middle surrounded by random impulses possibly triggered by it, but gradually it came to feel like the steady beat of minims (half notes) with strong accents and weak quavers (eighth notes) and semiquavers (sixteenth notes) following. Once I had found this rhythm it was difficult to get away from it, even though the timing of the small bubbles disappearing was never the same. What was it that happened to my perception here?

Theories from Gestalt psychology provided an interesting way of approaching this question. Gestalt psychology explains the mechanism whereby the mind processes things not as a mere set of individual messages but as a whole. The most commonly used example is a musical melody, which we do not perceive as a set of individual notes but as a whole — this is why we still hear the same melody even if it is transposed into a different key. In today's perceptual psychology, rhythm perception, which includes perception of pulses, is believed to be Gestalt in time, which means that we perceive pulse not as a mere set of impulses but as a pattern composed of repetitions of these impulses (Fraisse 1982). If particular elements in the pulse have an accent (in general, differentiation in strength, length, tone, etc.) then human beings tend to group the elements using those elements as keys. One 19th century study reported that subjects could group up to 25 notes (Dietze 1885, as cited by Fraisse 1982). Wertheimer (1923) proposed the first several 'laws' of such grouping to form the basic principle of Gestalt psychology, famously known as *Prägnanz* ('pithiness'). These laws include, for example: the Law of Similarity — similar objects tend to be grouped; the Law of Continuity — objects that are aligned along a smooth curve tend to be grouped; and the Law of Good Gestalt — objects that form a regular, simple and ordered pattern tend to be grouped. I could understand the music-like rhythm I sensed in the bubbles in Kihou Foam as the result of my mind unconsciously trying to group the one strong impulse in the middle and some consequent weak impulses into an ordered set, composed of elements with regular intervals like a music melody with quavers and semiquavers, and to perceive the bubbling by using this pattern. I will discuss rhythm perception in more detail in Chapter 6, in connection with findings from my other projects.

In summary, Kihou Foam shared much of its content with Kihou, and inherited the same level of minimalism from the original version. Removing the black oil reduced the emptiness, but instead the complex texture enhanced the unpredictability of the behaviour. This complexity also enhanced suggestiveness by establishing a more polysemous metaphor (e.g., breathing and metabolism of life). By having another timeline on top of that of Kihou, the work went one step further from a simple regular routine. This contributed to raising the quality of transience of the work. In addition, Kihou Foam gave me an interesting insight into the difference between pulse and rhythm, which I will revisit in the next chapter.

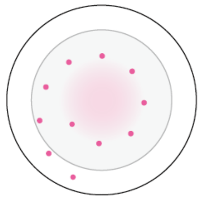
	Model	Content	Guide to the Content
 KIHOU FOAM		Metaphor of a repetitive motion of life, such as breathing.	Tempo mimicking human breathing, use of air (link to breathing), mucus-like stickiness of liquid, exhalation-like air sound.
	Suggestion in:	Emptiness in:	Transience in:
	No illustrative hint of life, the complex motion suggesting even more than the designated content (e.g., metabolism of life).	Subtle sound and complete silence in between, white plain bowl, clear colour of liquid.	Unpredictability and contingency in motion, foam growing over time with small bubbles appearing and disappearing.

Table 5.2 Reflections Summary on Kihou Foam

5.1.3 Tupperware — Pulse Changing over Time

One comment made by one of the interviewees when looking at the random bubbles in Kihou — 'complicated but dramatic' — remained in my mind for a while. Complete randomness was not really within the scope of my research interest, but it occurred to me that thinking about somewhere between pulse and non-pulse — introducing disorder, obstacles, and termination to pulse — could yield new ideas. This was the impetus for the explorations described in this subsection .

Disorder of Pulse

Pulse in life is sensitive and delicate; as mentioned earlier, biological and physiological studies on respiration clearly show this — but finding out more about disorders of pulse in life gave me further inspiration.

Abnormal breathing can be a sign of various disorders of the body. In medicine several typical types of abnormal breathing and their potential causes are known and can be checked through examinations. Examples include hyperpnoea (rapid deep breathing), which is potentially caused by anaemia, sepsis or side effects of medicine; Cheyne-Stokes respiration (deeper and sometimes faster breathing followed by a gradual decrease and a temporary cessation of breathing, which repeats) caused by hypoxia (lack of oxygen) in the reticular formation (which controls the pulse of breathing); and Biot's respiration (quick and shallow inhalations followed by regular or irregular periods of cessation of breathing) caused by damage to the pons (part of the brainstem) due to strokes or trauma or by pressure on the pons[2] .

Irregular heartbeat, also called arrhythmia, is another potential sign of a disorder of the body. A temporary short arrhythmia does not actually represent a critical

[2] Taber's Medical Dictionary, article on Breathing.

health problem in many cases, but some kinds of too-rapid or too-slow heart rate can be a matter of life and death. For example, a group of diseases called 'heart block', where the electrical system of the heart is blocked for some reason and the signal from the senatorial node (the 'trigger-maker' of the contraction of the heart) is not carried through, involve too slow and irregular heartbeat and can cause death in some cases[3].

Patients who have incurred damage to the neural connection between CPGs (central pattern generators, which establish walking patterns) and the brain because of spinal cord injury often have difficulties walking. It is known that CPGs have one timer function that generates each locomotive step and another that generates a pattern of walking — which I would call pulse because of the regular repetition. Such deviation from normal walking (called gait abnormality) is commonly seen in persons with different nervous problems[4]. Some patients have such gait abnormality congenitally.

Early Experiments

Partly inspired by these examples from biology and medicine, the initial idea for the next project was to work on a pulse that was not steady but fragile, and that could be affected by the environment or be damaged to cause irregularity. At the same time, because I had done many small experiments with materials such as liquids, air, magnets, powders, etc., before the Kihou project, I wanted to explore a different set of materials, and spent some time developing computer software and mechatronic ideas. The ideas I worked on in this round included:

Experiment 3-1) A Tupperware box was equipped with a solar-powered battery and a solenoid (linear actuator) so it made a pulsing sound and vibrated only

3 Taber's Medical Dictionary, article on Heart Block.

4 Taber's Medical Dictionary, article on Spinal Cord Injury.

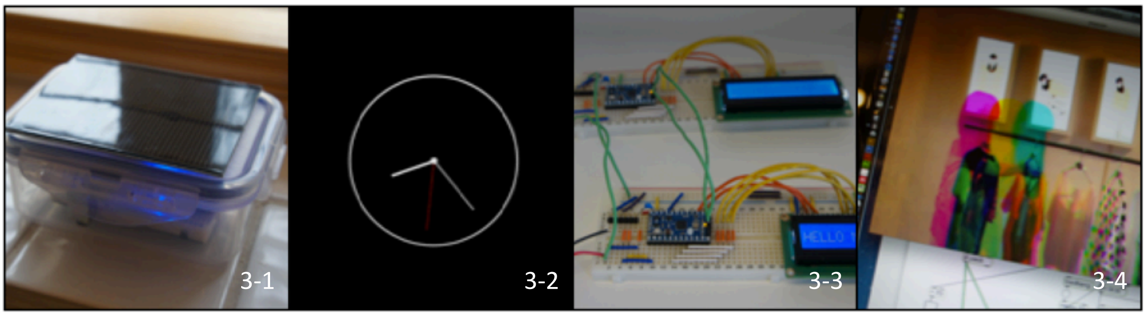


Figure 5.7 Experiment Series 3

when it was bright in the room. The idea was to introduce the concept of a 24-hour cycle to the pulse by linking my machine to sunlight.

Experiment 3-2) This simple clock on an iPhone app loses its time count (pulse) when a strong physical shock is given (e.g., the user throws or drops the phone). This experiment was about fragility of pulse.

Experiment 3-3) Two micro-controllers equipped with LCDs (Liquid Crystal Display) communicate sentences to each other. Once a randomly-generated software obstacle was introduced to the synchronisation of their clocks, the sentences could not be conveyed correctly and errors were made. This experiment was about fragility of communication based on a shared pulse.

Experiment 3-4) This software of a video player generates three pulses internally and links them to RGB planes of a video. The pulse is completely in synchronisation at the beginning but gradually loses the order, leading to the video becoming 'damaged'.

The concept behind these experiments was to seek another timeline and another quality that would be potentially linked to disorder of pulse. In moving from one experiment to another, I came to be interested in one idea: if pulse could have an analogy to life, as well as beating regularly it could tell a narrative on another level — for example relating to ageing and death.

Further Inspiration

In developing these experiments and planning my next major project idea, I took further inspiration from different creative fields. Glitch art was one of them. A glitch is 'a sudden, usually temporary malfunction or fault of equipment' (Oxford English Dictionary) and glitch art was developed in the 1900s as art involving these unexpected errors in, for example, video, image, audio, and electronic circuits to achieve unexpected expression in the output. In many cases glitch artists expect errors in the content or medium of their works and prepare for these, though how and when those errors happen and affect the output remains unpredictable. Iman Moradi, in his 2004 dissertation, proposed two kinds of glitch: 'pure glitch', 'an unpremeditated digital artefact, which may or may not have its own aesthetic merits', and 'glitch-alike', 'a collection of digital artefacts that resemble visual aspects of real glitches found in their original habitat'. According to these definitions, what many artists are dealing with is glitch-alikes. One of the most well-known glitch works is video artist Nam June Paik's MagnetTV (1965), where magnets are used to alter the electromagnetic flow of electrons in televisions. The force of attraction of the magnet results in the horizontal lines on the screen being moved upward, and the moving images keep changing unexpectedly as long as the magnet is moved around. I would not argue that any of the experiments described above 'qualify' as glitch art; however, there are similarities — the idea in Experiment 3-4, for example, actually involved artificially introducing errors into the synchronisation of pulses of RGB planes.

Figure 5.8 MagnetTV (1965) by Nam June Paik


Figure 5.9 Life 01 (2009) by Paul Cocksedge, with Living Flower and Dead Flower

The flower vase Life 01 (2009), designed by Paul Cocksedge for Flos, is another interesting project. This vase is equipped with a light source and a conductive sensor in the water, and illuminates when a fresh living flower is placed inside. When the flower has died, the light also turns off. Visualising life and death in a poetic way using an object such as a vase suggests the value of appreciating life in our everyday experience. The use of lighting to visualise aliveness would also enhance the impression of fragility or limit of life. Cocksedge's vase does not show any visible or audible pulse, but it certainly gave me inspiration, particularly with regard to the expression of the process of dying in design.

Another particularly inspiring project was Last Breath (2012) by Rafael Lozano-Hemmer. He gave a detailed description of the work, so let me borrow the text to explain it: 'Last Breath is an installation designed to store and circulate the breath of a person forever. The piece consists of a small brown paper bag which inflates and deflates automatically thanks to motorized bellows similar to those found in artificial respirators in hospitals. The apparatus hangs on a wall and is activated 10,000 times a day, the typical respiratory frequency

Figure 5.10 Last Breath (2012) by Rafael Lozano-Hemmer

Figure 5.11 Last Breath (2012), the original breath is sampled.

for an adult at rest, including 158 sighs. Each stroke of the machine advances a digital counter that beeps. The breath circulates between the bellows and the paper bag through a ribbed transparent plastic tube that emits a faint and hypnotic low sound. The tube can be as large as necessary to either hang the bag right beside the piece, on the same wall, or to create a labyrinth on the ceiling of the exhibition that ends with the bag suspended in the middle of the room. The brown paper bag makes a rhythmic crushing sound as it inflates and deflates'[5]. If we can put possible technical problems aside, a person's breath may thus be preserved and presented in a regularly inflating and deflating paper bag even after his or her death. This made me think of all kinds of questions about life and death. How many days or years has it been since the breath was sampled? How is he or she now? Is he or she still alive? The context of the work makes the pulse of the paper bag something more than just pulse. Here, I think this pulse is telling a story.

I was also inspired to reinterpret a work by composer Steve Reich called Pendulum Music (1968, see Reich 1974) from this perspective of life and narrative. This work is played by three or more suspended microphones with speakers placed on the floor. The microphones swing like pendulums and emit feedback tones every time they pass over the speakers from right to left and from left to right. The audience not only hears the sound but also sees the movement of the swinging pendulums. The pendulums gradually lose their kinetic energy and amplitude in their movement, so the whole sound is continuously changing until they all stop. For me this process felt as if the pendulums' pulses were being terminated little by little, like a life gradually gets closer to death. If I heard this composition with my eyes closed from the beginning to the end, not knowing the music was made by the swinging pendulums but just as a presentation of continuously changing sound, I could not have had the same impression. Because the audience knows this is the track

[5] www.lozano-hemmer.com/last_breath.php

of a ‘dying’ thing, the non-pulsing (i.e., continuous) sound that remains at the end seems somehow sorrowful.

The work by composer Alvin Lucier entitled I am Sitting in a Room (1969) is another example where a sound element is repeated with continuous change over time. The composer recorded his own narration of a text, and played it in a room. Then he recorded this playback as a new recording. This new recording is played in the room and it is rerecorded. As this process is repeated, particular frequencies are emphasised because of the resonance with the room, and the whole sound keeps changing its texture. The words of the initial narration become unintelligible after about 45 minutes, and we hear the distorted sound instead. It is interesting to hear both the amplification (of volume of particular frequencies) and loss (of initial narration) progressing little by little in the same process. The work gave me an impression of the ‘birth’ of new sound and at the same time the ‘death’ of initial sound, or a gradual exchange of these. Another notable thing about the work is that the sound changes cannot be predetermined, and are thus essentially unpredictable because the process of recording is greatly affected by environmental factors such as the size of the room.

What was common in all of these sources of inspiration was the suggestion (at least to me) of the process of life or death over a period. In 2012 I visited an exhibition entitled Death hosted by the Wellcome Collection in London. It curated a number of paintings of skulls and devils, medical drawings of surgery, sculptures expressing dead bodies, and pictures of killers. It was interesting in a general sense but at the same time not really inspiring for my research, because almost everything shown was an illustration of either the condition of death or a typical image about death, such as skulls, etc.; nothing in the exhibition was about the process of dying. In contrast, the works mentioned above deal with the processes by which a living thing actually dies or the motion of an object or sound gradually changes with a potential metaphor of death or disorder. Last Breath by Lozano-Hemmer is an exception in that it features motion that is supposed to be unchanging, but it still heightens awareness of life and death in its process. With this in mind, what I drew from this exploration was that pulse could tell a narrative about life when it is placed within a process in which the pulse makes or at least suggests a potential change that reminds the viewer of birth, ageing, death and all such changes in life.

Tupperware

I implemented this idea in a project I named 'Tupperware'. A food container (Tupperware) was equipped with an electronic pump (the same one as I used in Kihou), batteries and a custom circuit board, and was placed in a fish tank full of water. It emitted air bubbles regularly. I tuned the pump to 4.3 seconds and 35% On time, exactly the same as for Kihou, to retain the metaphor of 'breathing'; however, the breathing would stop eventually because it was dependent on the batteries, and water would eventually get in as the seal of the lid was inadequately watertight. I did not know how many days this unit would survive in the water. The pulse of the bubbles was the only sign by which I could know that it was still working, or 'living'.

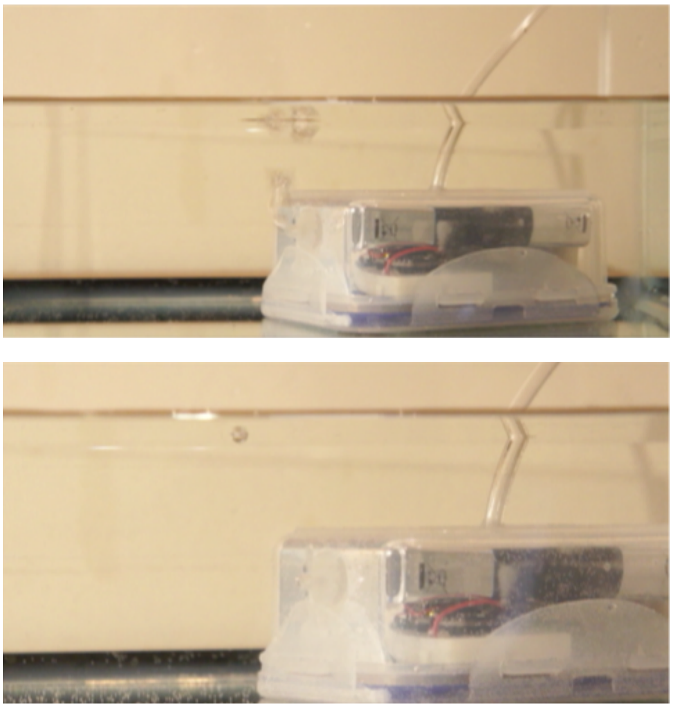


Figure 5.12 Tupperware, Bubble on Day 1 (Top) and Day 6 (Bottom)

The fish tank with the Tupperware was placed on my desk and I recorded a short video of it every day, like a diary, from the day I set batteries in it. I did not know when the 'final day' was coming — in one week, one month or one year. The day approached rather quickly. After four days the 'breathing' pulse seemed to get slower. It emitted little air on the sixth day, and on the morning of the seventh day it finally

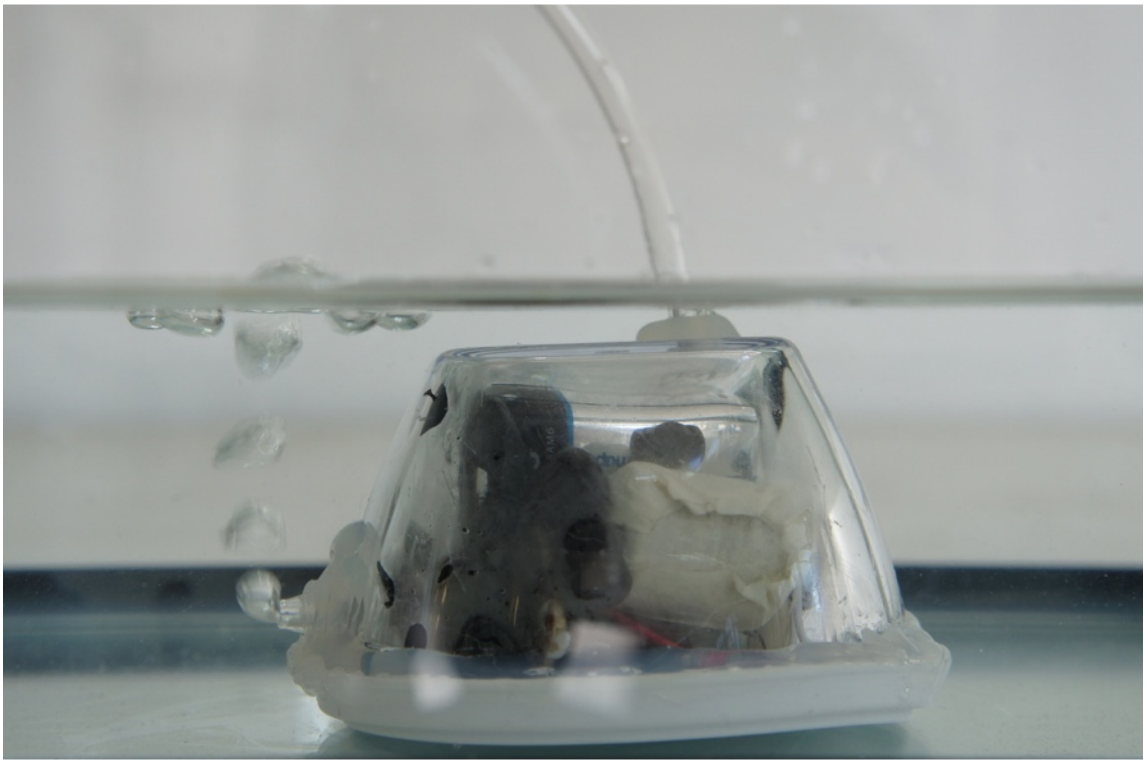


Figure 5.13 Tupperware

stopped breathing. I took the Tupperware out of the water and opened it, finding that the batteries had got wet and run down.

Before carrying out this observation, I had been imagining that the breathing-like pulse would stop suddenly one day. However, it actually got slower and slower, weaker and weaker, as it approached the end. This gradation seemed to mean more of a story. Somehow it allowed me to (emotionally) prepare for the end from the fourth day, when a clear reduction of pulse became visible. This process certainly enhanced my emotional attachment to this ugly box with electronics, as well as the pulse's analogy to breathing — also thanks to the setting of the fish tank.

For this project, I wanted to expand my model of pulse to show a gradual change over time (Figure 5.14). The pulse's content in each timeframe was a metaphor of breathing, but when seen in the sequence the other content appeared on top of that — a metaphor of dying life. This metaphor became the story of the object, and brought the definitive quality of transience to the work. Elements of the motion layer such as tempo and amplitude changed very slowly and subtly over time, which worked as a highly suggestive guide to the content. Other guides in the object layer, such as the fish tank setting, did not change, but could help viewers to link the pulse to life throughout the observation. The reason I did not want to put anything besides the Tupperware unit and water, such as waterweed or stones, in the fish tank, was to ensure an appreciation of emptiness. The quality of emptiness was also experienced in the very subtle sound of bubbling and the complete silence in between.

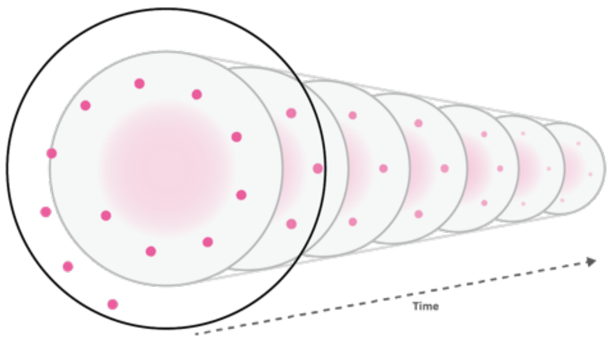


Figure 5.14 Model of Pulse Changing over Time

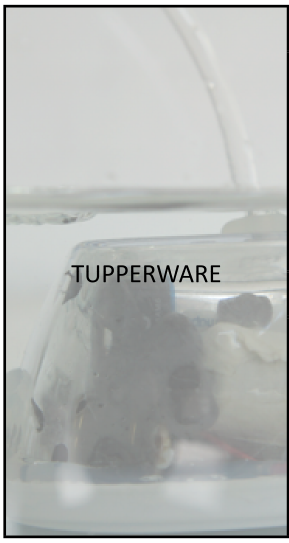
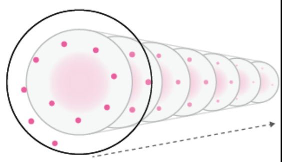
	Model	Content	Guide to the Content
		Metaphor of breathing. Metaphor of dying life.	Breath-like air bubbles, fish tank, use of battery with limited 'life' and consequent pulse's change over time.
	Suggestion in:	Emptiness in:	Transience in:
	Subtle change of pulse over time being the only hint of a metaphor of life approaching its end.	No physical elements other than water and the Tupperware, subtle bubbling sound and complete silence in between.	Change (decline) of pulse over time suggesting change (ageing and dying) of life over time.

Table 5.3 Reflections Summary on Tupperware

5.2 PULSE SYNCHRONISATION

Following the single pulse, this section describes my exploration into pulse synchronisation. Pulse synchronisation is seen widely in nature and I believed that borrowing ideas from such phenomena could expand the scope of pulse as an element of design. To begin with, I worked on Kihou again to develop it into a plural version featuring this idea of synchronisation.

5.2.1 Plural Kihou and Sync Cells

Kihou described in Subsection 5.1.1 was a successful exhibition piece that stimulated great public response. Following that success, I became interested in making a plural version of the work to give an even greater impact on audiences. Technically it was easy to insert multiple pump modules, but my main focus was how to relate these multiple sources of pulse. Just putting some pulses together would not represent progress.

Pulse Synchronisation

I looked for hints in other fields, and what caught my eye was synchronisation. It is well known that metronomes set at a similar tempo and placed on a shared base come to synchronise and tick in unison. The base needs to be hung or placed for example on two rollers so it can move freely back and forth. It moves slightly to cancel the acceleration of the majority of metronomes (more than 50% accelerate rightwards and the rest leftwards) and this movement returns the force to the metronomes (action and reaction) such that they gradually have the same acceleration. Ultimately, all metronomes synchronise in a few minutes. This phenomenon was firstly discovered by Christiaan Huygens in 1665 (as far as is known to the world). He discovered it while observing the movement of two pendulum clocks he was developing to work on a new method to calculate longitude, and later confirmed the mechanics of the phenomenon in the famous so-called 'Huygens' experiment' (Klarreich 2002).

More interestingly for my research, pulse synchronisation can be found in nature too, in various situations. One of the most well-known and well-studied phenomena is the flashing of firefly groups. Fireflies of the species *Photinus Carolinus*, commonly found in certain parts of Southeast Asia, are known to synchronise their flash to each other. The first to study this phenomenon scientifically were John Buck and his wife Elisabeth. They fastened a male *Pteroptyx Cribellata* firefly on its back to a wax pallet, and masked its head to keep it from seeing its own light emission. Then a flash of electric light was directed to its eyes using optical fibre, and they observed how the insect's flashing was affected by the artificial stimulus. They reported: 'When the stimuli are delivered at intervals shorter than the firefly's normal flashing period, the insect shortens its period correspondingly. When the period of the driver lamp is longer than that of the firefly, the insect lengthens its period to match that of the stimulus. Unexpectedly the firefly flashes simultaneously with the driver lamp only when the period is the same as the firefly's normal spontaneous flashing period of 1,000 milliseconds. If the lamp is flashed every 1,300 milliseconds, (…) the firefly flashes every 1,300 milliseconds, but each of its flashes precedes the corresponding lamp signal by 300 milliseconds. If the lamp period is 900 milliseconds, the firefly also flashes every 900 milliseconds, but always 100 milliseconds later than the corresponding lamp signal. (…) In all [more than 30] cases the fireflies promptly returned to their normal one-per-second flashing rhythm as soon as the rhythmic stimulation was stopped' (Buck 1976, p.76). From this observation, the Bucks developed the following model. Each firefly has a resettable pacemaker somewhere in its brain. This pacemaker increases its excitation steadily from a minimum level to a threshold level for about 800 milliseconds. When it hits the threshold level, the pacemaker sends a triggering signal to the light organ, which takes about 200 milliseconds to reach

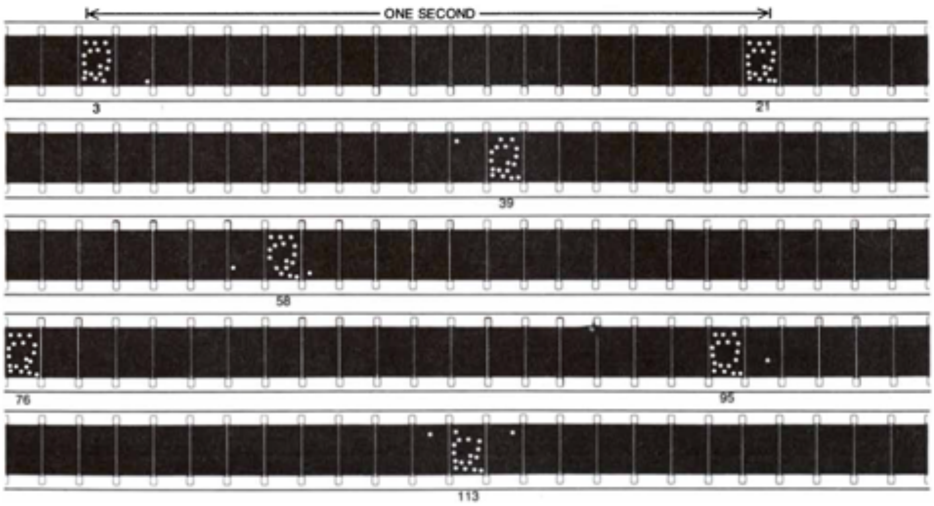


Figure 5.15 Recording of Fireflies' Synchronous Flashing (Copied from Buck (1976))

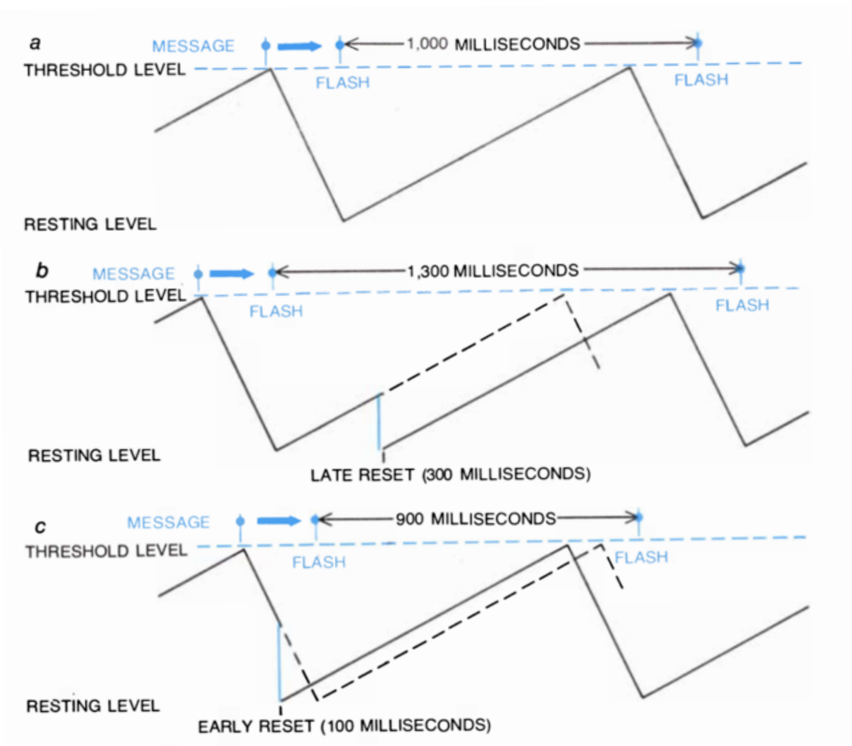


Figure 5.16 Buck's Model (1976) to Explain Fireflies' Synchronisation

it. At the same time, the excitation decreases to the minimum during these 200 milliseconds. Then it starts to rise again. When a firefly is stimulated by light, whether artificial light or another firefly's flash, this cycling pacemaker is reset. Therefore, if it is reset during the increase of the excitation the cycle is delayed and the next flash is delayed accordingly. If it is reset during the decrease of the excitation the cycle is shortened and the next flash happens earlier. In either case, the firefly synchronises to the external stimuli.

This synchronisation occurs only among male fireflies. The Bucks also proposed a hypothesis to explain the synchronisation, which they called the 'beacon hypothesis'. The courtship of other species of fireflies sometimes requires uninterrupted exchange of dozens of flashes between two sexes. This would be quite difficult for species like *Pteroptyx Cribellata*, which inhabits areas of heavy tropical vegetation in Southeast Asia. By synchronising their flashes, however, the group of males can make a beacon which is sufficiently large and bright to attract females in the area.

Another interesting synchronisation in nature is seen in female humans. It is known that the menstrual periods of women who live closely together, such as sisters or roommates, tend to synchronise. It was Martha McClintock (1971) who worked on this for the first time. In her studies, subjects with no previous contact gathered and a social setting was introduced to bond them, such as becoming roommates. The dates of the subjects' menses were recorded over a period of several months and a decrease in the difference between the dates was found. This phenomenon was defined as menstrual synchrony. In another experiment, McClintock applied extract taken from a donor subject's armpit to the upper lips of other subjects. The dates of their menses were recorded and, as before, a decrease in the difference was found. After this original study, some similar experiments were conducted with similar methods by researchers such as Graham and McGrew (1980), Russell et al. (1980) and Quadagno et al. (1981) — all reached the same conclusion about menstrual synchrony. However, some have refuted the theory. For example, Pfaff (1980) and Jarett (1984) could not find any synchrony in their studies, which were conducted in the same way as McClintock's. Potential reasons for the different results could be changed environmental settings, conditions of medical treatment of subjects, randomness of subjects' selection, their ages, etc.; a definitive conclusion about whether menstrual synchrony is a real phenomenon or an accidental case has not yet been made.

Another phenomenon of synchronisation is found in our heart. The contraction motion of heart muscles is triggered by electrical impulses generated by 'pacemaker cells'; it is a particular part of those cells called the 'sinoatrial node' that controls the timing of the pulse by initiating the impulse. The sinoatrial node is composed of about 10,000 cells in humans, each of which is oscillating its electrical voltage level. The oscillations of these cells are in complete synchronisation, and this synchronisation gives the heartbeat robustness and steadiness — if the heartbeat were driven by just one cell it would be very risky, as damage to that cell would immediately threaten life. Nakayama et al. (1984) took isolated individual cells from a sinoatrial node and found that they showed significant variety in their potential waveforms. It has also been suggested that such isolated cells may have irregular oscillating patterns (Opthof 1988). Such studies tell us what an important role the synchronisation between these cells plays in delivering a regular and steady heartbeat. Verheijck et al. (1998) investigated the synchronisation between two isolated sinoatrial nodal rabbit cells by connecting them via an artificial electrical system. This electrical connection between cells was computationally controlled and the researchers studied the changes in the process of synchronisation while altering the conductance between cells. Figure 5.17 on the next page shows the oscillations of the electric potential of two cells (solid line and dotted line in the upper graph) becoming synchronised while the electric current (Ic in the lower graph) passes through the artificial connection.

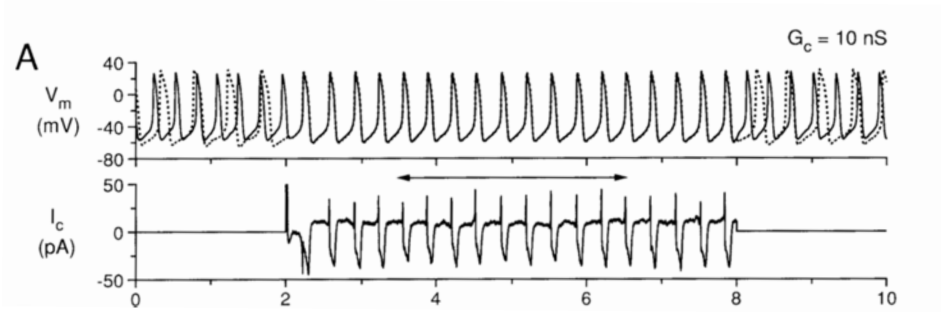


Figure 5.17 Electric potential of two sinoatrial nodal cells synchronise while the electric current passes through (Copied from Verheijck et al. (1998)).

Mathematical Models

From 1665, when Huygens discovered the synchronisation between his two pendulum clocks, such synchronisation has been an attractive problem for mathematicians too (Strogatz and Stewart 1993). The problem is often called 'coupled oscillators' and several mathematical models have been proposed to explain it. For example, Peskin (1975) proposed a rather simple model of synchronised pacemaker cells from a sinoatrial node. He used an analogy to an electronic oscillator circuit consisting of a capacitor in parallel with a resistor to model each cell, and supposed that the voltage of each cell is 'kicked up' by a fixed amount every time other cells reach the threshold in the oscillation. He analytically proved that this model can explain synchronisation in the case of the coupling of two oscillators. However, the evidence for the coupling of more than two was not sufficient (Strogatz 2000).

In 1967, Art Winfree proposed his model to explain several kinds of biological oscillations — including that of fireflies — with one principle (Winfree 1967). The difficulty in achieving this lies in the fact that oscillators in biology are non-identical — each oscillator has a stable cycle, corresponding to the individual's free-running oscillation (Strogatz 1997). For simplification, Winfree introduced the following two assumptions: each oscillator has its individual frequency allocated at random but is identical to the others, and each oscillator is influenced by the collective output produced by all the others. He discovered that synchronisation occurred among the oscillators in his model in both numerical and analytical studies, although his theorem was based on nonlinear differential equations, which were not an easy tool to use.

Kuramoto (1975, 1984) made an important contribution in relation to Winfree's model by simplifying it so that it could be solved completely. This 'beautiful and analytically tractable' (Strogatz 1997) model is now called the 'Kuramoto model' and became popular among researchers working on the coupled-oscillators problem. It is expressed as follows:

$$\frac{\partial \theta_i}{\partial t} = \omega_i + \frac{1}{N} \sum_{j=1}^{N} K_{ij} \sin(\theta_j - \theta_i)$$

where θ is the phase of each oscillator, ω is the characteristic angular speed of it, N is the number of oscillators and K is the coupling factor between the oscillators i and j.

Implementing Synchronisation in Kihou

My interest of course was in how to use this idea of synchronisation in my work, particularly the plural version of Kihou, to further explore pulse as an element of design. Perhaps it would give the design another kind of analogy to nature, another kind of content?

I began to implement the Kuramoto model in my software to simulate the process. The model was simple and easy enough for me to implement. I assumed factor K was constant, meaning any pair of oscillators is coupled with a fixed strength — this simplification is commonly used. The difference equation for computer simulation becomes the following:

$$\theta_i(k+1) = \theta_i(k) + \left(\omega_i + \frac{K}{N} \sum_{j=1}^{N} \sin(\theta_j(k) - \theta_i(k)) \right) \bullet dt$$

The parameter k means the timeframe. To calculate the behaviour of the particular oscillator i, the equation collects the differences of phase θ between i and all other oscillators in the timeframe k, and calculates the average. Then parameter K is multiplied to this value; the result indicates how much effect the oscillator i receives from other oscillators. If it is zero (when K = 0), synchronisation will never occur. Using this value, the equation obtains the new phase θ of the oscillator i at the timeframe k+1 by integration.

Figure 5.18 shows the result of a computer simulation where N = 3, K = 0.1, ω = 0.1 ~ 0.2 (radian/sec). The initial value θ was allocated randomly. The graph shows the behaviour of sinθ for the three oscillators. We can see that the oscillators that have different phase and frequency in the beginning come to synchronise, though with small lags.

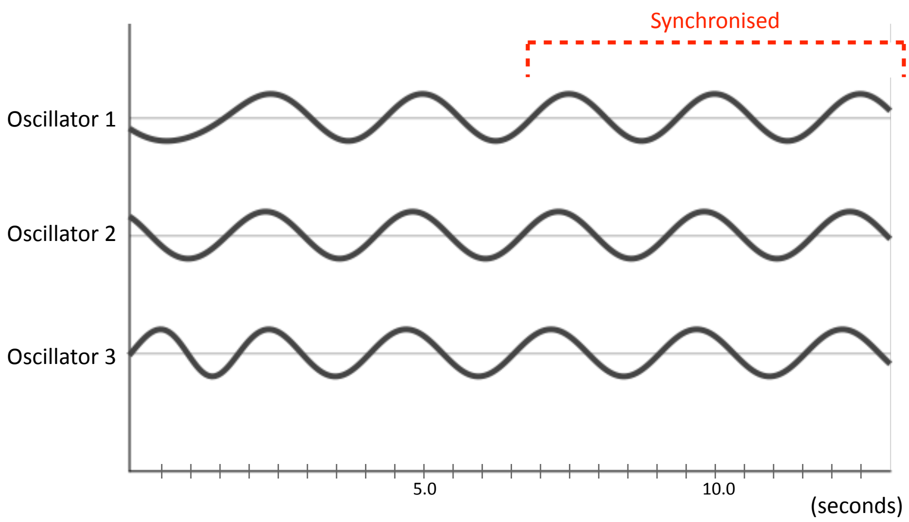


Figure 5.18 Simulation of Kuramoto Model (N = 3, K = 0.1, ω = 0.1 ~ 0.2 (radian/sec))


Figure 5.19 Plural Kihou

I programmed the same principle in the micro-controller controlling 19 air pumps in the new version of Kihou. Each pump module was identical to the original version. These modules were housed in a large container as shown in Figure 5.19. Each software oscillator, corresponding to each pump, was given randomised initial phase and characteristic angular speed so the 19 bubbles began to appear at random in the beginning, but gradually synchronised. I also added the code to break the synchronisation after a few minutes of synchronisation, so that the modules repeated synchronisation and desynchronisation. There were some latencies between pulses because of the viscosity of the liquid, so it was not a perfect synchronisation. Nevertheless, the first moment all the bubbles appeared at almost the same time was a powerful one. The moment of synchronisation was just like the climax of a performance. This work was exhibited at the Milan Design Fair 2013, where more than


Figure 5.20 Plural Kihou, Bubbles

30,000 people visited our exhibition area, and the impactful appearance and motion of the work went down well.

However, the content — the metaphor of biological synchronisation — was comparatively weak. The work was successful in connecting pulses in the motion layer using the mathematical mechanism, but not in the content layer (Figure 5.21); thus they ended up as merely a performative physical motion or a pretty visualisation of an equation. In addition, though each pulse had a certain level of suggestion, emptiness, and transience in the metaphor of breathing, this was all inherited from the original version of Kihou; the connection of the pulses and the process of synchronisation could not augment such qualities.

Figure 5.21 Models of Pulse Synchronisation; I want to distinguish synchronisation appearing only in the motion layer (left) and that appearing in the content layer too (right), meaning synchronisation becomes a core part of the content.

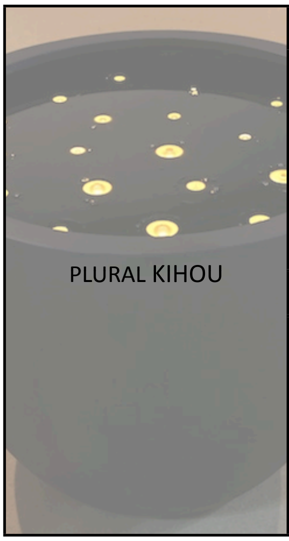
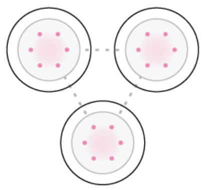
<table>
<tr><td rowspan="4"></td><td>Model</td><td>Content</td><td>Guide to the Content</td></tr>
<tr><td></td><td>[Failure] The work did not have a clearly designated content, except that of the original Kihou.</td><td>Same as the original Kihou + synchronisation based on Kuramoto model.</td></tr>
<tr><td>Suggestion in:</td><td>Emptiness in:</td><td>Transience in:</td></tr>
<tr><td>[Failure] The synchronisation was not a guide to anything.</td><td>Same as the original Kihou, except the colour of bowl.</td><td>Same as the original Kihou.
/ [Failure] No transience in the process of sync.</td></tr>
</table>

Table 5.4 Reflections Summary on Plural Kihou

Sync Cells

In parallel to Plural Kihou, I was developing another small project, which was also an expansion of my old idea. During the experiments I had worked on before, I had come across an interesting visual effect made using white cloth and LED. When I covered an LED light source with cloth at about 3 cm distance, it cast a beautiful circular reflection onto the cloth like an annular solar eclipse. As I moved the cloth closer to the light, the reflection became bigger. I decided to feature this visual effect working automatically with electronic control. I built a small box out of cardboard covered by a white elastic jersey; I attached the ends of artificial muscle fibres to the cloth via a rigid frame and the other ends to the bottom of the box. The muscle fibre was the same material I used in my early work Yuen (see Chapter 1), which shrinks when electric current goes through it. When the muscle fibres shrank the jersey cloth was gently pulled towards the inside of the box, and then released when the current stopped. Thus the distance between the light source and the cloth became shorter and greater accordingly, and this resulted in the reflected circular light becoming bigger and smaller. This effect somehow reminded me of a cell under a microscope. The moving circular light reflection looked like a cell nucleus and the cardboard frame like the cell wall. All of this I had seen before, but it was brought to life

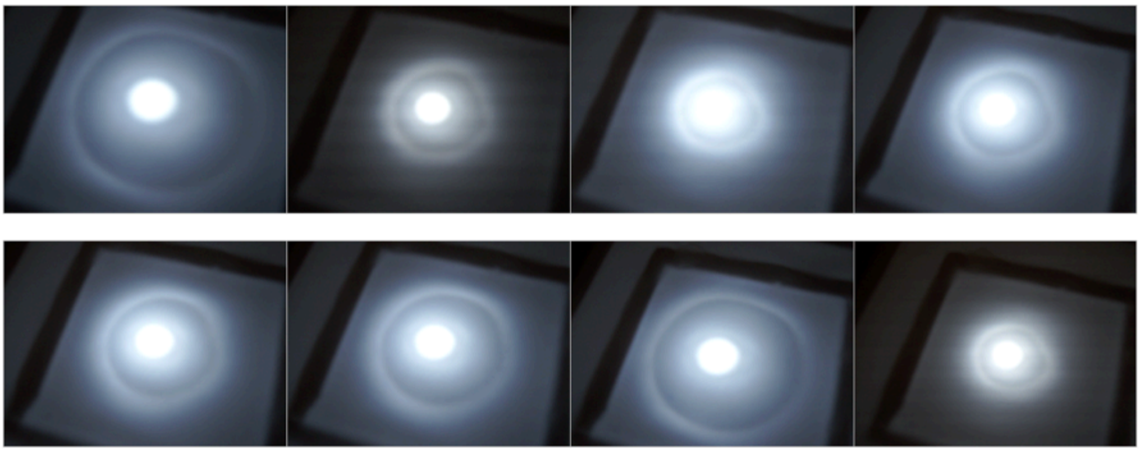


Figure 5.22 Cell-like Lighting Module


Figure 5.23 Sync Cells

again in my mind by the idea of linking it to the synchronous pacemaker cells of the heart.

I built four of these light modules with acrylic materials, and placed them on a shared base. The white elastic jersey cloth covered all of the modules to form an amoeba-like shape. The four modules shared one controlling circuit board like a 'brain', and the Kuramoto model was implemented into this so the modules behaved like synchronous biological oscillators. The result, however, was at about the same level as Plural Kihou. Synchronisation of the modules was certainly impactful, and it was pleasant to see this performative movement. The content was, nonetheless, as weak as in Plural Kihou. Each module had the content of the metaphor of a cell in a beating heart, but the synchronisation could not enhance the content. It just connected the modules physically and did not go beyond that. Emptiness was expressed in the presentation of the work, which used plain white material and minimal physical elements visible on the surface — but this did not contribute to reinforcing the content.

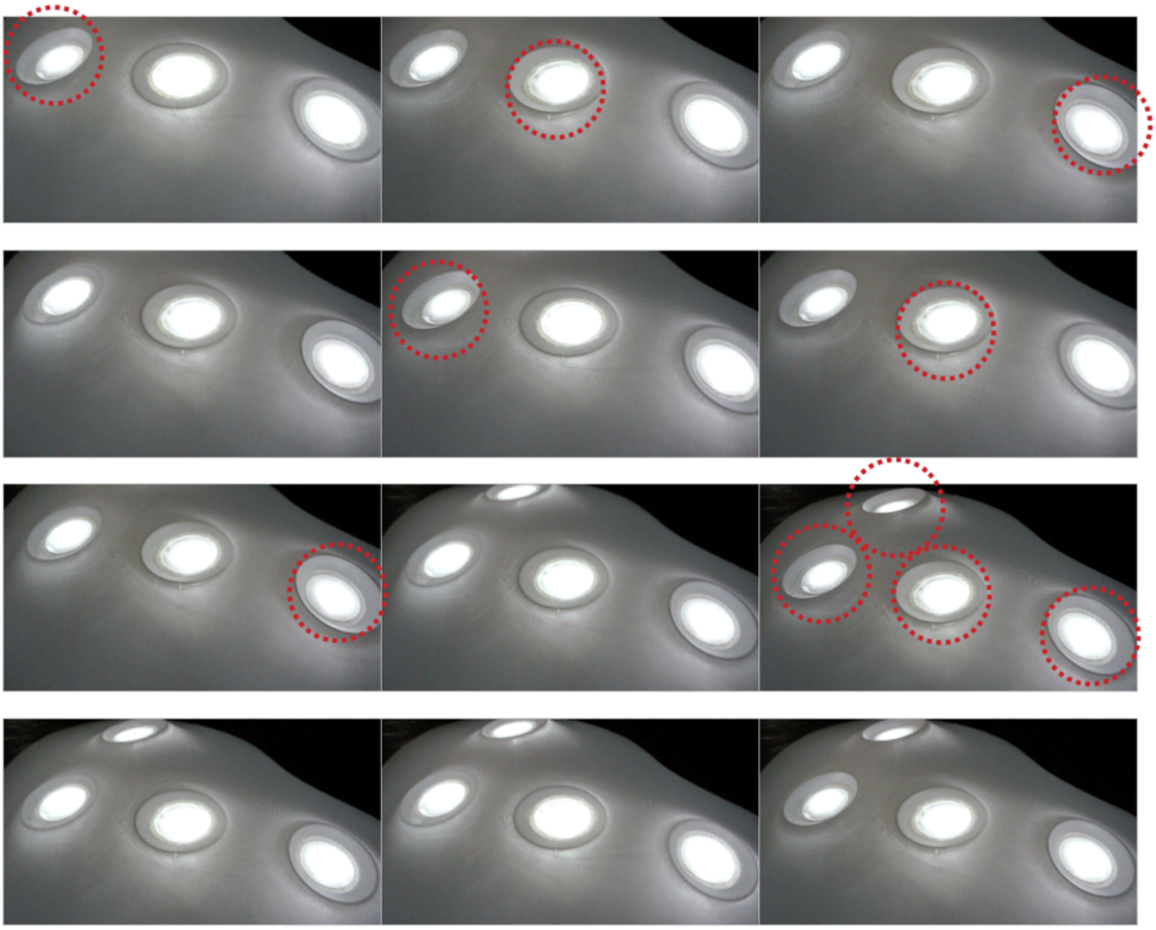


Figure 5.24 Sync Cells, Process of Synchronisation; The modules marked with red circle is being pulled by artificial muscle fibre.

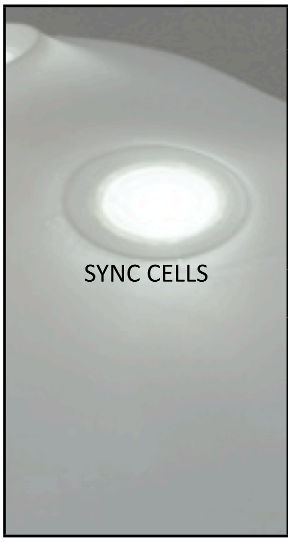
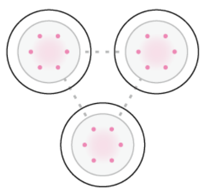
	Model	Content	Guide to the Content
 SYNC CELLS		Metaphor of synchronous cells.	Shape of the module, smooth motion driven by artificial muscle fibre, synchronisation based on Kuramoto model.
	Suggestion in:	Emptiness in:	Transience in:
	[Failure] The prepared synchronisation was not enough to guide a viewer to the content.	Plain white body, minimal physical elements on the surface.	[Failure] No transience in the process of sync.

Table 5.5 Reflections Summary on Sync Cells

5.2.2 Sync Clock — Reason to Synchronise

How could I improve the process of synchronisation to deliver stronger content, such as a metaphor of the communication of living things? A hint was to be found in nature once again. According to the Bucks' hypothesis, male fireflies synchronise to acquire a large and bright beacon to attract females. Pacemaker cells of sinoatrial nodes synchronise to make a steady and robust heartbeat. As mentioned, it is still a matter for debate whether and why human menstrual rhythms synchronise, but with rats there is an apparent tendency for a female in a group with a similar breeding cycle to have healthier babies than a rat that lives alone (Strogatz 2000). These biological synchronisations happen for a reason connected to life, whereas a purely physical phenomenon such as Huygens' pendulums or metronomes does not.

Figures 5.25 and 5.26 show an experiment to explore this idea. In this program-based on-screen animation, small rectangular objects were moving around. The behaviour of the objects was calculated with a certain randomness and rendered

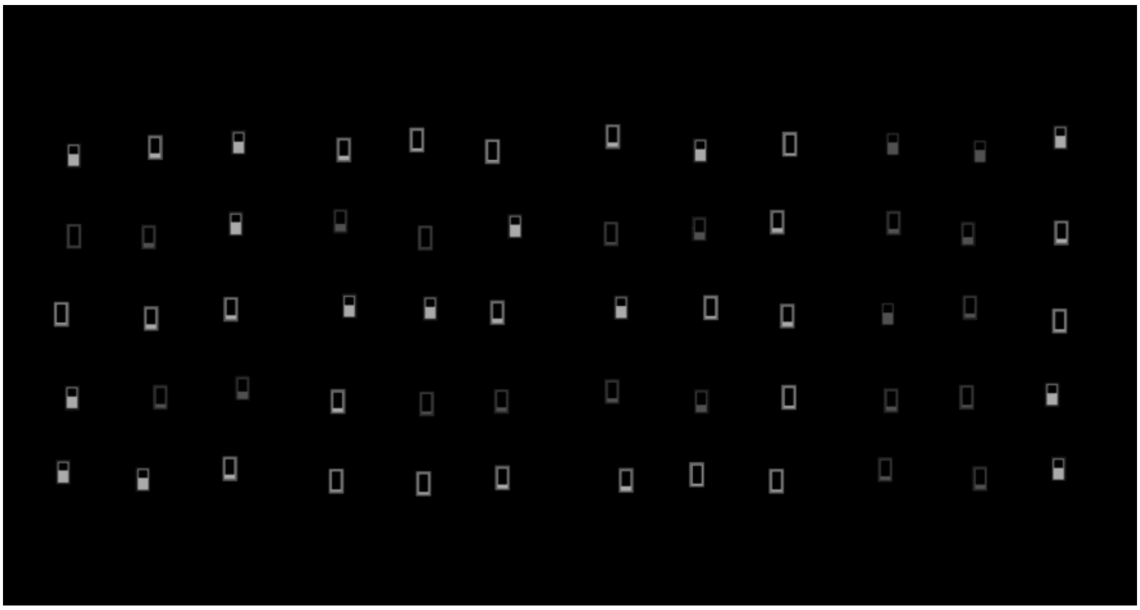


Figure 5.25 Sync Clock

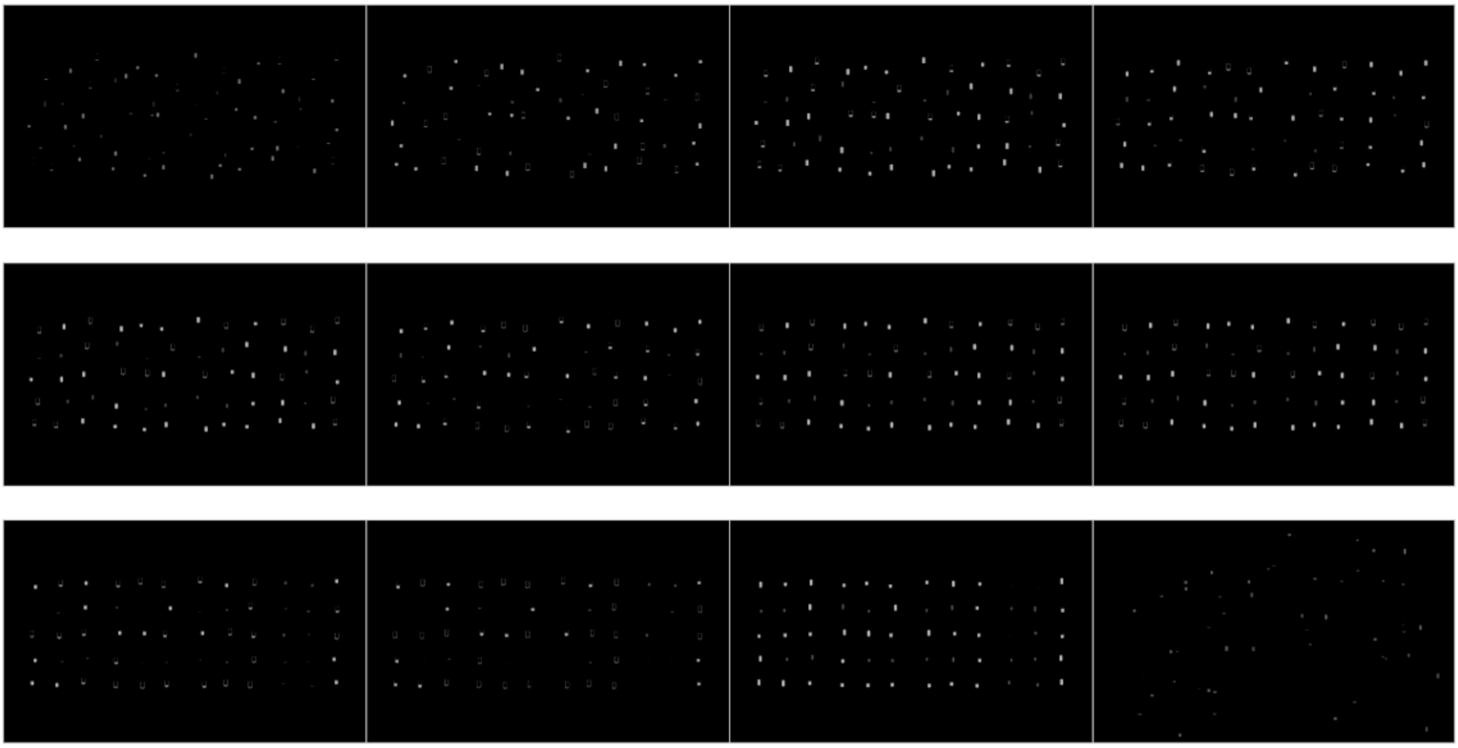


Figure 5.26 Sync Clock, Process of Synchronisation

in real time. Each object had a visual oscillator like a ‘slider’, whose value was changing from 0% to 100% repeatedly at a fixed rate. The idea of this work was to have these objects form a visual representation of the time (e.g., “22:31”) only when the cycle of their sliders synchronised — this was the reason for them to come together. Each object had the aligned ‘assigned position’ on the screen, which formed the ‘8888’ shapes on a digital clock, but was placed at a randomly calculated position at the beginning. They then moved from the initial positions towards their assigned positions slowly, as if swimming in water. At the same time, objects were chosen every minute to display the numbers of the time, and those objects began to synchronise based on the Kuramoto model. All other objects also synchronised in the opposite phase, so that the time appeared in the animation. I also added some codes which enabled the animation to respond to external sound using the computer’s microphone. The objects were desynchronised and scattered around to random positions when noise was detected. Then they moved towards the assigned positions again and synchronised to tell the time.

The idea itself worked and the synchronisation seemed to gain a context beyond the visualisation of a mathematical equation. The small objects looked like a

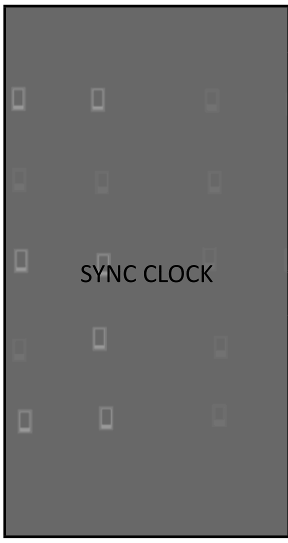
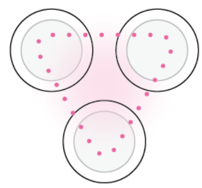
 SYNC CLOCK	Model	Content	Guide to the Content
		Metaphor of small living things communicating and synchronising to work.	Swimming-like movement of each module, synchronisation with a reason, reactivity to environmental sound.
	Suggestion in:	Emptiness in:	Transience in:
	Minimal yet metaphorical graphics, synchronisation to achieve a task the biggest guide to the content.	Plain black background, minimalism of graphics.	Synchronisation interrupted by environmental sound (though an unnecessary 'add-on' for the mechanism of sync).

Table 5.6 Reflections Summary on Sync Clock

flock of living things with the intention of working cooperatively to tell us the time. Synchronisation thus played a role not only in the motion layer of pulse but also in the content layer. In addition, compared to the LED + fabric modules or bubbles, which were physically fixed to a shared base in the previous couple of projects, the randomised swimming-like movement gave the objects separateness from each other in this project, which enhanced the impression of individual beings communicating with each other. Although this experiment used graphical outputs, the illustration was minimally drawn with little graphical hint of life; the guide to the content was therefore still not illustrative but suggestive. The responsiveness to environmental sound also enhanced the metaphor. It made the synchronisation breakable and delicate, as it is in nature, and contributed to heightening the quality of transience. However, I still felt there was a weakness in this project. The process of synchronisation was pre-programmed in the code, and therefore, though breakable, it was still guaranteed to happen. In nature, synchronisation is not prepared or guaranteed, but simply emerges. In short, synchronisation was still artificial here, not natural. There was still refinement to achieve.

5.2.3 iPhone Orchestra — Synchronisation Emerging from Local Rules

I continued with this idea of giving synchronisation a reason in the next project, 'iPhone Orchestra'. This work had two versions, and comparing these two versions eventually taught me the key to improving my work with a more convincing analogy to synchronous natural phenomena.

The fundamental idea shared by the two versions was to allow a number of smart phones (I used iPhones) to synchronise to compose a piece of music like an orchestra. I did not use the Kuramoto model this time. Instead, the model shown in Figure 5.16, which Buck (1976) proposed to explain firefly synchronisation, was chosen. With this model, each phone had an oscillator, and every time it heard the sound of one of the others it reset its oscillation. If there were only two phones they could synchronise in one or two cycles of oscillation. If there were three phones or more, however, the process became more complicated, and it took more time, a few minutes, to achieve synchronisation. I had two reasons for changing from the Kuramoto model to Buck's model.
Firstly, in the Kuramoto model, each oscillator needs to know the status (θ in the equation) of other oscillators all the time. However, each phone in this project had an individual program (app) and I thought it more analogous to life for each program to know the status of others only when those others make an observable output (sound in this case). If they share their status all the time then the individuality of each device is significantly weakened. Secondly, oscillators tend to have slight lags even when synchronised in the Kuramoto model, as can be seen in Figure 5.18. On the contrary, Buck's model is much simpler, and, although it might be less sophisticated mathematically, it allows the oscillators to synchronise completely. As the idea of this project was founded in the composition of music, and such perfect synchronisation was needed, Buck's model was well suited.

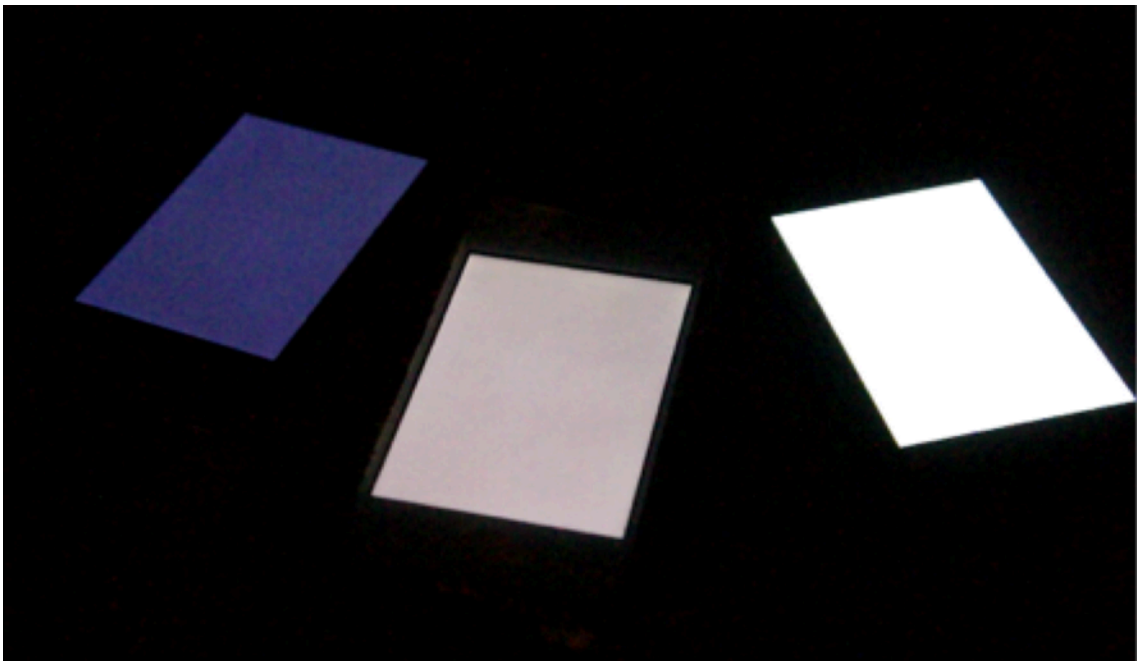


Figure 5.27 iPhone Orchestra

In the first version, three iPhones with a custom-made app shared WiFi and communicated with each other via this network. When each oscillator on each phone hit the threshold the phone made a short sound like 'p!' and at the same time informed other oscillators of its status via the network. The interval between the sounds of the three phones became shorter and shorter as the process of synchronisation progressed. Finally, after a minute or so, they were completely synchronised to each other. Once they knew they were synchronised, that is, that they were completely sharing the same timeline, each device started to add more notes semi-randomly to compose a melody together like an orchestra. By 'semi-randomly' I mean that the software had prepared a preset group of notes to avoid discords — I wanted the phones to play a clear musical melody as a reason for them to synchronise. By choosing notes from this group randomly, the 'orchestra' could play a different melody every time. I also wrote codes for the phones to have a minimal graphical feedback. When each phone made a sound, its screen instantly flashed a plain whitish colour.

This worked only as a visual feedback accompanying the sound; it was not meant to illustrate anything.

In the second version, I shut off the Internet connection and changed the code for the devices so that they communicated not via the wireless network but by using their own microphone and speaker. Each device made a sound and also 'heard' the others' sound with its microphone. This way of communication was much more unreliable than using the WiFi network because it was easily disturbed and broken by environmental noise. In fact, when I shot the video of this experiment, we needed or even wanted to keep silent in order to watch and see the devices' 'trial' of synchronisation. The moment synchronisation became most dramatic was one of delight — a feeling like 'Wow! They did it!'

Most design elements were shared between these two elements. The content was a metaphor of living things communicating to work together. By using no graphical drawings nor similar illustrative hints of life and letting the process of synchronisation be the only guide to the content, the metaphor was made highly suggestive. Emptiness was in the choice of minimal plain-colour graphics and minimal sound. The difference between the two versions was, however, much more significant for me. The difference was in the level of individuality of the synchronous modules (i.e., phones) and the delicateness of their communication. The phones were physically individual but were still tightly, artificially connected through the WiFi network in version 1. By cutting this connection and introducing a more unreliable and delicate means of communication, version 2 was able to achieve a more convincing metaphor of communicating life. The process of synchronisation emerged almost naturally from a set of individuals, each of which did not have a shared 'central rule', but rather an individual 'local rule'. This local rule described the way for an individual to try and synchronise with other individuals — what every firefly knows. This was different from the central rule, which described how the whole set of elements should synchronise, and which I had programmed in all the previous projects in this section. The synchronisation of individuals based on a local rule cannot be prepared, whereas that written in the central rule is already a preparation in itself. This principle differentiated the quality of transience in the two versions of this project. By having such a non-guaranteed, fragile synchronisation process, version 2 could embody transience as seen in nature. For me, the design of pulse synchronisation became satisfactory in this project for the first time.

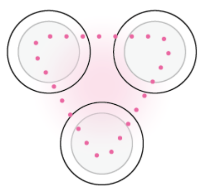
 IPHONE ORCHESTRA VERSION 1	Model	Content	Guide to the Content
		Metaphor of small living things communicating and synchronising to work.	Synchronisation with a reason, individuality of each device.
	Suggestion in:	Emptiness in:	Transience in:
	No illustrative hint of life, synchronisation to achieve a task being the biggest guide to the content.	Minimal plain-colour graphics, minimal sound.	[Failure] No transience in the guaranteed and steady process of sync.

Table 5.7 Reflections Summary on iPhone Orchestra Version 1

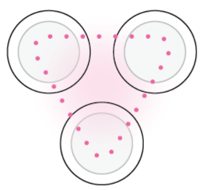
 IPHONE ORCHESTRA VERSION 2	Model	Content	Guide to the Content
		Metaphor of small living things communicating and synchronising to work.	Synchronisation with a reason, individuality of each device, emergence from local rules, use of mic and speaker for communication.
	Suggestion in:	Emptiness in:	Transience in:
	No illustrative hint of life, synchronisation to achieve a task being the biggest guide to the content.	Minimal plain-colour graphics, minimal sound.	Synchronisation being non-guaranteed and fragile against environmental noise.

Table 5.8 Reflections Summary on iPhone Orchestra Version 2

5.3 PULSE INTERFERENCE

So far I have described two directions of exploration — single pulse and pulse synchronisation — through seven of my works. The next project, Inaho, eventually opened up another direction — pulse interference. This became a new perspective for me to relate some kinds of natural phenomena that had not occurred to me to pulse, and to use such phenomena as inspiration for the content of pulse in design.

5.3.1 Inaho

The project Inaho was based on the foundations of my early work Yuen, which I described in Chapter 1. Yuen fascinated me with the smooth and 'organic' motion of the artificial muscle fibres, and I became determined to make even better use of the material to create organic pulsating motion. I collaborated with graphic designer Yoshinaka Ono, and in our discussions we came up with the idea of a plant-like object whose 'stem' would be made of a thin carbon-fibre tube so that the actuation of the artificial muscle fibre would be magnified by the elasticity of the tube to create a dramatic swaying motion.

Development

The sketch and prototype show our initial concept (Figure 5.28). The 'head' contains small LEDs assembled in a line with a sensor in the base so that the carbon-fibre tube's motion is triggered by the presence of a person. When it detects a person walking by, the artificial muscle fibre pulls the root of the carbon fibre tube slightly and the whole stem sways under its own elasticity. We named the work 'Inaho' because it reminded us of the ears of a rice plant (*inaho*

Figure 5.28 Inaho, Initial Sketch and Prototype

in Japanese) being blown by the wind — a typical scene in the Japanese countryside. In testing this prototype, however, we had the impression that the light of the LEDs was too direct, and the device became little more than a 'moving light bulb'; what we had aimed for was a more poetic, indirect lighting effect. Our ideas to improve it were to change the design of the head to maximise the effect of the projection of the light, and to place a white wall behind the installation to act as a screen for the projection. Five different designs were tested: a perforated tube with gold paint; a perforated tube with black paint on the outside and gold paint on the inside; a stem with many piano wires surrounding it; a stem surrounded by rectangular stripes; and a plain sheet of black metal, curved to hide the light source completely from the front and only allow the reflection on the wall to be visible. The perforated tube created the most dramatic projection, with a multitude of dots of light that became bigger and smaller, sparser and denser, and brighter and darker as the distance between the lighting head and wall changed (as the stem swayed). The light projection in the other three designs was much simpler and less interesting. The

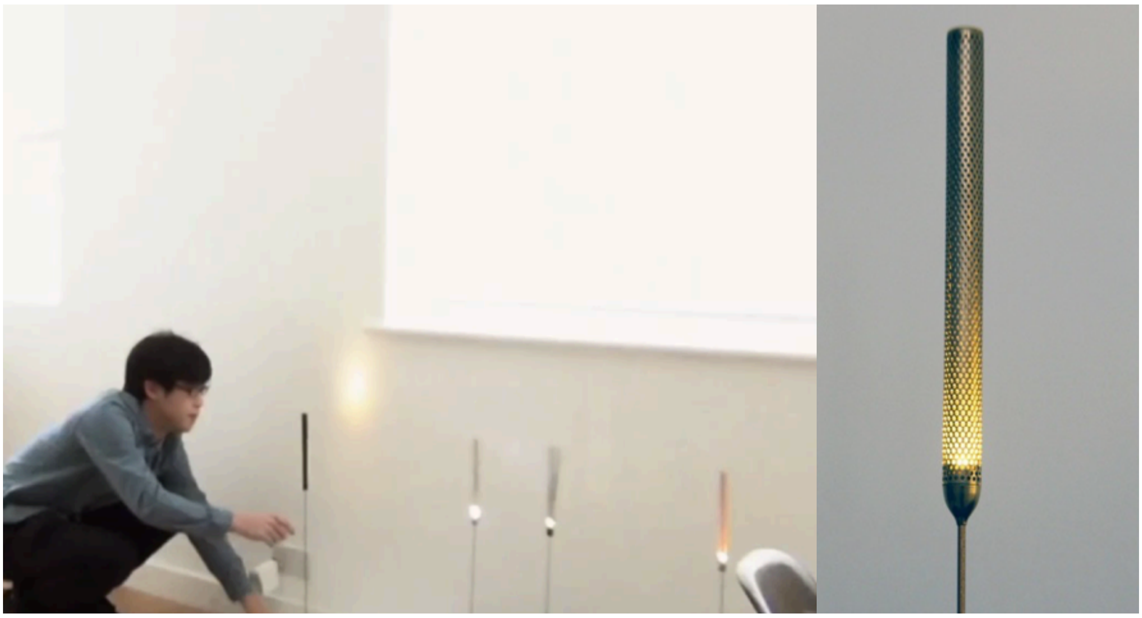


Figure 5.29 Testing Designs of the Lighting 'Head' (Left) / Final Design (Right)

gold perforated tube was most attractive because we could see the analogy to actual ears of rice in the colour, too. After this successful test, we decided to go ahead with this design.

The concept won an award and sponsorship from Lexus, the Japanese automotive brand, and we were given an opportunity to create a large-scale installation with 28 units (stems). The stems had three variations in height — 1950 mm, 1800 mm and 1650 mm — to reflect the different heights of a rice plant. In fact, we were initially thinking of making the tubes with lower height similar to a real rice plant, but tests with tubes of different height variations led us to these heights to take advantage of more impactful, dynamic movement. By using nylon in the 1950 mm stem, aluminium in the 1800 mm stem, and brass in the 1650 mm stem as the material for the connecting part between the carbon-fibre tube stem and the perforated tube head, all the stems were given a similar speed of swaying motion — around three seconds per cycle (side to side) at maximum amplitude — regardless of height.

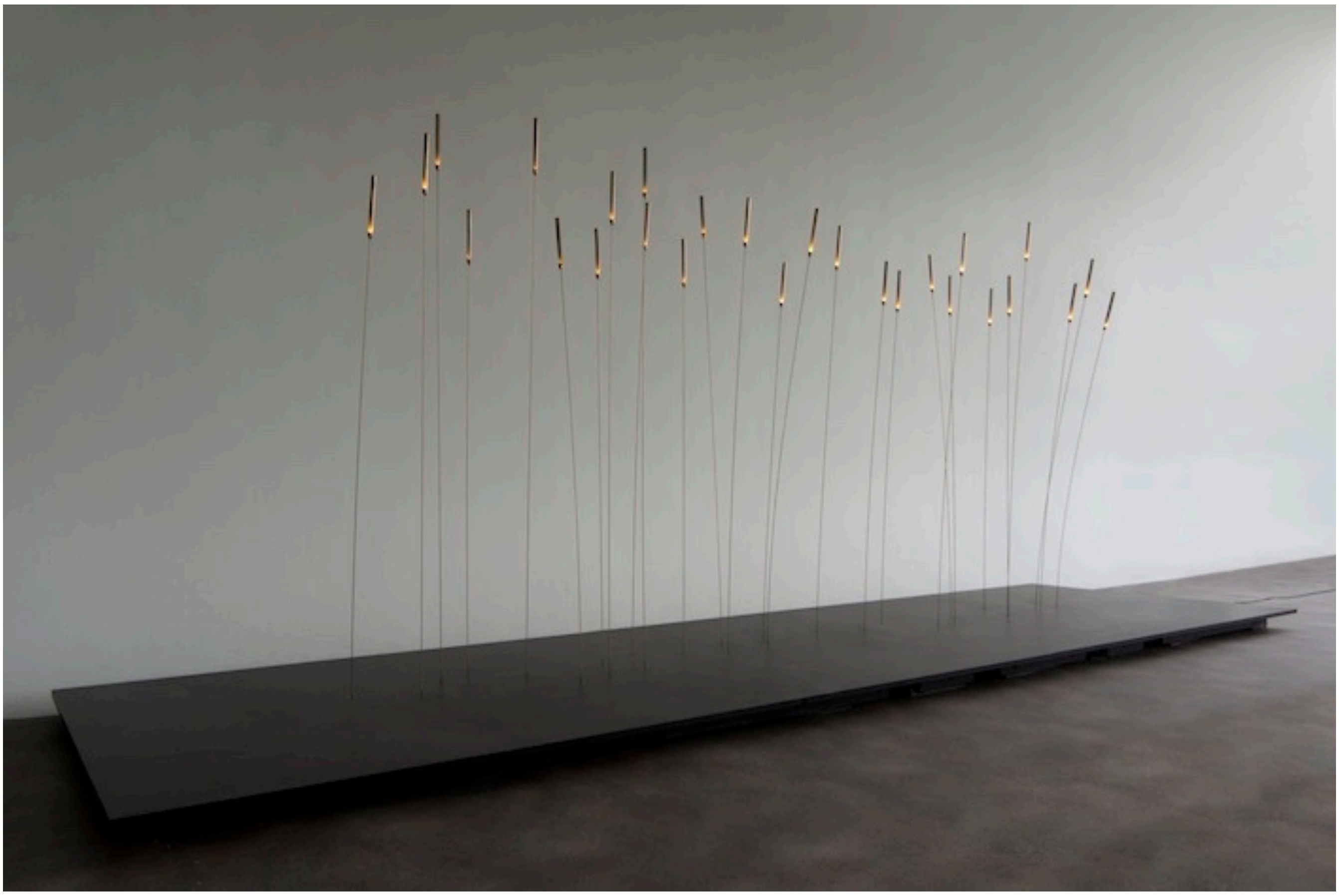


Figure 5.30 Inaho

Figure 5.31 Inaho, Lighting Head

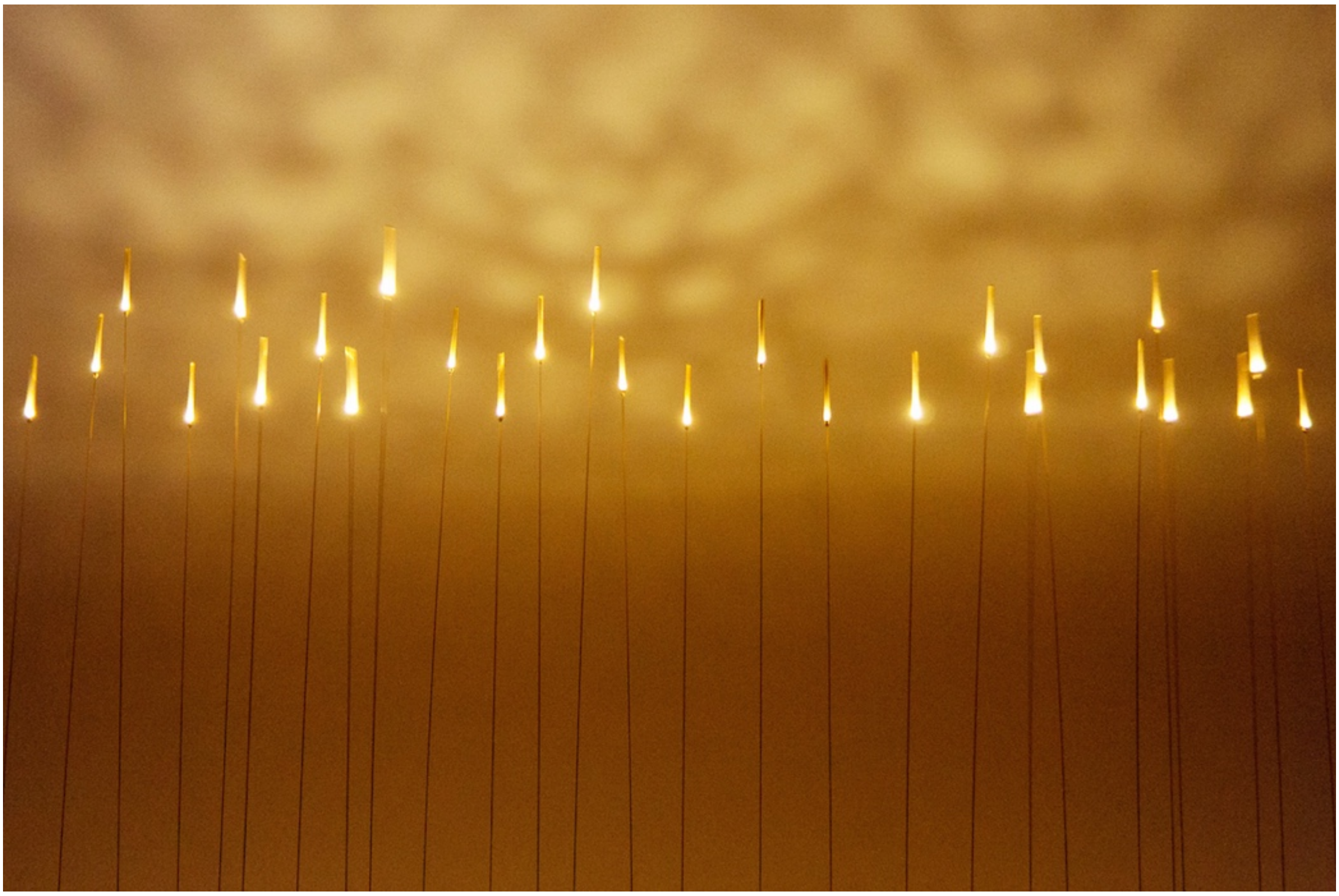


Figure 5.32 Inaho, Projection on Wall

When I saw the whole installation after the production of 28 stems, I caught my breath at the unexpectedly beautiful scenery of the complicated projection. The dots of light emitted from each head merged into one and created a chaotic moving texture as the stems swayed. I had not imagined such an effect when developing and testing an individual unit. The projection truly enhanced the attraction of the whole installation — I would say it was even more beautiful than the actual physical objects. At this point, for the first time I thought of the concept of pulse interference and resultant rhythm. Inaho was composed of 28 rather simple pulses (swaying movements) with randomised timings within a certain range. The chaotic output appeared when these pulses merged into one and no longer appeared to pulsate, but I still found it somehow rhythmic. An analogy to a paddy field being blown by the wind was definitely present in this rhythm.

Figure 5.33 Inaho, Projection on Ceiling

Pulse Interference in Nature and Design

This finding helped me develop a new way of seeing certain scenes in nature, including that of paddy fields blown by the wind. Each ear of rice moves back and forth, and thus makes a 'pulse'. When many plants are together and we see them from a certain distance, our eyes will not count each pulse but perceive the whole, a merged sum of pulses — and we will find rhythm in their interference. The same kind of phenomenon can be found, for example, in the sound of rain or the footsteps of a crowd, or the sight of leaves blown by wind or with sunlight shining through them, or water waves and their reflection of light.

We can find similar effects in some design works as well, although, as far as I know, no designer has explained them as I attempt here from the perspective of rhythm and pulse. The Spiral Pendant Light (1969) designed by Verner Panton is one example. In this piece several layers of chrome or gold spiral metal bars hang from the ceiling and give a rhythmic lighting effect. As the spiral keeps subtly moving in faint air currents, the reflected light appears to be continuously waving and the sum of these reflections creates a complicated yet somehow

Figure 5.34 Spiral Pendant Light (1969) by Verner Panton

rhythmic texture, which reminds one of sunlight shining on water. I like this work in particular because it achieves this effect without any mechanical or electrical controls, only using the subtle, natural force of air. Though my personal interest in my own creations is design combined with computational technology, I appreciate that such simple structures and mechanisms can create a beautiful effect.

The environmental artist Ned Kahn designed a 260-foot-long façade, which he named Wind Veil (2000), for a parking garage in North Carolina. The façade is covered with 80,000 small aluminium panels that are hinged to move freely in the wind. Viewed from the outside, the entire wall of the building appears to move in the wind and creates the impression of waves in a field of metallic grass. Each metal panel moves simply back and forth, thus pulsing, and when many of them gather together another layer of rhythmic movement emerges from the sum. This also creates an intricate projection onto the inside walls and floor of the building when sunlight passes through, reminding one of light filtered through leaves blown by the wind.

Ondulation (2002) by Thomas McIntosh is another notable work that contains a pulse interference effect. This installation is dominated by an immense basin of water; ripples radiate across the surface and light reflects on the water while sound plays in the installation space. The sound is emanating from speakers under the basin, and it is these sound vibrations that cause the ripples on the water's surface. The beams of light reflect the ripples onto the wall to produce a moving texture. The work is a beautiful visualisation of the interference of water waves, as taught in physics classes. When two propagating waves overlap,

Figure 5.35 Wind Veil (2000) by Ned Kahn

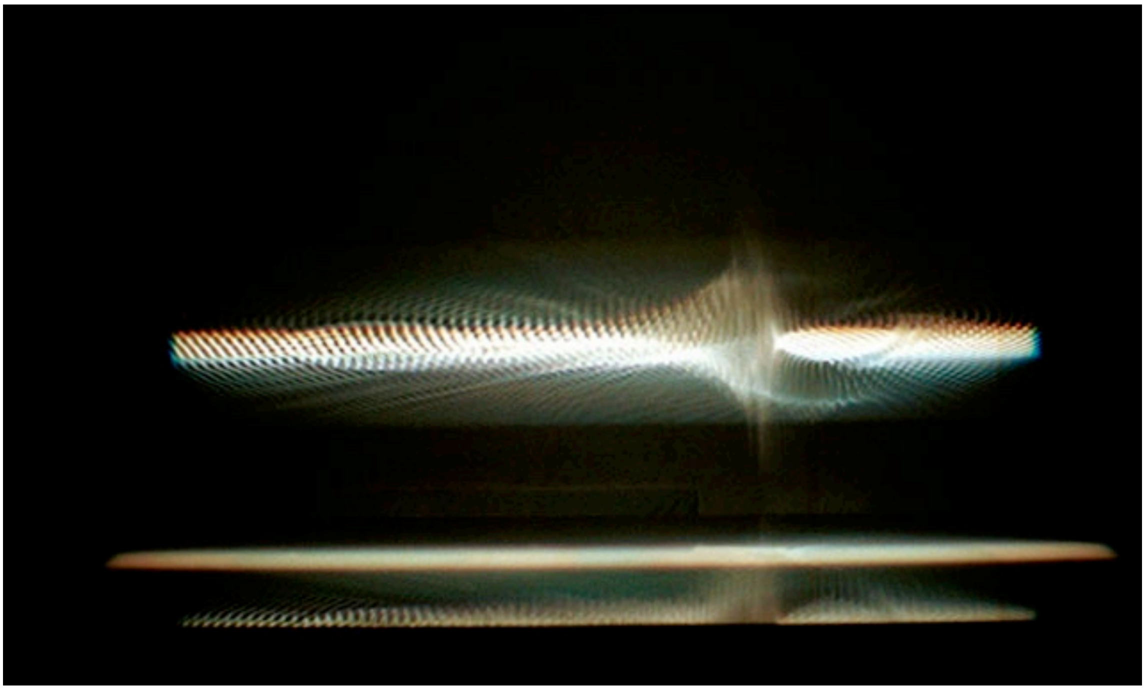


Figure 5.36 Ondulation (2002) by Thomas McIntosh

another form of wave is observed as the sum of these waves. If the properties of waves are different, or there are more than two waves, the resultant wave becomes more complicated.

The insight I gained from the Inaho project also allowed me reinterpret some musical works from the same perspective. The most notable one was Poème Symphonique for 100 Metronomes (1962) by György Ligeti. In this work 100 metronomes with random (within a certain range) tempo settings are played almost at the same time, making the start sound like a chaotic noise. As the metronomes stop one by one the sound of each becomes gradually clearer, and at last all the audience hears is just one pulse (Clendinning 1993). I heard this work not live but in a video; but the pulsing sound of the metronomes still merged and interfered. I somehow felt a rhythmic repetition in the sound; interestingly, it sounded like rain. The experience was like drifting from listening to one pattern to another. At one moment my ears focused on a group of pulses with a certain range of frequencies predominating, and I heard the whole sound with my attention on this rhythmic pattern. However, as it was almost impossible to keep following this particular group of sounds in the chaotic mass, my attention was then drawn by another set of pulses the next moment, and I kept drifting from one pattern of pulses to another. My brain unconsciously connected these experiences and created a sort of rhythmic flow in my mind. As the metronomes stopped one by one, my ears and my brain were more clearly and naturally guided by a particular set of pulses. The transition from this chaos to order was quite seamless.

Steve Reich used an interesting technique called 'phase shifting' in some of his works, such as Piano Phase (1967). In this work two pianists repeat the same simple phrase in unison at first, but as one of them starts to play slightly faster the phases become separated gradually until the lag becomes the same as the length of a semiquaver (sixteenth note); they then return to unison. This process is repeated over and over. Of course the melody sounds clear when the two pianists play in unison, but the slight time lag makes the whole very chaotic, so that the audience hears the tidily ordered melody and the chaotic, crowded sound alternately yet seamlessly. I found it interesting that such a subtle difference between two simple repetitions can create interference, and that we can still find a rhythmic sound texture in it.

Analysis of Pulse Interference of Inaho

The question is, what makes such pulse interferences rhythmic? To look into the mechanism of this phenomenon, I conducted a further analytical study of Inaho using image-processing technology. With custom-built software based on the often-used image-processing library OpenCV, I processed a video recording of the Inaho projection. This software compared every frame of the video with the first frame and displayed the differences. The snapshots (Figure 5.37 on the next page) show how these differences (drawn in white) changed over time. The white part apparently increases and decreases alternately.

I also plotted the percentage of these white pixels against the total pixels in every frame for a 26-second-long video clip (Figure 5.38). The vertical axis in the graph shows the percentage of the white area and the horizontal axis shows the frame number. This clearly shows oscillation at an almost regular frequency. This is the rhythm I was feeling in the interferences of pulses. Interestingly, these clear repetitions were not visible when I was looking at the projection, but I nevertheless somehow 'felt' them as a rhythm. Somehow, my perception was registering this regular repetition. The period of each cycle was 2.9 seconds on average (the frame rate of this footage was 30 frames per second). This figure is also interesting because each stem's speed of swaying is also between about 2.6 seconds and 3.2 seconds; it seems that these properties of each pulse determine the frequency of the emerging rhythm.

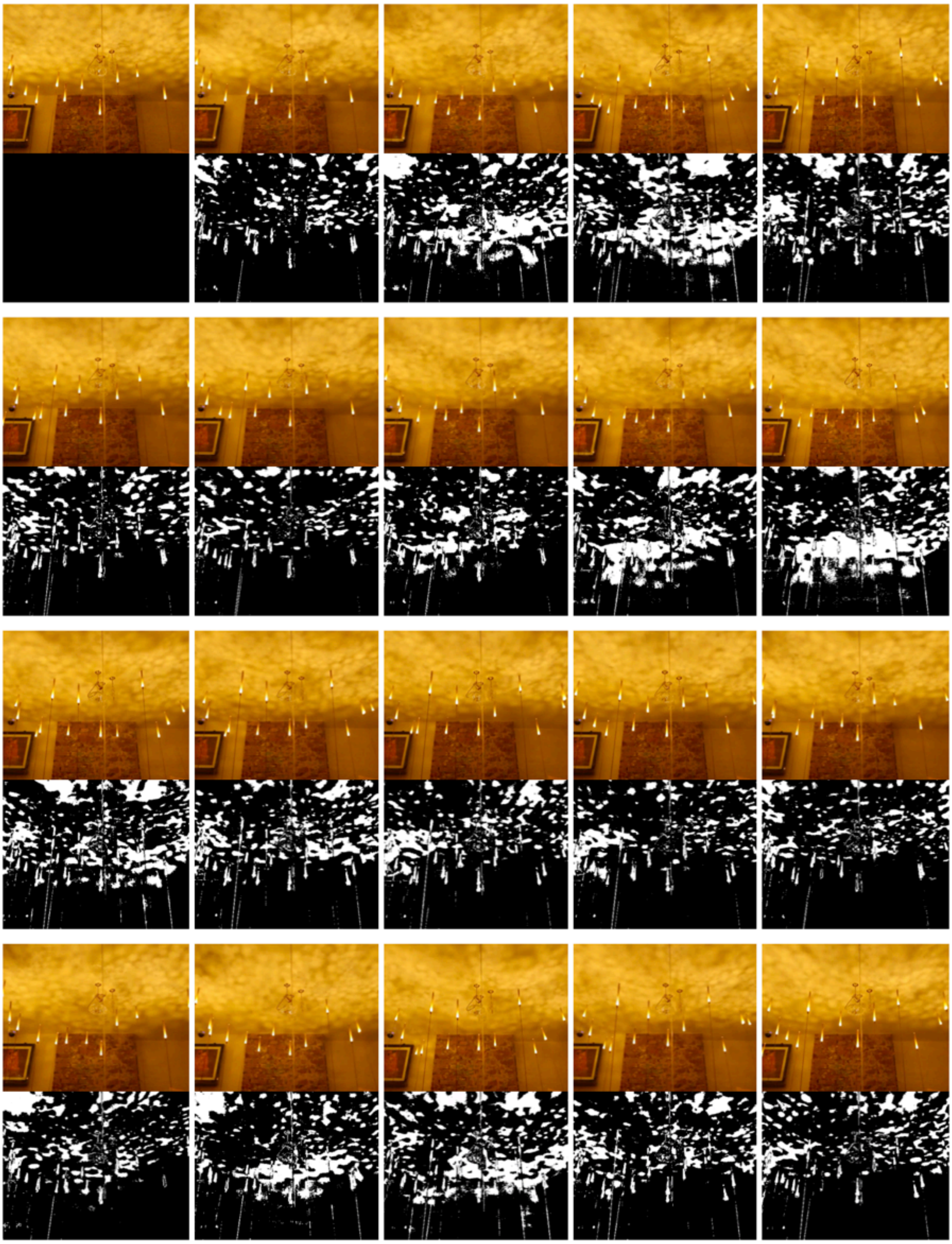


Figure 5.37 Inaho, Result of Image Analysis

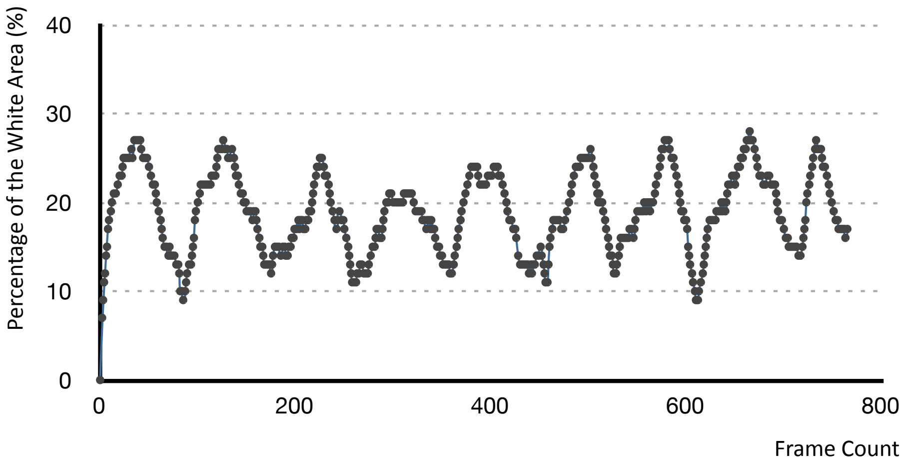


Figure 5.38 The Percentage of White Area against the Total Pixels in Each Frame

Eventually I was able to understand this effect with simple mathematics. When two multiple sine waves with the same angular speed (ω, meaning the same frequency) and different amplitudes (A_1 and A_2) and phases (φ_1 and φ_2) are added, the sum becomes another sine wave with the same angular speed, as shown in the equations below:

$$A_1 \sin(\omega t + \varphi_1) + A_2 \sin(\omega t + \varphi_2)$$
$$= A_1 \sin(\omega t)\cos\varphi_1 + A_1 \cos(\omega t)\sin\varphi_1 + A_2 \sin(\omega t)\cos\varphi_2 + A_2 \cos(\omega t)\sin\varphi_2$$
$$= (A_1 \cos\varphi_1 + A_2 \cos\varphi_2)\sin(\omega t) + (A_1 \sin\varphi_1 + A_2 \sin\varphi_2)\cos(\omega t)$$
$$= \sqrt{(A_1 \cos\varphi_1 + A_2 \cos\varphi_2)^2 + (A_1 \sin\varphi_1 + A_2 \sin\varphi_2)^2} \cdot \sin(\omega t + \varphi_3)$$
$$= \sqrt{A_1{}^2 + A_2{}^2 + 2A_1A_2 \cos(\varphi_1 - \varphi_2)} \cdot \sin(\omega t + \varphi_3)$$

$$\text{where } \varphi_3 = \tan^{-1}\left(\frac{A_1 \sin\varphi_1 + A_2 \sin\varphi_2}{A_1 \cos\varphi_1 + A_2 \cos\varphi_2}\right)$$

Then, if another sine wave is added to this composition, we have another sine wave with the same principle. Therefore, the sum of multiple sine waves with the same angular speed becomes a sine wave with that angular speed. This would be the same kind of principle seen at work in the case of Inaho, although the waves were not genuine sine waves and their angular speeds were not completely the same. Furthermore, the waves, or stems, were distributed in space, which was why this synthesis was not so clearly visible — though still somehow recognisable. The natural phenomena and effects in some of the creative works introduced above also share a similar principle.

In the case of Inaho, such an effect was observed only in the light projection and not in the movement of the physical stems. The individual stems did not merge visually with each other, whereas projected light could merge completely. The stems were perceived as multiple individuals but the projection was perceived as one image. Therefore, choosing a medium that can merge with itself would be one key to achieving the effect of interference.

In conclusion, pulse interference worked to enhance Inaho's content, the metaphor of a rice paddy field blown by wind, as well as other guides such as sculptural form, the dotted shape of the lighting, and the elastic motion of each pulse. In other words, pulse interference appeared in the content layer as well as the motion layer (Figure 5.39). By using this subtle, 'somehow rhythmic' effect of interference as the key guide, Inaho successfully achieved a suggestive quality in delivering its content. This effect also contributed to heightening the quality of transience of the work. The complexity of interference brought

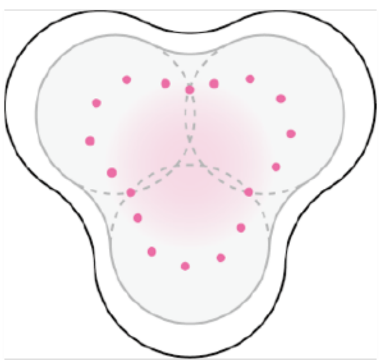


Figure 5.39 Model of Pulse Interference

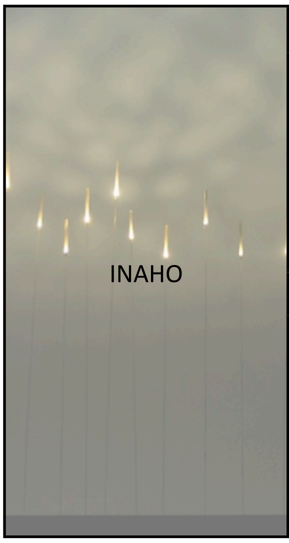
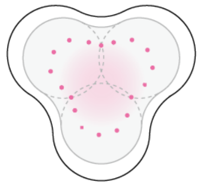
	Model	Content	Guide to the Content
 INAHO		Metaphor of plants blown by wind.	Form mimicking a plant, dotted shape of light reminiscent of paddy field, motion of the merged light reminiscent of waving rice stems.
	Suggestion in:	Emptiness in:	Transience in:
	Minimalistic design of form, guide to the paddy field appearing only in the projection with interference pulses.	Thinness of parts, black plain base, silence.	Unpredictability and contingency in motion caused by complex interference.

Table 5.9 Reflections Summary on Inaho

unpredictability and made the behaviour of the whole installation very different from a fixed routine. Emptiness was seen in the form and visual aspects of the work, rather than the pulse interference, i.e., in the use of thin materials, minimally designed parts such as the simple perforated tube, and limited colours (gold for the stems and black for the base), and in the silence of the work thanks to the use of artificial muscle fibre.

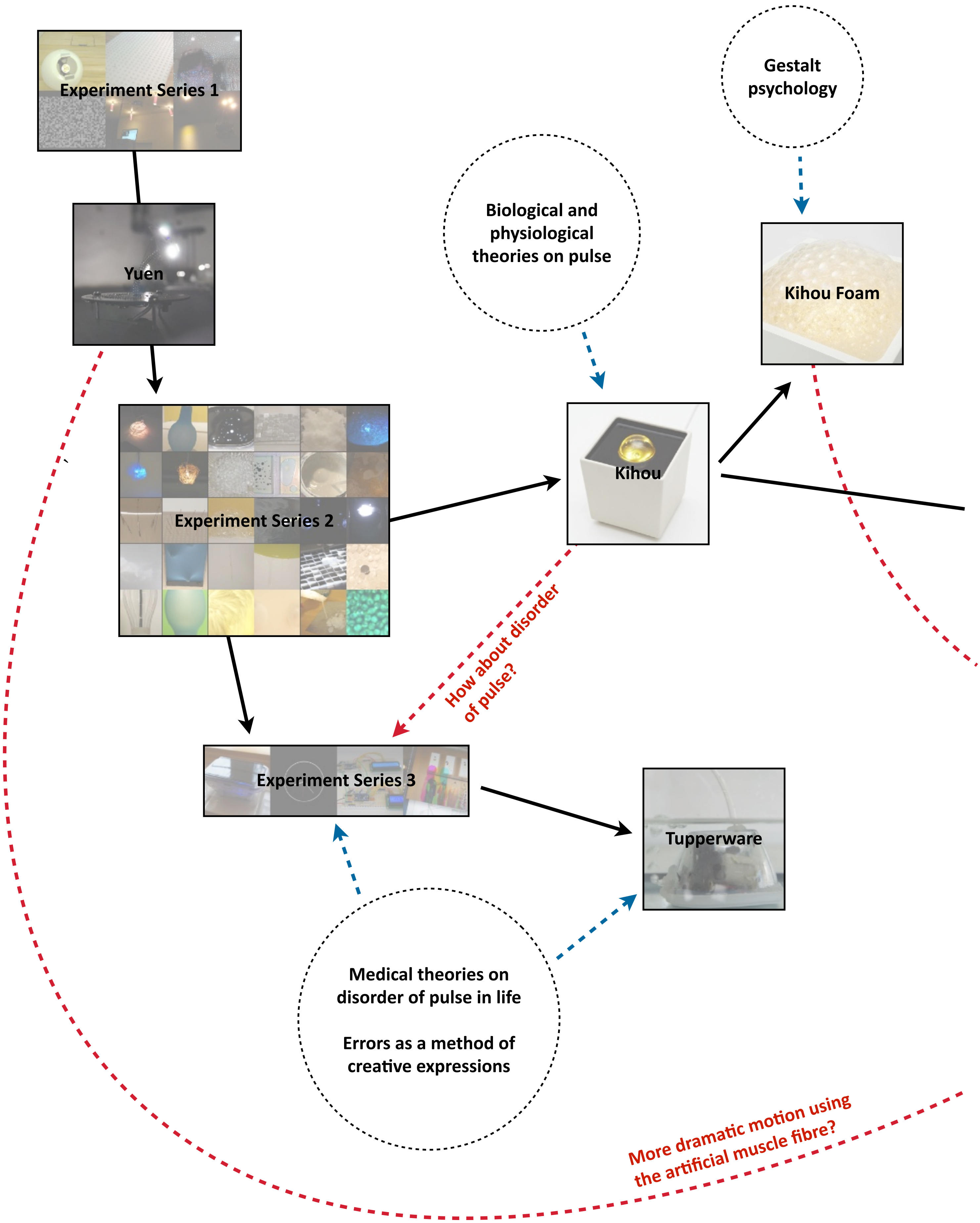
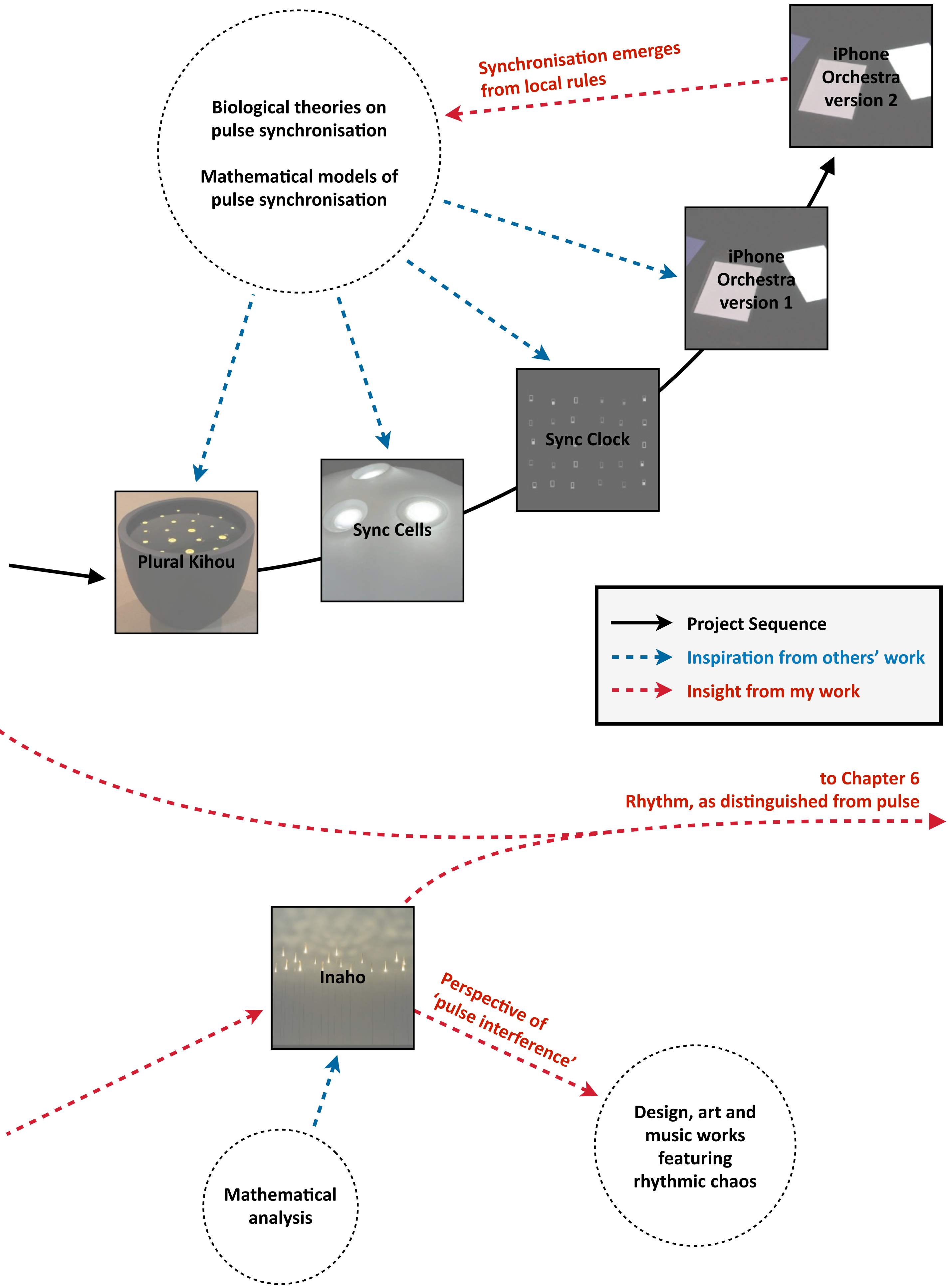


Figure 5.40 Project Map



Synchronisation emerges
from local rules
iPhone
Orchestra
version 2
Biological theories on
pulse synchronisation
Mathematical models of
pulse synchronisation
iPhone
Orchestra
version 1
Sync Clock
Sync Cells
Plural Kihou
Project Sequence
Inspiration from others' work
Insight from my work
to Chapter 6
Rhythm, as distinguished from pulse
Inaho
Perspective of
'pulse interference'
Design, art and
music works
featuring
rhythmic chaos
Mathematical
analysis

CHAPTER 6

REFLECTIONS ON RHYTHM

6.1 WHAT IS RHYTHM?

Of the eight projects described in the previous chapter, Kihou Foam and Inaho gave me the most important insights into the difference between rhythm and pulse. These two concepts are easily mixed up and misunderstood; in fact, before undertaking those two projects I was unable to truly distinguish between them. In this chapter, I want to look into this difference in more depth using some theoretical arguments, and reflect on my works from this perspective.

Defining 'Rhythm'

I will start with the definition of the term 'rhythm' in comparison to that of 'pulse', which I gave in Chapter 2. The same Oxford Dictionary of English defines rhythm as:

1) a strong, regular repeated pattern of movement or sound;

2) the measured flow of words and phrases in verse or prose as determined by the relation of long and short or stressed and unstressed syllables;

3) a regularly recurring sequence of events or processes;

4) (art) a harmonious sequence or correlation of colours or elements.

Some key words in these definitions, such as 'regular' and 'repeated', suggest something in common with pulse. Other words, such as 'pattern' or 'flow', however, indicate the differences. The dictionary defines the word 'pattern' as:

1) an arrangement or design regularly found in comparable objects;

2) a regular and intelligible form or sequence discernible in the way in which something happens or is done.

In other words, a pattern is something found or discerned by the observer. We might then automatically conclude that rhythm is also something found or discerned by the observer. On this, Fraisse (1982) wrote: 'we speak of the rhythm of the days and of the nights, of the seasons, and of rapid or of very slow physical phenomena (such as that of light frequencies or of the planets, respectively). If by direct or by indirect observation, we ascertain the successive phases of these phenomena, in none of these cases do we directly perceive the order — that is to say, the succession of the phases itself. The rhythm is thereby inferred from a mental construction' (p.150). This feature is not found in pulse. The other key word I picked up from the dictionary's definition was 'flow'. The etymology of the word 'rhythm' relates to the Greek words ρυθμος (*rhythmos* — rhythm) and ρέω (*rheo* — flow); this suggests that flow is an essential element of rhythm. Fraisse (ibid.) explained this aspect of rhythm as follows: 'we can predict on the basis of what is perceived, or, in other words, (...) we can anticipate what will follow' (p.150). Similarly, Martin (1972) wrote: 'inherent in the rhythmic concept is that the perception of early events in a sequence generates expectancies concerning later events in real time' (p.487). Based on these discussions, I will characterise rhythm by the following characteristics:

1) it is a pattern found by the observer;
2) the pattern is repeated;
3) the repetition is regular;
4) the repetition has flow, which allows the observer to predict what will happen based on what has been perceived already.

A lot of experiments were carried out by psychologists around the beginning of the 20th century to study human beings' perception of rhythm. Some of the results are interesting as they appear to support the notion that rhythm is constructed in a person's mental processes. The discovery of so-called 'subjective rhythmisation' (Bolton 1894) was one such finding. In his pioneering study, Bolton (ibid.) conducted an experiment with 30 subjects. Apparatus was developed using an induction circuit to generate regularly repeating, identical sound in a telephone receiver. The subjects were 'invited to be seated and listen to the telephone. (…) They were then invited to say anything that suggested itself to them, whatever the character' (p.184). In their responses to his questions Bolton found that the subjects tended to make groups of two, three, four, six or eight sound elements, even though there was no identifiable reason for them to do so in the sound itself. Miyake (1902) and MacDougall (1903) achieved similar results in their own studies. Koffka (1909, as cited by Fraisse 1982), used stimuli of light instead of sound in his experiment, and confirmed not only similar grouping of elements but also another interesting perceptional process. When the subjects were shown three lights — say, A, B and C — in turn and asked to continue the rhythm they perceived, they not only reproduced the intervals between A and B, and B and C, but also linked the groups of lights as if the interval between C of the first group and A of the second group had been a given. This result suggests that 'the perception of rhythm is not only that of a grouping but also that of a linking of groups' (Fraisse 1982, p.159). This establishes the flow of rhythm, which I discussed above.

Comparing Pulse and Rhythm

Based on this discussion, I want to compare the two key concepts — pulse and rhythm — from several different angles. The first question is, where or when do they occur? As I wrote above, rhythm essentially occurs when the observer, human in most cases, perceives and mentally processes an object. The rhythm is constructed in his or her mind. For example, natural phenomena such as the motion of leaves blown by the wind or the sound of rainfall do not have obvious regular repetitions, but we sometimes talk about their rhythms. It is an ability of our species to find rhythm in these phenomena. The rhythm I find and the one you find, however, will be different; at least, as far as I know, we have no way of saying whether they are the same. What about pulse? Although phenomenologists might say pulse is also a phenomenon, where we can discuss only what we experience, my position is that pulse exists in an object, and thus exists equally to all who observe it.

Secondly, I want to discuss regularity in these two concepts. Both pulse and rhythm should show regularity according to the definitions I have presented, but I believe that this regularity must be differentiated. The interval between the repeating elements of pulse should be measured as equal by any observer, the only difference being in the level of tolerance, as long as the measuring is carried out under the same standard conditions. In contrast, rhythm is created within the observer, so the regularity of the rhythm should be created within the observer. This regularity is not something to be 'measured' but rather to be 'recognised' by each observer. In simple terms, even if one person finds something to be regular, another may find it irregular.

The third point relates to the spatiality and temporality of pulse and rhythm. Are they limited to the object or the experience in time? From the general usage of these words, surely nobody would deny that pulse and rhythm deal with time. What about space? It seems that the word 'pulse' is not often used for spatial repetition. We do not call regularly repeated elements in space, for example bricks, a 'pulse', but rather a 'regular arrangement', or something similar. On the other hand, many architects, painters or sculptors often talk about rhythm in space. György Kepes (1944) once wrote: 'the orderly repetition or regular alternation of optical similarities or equalities dictates the rhythm of the (...) organisation. In recognising such order one learns when the next eye action is due and what particular neuromuscular adjustment will be necessary to grasp the next unit. To conserve the attentive energies of vision, therefore, the picture surface must have a temporal structure of organisation — it must be rhythmically articulated in a way that corresponds, for the eye, to the rhythm of any work process' (p.53). According to this articulation, the rhythm in space can be constructed in the process of the observer moving his gaze across it. In this process, he would perceive the spatial arrangement in time, and find the rhythm in his perception.

The last point I would like to raise is whether rhythm can emerge from pulse. To me, the answer is almost certainly yes. If one feels that a strictly regular pulse, such as that of a metronome, clock, flash-light or bass drum, is rhythmic, then one finds rhythm in that pulse.

6.2 REFLECTIONS ON RHYTHM IN MY WORKS

In this section I want to reflect on my works again from this new perspective relating to rhythm inferred from the pulses.

In Kihou, the perception of pulse in the activity of the bubble actually changed according to the setting of the pump. When the frequency of bubbles was increased (when the pump was operating continuously), I tended in my mind to form groups out every two or three bubbles —exactly the behaviour Gestalt psychology and the notion of subjective rhythmisation might have suggested. Bolton (1894), MacDougall (1903) and Fraisse (1982) proposed the maximum limit of the interval between stimuli for subjective rhythmisation to be between 1.5 seconds and two seconds; probably it is because the tempo of the bubbles came within this range that the subjective rhythmisation occurred in my perception. With the default setting of 4.3 seconds per cycle of repetition, in which each bubble appeared, popped, disappeared, and appeared again, the repetition in the perceived rhythm was the same as that of the pulse. What I experienced in it, however, was not only the regularly appearing elements in themselves. The sequence of a bubble slowly growing and then popping, followed by a short period of calmness with the expectation of the next bubble, allowed me to grasp a continuous flow in the pulse. Unpredictable small bubbles sometimes appeared at random; however, they did not break the flow but rather became accents of it.

My experience of Kihou Foam was different, as I have discussed in Subsection 5.1.2. I realised I was encountering a music-like rhythm in the complicated behaviour of the bubbles. It somehow felt like a combination of musical notes. Again, as argued in the theories of Gestalt psychology, this could have been the result of my mind grouping those stimuli and finding the music-like pattern.

The pulse in the Tupperware project was also clearly visible in the air bubbles, appearing in water in this case. Because the viscosity of water is much less than that of honey or bath soap, the materials used respectively in the previous two projects, the Tupperware unit emitted rather rapid, successive small bubbles in every repetition; imagine the difference you would encounter blowing bubbles with a straw in water and in thick honey. Therefore, even with the same setting of the pump as was used in Kihou — 4.3 seconds per cycle — pulses were presented differently. There was rapid repetition of small bubbles and silence. I perceived these bubbles as one group. The tempo of the actual pulse was too rapid to perceive it as it was.

In the projects Plural Kihou, Sync Cells, Sync Clock and iPhone Orchestra, a solid pulse appeared with emphasis on the synchronisation, and my perception of rhythm was guided by this to perceive the pulse as it was. In the case of iPhone Orchestra, my perception of rhythm continued to change after synchronisation as the devices added notes to the shared timeline to compose the music. Just after they were synchronised and before any notes were added, the rhythm I was feeling was in the same cycle as the original pulse. Once another note was added, however, this cycle suddenly felt like quadruple time (four-four time) music; this feeling became stronger as more notes were added.

Rhythms were experienced differently in these projects when they were not in synchronisation. In these cases, the pulses felt too random to grasp a pattern. Pulses in these projects were placed too far apart from each other to be merged, and gave the impression of interference, as in Inaho.

As for Inaho, I have already discussed the difference between the actual pulses and the rhythm I felt in the interference between them. This project became a crucial basis for me to move forward into the discussion presented in this chapter.

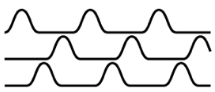
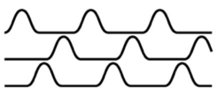
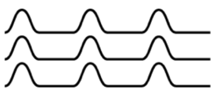
Project	Pulse in the Object	Rhythm I Experienced	Description
Kihou (Continuous blow)		→ 	Rapid pulse was experienced as a repetition of grouped elements, as Gestalt psychology argues.
Kihou (Breathing-like tempo)		→ 	Slower pulse (with longer interval than the perceptional limitation) was experienced as it was.
Kihou Foam		→ 	Big central pulse became the base and smaller random pulses were felt as if they were forming ordered groups.
Tupperware		→ 	Short burst of rapid pulse (of bubbling air) was considered as one group.
Plural Kihou (Unsynchronised)		→ 	When there was no connection felt between pulses, they were experienced as they were — multiple pulses.
Sync Cells Plural Kihou Sync Clock iPhone Orchestra (Synchronised)		→ 	When multiple pulses synchronised, they were experienced as one amplified pulse.
Inaho		→ 	When multiple pulses merged together, the sum of them was experienced as one ambiguous pulse.

Table 6.1 Reflections on Rhythm in My Works

6.3 PHILOSOPHY OF RHYTHM AND LIFE

Rhythm has been sometimes placed in the central position in philosophical arguments, and interestingly has been often associated with life. Klages (1933) formed his theory based on a discussion about the difference between pulse[1] and rhythm, where he argued that pulse takes us to awakening, consciousness and intelligence, which he called 'spirit', by making us aware of the separation in the repetition, while rhythm takes us to relaxation, unconsciousness and instinct, which he called 'life', by inducing us to 'float' in the flow. This can be easily understood if we imagine a baby falling asleep with the sensation of rocking in his mother's arms. It is not because he counts each vibration in the movement but because he can give himself over to the flow which he experiences in the movement. In other words, it is not the pulse but the rhythm that makes him fall asleep. Klages stressed that it is this human ability to experience rhythm that differentiates humans and human activity from machines, and characterised life in light of this difference.

Japanese design critic and philosopher Mukai Shutaro began his theory about rhythm with the Japanese word *furi*, which is translated as 'gesture'. Of several words that broadly mean the same thing in Japanese, *furi* is the oldest, and it is sometimes used in religious contexts as well. The Chinese character representing this word has the meanings of 'vibration' or 'oscillation', and its etymology, as described in the Iwanami Dictionary of Classical Japanese, is 'vibrating things to animate it' or '(things themselves) vibrating with life force' (Mukai 2008). Moreover, according to Shirakawa (2007, as cited by Mukai 2008) the origin of this Chinese character indicates an infant moving or being born; in other words, the creation of life. On the basis of this discussion Mukai concluded that rhythmical movement is the origin of life, and this relationship has thus been

[1] Actually the term he used was 'takt', which should strictly be translated into 'tactus' or 'beat', but I believe we can replace this with the word 'pulse' based on my definition.

represented in one of the oldest Japanese terms. He went on to argue that this notion was not only limited to the case of Japan but also common in the West, pointing out that the origin of the English word 'gesture', which is the Latin *gestus*, also has the meaning of 'bearing'.

Goethe mentioned rhythm in his famous Metamorphosis of Plants (1790). During his time in Italy, Goethe reached the hypothesis that all the organs in plants — the leaves, stems, calyxes, petals, stamens, pistils, fruits, seeds, etc. — are the transformation, which he called metamorphosis, of the one primitive leaf organ. He thought the rhythmic repetition of contraction and expansion was the fundamental driving force of this metamorphosis: leaves contract to become calyxes, calyxes expand to become petals, petals contract to become stamens and pistils, stamens and pistils expand to become fruits, and fruits contract to become seeds. He then expanded this principle to apply to the metamorphosis of animals (Goethe 1819). This theory of life as a process of transformation contributed to the creation and development of the academic field of morphology, but the most interesting part for me was the notion that rhythm drives life.

The mathematician and philosopher Alfred North Whitehead also argued that rhythm and life were linked together. In his view, represented in his theory of 'organicism', life is a system or series of networks of objects and events. He saw rhythm as the key link between these objects and events. He wrote: 'life is complex in its expression, involving more than percipience, namely desire, emotion, will, and feeling. It exhibits variations of grade, higher and lower, such that the higher grade presupposes the lower for its very existence. This suggests a closer identification of rhythm as the causal counterpart of life; namely, that wherever there is some rhythm, there is some life, only perceptible to us when the analogies are sufficiently close. The rhythm is then the life, in the sense in which it can be said to be included within nature' (Whitehead 1919, p.197). While Goethe's argument about the relationship between life and rhythm was focused on biological aspects, Whitehead linked rhythm with wider processes of life.

It was interesting to me to see how these philosophers relate rhythm to life. Despite differences in their perspectives, they all view rhythm as an essential part of life. We may use this conclusion to help us understand why pulse can often function in design to communicate metaphors of life, as in my projects and some of the examples mentioned in Chapter 2. People find rhythm in the pulse, and this rhythm may already suggest life in its very nature even before people identify particular metaphors of heartbeats, breathing, etc.

CHAPTER 7

RHYTHM IN NON-PULSING MOTION

7.1 INSPIRATIONS FROM MUSIC

Throughout this research I have sought to demonstrate that pulse and resultant rhythm can become elements of design that emotionally communicate with viewers in different ways. However, once I gained deeper understanding of rhythm as described in the previous chapter, I also developed another focus of interest outside of the range I had been dealing with, concerning a non-pulsing, much more complicated kind of rhythm, as represented in music. As a jazz musician myself, I know from my own experience how rich expressions of rhythm in music can be with various uses of 'musical expressions' such as accents, rests, staccatos, legatos, syncopations, etc. I want to look into this kind of rhythm in this chapter in depth.

Let me start the discussion about musical rhythms with some examples. One is In C (1964), a piece by Terry Riley, known as a pioneer of minimalist music. The piece starts with a pulse of the note C on piano in quavers, and various instruments (e.g., marimba, glockenspiel, violin, cello, contrabass, bassoon, French horn) join one after another. The composer prepared 53 numbered, short and simple phrases, and the musicians play these phrases from 1 to 53. The score directs: 'patterns are to be played consecutively with each performer having the freedom to determine how many times he or she will repeat each pattern before moving on to the next.' As a result of this rather free orchestration, the sum of simple phrases composes an ever-changing, rich rhythmic texture. In addition to the fact that several different phrases are played all at the same time, making a complicated ensemble, one factor giving extra richness is that all the phrases are played by human musicians, who naturally add musical expressions like accents. In C caused a sensation in the music scene and actually influenced many composers in and after that era. We can hear this influence in works such as Music for 18 Musicians (1976) by Steve Reich and Glassworks (1982) by Philip Glass.

The roots of this technique of using the sum of simple phrases to create a complicated texture can be found in some kinds of ethnic music, most notably in Gamelan, played in Indonesia. Gamelan musicians use drums, xylophones, glockenspiels, bamboo flutes, etc., to play rather simple repeating phrases. Some phrases are in quavers or semiquavers, and some are in minims or longer notes. The melody of each phrase changes between repetitions so that, as with In C, we hear an ever-changing sound texture in the sum of those phrases.

I would also like to refer to some other musical techniques. For example, syncopation is one of the fundamental elements of jazz. By shifting notes from the 'on-beat' points (at every quarter of a bar in the case of quadruple time) or placing accents on the notes outside the on-beat points, syncopation makes a rhythm that is not restricted by the meter; musicians call it 'groove'. Syncopation can also be found in some compositions of European classical music such as Beethoven's Seventh Symphony, but not as the style's fundamental element as in modern music. Polyrhythm (or cross-rhythm) is another often-used technique. Polyrhythm is characterised by two or more conflicting rhythms played simultaneously — they are not perceived as deriving from one another, however. It traditionally pervades African music as well as jazz or other popular music. Ewe music, with its heritage in West Africa, is one of the most notable examples of polyrhythmic music. Ewe master drummer Ladzekpo explains: 'In Anlo-Ewe cultural understanding, the technique of cross-rhythm is a highly developed systematic interplay of varying rhythmic motions simulating the dynamics of contrasting moments or emotional stress phenomena likely to occur in actual human existence' (Ladzekpo 1995). Like much other ethnic music, Ewe music features simply repeated drum beats, the interplay of two or more of these beats leading to a much richer rhythm.

7.2 SET-UP OF INTERVIEWS

This time I chose to conduct interview-based experiments using the Inaho installation as the basis for the questions. I had no clear plan about how to locate the discussion of such non-pulsing motions within the original context of the research, but expected to gain hints from conversations with participants. For this purpose, I did not set up a prefixed questionnaire, excepting a few questions to trigger the conversation. Natural conversations were preferred to gather the unguided reactions and thoughts of the participants.

Setting

I set up a 12-stem installation of Inaho in my studio with a semicircular base. Each participant was invited to take a seat on a couch placed in the middle of the semicircle, and the stems would sway towards this middle point. The couch was intended to enable the participant to relax and engage with the interview as a conversation with me rather than a formal one-to-one question-and-answer session. It also allowed him or her to look over the projections on the ceiling in a comfortable setting. The interview was done in the evening so that the projections of light of Inaho could be clearly seen.

The original design of Inaho was that the stems would light up and sway in response to the presence of people. This time I changed the program to make the light of each stem individually controllable with a wireless signal so that more widely differing lighting effects could be displayed. The structure of the electronics did not allow me to control each stem's swaying movement individually, so the motion was controlled for all of the stems at the same time, but from the same wireless signal as the light. With this setting, my idea was to bring more complex effects into Inaho, mainly (but not only) through its light. I

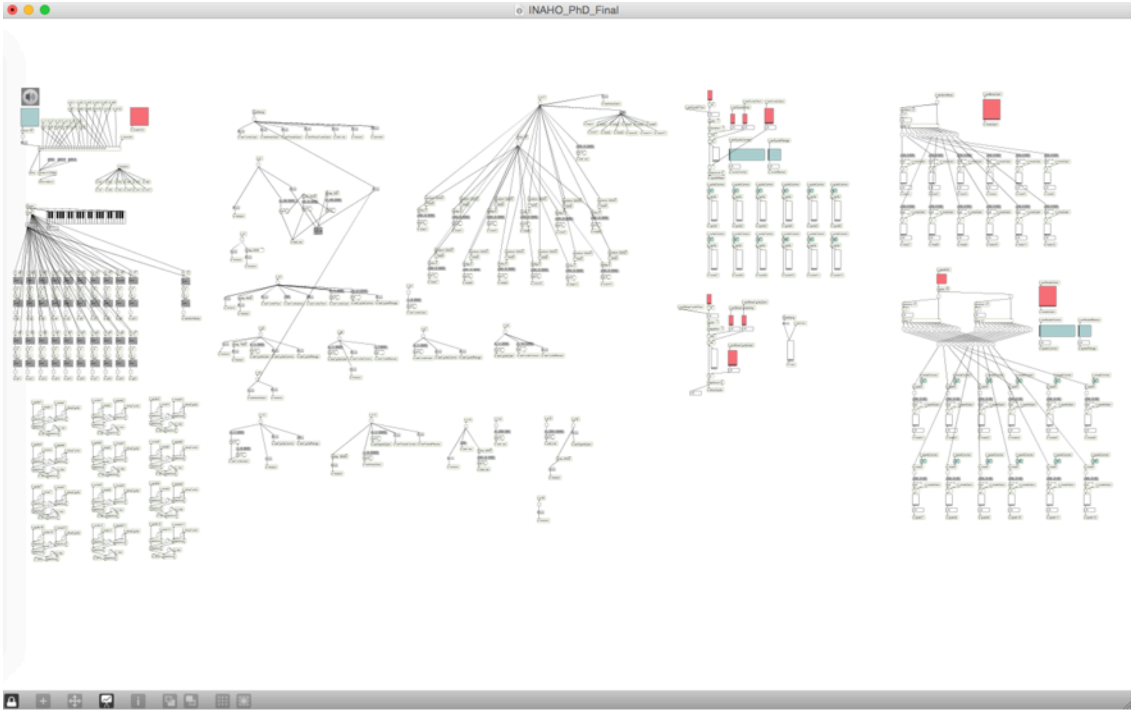


Figure 7.1 Signal Generator (Made with Max/MSP)

built custom software using the visual programming environment Max/MSP for controls, and the signal was sent to Inaho's micro-controller via a wireless network in real time.

Participants

Rather than people from the general public, I invited six students from the School of Design at the Royal College of Art. This was because the purpose of the interview was not collecting statistical data but finding ideas for use in design from these personal conversations. I chose to invite this small number of people and have an in-depth session with each of them. They needed to be designers, as I wanted to have conversations from the viewpoint of design, but they were not necessarily high-level professionals. A certain understanding in design was enough — students at the Royal College of Art were a good target group in this sense. The six students who participated had good variety in their professions and backgrounds — a design researcher with an astronautics background, a design researcher with a biology background, a service designer with a business marketing background, an interaction designer with a film background, an architect, and a product designer.

Method — Interview Part 1

I showed Inaho with 100% bright light on all of the stems and 70% swaying motion, and talked with the participant about it. As stated, I prepared three fixed questions to start the conversation: 'How do you describe what you are looking at now?', 'Where do you look at as you watch the installation?' and 'If you were to choose a few adjectives to describe this, what would you choose?' The intention behind this part was to establish a conversation with the participant about the piece of work in general terms, and to get to know how he or she perceived and interpreted the Inaho installation.

Method — Interview Part 2

For this part of the interview I prepared four basic modes of light:

Mode 1: All Stems Blinking — the lights of all stems blink according to a sine curve. This mode has three parameters: offset, amplitude, and frequency. Offset and amplitude relate to the minimum and maximum brightness of the blink, respectively. The frequency changes the speed of blinking.

Mode 2: Some Stems Blinking — only some of the stems' lights blink according to the sine curve, which is similar to mode 1. This mode has five parameters: offset, amplitude, frequency of blink, range and centre position of


Figure 7.2 Inaho Installation Set-up

the cluster of stems to illuminate. The offset, amplitude and frequency are the same as in mode 1. The range and centre position control these.

Mode 3: Sparkling Effect — stems illuminate momentarily one after another to create a sparkle effect. The position of each stem to be illuminated is chosen by a program at random. This mode has three parameters: speed of spark, range, and centre position of cluster of stems to illuminate. The speed of the spark controls how fast the light moves on to the next stem.

Mode 4: Musical Phrase Effect — by linking the Max/MSP with a music composition software (Logic Pro), the musical notes are 'played' with velocity and length as a visual lighting effect. The position of which stems to illuminate is also specified by the pitch of the notes.

Various effects could be achieved by mixing these four modes with changes in parameters such as offset, amplitude, frequency, position of light, timing of impulses, number of impulses, etc. For example, mixing modes 1 and 2 provides overlapping multiple pulses with accents, crescendo and decrescendo, and also a polyrhythmic effect by summing pulses with different frequencies. Mode 3 not only blinks but also spatially repositions the lights. Mode 4 can handle more complex musical expressions such as syncopation or polyrhythm by directly connecting the light and the musical notes. I also prepared a physical controller (Figure 7.3) to change the value of the parameters and the swaying movement (divided into levels 0 to 3).

In the interviews, I went through modes 1 to 4 one by one with each participant and discussed their impression of each one. Then I gave the physical controller to the participant and asked him or her to choose or mix his or her favourite settings. Once the participant was ready, we talked about the rationale behind his or her tuning. The intention of this part was to let the participant virtually design Inaho's light and movement and to observe and ask questions about his or her design, interrogating the kinds of processes they were using and their intentions in doing so.

Method — Interview Part 3

I had composed a song using the Logic Pro software and designed a sequence of lighting to accompany it. Inaho's swaying movement was also added with different amplitude. The sequence started with low, long notes and slow light oscillations; then, faster oscillations were gradually added as the song played. From the middle part, some melodious phrases and associated lighting effects appeared and the number of notes and volume of light increased. A sparkling effect resulted at the climax of the music, ending with a major chord with all the stems lit up, followed by a slow fade-out. A detailed explanation of this sequence is provided in Appendix K.

In this part of the interview, I gave headphones to the participant and showed the sequence with music described above. Then I asked how he or she felt about it. By this time, the participant had gone through parts 1 and 2 so had already developed some ideas about Inaho's light and movement. This part aimed to look into whether/how the music and the associated light and movement changed people's impression of the work.

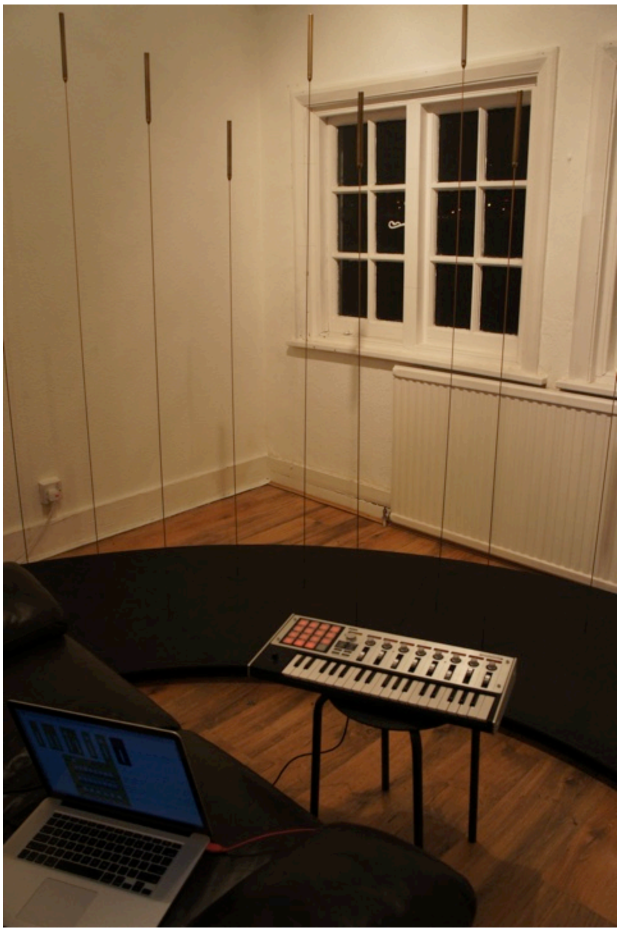


Figure 7.3 Inaho Installation and Physical Controller

7.3 INSIGHTS FROM THE INTERVIEWS

Each participant had a very different impression of the work. For example, one liked the calmness of it whereas another liked the moving light, which reminded her of a Halloween festival. One liked very subtle motion whereas another liked more aggressive motion. One wanted to look at the projections whereas another wanted to look at the physical objects. One was looking at the work as a whole whereas another was following one particular stem. One wanted a very slow blinking pattern with little brightness whereas another wanted a 'sparky' pattern that reminded him of explosions. One did not like the work accompanied by music whereas another loved it. As such, even with only six people, there was great variety of responses to the work. The full scripts of the interviews are available in Appendix K.

A more interesting insight, however, was that there were actually some similarities among the participants' reactions. These similarities were not so much in their preferences as in their choice of topics to talk about. Some of these topics concerned patterns and rhythm; some were not necessarily about rhythm but about the overall design concept. I grouped these topics as follows:

- Continuity and Change;
- Randomness and Unpredictability;
- Finding Order;
- Psychological Preferences;
- Link with Memory.

The fact that the participants talked about the work from more or less the same angles would suggest that these topics could be considered as particular points to be taken into account by designers. I accept that these findings are as yet based only on the interviews, and additional work will be needed to establish these as general guidelines for design — this could be an idea for future work after this PhD. Nonetheless, I have seen fit to include these insights in addition to the main chapters as an encouragement to my readers, particularly designers, to consider the value of investigating the wider area around pulse and rhythm. The rest of this section goes through the topics one by one, with supportive quotes from the participants. I limit the quotes to a few key comments here — more comments relevant to each topic can be found in the full script in Appendix K.

Continuity and Change

'Anything that is the same all the time is boring. (…) Because it is about how long you can get engaged with the object, and how you can discover it.' (Participant 1)

'I think I like something in the middle… something interesting still happening, but not very aggressive. So there is something to look for, but not too much. If it is static… I will get bored.' (Participant 2)

'It has to be very gentle. Because you know the moment just before the complete black, you see? That is good, that is beautiful. But if it goes off, it suddenly breaks. So the change along this level is gorgeous, it's beautiful.' (Participant 5)

Most participants talked about the value of change and appreciated it as key to avoid the work becoming boring. However, most of them also talked about continuity or consistency at the same time, and suggested the value of balancing these two. A rhythmic pattern already has changes in it in such that it oscillates, moves, and repeats. The designer could augment the quality of the experience by introducing gradual transitions to these changes. In part 2 of the interviews, some of the participants sought to establish such transitions by adding very slow oscillation to other modes such as the rather fast oscillation or the sparkling effect, adding gentle swaying motion to their choices of lighting modes, and using the modes involving randomness; in all cases, the resultant effect was formed on the basis of a vision of gradual change. This insight leads to the next point — unpredictability and randomness.

Randomness and Unpredictability

'When there were only the rhythmic movements and light, there was unpredictability. When it's synchronised with music, you removed the unpredictability. (…) And it is less interesting.' (Participant 1)

'I know it is not obviously completely random because there is some sort of basis or logic behind but at a certain level we do not pick it up.' (Participant 5)

'Yeah definitely randomness is needed. Randomness gives you… It keeps you interested about it, keeps you thinking about it.' (Participant 6)

Introducing a certain randomness would be one method to establish the change while keeping the continuity, as discussed above. Randomness makes the behaviour unpredictable, and keeps one interested and engaged in the process. I have mentioned the value of unpredictability in my works several times in the previous sections — in the behaviour of the bubble in Kihou and Kihou Foam, and the complex pulse interference of Inaho — relating it to the quality of transience. I have used the distinction drawn by Foerster between trivial and non-trivial machines to understand this value. In the case of pulse, especially a rather simple one such as that of Kihou, a little randomness could greatly affect an audience's impression of the work. We should note that such unpredictability does not require complete randomness, whether it is pulsing or non-pulsing. A certain level of order should be maintained to keep the work consistent.

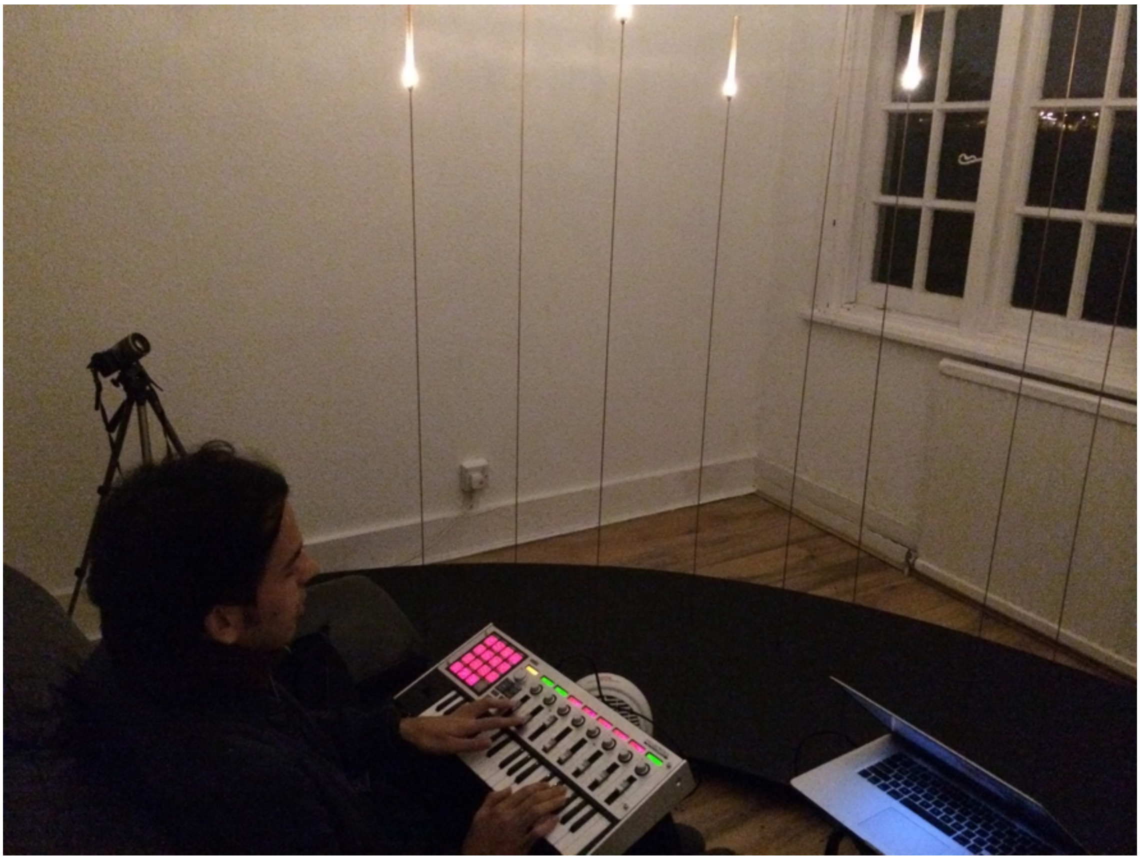


Figure 7.4 Participant Designing the Lighting and Motion Effect

Finding Order

‘Yes I like this very much. It has rhythm.’ (Participant 3)

‘I think I am trying to find things with similar movements… So, this (stem) and this (stem) are like moving similarly or even in sync but I am maybe trying to ignore others — or not really paying attention to them.’ (Participant 4)

‘Perhaps we have the perception we’re trying to understand the composition fully, or situation or environment. So my eyes are constantly moving around to try to understand this… the flow of it.’ (Participant 5)

‘I think I am trying to simplify this to have a sort of pattern in it.’ (Participant 6)

People found order, which they called rhythm or pattern, or tried to find it; finding such order seemed to help their understanding or interpretation of what they were perceiving. I have discussed this in the previous chapter on rhythm; the discussion is expanded here to include non-pulsing motions too. Musical psychologists, for example Gjerdingen (1989), Pressing (2002), and London (2004), have studied this process in the case of music in detail. According to them, as people hear a sound sequence, they seek information in the sequence ('attend to the sequence' is the articulation often used in the field), find similarities or a 'pattern' in the strength, timing, or pitch of the notes, 'anticipate' the next events using this pattern, and 'synchronise' this formed pattern in their mind to further sound inputs. This process, particularly the part of synchronisation, is also called 'entrainment'. What the participants did in my interviews with visual information could be understood using the same principle.

Psychological Preferences

'It is interesting because maybe people have internal rhythm… Some people like slow, very slow… This is a bit too slow for me… I want it to be a bit faster.' (Participant 1)

'And now they are moving around, and the shapes are very defined, so my eyes are moving very fast to try to catch them… That's not calming. It's interesting, beautiful — but it's not calming.' (Participant 2)

'I think my eyes are looking at these moving things but… It is a bit fast for me. Too fast to follow with my eyes. (…) But if it is as gentle as before, then it is comfortable.' (Participant 4)

On top of the process of finding order or enjoying unpredictability, psychological, particularly perceptional preferences seemed to affect the

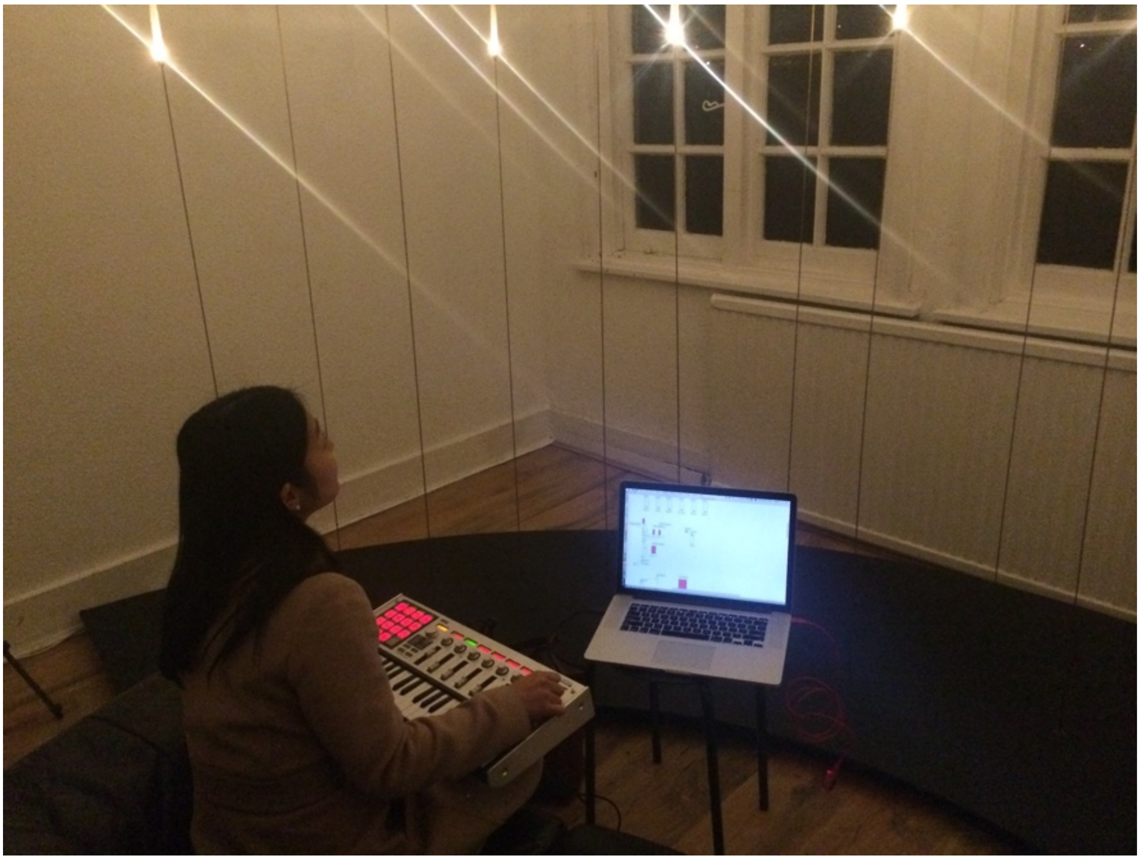


Figure 7.5 Participant Designing the Lighting and Motion Effect

participants' experience. When the pattern was difficult to perceive, for example when it was too fast, they tended to feel uncomfortable. On the contrary, when the pattern was easy to perceive or naturally harmonised with their preference, they tended to feel more comfortable. This seemed to be related to psychological theories on 'spontaneous tempo' and 'preferred tempo'. Spontaneous tempo is usually measured by the natural speed of finger tapping. Researchers have revealed that the length between two taps varies between individuals, but the variability in each individual is small, within 3 to 5% (Fraisse et al. 1949, as cited by Fraisse 1982). This means that the value of the spontaneous tempo is characteristic of the individual. The similar yet subtly different concept 'preferred tempo' is the tempo judged by the individual as 'neither too slow nor too fast'. This preferred tempo is usually measured using a metronome and studies have suggested it is about 500 msec intervals on average (Wallin 1911; Mishima 1956). This might be used as one standard in designing. Interestingly, the tempos of the heartbeat and of walking have been found to be of the same order of magnitude as the spontaneous and preferred tempo (intervals of from 500 to 700 msec) (Fraisse 1982).

Link with Memory

'Because it evokes memories of childhood… Well, depending on where you have grown up, but in my case, my grandparents' place; they had a lake nearby and I spent my childhood running around it, so, these experiences like summer camps and nice calm summer days where you have no stress, no problems, everything is very nice… Just enjoying this ambience.' (Participant 1)

'You know diamond has very small cuts and light can escape in certain ways… So if I look at this shadow, the shape reminded me of it. (…) It may have to be with my life perhaps. Because my mother used to work on diamonds…' (Participant 2)

'I think this moving light reminds me of animals or ghosts, but in a happy way, so, kind of a Halloween feeling for me.' (Participant 3)

'I like the parts of it that are… I don't know but relating things to life and… have nice memories… Things like of the nostalgic part. (...) In a foreign country, in the evening, and you saw that sort of calm, it's kind of still… Or in the morning as well… But it's just, you know, when it's not blown heavily and everything is going to be dark but still a bit of bright like the lights of a town or something…' (Participant 6)

All the participants talked about scenes from their own memory to describe the work and the patterns they found. It was interesting that for some of them the work evoked a really concrete, particular experience they had had with their friends or family. This provides even more convincing evidence that pulse and non-pulsing yet rhythmic motions can communicate emotional contents as an element of design.

CHAPTER 8

CONCLUSION

8.1 THE RESEARCH JOURNEY

Upon starting my exploration, I asked the following research question: How can I develop the value of pulse further as an element of design, with the qualities of suggestion, emptiness, and transience? I proposed the model of pulse composed of the object layer, the motion layer, the content layer and the guides to it, and assumed that stronger content would expand the value of the pulse as an element of design. Eight projects — Kihou, Kihou Foam, Tupperware, Plural Kihou, Sync Cells, Sync Clock, iPhone Orchestra, and Inaho — were carried out as well as some early experiments to explore the concrete ideas and methods that could enable stronger content in pulse, maintaining greater qualities of suggestion, emptiness, and transience. In this process, several theoretical and practical works of different kinds were curated and related to my projects in order to form a rich inspirational background, allowing the outcomes of the projects to be understood in more depth, providing support for my arguments. I have already summarised the lessons drawn from each project in the tables at the end of each section in Chapter 5; these tables show the variations of the models, including that of pulse synchronisation and pulse interference, the concrete methods I used to try to strengthen the content such as the metaphor of life, the results of these methods, and how these methods contributed to maintaining the qualities of Japanese aesthetics in the design. Following this exploration into pulse, I expanded the scope of my research into discussions on rhythm. I used psychological and philosophical notions to distinguish rhythm from pulse, and reflected on my works from this perspective. My discussion of rhythm in non-pulsing motions was presented based on an interview-based study using Inaho, where I drew further insights for future design practice.

My research progressed over the sequence of projects, rather than within each individual project. In the rest of this section I would like to look back at this sequence, or the research 'journey' as a whole, summarising how I moved from one point to another, reshaping my research interest.

The point of departure was Yuen, where I was interested in the interaction between people and object. What I meant by 'interaction' at this point was exchanges of physical input and output: the object sensed a human's actions and changed its behaviour accordingly, expecting people also to change their actions in response. However, it became a turning point when I realised people were impressed not so much by these 'interactive' exchanges of input and output but by the work's nature-analogous motion. Just as nature can move our hearts without engaging in a physical exchange with us, a projection from a design work could speak to people and affect them emotionally. This effect may sound obvious to many designers, but it was not to me. I had already devoted some time to researching Human-Computer Interaction, where the physical exchange between a computer and its user was the focus.

From the following series of experiments, which looked into several kinds of motion that might potentially move people like Yuen did, I developed a particular research interest in repetitive motion — 'pulse'. The Kihou and Kihou Foam projects featured pulse in their bubble motion, which felt somehow organic thanks to the unpredictable behaviour of liquid and gas. In the Tupperware project, pulse was the key to the metaphor of life in two layers — in the breathing-like bubbling motion and in the process in which the motion got weaker and weaker as if life were approaching its end. A notable change in this movement from Yuen to Tupperware through two Kihous was that the relationship between the object and the viewer became more intangible, relying more on the viewer's imagination. The communication between people and the Kihou and Kihou Foam works was not physical but emotional, and required people to use their imagination in order to participate in the communication (i.e., to understand the communication in the role of receiver of the work's projection). That of Yuen, on the other hand, featured — or was initially intended to feature — much more obvious exchanges of physical actions.

Tupperware demanded even more imagination from viewers in order to understand its metaphor of life in two layers. The object itself was as simple as a plastic box with pulsing air bubbles in the water; nothing changed in response to a human's presence. However, there was a certain room for people to imagine a story of life behind it.

Similar change in my exploration into pulse synchronisation also occurred in the progression through the projects Plural Kihou, Sync Cells, Sync Clock and iPhone Orchestra. In the Plural Kihou and Sync Cells projects, the pulse synchronisation was only seen in the physical motion of the work. As described in Chapter 5, the works were not beyond a visualisation of mathematical equation and did not have much of an intangible quality. The Sync Clock and iPhone Orchestra projects, however, were intended to have narratives behind the physical synchronisation and to invite people to participate in these using their imagination. The narratives were that each independent module 'wanted' to synchronise in order to achieve its mission — telling the time in the case of Sync Clock and composing music with iPhone Orchestra. Without the viewer's imagination, these works would have ended up in the same form as the former two projects, namely as a visualised mathematical mechanism. Some hints of a metaphor of life, such as the swimming-like animation or the delicate 'verbal' communication using the mic and speaker of the iPhone, which I called 'guide to the content', induced people to go beyond that.

The final project, Inaho, also invited people to imagine nature, particularly through the rhythmic interference of the shadow projection. Moreover, the expansion of the scope of my research from pulse to rhythm through this work brought an interesting discussion with interviewees. In studying their thinking processes behind their choice of rhythmic patterns, I came to see how widely their imaginations could vary, while still throwing particular common points to consider (listed in Chapter 7). For example, different interviewees imagined shining diamonds, fireworks, a Halloween party, or fireballs, all based on the same pattern. It was very interesting to learn about these differences and commonalities in the interviewees' interpretations of my work.

My research interest was shifting from obvious, tangible and physical communication to vague, intangible and emotional communication. A regular repetitive motion is a very simple kind of motion; compared to other complex composed motions, such as dancing, the number of parameters is limited and the expressions it physically provides are therefore also limited. Such motion can be fast or slow, sharp or soft, but the range of such expressions is rather small in itself. However, once a certain image was evoked in the viewer's mind, and he or she began to see the motion through this lens, the motion immediately became able to communicate more than what it physically was. It was able to become a powerful metaphor or tell a narrative. 'Pulse is more eloquent than you might think.' This was the ultimate lesson I learned from my studies, and the main one I want to pass on to the readers of this thesis.

To conclude, and to complete my answer to the research question, I want to extract generalised knowledge from the insights I have gained during this research journey. Below I provide it in the form of some recommendations for readers, particularly designers, who might want to work on this area around pulse and rhythm.

1) Variations of the content — A metaphor of breathing or heartbeat can certainly represent a content of pulse. However, it is deplorable that the scope designers currently seem to be considering when featuring pulse in design is limited to this small area. If one looks at the world, especially the natural world, to seek pulse synchronisation, pulse interference or single pulse, one will find a good variety of inspiring phenomena, from synchronising fireflies to paddy fields blown by wind. If one further considers the process over a certain period in which the pulse's properties change, further inspiring phenomena will be encountered. All of these can be included as the content of pulse in design.

2) Conviction in content — Oscillating an LED gently at a speed analogous to human breathing may suggest the metaphor of breathing in the pulse. However, there are ways to make the content more convincing. If the content deals with things inspired by nature, introducing unpredictability in the behaviour of the pulse can be one method to heighten its natural quality. If the content involves a metaphor of communication — for example synchronisation — seen in nature, one key to success could lie in letting the pulses communicate based on the local rule rather than controlling them with the central rule, thus allowing the communication to emerge and develop naturally. Such methods may not change the visual output of the work very radically, but definitely change the impression the design makes on people.

3) Suggestive guide to content — One of the things I wanted to demonstrate in particular through my projects was the power of pulse in suggesting content – this is what I meant by writing above that pulse is 'eloquent'. For example, even if one of my works did not give any graphical or sculptural indications of life, the pulse was enough to suggest a metaphor of life; I stressed this point many times in the reflective description of each project in Chapter 5. The simplicity of pulse allows it to be interpreted from multiple perspectives, rather than forcing one particular image onto the viewer; the viewer's imagination is given freer reign. Such simplicity can be an advantage in design when such suggestive communication is appropriate, and this can be one reason for a designer to choose a repetitive motion as an element of his or her design. Therefore, my recommendation is to believe in this power of pulse. Practically speaking, minimalistic approaches to design can help designers omit surplus elements and concentrate on the essential parts. Hiding technical complexity behind the visible phenomenon is also useful if a design involves mechanical or electrical motion controls.

4) Emptiness and transience — This notion has some overlap with the points argued above. Although choosing to draw the design criteria from Japanese aesthetics was my personal decision, and may not be something to be

recommended generally to all cases, I now believe these criteria were especially appropriate for pulse. One reason for this is that pulse worked very well in suggesting content, as discussed in point 3; this is relevant not only to the Japanese quality of suggestion but also to that of emptiness. Achieving emptiness often requires a minimalistic approach, so concentrating on the design of pulse as recommended in point 3 is likely to achieve a certain emptiness. In addition, if one observes my recommendation of including unpredictability or gradual change over time in the pulse, as mentioned in points 1 and 2, then the quality of transience will also be achieved. In short, pursuing the qualities of emptiness and transience as well as suggestion will often result in strengthening the value of pulse as an element of design. The criteria of Japanese aesthetics are just one general option, but could be particularly useful to frame a strategy for design with pulse.

5) Think about people's experience — The four points above relate to how the pulse is 'made'. The counterpart to this in design is how that pulse is 'taken', i.e., people's experience of the pulse. This leads us to the discussion of rhythm. As studied in Chapters 6 and 7, psychological processes affect one's perception, 'taking' the pulse and 'making' rhythm. Therefore, it is valuable to consider mental processes and phenomena such as subject rhythmisation, spontaneous tempo, and preferred tempo, and to reflect these in design, for example by tuning the timing of the pulse or changing the arrangement of the pulses.

8.2 ARISING QUESTIONS

As I gained greater understanding about the themes of pulse and rhythm, and the research structure became clearer, some new questions arose that I had not asked at the beginning. These questions are left unanswered in this thesis but I believe they have some potential to be raised as new research questions in future study that expands this work.

With regard to variations in the content, I took inspiration from life and nature, but what could be a source of inspiration in the artificial world? It would have to be something that involves a repetitive motion as one of its essential attributes, and which would impress people when represented in design. One possible idea would be to find something associated with a particular cultural background. Shishi-odoshi, which is a Japanese traditional water fountain made of bamboo, could be a good example. A bamboo tube with a lid on one end is pivoted in the middle and the water is poured into the tube from the other end. Once the amount of water in the tube reaches a certain level, the balance changes and the tube tips until the heavier end rests against a rock placed underneath, giving the characteristic sound of bamboo hitting rock. As the open end of the tube is down in this position the water flows out, the balance returns to the initial state and the tube tips back to the original position. This process is repeated again and again, and people hear the regular repeating sound of the bamboo hitting the rock. For most Japanese people, this particular pulsing sound instantly reminds them of this very traditional cultural object.

As for conviction in content, what could be some methods to strengthen the content, other than those tested in my projects? These included using natural material (e.g., liquid and gas) to introduce unpredictability in the pulsing motion, or using the local rule rather than the central rule for synchronisation. Considering that there was a clear tendency found in my interview (Chapter 7) for people to associate what they saw with their personal memories, it could be one interesting idea to place more focus on this connection with memory. For example, how strong an impression can be made by a simple pulse if the design is highly personalised so that a particular memory is evoked? How differently can a simple pulse be taken if it is shown to people who associate completely different memories to it? These would be interesting questions to ask.

I have written above that my research interest shifted from tangible and physical exchanges in communication to intangible and emotional projection. But another question would be, can my works be expanded/strengthened if tangible interactions are added to them? If yes, how? For example, one potential idea I came up with during the Kihou project was to synchronise the tempo of the bubbles to that of the viewer's breathing, which could be detected using a sensor or a thermo-camera. In my experience, this work certainly had a meditative effect and made people feel relaxed, making their breathing slower; it would therefore be interesting if the work could engage this connection between the pulse of bubbles and human breathing in a two-way communication. This idea would feature a very subtle effect but the change from one-way projection to two-way interaction would mean a lot. Another idea would be to have the Tupperware project somehow engage with a human's actions — for example, the battery could be solar-powered and people could charge it by spotting light onto it, like 'feeding'. This would also mean a subtle but radical change from a one-way mode of communication to a two-way mode.

I have to admit that this research also had limitations. Firstly, by choosing to do many projects and learn from the sequence of them instead of going deeper into a smaller number of projects, I ensured a variety of insights, but at the same time might have lost some potential knowledge. However, I believe this was a matter of choice regarding my style of research, and has not affected my achievements in my chosen research context. Secondly, I did not carry out many 'user tests' involving third persons in order to obtain more objective evaluations. Evaluations or reflections were mostly my own and choosing this style might have limited the knowledge delivered. The exception was the interview where I looked into humans' perception and interpretation of rhythmic patterns. All the work before this study was dedicated to the quality of each work, particularly the width and depth of the content of pulse, and I wanted to evaluate this quality in self-reflections using the Japanese aesthetics as the criteria. In this interview study, however, I was more interested in the human side, expanding the scope of my target from pulse to rhythm. This was beyond what I could do in self-reflections and the result of the interview actually gave me interesting insights. I could lean what was common between people's reactions, which successfully suggested some key topics which one could consider in design. I also learned what was different, which revealed how variously the rhythmic patterns could be interpreted. The success of this interview was different from the success of other earlier works in that it helped me to understand people whereas other works helped me to understand the topic of pulse in itself.

8.3 PERSONAL PROSPECTS

When I started my PhD study, it was as if I were walking into the bush without a map or a compass, not knowing where I was, which way to head, or how to forge my path. Now at the end of this long journey, I feel as if I am standing at the summit of a (small) hill, which I had not seen from the bush where I began. In climbing up this hill, I have gained many things which I did not have — the designer's way of thinking, the attitude of learning through trials and errors, the critical view for reflections, the ability of storytelling, the methodology to research weaving theory and practice, and the confidence to propose the future, as well as a deep understanding of the theme — pulse and rhythm. Learning to expand my skills from those of an engineer to those of a designer and researcher was another aspect of my PhD.

What is the next step? On top of the new questions described above, which possibly extend this research further in the same direction, there are also some major new directions that would still be relevant. Firstly, much slower pulse and rhythm, with hourly, daily, monthly or annual cycles is interesting, and different from what I have explored in this study. It is by far beyond humans' capability of perception to perceive such slow pulses as a regular repetition, but we can still recognise that the repetition is happening. To look into this phenomenon, one would need to explore studies of cognition and psychology, particularly in relation to people's relationship with their environment. It is an exciting topic that could potentially yield new value for design. Secondly, it would also be interesting to scientifically investigate the effect of pulse in design. Some studies have already looked into this, for example in relation to the psychological effect of rocking referred to in Chapter 2, but I believe there is still much to do around this topic for a designer through his or her practice. Thirdly, research on the relationship between people's cultural background and their impression of pulse and rhythm would be valuable. I feel there is a potential correlation between people's cultural background and how they understand and interpret pulse and rhythm in design works — as I have remarked, I felt Japanese aesthetics provided particularly useful criteria for these concepts. Lastly, what I am keen to do in the nearest future is to keep working on projects featuring pulse and rhythm in industrial activity. In other words, I will be seeking to expand the concept on a commercial level to create products or interiors that can actually be distributed on the market. By being included in economic and industrial activities, pulse and rhythm will be able to become more established as elements of design. Some of my works have been already well accepted in this context too, as mentioned above. I am sure it is possible to bring the concepts I argue for in this research onto the market where they can make a more radical and direct impact on design industries.

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APPENDIX

INDEX

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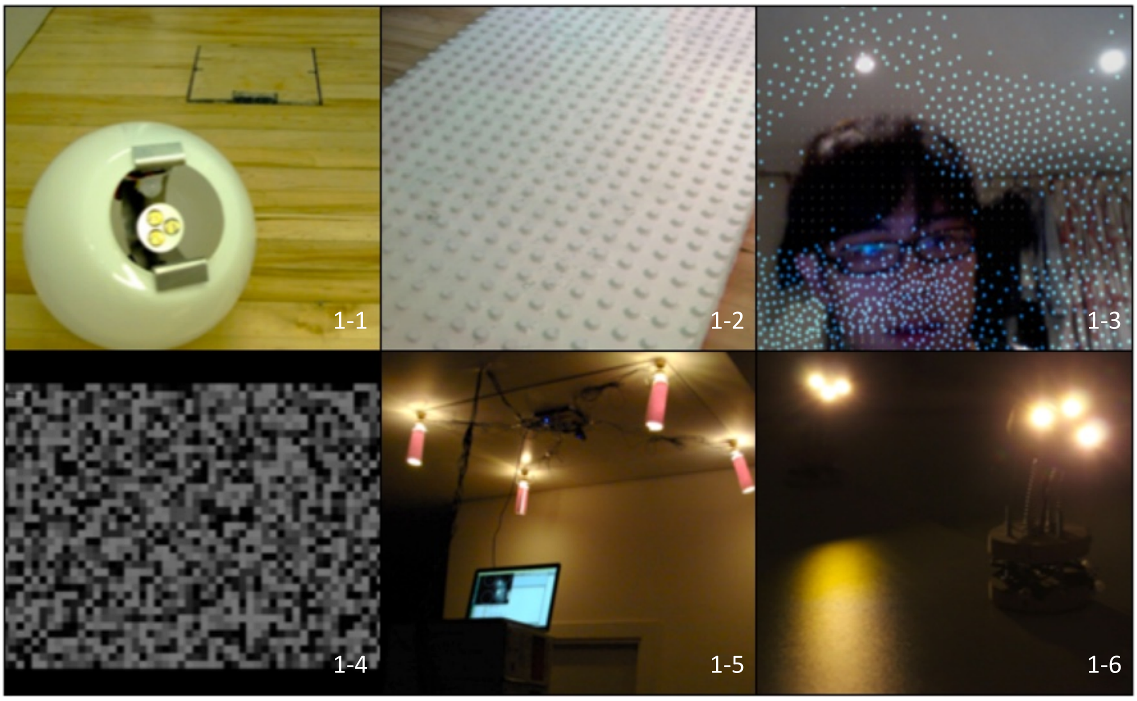
Appendix L : EXHIBITION, AWARD, MEDIA COVERAGE

APPENDIX A

LIST OF EARLY EXPERIMENTS

EXPERIMENT SERIES 1



1-1) A glass sphere equipped with light, servo motor, and human detection sensor, which rolled when people came by.

1-2) A 0.7 m x 1.2 m wood floor board with many projections painted with super-water-repellent paint so that the water behave unexpectedly when people walk on it.

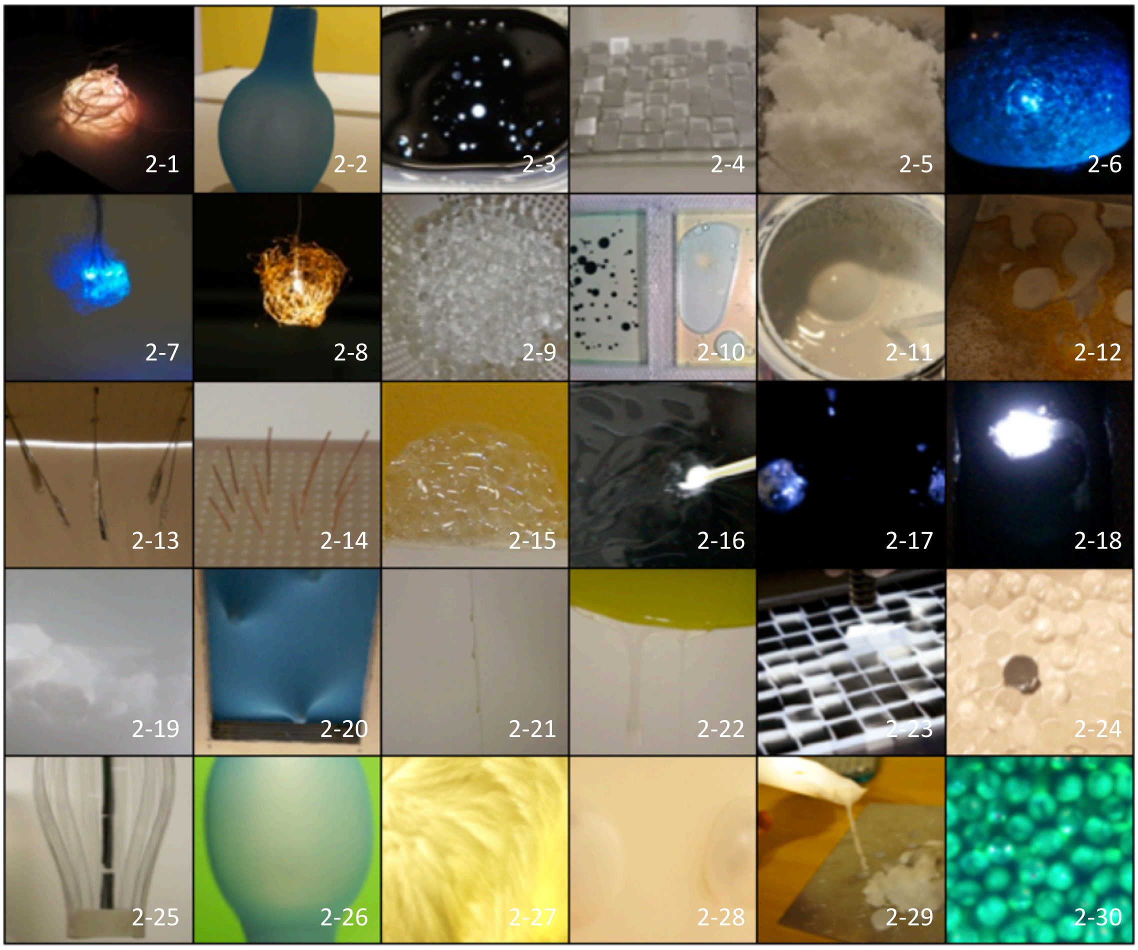
1-3) A computer program with a number of moving tiny dots emulating flocking birds responding to camera image.

1-4) A black-and-white geometrical animation, which change its visual pattern corresponding to the sound level in the environment and camera image.

1-5) Four spot-lights which move to light up the darkest point in the field detected by the camera set in the middle.

1-6) The floor-light version of the (1-5) with light sensors instead of the camera.

EXPERIMENT SERIES 2



2-1) A blinking LED in a structure made of paper and strings.

2-2) Elastic fabric covering a rubber balloon which is inflating and deflating.

2-3) Oil drops floating on the thin layer of black-coloured water, through which the light is visible.

2-4) Small scale-like metal parts hinged to a board and a magnet which moves those parts.

2-5) Looking into the motion of condensed salt when stirred.

2-6) An LED whose light is reflected in the foam of soap.

2-7) A blinking LED version of the (2-6).

2-8) A blinking LED whose light is reflected in the copper wire nest.

2-9) Looking into the motion of jelly beads.

2-10) Looking into the motion of oil coloured oil drops floating on water.

2-11) Blowing air bubble in thick paint.

2-12) Looking into the progress of rusting of a metal plate.

2-13) Metal sticks moving with magnetic force.

2-14) Copper wires standing through holes being moved from the beneath.

2-15) Looking into the motion of foam of soap growing.

2-16) Blowing air onto the surface of the mixture of oil and water so that the layer of oil is blown and clear water is visible behind it.

2-17) Looking at the (2-3) from the bottom.

2-18) Looking at the (2-16) from the bottom.

2-19) Looking into the motion of salt precipitated out in the water and stirred.

2-20) Elastic fabric covering moving wood projections.

2-21) Honey going down along a thin string, making drips.

2-22) Looking into the motion of honey flowing out from a container.

2-23) Placing the (2-4) on a light source.

2-24) A magnet forging the path in the jelly beads.

2-25) A plastic structure shrinking and expanding.

2-26) A balloon moving up and down inside a tube of elastic fabric.

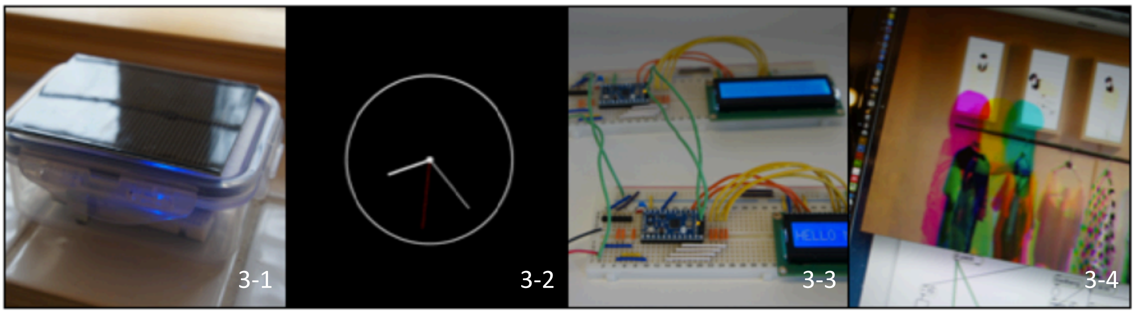
2-27) Looking into the motion of feather fabric affected by the static electricity.

2-28) Balloons inflating from a small holes.

2-29) Looking into the behaviour of heated wax coagulating on a cold plate.

2-30) Placing the (2-24) on a light source.

EXPERIMENT SERIES 3



3-1) A Tupperware box equipped with a solar-powered battery and a solenoid making pulsing sound and vibrating only when it is bright.

3-2) The simple clock on an iPhone app losing its time when a strong physical shock is given.

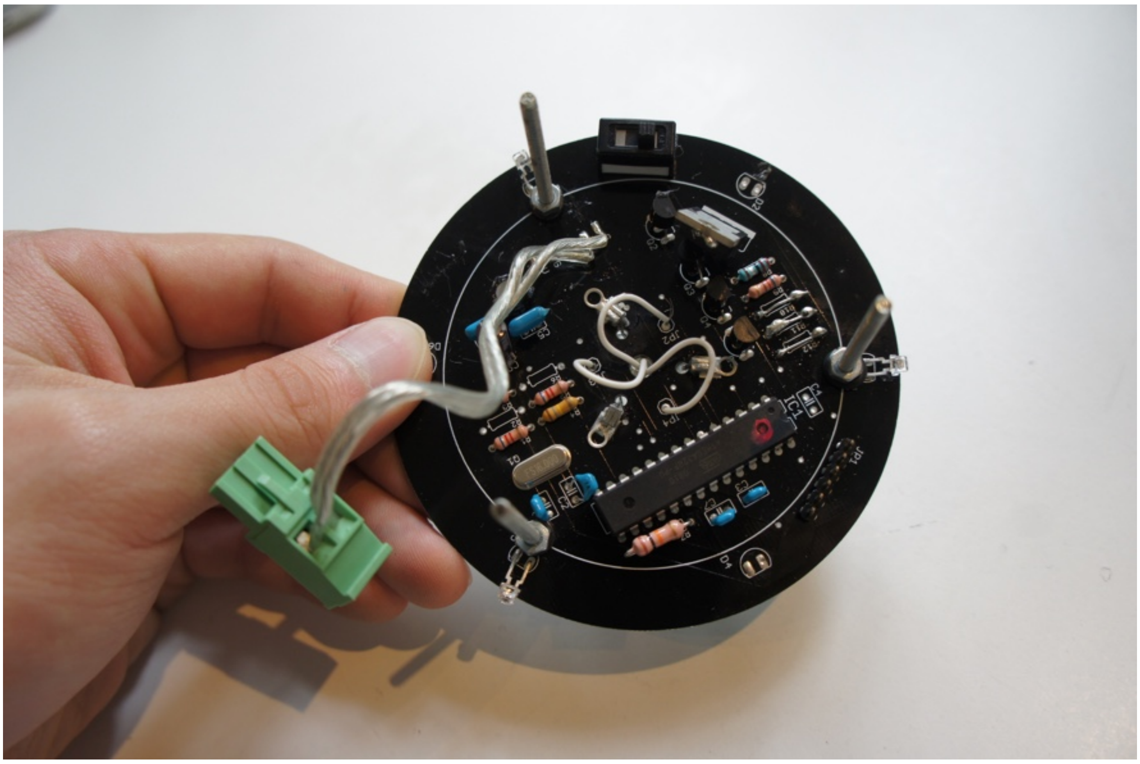
3-3) Two microcontrollers equipped with LCDs communicating information, which breaks and being lost gradually.

3-4) A video player whose internal error being visible as the damage of RGB planes of the video.

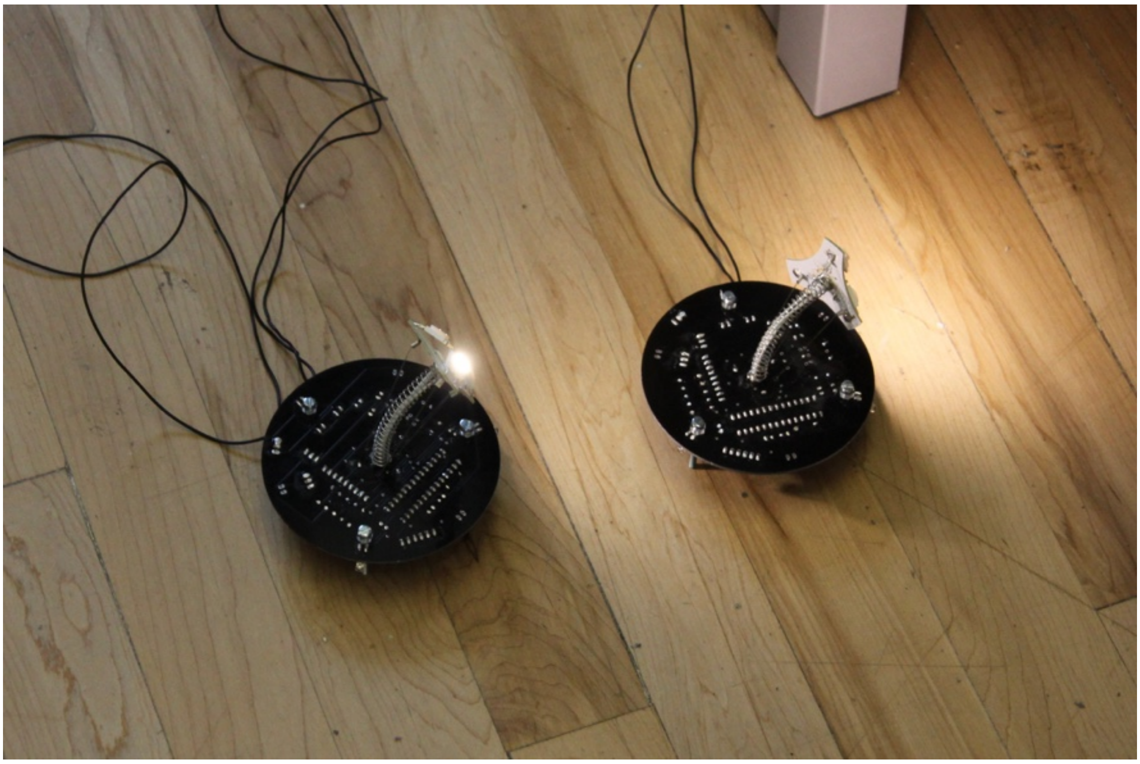
APPENDIX B

YUEN

PROJECT IMAGES



(Top) Custom-made circuit board, also working as the body of the lamp.
(Bottom) An assembled Yuen lamp.

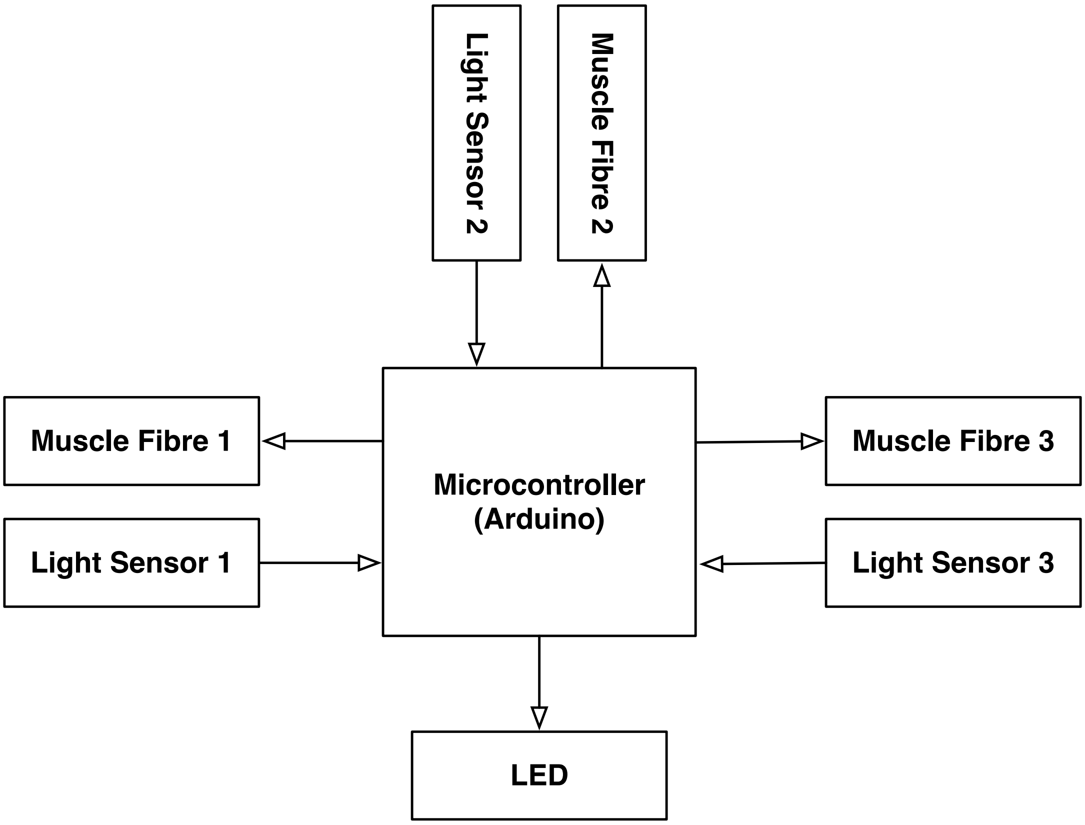


(Top) Uploading the computer program to the Yuen board.
(Bottom) Testing the shadow-following function with two pieces of Yuen.

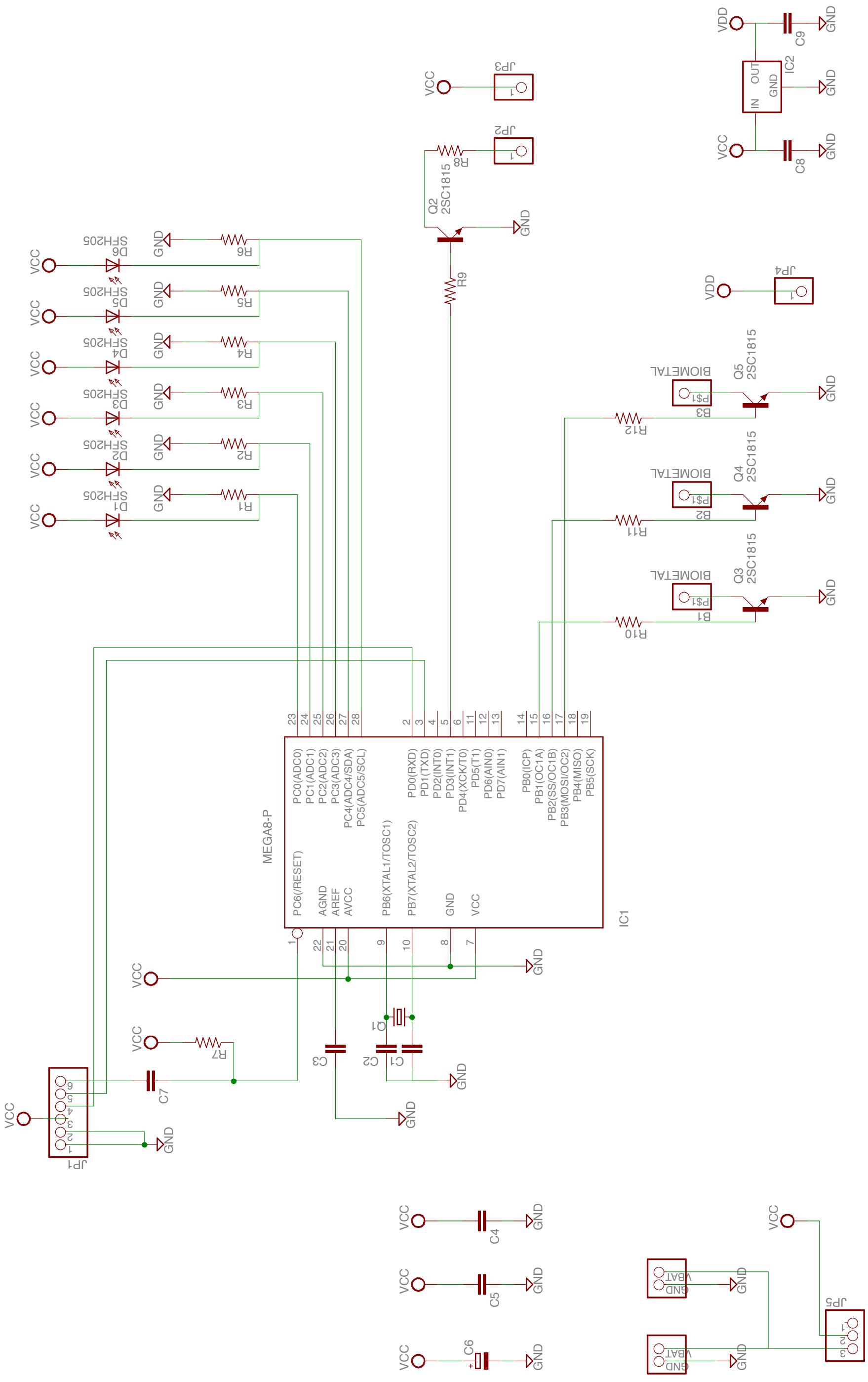
(Top) Setting up a test installation.
(Bottom) Testing the functions in the installation.

(Top&Bottom) A test installation in the college's storage space.

SYSTEM BLOCK DIAGRAM



CIRCUIT BOARD SCHEMATICS



PROGRAM CODE

```
/**************************************************/
// Project : YUEN
// Language : Arduino
// Program By : Hideki Yoshimoto
/**************************************************/

// TUNING PART //
float bigLimit = 30.0;
int maxLED = 110;
int smallLED = 20;
unsigned long smallDelay = 0L;
unsigned long bigDelay = 1000L;
int smallSpeed = 65;
int bigSpeed = 80;

int i;
int counter;
int counterLimit = 1000;

float sensor1;
float sensor2;
float sensor3;
float oldSensor1;
float oldSensor2;
float oldSensor3;
float diff1;
float diff2;
float diff3;
float maxSensor;
float minSensor;
float middleSensor;

unsigned long delayTime;
boolean changed = false;
int wireSpeed;
int ledValue;
int statusFlg;
int statusFlgOld;
int quietCount;



/**************************************************/
void setup(){
    pinMode(9, OUTPUT);
    pinMode(10, OUTPUT);
    pinMode(11, OUTPUT);
    pinMode(3, OUTPUT);

    sensor1 = 0.0;
    sensor2 = 0.0;
    sensor3 = 0.0;
    oldSensor1 = 0.0;
    oldSensor2 = 0.0;
    oldSensor3 = 0.0;
    statusFlg = 0;
    statusFlgOld = 0;
    counter = 0;
    quietCount = 0;

    wireSpeed = bigSpeed;
    delayTime = bigDelay;

    ledValue = maxLED;
```

```
    analogWrite(3,ledValue);

    Serial.begin(9600);
}

/***************************************************/
void loop(){

    sensor1 += analogRead(0);
    sensor2 += analogRead(2);
    sensor3 += analogRead(4);

    if(counter == counterLimit){

        sensor1 /= float(counterLimit);
        sensor2 /= float(counterLimit);
        sensor3 /= float(counterLimit);
        maxSensor = max(max(sensor1, sensor2), sensor3);
        minSensor = min(min(sensor1, sensor2), sensor3);
        middleSensor = sensor1 + sensor2 + sensor3 - maxSensor - minSensor;

        statusUpdateFromSensor();
        if(changed){
            quietCount = 0;
            lightOn();
            analogWrite(9,0);
            analogWrite(10,0);
            analogWrite(11,0);
            delay(600);
            move();
        }
        else{
            quietCount++;
        }

        if(quietCount > 50){
            lightOff();
        }


        if((quietCount > 50)&&(quietCount % 15 == 0)){
            randomWalk();
        }

        statusFlgOld = statusFlg;
        counter = 0;
    }

    counter++;

}

/***************************************************/
void statusUpdateFromSensor(){

    if(middleSensor > (maxSensor + minSensor)/2){
        if(minSensor == sensor1){
            statusFlg = 1;
        }
        else if(minSensor == sensor2){
            statusFlg = 2;
        }
        else if(minSensor == sensor3){
            statusFlg = 3;
        }
    }
    else{
        if(maxSensor == sensor1){
```

```
            statusFlg = 4;
        }
        else if(maxSensor == sensor2){
            statusFlg = 5;
        }
        else if(maxSensor == sensor3){
            statusFlg = 6;
        }
    }

    if(statusFlg != statusFlgOld){
        changed = true;
    }
    else{
        changed = false;
    }

}

/**************************************************/
void randomWalk(){

    int randomStatus = 1 + random(6);

    analogWrite(9,0);
    analogWrite(10,0);
    analogWrite(11,0);
    delay(300);

    wireSpeed = smallSpeed;

    if(randomStatus == 1){
        analogWrite(9,wireSpeed);
        analogWrite(10,0);
        analogWrite(11,0);
    }
    if(randomStatus == 2){
        analogWrite(9,0);
        analogWrite(10,wireSpeed);
        analogWrite(11,0);
    }
    if(randomStatus == 3){
        analogWrite(9,0);
        analogWrite(10,0);
        analogWrite(11,wireSpeed);
    }
    if(randomStatus == 4){
        analogWrite(9,0);
        analogWrite(10,wireSpeed);
        analogWrite(11,wireSpeed);
    }
    if(randomStatus == 5){
        analogWrite(9,wireSpeed);
        analogWrite(10,0);
        analogWrite(11,wireSpeed);
    }
    if(randomStatus == 6){
        analogWrite(9,wireSpeed);
        analogWrite(10,wireSpeed);
        analogWrite(11,0);
    }

    delay(delayTime);
}

/**************************************************/
void move(){
```

```
    wireSpeed = bigSpeed;

    if(statusFlg == 1){
        analogWrite(9,wireSpeed);
        analogWrite(10,0);
        analogWrite(11,0);
    }
    if(statusFlg == 2){
        analogWrite(9,0);
        analogWrite(10,wireSpeed);
        analogWrite(11,0);
    }
    if(statusFlg == 3){
        analogWrite(9,0);
        analogWrite(10,0);
        analogWrite(11,wireSpeed);
    }
    if(statusFlg == 4){
        analogWrite(9,0);
        analogWrite(10,wireSpeed);
        analogWrite(11,wireSpeed);
    }
    if(statusFlg == 5){
        analogWrite(9,wireSpeed);
        analogWrite(10,0);
        analogWrite(11,wireSpeed);
    }
    if(statusFlg == 6){
        analogWrite(9,wireSpeed);
        analogWrite(10,wireSpeed);
        analogWrite(11,0);
    }

    delay(delayTime);
}


/***************************************************/
void lightOn(){

    if(ledValue < maxLED){
        int iteration = maxLED - ledValue;
        for(i=0;i<iteration;i++){
            ledValue += 1;
            analogWrite(3,ledValue);
            delay(10);
        }
        ledValue = maxLED;
    }
}


/***************************************************/
void lightOff(){

    if(ledValue == maxLED){
        for(i=0;i<(maxLED - smallLED);i++){
            ledValue -= 1;
            analogWrite(3,ledValue);
            delay(80);
        }
    }
}
```

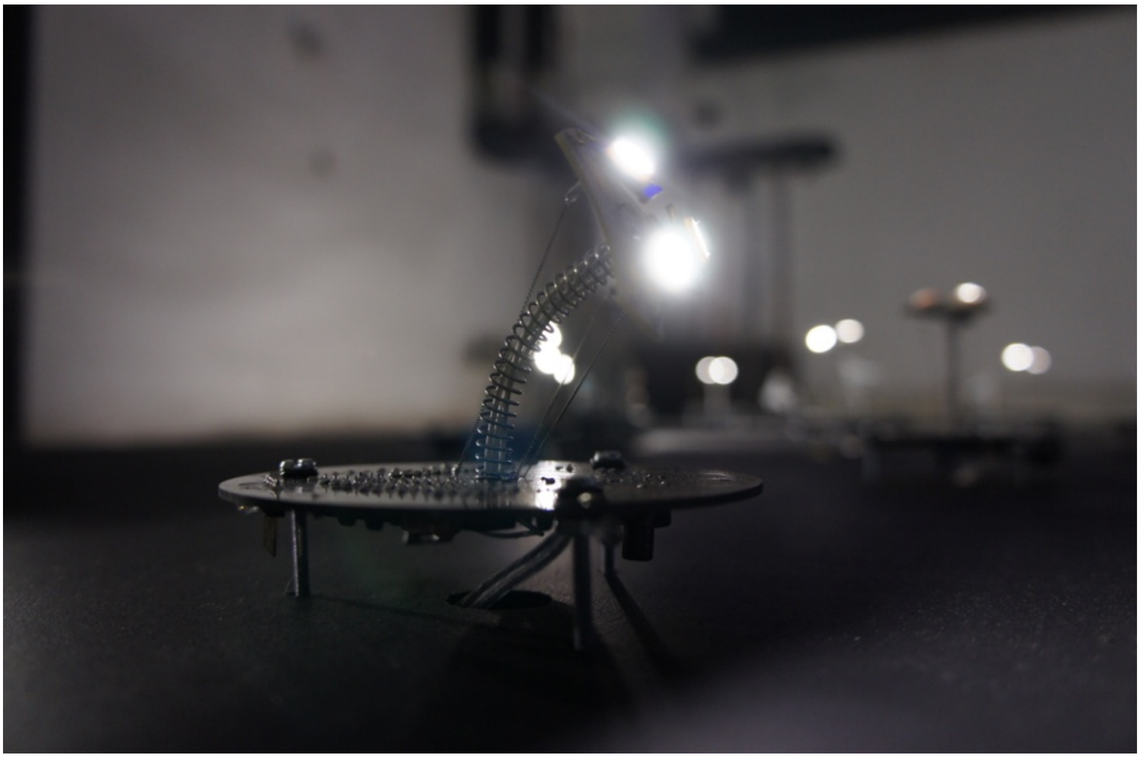
EXPERIMENTAL INSTALLATIONS

(Top) Installation in the college's meeting room on the desk.
(Bottom) Installation in the college's entrance.

(Top&Bottom) Installation in the college's hallway.

(Top) Installation in Hyde Park.
(Bottom) Installation in the college's hallway.

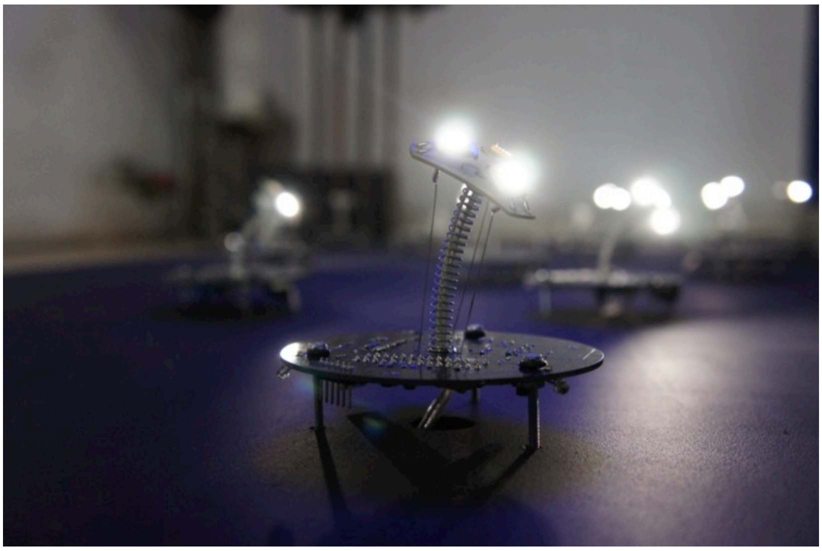
INSTALLATION AT THE MILAN DESIGN FAIR 2012



(Top&Bottom) Flower-bed like setting in the Milan exhibition.

Flower-bed like setting in the Milan exhibition.

REDDOT DESIGN CONCEPT AWARD - APPLICATION



yuen (由緣 - acquaintance, relation, affinity, reason)

1/5

CHALLENGE - Interactive relationship that develops between people and environment

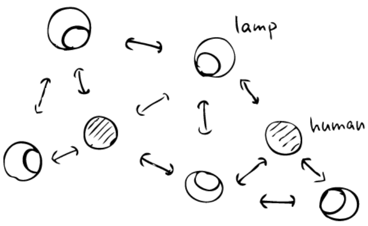
The progress and spread of information technology in the last few decades has had a tremendous impact on our lives by making the built environment more active. The environment can now talk to us and communicate real-time information. With this in mind one of the most popular keywords today must be “interactive”. Two-way real-time communication will make people’s experience in the environment richer than ever.

However, looking over the practices of this “interaction” between people and environment, I cannot help but have some doubts. Most of these practices are a process guided by a wholly prepared scenario of input and output like “touch here and then it happens”. This is far from true interaction where a narrative communication grows through reciprocal exchange. They are actually reactive rather than interactive. The confused usage of these two may inhibit the ability of the latest technology to flower in the contemporary built environment and provide novel delightful experiences to people. The new stage of “interactive”, which is not “so-called interactive” but “truly interactive”, is expected to be opened up.

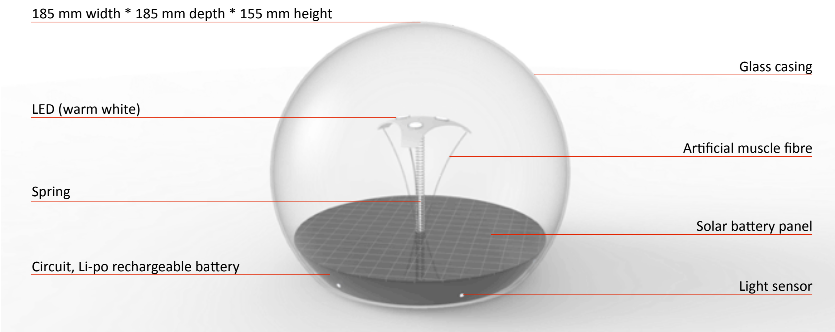
What will the new truly interactive relationship be like? My proposed answer to this question is, a “relationship that develops through exchange”— like the process in which an empty house gradually becomes your home. This is the challenge of the project, *yuen*.

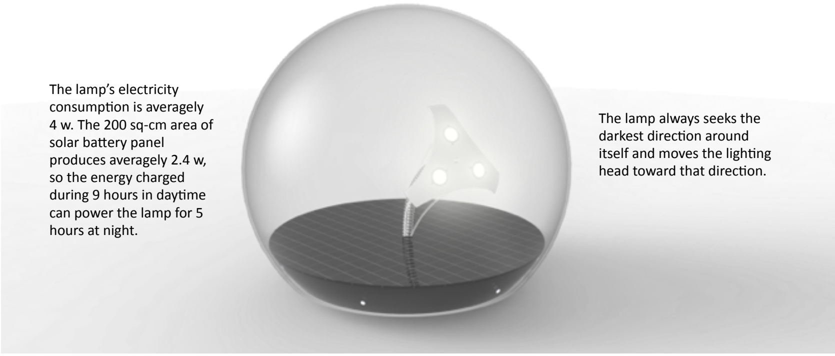
DESIGN - Involved in a system of lamps, light and shadow

yuen is an installation composed of several pieces of floor lamps, each of which has light sensors and muscle-like actuators. Each lamp organically moves its head, seeking the darkest direction around it. One lamp’s movement affects another’s by changing the light and shadow field in the environment, which results in indirectly connecting all lamps and creating a system in the environment. People who come to the environment can be also involved in this system by dropping their shadow. People cannot know what is going on and how the lamps will behave next because it is an analog complex system which somehow responds to people. It gives people ignorance and people try to find a way of interacting with it. The relationship develops through this exchange.



CONCEPT MODEL

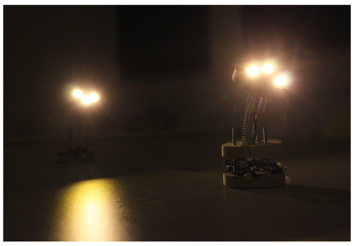


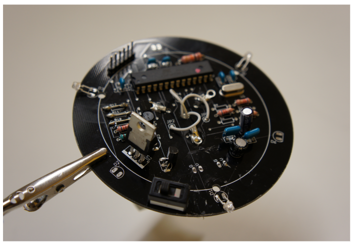


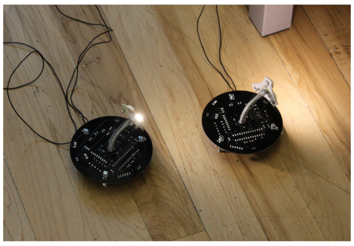
3/5

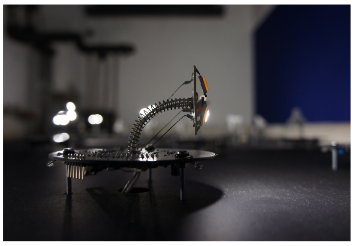
SCENARIOS

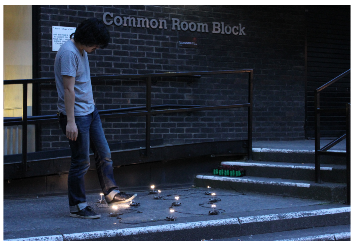
PROTOTYPING HISTORY

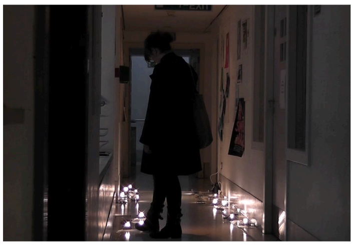




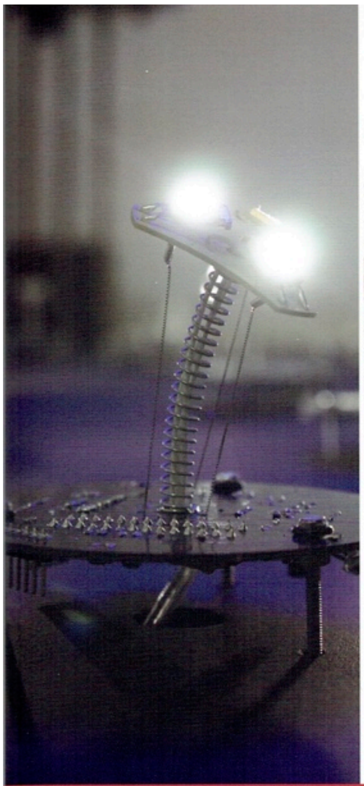








REDDOT DESIGN CONCEPT AWARD - AWARD CATALOGUE



Yuen
Hideki YOSHIMOTO,
Moto TAKABATAKE,
U.K, Japan

Illumination

Yuen is a lighting installation composed of multiple floor lamps, each of which senses the light conditions around it and moves its head to illuminate the darkest zone. One lamp's movement affects another's, which results in the indirect connection of all lamps and the creation of an interactive system.

The progress and spread of information technology in the last few decades has had a tremendous impact on our lives by making the built environment more active. With this in mind, one of the most popular keywords today must be 'interactive'. Two-way real-time communication will make people's experience in the environment richer than ever.

However, looking over the practices of this 'interaction' between people and environment, one finds that most are processes guided by wholly prepared scenarios of input and output like "touch here and then it happens". This is far from true interaction, where a narrative communication grows through reciprocal exchange.They are actually reactive rather than interactive.

The confused usage of these two terms may inhibit the ability of the latest technology to flower in the contemporary built environment and provide novel delightful experiences to people. What will the new, truly interactive relationship be like? The designers of *Yuen* propose the following answer: relationships that develop through exchange.

Yuen is an installation composed of multiple floor lamps, each of which contains light sensors and muscle-like actuators. Each lamp organically moves its head, seeking the darkest direction around it. One lamp's movement affects another's by changing the light and shadow field in the environment, which results in the indirect connection of all lamps and the creation of a system in the environment. People who come to the environment can be also involved in this system by dropping their shadow. People cannot know what is going on and how the lamps will behave next because it is an analog complex system that somehow responds to people. It raises intrigue and people try to find a way of interacting with it. The relationship develops through this exchange.

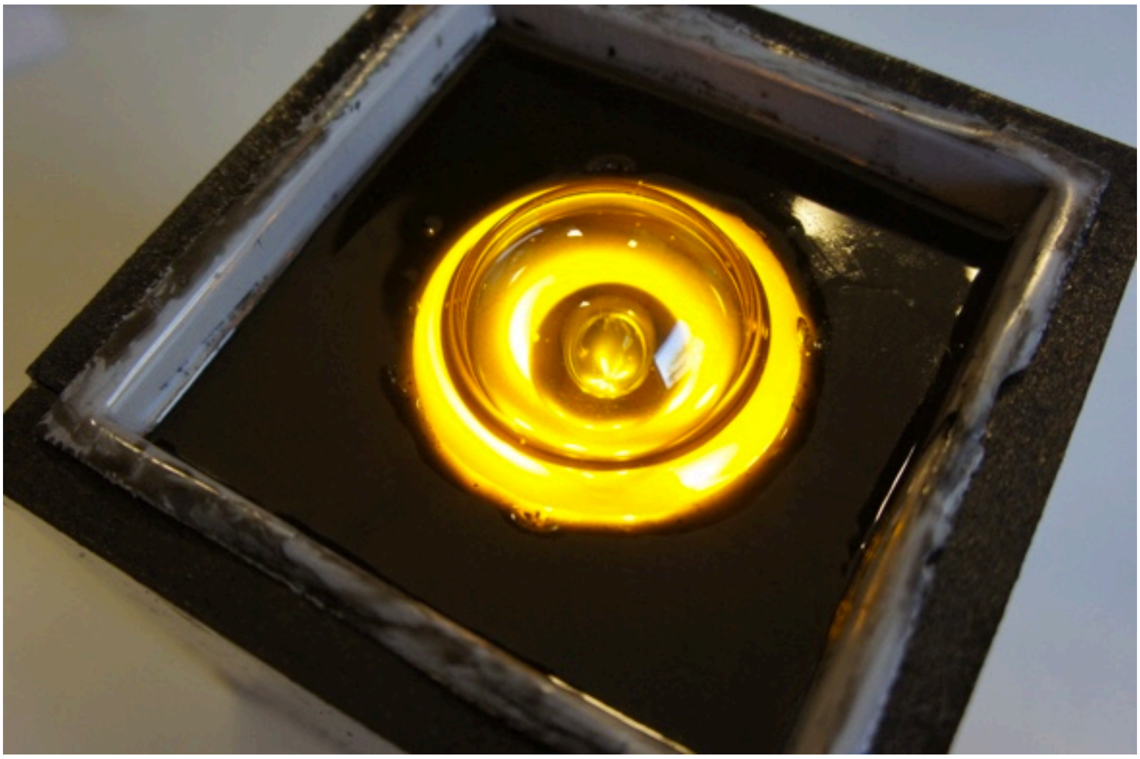
Hideki YOSHIMOTO,
Moto TAKABATAKE

Hideki Yoshimoto is a PhD candidate who is studying in the field of innovation design engineering at the Royal College of Art (United Kingdom). Moto Takabatake is a designer / planner at the Design Centre, Toyota Motor Corporation (Japan). They met at the Royal College of Art and worked collaboratively in 2010 and 2011.

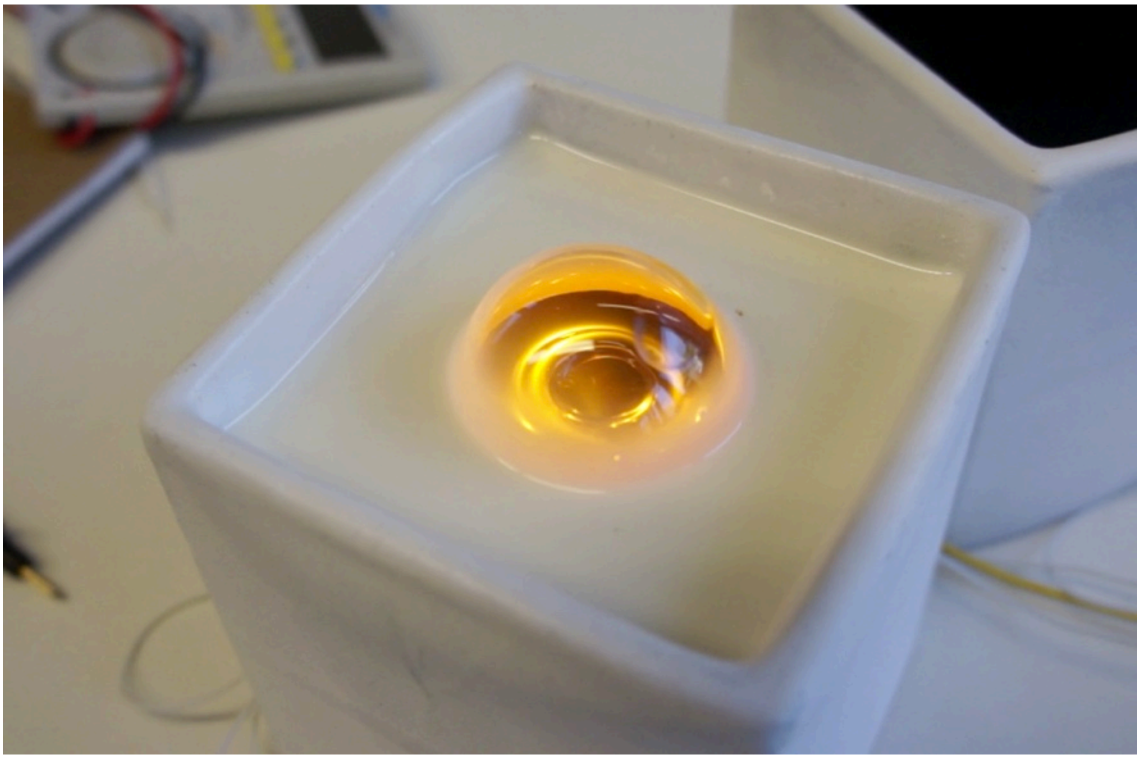
APPENDIX C

KIHOU

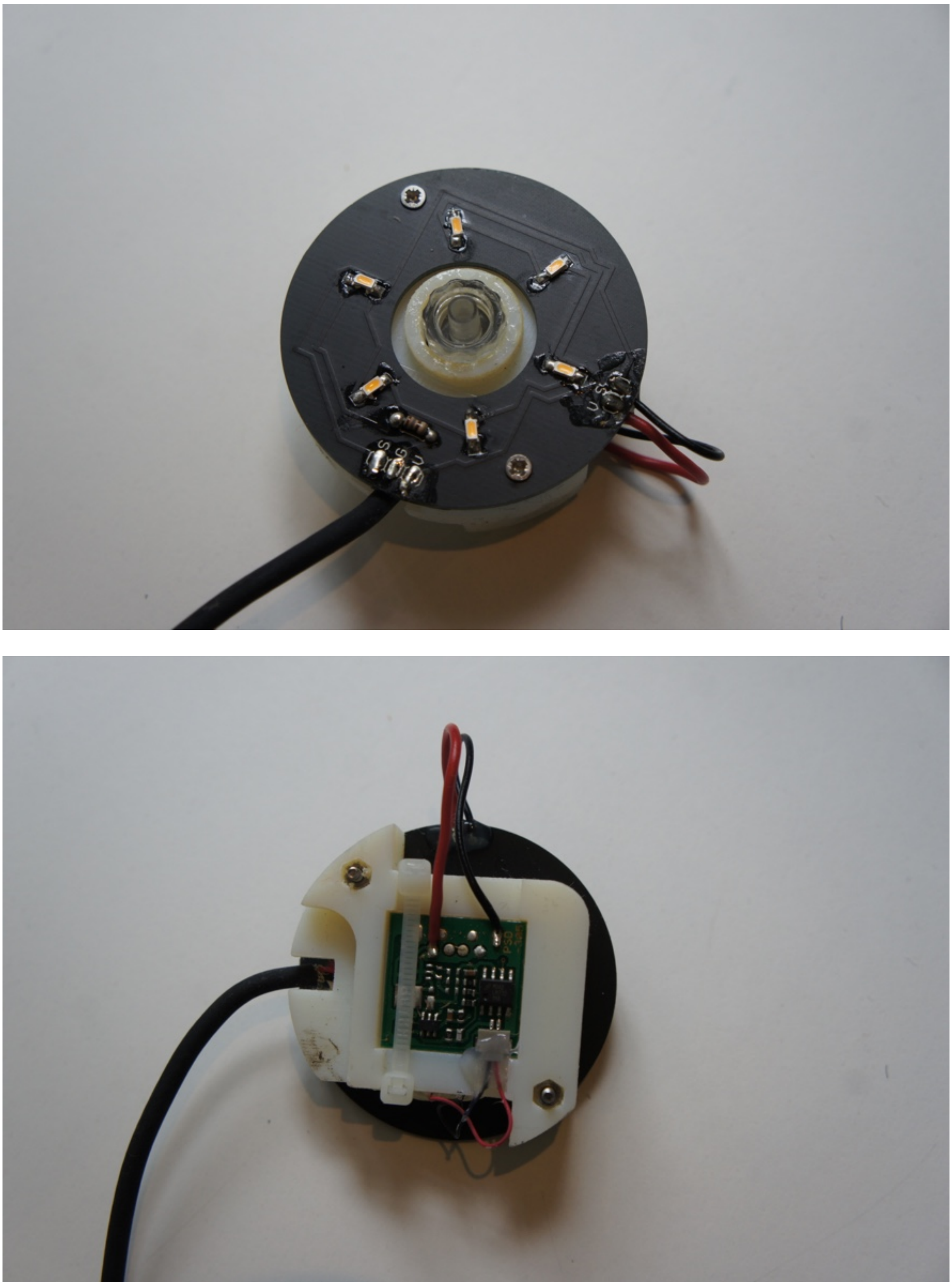
PROJECT IMAGES



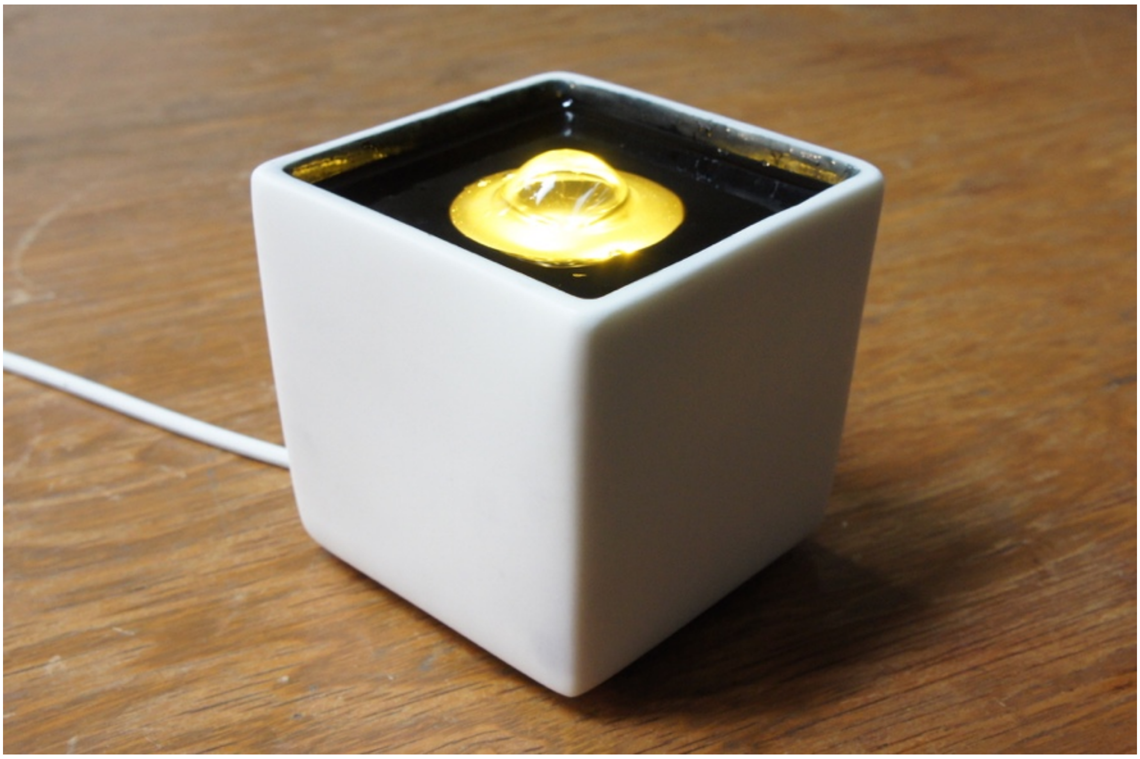
(Top) Firstly testing the combination of honey and black-dyed oil.
(Bottom) Prototyping the first ceramic bowl.



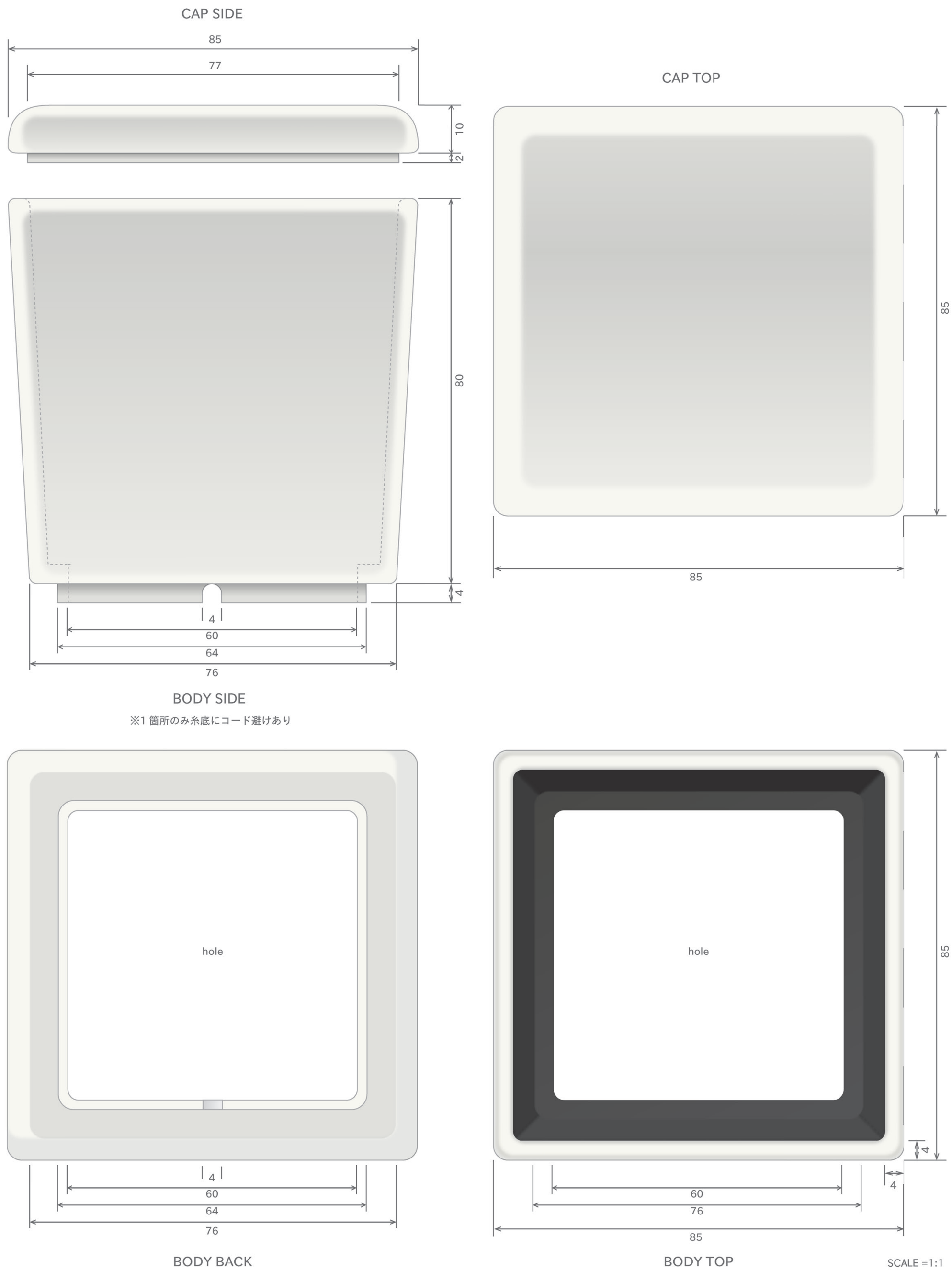
(Top) Testing multiple bubble openings.
(Bottom) Testing white oil instead of black.



(Top&Bottom) Custom-made pump&LED module.

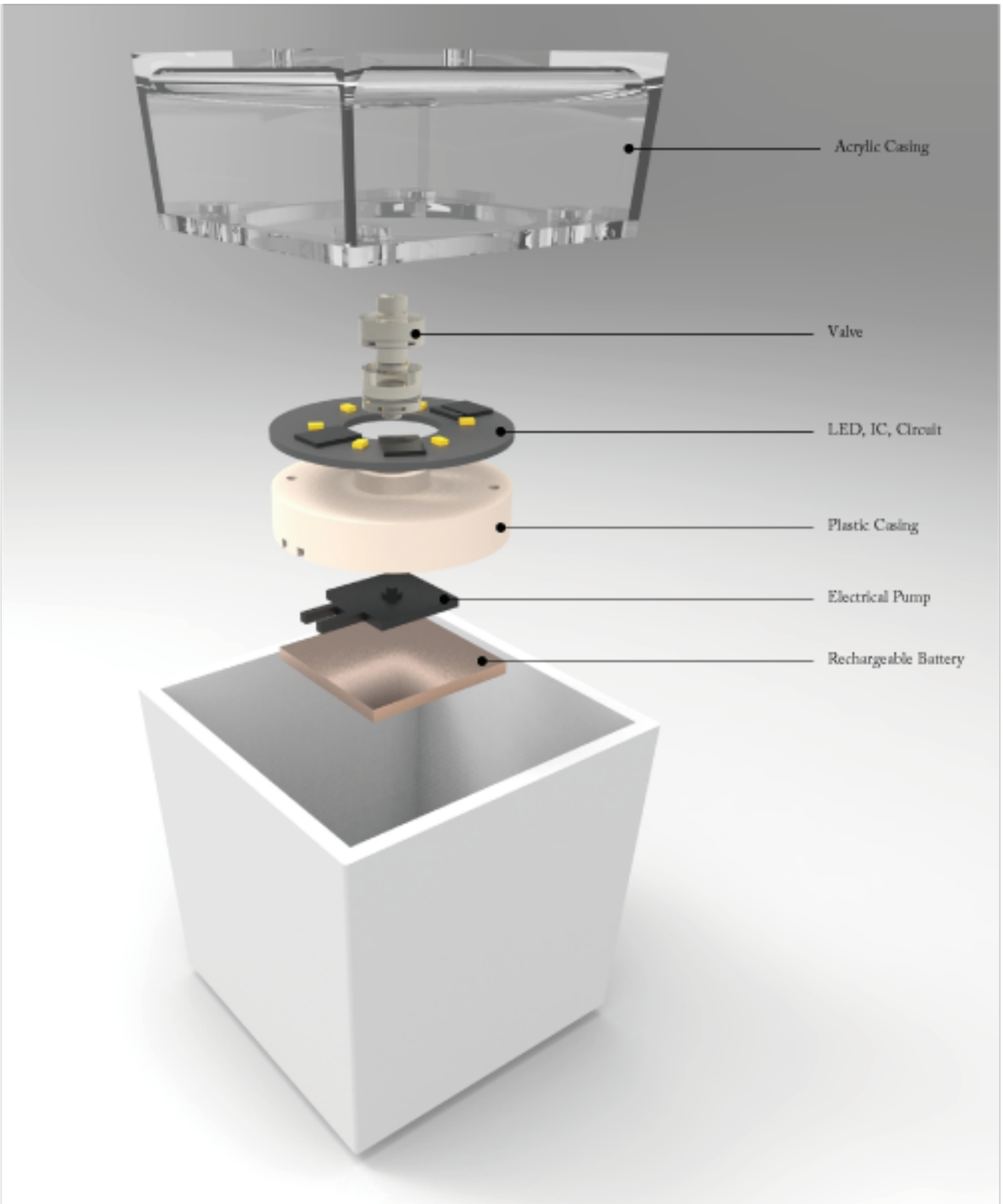


(Top) The first completed exhibition model.
(Bottom) The second completed exhibition model.

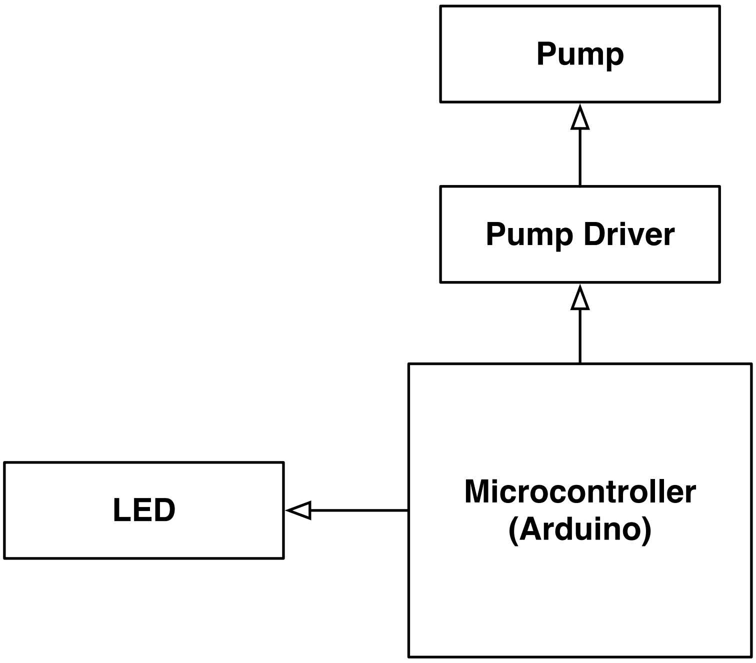


KIHOU

STRUCTURE


Acrylic Casing
Valve
LED, IC, Circuit
Plastic Casing
Electrical Pump
Rechargeable Battery

SYSTEM BLOCK DIAGRAM



PROGRAM CODE

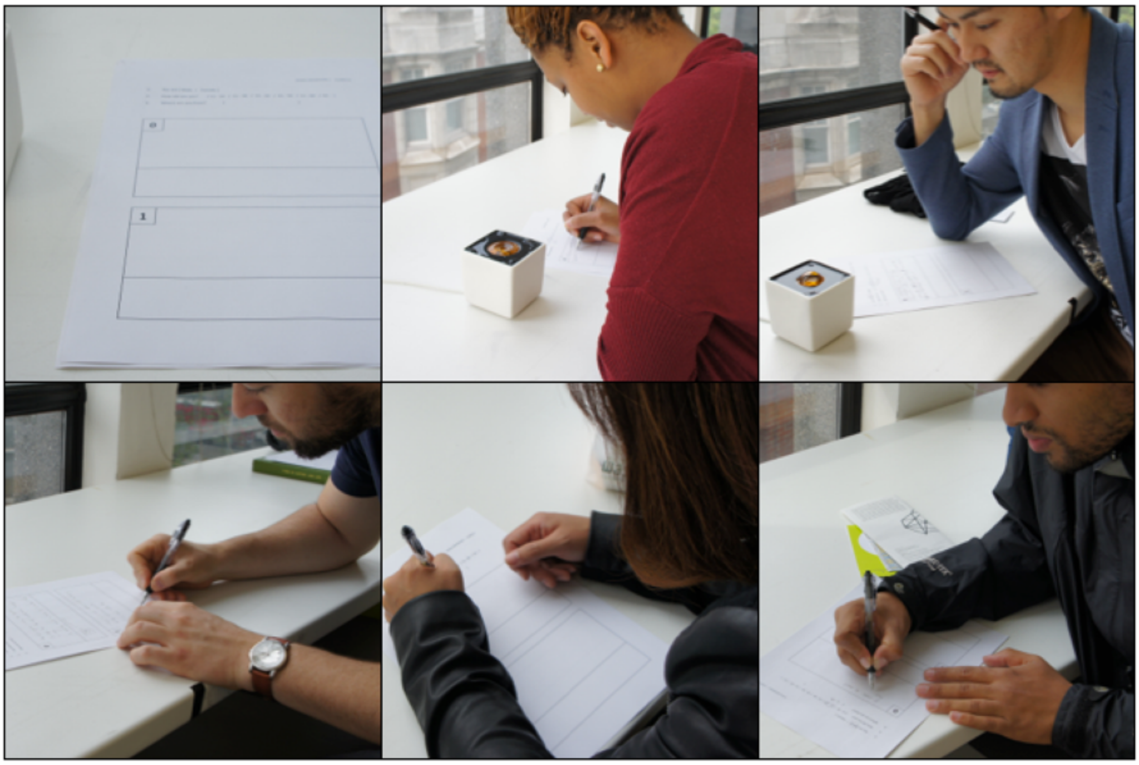
```
/************************************************/
// Project : KIHOU
// Language : Arduino
// Program By : Hideki Yoshimoto
/************************************************/

unsigned long onTime = 1500;
unsigned long totalTime = 4300;
unsigned long now;

void setup(){
    pinMode(7,OUTPUT);
    now = millis();
}

void loop(){
    if(millis() - now < onTime){
        digitalWrite(7,HIGH);
    }
    else if(millis() - now < totalTime){
        digitalWrite(7 ,LOW);
    }
    else{
        now = millis();
    }
}
```

INSTALLATION AT THE MILAN DESIGN FAIR 2013

(Top) Displaying several colour&material variations.
(Bottom) Two ceramic coloured versions (right-top) and four Japanese lacquerware versions.

INTERVIEW ANSWERS

The interviewees were asked to describe how they felt about each of five modes (a) - (e), corresponding (0) - (4) in the form presented in this section from the next page. They were also asked to add their drawings to represent each mode. At last they chose one mode which they liked the most and described the reason why they chose this particular one.



Participant 1 (In Japanese — English translation was added.)

KIHOU INTERVIEW 1 21/09/12

1: You are [Male / Female]

2: How old are you? [11 - 20 / 21 - 30 / 31 - 40 / 41 - 50 / 51 - 60 / 61 -]

3: Where are you from? [日本]

0 魚の目みたい。波紋がのこってていい。ずっとうごいてるから あきない。

(It is like a corn. I like the ripples staying there. I don't get bored because it is always moving.)

1 穴がとじそうでとじなさそうなイライラ感….

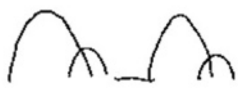
あわよりも、外側の上下うんどうが海っぽい？

呼吸っぽい。

(It is annoying to see the hole is about to close but does not. I am more interested in the motion of the liquid surface than the bubble. It's like sea, or breathing.)

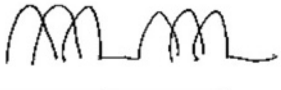
2 一度ちゃんと穴が閉じて、からの大きい泡が出る感じが怖くていい。暗いところから何か出てくる怖いかんじ。
穴が閉じたら、もう少し"ため"が欲しい。1〜2秒ぐらい？
そうすると、泡の発生の時の印象がきわだつと思う。

(I like it that the hole closes completely then another big bubble appears. It feels scary — the way something appears from the darkness. I want a bit longer silence after the hole closes — probably a few seconds. It would contrast the bubble better.)



3 なんか、カオスっぽい…3連続だからちょっと"いっぱい"な感じに思える。
なんか、もっとずっと出ればいいのに…って思うモヤモヤ感

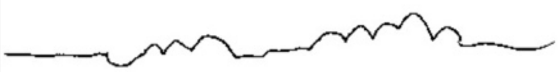
(It it chaotic. It feels too much because of too many bubbles. I would want it to be continuous — bit frustrating.)



4 "タメ"の時間が長めで、いい。
(まっくら)
ランダムっぽく感じれて、ドラマ性感じる。
よいこと。
他のヤツより複雑だから。

水面の上下運動が肺呼吸っぽくて生物っぽい

(I like it has longer time for the dark interval. It is more complicated than others and feels random — I feel it dramatic. The vertical motion of the liquid surface feels breathing and like the motion of life.)



0か、4。

0は、ずっと出てる、イライラしない

4はドラマ性がある。

(0 is continuous and not annoying. 4 is dramatic.)

Participant 2

KIHOU INTERVIEW 1 21/09/12

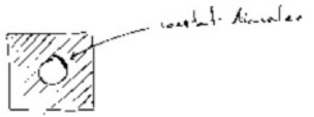
1: You are [Male / ~~Female~~]

2: How old are you? [11 - 20 / 21 - 30 / 31 - 40 / 41 - 50 / 51 - 60 / 61 -]

3: Where are you from? [FRANCE]

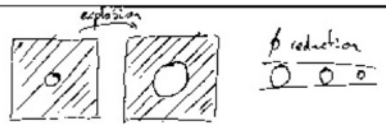
0

The first impression is funny, like hypnotic.
It looks like the first computer mouses / trackpad in a way
I definitely want to touch it to see how it feels.



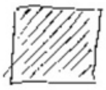
1

There is a new movement with the reducing of the black area diameter.
It is more bubble-like



2

Now the tempo is really close to Human respiration
The orange completely dispears before a bubble goes out



and then close to the #1 except that 2 bubbles seem to go out.

3

You now really feel the bubbles

Close to the #1 but the bubbles keep for a longer time

4

This one is really low tempo.
The bubble is very small
You actually wait for it.
Irregular

I prefer the #0 and #2 :

#0 because it is almost solid when you see it for the first time (it tricks your mind)

#2 because it looks like alive and calm. (rythm)

Participant 3 (In Japanese — English translation was added.)

KIHOU INTERVIEW 1 21/09/12

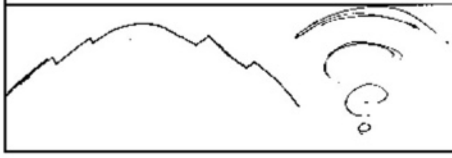
1: You are [Male / Female].

2: How old are you? [11 - 20 / 21 - 30 / 31 - 40 / 41 - 50 / 51 - 60 / 61 -]

3: Where are you from? [Tokyo]

0

・科学的アプローチなので—
・形あそびではないのでOK.
・色のコントラストも良い．・沢山ならべてみたくなる．
・ぱっと見のおどろきがある！・んで話しを聞くと深みある．すばらしい！



コントラストが鮮やかでいい．
ちょっと地ゴク感あり

(It is a scientific approach. It is not just about shape — I like it. I like the contrast of the colour. I would want to have many of these. It is surprising at first glance — then I find the deepness when I hear the concept of it. Very nice. It looks bit like the hell.)

1

イカスミとめだまやき．0同様どっちのぱたーんもおもしろい！
フェードアウト．フェードインのリズム．動きがおもしろい！

めだまやき！
コントラスト，有機物と，科学．

iida的 キーワード→生まれ出る感じ
→誕生

(I found it is like squid ink and a fried egg. Both patterns of 0 and 1 are interesting. The rhythm of fading out/ in and the motion is interesting. It includes organic matters and science. The keyword I would choose is 'birth'.)

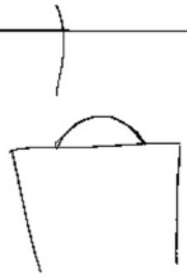
2 こうせいようそがシンプルなのに、動きがドラマティック！シンプルなのに、、、
1番シンプルな動き。無から有
でかいきほう。

(It is a very simple structure but the motion is dramatic! This mode is the simplest; something— a big bubble— appears from nothing. I feel 'birth' in it.)

ハゴロモフーズ感あり。何から○がうまれてくるような"誕生"を感じる！

3 うつわや、個数などなどと様々な見せ方が可能。どうしたらよりこのメッセージが魅力的に見た人に伝わるのか等、すごく可能性を感じる!!

(It will be possible to have variations in the bowls and the numbers of units. I find a lot of possibilities — there would be many ideas on how this message can become attractive to people.)



サイドビューが
1番おもしろいのは3番。
(変化が大きいから!)

(The mode 3 is interesting when I look at it from the side.)

KIHOU

4 リズムのバリエーションと言うよりも、自然現象のおもしろさや、ファーストインパクトにみなやられてしまうのではないか?!(ポジティブ).

(I think it is more attractive that it has organic, natural phenomenon and gives the strong first impression, than that the rhythm has variations.)

2

Participant 4

KIHOU INTERVIEW 1 21/09/12

1: You are [Male / Female].

2: How old are you? [11 - 20 / 21 - 30 / 31 - 40 / 41 - 50 / 51 - 60 / 61 -]

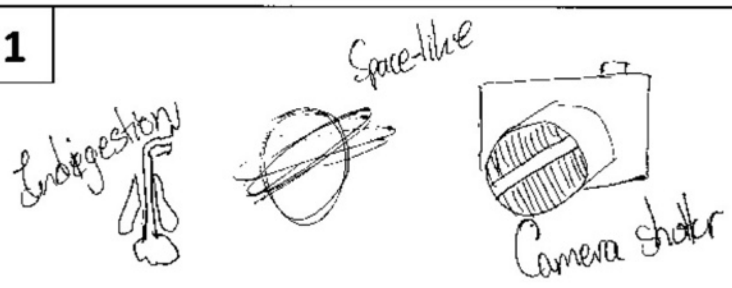
3: Where are you from? [Uk.]

0 Bulbous wounds, Pnemonic plague
Sexual in rythm.
Meditational, Dark layer gives way to visons of the underworld.

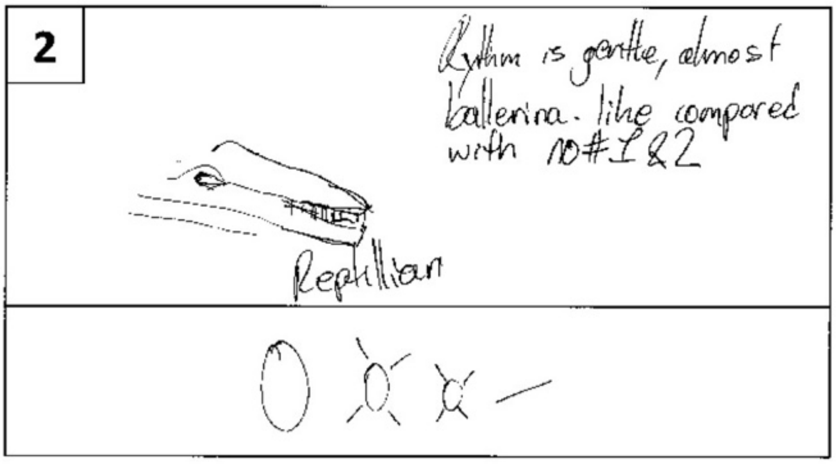
Apocolyptic

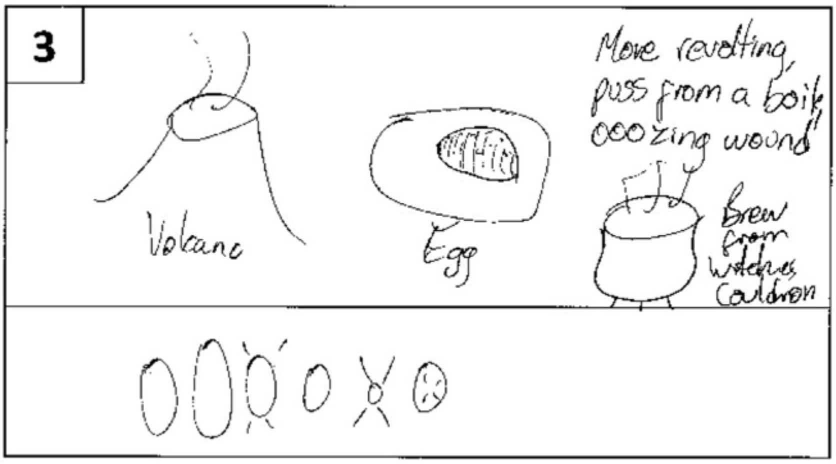
0 0 0 0

1



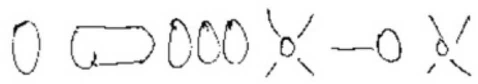
O X O X


2
Rythm is gentle, almost ballerina-like compared with no# I & 2
Reptillian


3
More revolting, puss from a boil, oozing wound
Volcano
Egg
Brew from witches Cauldron

4

Lazer, weapon } travel
Explosive beam } by Light speed



3 Unpredictable rythm, NO#0 was more in tune with my rythm & NO#2 very relaxing, but I felt NO#3 had an energy that signaled action. The frying of an egg, the bubbling of lava, the bubbling of a wound, things happening on a molecular level, in the heat of the moment.

Participant 5

KIHOU INTERVIEW 1   21/09/12

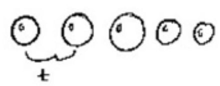
1: You are [$\boxed{\text{Male}}$ / Female].

2: How old are you? [11 - 20 / $\boxed{21 - 30}$ / 31 - 40 / 41 - 50 / 51 - 60 / 61 -]

3: Where are you from? [USA]

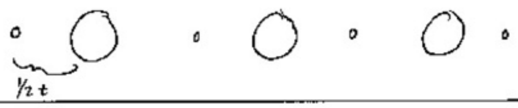
0

I FEEL A REST.
THE SPEED IS FAST BUT NOT TOO FAST.



1

I FEEL A HEART BEAT.
VERY SLOW ~~FEELING~~
BERTH
GROWTH
MOVING UP



1/3 t

2

two times

SLEEP

VERY SLOW SPEED

FEELS LIKE A SLOW DEEP BASS DRUM KICK

YOU WANT TO WAIT FOR THE NEXT TO COME UP

YOU WANT TO KNOW IF THEY WILL STOP COMING UP OR NOT.

3

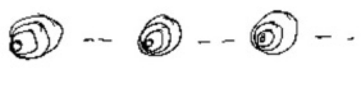
I FEEL LIKE THE PATTERN IS UNFINISHED

MAYBE IT SHOULD BE 5 TIMES TO MAKE

ME FEEL MORE RELAXED.

I FIND MYSELF WAITING FOR ANOTHER TO RISE.

THE TIME BETWEEN IS TOO LONG.

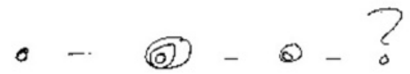


4

THE FIRST
POP! FEELS SMALL BUT LOUD
~~HA~~ SOME POWER

BECAUSE I FEEL LIKE IT IS POWERFUL EVEN IF IT IS SMALL AND ALONE

FEELS A BIT RANDOM
I DONT KNOW WHAT IS HAPPENING
CANT CATCH THE PATTERN
FEELS A LITTLE UNEASY / I LIKE THE SMALL SINGLE



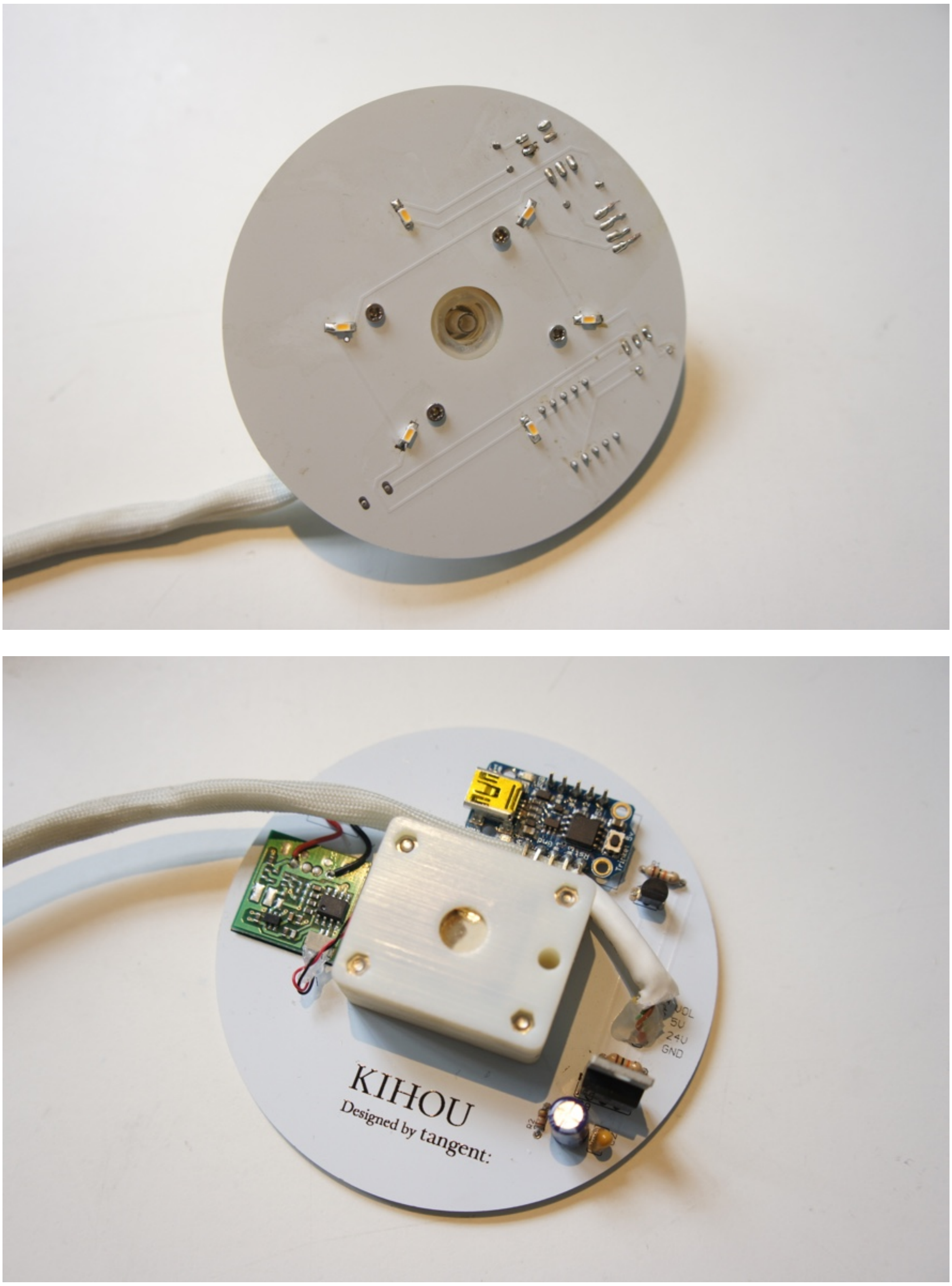
#1 WAS THE MOST PEACEFUL FOR ME
THERE WAS A FEELING OF LIFE BUT
AT THE SAME TIME I FEEL THE PATTERN
IS NICE AND SMOOTH.

APPENDIX D

KIHOU FOAM

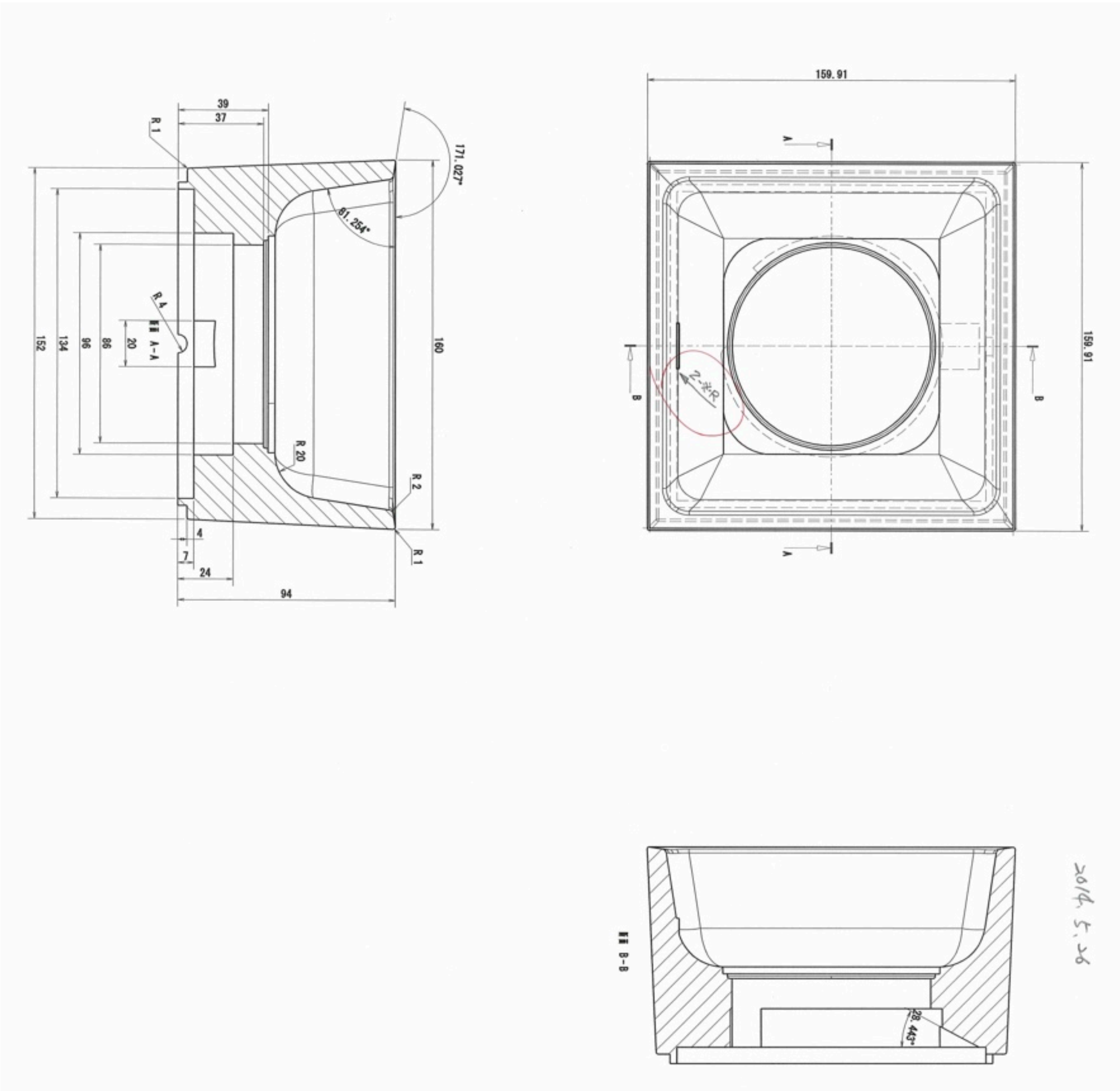
PROJECT IMAGES

(Top) The box (chemical wood) in prototyping, top-view.
(Bottom) The box (chemical wood) in prototyping, bottom-view.



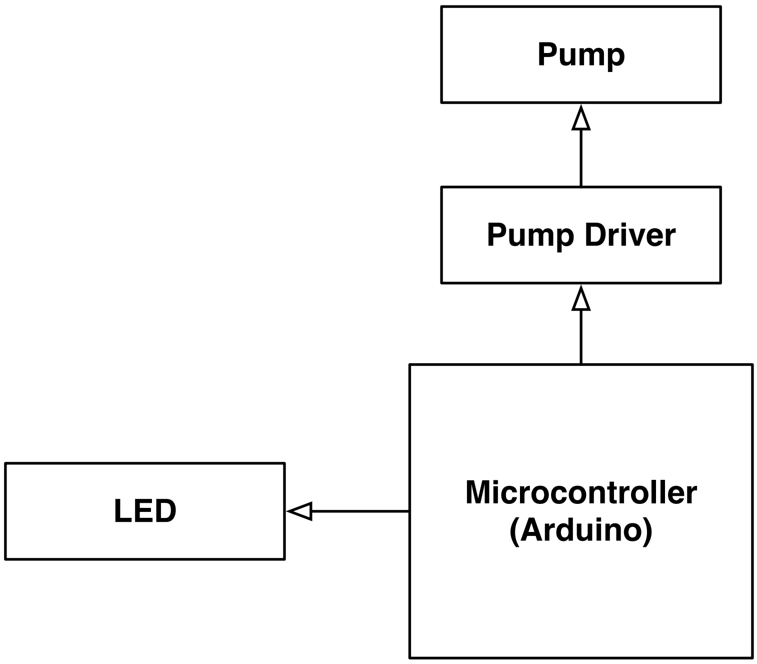
(Top&Bottom) Custom-made pump&LED module.

(Top&Bottom) The first completed exhibition model.



Technical drawings of the box.

SYSTEM BLOCK DIAGRAM



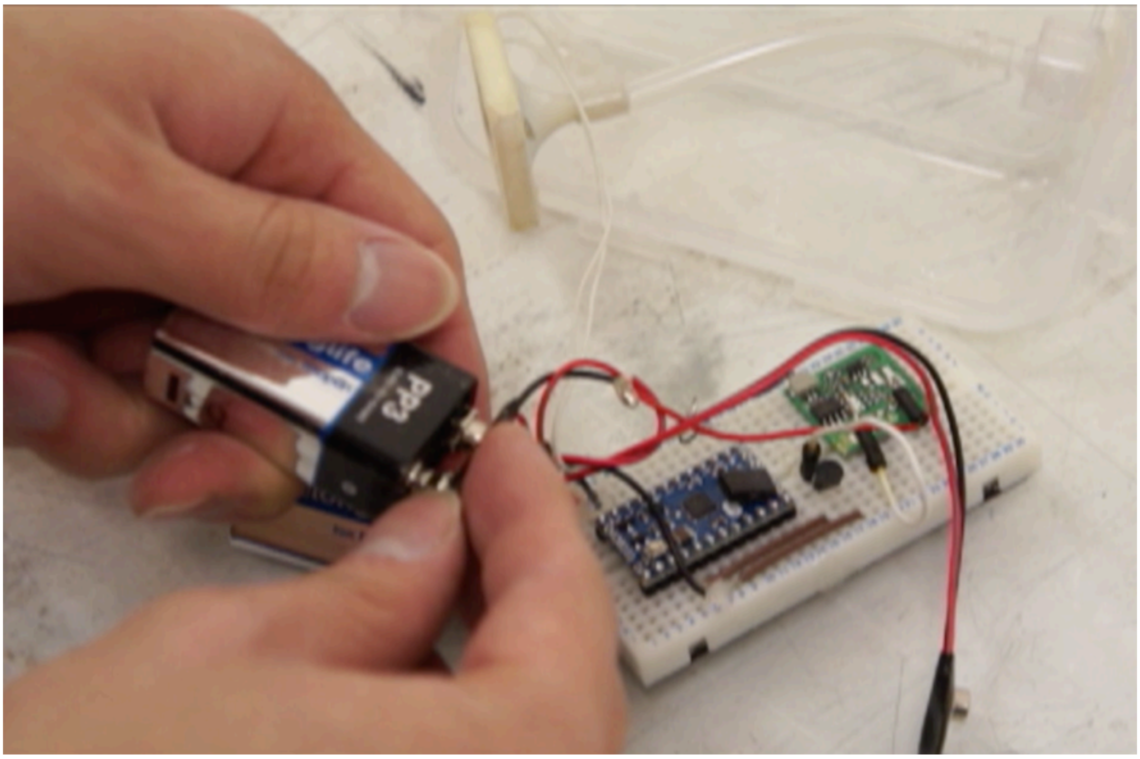
PROGRAM CODE

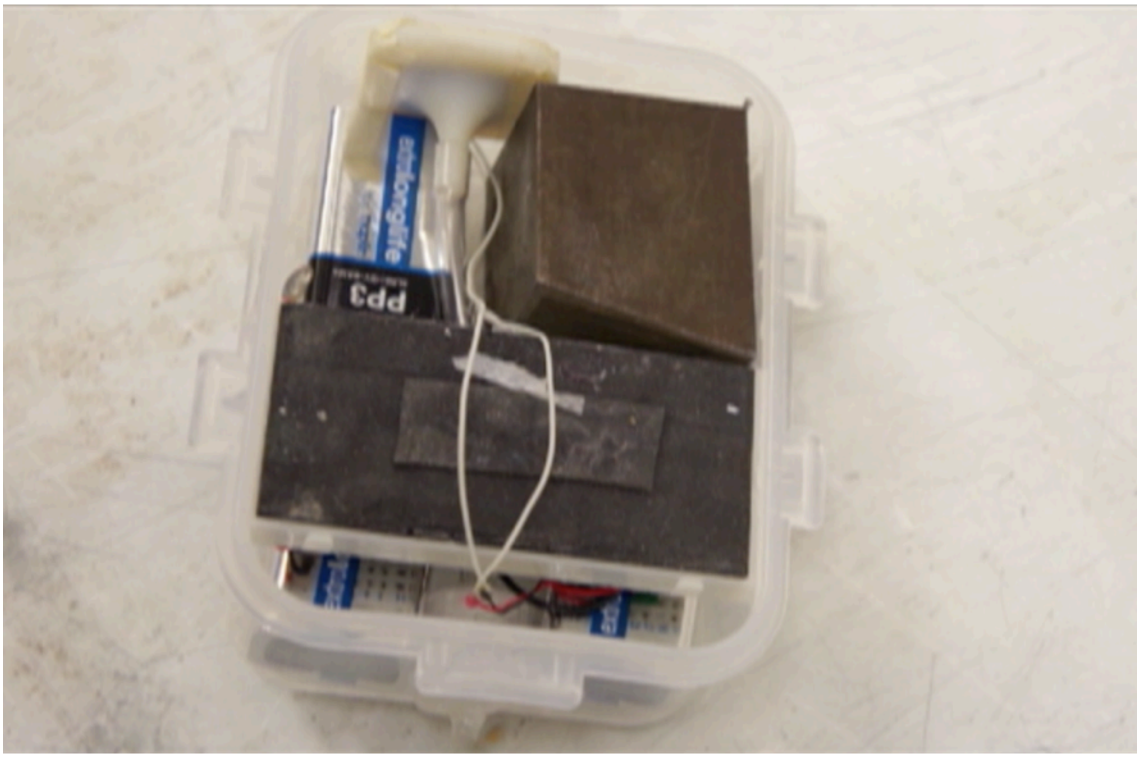
```
/************************************************/
// Project : KIHOU FOAM
// Language : Arduino
// Program By : Hideki Yoshimoto
/************************************************/

unsigned long onTime = 1500;
unsigned long totalTime = 3000;
unsigned long now;
unsigned long start;

void setup(){
    pinMode(7,OUTPUT);
    now = millis();
    start = millis();
}

void loop(){
    if(millis() - now < onTime){
        digitalWrite(7,HIGH);
    }
    else if(millis() - now < totalTime){
        digitalWrite(7 ,LOW);
    }
    else{
        now = millis();
    }

    if(millis() - start > 60 * 1000 * 10){
        totalTime = 5000;
    }
    if(millis() - start > 60 * 1000 * 20){
        totalTime = 7000;
    }
}
```

APPENDIX E

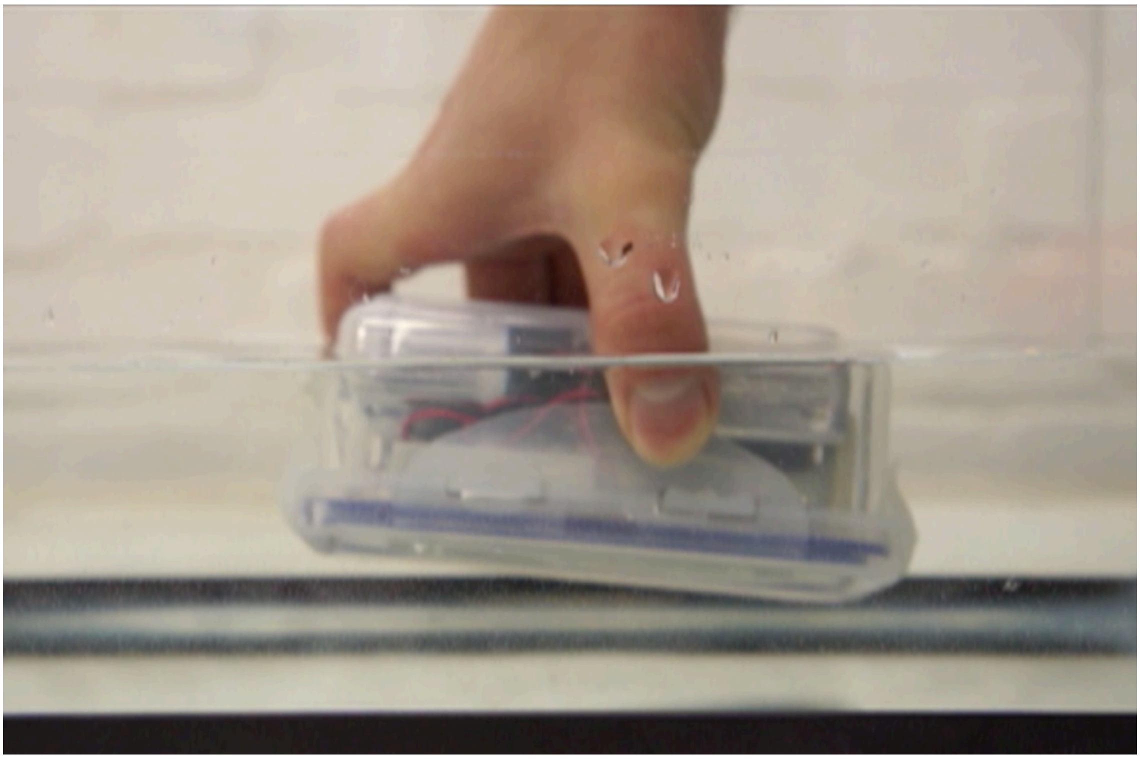
TUPPERWARE

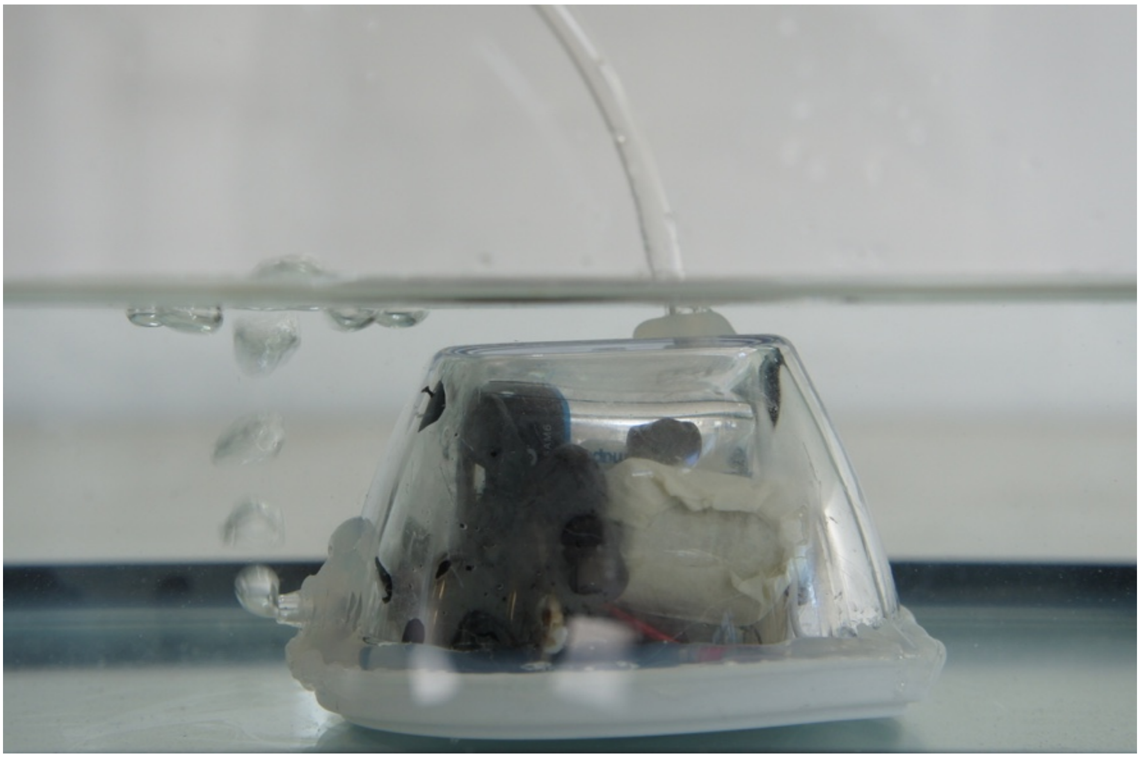
PROJECT IMAGES





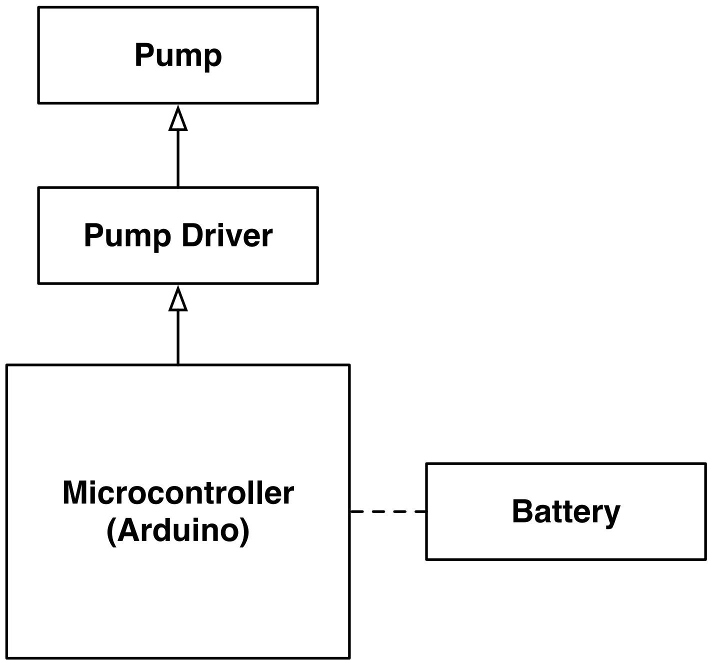
(Top&Bottom) The inside of the Tupperware.





(Top) The first prototype is being placed in the water.
(Bottom) The second prototype is blowing air in the water.

SYSTEM BLOCK DIAGRAM



PROGRAM CODE

```
/************************************************/
// Project : TUPPERWARE
// Language : Arduino
// Program By : Hideki Yoshimoto
/************************************************/

unsigned long onTime = 1500;
unsigned long totalTime = 4300;
unsigned long now;

void setup(){
    pinMode(7,OUTPUT);
    now = millis();
}

void loop(){
    if(millis() - now < onTime){
        digitalWrite(7,HIGH);
    }
    else if(millis() - now < totalTime){
        digitalWrite(7 ,LOW);
    }
    else{
        now = millis();
    }
}
```

APPENDIX F

PLURAL KIHOU

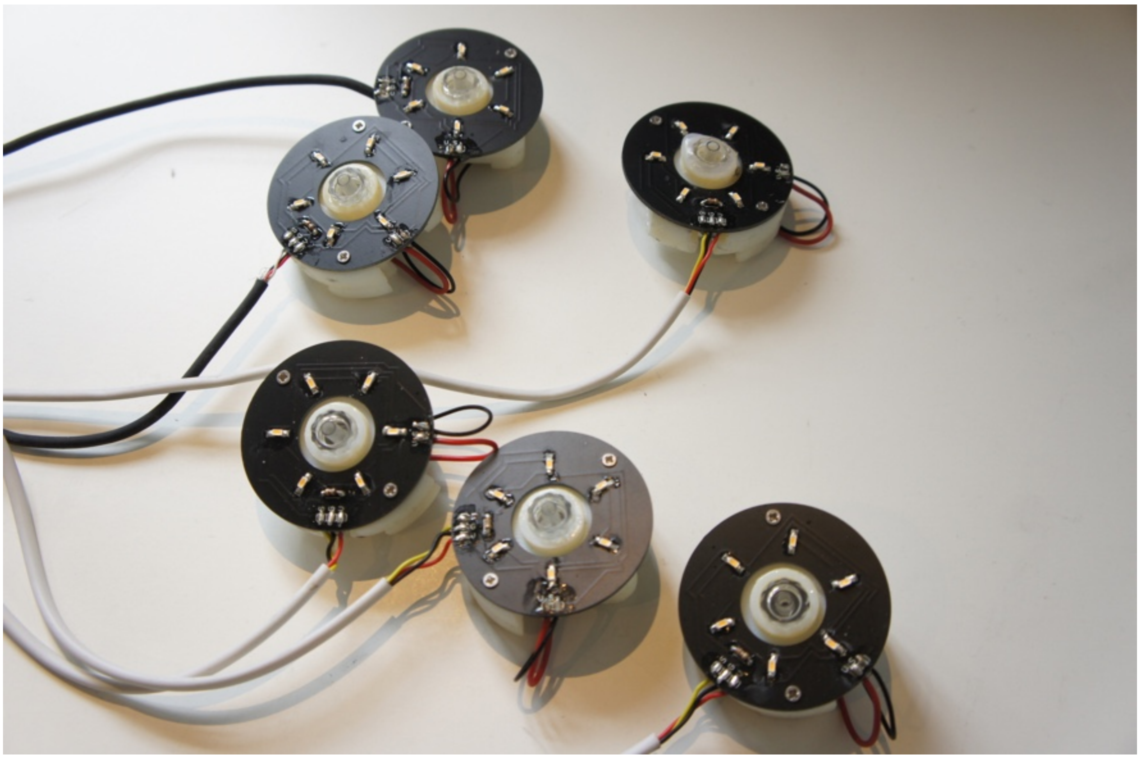
KURAMOTO MODEL SIMULATOR

```
//--------------------------------------------------------------
// Project : KURAMOTO MODEL SIMULATION
// File : MAIN.CPP
// Language : OPENFRAMEWORKS + OFXCSV-MASTER ADDON
// Program By : Hideki Yoshimoto
//--------------------------------------------------------------

#include "ofMain.h"
#include "ofApp.h"

//========================================================================
int main( ){

      ofSetupOpenGL(1024,768, OF_WINDOW);                   // <-------- setup the GL
context

      // this kicks off the running of my app
      // can be OF_WINDOW or OF_FULLSCREEN
      // pass in width and height too:
      ofRunApp( new ofApp());

}
```

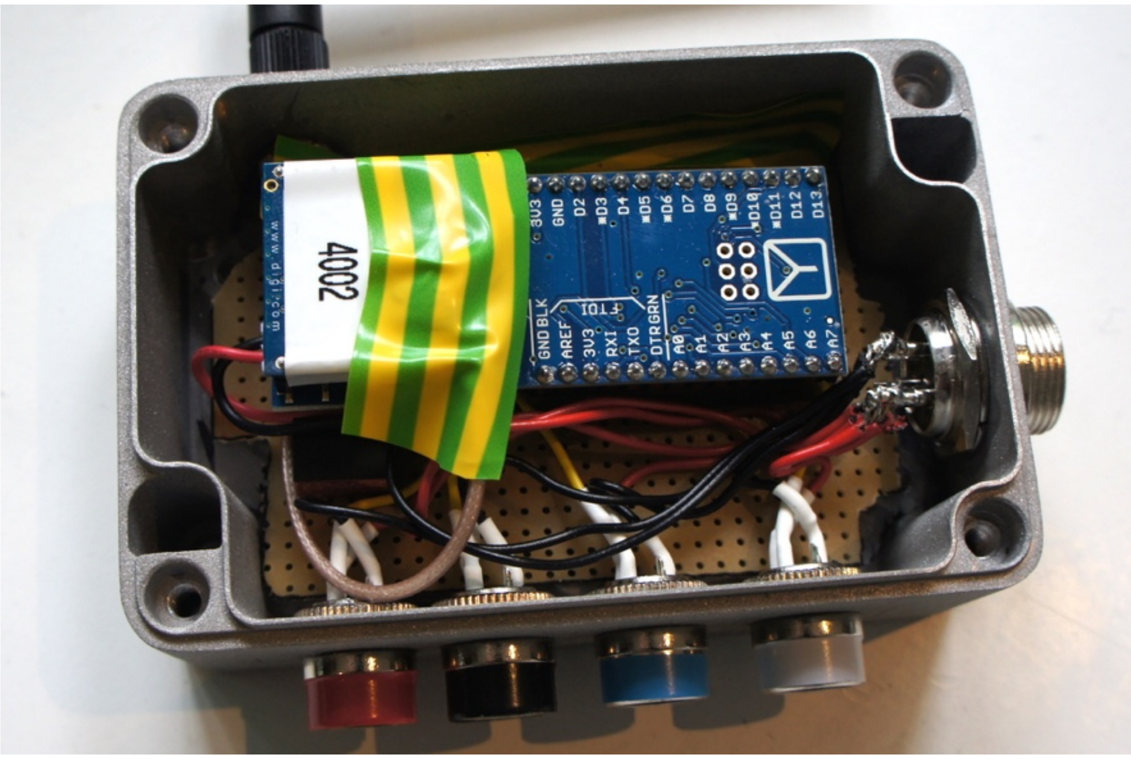
```
//--------------------------------------------------------------
// Project : KURAMOTO MODEL SIMULATION
// File : OFAPP.CPP
// Language : OPENFRAMEWORKS + OFXCSV-MASTER ADDON
// Program By : Hideki Yoshimoto
//--------------------------------------------------------------

#include "ofApp.h"

//--------------------------------------------------------------
void ofApp::setup(){
    csv.loadFile(ofToDataPath("file.csv")); //Save the data as CSV to handle in Excel

    n = 5;
    k = 0.1;
    dt = 0.3;

    for(int i=0;i<n;i++){
        omega[i] = 0.1 + ofRandom(0.1);
        theta[i] = ofRandom(6.24);
    }
}

//--------------------------------------------------------------
void ofApp::update(){

    for(int i=0;i<n;i++){
        float s = 0;
        for(int j=0;j<n;j++){
            s += sin(theta[j] - theta[i]);
        }
        theta[i] += dt * (omega[i] + (k / n) * s); //Kuramoto Model Equation
    }

    int row = csv.numRows;
    for(int i=0;i<n;i++){
        csv.setFloat(row, i, 5 * i + sin(theta[i]));
    }
```

```
}

//--------------------------------------------------------------
void ofApp::draw(){

    ofBackground(255);

    for(int i=0;i<n;i++){
        ofNoFill();
        ofSetColor(0);
        ofCircle(200 + (i%5) * 100,200 + 100 * (i/5),30);
    }
    for(int i=0;i<n;i++){
        ofFill();
        ofSetColor(0);
        ofCircle(200 + (i%5) * 100 + 30 * cos(theta[i]),200 + 100 * (i/5) + 30 *
sin(theta[i]),10);
    }
}

//--------------------------------------------------------------
void ofApp::keyPressed(int key){
    if(key == 's'){
        csv.saveFile(ofToDataPath("file.csv"));
    }
 }




//--------------------------------------------------------------
// Project : KURAMOTO MODEL SIMULATION
// File : OFAPP.H
// Language : OPENFRAMEWORKS + OFXCSV-MASTER ADDON
// Program By : Hideki Yoshimoto
//--------------------------------------------------------------

#pragma once

#include "ofMain.h"

#include "ofxOpenCv.h"
#include "ofxCsv.h"

using namespace wng;

//#define _USE_LIVE_VIDEO

class ofApp : public ofBaseApp{

      public:
               void setup();
               void update();
               void draw();
               void keyPressed(int key);

    float omega[20];
    float theta[20];
    float k;
    int n;
    float dt;
    ofxCsv csv;
};
```

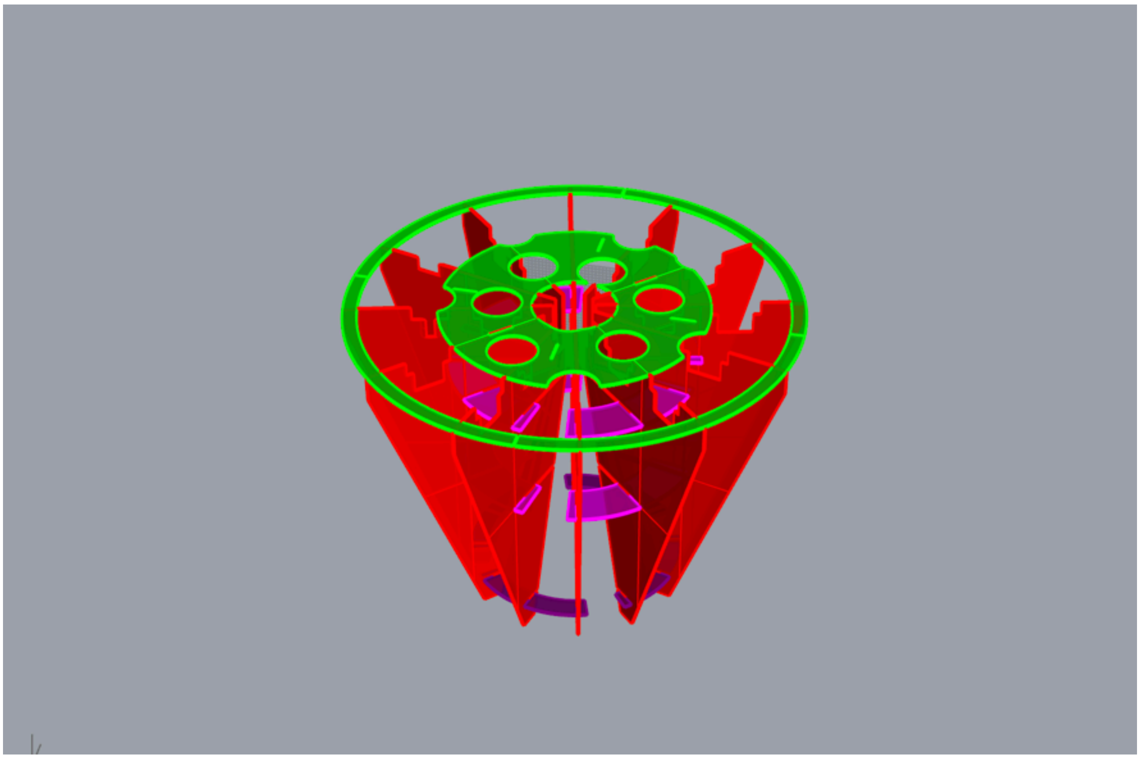
PROJECT IMAGES

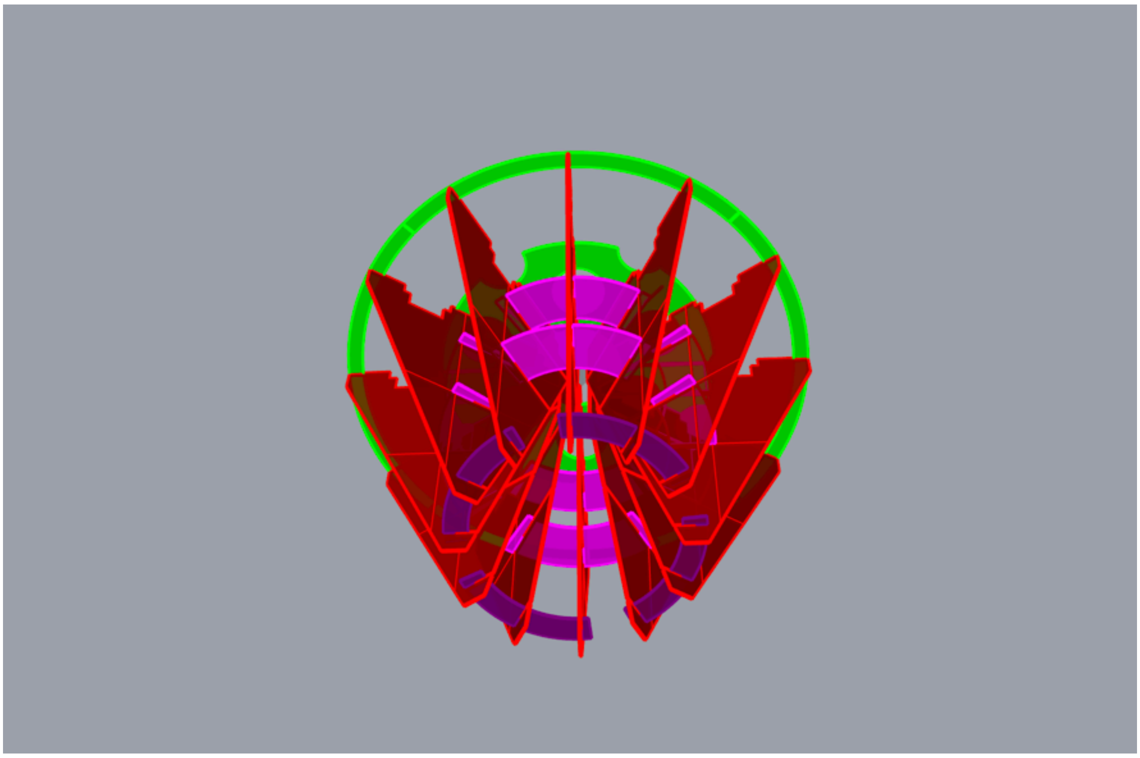


(Top) The pump&LED modules.
(Bottom) The big pot with supporting structure.



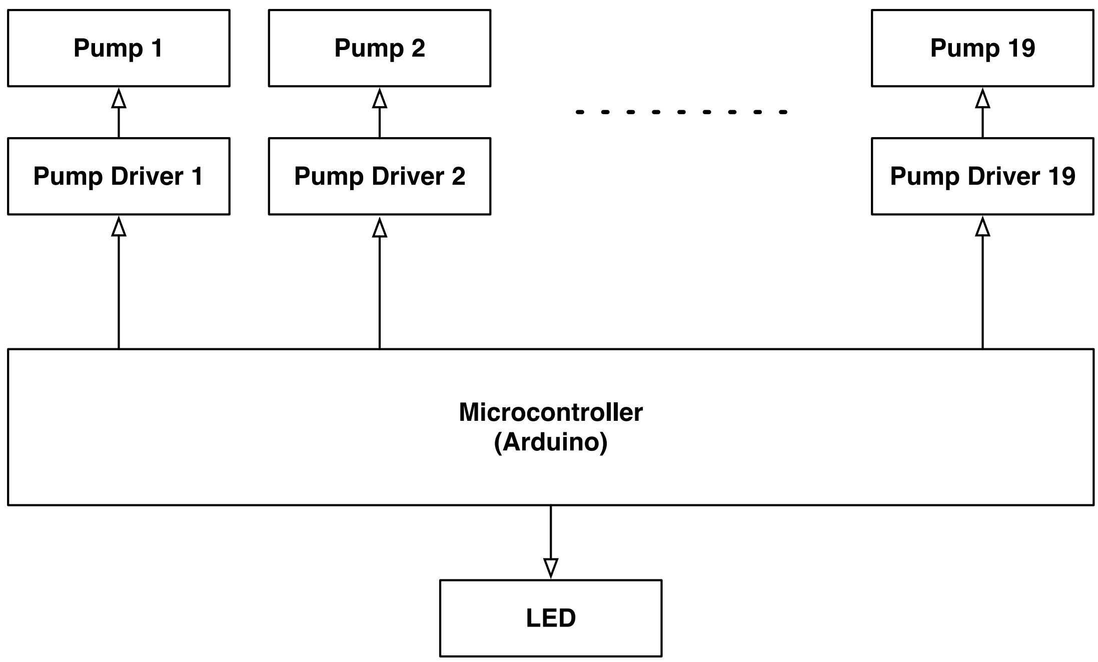
(Top) The inside of the control box.
(Bottom) The first completed exhibition model.





(Top&Bottom) The CAD drawings of the internal structure of the big pot.

SYSTEM BLOCK DIAGRAM



PROGRAM CODE

```
/**************************************************/
// Project : PLURAL KIHOU
// Language : Arduino
// Program By : Hideki Yoshimoto
/**************************************************/

float omega[19];
float theta[19];
float k;
int n;

unsigned long start;

void setup(){
    pinMode(7,OUTPUT);
    start = millis();

    n = 19;
    k = 0.1;
    dt = 0.3;
    for(int i=0;i<n;i++){
        omega[i] = 0.1 + ofRandom(0.1);
        theta[i] = ofRandom(6.24);
        pinMode(i,OUTPUT);
    }
}

void loop(){
    kuramoto();

    for(int i=0;i<n;i++){
        if(theta[i] < 0.7 * PI){
            digitalWrite(i,HIGH);
        }
        else{
            digitalWrite(i,LOW);
        }
    }

    if(millis() - start > 1000 * 60 * 3){
        omega[i] = 0.1 + ofRandom(0.1);
        theta[i] = ofRandom(6.24);
        start = millis();
    }

    delay(30);
}

void kuramoto(){
    for(int i=0;i<n;i++){
        float s = 0;
        for(int j=0;j<n;j++){
            s += sin(theta[j] - theta[i]);
        }
        theta[i] += dt * (omega[i] + (k / n) * s);
        if(theta[i] >= 2 * PI){
            theta[i] = 0;
        }
    }
}
```

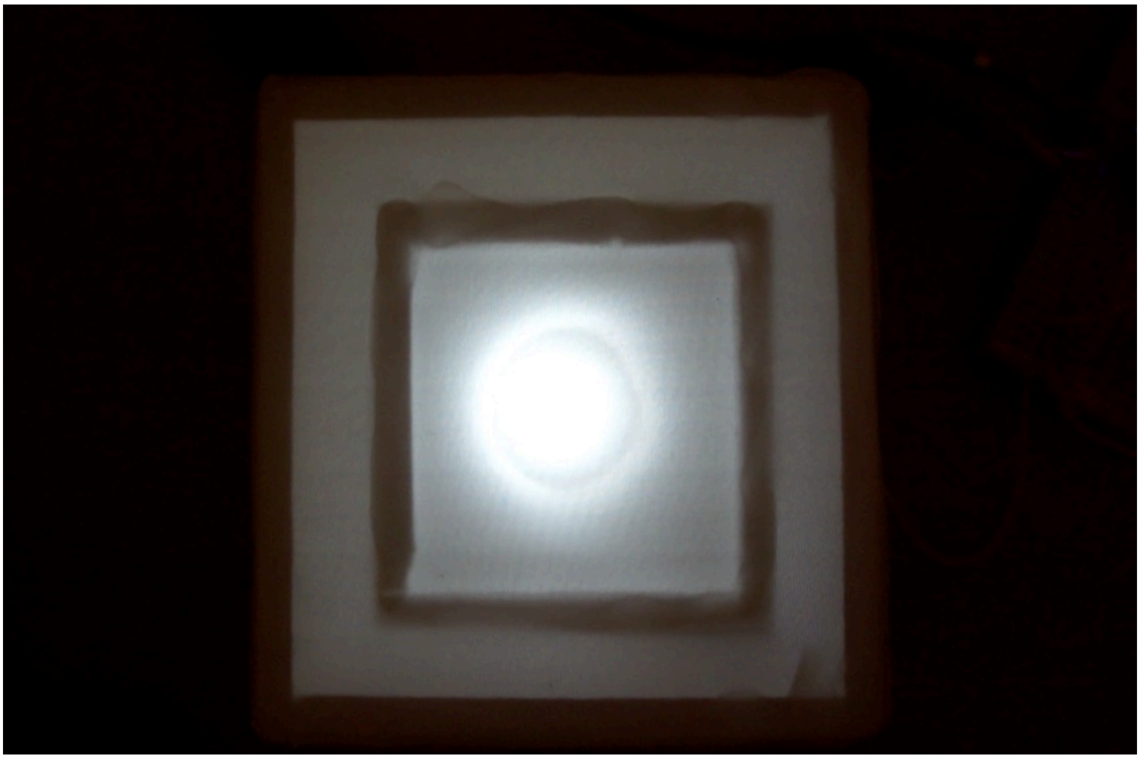
INSTALLATION AT THE MILAN DESIGN FAIR 2013

(Top&Bottom) Exhibiting the Kihou and Inaho in our own booth.

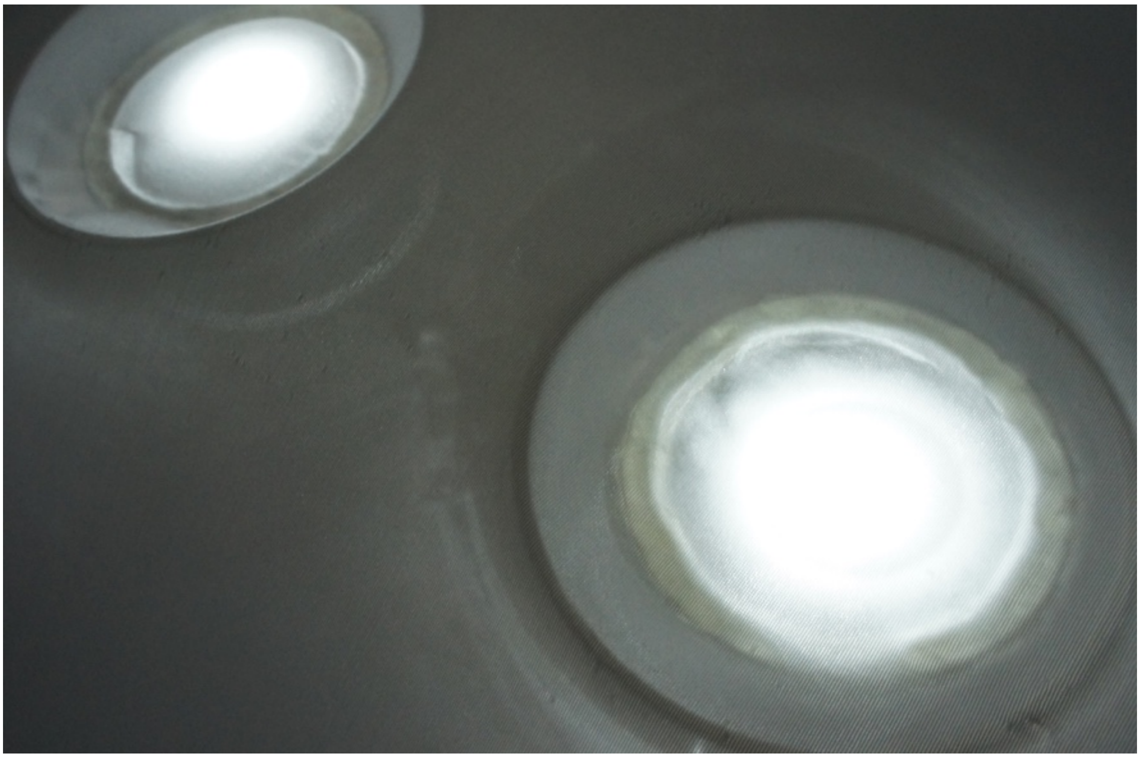
APPENDIX G

SYNC CELLS

PROJECT IMAGES

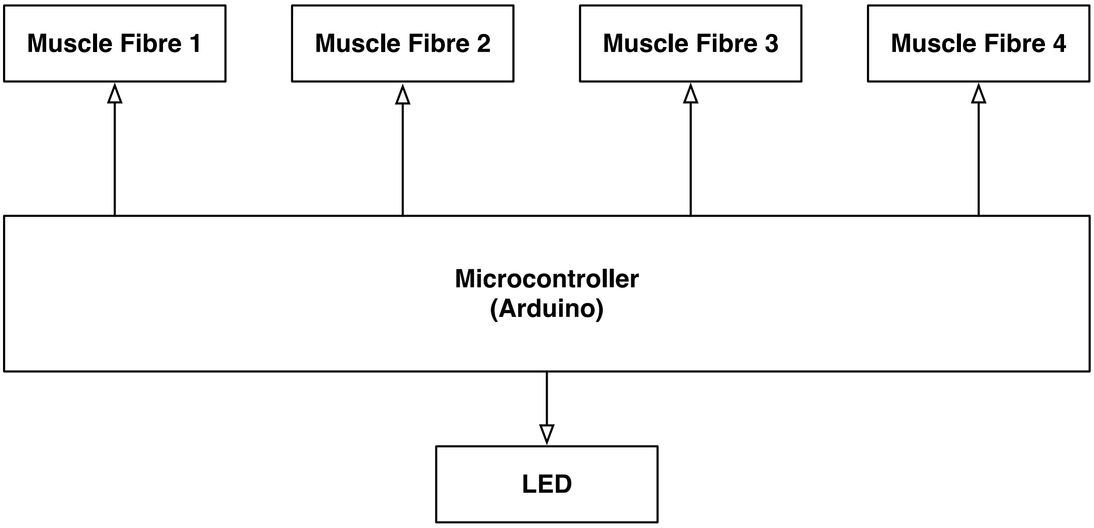


(Top) Firstly testing the idea of putting a light beneath moving elastic fabric.
(Bottom) Overview of the test model.



(Top&Bottom) The test model in motion.

SYSTEM BLOCK DIAGRAM



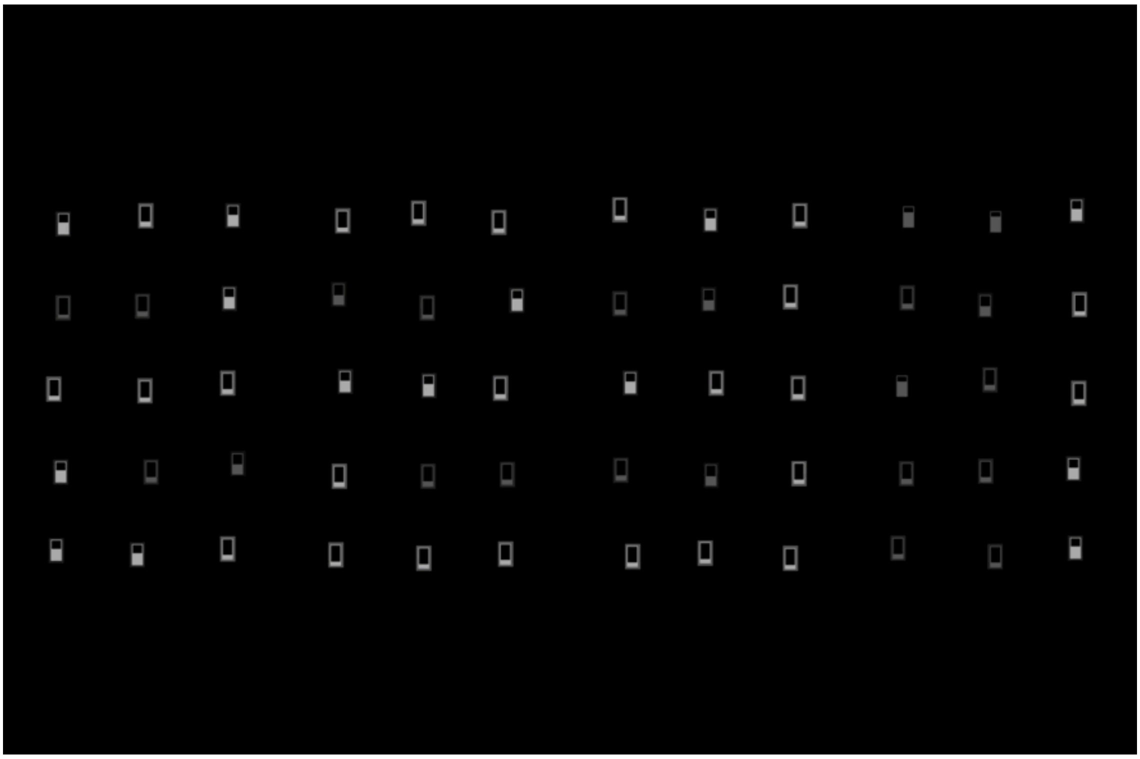
PROGRAM CODE

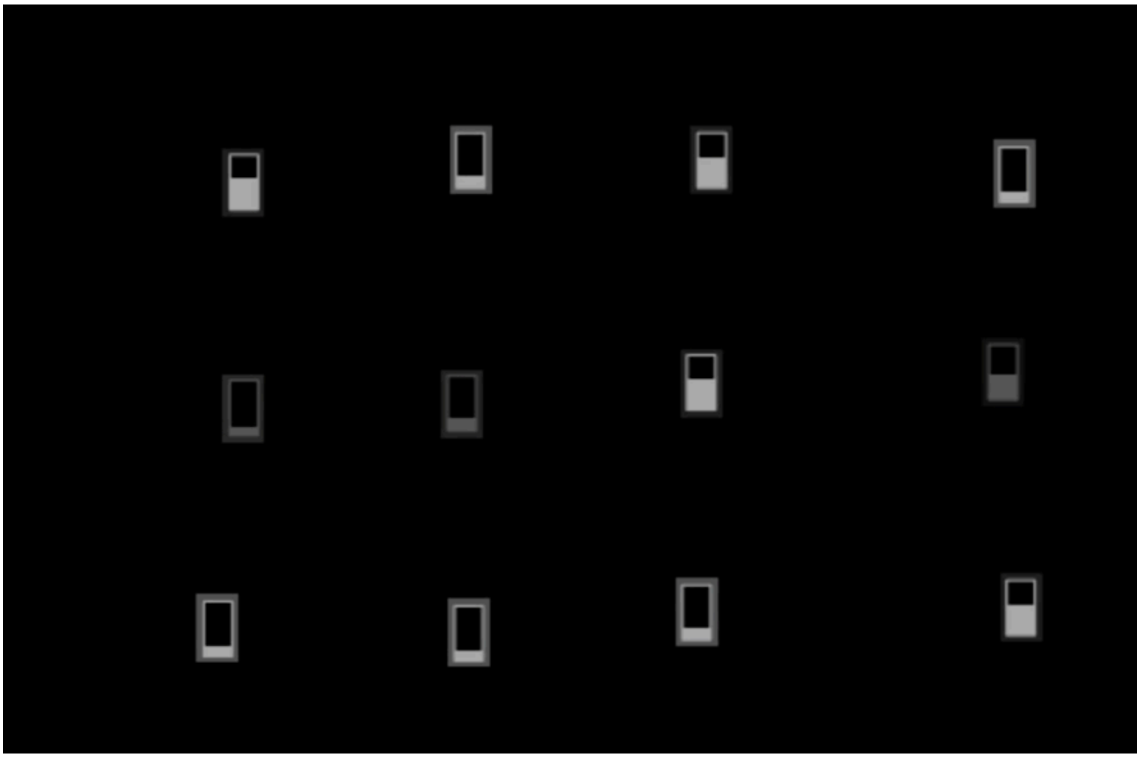
```
/************************************************/
// Project : SYNC CELLS
// Language : Arduino
// Program By : Hideki Yoshimoto
/************************************************/

float omega[4];
float theta[4];
float k;
int n;

unsigned long start;

void setup(){
    pinMode(7,OUTPUT);
    start = millis();

    n = 4;
    k = 0.1;
    dt = 0.1;
    for(int i=0;i<n;i++){
        omega[i] = 0.1 + ofRandom(0.1);
        theta[i] = ofRandom(6.24);
        pinMode(i+2,OUTPUT);
    }
}

void loop(){
    kuramoto();

    for(int i=0;i<n;i++){
        if(theta[i] < 0.1 * PI){
            digitalWrite(i+2,HIGH);
        }
        else{
            digitalWrite(i+2,LOW);
        }
    }

    if(millis() - start > 1000 * 60 * 1){
        omega[i] = 0.1 + ofRandom(0.1);
        theta[i] = ofRandom(6.24);
        start = millis();
    }

    delay(30);
}

void kuramoto(){
    for(int i=0;i<n;i++){
        float s = 0;
        for(int j=0;j<n;j++){
            s += sin(theta[j] - theta[i]);
        }
        theta[i] += dt * (omega[i] + (k / n) * s);
        if(theta[i] >= 2 * PI){
            theta[i] = 0;
        }
    }
}
```

APPENDIX H

SYNC CLOCK

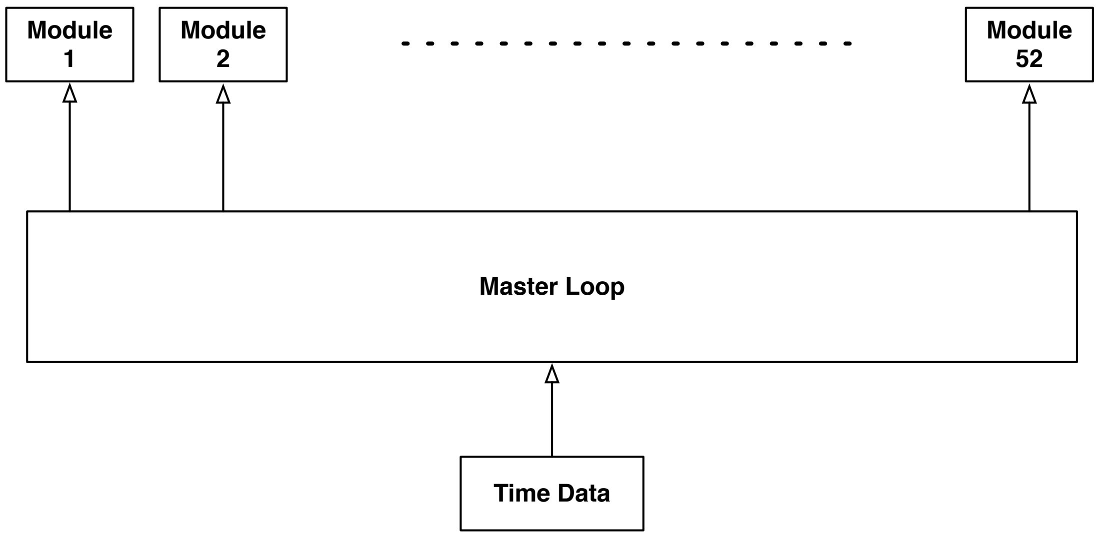
PROJECT IMAGES





(Top) The modules in the process of synchronisation.
(Bottom) Closer look at each module.

SYSTEM BLOCK DIAGRAM



PROGRAM CODE

```
//--------------------------------------------------------------
// Project : SYNC CLOCK
// File : MAIN.CPP
// Language : OPENFRAMEWORKS + OFXUI + OFXXMLSETTING ADDON
// Program By : Hideki Yoshimoto
//--------------------------------------------------------------


#include "testApp.h"
#include "ofAppGlutWindow.h"

//--------------------------------------------------------------
int main(){
      ofAppGlutWindow window; // create a window
      // set width, height, mode (OF_WINDOW or OF_FULLSCREEN)
      ofSetupOpenGL(&window, 1024, 768, OF_WINDOW);
      ofRunApp(new testApp()); // start the app
}
```

```
//--------------------------------------------------------------
// Project : SYNC CLOCK
// File : TESTAPP.CPP
// Language : OPENFRAMEWORKS + OFXUI + OFXXMLSETTING ADDON
// Program By : Hideki Yoshimoto
//--------------------------------------------------------------


#include "testApp.h"

//--------------------------------------------------------------
void testApp::setup(){
    ofBackground(0, 0, 0);
    //ofSetFrameRate(30);
    ofEnableSmoothing();

    ofSetWindowShape(1350, 550);
    ofSetFullscreen(true);
    ofHideCursor();

    width = 1350;//ofGetWindowWidth();
    height = 550;//ofGetWindowHeight();
    interval = 100;
    numW = 12;//width/interval;
    numH = 5;//height/interval;
    numDots = numW * numH;
    myDots = new ofDot*[numDots];

    originalSpeed = 0.001;
    hiccupSpeed = 0.005;
    breakerWeight = 50;
    animationMode = 4;
    syncSpeed = 0.5;
    audioResponse = true;
    showMessage = false;

    for(int i=0;i<numW;i++){
        for(int j=0;j<numH;j++){
            myDots[j*numW+i] = new ofDot(ofGetScreenWidth()/2 - width/2 + 125 + 100 * i,
                                         ofGetScreenHeight()/2 - height/2 + 75 + 100 * j,
                                         6, animationMode, originalSpeed);
```

```
            if(i<3){
                myDots[j*numW+i]->originalX -= 50;
            }
            else if(i<6){
                myDots[j*numW+i]->originalX -= 20;
            }
            else if(i<9){
                myDots[j*numW+i]->originalX += 20;
            }
            else if(i<12){
                myDots[j*numW+i]->originalX += 50;
            }

            myDots[j*numW+i]->setLevel(ofRandom(1));

            if(swimming){
                myDots[j*numW+i]->scatter(100);
            }

            syncDots1.push_back(myDots[j*numW+i]);
        }
    }

    for(int i=0;i<10;i++){
        for(int j=0;j<15;j++){
            if(hourLeft[i][j] != -1){
                hourRight[i][j] = hourLeft[i][j] + 3;
                minuteLeft[i][j] = hourLeft[i][j] + 6;
                minuteRight[i][j] = hourLeft[i][j] + 9;
            }else{
                hourRight[i][j] = -1;
                minuteLeft[i][j] = -1;
                minuteRight[i][j] = -1;
            }
        }
    }

    int bufferSize = 256;
      left.assign(bufferSize, 0.0);
      right.assign(bufferSize, 0.0);
    soundStream.setup(this, 0, 2, 44100, bufferSize, 4);
}

//--------------------------------------------------------------
void testApp::update(){

    if((clockUpdate == 0)&&clockMode){
        //delete elements in sync1,2
        syncDots1.clear();
        syncDots2.clear();

        //time update
        int hl = ofGetHours() / 10;
        int hr = ofGetHours() % 10;
        int ml = ofGetMinutes() / 10;
        int mr = ofGetMinutes() % 10;

        //grouping
        int sync1[52];
        for(int i=0;i<52;i++){
            if(i<13){
                sync1[i] = hourLeft[hl][i];
            }else if(i<26){
                sync1[i] = hourRight[hr][i-13];
            }else if(i<39){
                sync1[i] = minuteLeft[ml][i-26];
            }else if(i<52){
                sync1[i] = minuteRight[mr][i-39];
```

```
            }
        }

        //is the dot included for sync?
        for(int i=0;i<numDots;i++){
            int included = 0;
            int jj=0;
            while(1){
                if(i == sync1[jj]){
                    included = 1;
                    break;
                }
                jj++;
                if(jj == 52){
                    break;
                }
            }
            if(included == 1){
                syncDots1.push_back(myDots[i]);
            }else{
                syncDots2.push_back(myDots[i]);
            }
        }
    }

    int kickups1 = 0;
    for(int i=0;i<syncDots1.size();i++){
        syncDots1[i]->update();
        if(syncDots1[i]->level == 0){
            kickups1++;
        }
    }
    if(kickups1 > 0){
        if(breaker1>0){
            kickup1Update = 0;
        }else{
            if(kickups1 > kickup1Update){
                kickup1Update = kickups1;
            }
            for(int i=0;i<syncDots1.size();i++){
                syncDots1[i]->kickup(syncSpeed * 0.8 * ((float)kickups1/
(float)syncDots1.size()));
                if(syncAlpha){
                    syncDots1[i]->syncAlpha = MIN((float)kickup1Update / (float)numDots
* 1.5 + 0.2,1.0);
                }
            }
        }
    }

    int kickups2 = 0;
    for(int i=0;i<syncDots2.size();i++){
        syncDots2[i]->update();
        if(syncDots2[i]->level == 0){
            kickups2++;
        }
    }
    if(kickups2 > 0){
        if(breaker2>0){
            kickup2Update = 0;
        }else{
            if(kickups2 > kickup2Update){
                kickup2Update = kickups2;
            }
            for(int i=0;i<syncDots2.size();i++){
                syncDots2[i]->kickup(syncSpeed * 0.8 * ((float)kickups2/
(float)syncDots2.size()));
                if(syncAlpha){
```

```
                    syncDots2[i]->syncAlpha = MIN((float)kickup2Update / (float)numDots
                                                + 0.2,0.3);
                }
            }
        }
    }

    if(swimming){
        if(countAfterBreak < 500){
            for(int i=0;i<numDots;i++){
                myDots[i]->gather(0.00005);
            }
        }else if(countAfterBreak < 6000){
            for(int i=0;i<numDots;i++){
                myDots[i]->gather(0.00005 + 0.00001*countAfterBreak/200);
            }
        }else{
            for(int i=0;i<numDots;i++){
                myDots[i]->gather(0.00005 + 0.0003);
            }
        }
    }

    if(breaker1>0){
        breaker1--;
        for(int i=0;i<syncDots1.size();i++){
            syncDots1[i]->breakdown(ofRandom(0.2));
            syncDots1[i]->speed -= (hiccupSpeed - originalSpeed)/breakerWeight;
            float currentAlpha = syncDots1[i]->syncAlpha;
            syncDots1[i]->syncAlpha = MAX(0.2,currentAlpha-0.02);
            if(swimming){
                syncDots1[i]->scatter(breaker1);
            }
        }
    }
    if(breaker2>0){
        breaker2--;
        for(int i=0;i<syncDots2.size();i++){
            syncDots2[i]->breakdown(ofRandom(0.2));
            syncDots2[i]->speed -= (hiccupSpeed - originalSpeed)/breakerWeight;
            float currentAlpha = syncDots2[i]->syncAlpha;
            syncDots2[i]->syncAlpha = MAX(0.2,currentAlpha-0.02);
            if(swimming){
                syncDots2[i]->scatter(breaker2);
            }

        }
    }

    if((breaker1 > 0)||(breaker2 > 0)){
        countAfterBreak = 0;
    }
    if((breaker1 == 0)&&(breaker2 == 0)){
        countAfterBreak++;
    }

    clockUpdate++;
    if(clockUpdate == 500){
        clockUpdate = 0;
    }

}

//--------------------------------------------------------------
void testApp::draw(){
    for(int i=0;i<numDots;i++){
        myDots[i]->draw();
    }
```

```
    if(showMessage){
        ofEnableAlphaBlending();
        ofSetColor(0, 0, 0, 50);
        ofRect(0, 0, width, height);
        ofDisableAlphaBlending();
        ofSetColor(255);
        ofDrawBitmapString("Press '1 - 4' to change the animation mode. The current
setting is: " + ofToString(animationMode),20,30);
        ofDrawBitmapString("Press '<' or '>' to change the time to synchronise. The
current setting is: " + ofToString(syncSpeed),20,50);
        ofDrawBitmapString("Press 'C' to toggle the clock mode. The current setting is:
" + ofToString(clockMode),20,70);
        ofDrawBitmapString("Press 'A' to toggle the alpha animation. The current setting
is: " + ofToString(syncAlpha),20,90);
        ofDrawBitmapString("Press 'S' to toggle the swimming animation. The current
setting is: " + ofToString(swimming),20,110);
        ofDrawBitmapString("Press 'R' to toggel the audio response. The current setting
is: " + ofToString(audioResponse),20,130);
    }
}

//--------------------------------------------------------------
void testApp::keyPressed(int key){

    if(key == '1'){
        animationMode = 1;
        for(int i=0;i<numDots;i++){
            myDots[i]->shape = 1;
        }
    }else if(key == '2'){
        animationMode = 2;
        for(int i=0;i<numDots;i++){
            myDots[i]->shape = 2;
        }
    }else if(key == '3'){
        animationMode = 3;
        for(int i=0;i<numDots;i++){
            myDots[i]->shape = 3;
        }
    }else if(key == '4'){
        animationMode = 4;
        for(int i=0;i<numDots;i++){
            myDots[i]->shape = 4;
        }
    }else if(key == ' '){
        breaker1 = breakerWeight;
        breaker2 = breakerWeight;
        for(int i=0;i<numDots;i++){
            myDots[i]->speed = hiccupSpeed;
        }
    }else if(key == 'c'){
        breaker1 = breakerWeight;
        breaker2 = breakerWeight;
        for(int i=0;i<numDots;i++){
            myDots[i]->speed = hiccupSpeed;
        }
        if(clockMode){
            clockMode = false;
            syncDots1.clear();
            syncDots2.clear();
            for(int i=0;i<numDots;i++){
                syncDots1.push_back(myDots[i]);
            }
        }else{
            clockMode = true;
        }
    }else if(key == ','){
```

```
        if(syncSpeed > 0.1){
            syncSpeed -= 0.1;
        }
    }else if(key == '.'){
        if(syncSpeed < 1.0){
            syncSpeed += 0.1;
        }
    }else if(key == 'a'){
        if(syncAlpha){
            syncAlpha = false;
            for(int i=0;i<numDots;i++){
                myDots[i]->syncAlpha = 1.0;
            }
        }else{
            syncAlpha = true;
        }
    }else if(key == 's'){
        if(swimming){
            swimming = false;
            for(int i=0;i<numDots;i++){
                myDots[i]->x = myDots[i]->originalX;
                myDots[i]->y = myDots[i]->originalY;
            }
        }else{
            swimming = true;
        }
    }else if(key == 'r'){
        if(audioResponse){
            audioResponse = false;
        }else{
            audioResponse = true;
        }
    }else if(key == 'h'){
        if(showMessage){
            showMessage = false;
        }else{
            showMessage = true;
        }
    }else if(key == 'f'){
        ofToggleFullscreen();
    }

}

//--------------------------------------------------------------
void testApp::keyReleased(int key){

}

//--------------------------------------------------------------
void testApp::mouseMoved(int x, int y){

}

//--------------------------------------------------------------
void testApp::mouseDragged(int x, int y, int button){

}

//--------------------------------------------------------------
void testApp::mousePressed(int x, int y, int button){

}

//--------------------------------------------------------------
void testApp::mouseReleased(int x, int y, int button){

}
```

```
//--------------------------------------------------------------
void testApp::windowResized(int w, int h){

}

//--------------------------------------------------------------
void testApp::gotMessage(ofMessage msg){

}

//--------------------------------------------------------------
void testApp::dragEvent(ofDragInfo dragInfo){

}

//--------------------------------------------------------------
void testApp::audioIn(float * input, int bufferSize, int nChannels){

	float curVol = 0.0;

	// samples are "interleaved"
	int numCounted = 0;

	//lets go through each sample and calculate the root mean square which is a rough
way to calculate volume
	for (int i = 0; i < bufferSize; i++){
		left[i]		= input[i*2]*0.5;
		right[i]	= input[i*2+1]*0.5;

		curVol += left[i] * left[i];
		curVol += right[i] * right[i];
		numCounted+=2;
	}

	//this is how we get the mean of rms :)
	curVol /= (float)numCounted;

	// this is how we get the root of rms :)
	curVol = sqrt( curVol );

	smoothedVol *= 0.93;
	smoothedVol += 0.07 * curVol;

    if(audioResponse){
        if(smoothedVol > 0.02){
            breaker1 = breakerWeight;
            breaker2 = breakerWeight;
            for(int i=0;i<numDots;i++){
                myDots[i]->speed = hiccupSpeed;
            }
        }
    }
}



//--------------------------------------------------------------
// Project : SYNC CLOCK
// File : TESTAPP.H
// Language : OPENFRAMEWORKS + OFXUI + OFXXMLSETTING ADDON
// Program By : Hideki Yoshimoto
//--------------------------------------------------------------


#pragma once
```

```
#include "ofMain.h"
#include "ofDot.h"

class testApp : public ofBaseApp{
	public:
		void setup();
		void update();
		void draw();

		void keyPressed(int key);
		void keyReleased(int key);
		void mouseMoved(int x, int y);
		void mouseDragged(int x, int y, int button);
		void mousePressed(int x, int y, int button);
		void mouseReleased(int x, int y, int button);
		void windowResized(int w, int h);
		void dragEvent(ofDragInfo dragInfo);
		void gotMessage(ofMessage msg);
	    void audioIn(float * input, int bufferSize, int nChannels);

    vector <float> left;
    vector <float> right;
    float smoothedVol;
    int bufferCounter;
    ofSoundStream soundStream;

    private:

    int width;
    int height;
    int numW;
    int numH;
    int interval;
    int animationMode;
    bool audioResponse;
    bool showMessage;

    int numDots;
    ofDot** myDots;
    vector<ofDot*> syncDots1;
    vector<ofDot*> syncDots2;

    int breaker1;
    int breaker2;
    int countAfterBreak;
    int kickup1Update = 0;
    int kickup2Update = 0;
    int breakerWeight;
    float originalSpeed;
    float hiccupSpeed;

    int hourLeft[10][13] = {{0,1,2,12,14,24,26,36,38,48,49,50,-1}, //0
                            {2,14,26,38,50,62,-1,-1,-1,-1,-1,-1,-1}, //1
                            {0,1,2,14,24,25,26,36,48,49,50,-1,-1}, //2
                            {0,1,2,14,24,25,26,38,48,49,50,-1,-1}, //3
                            {0,2,12,14,24,25,26,38,50,-1,-1,-1,-1}, //4
                            {0,1,2,12,24,25,26,38,48,49,50,-1,-1}, //5
                            {0,1,2,12,24,25,26,36,38,48,49,50,-1}, //6
                            {0,1,2,14,26,38,50,-1,-1,-1,-1,-1,-1}, //7
                            {0,1,2,12,14,24,25,26,36,38,48,49,50}, //8
                            {0,1,2,12,14,24,25,26,38,48,49,50,-1},}; //9
    int hourRight[10][15];
    int minuteLeft[10][15];
    int minuteRight[10][15];

    int clockUpdate;
    bool clockMode = true;
    float syncSpeed;
```

```
    bool syncAlpha = true;
    bool swimming = true;
};




//----------------------------------------------------------------
// Project : SYNC CLOCK
// File : OFDOT.CPP
// Language : OPENFRAMEWORKS + OFXUI + OFXXMLSETTING ADDON
// Program By : Hideki Yoshimoto
//----------------------------------------------------------------


#include "ofDot.h"

ofDot::ofDot(float _x, float _y, float _radius, int _shape, float _speed){
    x = _x;
    y = _y;
    originalX = _x;
    originalY = _y;
    radius = _radius;
    shape = _shape;
    speed = _speed;
    syncAlpha = 0.2;
}

void ofDot::update(){
    level += speed;
    if(level > 1.0){
        level = 0.0;
    }
}

void ofDot::kickup(float _kickupAmount){
    if(level > 0.0){
        level += _kickupAmount;
    }
    if(level > 1.0){
        level = 0.0;
    }
}

void ofDot::breakdown(float _breakdownAmount){
    level += _breakdownAmount;
    if(level > 1.0){
        level = 0.0;
    }
}

void ofDot::draw(){
    alpha = (MAX(0, 0.8 - level))/0.8 * syncAlpha;
    updatedRadius = radius;

    if(shape == 1){
        ofSetColor((int)(255 * alpha),(int)(255 * alpha),(int)(255 * alpha));
        ofCircle(x, y, updatedRadius);
    }
    if(shape == 2){
        ofSetColor((int)(255 * alpha),(int)(255 * alpha),(int)(255 * alpha));
        ofRect(x - radius, y - radius, radius * 2, radius * 4);
    }
    if(shape == 3){
        ofSetColor((int)(255 * syncAlpha),(int)(255 * syncAlpha),(int)(255 *
syncAlpha));
        ofNoFill();
        ofRect(x - radius, y - radius, radius * 2, radius * 4);
```

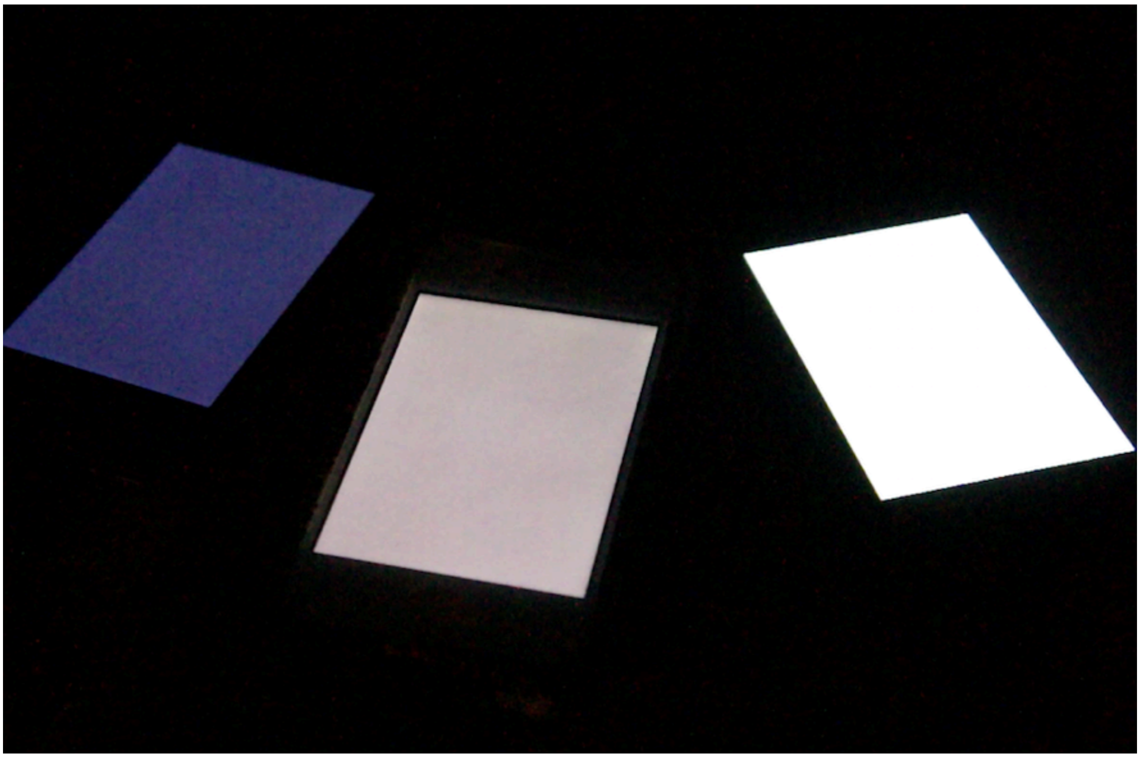
```
        ofFill();
        ofRect(x - radius, y - radius + radius * 4 * (1.0 - level), radius * 2, radius *
4 * level);
    }
    if(shape == 4){
        ofSetColor((int)(155 * alpha),(int)(155 * alpha),(int)(155 * alpha));
        ofRect(x - radius*1.5, y - radius*1.5, radius * 3, radius * 5);

        ofSetColor(0,0,0);
        ofRect(x - radius, y - radius, radius * 2, radius * 4);

        ofSetColor((int)(255 * syncAlpha),(int)(255 * syncAlpha),(int)(255 *
syncAlpha));
        ofNoFill();
        ofRect(x - radius, y - radius, radius * 2, radius * 4);

        ofFill();
        ofRect(x - radius, y - radius + radius * 4 * (1.0 - level), radius * 2, radius *
4 * level);
    }

}

void ofDot::setLevel(float _level){
    level = _level;
}

void ofDot::setSpeed(float _speed){
    speed = _speed;
}

void ofDot::scatter(float _amount){
    x += ofRandom(_amount*2) - _amount;
    y += ofRandom(_amount*2) - _amount;
}

void ofDot::gather(float _gatherSpeed){
    x = (originalX - x)*_gatherSpeed + x;
    y = (originalY - y)*_gatherSpeed + y;

    x += ofRandom(0.2) - 0.1;
    y += ofRandom(0.2) - 0.1;
}



//--------------------------------------------------------------
// Project : SYNC CLOCK
// File : OFDOT.H
// Language : OPENFRAMEWORKS + OFXUI + OFXXMLSETTING ADDON
// Program By : Hideki Yoshimoto
//--------------------------------------------------------------


#ifndef __sync_exp1__ofDot__
#define __sync_exp1__ofDot__

#include "ofMain.h"

class ofDot{

    public:

    void update();
    void draw();
    void kickup(float kickupAmount);
```

```
    void breakdown(float breakdownAmount);
    void setLevel(float level);
    void setSpeed(float speed);
    void scatter(float amount);
    void gather(float gatherSpeed);

    ofDot(float x, float y, float radius, int shape, float speed);

    float level;
    float speed;
    float x;
    float y;
    float originalX;
    float originalY;
    float radius;
    int shape; //1:circle 2:rectangle
    float syncAlpha;

    private:
    float alpha;
    float updatedRadius;
};

#endif /* defined(__sync_exp1__ofDot__) */
```

APPENDIX I

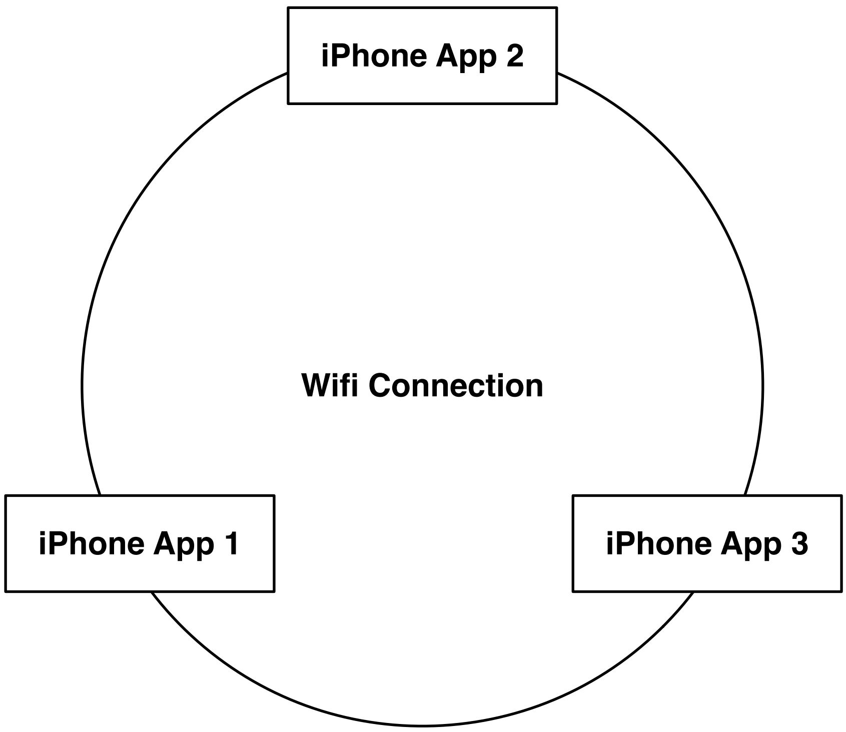
IPHONE ORCHESTRA

PROJECT IMAGES



(Top&Bottom) Testing the idea with three iPhones.

SYSTEM BLOCK DIAGRAM (VERSION 1)



PROGRAM CODE (VERSION 1)

```
//----------------------------------------------------------------
// Project : IPHONE ORCHESTRA VERSION 1
// File : MAIN.MM
// Language : OPENFRAMEWORKS + OFXOSC ADDON
// Program : Hideki Yoshimoto
//----------------------------------------------------------------


#include "ofMain.h"
#include "testApp.h"

int main(){
	ofSetupOpenGL(1024,768, OF_FULLSCREEN);
	ofRunApp(new testApp());
}




//----------------------------------------------------------------
// Project : IPHONE ORCHESTRA VERSION 1
// File : TESTAPP.MM
// Language : OPENFRAMEWORKS + OFXOSC ADDON
// Program : Hideki Yoshimoto
//----------------------------------------------------------------


#include "testApp.h"

//----------------------------------------------------------------
void testApp::setup(){

	ofBackground(0, 0, 0);
    receiver.setup( PORT );
    SQ.start();

    ofSetFrameRate(60);
}

//----------------------------------------------------------------
void testApp::update(){

	while( receiver.hasWaitingMessages() ){
			ofxOscMessage m;
			receiver.getNextMessage( &m );
        if(m.getAddress() == "/beat"){
            SQ.oscReport(0);
        }
        else if(m.getAddress() == "/sync"){
            SQ.oscReport(1);
        }

	}
}

//----------------------------------------------------------------
void testApp::draw(){
    SQ.draw();

}

//----------------------------------------------------------------
void testApp::exit(){
    SQ.stop();
```

```
}

//--------------------------------------------------------------




//--------------------------------------------------------------
// Project : IPHONE ORCHESTRA VERSION 1
// File : TESTAPP.H
// Language : OPENFRAMEWORKS + OFXOSC ADDON
// Program : Hideki Yoshimoto
//--------------------------------------------------------------


#pragma once

#include "ofMain.h"
#include "ofxiPhone.h"
#include "ofxiPhoneExtras.h"
#include "sequencer.h"
#include "ofxOsc.h"

#define PORT 12345

class testApp : public ofxiPhoneApp{

public:
	void setup();
	void update();
	void draw();

    void exit();

    int width;
    int height;

    float rt;
    float gt;
    float bt;
    float rb;
    float gb;
    float bb;

    float rl;
    float gl;
    float bl;

    sequencer SQ;
    ofSoundPlayer synthP;

    ofxOscReceiver receiver;
};




//--------------------------------------------------------------
// Project : IPHONE ORCHESTRA VERSION 1
// File : MYCIRCLE.CPP
// Language : OPENFRAMEWORKS + OFXOSC ADDON
// Program : Hideki Yoshimoto
//--------------------------------------------------------------


#include "myCircle.h"

myCircle::myCircle(){
```

```
    count = 0;
    speed = 1;
}

void myCircle::update(){

}

void myCircle::draw(){

    a -= aspeed;

    if(a < 0){
        a = 0;
    }

    ofEnableAlphaBlending();
    ofEnableSmoothing();
    //ofSetColor(0,0,0,0);
    //ofRect(0,0,320,480);
    ofSetColor(100,100,100,100);
    ofRect(0,0,320,480);
    ofDisableAlphaBlending();
    ofDisableSmoothing();

}

void myCircle::disappear(){
    a = 0;
}

void myCircle::appear(float _radius, int _white){
    a = 200;

    if(_white == 0){
        r = (int)ofRandom(70) + 150;
        g = (int)ofRandom(70) + 150;
        b = (int)ofRandom(70) + 150;
        aspeed = 4;
    }
    else if(_white == 1){
        r = 220;
        g = 220;
        b = 220;
        aspeed = 4;
    }
}



//--------------------------------------------------------------
// Project : IPHONE ORCHESTRA VERSION 1
// File : MYCIRCLE.H
// Language : OPENFRAMEWORKS + OFXOSC ADDON
// Program : Hideki Yoshimoto
//--------------------------------------------------------------


#ifndef __fireflyIOS__myCircle__
#define __fireflyIOS__myCircle__

#include <iostream>
#include "ofMain.h"

class myCircle{

public:
```

```
    void update();
    void draw();

    void disappear();
    void appear(float _radius, int _white);

    myCircle();

    int r;
    int g;
    int b;
    int a;
    int aspeed;

    float x;
    float y;
    float radius;

    int count;
    int speed;

};

#endif /* defined(__laptopOrchestra__myCircle__) */




//--------------------------------------------------------------
// Project : IPHONE ORCHESTRA VERSION 1
// File : SEQUENCER.H
// Language : OPENFRAMEWORKS + OFXOSC ADDON
// Program : Hideki Yoshimoto
//--------------------------------------------------------------


#ifndef fireflyOrchestra_sequencer_h
#define fireflyOrchestra_sequencer_h
#include "ofMain.h"
#include "ofxiPhone.h"
#include "ofxiPhoneExtras.h"
#include "ofxOsc.h"
#include "myCircle.h"

#define M_HOST "192.168.0.8"
#define M_PORT 12345

class sequencer: public ofThread {

public:

    bool soundCaught;
    unsigned long sungTime;
    unsigned long sound1Time;
    unsigned long sound2Time;
    int timeTo1;
    int timeTo2;
    int loopTime;
    int defaultLoop;
    int deadTime;

    int soundCounter;
    bool sync;
    int syncCounter;
    int partnerCounter;
    bool partner;
```

```
float vol;
float volLimit;
ofSoundPlayer d;
ofSoundPlayer f;
ofSoundPlayer a;
ofSoundPlayer hd;
ofSoundPlayer he;
ofSoundPlayer hf;
ofSoundPlayer ha;
ofSoundPlayer hds;

bool sqBool[15];
int sqNotes[15];
int sqCounter;
int noteCount;
int noteMax;
int sqStartRemove;
bool reported;

vector<myCircle*> circles;

ofxOscSender sender;

sequencer() {
    volLimit = 0.008;

    sungTime = 0;
    defaultLoop = 2800;
    loopTime = defaultLoop;
    soundCounter = 0;
    timeTo1 = -1;

    sync = false;
    syncCounter = 0;
    sqCounter = 0;
    for(int i=0;i<15;i++){
        sqNotes[i] = 0;
    }
    noteMax = 4;
    sqStartRemove = 1000;//(int)ofRandom(40, 60);

    for(int i=0;i<17;i++){
        circles.push_back(new myCircle());
        circles[i]->disappear();
    }

    sender.setup(M_HOST, M_PORT);
    reported = false;
}

void start(){
    hds.loadSound("sounds/HDs.caf");
    hds.setVolume(1.0f);
    hds.setMultiPlay(true);

    hd.loadSound("sounds/HD.caf");
    hd.setVolume(1.0f);
    hd.setMultiPlay(true);
    he.loadSound("sounds/HE.caf");
    he.setVolume(1.0f);
    he.setMultiPlay(true);
    hf.loadSound("sounds/HF.caf");
    hf.setVolume(1.0f);
    hf.setMultiPlay(true);
    ha.loadSound("sounds/HA.caf");
    ha.setVolume(1.0f);
    ha.setMultiPlay(true);
    d.loadSound("sounds/D.caf");
```

```
    d.setVolume(1.0f);
    d.setMultiPlay(true);
    f.loadSound("sounds/F.caf");
    f.setVolume(1.0f);
    f.setMultiPlay(true);
    a.loadSound("sounds/A.caf");
    a.setVolume(1.0f);
    a.setMultiPlay(true);

    startThread(true, false);

    ofxOscMessage m;
    m.setAddress("/report");
    m.addIntArg(1);
    sender.sendMessage(m);
}

void stop(){
    stopThread();
}

void oscReport(int m){
    if(m == 0){
        timeTo1 = ofGetElapsedTimeMillis() - sungTime;
        if(sync != true){
          sungTime = ofGetElapsedTimeMillis();
            sync = true;
        }
    }
    if(m == 1){
        sync = true;
        syncCounter = 0;
        loopTime = defaultLoop;

        if(sync != true){
            sungTime = ofGetElapsedTimeMillis();
            sync = true;
        }
    }
}

void breakRhythm(){
    if(sync){
        sungTime = 0;
        defaultLoop = 2800;
        loopTime = (int)ofRandom(20,36) * 100 + 7000;
        soundCounter = 0;
        timeTo1 = -1;

        sync = false;
        syncCounter = 0;
        sqCounter = 0;
        for(int i=0;i<15;i++){
            sqNotes[i] = 0;
        }
        noteCount = 0;
        reported = false;
    }
}

void threadedFunction() {
    while( isThreadRunning() != 0 ){
        if( lock() ){
            sequence();
            unlock();
            ofSleepMillis(2);
        }
    }
```

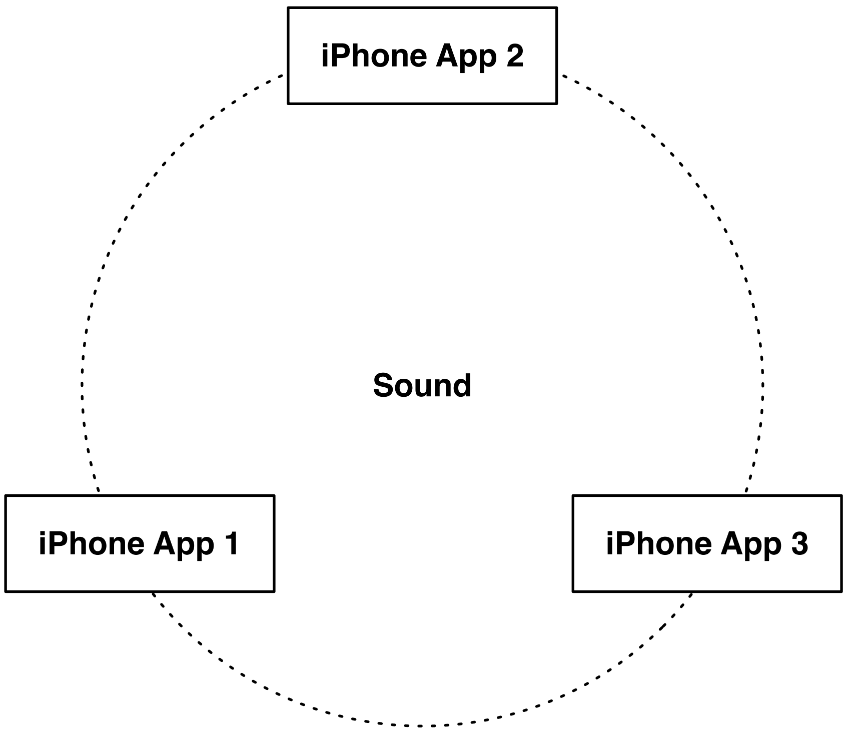
```
}

void sequence() {

    if(ofGetElapsedTimeMillis() - sungTime > loopTime){

        if(sync){
            hd.play();
            circles[0]->appear(15,0);

            sqCounter++;
            if(sqCounter < sqStartRemove){
                if((sqCounter > 2)&&(sqCounter%2 == 0)){
                    if(noteCount < noteMax){
                        addNote();
                    }else{
                        changeNote();
                    }
                }
            }
            else{
                if((sqCounter%2 == 0)&&(noteCount > 0)){
                    removeNote();
                }
                if(noteCount == 0){
                    breakRhythm();
                }
            }
            sungTime = ofGetElapsedTimeMillis();
            soundCounter++;
            for(int i=0;i<15;i++){
                sqBool[i] = true;
            }
        }
    }

    if(sync){
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 1){
            if(sqBool[0]){
                playNote(0);
                sqBool[0] = false;
            }
        }
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 2){
            if(sqBool[1]){
                playNote(1);
                sqBool[1] = false;
            }
        }
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 3){
            if(sqBool[2]){
                playNote(2);
                sqBool[2] = false;
            }
        }
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 4){
            if(sqBool[3]){
                playNote(3);
                sqBool[3] = false;
            }
        }
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 5){
            if(sqBool[4]){
                playNote(4);
                sqBool[4] = false;
            }
        }
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 6){
```

```
            if(sqBool[5]){
                playNote(5);
                sqBool[5] = false;
            }
        }
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 7){
            if(sqBool[6]){
                playNote(6);
                sqBool[6] = false;
            }
        }
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 8){
            if(sqBool[7]){
                playNote(7);
                sqBool[7] = false;
            }
        }
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 9){
            if(sqBool[8]){
                playNote(8);
                sqBool[8] = false;
            }
        }
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 10){
            if(sqBool[9]){
                playNote(9);
                sqBool[9] = false;
            }
        }
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 11){
            if(sqBool[10]){
                playNote(10);
                sqBool[10] = false;
            }
        }
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 12){
            if(sqBool[11]){
                playNote(11);
                sqBool[11] = false;
            }
        }
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 13){
            if(sqBool[12]){
                playNote(12);
                sqBool[12] = false;
            }
        }
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 14){
            if(sqBool[13]){
                playNote(13);
                sqBool[13] = false;
            }
        }
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 15){
            if(sqBool[14]){
                playNote(14);
                sqBool[14] = false;
            }
        }
    }

}

void addNote(){
    int noteID = (int)ofRandom(-0.1, 6.9) + 1;
    int pos = (int)ofRandom(-0.1, 14.9);
    sqNotes[pos] = noteID;
    int currentNoteCount = 0;
```

```
    for(int i=0;i<15;i++){
        if(sqNotes[i] > 0){
            currentNoteCount++;
        }
    }
    noteCount = currentNoteCount;
}

void changeNote(){
    int noteID = (int)ofRandom(-0.1, 6.9) + 1;
    int pos;
    while(1){
        pos= (int)ofRandom(-0.1, 14.9);
        if(sqNotes[pos] > 0){
            break;
        }
    }
    sqNotes[pos] = noteID;
}

void removeNote(){
    int pos;
    while(1){
        pos= (int)ofRandom(-0.1, 14.9);
        if(sqNotes[pos] > 0){
            break;
        }
    }
    sqNotes[pos] = 0;
    int currentNoteCount = 0;
    for(int i=0;i<15;i++){
        if(sqNotes[i] > 0){
            currentNoteCount++;
        }
    }
    noteCount = currentNoteCount;
}


void playNote(int pos){
    int radius;
    switch(sqNotes[pos]){
        case 0:
            ;
            break;
        case 1:
            d.play();
            radius = 30;
            break;
        case 2:
            f.play();
            radius = 25;
            break;
        case 3:
            a.play();
            radius = 20;
            break;
        case 4:
            hd.play();
            radius = 15;
            break;
        case 5:
            he.play();
            radius = 13;
            break;
        case 6:
            hf.play();
            radius = 11;
```

```
                break;
            case 7:
                ha.play();
                radius = 9;
                break;
            default:
                ;
                break;
        }
        if(sqNotes[pos] > 0){
            circles[pos+1]->appear(radius, 0);
        }
    }

    void draw(){
        for(int i=0;i<16;i++){
            circles[i]->draw();
        }

    }

};


#endif
```

SYSTEM BLOCK DIAGRAM (VERSION 2)



PROGRAM CODE (VERSION 2)

```
//--------------------------------------------------------------
// Project : IPHONE ORCHESTRA VERSION 2
// File : MAIN.MM
// Language : OPENFRAMEWORKS
// Program By : Hideki Yoshimoto
//--------------------------------------------------------------


#include "ofMain.h"
#include "testApp.h"

int main(){
      ofSetupOpenGL(1024,768, OF_FULLSCREEN);
      ofRunApp(new testApp());
}
```

```
//--------------------------------------------------------------
// Project : IPHONE ORCHESTRA VERSION 2
// File : TESTAPP.MM
// Language : OPENFRAMEWORKS
// Program By : Hideki Yoshimoto
//--------------------------------------------------------------


#include "testApp.h"

//--------------------------------------------------------------
void testApp::setup(){

    width = 1350;
    height = 850;
    ofSetWindowShape(width, height);
      ofBackground(0, 0, 0);
    rt = 0;
    gt = 0;
    bt = 0;
    rb = 0;
    gb = 0;
    bb = 0;

    rl = ofRandom(200,235);
    gl = ofRandom(200,235);
    bl = ofRandom(200,235);

      //for some reason on the iphone simulator 256 doesn't work - it comes in as 512!
      //so we do 512 - otherwise we crash
      initialBufferSize = 512;
      sampleRate = 44100;
      drawCounter = 0;
      bufferCounter = 0;
    smoothedVol = 0;

    SQ.start();

      buffer = new float[initialBufferSize];
      memset(buffer, 0, initialBufferSize * sizeof(float));

      // 0 output channels,
      // 1 input channels
      // 44100 samples per second
      // 512 samples per buffer
```

```
        // 4 num buffers (latency)
        ofSoundStreamSetup(0, 1, this, sampleRate, initialBufferSize, 4);
        ofSetFrameRate(60);

    ofHideCursor();
    ofSetFullscreen(true);
}

//--------------------------------------------------------------
void testApp::update(){

    if(SQ.sync){
        rt += 0.1;
        gt += 0.1;
        bt += 0.1;
        if(rt > 254){
            rt = 255;
        }
        if(gt > 254){
            gt = 255;
        }
        if(bt > 254){
            bt = 255;
        }

        rb += 0.1;
        gb += 0.1;
        bb += 0.1;
        if(rb > rl){
            rb = rl;
        }
        if(gb > gl){
            gb = gl;
        }
        if(bb > bl){
            bb = bl;
        }

    }else{
        rt -= 1;
        gt -= 1;
        bt -= 1;
        if(rt < 0){
            rt = 0;
        }
        if(gt < 0){
            gt = 0;
        }
        if(bt < 0){
            bt = 0;
        }

        rb -= 1;
        gb -= 1;
        bb -= 1;
        if(rb < 0){
            rb = 0;
        }
        if(gb < 0){
            gb = 0;
        }
        if(bb < 0){
            bb = 0;
        }
    }

    SQ.volReport(smoothedVol);
    //ofSoundUpdate();
```

```
}

//--------------------------------------------------------------
void testApp::draw(){

    ofBackgroundGradient(ofColor((int)rt,(int)gt,(int)bt),ofColor((int)rb,(int)gb,
(int)bb), OF_GRADIENT_LINEAR);
    if(SQ.sqCounter < 4){
        ofSetColor(255 - 50 * SQ.sqCounter, 255 - 50 * SQ.sqCounter, 255 - 50 *
SQ.sqCounter);
        for(int i = 0; i < initialBufferSize; i++){
            ofLine(i * width / initialBufferSize, height/2, i * width /
initialBufferSize, height/2 + buffer[i] * 300.0f);
        }
    }

    SQ.draw();
}

//--------------------------------------------------------------
void testApp::exit(){
    SQ.stop();
}

//--------------------------------------------------------------
void testApp::keyPressed(int key){
    SQ.breakRhythm();
}

//--------------------------------------------------------------
void testApp::audioIn(float * input, int bufferSize, int nChannels){
    if(initialBufferSize != bufferSize){
        ofLog(OF_LOG_ERROR, "your buffer size was set to %i - but the stream needs a
buffer size of %i", initialBufferSize, bufferSize);
        return;
    }

    float curVol = 0.0;
    int numCounted = 0;

    // samples are "interleaved"
    for(int i = 0; i < bufferSize; i++){
        buffer[i] = input[i];
        curVol += input[i] * input[i];
        numCounted++;
    }
    //bufferCounter++;

    curVol /= (float)numCounted;
    curVol = sqrt( curVol );

    smoothedVol *= 0.93;
    smoothedVol += 0.07 * curVol;
}



//--------------------------------------------------------------
// Project : IPHONE ORCHESTRA VERSION 2
// File : TESTAPP.H
// Language : OPENFRAMEWORKS
// Program By : Hideki Yoshimoto
//--------------------------------------------------------------


#pragma once
```

```
#include "ofMain.h"
#include "sequencer.h"

class testApp : public ofBaseApp{

public:
      void setup();
      void update();
      void draw();

    void exit();
    void keyPressed(int key);

      void audioIn(float * input, int bufferSize, int nChannels);

      int       initialBufferSize;
      int       sampleRate;
      int       drawCounter;
    int bufferCounter;
      float * buffer;
    float smoothedVol;

    int width;
    int height;

    sequencer SQ;
    float rt;
    float gt;
    float bt;
    float rb;
    float gb;
    float bb;

    float rl;
    float gl;
    float bl;
};



//----------------------------------------------------------------
// Project : IPHONE ORCHESTRA VERSION 2
// File : MYCIRCLE.CPP
// Language : OPENFRAMEWORKS
// Program By : Hideki Yoshimoto
//----------------------------------------------------------------


#include "myCircle.h"

myCircle::myCircle(){
    count = 0;
    speed = 1;
}

void myCircle::update(){

}

void myCircle::draw(){

    a -= aspeed;

    if(a < 0){
        a = 0;
    }
```

```
    ofEnableAlphaBlending();
    ofEnableSmoothing();
    //ofSetColor(0,0,0,0);
    //ofRect(0,0,320,480);
    ofSetColor(100,100,100,100);
    ofRect(0,0,320,480);
    ofDisableAlphaBlending();
    ofDisableSmoothing();

}

void myCircle::disappear(){
    a = 0;
}

void myCircle::appear(float _radius, int _white){
    a = 200;

    if(_white == 0){
        r = (int)ofRandom(70) + 150;
        g = (int)ofRandom(70) + 150;
        b = (int)ofRandom(70) + 150;
        aspeed = 4;
    }
    else if(_white == 1){
        r = 220;
        g = 220;
        b = 220;
        aspeed = 4;
    }
}



//--------------------------------------------------------------
// Project : IPHONE ORCHESTRA VERSION 2
// File : MYCIRCLE.H
// Language : OPENFRAMEWORKS
// Program By : Hideki Yoshimoto
//--------------------------------------------------------------


#ifndef __fireflyIOS__myCircle__
#define __fireflyIOS__myCircle__

#include <iostream>
#include "ofMain.h"

class myCircle{

public:

    void update();
    void draw();

    void disappear();
    void appear(float _radius, int _white);

    myCircle();

    int r;
    int g;
    int b;
    int a;
    int aspeed;

    float x;
```

```
    float y;
    float radius;

    int count;
    int speed;

};

#endif /* defined(__laptopOrchestra__myCircle__) */




//--------------------------------------------------------------
// Project : IPHONE ORCHESTRA VERSION 2
// File : SEQUENCER.CPP
// Language : OPENFRAMEWORKS
// Program By : Hideki Yoshimoto
//--------------------------------------------------------------


#include "myCircle.h"

class sequencer: public ofThread {

public:

    bool soundCaught;
    unsigned long sungTime;
    unsigned long sound1Time;
    unsigned long sound2Time;
    int timeTo1;
    int timeTo2;
    int loopTime;
    int defaultLoop;
    int deadTime;

    int soundCounter;
    bool sync;
    int syncCounter;
    int partnerCounter;
    bool partner;

    float vol;
    float volLimit;
    ofSoundPlayer d;
    ofSoundPlayer f;
    ofSoundPlayer a;
    ofSoundPlayer hd;
    ofSoundPlayer he;
    ofSoundPlayer hf;
    ofSoundPlayer ha;
    ofSoundPlayer hds;

    bool sqBool[15];
    int sqNotes[15];
    int sqCounter;
    int noteCount;
    int noteMax;

    vector<myCircle*> circles;

    sequencer() {
        volLimit = 0.008;

        soundCaught = false;
        sungTime = 0;
        sound1Time = 0;
```

```
    sound2Time = 0;
    defaultLoop = 2800;
    loopTime = defaultLoop;
    soundCounter = 0;
    deadTime = 130;

    sync = false;
    syncCounter = 0;
    partner = false;
    partnerCounter = 0;
    sqCounter = 0;
    for(int i=0;i<15;i++){
        sqNotes[i] = 0;
    }
    noteMax = 6;

    for(int i=0;i<16;i++){
        circles.push_back(new myCircle());
        circles[i]->disappear();
    }
}

void start(){
    hds.loadSound("sounds/HDs.aif");
    hds.setVolume(1.0f);
    hds.setMultiPlay(true);

    hd.loadSound("sounds/HD.aif");
    hd.setVolume(1.0f);
    hd.setMultiPlay(true);
    he.loadSound("sounds/HE.aif");
    he.setVolume(1.0f);
    he.setMultiPlay(true);
    hf.loadSound("sounds/HF.aif");
    hf.setVolume(1.0f);
    hf.setMultiPlay(true);
    ha.loadSound("sounds/HA.aif");
    ha.setVolume(1.0f);
    ha.setMultiPlay(true);
    d.loadSound("sounds/D.aif");
    d.setVolume(1.0f);
    d.setMultiPlay(true);
    f.loadSound("sounds/F.aif");
    f.setVolume(1.0f);
    f.setMultiPlay(true);
    a.loadSound("sounds/A.aif");
    a.setVolume(1.0f);
    a.setMultiPlay(true);

    startThread(true, false);
}

void stop(){
    stopThread();
}

void volReport(float smoothedVol){
    vol = smoothedVol;
}

void breakRhythm(){
    if(sync){
        soundCaught = false;
        sungTime = 0;
        sound1Time = 0;
        sound2Time = 0;
        defaultLoop = 2800;
        loopTime = defaultLoop;
```

```
        soundCounter = 0;
        partner = false;
        partnerCounter = 0;
        sync = false;
        syncCounter = 0;
        sqCounter = 0;
        for(int i=0;i<15;i++){
            sqNotes[i] = 0;
        }
        noteCount = 0;
    }
}

void threadedFunction() {
    while( isThreadRunning() != 0 ){
        if( lock() ){
            sequence();
            unlock();
            ofSleepMillis(2); // tweak this to a tolerable resolution
        }
    }
}

void sequence() {

    //printf("%ld\n",ofGetElapsedTimeMillis() - sungTime);

    if(ofGetElapsedTimeMillis() - sungTime > loopTime){

        if(sound1Time > sungTime){
            timeTo1 = sound1Time - sungTime;
        }else{
            timeTo1 = -1;
        }

        if(sound2Time > sungTime){
            timeTo2 = ofGetElapsedTimeMillis() - sound2Time;
        }else{
            timeTo2 = -1;
        }

        if(timeTo1 > 0){
            partnerCounter++;
            if(partnerCounter == 3){
                partner = true;
                partnerCounter = 0;
            }
        }else{
            partnerCounter = 0;
        }

        if(partner){
            if(!sync){
                if(timeTo1 > 0){
                    if(soundCounter%2 == 0){
                        if(timeTo2 > 0){
                            if(timeTo2 < timeTo1){//oo1oo2o
                                loopTime -= timeTo2/2;
                            }else{//o1oo2oo
                                loopTime += timeTo1/2;
                            }
                        }else{
                            if(timeTo1 < defaultLoop/2){//oo1oooo
                                loopTime += timeTo1/2;
                            }else{//oooo1oo
                                loopTime -= (defaultLoop - timeTo1)/2;
                            }
                        }
```

```
                }else{
                    loopTime = defaultLoop;
                }
                syncCounter = 0;
            }else{//no other sound heard
                loopTime = defaultLoop;
                syncCounter++;
                if(syncCounter == 2){
                    ///////////SYNC/////////
                    sync = true;
                    syncCounter = 0;
                }
            }
        }
    }

    //soundMake
    if(!sync){
        hds.play();
    }else{
        hd.play();
        circles[0]->appear(15);

        sqCounter++;
        if((sqCounter > 4)&&(sqCounter%2 == 0)){
            if(noteCount < noteMax){
                addNote();
            }else{
                changeNote();
            }
        }
    }

    sungTime = ofGetElapsedTimeMillis();
    soundCounter++;

    for(int i=0;i<15;i++){
        sqBool[i] = true;
    }

}

if(ofGetElapsedTimeMillis() - sungTime > deadTime){
    if(vol > volLimit){
        if(!soundCaught){

            //catch!!
            //printf("%f\n",vol);

            if(sound1Time <= sungTime){
                sound1Time = ofGetElapsedTimeMillis();
            }else{
                sound2Time = ofGetElapsedTimeMillis();
            }
        }
        soundCaught = true;
    }else{
        soundCaught = false;
    }
}else{
    soundCaught = true;
}

if(sync){
    if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 1){
        if(sqBool[0]){
            playNote(0);
            sqBool[0] = false;
```

```
        }
    }
    if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 2){
        if(sqBool[1]){
            playNote(1);
            sqBool[1] = false;
        }
    }
    if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 3){
        if(sqBool[2]){
            playNote(2);
            sqBool[2] = false;
        }
    }
    if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 4){
        if(sqBool[3]){
            playNote(3);
            sqBool[3] = false;
        }
    }
    if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 5){
        if(sqBool[4]){
            playNote(4);
            sqBool[4] = false;
        }
    }
    if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 6){
        if(sqBool[5]){
            playNote(5);
            sqBool[5] = false;
        }
    }
    if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 7){
        if(sqBool[6]){
            playNote(6);
            sqBool[6] = false;
        }
    }
    if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 8){
        if(sqBool[7]){
            playNote(7);
            sqBool[7] = false;
        }
    }
    if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 9){
        if(sqBool[8]){
            playNote(8);
            sqBool[8] = false;
        }
    }
    if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 10){
        if(sqBool[9]){
            playNote(9);
            sqBool[9] = false;
        }
    }
    if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 11){
        if(sqBool[10]){
            playNote(10);
            sqBool[10] = false;
        }
    }
    if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 12){
        if(sqBool[11]){
            playNote(11);
            sqBool[11] = false;
        }
    }
```

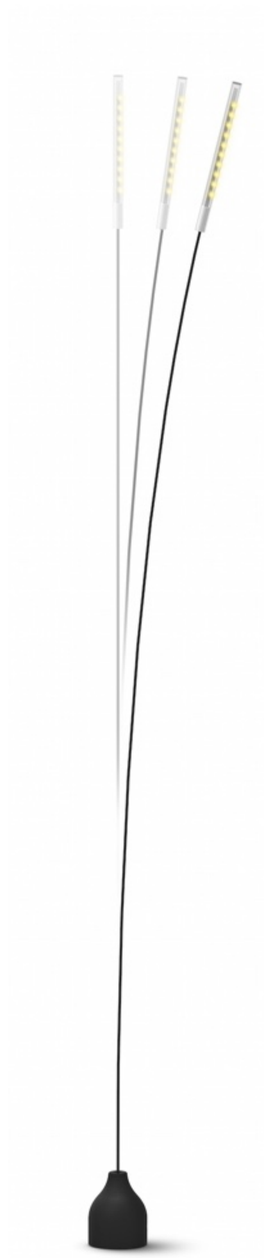
```
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 13){
            if(sqBool[12]){
                playNote(12);
                sqBool[12] = false;
            }
        }
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 14){
            if(sqBool[13]){
                playNote(13);
                sqBool[13] = false;
            }
        }
        if(ofGetElapsedTimeMillis() - sungTime > defaultLoop/16 * 15){
            if(sqBool[14]){
                playNote(14);
                sqBool[14] = false;
            }
        }
    }

}

void addNote(){
    int noteID = (int)ofRandom(-0.1, 6.9) + 1;
    int pos = (int)ofRandom(-0.1, 14.9);
    sqNotes[pos] = noteID;
    int currentNoteCount = 0;
    for(int i=0;i<15;i++){
        if(sqNotes[i] > 0){
            currentNoteCount++;
        }
    }
    noteCount = currentNoteCount;
}

void changeNote(){
    int noteID = (int)ofRandom(-0.1, 6.9) + 1;
    int pos;
    while(1){
        pos= (int)ofRandom(-0.1, 14.9);
        if(sqNotes[pos] > 0){
            break;
        }
    }
    sqNotes[pos] = noteID;
}

void playNote(int pos){
    int radius;
    switch(sqNotes[pos]){
        case 0:
            ;
            break;
        case 1:
            d.play();
            radius = 30;
            break;
        case 2:
            f.play();
            radius = 25;
            break;
        case 3:
            a.play();
            radius = 20;
            break;
        case 4:
            hd.play();
            radius = 15;
```

```
                break;
            case 5:
                he.play();
                radius = 13;
                break;
            case 6:
                hf.play();
                radius = 11;
                break;
            case 7:
                ha.play();
                radius = 9;
                break;
            default:
                ;
                break;
        }
        if(sqNotes[pos] > 0){
            circles[pos+1]->appear(radius);
        }
    }

    void draw(){
        //ofDrawBitmapString("Caught: " + ofToString(soundCaught),70,400);
        for(int i=0;i<16;i++){
            circles[i]->draw();
        }
    }
};

#endif
```

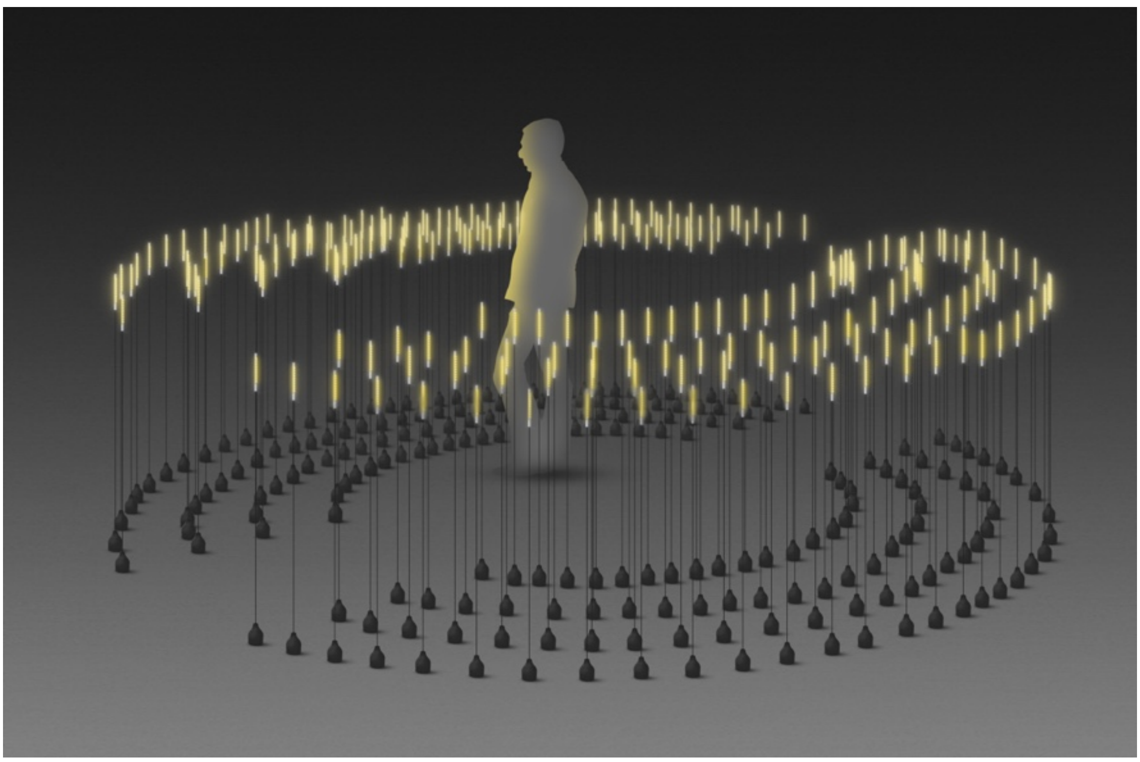
APPENDIX J

INAHO

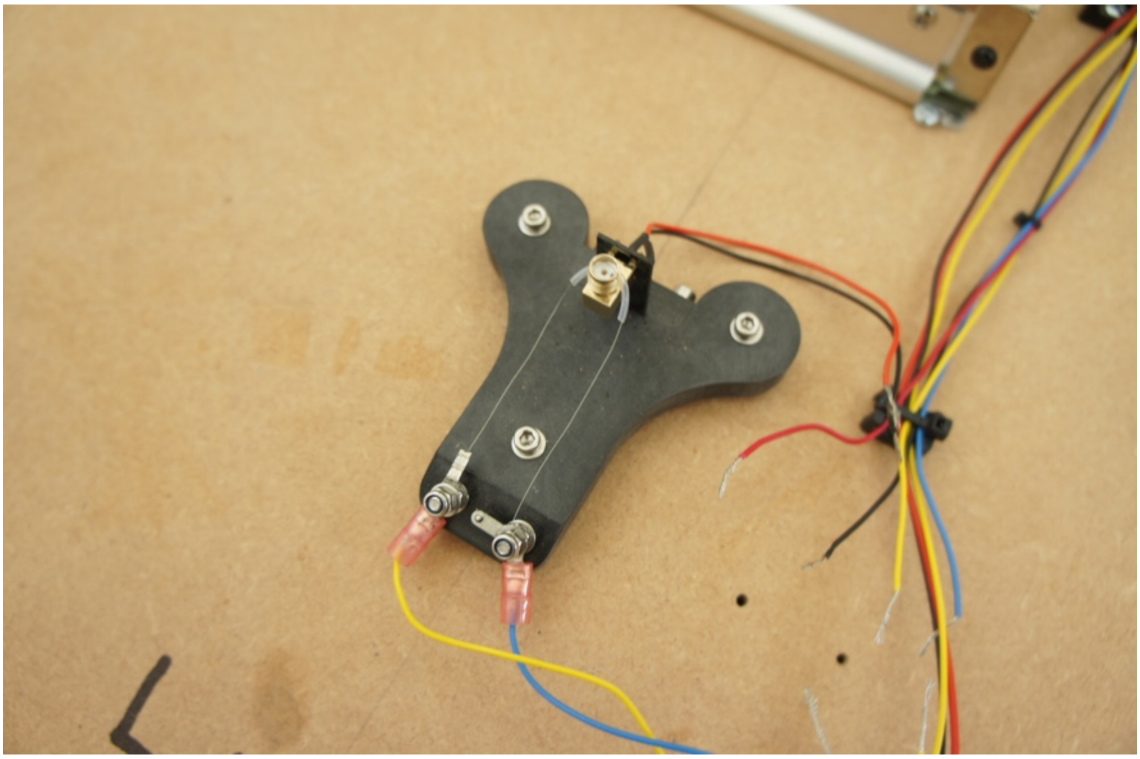
PROJECT IMAGES

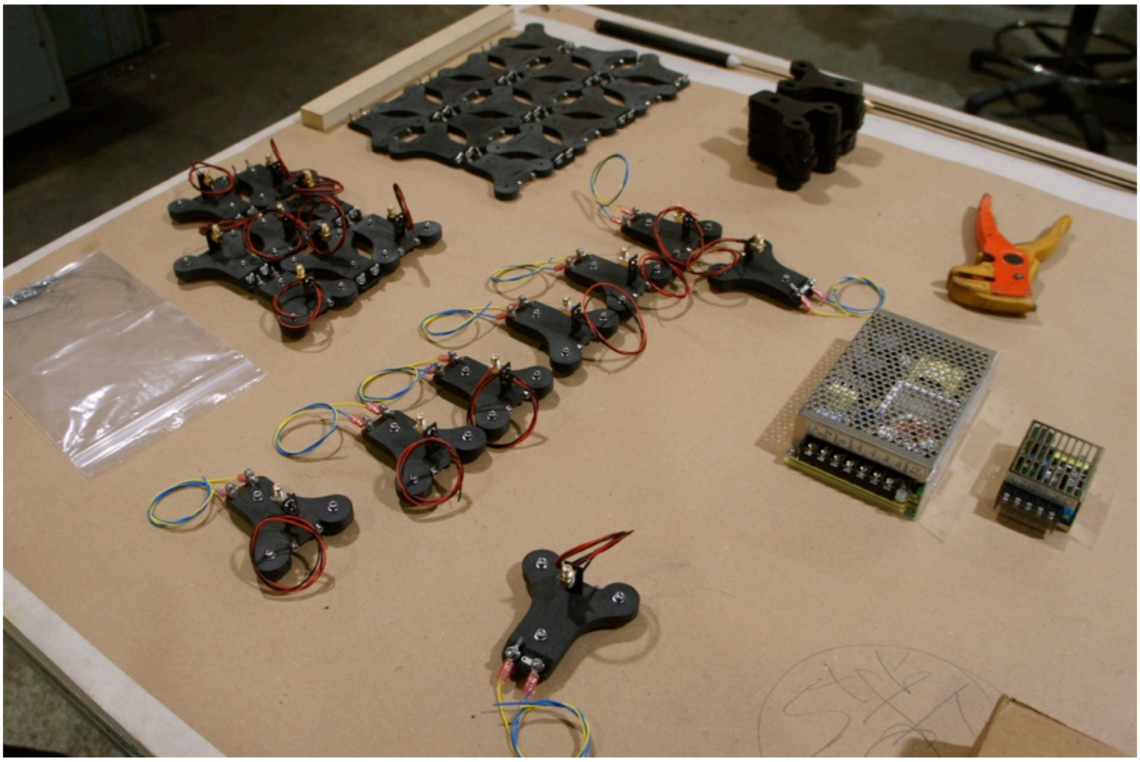


(Left) The first technical prototype.
(Right) The initial sketch of the idea.

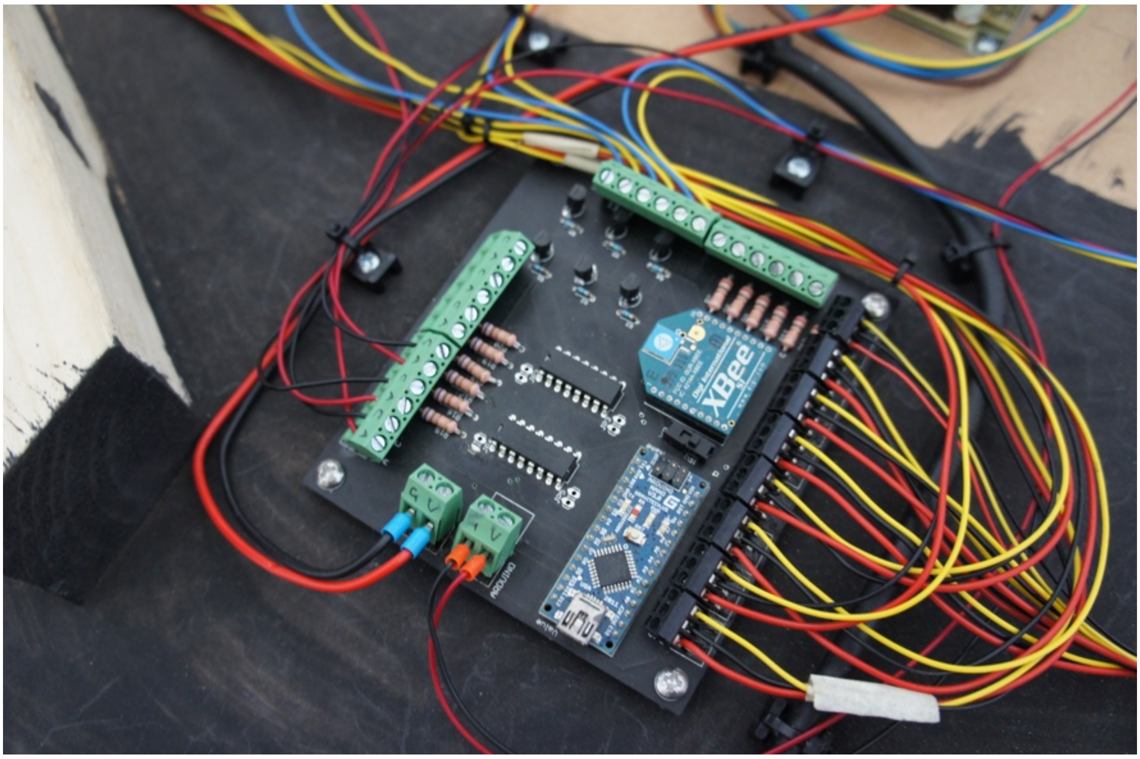


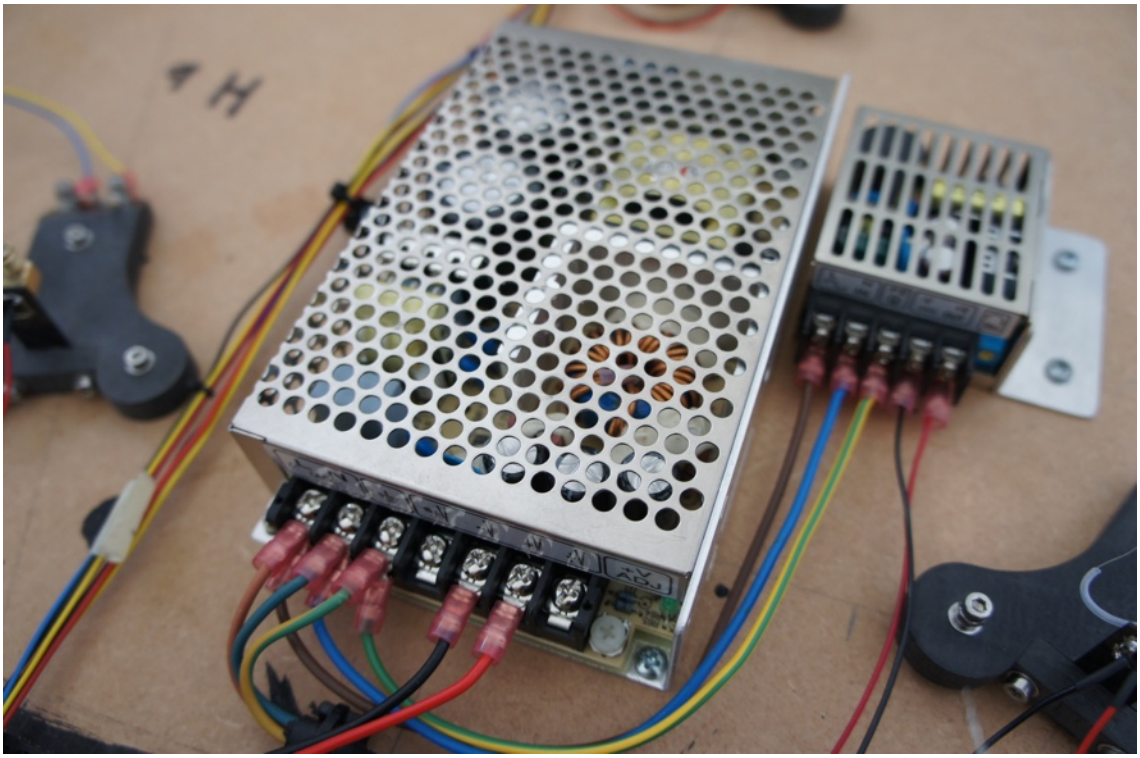
(Top) The initial sketch of the idea - mechanism.
(Bottom) The initial sketch of the idea - installation.



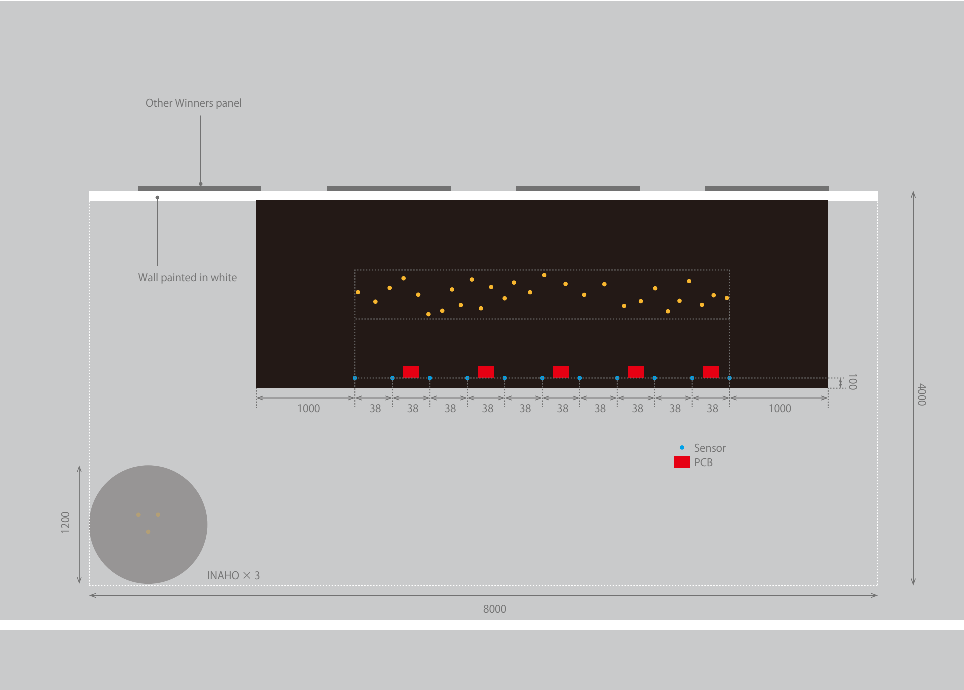


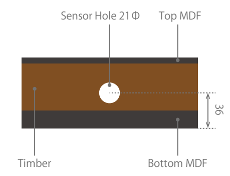
(Top&Bottom) The actuating part with artificial muscle fibre.





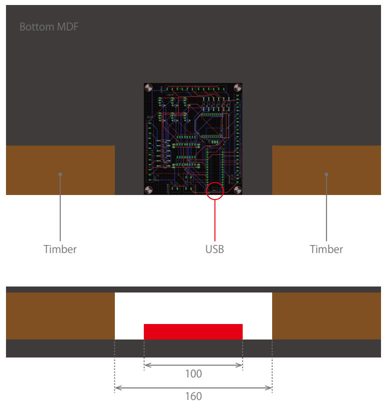
(Top) Custom-made circuit board.
(Bottom) Power supply units.





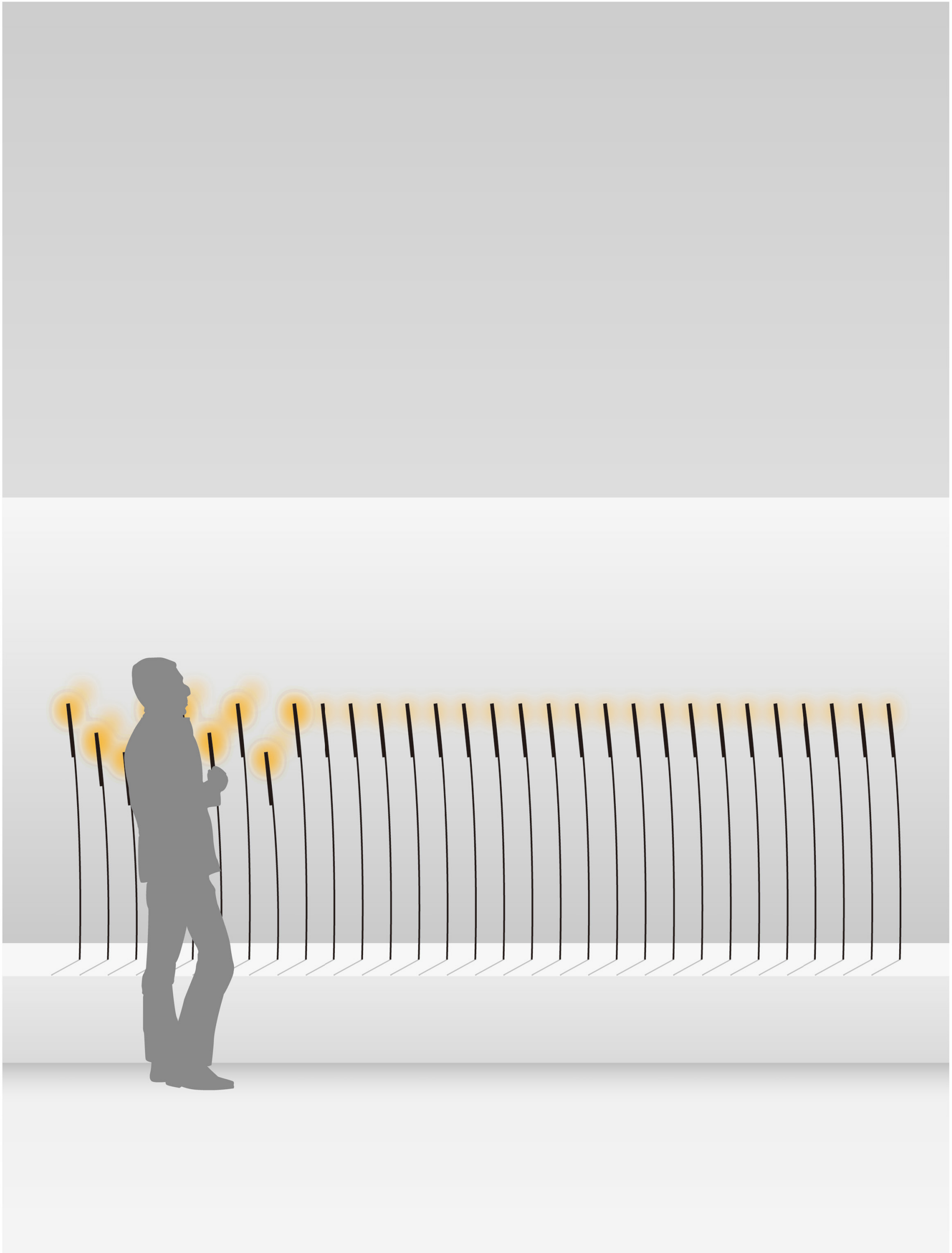
Sensor settings

The sensor (Panasonic AMN23111) is attached with a 3D printed housing.



PCB settings (The placement can be flexible according to the MDF cutting pattern)

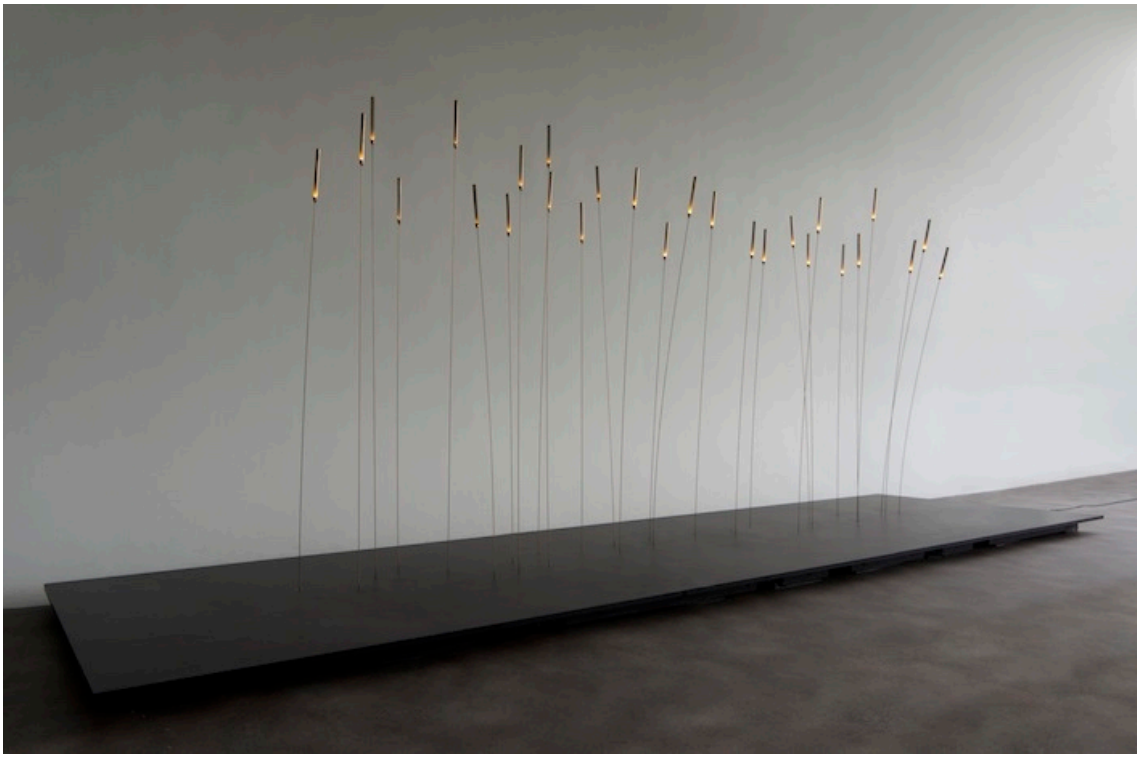
The technical instructions for installation.



INAHO

Previous Plan - Plural

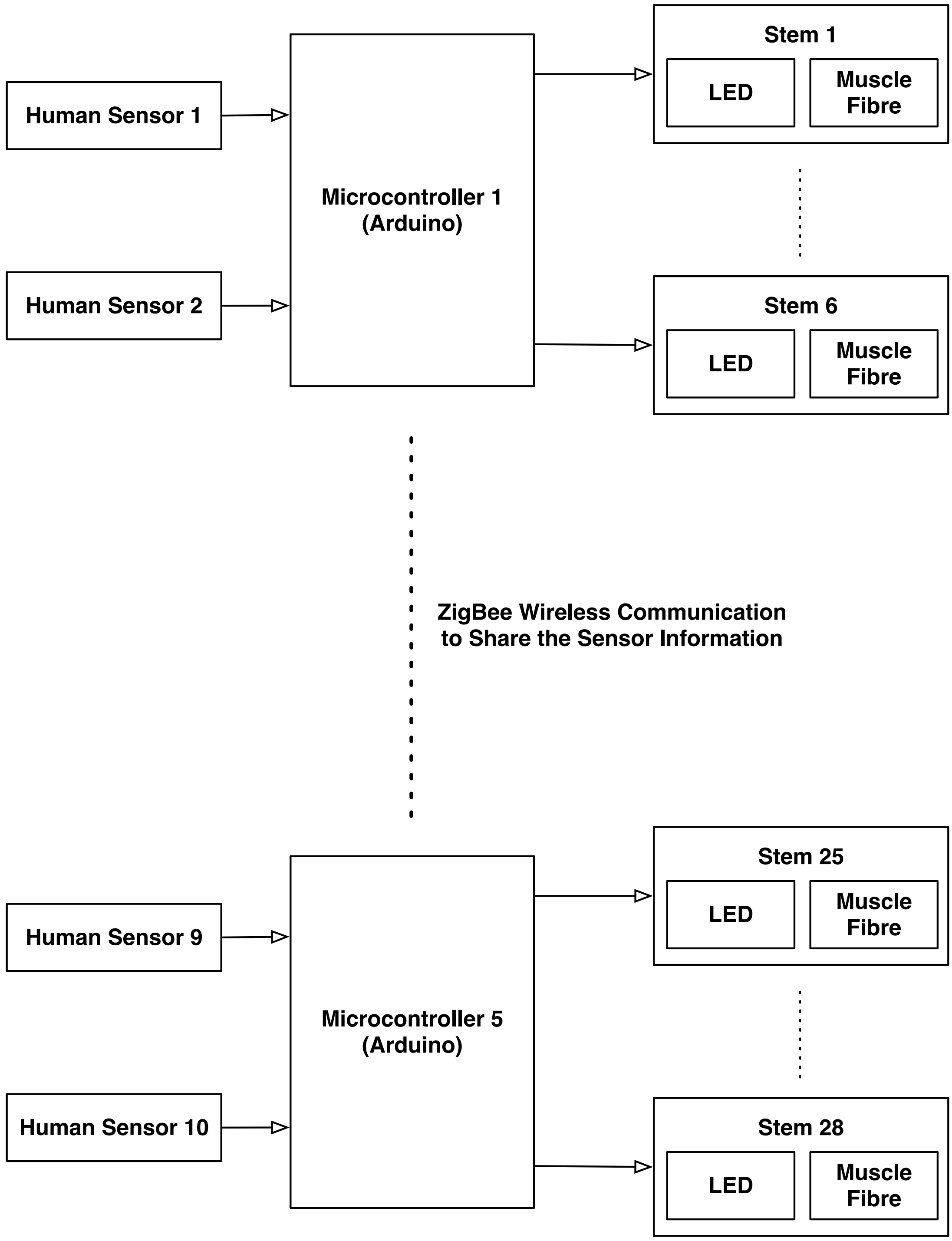
Early sketch of the installation.



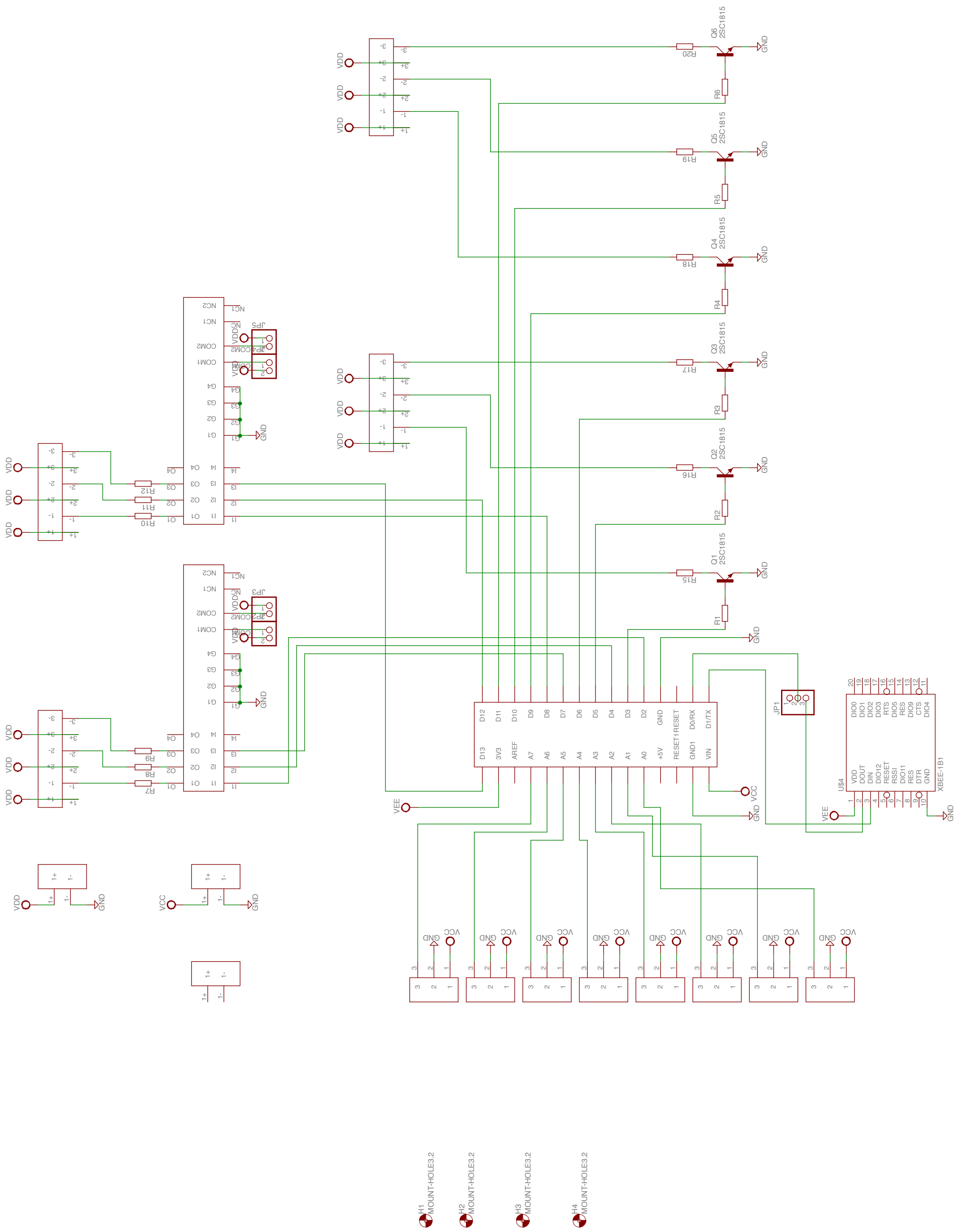
(Top&Bottom) Exhibition in New York.

(Top) Exhibition in New York.
(Bottom) Exhibition in London, at a restaurant.

SYSTEM BLOCK DIAGRAM



CIRCUIT BOARD SCHEMATICS



PROGRAM CODE

```
/**************************************************/
// Project : INAHO BOARD 1
// Language : Arduino
// Program By : Hideki Yoshimoto
/**************************************************/


//*********** ID ***********
int myID = 0;
int myLED1 = 0;
int myLED2 = 1;
int myLED3 = 1;

int LED1Pins[] = {
    3,5,6};
int LED1PinSize = 3;
int LED2Pins[] = {
    9,10,11};
int LED2PinSize = 3;

int motion1Pins[] = {
    2,4,7};
int motion1PinSize = 3;
int motion2Pins[] = {
    8,12,13};
int motion2PinSize = 3;

int LED3Pins[] = {
    0};
int LED3PinSize = 0;
int motion3Pins[] = {
    0};
int motion3PinSize = 0;


//*********** TUNING ***********
float LEDStep = 0.1;
unsigned long motionDelayLimit = 1000;
int countLimit = 30; //sensor
unsigned long sensorInterval = 50;
int motionCountLimit = 30;
int LEDCountLimit = 15;
int zeroCountLimit = 80;

//*********** SENSOR ***********
int sensor1;
int sensor2;
int sensor3;

int sensorSmoothed1;
int sensorSmoothed2;
int sensorSmoothed3;

int count;

int flg1 = 0;
int flg2 = 0;
int flg3 = 0;
int flgs[11];

unsigned long sensorStart;

int inByte;
int inFlg1 = 0;
```

```
int inFlg2 = 0;
int inFlg3 = 0;

//*********** LED ***********
int spectrum[11];

unsigned long LED1Start;
unsigned long LED2Start;
unsigned long LED3Start;
unsigned long LED1Lap;
unsigned long LED2Lap;
unsigned long LED3Lap;

float LED1current[3];
float LED2current[3];
float LED3current[3];
float LED1target = 0;
float LED2target = 0;
float LED3target = 0;
int LED1direction = 0;
int LED2direction = 0;
int LED3direction = 0;

int zeroCount1 = 0;
int zeroCount2 = 0;
int zeroCount3 = 0;


//*********** MOTION ***********
unsigned long motion1Start;
unsigned long motion2Start;
unsigned long motion3Start;
unsigned long motion1;
unsigned long motion2;
unsigned long motion3;

int nonZeroCount1;
int nonZeroCount2;
int nonZeroCount3;

unsigned long delays1[3];
unsigned long delays2[3];
unsigned long delays3[3];

//**********************************************

void setup(){
    pinMode(2,OUTPUT);
    pinMode(4,OUTPUT);
    pinMode(7,OUTPUT);
    pinMode(8,OUTPUT);
    pinMode(12,OUTPUT);
    pinMode(13,OUTPUT);

    Serial.begin(57600);
    delay(2000);
    sensorStart = millis();
}

void loop(){

    //*********** GET SIGNAL ***********

    if(Serial.available()>0){
        inByte = Serial.read();
        inFlg1 = inByte/100;
        inFlg2 = (inByte - (inFlg1 * 100))/10;
        inFlg3 = (inByte - (inFlg1 * 100) - (inFlg2 * 10));
```

```
    if((inFlg3 == 8)||(inFlg3 == 9)){
        flgs[4] = inFlg1;
        flgs[5] = inFlg2;
        flgs[6] = inFlg3 - 8;
    }
    else{
        if(inFlg3 == 1){
            flgs[2] = inFlg1;
            flgs[3] = inFlg2;
        }
        else if(inFlg3 == 3){
            flgs[7] = inFlg1;
            flgs[8] = inFlg2;
        }
        else if(inFlg3 == 4){
            flgs[9] = inFlg1;
            flgs[10] = inFlg2;
        }
    }
}

//*********** LED ***********

for(int i=0;i<LED1PinSize;i++){
    if(millis() > LED1Start + delays1[i]/5){
        if(LED1direction > 0){
            if(LED1current[i] < LED1target){
                LED1current[i] += LEDStep;
            }
        }
        else if(LED1direction < 0){
            if(LED1current[i] > LED1target){
                if(LED1target != 0){
                    LED1current[i] -= LEDStep;
                }
                else{
                    LED1current[i] -= LEDStep/4;
                }
            }
        }
    }
}

for(int i=0;i<LED2PinSize;i++){
    if(millis() > LED2Start + delays2[i]/5){
        if(LED2direction > 0){
            if(LED2current[i] < LED2target){
                LED2current[i] += LEDStep;
            }
        }
        else if(LED2direction < 0){
            if(LED2current[i] > LED2target){
                if(LED2target != 0){
                    LED2current[i] -= LEDStep;
                }
                else{
                    LED2current[i] -= LEDStep/4;
                }
            }
        }
    }
}

for(int i=0;i<LED3PinSize;i++){
    if(millis() > LED3Start + delays3[i]/5){
        if(LED3direction > 0){
            if(LED3current[i] < LED3target){
                LED3current[i] += LEDStep;
```

```
                }
            }
            else if(LED3direction < 0){
                if(LED3current[i] > LED3target){
                    if(LED3target != 0){
                        LED3current[i] -= LEDStep;
                    }
                    else{
                        LED3current[i] -= LEDStep/4;
                    }
                }
            }
        }
    }


    for(int i=0;i<LED1PinSize;i++){
        analogWrite(LED1Pins[i],int(LED1current[i]));
    }
    for(int i=0;i<LED2PinSize;i++){
        analogWrite(LED2Pins[i],int(LED2current[i]));
    }
    for(int i=0;i<LED3PinSize;i++){
        analogWrite(LED3Pins[i],int(LED3current[i]));
    }


    //*********** MOTION ***********

    for(int i=0;i<motion1PinSize;i++){
        if((millis() > motion1Start + delays1[i])&&(millis() < motion1Start + delays1[i]
+ motion1)){
            digitalWrite(motion1Pins[i],HIGH);
        }
        else{
            digitalWrite(motion1Pins[i],LOW);
        }
    }

    for(int i=0;i<motion2PinSize;i++){
        if((millis() > motion2Start + delays2[i])&&(millis() < motion2Start + delays2[i]
+ motion2)){
            digitalWrite(motion2Pins[i],HIGH);
        }
        else{
            digitalWrite(motion2Pins[i],LOW);
        }
    }

    for(int i=0;i<motion3PinSize;i++){
        if((millis() > motion3Start + delays3[i])&&(millis() < motion3Start + delays3[i]
+ motion3)){
            digitalWrite(motion3Pins[i],HIGH);
        }
        else{
            digitalWrite(motion3Pins[i],LOW);
        }
    }

    //*********** SENSOR ***********

    sensor1 += analogRead(6);
    sensor2 += analogRead(5);
    sensor3 += analogRead(4);

    count++;

    if(count == countLimit){
```

```
    sensorSmoothed1 = sensor1/countLimit/4;
    sensorSmoothed2 = sensor2/countLimit/4;
    sensorSmoothed3 = sensor3/countLimit/4;
    sensor1 = 0;
    sensor2 = 0;
    sensor3 = 0;

    if(sensorSmoothed1 > 250){
        flg1 = 1;
    }
    if(sensorSmoothed2 > 250){
        flg2 = 1;
    }
    if(sensorSmoothed3 > 250){
        flg3 = 1;
    }

    count = 0;
}

if(millis() - sensorStart > sensorInterval){
    flgs[0] = flg1;
    flgs[1] = flg2;

    //spectrum make
    for(int i=0;i<11;i++){
        spectrum[i] = 0;
        if(flgs[i] == 1){
            spectrum[i] = 5;
        }
    }
    for(int i=0;i<10;i++){
        if((spectrum[i] == 0)&&(spectrum[i+1] == 5)){
            spectrum[i] = 4;
        }
    }
    for(int i=1;i<11;i++){
        if((spectrum[i] == 0)&&(spectrum[i-1] == 5)){
            spectrum[i] = 4;
        }
    }
    for(int i=0;i<10;i++){
        if((spectrum[i] == 0)&&(spectrum[i+1] == 4)){
            spectrum[i] = 3;
        }
    }
    for(int i=1;i<11;i++){
        if((spectrum[i] == 0)&&(spectrum[i-1] == 4)){
            spectrum[i] = 3;
        }
    }
    for(int i=0;i<10;i++){
        if((spectrum[i] == 0)&&(spectrum[i+1] == 3)){
            spectrum[i] = 2;
        }
    }
    for(int i=1;i<11;i++){
        if((spectrum[i] == 0)&&(spectrum[i-1] == 3)){
            spectrum[i] = 2;
        }
    }
    for(int i=0;i<10;i++){
        if((spectrum[i] == 0)&&(spectrum[i+1] == 2)){
            spectrum[i] = 1;
        }
    }
    for(int i=1;i<11;i++){
        if((spectrum[i] == 0)&&(spectrum[i-1] == 2)){
```

```
            spectrum[i] = 1;
        }
    }

    /*
     spectrum[0] = 1;
     spectrum[1] = 2;
     spectrum[2] = 3;
     spectrum[3] = 4;
     spectrum[4] = 5;
     spectrum[5] = 5;
     spectrum[6] = 4;
     spectrum[7] = 3;
     spectrum[8] = 2;
     spectrum[9] = 1;
     spectrum[10] = 0;
     */

    //Send the spectrum
    Serial.write(9);
    for(int i=0;i<11;i++){
        Serial.write(spectrum[i]);
    }
    sensorStart = millis();
    flg1 = 0;
    flg2 = 0;
    flg3 = 0;

    //for myself
    if(spectrum[myLED1] != 0){
        zeroCount1 = 0;
        nonZeroCount1++;
        if(nonZeroCount1 == 1){
            for(int i=0;i<3;i++){
                delays1[i] = random(motionDelayLimit);
            }
            delays1[int(random(motion1PinSize))] = 0;
        }
        if(nonZeroCount1%motionCountLimit == 1){
            motion1 = long(spectrum[myLED1] * 70 + 300);
            motion1Start = millis();
        }
        if(nonZeroCount1%LEDCountLimit == 1){
            LED1target = float(min(255, spectrum[myLED1] * spectrum[myLED1] * 10 +
15));

            LED1Start = millis();
        }
    }
    else{
        zeroCount1++;
        if(zeroCount1 > zeroCountLimit){
            nonZeroCount1 = 0;
            LED1target = 0;
        }
    }

    if(spectrum[myLED2] != 0){
        zeroCount2 = 0;
        nonZeroCount2++;
        if(nonZeroCount2 == 1){
            for(int i=0;i<3;i++){
                delays2[i] = random(motionDelayLimit);
            }
            delays2[int(random(motion2PinSize))] = 0;
        }
        if(nonZeroCount2%motionCountLimit == 1){
            motion2 = long(spectrum[myLED2] * 70 + 300);
            motion2Start = millis();
```

```
            }
            if(nonZeroCount2%LEDCountLimit == 1){
                LED2target = float(min(255, spectrum[myLED2] * spectrum[myLED2] * 10 +
15));
                LED2Start = millis();
            }
        }
        else{
            zeroCount2++;
            if(zeroCount2 > zeroCountLimit){
                nonZeroCount2 = 0;
                LED2target = 0;
            }
        }

        if(spectrum[myLED3] != 0){
            zeroCount3 = 0;
            nonZeroCount3++;
            if(nonZeroCount3 == 1){
                for(int i=0;i<3;i++){
                    delays3[i] = random(motionDelayLimit);
                }
                delays3[int(random(motion3PinSize))] = 0;
            }
            if(nonZeroCount3%motionCountLimit == 1){
                motion3 = long(spectrum[myLED3] * 70 + 300);
                motion3Start = millis();
            }
            if(nonZeroCount3%LEDCountLimit == 1){
                LED3target = float(min(255, spectrum[myLED3] * spectrum[myLED3] * 10 +
15));
                LED3Start = millis();
            }
        }
        else{
            zeroCount3++;
            if(zeroCount3 > zeroCountLimit){
                nonZeroCount3 = 0;
                LED3target = 0;
            }
        }

        //LED DIRECTION
        if(LED1target > LED1current[0]){
            LED1direction = 1;
        }
        else if(LED1target == LED1current[0]){
            LED1direction = 0;
        }
        else if(LED1target < LED1current[0]){
            LED1direction = -1;
        }

        if(LED2target > LED2current[0]){
            LED2direction = 1;
        }
        else if(LED2target == LED2current[0]){
            LED2direction = 0;
        }
        else if(LED2target < LED2current[0]){
            LED2direction = -1;
        }

        if(LED3target > LED3current[0]){
            LED3direction = 1;
        }
        else if(LED3target == LED3current[0]){
            LED3direction = 0;
```

```
        }
        else if(LED3target < LED3current[0]){
            LED3direction = -1;
        }
    }
}



/**************************************************/
// Project : INAHO BOARD 2
// Language : Arduino
// Program By : Hideki Yoshimoto
/**************************************************/

boolean photomotion = true;
int firstByte;

//*********** ID ***********
int myID = 1;
int myLED1 = 2;
int myLED2 = 3;
int myLED3 = 3;

int LED1Pins[] = {
    3,5,6};
int LED1PinSize = 3;
int LED2Pins[] = {
    9,10,11};
int LED2PinSize = 3;
int LED3Pins[] = {
    0};
int LED3PinSize = 0;

int motion1Pins[] = {
    2,4,7};
int motion1PinSize = 3;
int motion2Pins[] = {
    8,12,13};
int motion2PinSize = 3;
int motion3Pins[] = {
    0};
int motion3PinSize = 0;

/*
 int LED1Pins[] = {
 3,5};
 int LED1PinSize = 2;
 int LED2Pins[] = {
 6,9};
 int LED2PinSize = 2;
 int LED3Pins[] = {
 10,11};
 int LED3PinSize = 2;

 int motion1Pins[] = {
 2,4};
 int motion1PinSize = 2;
 int motion2Pins[] = {
 7,8};
 int motion2PinSize = 2;
 int motion3Pins[] = {
 12,13};
 int motion3PinSize = 2;
 */
//*********** TUNING ***********
float LEDStep = 0.1;
```

```
unsigned long motionDelayLimit = 1000;
int countLimit = 30; //sensor
unsigned long sensorInterval = 50;
int motionCountLimit = 30;
int LEDCountLimit = 15;
int zeroCountLimit = 80;

//*********** SENSOR ***********
int sensor1;
int sensor2;
int sensor3;

int sensorSmoothed1;
int sensorSmoothed2;
int sensorSmoothed3;

int count;

int flg1 = 0;
int flg2 = 0;
int flg3 = 0;

unsigned long sensorStart;

//*********** LED ***********
int spectrum[11];

unsigned long LED1Start;
unsigned long LED2Start;
unsigned long LED3Start;
unsigned long LED1Lap;
unsigned long LED2Lap;
unsigned long LED3Lap;

float LED1current[3];
float LED2current[3];
float LED3current[3];
float LED1target = 0;
float LED2target = 0;
float LED3target = 0;
int LED1direction = 0;
int LED2direction = 0;
int LED3direction = 0;

int zeroCount1 = 0;
int zeroCount2 = 0;
int zeroCount3 = 0;

//*********** MOTION ***********
unsigned long motion1Start;
unsigned long motion2Start;
unsigned long motion3Start;
unsigned long motion1;
unsigned long motion2;
unsigned long motion3;

int nonZeroCount1;
int nonZeroCount2;
int nonZeroCount3;

unsigned long delays1[3];
unsigned long delays2[3];
unsigned long delays3[3];


//**********************************************

void setup(){
```

```
    pinMode(2,OUTPUT);
    pinMode(4,OUTPUT);
    pinMode(7,OUTPUT);
    pinMode(8,OUTPUT);
    pinMode(12,OUTPUT);
    pinMode(13,OUTPUT);

    Serial.begin(57600);
    delay(2000);
    sensorStart = millis();
}

void loop(){

    //*********** GET SIGNAL ***********

    if(Serial.available()>11){

        firstByte = Serial.read();
        if((firstByte == 9)||(firstByte == 99)){
            if(firstByte == 99){
                photomotion = false;
            }
            if(firstByte == 9){
                photomotion = true;
            }

            for(int i=0;i<11;i++){
                spectrum[i] = Serial.read();
            }

            //TARGET
            if(spectrum[myLED1] != 0){
                zeroCount1 = 0;
                nonZeroCount1++;
                if(nonZeroCount1 == 1){
                    for(int i=0;i<3;i++){
                        delays1[i] = random(motionDelayLimit);
                    }
                    delays1[int(random(motion1PinSize))] = 0;
                }
                if(nonZeroCount1%motionCountLimit == 1){
                    motion1 = long(spectrum[myLED1] * 70 + 300);
                    motion1Start = millis();
                }
                if(nonZeroCount1%LEDCountLimit == 1){
                    LED1target = float(min(255, spectrum[myLED1] * spectrum[myLED1] * 10
+ 15));
                    LED1Start = millis();
                }
            }
            else{
                zeroCount1++;
                if(zeroCount1 > zeroCountLimit){
                    nonZeroCount1 = 0;
                    LED1target = 0;
                }
            }

            if(spectrum[myLED2] != 0){
                zeroCount2 = 0;
                nonZeroCount2++;
                if(nonZeroCount2 == 1){
                    for(int i=0;i<3;i++){
                        delays2[i] = random(motionDelayLimit);
                    }
                    delays2[int(random(motion2PinSize))] = 0;
                }
```

```
            if(nonZeroCount2%motionCountLimit == 1){
                motion2 = long(spectrum[myLED2] * 70 + 300);
                motion2Start = millis();
            }
            if(nonZeroCount2%LEDCountLimit == 1){
                LED2target = float(min(255, spectrum[myLED2] * spectrum[myLED2] * 10
+ 15));
                LED2Start = millis();
            }
        }
        else{
            zeroCount2++;
            if(zeroCount2 > zeroCountLimit){
                nonZeroCount2 = 0;
                LED2target = 0;
            }
        }

        if(spectrum[myLED3] != 0){
            zeroCount3 = 0;
            nonZeroCount3++;
            if(nonZeroCount3 == 1){
                for(int i=0;i<3;i++){
                    delays3[i] = random(motionDelayLimit);
                }
                delays3[int(random(motion3PinSize))] = 0;
            }
            if(nonZeroCount3%motionCountLimit == 1){
                motion3 = long(spectrum[myLED3] * 70 + 300);
                motion3Start = millis();
            }
            if(nonZeroCount3%LEDCountLimit == 1){
                LED3target = float(min(255, spectrum[myLED3] * spectrum[myLED3] * 10
+ 15));
                LED3Start = millis();
            }
        }
        else{
            zeroCount3++;
            if(zeroCount3 > zeroCountLimit){
                nonZeroCount3 = 0;
                LED3target = 0;
            }
        }

        //LED DIRECTION
        if(LED1target > LED1current[0]){
            LED1direction = 1;
        }
        else if(LED1target == LED1current[0]){
            LED1direction = 0;
        }
        else if(LED1target < LED1current[0]){
            LED1direction = -1;
        }

        if(LED2target > LED2current[0]){
            LED2direction = 1;
        }
        else if(LED2target == LED2current[0]){
            LED2direction = 0;
        }
        else if(LED2target < LED2current[0]){
            LED2direction = -1;
        }

        if(LED3target > LED3current[0]){
            LED3direction = 1;
```

```
        }
        else if(LED3target == LED3current[0]){
            LED3direction = 0;
        }
        else if(LED3target < LED3current[0]){
            LED3direction = -1;
        }
    }
}

//*********** LED ***********

for(int i=0;i<LED1PinSize;i++){
    if(millis() > LED1Start + delays1[i]/5){
        if(LED1direction > 0){
            if(LED1current[i] < LED1target){
                LED1current[i] += LEDStep;
            }
        }
        else if(LED1direction < 0){
            if(LED1current[i] > LED1target){
                if(LED1target != 0){
                    LED1current[i] -= LEDStep;
                }
                else{
                    LED1current[i] -= LEDStep/4;
                }
            }
        }
    }
}

for(int i=0;i<LED2PinSize;i++){
    if(millis() > LED2Start + delays2[i]/5){
        if(LED2direction > 0){
            if(LED2current[i] < LED2target){
                LED2current[i] += LEDStep;
            }
        }
        else if(LED2direction < 0){
            if(LED2current[i] > LED2target){
                if(LED2target != 0){
                    LED2current[i] -= LEDStep;
                }
                else{
                    LED2current[i] -= LEDStep/4;
                }
            }
        }
    }
}

for(int i=0;i<LED3PinSize;i++){
    if(millis() > LED3Start + delays3[i]/5){
        if(LED3direction > 0){
            if(LED3current[i] < LED3target){
                LED3current[i] += LEDStep;
            }
        }
        else if(LED3direction < 0){
            if(LED3current[i] > LED3target){
                if(LED3target != 0){
                    LED3current[i] -= LEDStep;
                }
                else{
                    LED3current[i] -= LEDStep/4;
                }
            }
```

```
            }
        }
    }


    for(int i=0;i<LED1PinSize;i++){
        analogWrite(LED1Pins[i],int(LED1current[i]));
    }
    for(int i=0;i<LED2PinSize;i++){
        analogWrite(LED2Pins[i],int(LED2current[i]));
    }
    for(int i=0;i<LED3PinSize;i++){
        analogWrite(LED3Pins[i],int(LED3current[i]));
    }

    //*********** MOTION ***********
    if(photomotion){

        for(int i=0;i<motion1PinSize;i++){
            if((millis() > motion1Start + delays1[i])&&(millis() < motion1Start +
delays1[i] + motion1)){
                digitalWrite(motion1Pins[i],HIGH);
            }
            else{
                digitalWrite(motion1Pins[i],LOW);
            }
        }

        for(int i=0;i<motion2PinSize;i++){
            if((millis() > motion2Start + delays2[i])&&(millis() < motion2Start +
delays2[i] + motion2)){
                digitalWrite(motion2Pins[i],HIGH);
            }
            else{
                digitalWrite(motion2Pins[i],LOW);
            }
        }

        for(int i=0;i<motion3PinSize;i++){
            if((millis() > motion3Start + delays3[i])&&(millis() < motion3Start +
delays3[i] + motion3)){
                digitalWrite(motion3Pins[i],HIGH);
            }
            else{
                digitalWrite(motion3Pins[i],LOW);
            }
        }
    }

    //*********** SENSOR ***********

    sensor1 += analogRead(6);
    sensor2 += analogRead(5);
    sensor3 += analogRead(4);

    count++;

    if(count == countLimit){
        sensorSmoothed1 = sensor1/countLimit/4;
        sensorSmoothed2 = sensor2/countLimit/4;
        sensorSmoothed3 = sensor3/countLimit/4;
        sensor1 = 0;
        sensor2 = 0;
        sensor3 = 0;

        if(sensorSmoothed1 > 250){
            flg1 = 1;
        }
```

```
        if(sensorSmoothed2 > 250){
            flg2 = 1;
        }
        if(sensorSmoothed3 > 250){
            flg3 = 1;
        }

        count = 0;
    }

    if(millis() - sensorStart > sensorInterval){
        if((myID == 1)||(myID > 2)){
            Serial.write(flg1 * 100 + flg2 * 10 + myID);
        }
        else if(myID == 2){
            Serial.write(flg1 * 100 + flg2 * 10 + flg3 + 8);
        }
        flg1 = 0;
        flg2 = 0;
        flg3 = 0;
        sensorStart = millis();
    }
}



/**************************************************/
// Project : INAHO BOARD 3
// Language : Arduino
// Program By : Hideki Yoshimoto
/**************************************************/

boolean photomotion = true;
int firstByte;

//*********** ID ***********
int myID = 2;
int myLED1 = 4;
int myLED2 = 5;
int myLED3 = 6;

/*
 int LED1Pins[] = {
 3,5,6};
 int LED1PinSize = 3;
 int LED2Pins[] = {
 9,10,11};
 int LED2PinSize = 3;
 int LED3Pins[] = {
 0};
 int LED3PinSize = 0;

 int motion1Pins[] = {
 2,4,7};
 int motion1PinSize = 3;
 int motion2Pins[] = {
 8,12,13};
 int motion2PinSize = 3;
 int motion3Pins[] = {
 0};
 int motion3PinSize = 0;
 */

int LED1Pins[] = {
    3,5};
int LED1PinSize = 2;
int LED2Pins[] = {
```

```
    6,9};
int LED2PinSize = 2;
int LED3Pins[] = {
    10,11};
int LED3PinSize = 2;

int motion1Pins[] = {
    2,4};
int motion1PinSize = 2;
int motion2Pins[] = {
    7,8};
int motion2PinSize = 2;
int motion3Pins[] = {
    12,13};
int motion3PinSize = 2;

//*********** TUNING ***********
float LEDStep = 0.1;
unsigned long motionDelayLimit = 1000;
int countLimit = 30; //sensor
unsigned long sensorInterval = 50;
int motionCountLimit = 30;
int LEDCountLimit = 15;
int zeroCountLimit = 80;

//*********** SENSOR ***********
int sensor1;
int sensor2;
int sensor3;

int sensorSmoothed1;
int sensorSmoothed2;
int sensorSmoothed3;

int count;

int flg1 = 0;
int flg2 = 0;
int flg3 = 0;

unsigned long sensorStart;

//*********** LED ***********
int spectrum[11];

unsigned long LED1Start;
unsigned long LED2Start;
unsigned long LED3Start;
unsigned long LED1Lap;
unsigned long LED2Lap;
unsigned long LED3Lap;

float LED1current[3];
float LED2current[3];
float LED3current[3];
float LED1target = 0;
float LED2target = 0;
float LED3target = 0;
int LED1direction = 0;
int LED2direction = 0;
int LED3direction = 0;

int zeroCount1 = 0;
int zeroCount2 = 0;
int zeroCount3 = 0;

//*********** MOTION ***********
unsigned long motion1Start;
```

```
unsigned long motion2Start;
unsigned long motion3Start;
unsigned long motion1;
unsigned long motion2;
unsigned long motion3;

int nonZeroCount1;
int nonZeroCount2;
int nonZeroCount3;

unsigned long delays1[3];
unsigned long delays2[3];
unsigned long delays3[3];


//**********************************************

void setup(){
    pinMode(2,OUTPUT);
    pinMode(4,OUTPUT);
    pinMode(7,OUTPUT);
    pinMode(8,OUTPUT);
    pinMode(12,OUTPUT);
    pinMode(13,OUTPUT);

    Serial.begin(57600);
    delay(2000);
    sensorStart = millis();
}

void loop(){

    //*********** GET SIGNAL ***********

    if(Serial.available()>11){

        firstByte = Serial.read();
        if((firstByte == 9)||(firstByte == 99)){
            if(firstByte == 99){
                photomotion = false;
            }
            if(firstByte == 9){
                photomotion = true;
            }

            for(int i=0;i<11;i++){
                spectrum[i] = Serial.read();
            }

            //TARGET
            if(spectrum[myLED1] != 0){
                zeroCount1 = 0;
                nonZeroCount1++;
                if(nonZeroCount1 == 1){
                    for(int i=0;i<3;i++){
                        delays1[i] = random(motionDelayLimit);
                    }
                    delays1[int(random(motion1PinSize))] = 0;
                }
                if(nonZeroCount1%motionCountLimit == 1){
                    motion1 = long(spectrum[myLED1] * 70 + 300);
                    motion1Start = millis();
                }
                if(nonZeroCount1%LEDCountLimit == 1){
                    LED1target = float(min(255, spectrum[myLED1] * spectrum[myLED1] * 10
+ 15));

                    LED1Start = millis();
                }
```

```
        }
        else{
            zeroCount1++;
            if(zeroCount1 > zeroCountLimit){
                nonZeroCount1 = 0;
                LED1target = 0;
            }
        }

        if(spectrum[myLED2] != 0){
            zeroCount2 = 0;
            nonZeroCount2++;
            if(nonZeroCount2 == 1){
                for(int i=0;i<3;i++){
                    delays2[i] = random(motionDelayLimit);
                }
                delays2[int(random(motion2PinSize))] = 0;
            }
            if(nonZeroCount2%motionCountLimit == 1){
                motion2 = long(spectrum[myLED2] * 70 + 300);
                motion2Start = millis();
            }
            if(nonZeroCount2%LEDCountLimit == 1){
                LED2target = float(min(255, spectrum[myLED2] * spectrum[myLED2] * 10
+ 15));

                LED2Start = millis();
            }
        }
        else{
            zeroCount2++;
            if(zeroCount2 > zeroCountLimit){
                nonZeroCount2 = 0;
                LED2target = 0;
            }
        }

        if(spectrum[myLED3] != 0){
            zeroCount3 = 0;
            nonZeroCount3++;
            if(nonZeroCount3 == 1){
                for(int i=0;i<3;i++){
                    delays3[i] = random(motionDelayLimit);
                }
                delays3[int(random(motion3PinSize))] = 0;
            }
            if(nonZeroCount3%motionCountLimit == 1){
                motion3 = long(spectrum[myLED3] * 70 + 300);
                motion3Start = millis();
            }
            if(nonZeroCount3%LEDCountLimit == 1){
                LED3target = float(min(255, spectrum[myLED3] * spectrum[myLED3] * 10
+ 15));

                LED3Start = millis();
            }
        }
        else{
            zeroCount3++;
            if(zeroCount3 > zeroCountLimit){
                nonZeroCount3 = 0;
                LED3target = 0;
            }
        }

        //LED DIRECTION
        if(LED1target > LED1current[0]){
            LED1direction = 1;
        }
        else if(LED1target == LED1current[0]){
```

```
            LED1direction = 0;
        }
        else if(LED1target < LED1current[0]){
            LED1direction = -1;
        }

        if(LED2target > LED2current[0]){
            LED2direction = 1;
        }
        else if(LED2target == LED2current[0]){
            LED2direction = 0;
        }
        else if(LED2target < LED2current[0]){
            LED2direction = -1;
        }

        if(LED3target > LED3current[0]){
            LED3direction = 1;
        }
        else if(LED3target == LED3current[0]){
            LED3direction = 0;
        }
        else if(LED3target < LED3current[0]){
            LED3direction = -1;
        }
    }
}

//*********** LED ***********

for(int i=0;i<LED1PinSize;i++){
    if(millis() > LED1Start + delays1[i]/5){
        if(LED1direction > 0){
            if(LED1current[i] < LED1target){
                LED1current[i] += LEDStep;
            }
        }
        else if(LED1direction < 0){
            if(LED1current[i] > LED1target){
                if(LED1target != 0){
                    LED1current[i] -= LEDStep;
                }
                else{
                    LED1current[i] -= LEDStep/4;
                }
            }
        }
    }
}

for(int i=0;i<LED2PinSize;i++){
    if(millis() > LED2Start + delays2[i]/5){
        if(LED2direction > 0){
            if(LED2current[i] < LED2target){
                LED2current[i] += LEDStep;
            }
        }
        else if(LED2direction < 0){
            if(LED2current[i] > LED2target){
                if(LED2target != 0){
                    LED2current[i] -= LEDStep;
                }
                else{
                    LED2current[i] -= LEDStep/4;
                }
            }
        }
    }
```

```
    }

    for(int i=0;i<LED3PinSize;i++){
        if(millis() > LED3Start + delays3[i]/5){
            if(LED3direction > 0){
                if(LED3current[i] < LED3target){
                    LED3current[i] += LEDStep;
                }
            }
            else if(LED3direction < 0){
                if(LED3current[i] > LED3target){
                    if(LED3target != 0){
                        LED3current[i] -= LEDStep;
                    }
                    else{
                        LED3current[i] -= LEDStep/4;
                    }
                }
            }
        }
    }


    for(int i=0;i<LED1PinSize;i++){
        analogWrite(LED1Pins[i],int(LED1current[i]));
    }
    for(int i=0;i<LED2PinSize;i++){
        analogWrite(LED2Pins[i],int(LED2current[i]));
    }
    for(int i=0;i<LED3PinSize;i++){
        analogWrite(LED3Pins[i],int(LED3current[i]));
    }

    //*********** MOTION ***********
    if(photomotion){

        for(int i=0;i<motion1PinSize;i++){
            if((millis() > motion1Start + delays1[i])&&(millis() < motion1Start +
delays1[i] + motion1)){
                digitalWrite(motion1Pins[i],HIGH);
            }
            else{
                digitalWrite(motion1Pins[i],LOW);
            }
        }

        for(int i=0;i<motion2PinSize;i++){
            if((millis() > motion2Start + delays2[i])&&(millis() < motion2Start +
delays2[i] + motion2)){
                digitalWrite(motion2Pins[i],HIGH);
            }
            else{
                digitalWrite(motion2Pins[i],LOW);
            }
        }

        for(int i=0;i<motion3PinSize;i++){
            if((millis() > motion3Start + delays3[i])&&(millis() < motion3Start +
delays3[i] + motion3)){
                digitalWrite(motion3Pins[i],HIGH);
            }
            else{
                digitalWrite(motion3Pins[i],LOW);
            }
        }
    }

    //*********** SENSOR ***********
```

```
    sensor1 += analogRead(6);
    sensor2 += analogRead(5);
    sensor3 += analogRead(4);

    count++;

    if(count == countLimit){
        sensorSmoothed1 = sensor1/countLimit/4;
        sensorSmoothed2 = sensor2/countLimit/4;
        sensorSmoothed3 = sensor3/countLimit/4;
        sensor1 = 0;
        sensor2 = 0;
        sensor3 = 0;

        if(sensorSmoothed1 > 250){
            flg1 = 1;
        }
        if(sensorSmoothed2 > 250){
            flg2 = 1;
        }
        if(sensorSmoothed3 > 250){
            flg3 = 1;
        }

        count = 0;
    }

    if(millis() - sensorStart > sensorInterval){
        if((myID == 1)||(myID > 2)){
            Serial.write(flg1 * 100 + flg2 * 10 + myID);
        }
        else if(myID == 2){
            Serial.write(flg1 * 100 + flg2 * 10 + flg3 + 8);
        }
        flg1 = 0;
        flg2 = 0;
        flg3 = 0;
        sensorStart = millis();
    }
}



/**************************************************/
// Project : INAHO BOARD 4
// Language : Arduino
// Program By : Hideki Yoshimoto
/**************************************************/

boolean photomotion = true;
int firstByte;

//*********** ID ***********
int myID = 3;
int myLED1 = 7;
int myLED2 = 8;
int myLED3 = 8;

int LED1Pins[] = {
    3,5,6};
int LED1PinSize = 3;
int LED2Pins[] = {
    9,10,11};
int LED2PinSize = 3;
int LED3Pins[] = {
    0};
```

```
int LED3PinSize = 0;

int motion1Pins[] = {
    2,4,7};
int motion1PinSize = 3;
int motion2Pins[] = {
    8,12,13};
int motion2PinSize = 3;
int motion3Pins[] = {
    0};
int motion3PinSize = 0;

/*
 int LED1Pins[] = {
 3,5};
 int LED1PinSize = 2;
 int LED2Pins[] = {
 6,9};
 int LED2PinSize = 2;
 int LED3Pins[] = {
 10,11};
 int LED3PinSize = 2;

 int motion1Pins[] = {
 2,4};
 int motion1PinSize = 2;
 int motion2Pins[] = {
 7,8};
 int motion2PinSize = 2;
 int motion3Pins[] = {
 12,13};
 int motion3PinSize = 2;
 */
//*********** TUNING ***********
float LEDStep = 0.1;
unsigned long motionDelayLimit = 1000;
int countLimit = 30; //sensor
unsigned long sensorInterval = 50;
int motionCountLimit = 30;
int LEDCountLimit = 15;
int zeroCountLimit = 80;

//*********** SENSOR ***********
int sensor1;
int sensor2;
int sensor3;

int sensorSmoothed1;
int sensorSmoothed2;
int sensorSmoothed3;

int count;

int flg1 = 0;
int flg2 = 0;
int flg3 = 0;

unsigned long sensorStart;

//*********** LED ***********
int spectrum[11];

unsigned long LED1Start;
unsigned long LED2Start;
unsigned long LED3Start;
unsigned long LED1Lap;
unsigned long LED2Lap;
unsigned long LED3Lap;
```

```
float LED1current[3];
float LED2current[3];
float LED3current[3];
float LED1target = 0;
float LED2target = 0;
float LED3target = 0;
int LED1direction = 0;
int LED2direction = 0;
int LED3direction = 0;

int zeroCount1 = 0;
int zeroCount2 = 0;
int zeroCount3 = 0;

//*********** MOTION ***********
unsigned long motion1Start;
unsigned long motion2Start;
unsigned long motion3Start;
unsigned long motion1;
unsigned long motion2;
unsigned long motion3;

int nonZeroCount1;
int nonZeroCount2;
int nonZeroCount3;

unsigned long delays1[3];
unsigned long delays2[3];
unsigned long delays3[3];


//**********************************************

void setup(){
    pinMode(2,OUTPUT);
    pinMode(4,OUTPUT);
    pinMode(7,OUTPUT);
    pinMode(8,OUTPUT);
    pinMode(12,OUTPUT);
    pinMode(13,OUTPUT);

    Serial.begin(57600);
    delay(2000);
    sensorStart = millis();
}

void loop(){

    //*********** GET SIGNAL ***********

    if(Serial.available()>11){

        firstByte = Serial.read();
        if((firstByte == 9)||(firstByte == 99)){
            if(firstByte == 99){
                photomotion = false;
            }
            if(firstByte == 9){
                photomotion = true;
            }

            for(int i=0;i<11;i++){
                spectrum[i] = Serial.read();
            }

            //TARGET
            if(spectrum[myLED1] != 0){
```

```
            zeroCount1 = 0;
            nonZeroCount1++;
            if(nonZeroCount1 == 1){
                for(int i=0;i<3;i++){
                    delays1[i] = random(motionDelayLimit);
                }
                delays1[int(random(motion1PinSize))] = 0;
            }
            if(nonZeroCount1%motionCountLimit == 1){
                motion1 = long(spectrum[myLED1] * 70 + 300);
                motion1Start = millis();
            }
            if(nonZeroCount1%LEDCountLimit == 1){
                LED1target = float(min(255, spectrum[myLED1] * spectrum[myLED1] * 10
+ 15));
                LED1Start = millis();
            }
        }
        else{
            zeroCount1++;
            if(zeroCount1 > zeroCountLimit){
                nonZeroCount1 = 0;
                LED1target = 0;
            }
        }

        if(spectrum[myLED2] != 0){
            zeroCount2 = 0;
            nonZeroCount2++;
            if(nonZeroCount2 == 1){
                for(int i=0;i<3;i++){
                    delays2[i] = random(motionDelayLimit);
                }
                delays2[int(random(motion2PinSize))] = 0;
            }
            if(nonZeroCount2%motionCountLimit == 1){
                motion2 = long(spectrum[myLED2] * 70 + 300);
                motion2Start = millis();
            }
            if(nonZeroCount2%LEDCountLimit == 1){
                LED2target = float(min(255, spectrum[myLED2] * spectrum[myLED2] * 10
+ 15));
                LED2Start = millis();
            }
        }
        else{
            zeroCount2++;
            if(zeroCount2 > zeroCountLimit){
                nonZeroCount2 = 0;
                LED2target = 0;
            }
        }

        if(spectrum[myLED3] != 0){
            zeroCount3 = 0;
            nonZeroCount3++;
            if(nonZeroCount3 == 1){
                for(int i=0;i<3;i++){
                    delays3[i] = random(motionDelayLimit);
                }
                delays3[int(random(motion3PinSize))] = 0;
            }
            if(nonZeroCount3%motionCountLimit == 1){
                motion3 = long(spectrum[myLED3] * 70 + 300);
                motion3Start = millis();
            }
            if(nonZeroCount3%LEDCountLimit == 1){
```

```
                    LED3target = float(min(255, spectrum[myLED3] * spectrum[myLED3] * 10
+ 15));
                    LED3Start = millis();
                }
            }
            else{
                zeroCount3++;
                if(zeroCount3 > zeroCountLimit){
                    nonZeroCount3 = 0;
                    LED3target = 0;
                }
            }

            //LED DIRECTION
            if(LED1target > LED1current[0]){
                LED1direction = 1;
            }
            else if(LED1target == LED1current[0]){
                LED1direction = 0;
            }
            else if(LED1target < LED1current[0]){
                LED1direction = -1;
            }

            if(LED2target > LED2current[0]){
                LED2direction = 1;
            }
            else if(LED2target == LED2current[0]){
                LED2direction = 0;
            }
            else if(LED2target < LED2current[0]){
                LED2direction = -1;
            }

            if(LED3target > LED3current[0]){
                LED3direction = 1;
            }
            else if(LED3target == LED3current[0]){
                LED3direction = 0;
            }
            else if(LED3target < LED3current[0]){
                LED3direction = -1;
            }
        }
    }

    //*********** LED ***********

    for(int i=0;i<LED1PinSize;i++){
        if(millis() > LED1Start + delays1[i]/5){
            if(LED1direction > 0){
                if(LED1current[i] < LED1target){
                    LED1current[i] += LEDStep;
                }
            }
            else if(LED1direction < 0){
                if(LED1current[i] > LED1target){
                    if(LED1target != 0){
                        LED1current[i] -= LEDStep;
                    }
                    else{
                        LED1current[i] -= LEDStep/4;
                    }
                }
            }
        }
    }
```

```
    for(int i=0;i<LED2PinSize;i++){
        if(millis() > LED2Start + delays2[i]/5){
            if(LED2direction > 0){
                if(LED2current[i] < LED2target){
                    LED2current[i] += LEDStep;
                }
            }
            else if(LED2direction < 0){
                if(LED2current[i] > LED2target){
                    if(LED2target != 0){
                        LED2current[i] -= LEDStep;
                    }
                    else{
                        LED2current[i] -= LEDStep/4;
                    }
                }
            }
        }
    }

    for(int i=0;i<LED3PinSize;i++){
        if(millis() > LED3Start + delays3[i]/5){
            if(LED3direction > 0){
                if(LED3current[i] < LED3target){
                    LED3current[i] += LEDStep;
                }
            }
            else if(LED3direction < 0){
                if(LED3current[i] > LED3target){
                    if(LED3target != 0){
                        LED3current[i] -= LEDStep;
                    }
                    else{
                        LED3current[i] -= LEDStep/4;
                    }
                }
            }
        }
    }


    for(int i=0;i<LED1PinSize;i++){
        analogWrite(LED1Pins[i],int(LED1current[i]));
    }
    for(int i=0;i<LED2PinSize;i++){
        analogWrite(LED2Pins[i],int(LED2current[i]));
    }
    for(int i=0;i<LED3PinSize;i++){
        analogWrite(LED3Pins[i],int(LED3current[i]));
    }

    //*********** MOTION ***********
    if(photomotion){

        for(int i=0;i<motion1PinSize;i++){
            if((millis() > motion1Start + delays1[i])&&(millis() < motion1Start +
delays1[i] + motion1)){
                digitalWrite(motion1Pins[i],HIGH);
            }
            else{
                digitalWrite(motion1Pins[i],LOW);
            }
        }

        for(int i=0;i<motion2PinSize;i++){
            if((millis() > motion2Start + delays2[i])&&(millis() < motion2Start +
delays2[i] + motion2)){
                digitalWrite(motion2Pins[i],HIGH);
```

```
            }
            else{
                digitalWrite(motion2Pins[i],LOW);
            }
        }

        for(int i=0;i<motion3PinSize;i++){
            if((millis() > motion3Start + delays3[i])&&(millis() < motion3Start + 
delays3[i] + motion3)){
                digitalWrite(motion3Pins[i],HIGH);
            }
            else{
                digitalWrite(motion3Pins[i],LOW);
            }
        }
    }

    //*********** SENSOR ***********

    sensor1 += analogRead(6);
    sensor2 += analogRead(5);
    sensor3 += analogRead(4);

    count++;

    if(count == countLimit){
        sensorSmoothed1 = sensor1/countLimit/4;
        sensorSmoothed2 = sensor2/countLimit/4;
        sensorSmoothed3 = sensor3/countLimit/4;
        sensor1 = 0;
        sensor2 = 0;
        sensor3 = 0;

        if(sensorSmoothed1 > 250){
            flg1 = 1;
        }
        if(sensorSmoothed2 > 250){
            flg2 = 1;
        }
        if(sensorSmoothed3 > 250){
            flg3 = 1;
        }

        count = 0;
    }

    if(millis() - sensorStart > sensorInterval){
        if((myID == 1)||(myID > 2)){
            Serial.write(flg1 * 100 + flg2 * 10 + myID);
        }
        else if(myID == 2){
            Serial.write(flg1 * 100 + flg2 * 10 + flg3 + 8);
        }
        flg1 = 0;
        flg2 = 0;
        flg3 = 0;
        sensorStart = millis();
    }
}
```

```
/************************************************/
// Project : INAHO BOARD 5
// Language : Arduino
// Program By : Hideki Yoshimoto
/************************************************/

boolean photomotion = true;
int firstByte;

//*********** ID ***********
int myID = 4;
int myLED1 = 9;
int myLED2 = 10;
int myLED3 = 10;

int LED1Pins[] = {
    3,5,6};
int LED1PinSize = 3;
int LED2Pins[] = {
    9,10,11};
int LED2PinSize = 3;
int LED3Pins[] = {
    0};
int LED3PinSize = 0;

int motion1Pins[] = {
    2,4,7};
int motion1PinSize = 3;
int motion2Pins[] = {
    8,12,13};
int motion2PinSize = 3;
int motion3Pins[] = {
    0};
int motion3PinSize = 0;

/*
 int LED1Pins[] = {
 3,5};
 int LED1PinSize = 2;
 int LED2Pins[] = {
 6,9};
 int LED2PinSize = 2;
 int LED3Pins[] = {
 10,11};
 int LED3PinSize = 2;

 int motion1Pins[] = {
 2,4};
 int motion1PinSize = 2;
 int motion2Pins[] = {
 7,8};
 int motion2PinSize = 2;
 int motion3Pins[] = {
 12,13};
 int motion3PinSize = 2;
 */
//*********** TUNING ***********
float LEDStep = 0.1;
unsigned long motionDelayLimit = 1000;
int countLimit = 30; //sensor
unsigned long sensorInterval = 50;
int motionCountLimit = 30;
int LEDCountLimit = 15;
int zeroCountLimit = 80;

//*********** SENSOR ***********
int sensor1;
int sensor2;
```

```
int sensor3;

int sensorSmoothed1;
int sensorSmoothed2;
int sensorSmoothed3;

int count;

int flg1 = 0;
int flg2 = 0;
int flg3 = 0;

unsigned long sensorStart;

//*********** LED ***********
int spectrum[11];

unsigned long LED1Start;
unsigned long LED2Start;
unsigned long LED3Start;
unsigned long LED1Lap;
unsigned long LED2Lap;
unsigned long LED3Lap;

float LED1current[3];
float LED2current[3];
float LED3current[3];
float LED1target = 0;
float LED2target = 0;
float LED3target = 0;
int LED1direction = 0;
int LED2direction = 0;
int LED3direction = 0;

int zeroCount1 = 0;
int zeroCount2 = 0;
int zeroCount3 = 0;

//*********** MOTION ***********
unsigned long motion1Start;
unsigned long motion2Start;
unsigned long motion3Start;
unsigned long motion1;
unsigned long motion2;
unsigned long motion3;

int nonZeroCount1;
int nonZeroCount2;
int nonZeroCount3;

unsigned long delays1[3];
unsigned long delays2[3];
unsigned long delays3[3];


//**********************************************

void setup(){
    pinMode(2,OUTPUT);
    pinMode(4,OUTPUT);
    pinMode(7,OUTPUT);
    pinMode(8,OUTPUT);
    pinMode(12,OUTPUT);
    pinMode(13,OUTPUT);

    Serial.begin(57600);
    delay(2000);
    sensorStart = millis();
```

```
}

void loop(){

    //*********** GET SIGNAL ***********

    if(Serial.available()>11){

        firstByte = Serial.read();
        if((firstByte == 9)||(firstByte == 99)){
            if(firstByte == 99){
                photomotion = false;
            }
            if(firstByte == 9){
                photomotion = true;
            }

            for(int i=0;i<11;i++){
                spectrum[i] = Serial.read();
            }

            //TARGET
            if(spectrum[myLED1] != 0){
                zeroCount1 = 0;
                nonZeroCount1++;
                if(nonZeroCount1 == 1){
                    for(int i=0;i<3;i++){
                        delays1[i] = random(motionDelayLimit);
                    }
                    delays1[int(random(motion1PinSize))] = 0;
                }
                if(nonZeroCount1%motionCountLimit == 1){
                    motion1 = long(spectrum[myLED1] * 70 + 300);
                    motion1Start = millis();
                }
                if(nonZeroCount1%LEDCountLimit == 1){
                    LED1target = float(min(255, spectrum[myLED1] * spectrum[myLED1] * 10
+ 15));

                    LED1Start = millis();
                }
            }
            else{
                zeroCount1++;
                if(zeroCount1 > zeroCountLimit){
                    nonZeroCount1 = 0;
                    LED1target = 0;
                }
            }

            if(spectrum[myLED2] != 0){
                zeroCount2 = 0;
                nonZeroCount2++;
                if(nonZeroCount2 == 1){
                    for(int i=0;i<3;i++){
                        delays2[i] = random(motionDelayLimit);
                    }
                    delays2[int(random(motion2PinSize))] = 0;
                }
                if(nonZeroCount2%motionCountLimit == 1){
                    motion2 = long(spectrum[myLED2] * 70 + 300);
                    motion2Start = millis();
                }
                if(nonZeroCount2%LEDCountLimit == 1){
                    LED2target = float(min(255, spectrum[myLED2] * spectrum[myLED2] * 10
+ 15));

                    LED2Start = millis();
                }
            }
```

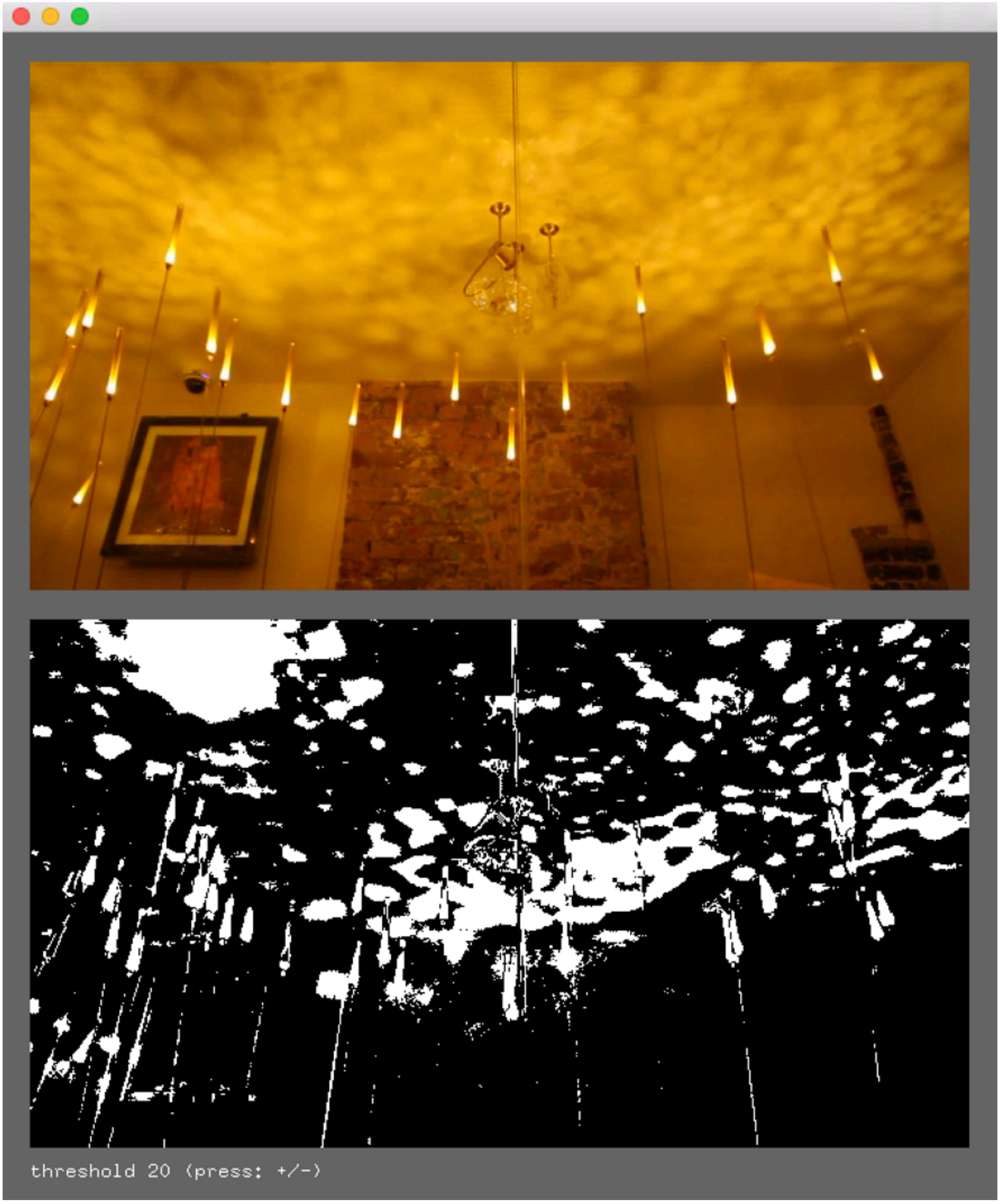
```
        else{
            zeroCount2++;
            if(zeroCount2 > zeroCountLimit){
                nonZeroCount2 = 0;
                LED2target = 0;
            }
        }

        if(spectrum[myLED3] != 0){
            zeroCount3 = 0;
            nonZeroCount3++;
            if(nonZeroCount3 == 1){
                for(int i=0;i<3;i++){
                    delays3[i] = random(motionDelayLimit);
                }
                delays3[int(random(motion3PinSize))] = 0;
            }
            if(nonZeroCount3%motionCountLimit == 1){
                motion3 = long(spectrum[myLED3] * 70 + 300);
                motion3Start = millis();
            }
            if(nonZeroCount3%LEDCountLimit == 1){
                LED3target = float(min(255, spectrum[myLED3] * spectrum[myLED3] * 10
+ 15));

                LED3Start = millis();
            }
        }
        else{
            zeroCount3++;
            if(zeroCount3 > zeroCountLimit){
                nonZeroCount3 = 0;
                LED3target = 0;
            }
        }

        //LED DIRECTION
        if(LED1target > LED1current[0]){
            LED1direction = 1;
        }
        else if(LED1target == LED1current[0]){
            LED1direction = 0;
        }
        else if(LED1target < LED1current[0]){
            LED1direction = -1;
        }

        if(LED2target > LED2current[0]){
            LED2direction = 1;
        }
        else if(LED2target == LED2current[0]){
            LED2direction = 0;
        }
        else if(LED2target < LED2current[0]){
            LED2direction = -1;
        }

        if(LED3target > LED3current[0]){
            LED3direction = 1;
        }
        else if(LED3target == LED3current[0]){
            LED3direction = 0;
        }
        else if(LED3target < LED3current[0]){
            LED3direction = -1;
        }
    }
}
```

```
//*********** LED ***********

for(int i=0;i<LED1PinSize;i++){
    if(millis() > LED1Start + delays1[i]/5){
        if(LED1direction > 0){
            if(LED1current[i] < LED1target){
                LED1current[i] += LEDStep;
            }
        }
        else if(LED1direction < 0){
            if(LED1current[i] > LED1target){
                if(LED1target != 0){
                    LED1current[i] -= LEDStep;
                }
                else{
                    LED1current[i] -= LEDStep/4;
                }
            }
        }
    }
}

for(int i=0;i<LED2PinSize;i++){
    if(millis() > LED2Start + delays2[i]/5){
        if(LED2direction > 0){
            if(LED2current[i] < LED2target){
                LED2current[i] += LEDStep;
            }
        }
        else if(LED2direction < 0){
            if(LED2current[i] > LED2target){
                if(LED2target != 0){
                    LED2current[i] -= LEDStep;
                }
                else{
                    LED2current[i] -= LEDStep/4;
                }
            }
        }
    }
}

for(int i=0;i<LED3PinSize;i++){
    if(millis() > LED3Start + delays3[i]/5){
        if(LED3direction > 0){
            if(LED3current[i] < LED3target){
                LED3current[i] += LEDStep;
            }
        }
        else if(LED3direction < 0){
            if(LED3current[i] > LED3target){
                if(LED3target != 0){
                    LED3current[i] -= LEDStep;
                }
                else{
                    LED3current[i] -= LEDStep/4;
                }
            }
        }
    }
}


for(int i=0;i<LED1PinSize;i++){
    analogWrite(LED1Pins[i],int(LED1current[i]));
}
for(int i=0;i<LED2PinSize;i++){
    analogWrite(LED2Pins[i],int(LED2current[i]));
```

```
    }
    for(int i=0;i<LED3PinSize;i++){
        analogWrite(LED3Pins[i],int(LED3current[i]));
    }

    //*********** MOTION ***********
    if(photomotion){

        for(int i=0;i<motion1PinSize;i++){
            if((millis() > motion1Start + delays1[i])&&(millis() < motion1Start +
delays1[i] + motion1)){
                digitalWrite(motion1Pins[i],HIGH);
            }
            else{
                digitalWrite(motion1Pins[i],LOW);
            }
        }

        for(int i=0;i<motion2PinSize;i++){
            if((millis() > motion2Start + delays2[i])&&(millis() < motion2Start +
delays2[i] + motion2)){
                digitalWrite(motion2Pins[i],HIGH);
            }
            else{
                digitalWrite(motion2Pins[i],LOW);
            }
        }

        for(int i=0;i<motion3PinSize;i++){
            if((millis() > motion3Start + delays3[i])&&(millis() < motion3Start +
delays3[i] + motion3)){
                digitalWrite(motion3Pins[i],HIGH);
            }
            else{
                digitalWrite(motion3Pins[i],LOW);
            }
        }
    }

    //*********** SENSOR ***********

    sensor1 += analogRead(6);
    sensor2 += analogRead(5);
    sensor3 += analogRead(4);

    count++;

    if(count == countLimit){
        sensorSmoothed1 = sensor1/countLimit/4;
        sensorSmoothed2 = sensor2/countLimit/4;
        sensorSmoothed3 = sensor3/countLimit/4;
        sensor1 = 0;
        sensor2 = 0;
        sensor3 = 0;

        if(sensorSmoothed1 > 250){
            flg1 = 1;
        }
        if(sensorSmoothed2 > 250){
            flg2 = 1;
        }
        if(sensorSmoothed3 > 250){
            flg3 = 1;
        }

        count = 0;
    }
```

```
    if(millis() - sensorStart > sensorInterval){
        if((myID == 1)||(myID > 2)){
            Serial.write(flg1 * 100 + flg2 * 10 + myID);
        }
        else if(myID == 2){
            Serial.write(flg1 * 100 + flg2 * 10 + flg3 + 8);
        }
        flg1 = 0;
        flg2 = 0;
        flg3 = 0;
        sensorStart = millis();
    }
}
```

IMAGE PROCESSING SOFTWARE



Screenshot of the software analysing the shadow projection.

IMAGE PROCESSING SOFTWARE CODE

```
//--------------------------------------------------------------
// Project : INAHO IMAGE PROCESSOR
// File : MAIN.CPP
// Language : OPENFRAMEWORKS + OFXCSVMASTER + OFXOPENCV ADDON
// Program By : Hideki Yoshimoto
//--------------------------------------------------------------


#include "ofMain.h"
#include "ofApp.h"

//========================================================================
int main( ){

      ofSetupOpenGL(680,800, OF_WINDOW);
      ofRunApp( new ofApp());

}




//--------------------------------------------------------------
// Project : INAHO IMAGE PROCESSOR
// File : OFAPP.CPP
// Language : OPENFRAMEWORKS + OFXCSVMASTER + OFXOPENCV ADDON
// Program By : Hideki Yoshimoto
//--------------------------------------------------------------


#include "ofApp.h"

//--------------------------------------------------------------
void ofApp::setup(){

      #ifdef _USE_LIVE_VIDEO
         vidGrabber.setVerbose(true);
         vidGrabber.initGrabber(640,360);
      #else
         vidPlayer.loadMovie("inaho.mov");
         vidPlayer.play();
      #endif

    colorImg.allocate(640,360);
      grayImage.allocate(640,360);
      grayBg.allocate(640,360);
      grayDiff.allocate(640,360);

      bLearnBakground = true;
      threshold = 20;

    csv.loadFile(ofToDataPath("file.csv"));
}

//--------------------------------------------------------------
void ofApp::update(){
      ofBackground(100,100,100);

    bool bNewFrame = false;

      #ifdef _USE_LIVE_VIDEO
        vidGrabber.update();
          bNewFrame = vidGrabber.isFrameNew();
    #else
```

```
        vidPlayer.update();
        bNewFrame = vidPlayer.isFrameNew();
      #endif

      if (bNewFrame){

                 #ifdef _USE_LIVE_VIDEO
            colorImg.setFromPixels(vidGrabber.getPixels(), 640,360);
          #else
            colorImg.setFromPixels(vidPlayer.getPixels(), 640,360);
        #endif

        grayImage = colorImg;
               if (bLearnBakground == true){
                      grayBg = grayImage;
                      bLearnBakground = false;
               }

        grayDiff.absDiff(grayBg, grayImage);
               grayDiff.threshold(threshold);

        int row = csv.numRows;
        int dif = int(100 * float(grayDiff.countNonZeroInRegion(0, 0, 640, 360))/
(640*360));
        csv.setInt(row, 0, 0);
        csv.setInt(row, 1, dif);
    }
}

//--------------------------------------------------------------
void ofApp::draw(){

      colorImg.draw(20,20);
      grayDiff.draw(20,400);

      ofSetHexColor(0xffffff);
      stringstream reportStr;
     reportStr << "threshold " << threshold << " (press: +/-)" << endl;
      ofDrawBitmapString(reportStr.str(), 20, 780);

}

//--------------------------------------------------------------
void ofApp::keyPressed(int key){

      switch (key){
               case ' ':
                      bLearnBakground = true;
                      break;
               case '+':
                      threshold ++;
                      if (threshold > 255) threshold = 255;
                      break;
               case '-':
                      threshold --;
                      if (threshold < 0) threshold = 0;
                      break;
        case 's':
            csv.saveFile(ofToDataPath("file.csv"));
            break;
      }
}
```

```
//------------------------------------------------------------------
// Project : INAHO IMAGE PROCESSOR
// File : OFAPP.H
// Language : OPENFRAMEWORKS + OFXCSVMASTER + OFXOPENCV ADDON
// Program By : Hideki Yoshimoto
//------------------------------------------------------------------


#pragma once

#include "ofMain.h"

#include "ofxOpenCv.h"
#include "ofxCsv.h"

using namespace wng;

class ofApp : public ofBaseApp{

      public:
              void setup();
              void update();
              void draw();
              void keyPressed(int key);

        #ifdef _USE_LIVE_VIDEO
                ofVideoGrabber              vidGrabber;
              #else
                ofVideoPlayer               vidPlayer;
              #endif

        ofxCvColorImage                     colorImg;

        ofxCvGrayscaleImage   grayImage;
              ofxCvGrayscaleImage    grayBg;
              ofxCvGrayscaleImage    grayDiff;

        ofxCvContourFinder    contourFinder;

              int                           threshold;
              bool                          bLearnBakground;

        ofxCsv csv;
};
```

INSTALLATION AT THE MILAN DESIGN FAIR 2013

(Top) Setting up the installation.
(Bottom) A visitor approaching the installation.

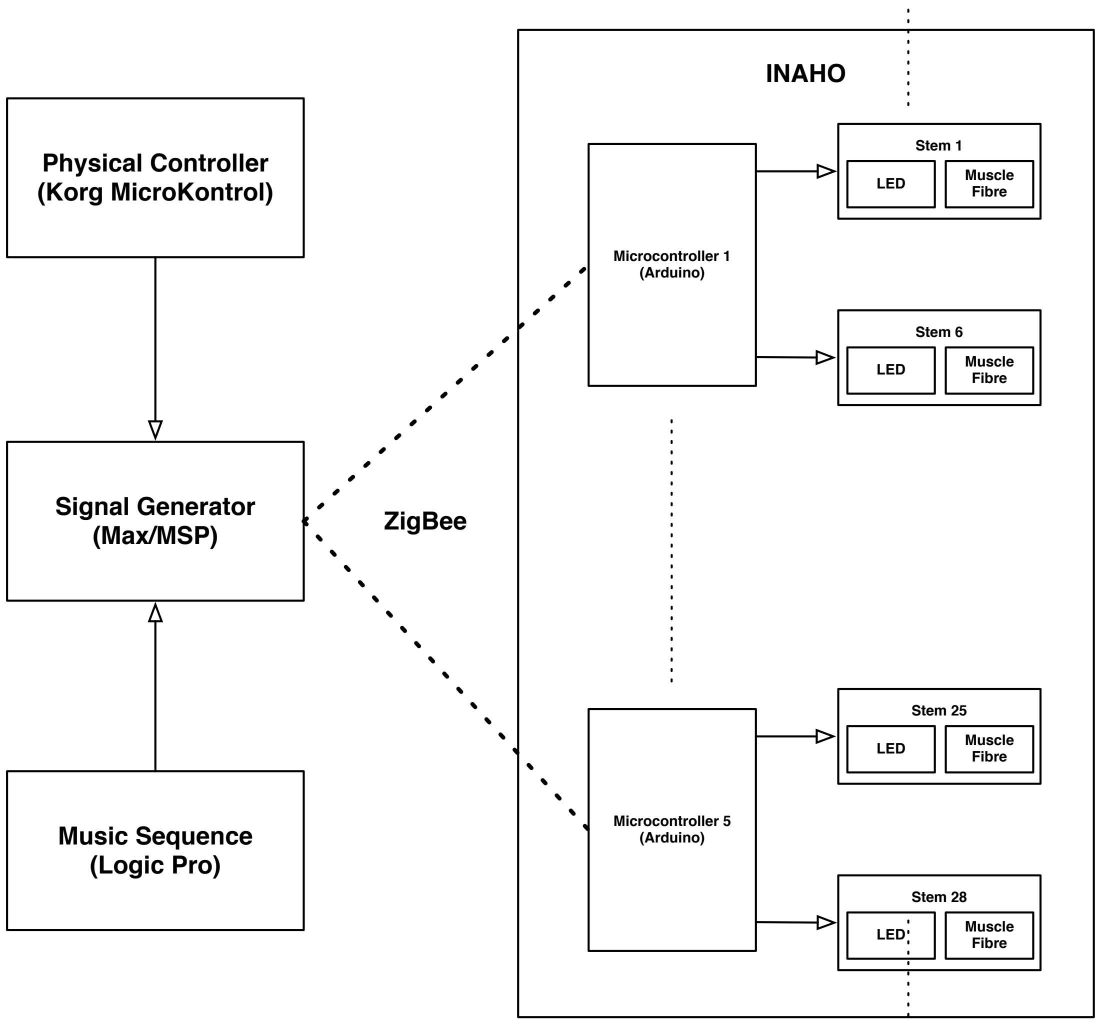
INSTALLATION AT THE PARIS MAISON ET OBJET 2014

INSTALLATION AT THE DESIGN DAYS DUBAI 2015

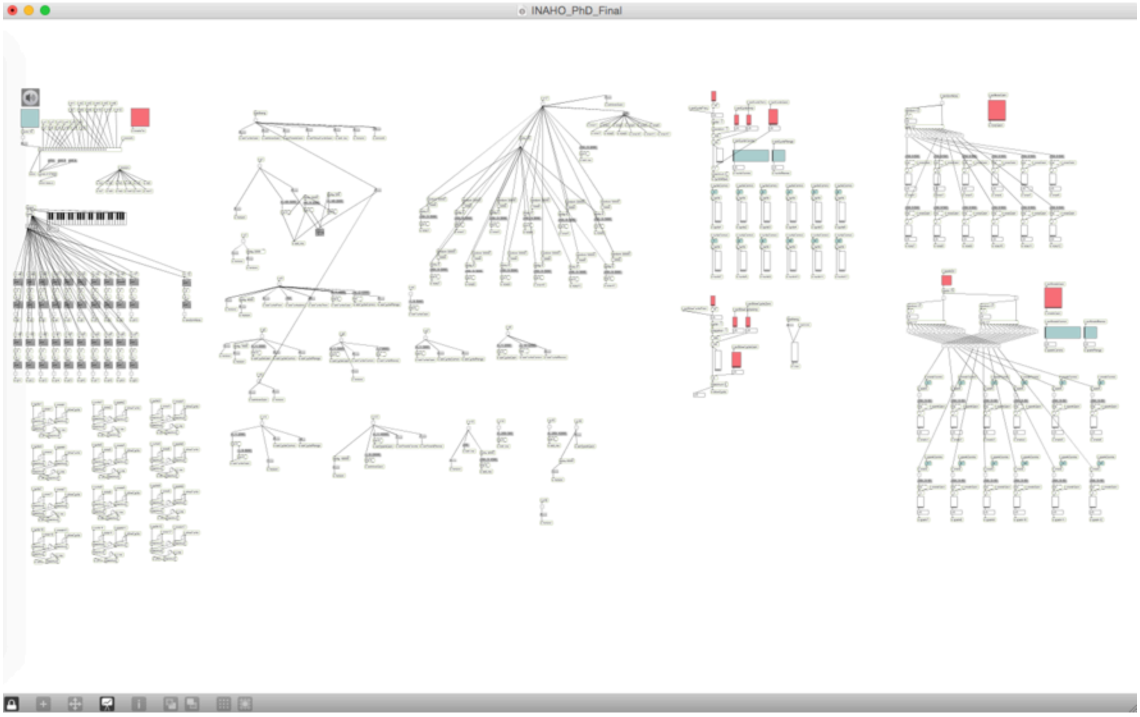
APPENDIX K

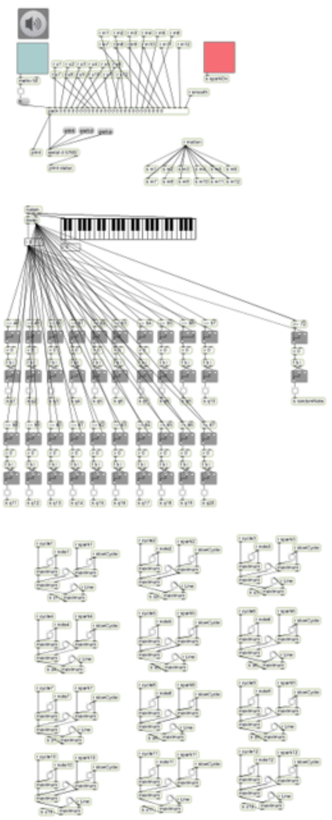
INAHO INTERVIEW STUDY

SYSTEM BLOCK DIAGRAM

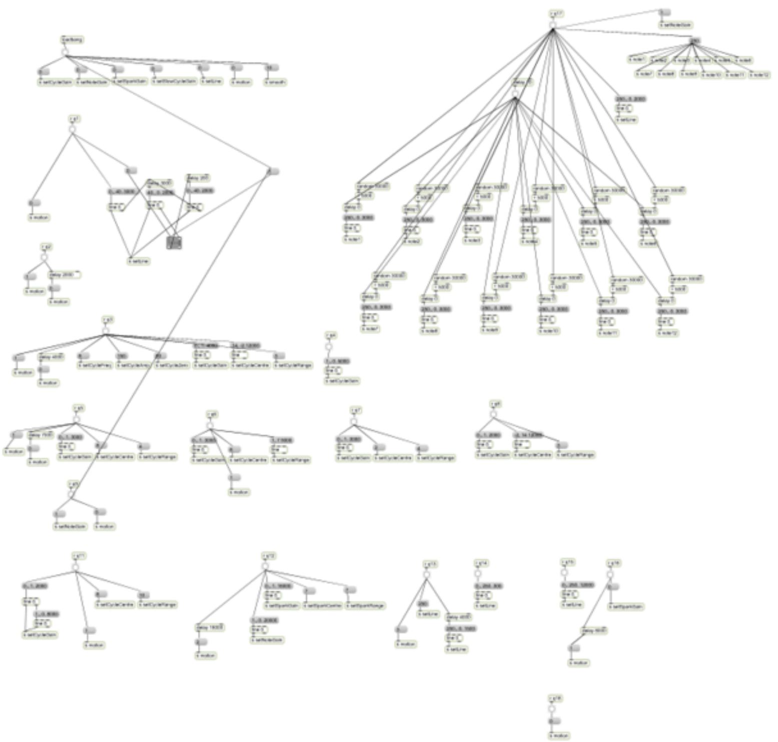


SIGNAL GENERATOR



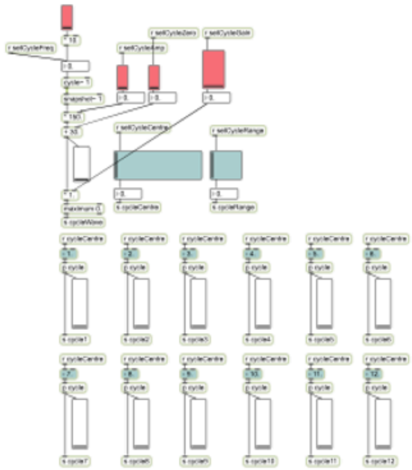


Coordinating and
sending the signal

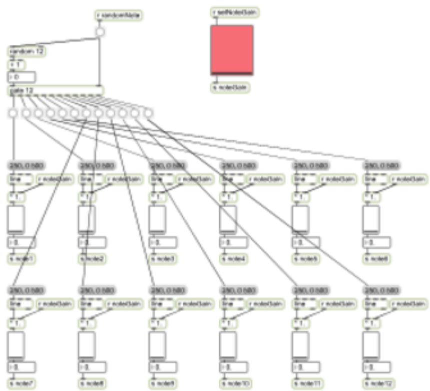


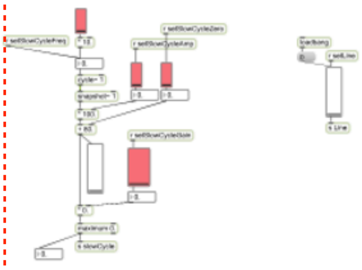
Making cues for the music
sequence (the interview part 3)

Mode 2 —
Some stems blinking

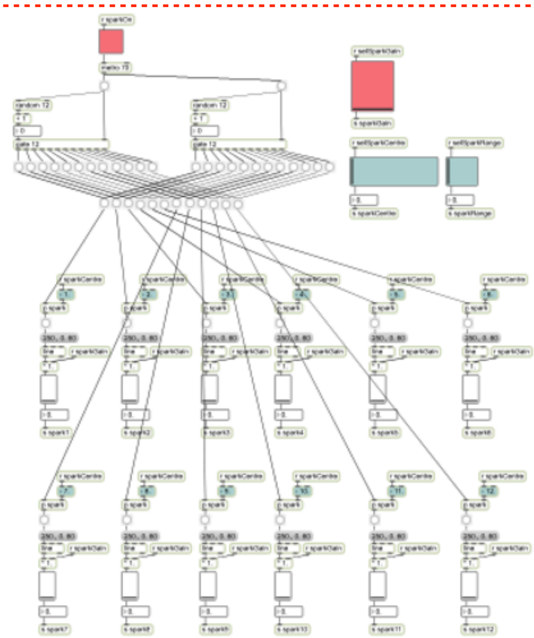


Mode 4 —
Music phrase effect



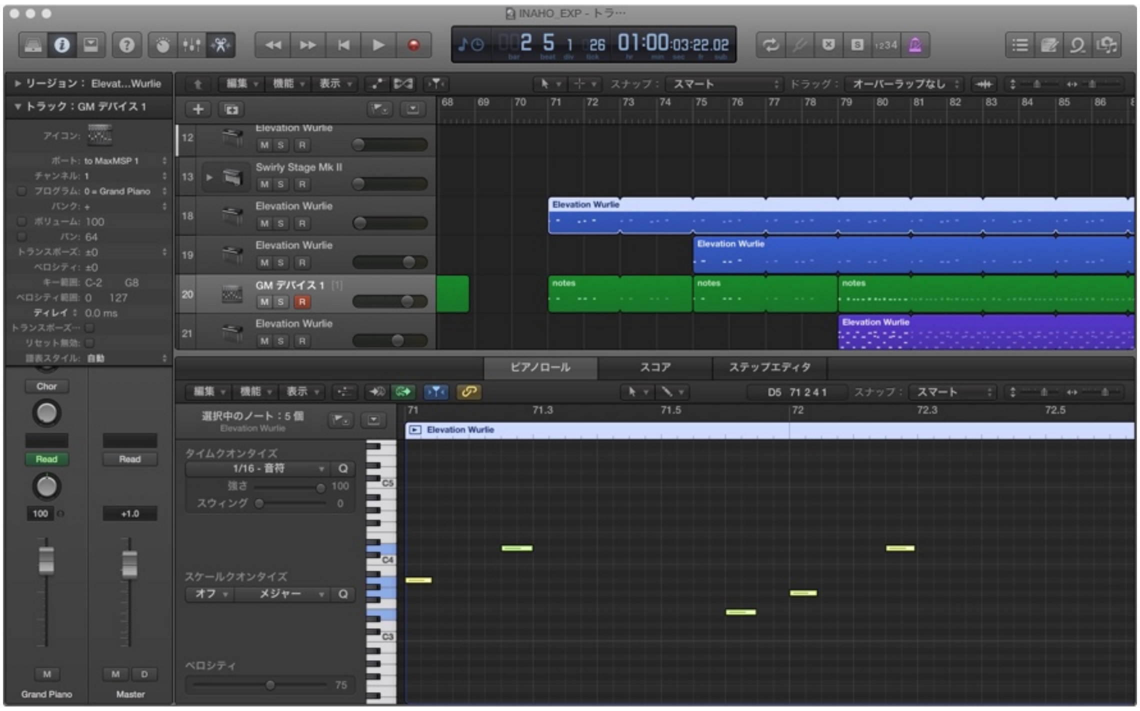


Mode 1 —
All stems blinking



Mode 3 —
Sparkling effect

MUSIC SEQUENCE



The sequence was completely seamless, but representative scenes are as follows:

Scene 1 (0:00): The song begins quietly with a repetitive phrase of softened electronic piano sound in Dsus4. Tempo is 155 beats per minute. The idea is a calm, peaceful dawn. The stems are not moving yet but blinking slowly (about eight seconds per cycle) within the range of 0% -20% brightness (mode 1).

Scene 2 (0:30): Fast-pulsing (semiquavers) low tone of electronic piano sound comes in with crescendo and decrescendo. The chord is Dsus4 (9), which still transmits peaceful harmony. No change from scene 1 in the stems.

Scene 3 (0:55): The chord changes to Bm7 (11), which is a minor chord with a gloomy feeling. The volume of the song is increasing, with partial crescendos and decrescendos. The stems start to move with 20% amplitude.

Scene 4 (1:02): On top of scene 3, a very fast-pulsing (demisemiquaver) high-E note comes in, panning from right to left, then left to right. The idea is to represent wind. An accompanying fast blink of light moves from right to left, then left to right (mode 2). The level of stems' movement is increasing to 40%.

Scene 5 (1:25): Now the chord changes to C (9/13) with floating harmony, and the same very fast pulse of scene 4 appears again with more dynamics. The light pattern is the same as in scene 4, and the level of movement keeps increasing.

Scene 6 (1:50): The chord is Bm7 (11/13) with more uneasy harmony, and again with the demisemiquaver pulse with a high G note. The level of movement is now 70%. The idea is a blast of wind.

Scene 7 (2:25): As if the winds have stopped and the sky is becoming brighter, the harmony is now back, the same as in scene 1. The light slowly fades out and the movement also gradually stops.

Scene 8 (2:45): A new simple repetitive melody of electric piano in the chord of Dsus4 (9) starts. The stems' light corresponds to the notes of this melody (mode 4). They are not moving yet.

Scene 9 (3:01): A counter melody is added: the chord Bm7 (11) on D, which is a little darker. Accordingly the number of lighting stems in mode 4 increases.

Scene 10 (3:25): The low base note of Bm is added, so the mood gets even darker. Some more counter melodies, including polyrhythmic ones, are added. It is as if a storm were approaching from the distance. On top of the lighting from scene 9, rapid sparks (mode 3) appear. The stems start to sway with 20% amplitude.

Scene 11 (4:00): On top of scene 10, fast pulses of demisemiquavers of high notes appear again and the volume of the whole song keeps increasing. The melodic mode 4 lighting gradually disappears and is replaced by very rapid sparks. The level of stems' movement is gradually increasing to 100%.

Scene 12 (4:48): Now it is the climax of the song. Bass moves to keep the tension and the whole song's harmony changes accordingly. The whole stems illuminate at 100% brightness and move with 100% amplitude.

Scene 13 (5:17): As if the storm had gone, the chord is back to the initial Dsus4 (9) with peaceful harmony. Each musical element, such as the several melodies, pulses and bass, slowly fade out one by one. The stems also fade out one by one, and the movement also gradually stops.

Scene 10 (3:25) — The low base note of Bm is added, so it gets even darker. Some more counter melodies including polyrhythmic ones are added. It's as if a storm were approaching from the distance. On top of the lighting of the scene 9, rapid sparks (mode 3) appears. The stems start to sway with the 20% amplitude.

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INTERVIEW SCRIPT

Participant 1 — Design Researcher with Astronautics Background

This participant knew about my research and key words, pulse and rhythm.

Part 1)

Interviewer (I) : I would like to ask you to give me some descriptions of what you are looking at.

Participant (P) : The first observations are rods and at the very end of the rods there are installations which are mesh inside of those are light… and probably there are some kind of machineries underneath moving the whole things… some of that are in a random way… and providing the shadows on the ceiling. Now this is very much reminding me of reeds in lakes as the wind is going around… maybe because of the lighting and everything gives me an impression of it… because the light and shadows on the ceiling of the room and the movement and the shape of these… it's just reminding me very much of nice calm summer day next to a lake… and reeds are being in my sight.

I : Brilliant. Can you describe more about this motion?

P : Yes.. It is very like a rhythmic motion. Each of these, I call this reed like element, has each frequency and all have their own harmonics. But not in the same like marching… because the variety of frequency ends up some sort of rhythmic yet… it's not chaotic motion but… it's rhythm motion, it's very nice that it's not… predictable. It's some sort of predictable but not predictable… do you know what I mean? Because you have rhythm, and you pick up individual movements, and follow those, and they have nice harmony between them… because the amplitude is similar but different because of different length (of stems). But it still gives you a nice feeling because focus on the one and your partial visual perception of other ones… you can focus on one for a while and you can see the broader whole… and you can again pick up individual some kind of rhythm from the movement of these.

I : Great, great. Probably the last question for this is… if you choose two or three words, adjectives, to describe this work, your impressions of this work, what do you choose?

P : Rhythmic, elegant, calm… and maybe familiar in an interesting way. Because it evokes memories of childhood… well, depending on where you have grown up, but in my case, my grandparents' place, they had a lake nearby and I spent my childhood running around it so these experiences like summer camps and nice calm summer days where you have no stress no problems, everything is very nice… just enjoying this ambience.

I : It was interesting that you mentioned rhythm. Is it because you know my subject?

P : Uh… kind of both actually. On one hand I know your subject, but on the other hand it's still rhythmic I think… in the movement.

I : And it was also interesting that you describe how you are looking at this… you focus on one sometimes and then you look at the broader whole.

P : Yes yes… playing with it. I wrote a paper that I presented in this October, and I was talking about different aspects of interactive within environment. One of them was focusing on one thing when environment can disappear and you see the picture and you play with that… This one allows you to do that because you do not have pre-described identical motion so you can pick up individual ones and they still have variety, which are different from others and you can focus on that… Are you changing the amplitude now?

I : Oh no but… the actuation resonates with the stems so, like a swing, it becomes bigger over time.

P : It's interesting because it feels more imposing now. But depending on the amplitude, at one point, if you play with that it becomes threatening. You can move from calm to threatening probably when it is too much… and it's very interesting to play with… is that comfortable or uncomfortable? Because reeds coming toward you and the velocity of them… how they approach… and you still play with rhythm, that's interesting.

I : Does it make change if you stand up?

P : Again, that is interesting about perspective. Because you sit down, everything is above you, but now they are on the eye level, and getting closer to face when they are moving. But at the same time, further closer to them, you can play with… play more with this focused one because of distance but you still play with broader whole too and refocus on one. Because if it is closer it is easier for you to focus on this. But if you stand up you loose the shadow on the ceiling, which is a bit shame… when you sit down from this perspective, this perspective includes the shadow and this full experience is the experience of course.

Part 2)

<I (interviewer) asked the participant to create his favourite lighting and motion with the physical controller. I did not ask the impression of each mode one by one. He mixed the mode * and mode * so that whole stems were blinking with the speed of about 6 seconds per cycle and had sequenced soft impulses at random positions. He added level 1 swaying motion to it.>

P : It is interesting because maybe people have internal rhythm… some people like slow, very slow… this is a bit too slow for me… want it to be a bit faster.

I : So like looking for a sweet spot?

P : Yeah. Then it's now harmonising with the rhythm I was expecting. Now it's comfortable… its speed. Because even with the same rhythm if it's very slow it suddenly becomes uncomfortable, boring, whereas if you have too much, too much movements, it's just too intruding. So the movement is just enough with small, and the rhythm of light is such. And it gives rhythm sequence on top of it. The rhythm of sequence is interesting because… it's how to compare the speed of rhythm of light and movement. Because there is also correlation between the movement and light. Now the rhythm (of light) is a bit out of phase with the movement. The interesting thing is that they are a little bit out of sync, which is great. Because being out of sync provides some interest. It's a little bit minimalist music… people like Steve Reich and such. They end up with rhythm with a little bit change. This allows you to have a kind of visual minimalist music… minimalist visual experience. Minimalist music sets some set of parameters which you can change one by one, but this one doesn't allow you to change one by one, but it's very ad-hoc, very unpredictable. Maybe I need a bit more time to learn this then I can become a musician to tune this and play this sequence. So it is almost like a sequencer, you can play by switching one on and switching off another one and then you go through this experience. The movement changes, and the light change, but still they are out of phase, so it provides extra overlay that allows you to go to the next experience. Maybe it's good if you have affordances. You have affordances of light, and you have affordances of movement. And you mix them as a designer, to make sure they are always in harmony. They cannot be too much out of sync. Cannot be too mess. It's nice, it's still nice, harmonious sync, but the experience is not too much jointed.

I : So we have some freedom, but not 100% freedom, like a designed freedom.

P : Yes we have affordances, within a certain harmony. We have a diversity, but have a consistence, that is a harmonious experience.

I : Fantastic. I was interested in two things you mentioned in particular. One is that you talked about your internal rhythm… and this (Inaho's) rhythm matches with your rhythm. Is that rhythm coming from this work?

P : No, I think it's coming from personality. So if I go to the southern part of United States, people are much slower, much calmer. If you go to New York, people are much hectic. People who're in the environment may be comfortable with the environment. Some people speak very fast… I speak very fast, some people speak very slow. And this again inner rhythm. So this (interview) is almost like a personality test. People pick up a certain rhythm, comfortable rhythm, but defining their… your rhythm. So they're tuning this rhythm like an environment that you feel comfortable with. And some people may choose slower one.

I : It was also interesting that you chose the words calm, elegant… because when I exhibit at some big exhibitions, many people said it's magnificent, dynamic, which feel very different. Do you think it's because of your personality, or personal rhythm?

P : Mmm… I think it's personal style. How you express yourself. The vocabulary they have. Some people want to be more fun and buoyant, some people are more subtle. If you go to Germany maybe people are more controlled, precise, and there are some people are more outgoing cultural like Spanish or Italian or South American maybe… much more… expressive?

I : Interesting. The other interesting thing for me was that you mentioned being out of sync but still in harmony and associated it with minimalist music. Is it actually you feel in minimalist music?

P : The thing is that people find a pattern. That is human nature, people are trying to find a pattern. And this is same in minimalist music. It can be very boring… kind of boring rhythm, but somehow you introduce overlays, somehow the combination is interesting. Otherwise you can be bored, because you will be used to it. But minimalism music changes one thing… and it changes the sound a little bit. So you do not listen the same rhythm for 45 minutes. You are still familiar with that rhythm, but after a while one thing changes, and you notice the change. It is not a change enough to make a different experience, you are still in the same experience, but interestingly in a variety. The same thing here. I sit down here, looking at the movements and light for 45 minutes and if it does not change, I would say, OK that's enough! But you have this synthesiser or mixer, and allow you to change one thing a little bit, you still stay in the familiarity, but at the same time it allows you to pick up and interpret a new pattern. That keeps you interested in the activity.

I : You mentioned the analogy to reeds of this work. Do you think that connection is still here?

P : Yes yes, well, obviously the shape has strong connection to it. And an interesting thing is that, when you go out on nice warm summer night, moon is up there, and clouds are coming around… it's almost the kind of experience. Because you have light source of moon… well we do not have external light source here anyway but light is reflected, and clouds are here, and there is a pattern. Here your reeds have light but it's almost same that reeds are reflecting light of moon. Still have same experience.

I : Interesting. I was thinking that was my last question, but because your descriptions are really helpful… I want to ask some more things. Can you choose a motion that you do not like?

P : Yes yes, it is a really big one, really heavy one, imposing one. In a way, when you have smaller motion, it has cool elegance. Small circle at the very end, moving around just a little bit, so that there is enough structure that is built self-contained. It's in control, individually self controlled. If you increase the amplitude, then you feel suddenly uncomfortable. Because it has mass at the end, light source like, I don't know but, like fire, it can be danger, coming to my face over time, and I do not know how strong these stems are, if they can break when it hits my face. So suddenly the interaction is changing. I am here as an observer, it is my own business, and I am enjoying this movement. Suddenly it is imposing me, imposing my personal space. I think if I see this movements at distance, maybe I feel more comfortable. Maybe the reason why of this uncomfortableness is that there is a large amplitude and I do not know the property of this whole thing, so it's imposing my personal space. I don't know what to expect.

I : What about lighting pattern? Most uncomfortable lighting pattern?

P : Well, not uncomfortable, but boring. Anything that is same all the time is boring. If it has a set pattern, set rigid pattern, it is OK, but after a while you will loose your interest. Because it is about how long you can get engaged with the object, and how you can discover it. If it's always three lights on, again, you will get it away. But if there is some pattern, suddenly you think, oh wow what is this pattern, then you start pay attention to what is the rhythm of this, and once you discover, you will lose interest. So you have possibility of changing it… just a little bit. But again, if it's still too much, too hectic, people will get uncomfortable because it is becoming a noise.

Part 3)

I : What do you think of it?

P : How honest do you want me to be?

I : Very honest, very honest, please.

P : There are three things. Music itself is very pleasant. Very professional, very pleasantly put together. At the same time, I have heard this before… so, nice ambient music. So it can be something done by any nameless… but it's very professionally done. Really enjoyable. But there is a problem. When there were only the rhythmic movements and light, there was unpredictability. When it's synchronised with music, you removed the unpredictability. It becomes very forcing, too rhythmic, too synchronised. Suddenly you removed the element of unpredictability, because this lighting, movement, they are now very predictable after a while. And it is less interesting. And also, the perception has now a different emphasis. Music suddenly takes over the experience. I pay less attention to movement, light, well, I do not pay attention to shadows any more. I just look at this movement and light synchronised to sound, because just it is too synchronised…. and… The calmness, quiet, movement, rhythmic movement, they are almost meditation. You focus on that. It's allowed to focus on that. But suddenly music takes over it. You cannot think of it. You cannot reflect on the experience but you are listening to the music. Maybe it is a reason why it lowers the experience. Because it removes the meditating elements.

I : It is interesting to have this comment here because… you know, I composed this music, this lighting and motion and have been working on this for the last two weeks, and now, even if I see this work without music, I still hear the sound in my head. I cannot get rid of it…

P : So the interesting thing is that you are closing the loop. In the way that, you are the designer, there is the object, and you are the observer. And then your personal experience, expectation is reflecting back on the design and also back on the designer. So it's closed loop. If you are not an audience, then there is another person of audience, that person may have inner expectations and these people are trying to be reflecting and experiencing differently. Because it means something to you this combination of light, movement and music right? You expected other people to experience the same kind of movement and light and music. Whether they are interested in music, or not interested in music, it is up to the observer, to choose the music or not. It is an option. You can have that possibility. As an extra element, do you want this music or not? Do you want light? Do you want movement? Do you want rhythm? Do you want music? It is up to me to have the music. If I say excuse me I don't want music then I can switch it off. And basically as a designer, you are building affordances into the design. But you have to allow the variety. The thing is my variety as an observer may be broader than your variety because you designed this certain thing. So when you offer this, what you want to do is… this is affordance I built with this, you can use any of them, some of them, all of them, you can bring your own experience and augment it with this, and use it differently than intended to be used, but I do not shut down anything you think. Maybe that is the point I wanted to make. You allowed me to play with everything, you allowed me to choose what I prefer, but you did not give me the option to switch off the music. So therefore, I as an observer am losing my control, suddenly you are forcing your experience to me.

I : Yes true, true. Does it make any difference to add another kind of music like… for example… like the Gregorian chant, with no beating, no pulse, but very slow and continuous…?

P : If you google… Steve Reich… and yes this one, Music for 18 Musicians.

I : Ah yes of course I know.

P : This kind of music. It's so simple, it's like just simple rhythm, just two sticks, sticking together to make a certain rhythm, and break it. If you can create an personal experience where quietly the sound is in the background while the person is seeing this. The rhythm (of music) can come front but not take over.

I : That was very good. Thank you very much.

Participant 2 — Design Researcher with Biology Background

This participant knew about my research and key words, pulse and rhythm.

Part 1)

Interviewer (I) : To begin with, I want to ask you to give me some descriptions of what you are looking at.

Participant (P) : Now?

I : Yes.

P : I am looking at the shadows…

I : Can you describe it?

P : Yeah… they look like flower… that blend and go apart. It's quite calming.

I : What do you think makes you feel calm?

P : I think it is the durability of the movement, and because I am looking at shadows, which is like… just white and grey, which is very minimal. I try not to focus on the light (lighting object) at the moment.

I : What about the movement?

P : Yes… there're durability in the movement… and blending, that is the calming part.

I : So you are not really paying attention to the physical objects.

P : I am trying not to pay attention to it. I decided to do so. That has to be because of the time and day, because I am quite tired, so I like to watch the shadows not the object… if you want me to focus on the object I can though.

I : Then what is your impression of these physical things… and why do you want to avoid looking at this when you are tired?

P : If I look at this now, I think it's very elegant, very thin and long, and colour is quite… yeah elegant, I think that is how I describe it. But I am avoiding looking at them because I am so tired, this movement and light is so much information, so I much want to stay in this greyness.

I : If you're back to this shadow, can you have some articulations of how your eyes are moving and how you are capturing this shadow?

P : I am trying to focusing on the centre.

I : Centre of what?

P : Well, all of these geometrical circles.

I : So you mean you are looking at one particular shadow or middle point of the ceiling?

P : I am not focusing on any of them, looking at general whole but my eyes are in the centre. So I am looking at the centre but also looking at the landscape.

I : Then… does it make any difference when you focus on one particular circle of shadow?

P : Yes… if I focus on one it gives you so much definition of the shape.

I : But you prefer to see this whole…

P : Atmosphere. I think it is perhaps today I am very tired. I am very glad to see gentle thing.

I : It's quite interesting that your emotional status or even physical status change your impression of the work.

P : Yes totally. If this was exhibited in a gallery and if I came to visit that, I would be much more looking at the details of the artefact. But here we are sitting on this couch and we have this heater on… it's perfect. You know the direction which I am looking over… so if I stand up, if we were in a gallery and standing up, then we have move my face up to see the shadows and it's really uncomfortable for a long time, so now I am enjoying this kind of relax.

I : Interesting. Do you come up with… well as you know I was inspired by nature to make this work but… do you have a particular something in your mind to associate with this work?

P : If I say some few words, the first few things that came to my mind were, flower, something about the shape of flower, and I would say… it has to be something with snakes… winding and bumping… then you can also say this is diamond.

I : Diamond?

P : Yes and the way it's cut.

I : In which sense?

P : You know diamond has very small cuts and light can escape in certain ways… So if I look at this shadow, the shape reminded me of it.

I : You're the first person to…

P : say diamond?

I : Yes yes yes…

P : It may have to be with my life perhaps. Because my mother used to work on diamonds, so that is maybe…

I : Ah nice… ok so this is the last question of the part. If you choose a few… this time, adjectives, what do you choose for this work?

P : Calming, elegant, and… yeah, beautiful.

Part 2)

<I asked the participant to create her favourite lighting and motion, and we had some conversations naturally during the process of this creation.>

<She was choosing the mode 1 with level 2 motion.>

I : What do you think on this blinking?

P : Of what I have now?

I : Yes.

P : It confuses me.

I : Why?

P : It's not very harmonic…

I : You mean what and what are not in harmony?

P : Shapes together. At the beginning I could looking at the centre… the centre of the whole movement, but now shadows are always there so… it's much more confusing. But there are different rhythms.

I : Different from the original (of part 1)?

P : Yeah different from the original, and also different from each other. And this stroke it is too much and not calming now…

<She changed the motion to level 1.>

P : Yeah this reminds me of… when you're on the coast of lake, and you have this… water and there is wave, water coming to the shore and water going out… It reminds me of that… movement of water. This is much more calmer.

I : What do you think is the key element to make you have such analogy?

P : Well… the shapes and shadows all go around the room, so not focused on one corner, and also how they are moving… it's like a gentle wave. And the shape is also not really fine.

I : Shape of shadow?

P : Yes. So that is like a lake thing…

<Then moved to the mode 3.>

I : How about this?

P : This is very intense… It reminds me of a fast movie, it puts many images into it you know… I think it is interesting because of its thicker movement, but that's not very calming… intense and you need to have focus to follow the pattern…

<I suggested the mode 4.>

I : What about this mode?

P : It reminds me of an eye…

I : Eye?

P : Yes.

I : In which sense?

P : Because the shadow… the circular shadow in the centre looks like an eye… because now you see one circle clearly.

I : Ah, so you mean, it looks like rather than feels like?

P : Yes. And now are they are moving around, and the shapes are very defined, so my eyes are moving very fast to trying to catch them… that's not calming. It's interesting, beautiful, but it's not calming.

I : So your eyes are trying to follow them?

P : Yes.

I : But at the same time you are feeling some sort of difficulties in doing so?

P : Yes.

I : And it is not very comfortable for you?

P : No.

I : Then, what will be the best combination of light and motion for you?

P : I think the one I mentioned lake…

I : So it was all light on, slowly oscillating, and gently subtly swaying…

P : Yes, perhaps it doesn't have to be all on, but has to be gentle. It makes me calm. Now it feels like cloud as well as lake… both are very calming, both have this you know general, or gentle broad landscape… which calms me.

I : Do you want to keep the motion like this very subtle motion or want some more dynamics?

P : I want to keep this.

I : So this very small subtle motion.

P : Yes.

I : What about, if I stop this motion completely?

P : I think I like something in the middle… something interesting still happening, but not very aggressive. So there is something to look for, but not too much. If it is static… I will get bored.

Part 3)

I : So what do you think?

P : The really good thing is that it gets more accurate… the image and sound match quite nicely, quite accurate rhythm. There was something like disturbing when you had several seconds of nothing… I mean no light or no motion… kind of, distracting the flower like effect. I think… I used to like minimal techno so I loved a kind of minimal visual come synchronised with minimal music, but in this case… you have abstract shadow, very defined objects, shapes, and minimal music, with very accurate timings, I think it is a bit distracting… when these different things come at the same time… but that's it. I think it is really beautiful anyway.

I : Are you experiencing it as a music based installation or as a design based performance?

P : I think I am trying to have both.

I : Do you think adding music, this kind of music, improve this work?

P : Yes.

I : Yes? You said you like calm, gentleness, but this is completely different.

P : The music you chose is still calming for me.

I : Even if you have the sort of sparkling, or fast blinking light?

P : Well yes it was nice, it was still calming, you know, because there is almost a flow, continuity.

I : Is it what music gives to you?

P : Yes. I am flowing in the sound, with the images together.

Participant 3 — Service Designer with Business Marketing Background

This participant did not know about my research.

Part 1)

Interviewer (I) : Could you give me some descriptions of what you are looking at.

Participant (P) : Descriptions?

I : Yes.

P : I see the many these lights… orange lights… It looks really comfortable and warm, artistic as well and it's moving rhythmically. It kind of looks like rice field but it also looks like some kind of cute animals for me. I think I describe it cute and funny as well.

I : I was interested in that you are looking at the orange lights. By that do you mean you're looking at this physical object or the projection on the ceiling?

P : Um… I think I was looking at the lighting object first. But since you start to talk about this shadow…

I : Ah so you did not look at the projection?

P : I didn't but after you mentioned it I stopped to focus on the object and started looking at the shadow, which is really really beautiful.

I : You said it looks like rice field and somehow cute animals… so do you mean these physical object looked like those?

P : I think the way they move… kind of looks like animal…

I : What do you think about this projection?

P : It's really beautiful. It is strange because I don't relate the shadow from looking at the object. I don't know how these objects make this shadow. Is it from the object?

I : Yes yes. Because this tube at the end is perforated and has many holes so…

P : Oh I see. I think it's amazing… because looking at these objects, you do not imagine this kind of big shadow like… lace? or kaleidoscope? It's interesting how they make these shadows.

I : Do you have any difference between looking at this object and this shadow?

P : Yes for me it's really different.

I : How?

P : Because looking at the object, it looks very sophisticated… tiny… but the shadow on the ceiling is much bigger, softer… And it's interesting that the shadow is more round but the object is more solid.

I : What about the motion of the shadows?

P : It's beautiful… At first I was thinking of kaleidoscope but now I am kind of thinking of being under water as well.

I : In which sense?

P : How it is really vague… I think it really reminds me of water… how it looks and the motion as well.

I : So does it look like the reflection of light you see from within the water you mean?

P : I think looking up from the bottom of sea… because when you are in the water, you have the reflection of light from above… I think it's similar to this…

I : Can you describe your perception? Like how your eyes are moving, how you are capturing this sight…

P : Umm… I think it gives me a strange feeling. Because at first I was looking at this object, it's beautiful, it's sophisticated. It's subtle. But after you realised this shadow, the object is now not subtle, it's a big movement…

I : So you thought the motion of the object was subtle at first but when you compare this and the projection you realised it is not subtle.

P : Yes yes.

I : Are you looking at whole or are you looking at one of them, each of them?

P : I think I am looking at them separately… one by one but not focusing on any of them… moving from left to right and from bottom to top…

I : Thank you. Then the last question is, if you choose a few adjectives for this scene, what will you choose?

P : I think, sophisticated, unreal, or… umm… illusion… or maybe Halloween?

I : Halloween?

P : I think this moving light reminds me of animals or ghosts but in a happy way so kind of Halloween feeling for me.

I : So if I stop this movement, doe this feel really different?

P : Yes it is very different. Definitely. It feels more like sophisticated but I don't imagine such unreal fantasy animals so I think it's very different. I like it moving.

Part 2)

<We went go through from mode 1 to mode * and I asked the participant some questions on each of them.>

<We are in the mode 1 with no movement.>

I : How do you want to do it, for its speed? How fast or slow do you want this blink to be?

P : I think slow…

I : How slow do you want?

P : Umm a bit more…

<Now it is about 5 seconds per cycle.>

P : Yes like this…

I : But what if I make it even much slower like very slow?

P : Umm I think it's too slow.

I : Then why do you like that particular range of slowness?

P : I think if it's too slow I just get sleepy so…

I : Ah OK. Do you like this blink? Do you think this blinking is better than the static lighting?

P : Yes definitely definitely.

I : So, you want this blink?

P : Yes.

I : Why?

P : I think it gives you some changes… it is more interesting.

I : What about this motion?

<I added swaying movement with the level 2.>

P : I think it's interesting. I want it to start with very subtle, small motion and slowly getting bigger.

I : You said, when it is not moving, blinking light is better than static light. Now with this kind of movement, does the blinking light is still better for you?

P : It's hard to tell. I guess… I like both…

I : OK OK.

<Now we moved to the mode 2.>

I : How do you feel about this? If it's moving around…

P : Yes I like this very much. It's kind of cute and like fantasy atmosphere… I like it when it is only one or two light… making flower like shape?

I : Why?

P : Um… I just like this flower like shape and it is more clear now so.

I : Then do you like looking at these flower like shadow shape clearly, rather than looking at the whole merged projections?

P : Yes.

I : Why?

P : Because it is… more beautiful.

I : More beautiful? In which sense?

P : I think… the shape.

I : So you really like the shape, flower like shape?

P : Yes. Before we had too much shadow I think.

<Now in the mode 3.>

I : How about this?

P : I think it makes me dizzy… too much…

I : So if I make it even faster, then will it be more…

P : More dizzy.

<Then in the mode 4.>

I : Then how about this sequencer like mode?

P : Yes I like this very much. It has rhythm. It reminds me of an electrical keyboard which has lighting guid… So I think it lets me have fun feeling. And also it reminds me of… the hopscotch. So in my memory on the river bank I played with friends this hopscotch… I remember that. It has a memory of childhood.

I : What makes you to remember that?

P : This rhythm.

<I gave the participant the physical controller and asked her to create her favourite mode. She chose the mode 4 with "On On On Off, On On On Off" pattern but asked me to modify the program so that each "On" light stays for about 2 seconds and gently turns off. On top that, she wanted to keep one stem in the middle always turned on. She did not add swaying movement.>

I : Why did you choose this?

P : It reminds me of the hopscotch which I really liked. I like how it's rhythmical… subtle rhythm, not too messy too chaotic. And for me it's like touching kindly… it feels making me very relaxed. I want to have this at the end of day in my bedroom before I sleep. I think this regular rhythm makes me really relaxed and comfortable, and guides me to sleep. I think it is just how I feel. And I heard before that when you were a baby inside your mother, womb, that's what you hear… like a regular rhythm. I think that of breathing, or heartbeat. And it is also similar to the sound on the train. So I think it makes people relaxed… hearing that kind of regular rhythm and also feeling the movement.

I : It is interesting that you chose this particular pattern… why is this so special for you?

P : I think the link with my memory of hopscotch is very… strong and powerful… I mean very enjoyable. So you bring me back to that fun memory.

I : Then why do you want to keep this particular middle one turned on all the time?

P : Umm… I just wanted to have it. You know, if it's music, it's kind of bass… it is always there while other instruments are playing… so it's like the core.

I : Interesting. But why do you want this only one stem to play the role of bass?

P : I think if the bass is played by this only one stem, it still stands out the rhythmic hopscotch. If I have all the stems lighting then this hopscotch will be… a kind of weak. But when I have one middle stem as the core and at the same time this hopscotch around it, it makes me associate this with music with rhythm, so I think I like it.

I : It is interesting that you are enjoying this associating it with music, but this work, shape, appearance of the installation, does not has to be associated with music. As you said it has a sort of analogy to paddy rice, that sort of natural scenery. It's not something to do with music. Then why do you prefer linking it with music?

P : Umm… I think it's just personal preference. I love music. I like paddy rice but seems that it gives some uniqueness in this combination. I think… yeah it's just personal preference.

I : OK thank you.

Part 3)

I : What did you think about adding music to this installation?

P : It's amazing. I really liked it. Much much better with sound.

I : Why?

P : Umm…. because it has more richness in contents? And I also had much more senses when I experienced this. It's much better not just seeing or hearing… in this way I could feel the work in depth.

I : How did you think about the sequence of light, motion, and sound?

P : I liked it. I liked it. It was very subtle in the beginning. I also liked the light corresponding to sound like… when sound comes from left to right, light follows that. It was really comfortable. And when music comes like rhythmic melody, and light together, I liked it very much and I thought it's much better in this way. With the music, it was kind of watching a show. It reminded of… Singapore fountain show or Disney parade… Just to see the light corresponding to music… it was amazing.

I : It is quite interesting you say that because some other people said that music is very strong or maybe too strong and may kill the subtleness of gentleness of the work. What do you think about such comments?

P : Umm… to me, the music doesn't kill the atmosphere. To me it's more lively and for me better. I like, toward the end, both music and light calm down… into darkness. I really liked it. Like finishing the day, being relaxed.

Participant 4 — Interaction Designer with Film Background

This participant did not know about my research.

Part 1)

Interviewer (I) : Can you give me some descriptions of what you are looking at?

Participant (P) : At first what captured me was this shadow like wave… or water surface, reflecting light. And I saw the differences between long stems and short stems, but at the same time there is some difference even between two long stems or two short stems so I am wondering what makes this differences here. Is it something intended or something that happens naturally… but maybe intended? But I do not know yet. Then… the light at the end reminds me of flame of candle at a glance. The swaying motion is maybe in one direction but it feels somehow strange or… unnatural for me.

I : What about its form?

P : Regarding the form… because it is dark in this room… well the form, shape is very beautiful… reminding me of a reed…

I : You mentioned the projections on the ceiling and said it's like water surface. What made you think so?

P : Well, I was working on film before and when, let's say at a swimming pool, we have lighting reflecting on the water surface, the reflection becomes like this. So I remembered that.

I : What would be common between this projection here and the reflection of light on the water surface at the swimming pool?

P : Umm… maybe the motion itself is not really similar but its pattern I think.

I : You mean the visual, graphical pattern?

P : Yes yes. So it is like circular things gathering… and it is similar to the reflected light on water. Well the light on the water does not move as such so it may be a bit different though…

I : Do you know how your perception works… or how your eyes are moving?

P : I think my eyes are following this light or shadow.

I : You mean they are following one particular light source or shadow?

P : Yes… I think… I am looking at this one, this in front of me. I am not following others.

I : So you are focusing on this particular one but at the same time others should be in your sight right? In that case, how are you capturing the whole? If you can articulate it…

P : I think, maybe because of the short distance between the light source and the ceiling, the motion feels a bit too fast for me to follow. So if we have more distance it may be more gentle…

I : Ah I can reduce the amplitude of the motion actually…

P : Ah yes this is very different now… it's more gentle and comfortable.

I : Then has your perception changed as well?

P : I now recognised that the shadows of this… this head on the ceiling. Before I only found the water-surface like projections but now, it is mixed with these shadows of tubes too.

I : OK I want to move this a bit more…. then how are your eyes moving here?

P : Umm, I think my eyes are looking at these moving things but… it is a bit fast for me. Too fast to follow with eyes. I was imagining that this, as a product, being placed at a restaurant or somewhere and… then in that case I think it is too fast, maybe too busy. But if it is as gentle as before, then it is comfortable.

I : How do you see… do you feel this is random? Or you find some sort of order in it?

P : I think I am trying to find things with similar movements… so this (stem) and this (stem) are like moving similarly or even in sync but I am maybe trying to ignore others… or not really paying attention to.

I : Is it like that for shadows too?

P : Umm… no. Shadows are different. In shadows, I am looking at the middle one… in front of me.

I : OK then the last question of this part 1. If you express this scene with two or three adjectives, what do you choose?

P : Comfortable… sorrow… maybe?

Part 2)

<We went through from the mode 1 to mode 4.>

<We are in the mode 1 with level 1 swaying movement.>

I : What do you feel about this blinking mode? Like which do you prefer, how do you want it, its speed or brightness?

P : The fade between dark and bright feels comfortable now… if it is fast I think it does not feel continuous, like broken. But if the fade is slow, it looks like a continuous, flowing motion.

I : How slow do you want?

P : I think slower…

<Now the blinking is about 10 seconds per cycle.>

P : Mmm it may be too slow. A bit, little bit faster…

<Then about 6 seconds per cycle.>

P : Yes I think around this speed.

I : Why is it, do you think? Why do you want to keep it in this certain range?

P : If it's too fast, it feels broken and not continuous… and if it's too slow… I thought the ratio of darkness increasing and this also breaks the continuity.

<We moved to the mode 2.>

P : I like this actually. You know when only this one at the left end is on, and all others look in the shadow, I though it is interesting. Well generally light at home has only one or two light sources, this feels relaxing by reminding me of it. If the speed of the change in position is always slow, it is more comfortable.

I : Do you want this blinking or not?

P : Blinking… well… I think if one turns on and fades out, then moves to the next one, fades in and slowly fades out… if you can do it I think it is nice…

<I modified the program to make what he imagined.>

I : Like this?

P : Ah yes. It is like… so like transition of scenes you know?

I : Of a film?

P : Yes. Fade in, out, and then another fade in and out.

I : Why do you like this?

P : For me, I think, it is more beautiful when only one unit is illuminating.

I : Why?

P : Why… why… because I can look at each of these objects? This beautiful object? If all of them are on, I ca see it only as a whole… well it should be your intention I think, but for me each of them is beautiful as a lighting object so I like it.

I : I see.

<Now in the mode 3.>

P : This is also interesting. This is very different from others, like gentle ones, but the lighting pattern is simply interesting. Now I am not looking at the swaying motion any more.

I : What if it moves more?

<The swaying motion is increased to the level 3.>

P : Ah yes now I am looking at it too. It's like… threatening. I prefer this lighting with no motion because I can concentrate on the lighting simply.

<Then in the mode 4.>

P : Simply it is enjoyable. Perhaps because of its rhythm.

I : Does the rhythm feel enjoyable?

P : Well… if I feel a rhythm, that means I sense an intention behind. For example, compared to notes of sound are playing randomly, if they are in a rhythm, so in an order, I think simply it is enjoyable. I do not why it is enjoyable though…

I : I see.

P : Same as music… I think. Like a melody.

I : Then if I add more impulses…

P : So it's getting more beaty? I think… I think the last one was more rhythmic. This time it's getting a bit more random in my feeling. It's less rhythmic.

I : And you preferred the last one?

P : Yes. Yes.

<Then I gave the physical controller to the participant. He chose the modified mode 2 described above with level 1 movement.>

P : I supposed the scene is in an restaurant. So each light source should be clear, and the transition should be slow, so that it does not disturb customers. As for movement, if it is too subtle, the customers may think it is blown by wind or something and will not know it is moved with intention. So I wanted to have a sort of movement which allows customers realise the intention but not too fast, too slow. If this is in an restaurant… it is beautiful and will not disturb them.

I : This speed of transition of light… what makes you to choose this speed?

P : I think… as I mentioned before, it is about continuity. Not separated, but not too mixed.

I : This transition is done at a regular pace… do you think it is better than randomised transition?

P : I thought it is better.

I : Why?

P : Umm… if it is not rhythmic, it becomes another information, and I cannot concentrate on the light, shadow and movement. Light and shadow, and such random timing… is probably too much. If it is regular rhythm, we do not have to pay attention to it.

I : So you man if it is sometimes fast and sometimes slow, it irritates you?

P : Yes that is the thing.

Part 3)

P : The overall impression is… I thought it was better without music. But what I liked with music was, firstly in the middle of the song all the light turns on and off regardless of the sound, and secondly at last the light turned off one by one slowly, I liked that. The reason why I liked it was, because we have been looking at one light and another for a while so it felt fresh to me to see all the light turned on, and the last scene, where the light goes off one by one, was what I have not seen and new. Also if the sound and visual matches too perfectly, it feels like a 'typical' installation… I thought this work is better when it moves or illuminates regardless of sound, even if it has sound, personally. It is same in video or film. It does not feel comfortable when image and sound matches too perfectly. There can be sound in one layer, but movement and light should be another layer. It works better for me.

I : It is interesting because I think I can understand what you mean by 'typical' installation. But do you know why it becomes like that if sound and visual matches perfectly? The comparison to film is also interesting. Why will it be boring when sound and image matches?

P : Well, I think it may be because of the differences in purpose. I was looking at this work as a lighting object. However, when it is played with music, suddenly it becomes something for music. A kind of device built for music. Then I felt it is like cheap… kind of it's becoming a supporting role.

I : I see, I see.

P : It may depends on kind of music. This music is like electronica… but it may be different feeling if it is like piano or guitar sound. I have an impression that music for such installation art is often like this kind of electronica music so maybe that impression had some influences.

Participant 5 — Architect

This participant did not know about my research.

Part 1)

Interviewer (I) : Can you give me some descriptions of what you are looking at?

Participant (P) : Well, I think, it has a lot of something like reeds, you know, swaying in the wind. And also they are enhanced by… so not all the stems are swaying necessarily in the same direction… and I was also very interested in this lighting… I did know you intended this sort of effect…

I : You mean the projection?

P : Yeah so it has to be something with the light through holes… that makes this kind of effect which is really nice actually.

I : What about this motion?

P : This motion… I think…

I : How do you describe it?

P : How do I describe it? Well it was very natural. Because it was very much like a sense of flow going on… like a pendulum almost. I think pendulum individually but if I see them as a whole then that give me a sort of reeds, a sort of naturalistic feeling to it. But again when I see it individually, that reduces that effect slightly. It suddenly reduces the kind of grass or kind of natural thing I mean… almost texture. So I think it is really nice it has that but because they are swaying in different directions it has some sort of unsettleness you know? A little bit. Because it does not follow exactly the property of reeds or… how you normally see those, that is unsettling part. So I guess it is even more interesting that you have this curiosity of what's going on. Because it has a feeling of natural but also something not natural about it. It's a kind of tricky perception of it. That's my first reaction to it.

I : Are you looking at this physical object? Or shadow or projection?

P : In the beginning definitely the physical object because you cannot get away from that. But when it does light up in a dark room like this… well if it is not a sort of spectacular scene like this but a just physical sort of sculpture or something I think it is just a sort of physical minimal lighting and it would not be like that. But firstly for me physicality of that comes… yes…

I : So when you are looking at this physical elements, how are you perceiving it like how your eyes are moving?

P : For me of course I think we, in a long time of evolution, we respond to movement because even if you see something tiny little bit moving, in a corner of your eye, your eye will definitely catch that. So what happens I think is initially your eyes are following movement, sort of pendulum like movement of each one… I also sort of rapidly moving, I cannot keep one. Because I see everyone kind of crossing to it, and I follow that. But interestingly most of the time I am following the movement, and interestingly you know this one (stem) for example is not following the same pattern of that (stem), so this distracts you. And you continue this until… perhaps maybe we have perception we're trying to understand the composition fully, or situation or environment. So my eyes are constantly moving around to try to understand this… the flow of it. So potentially does not have calming… actually… I think it may be another unsettling part that I mentioned. You know you cannot be too relaxed because you have to be wondering what is going on.

I : Do you think that will change over time?

P : Yes I'm kind of getting a sense of that. Initially it feels like they are moving in the same direction for a moment… there was a sense of that but having this here for a few minutes now, I do not really recall the consistency. I don't feel that.

I : How about the projections on the ceiling? How are you capturing that?

P : Yeah. I don't know I think it's a background thing personally. I like the sort of laced effect that is being produced, but I think light is also actual element themselves so for me that is always kind of a background rather than foreground sort of thing.

I : But when you are asked to see it, how do you see it?

P : Still inconsistent isn't it? It is constantly moving around and it has somehow a trick of the patterns that you sometimes see, like in black and white. Well… I don't know what I am making now actually…

I : Someone said he is looking at the middle point all the time, or other person said he was following a particular one circle. So it can be quite different so I was interested in asking that…

P : Yes I think similarly I haven't fixed my gaze at one point particularly. I had a similar effect kind of looking around constantly… so I was, my eyes were always moving looking for the strongest area of contrast. I think what is different from looking at object, compared to looking at the shadow, is it (shadow) does begin to have feeling of repetitive. Because this (object) does not look changing so much. I don't know why… I don't know why… I think this object has a sort of accuracy you know this fine shape so even if it moves a tiny bit, you know it is moving. If it is a light projected like this and if it is blended like that, we cannot, you know, see the small change but we find that moving backward and forward so it's kind of repetitiveness in it. But I am not sure…

I : OK thank you. The last question. If you choose a few adjectives to describe this work, what do you choose?

P : Umm… sway? For me… I actually had some sort of unusual unsettling thing from it. I want to be relaxed but I cannot…

I : I think it may be because of this amplitude of motion maybe? So if I reduce it…

P : Oh, oh wow, yes it is very different. It's now more relaxing actually. I think poetic is a good word maybe.

Part 2)

<We went through from the mode 1 to mode 4.>

<We are in the mode 1 with level 1 swaying movement.>

I : What do you think about this?

P : I think this oscillation (of light) needs to be very gentle. Very very gentle. I think it's good have this oscillation. Because when it gets closer to the black in the pitch we see the details of those holes and shape. So it has to be very gentle. Because you know the moment just before the complete black, you see? That is good, that is beautiful. But if it goes off, it suddenly breaks. So the change along this level is gorgeous, it's beautiful. It's really really nice. So I am trying to change it within that level. It's very beautiful. No off.

I : Do you want to keep this level statically rather than oscillating?

P : I like the static actually but slight change with that level as the starting point and finishing point is still nice. It is interesting…

I : Why?

P : Because if it goes from this level to zero, the change is quite sharp, but like the last one if it goes around this level it is gradual. And it is natural. You know I think anything in nature doesn't do the sudden shut off. They gradually change you know, like waves, night light…

I : Yes interesting, but in that sense, I do not think natural things are static. Then what do you think about the difference between being static at this level and slowly changing around this level, from this point?

P : Well in nature change is always in relationship with something, isn't it? You can argue that if it is consistent or depends on time…. but anyway I think the slight change is nice to have. I don't know but I think it depends on what the purpose of it is. You know is it a background light? It really depends on what the purpose of it is. If it's about purely aesthetic preferences, I think it is nice to see that.

<Then we are in the mode 2.>

P : Wow, that is really cool.

I : Why?

P : Why? Because… I think it's really cool somehow. The sort of movement, your consistent movement of physical but also light, you can trace that back and forward.

I : So you are positive to have this kind of effect.

P : Well I mean it is interesting to see it, whether I want to have it or not. I think it's stronger than conceptual thing, sort of aesthetic or ambient… This is like things that look cool but there is no reason for it, I am not so sure why you are presenting it like that. Because if there is no reason for it, it becomes just a light trick.

<Then we moved to the mode 3.>

P : Wow, it looks like a kind of night club… is it random?

I : Yes the position is random.

P : Can you change the brightness?

I : Yes I can change it like this darker…

P : Yeah that is nice, this subtle light is nice. I like it. That is really good actually. This is almost like flames.

I : What do you think of this kind of effect?

P : I like it actually. I did not, but I like it now. It is very interesting effect like flames. And also it's a nature link, it's almost like natural flames you know.

I : So it is now like flames, and becoming different from your initial impression of reeds?

P : Umm, for me this looks like flames like fire and… that has link to some sort of how you see that in the wind… like flames control and movement of air of that, so that has the kind of effect in it actually. But yeah it's not like something like reed. But it has some elements of sort of natural feeling. It does not feel artificial.

<We are in the mode 4.>

P : It's nice to see, but again, it's getting away from what is really the point of this piece of work… I think. Unless we have some kind of music or something… This should be something called like rhythmical.. rhythmic.. and rhythm is usually associated with music or sound… again rhythm is almost trying to control me in a way. So you're trying to understand this rhythm… or order… I mean this kind of stuff is found everywhere in the market like toys or whatever and they are not really… beautiful. So I do not think this is your intention to do this with this piece of work… I think.

<Now the participant mixed the mode 1 blinking in the range between about 5% - 15% brightness and the mode 3 spark effect. He added the level 1 swaying movement to it.>

P : Personally for me, I quite like this lower level, not starting from zero but quite low level, and in terms of changes I quite like that effect you get, sort of sparky flame like effect. Again it does not have order in it or at least it does not feel like that. I don't want it to be ordered. I don't want it to be understandable… so much. I don't feel that I want to have that sort of understanding 'oh i got it' like you know such sort of point. You can just appreciate the whole…

I : But can it be completely random?

P : I mean for me it does not matter. I know it is not obviously completely random because it is some sort of basis or logic behind but at a certain level we do not pick it up. You don't have to program a randomiser into it. I think above a certain level or in a certain situation or condition, you can perceive the order or rhythm, at certain scale I think. Just because it's so gentle and we have so many of them, that may be not so solvable. I think the same thing happens to the movement because that… maybe they're moving in the same direction but because there are so many of them you do not necessarily feel like that.. that for example it is repetitive.

Part 3)

I : So, what do you think? What do you think about adding music to it?

P : I think this is what I talked about. Turning on and off, animating, this sort of things… I think it is definitely enhanced when it is a part of this composition. I think seeing it alone… I think it still even had that sort of atmosphere of rhythmic music somehow in the motion and light but… actually I may change a couple of my opinions that I made before. Before seeing this music thing I thought I quite liked the ambient atmosphere but this… it convinced me it has a sort of performance sort of aspect in it, which is beautiful actually and yeah, that is really nice.

I : Interesting, because some people said that music is too strong and kill or take over the attraction of this work, so it's much better without music.

P : No no I don't agree with that simply. I think it has to have duality in it. On one level it's successful in both ways but on one level it has to have some sort of naturalistic things like candle you know… flames, flaring, movement, this all sort of naturalness you know fireflies, reeds, these all examples from nature. You can really define the beautifulness of this installation with them, but I think what is nice if you are going to try to make it animated then… sort of turning on and off and coordination of those changes… that is much much more believable and enjoyable and this is now musical and multi sensory feeling in it, because movement, changes in light, the sound, all the things suddenly come to make me believe such kind of cinematic feeling which is quite nice. So in that sense, it is quite strong to add music to it because it enhances the things you showed to me… so it depends how you want to.. experience it.

Participant 6 — Product Designer

This participant did not know about my research.

Part 1)

Interviewer (I) : Can you give me some descriptions of what you are looking at?

Participant (P) : OK. I describe it as… long rods like reed, and swaying in the breeze, I find it very relaxing to watch them because it's sort of mimicking the natural movement. So it makes me very peaceful… yes peaceful… and it's weird because it's form I have seen before but it includes light and includes shapes that sways, things like that, so combines two things so makes kind of juxtaposing… which is actually quite nice, I like that.

I : How do you describe this motion?

P : I describe the motion… kind of… yeah I describe it as close to waves. Especially when you have two layers of them, one layer which goes forward and the other layer backward, it reminds me of waves that goes backward and pauses and then forward…

I : So are you grouping them into two clusters or groups in two layers?

P : Yeah I think so.

I : And those two go in the opposite direction?

P : Yes kind of… so I think I am trying to simplify this to have a sort of pattern of it… and you know for me it's easy to separate them like that. But it's also sort of automated and looking natural at the same time.

I : When you describe the motion like that, do you mean the motion of this physical object, or the projections on the ceiling?

P : Umm.. I think kind of half and half. Because the projection reminds me of thing in nature… well of course this physical elements have some qualities from nature but this projection also reminds me of reflection on water. The motion reminds things in the breeze but because it's so much taller it reminds me of, as a whole large thing, it reminds me of sort of rhythmic pattern of nature or things like that. I like the fact that it is quite rhythmic.

I : What about light?

P : I think again it's relaxing. It's relaxing because of the fact that… it's actually quite a lot (of light sources) right? so it's illuminating the room but at the same time it's not bright so like harsh light or anything… I like the fact it's simple shape with many holes in it… because of that pattern. The fact is it creates this sort of half natural half surreal pattern on the ceiling. And also I like the fact that this randomised but also preprogrammed elements still cross over. Yeah I like that, I like this light pattern.

I : Can I ask about your perception. How are your eyes moving? How are you capturing this?

P : Yeah it's interesting about eye movement cos I haven't realised that. But once you say it, once I look up I focus on this light coming toward me.

I : So you now look at this physical object.

P : Yeah I definitely focus on the height and light at the top of the stem… yes I am focusing on that more than the pattern… pattern of this subliminal… well I haven't realised that but yes definitely focusing on this physical element.

I : Do you know why?

P : I guess… maybe because the lights on the ceiling are in undefined shape? It doesn't have like pinpoint on… so nothing that I can focus on in an easy way… but the forms of these (physical) elements, it's easy to focus on this defined shape.

I : Then if you're asked to look over the shadows, how do you look at it?

P : My eyes are moving up and down but like in the middle. So sort of… seems like following the circles… seems to follow the outline of the circle at the bottom… the rim, so yeah seems to be following the rim because it's in the middle point where they get more blurry so… I think my eyes are trying to make out the different patterns so trying to follow different circles at the same time…

I : Thank you. The last question of this part is, if you choose two or three adjectives to describe this, what do you choose?

P : OK I like that. I choose peaceful…year definitely. Peaceful… and also… nostalgic? because I feels growing up in the nature. And also elegant… very elegant… very thin it almost looks like breaking but not.

Part 2)

<We went through from the mode 1 to mode 4.>

<We are in the mode 1 with no swaying movement.>

I : What do you think about this oscillation?

P : I think I like it… I can see a lot of emphasis that would be really nice in having this in the setting… This somehow feels like it shouldn't go all the way to black… because if it's alway black all the way and up again, feel like it captures eyes a bit… so it should have something a bit light at the bottom…

I : Maybe.. like this?

<The minimum limit of the brightness was added so that it oscillated between 5% and 100% brightness.>

P : Yes but not fast.

<Getting slower.>

P : Yeah yeah like this. Maybe more dark somehow…

<Now it's oscillating between about 5% and 30% brightness and with about 6 seconds per cycle speed.>

P : Yeah it's nicer definitely I like this.

I : Why do you think so?

P : I think for me if it has clear contrast between dark and light it's almost flashing sensation rather than calming… because it's so much calming now… this slow up and down… yes this slowness is really nice.

I : How slow do you want?

P : Yeah I like this.

I : What if it's much slower? Why do you want that particular, not too slow or not too fast range?

P : Umm probably, well it might be stupid to mention like this but you know the Mac has the sleep light it blinks like that, I think it's mimicking a person's breathing… yeah it makes you think about breathing or something… and also if it's too fast it grabs my attention too much and if it's too slow I am not sure what's happening so…

I : OK interesting.

<We moved to the mode 2.>

P : I think it's nice. It's playful… yeah really. I don't know but it feels like little characters of like… that's cool.

I : In which sense do you think this is playful?

P : Because it's sort of some of them are waking up like 'hey' and some of them turned up… yeah it makes sure you look at them, makes sure you play with them… because you are trying to follow them like cats like trying to follow where they're going. Definitely grabs your attention.

<We are now in the mode 3.>

I : Then how about this?

P : That's nice. Like fireworks. I think it looks like lots of little explosions… yeah all dark around, kind of lots of sparks around… I like that one.

<We moved to the mode 4.>

I : What do you think?

P : It seems difficult… I definitely like it. Yeah it looks like combination of lots of settings. The fact is it gets darker. The fact is it's playful because it's moving around. But also it's… kind of calming but also grabs my attention same time.. so for me it's like everything. I don't know difficult but still relaxing and nice… I like that the position is random so I still try to find what's next…

I : How about this timing?

P : Oh timing is nice, I like the… the… rhythm of it. Yeah its rhythm is nice..

I : Because it is based on this regular beat?

P : Beat… oh yes, ah, I haven't realised that. Ah yes it's kind of strange because I didn't realise this. Now you said that I completely know that. Ah this is interesting and strange I did not notice it.. It makes sense now.

I : Then what do you feel when you realise it?

P : It makes sense because you are trying to find out what the pattern is. Now it makes sense that it's rhythmic pattern.

I : Is it better for you to realise it?

P : Yes yes I like to realise this.

I : How? Why?

P : Umm… probably… I think people like to work out the patterns, so I think once you recognised the patterns you sort of… but it's also nice to try to find out the patters before. I think it's understanding what it is and I like that because I now understand that…

<The participant mixed the mode 1 blinking in the range between about 5% - 30% brightness and the mode 4 with a polyrhythmic pattern. He added the level 1 swaying movement to it.>

P : I like the parts of it that are… I don't know but relating things to life and… have nice memories… things like of nostalgic part. So it's kind of… yeah I always like, in a foreign country, in the evening, and you saw that sort of calm, its kind of still… or in the morning as well… but it's just you know when it's not blown heavily and everything is going to be dark but still a bit of bright like lights of town or something… so I still kind of trying to make such… sort of ending of the day and then…

I : So it's sort of slow, gentle, dark, subtle part and on top of that it's a kind of flickering effect…

P : Yeah definitely randomness is needed. Randomness gives you… it keeps you interested about it, keeps you think about it. If it is too simple, then it was sort of… yeah it would be too simple. So it makes you feel like a part of atmosphere where everything in nature has sort of randomness… so such kind of images it gives.

Part 3)

I : What do you think?

P : It's a lot. It's a lot to say… I thought the music suited a lot to the physical appearance. So the fact is sort of… I am not very good at music to be honest but… but it's kind of techno sort of… electronic… any distinct sort of music I think… so the fact is… none of the sound is sort of piano, guitar, violin or anything and I thought that's good because it's sort of keeping digital, vague like… so interpreted the way you did. I thought the parts where the light switching on and off follow the music was good, apart from when it was for instance some of the stems which highlighted one beat and some of them did another, but there was also the third one which did another thing… I thought it works really well when… when one's following a few of beats. When it's following too many of the beats then you can't follow which pattern it is… but yeah it works really well… but I think if you have a room to follow them then you can do it like ah this one follows that one, this one follows that one, that one, that one… Umm… I think the parts I think very important when it's having music than something to watch is editing clips so that when music changes the feeling changes so you make sure it's synchronised which you did very well because that is sort of you are engaged with what happens. When it stops being engaging each other, then you also feel disengaged from it because you cannot get patterns, it's like you cannot get the clips you naturally expect from the clips you see… and I thought it was nice when it completely faded out in the middle sort of no lights and it's back up again because it was nice to see the different volumes or different motions of the stuff like… if you had such completely black then everything becomes fresh you know feeling another bit of start, which was nice. I liked that. Another bit of… I liked it when the spark like effect move from left to right corresponding to music, it was quite nice… what else… yeah I think music is the fact it's sort of… Umm…

I : So you are positive about adding music to it?

P : Yeah yeah definitely I think music leads you to the story… because music keeps giving you some clues of what happens next, it keeps sure you're engaged with that, yeah, and it helps you to find more patterns in it as well…

I : So do you think this music even improve this piece of work?

P : Yeah I think so. But I mean it also depends on the situation where it is… but I think it is a sort of experience of it… I think it is nice to have something where it creates an atmosphere, it creates something to… becomes a piece that you are engaged with more…. and you can sort of… you're allowed to explore it more I guess… because you can have time to take in and you can have reasons to take in… I think music definitely aids that.

APPENDIX L

EXHIBITION, AWARD, MEDIA COVERAGE

LIST OF EXHIBITIONS

RCA Group Exhibition (Yuen), Fuori Salone, Milan 2012

RCA Interim Show (Yuen), RCA, London 2012

Reddot Design Concept Winners Exhibition (Yuen), Reddot Design Museum, Singapore 2012

Salone Satellite (Kihou, Plural Kihou), Salone del Mobile, Milan 2013

Lexus Design Award Winners Exhibition (Inaho), Fuori Salone Milano, Milan 2013

Lexus 'Design Matters' Exhibition (Inaho), Chelsea Pier 59, New York 2013

RCA Interim Show (Kihou), RCA, London 2013

RCA Biennial Research Exhibition (Tupperware), RCA, UK 2013

'Traditional & Evolution' Exhibition (Inaho), London Fashion Week, London 2014

Francois Bernard 'Experiential' Exhibition (Inaho), Maison et Objet, Paris 2014

Gallery S. Bensimon Exhibition (Inaho), Design Days Dubai, Dubai 2015

LIST OF AWARDS

Reddot Design Concept - Best of the Best Award (Yuen), 2012

:output Award - Winner (Yuen), 2012

AZ Award - Shortlisted (Yuen), 2012

Laval Virtual Award - Shortlisted (Yuen), 2012

Lexus Design Award - Winner (Inaho), 2013

MEDIA COVERAGE (SELECTED)

漆黒の表面が突然割れて、底のほうから円形の金色の光が現れ、表面に浮上、半球状に盛り上がって、消えていく。そんな幻想的なプロダクト。

これは2種類の液体と空気の泡を利用した間接照明器具である。陶製の器の中には、粘度の高い液体が充填されており、その上には黒く着色されたシリコンオイルの薄い層が浮いている。器の底には小さなポンプとLEDが仕込まれていて、起動させると、底から黒い液体の表面に光の泡がわき上がるという仕掛けだ。

器の形を四角にすることで、円形の光を際立たせ、器の白が、液体の黒と泡の光の金色とのコントラストを生み出している。器は両手に収まるサイズにすることによって、「泡の光の幻想的な現象を、心理的にも物理的にも近い距離感で人々に体験してほしいと考えた」とデザイナーは語る。

ポンプの動きは一定ではなく、泡の動きにはゆらぎがあるため、見つめているとその微妙な違いに、かすかに心を揺さぶられる。どこか生物的な感じがする不思議なプロダクトだ。

The pitch black surface suddenly opens up and a golden globe of light appears from underneath. Rising to the surface, it swells into a hemispherical form and then disappears. It's a fantastical product.

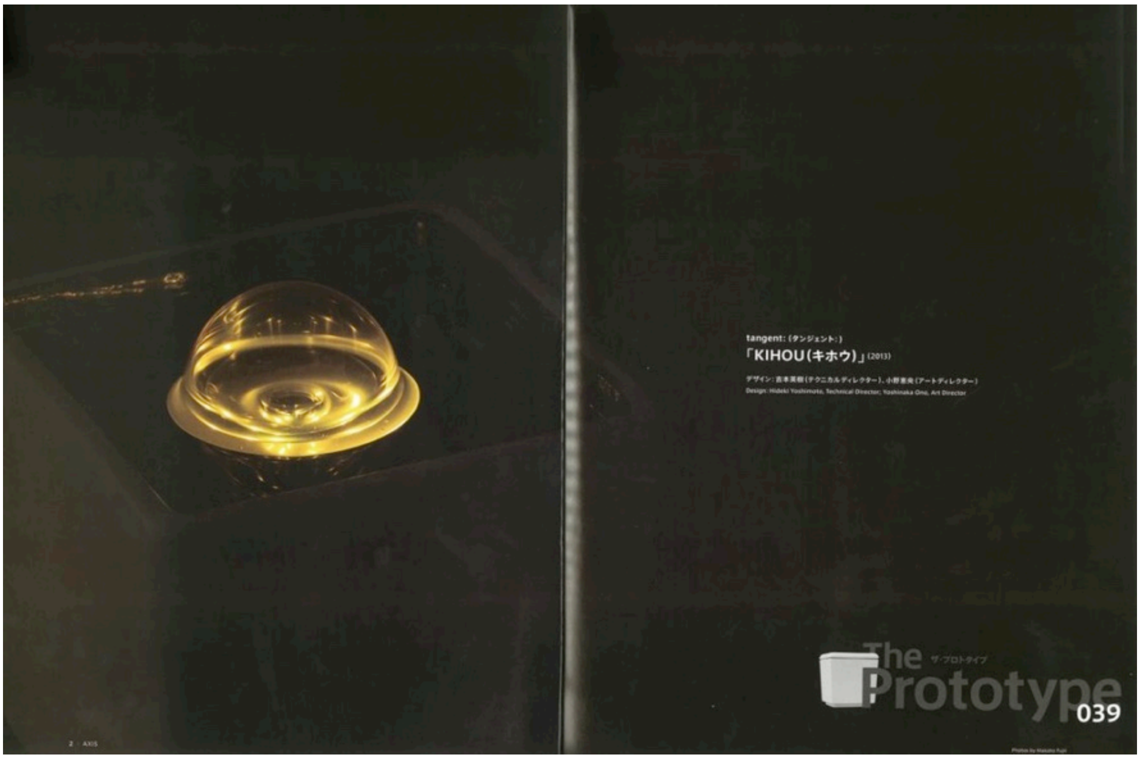
This is an indirect lighting device that uses two kinds of fluid and air bubbles. Highly viscous fluid is contained in the ceramic vessel, and a thin layer of silicon oil colored in black floats over it. A small pump and LEDs are placed at the bottom of the vessel, and when they are activated, bubble of light appears from the bottom on the black liquid surface.

The round light is accentuated by making the vessel cubic, and the white ceramic gives contrast to the black fluid and the golden light of the bubble. The designers say, "We wanted to have the users experience the fantastical phenomenon of the lit bubble both physically and psychologically in a familiar setting by making the vessel fit in the hands comfortably."

As the rhythm of the pump is not constant, there is subtle fluctuation in the movement of the bubble, and the viewer's emotion is also affected subtly due to that slight difference. It is a mysterious product that seems somehow like a lifelike being.

The Prototype

4 / AXIS



tangent:（タンジェント：）

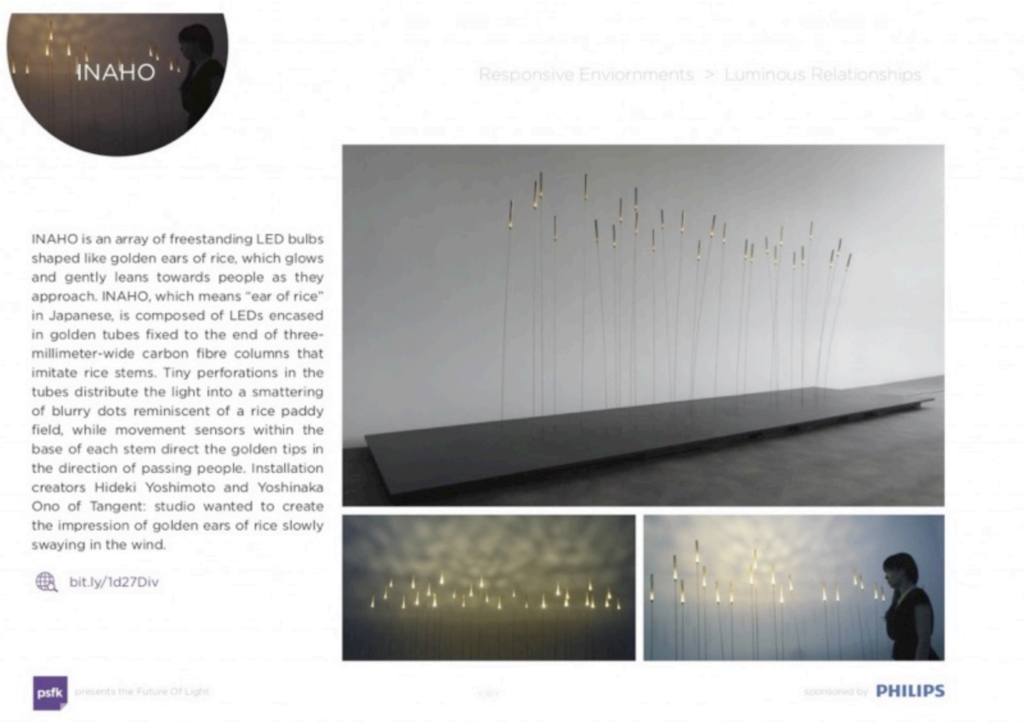
「KIHOU（キホウ）」(2013)

デザイン：吉本英樹（テクニカルディレクター）、小野義尚（アートディレクター）

Design: Hideki Yoshimoto, Technical Director; Yoshinaka Ono, Art Director

The Prototype 039

2 / AXIS


Responsive Enviornments > Luminous Relationships

INAHO

INAHO is an array of freestanding LED bulbs shaped like golden ears of rice, which glows and gently leans towards people as they approach. INAHO, which means "ear of rice" in Japanese, is composed of LEDs encased in golden tubes fixed to the end of three-millimeter-wide carbon fibre columns that imitate rice stems. Tiny perforations in the tubes distribute the light into a smattering of blurry dots reminiscent of a rice paddy field, while movement sensors within the base of each stem direct the golden tips in the direction of passing people. Installation creators Hideki Yoshimoto and Yoshinaka Ono of Tangent: studio wanted to create the impression of golden ears of rice slowly swaying in the wind.

bit.ly/1d27Div

psfk presents the Future Of Light

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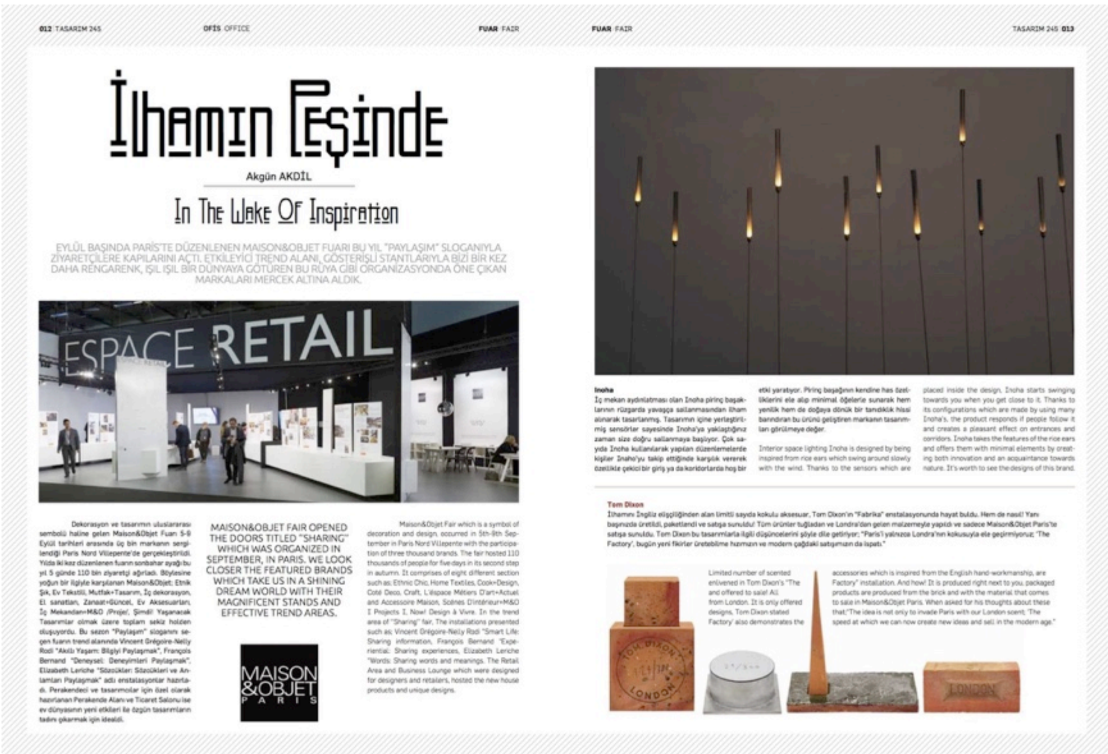

012 TASARIM 245 OFİS OFFICE FUAR FAIR

İlhamın Peşinde

Akgün AKDİL

In The Wake Of Inspiration

EYLÜL BAŞINDA PARİS'TE DÜZENLENEN MAISON&OBJET FUARI BU YIL "PAYLAŞIM" SLOGANIYLA ZİYARETÇİLERE KAPILARINI AÇTI. ETKİLEYİCİ TREND ALANI, GÖSTERİŞLİ STANTLARIYLA BİZİ BİR KEZ DAHA RENGARENK, IŞIL IŞIL BİR DÜNYAYA GÖTÜREN BU RÜYA GİBİ ORGANİZASYONDA ÖNE ÇIKAN MARKALARI MERCEK ALTINA ALDIK.

Dekorasyon ve tasarımın uluslararası sembolü haline gelen Maison&Objet Fuarı 5-9 Eylül tarihleri arasında üç bin markanın sergilendiği Paris Nord Villepente'de gerçekleştirildi. Yılda iki kez düzenlenen fuarın sonbahar ayağı bu yıl 5 günde 110 bin ziyaretçi ağırladı. Böylesine yoğun bir ilgiyle karşılanan Maison&Objet; Etnik Şık, Ev Tekstili, Mutfak+Tasarım, İç dekorasyon, El sanatları, Zanaat+Güncel, Ev Aksesuarları, İç Mekandan+M&O /Proje/, Şimdi! Yaşanacak Tasarımlar olmak üzere toplam sekiz holden oluşuyordu. Bu sezon "Paylaşım" sloganını seçen fuarın trend alanında Vincent Grégoire-Nelly Rodi "Akıllı Yaşam: Bilgiyi Paylaşmak", François Bernand "Deneysel: Deneyimleri Paylaşmak", Elizabeth Leriche "Sözcükler: Sözcükleri ve Anlamları Paylaşmak" adlı enstalasyonlar hazırladı. Perakendeci ve tasarımcılar için özel olarak hazırlanan Perakende Alanı ve Ticaret Salonu ise ev dünyasının yeni etkileri ile özgün tasarımların tadını çıkarmak için idealdi.

MAISON&OBJET FAIR OPENED THE DOORS TITLED "SHARING" WHICH WAS ORGANIZED IN SEPTEMBER, IN PARIS. WE LOOK CLOSER THE FEATURED BRANDS WHICH TAKE US IN A SHINING DREAM WORLD WITH THEIR MAGNIFICENT STANDS AND EFFECTIVE TREND AREAS.

MAISON &OBJET PARIS

Maison&Objet Fair which is a symbol of decoration and design, occurred in 5th-9th September in Paris Nord Villepente with the participation of three thousand brands. The fair hosted 110 thousands of people for five days in its second step in autumn. It comprises of eight different section such as; Ethnic Chic, Home Textiles, Cook+Design, Coté Deco, Craft, L'éspace Métiers D'art+Actuel and Accessoire Maison, Scènes D'intérieur+M&O I Projects I, Now! Design à Vivre. In the trend area of "Sharing" fair, The installations presented such as; Vincent Grégoire-Nelly Rodi "Smart Life: Sharing information, François Bernand "Experiential: Sharing experiences, Elizabeth Leriche "Words: Sharing words and meanings. The Retail Area and Business Lounge which were designed for designers and retailers, hosted the new house products and unique designs.

FUAR FAIR TASARIM 245 013

Inoha

İç mekan aydınlatması olan Inoha pirinç başaklarının rüzgarda yavaşça sallanmasından ilham alınarak tasarlanmış. Tasarımın içine yerleştirilmiş sensörler sayesinde Inoha'ya yaklaştığınız zaman size doğru sallanmaya başlıyor. Çok sayıda Inoha kullanılarak yapılan düzenlemelerde kişiler Inaho'yu takip ettiğinde karşılık vererek özellikle çekici bir giriş ya da koridorlarda hoş bir etki yaratıyor. Pirinç başağının kendine has özelliklerini ele alıp minimal öğelerle sunarak hem yenilik hem de doğaya dönük bir tanıdıklık hissi barındıran bu ürünü geliştiren markanın tasarımları görülmeye değer.

Interior space lighting Inoha is designed by being inspired from rice ears which swing around slowly with the wind. Thanks to the sensors which are placed inside the design, Inoha starts swinging towards you when you get close to it. Thanks to its configurations which are made by using many Inoha's, the product responds if people follow it and creates a pleasant effect on entrances and corridors. Inoha takes the features of the rice ears and offers them with minimal elements by creating both innovation and an acquaintance towards nature. It's worth to see the designs of this brand.

Tom Dixon

İlhamını İngiliz elişçiliğinden alan limitli sayıda kokulu aksesuar, Tom Dixon'ın "Fabrika" enstalasyonunda hayat buldu. Hem de nasıl! Yanı başınızda üretildi, paketlendi ve satışa sunuldu! Tüm ürünler tuğladan ve Londra'dan gelen malzemeyle yapıldı ve sadece Maison&Objet Paris'te satışa sunuldu. Tom Dixon bu tasarımlarla ilgili düşüncelerini şöyle dile getiriyor; "Paris'i yalnızca Londra'nın kokusuyla ele geçirmiyoruz; 'The Factory', bugün yeni fikirler üretebilme hızımızın ve modern çağdaki satışımızın da ispatı."

Limited number of scented accessories which is inspired from the English hand-workmanship, are enlivened in Tom Dixon's "The Factory" installation. And how! It is produced right next to you, packaged and offered to sale! All products are produced from the brick and with the material that comes from London. It is only offered to sale in Maison&Objet Paris. When asked for his thoughts about these designs, Tom Dixon stated that;"The idea is not only to invade Paris with our London scent; 'The Factory' also demonstrates the speed at which we can now create new ideas and sell in the modern age."


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