Learning from the void:
Researching design methods towards a new spatial paradigm

Weiyi Li
Department of Innovation Design Engineering
Royal College of Art

Learning from the void:
Researching design methods towards a new spatial paradigm

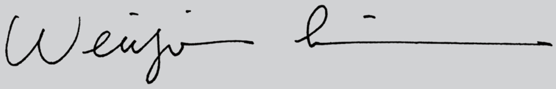
Weiyi Li
Department of Innovation Design Engineering
Royal College of Art

This thesis is submitted in partial fulfilment of the requirement of the Royal College of Art for the degree of Doctor of Philosophy.

Author's 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.

Weiyi Li, 11.08.2022
Date: 11th August 2022
Signature:



Abstract

This research focuses on a construction method based on digital cavities and surfaces. Today, any entity simulated by software is essentially a cavity wrapped in a thin film. This void is a space that is entirely invisible to others and belongs only to designers and manufacturers. It existed before the computer, and though ancient masons or potters may not have been aware of it, the craftsperson who cast metal must have discovered this space long ago: to shape hot liquid copper, a cavity of the same shape must be created in advance. Since ancient times, we have shaped form by creating cavities.

Today, modelling software shows this cavity to builders with unprecedentedly clarity. Here, the absence and presence of substance are directly equivalent. Even a substantial wall that is about to be constructed in the real world is nothing more than a void defined by a virtual surface in computer-aided design (CAD) software. This emptiness is the mechanism that allows us to oscillate between operability and perceivability, abstraction and materiality, concept and final product.

Design representation and illustration are frequently correlated with design outcome. They are the paths to the final construction and establish its predetermined boundaries. Through studying and reflecting on the new visual means of digital representational tools, as well as a series of practical projects, I seek to answer the following research question: **is there a new method, or a new set of methods, of making things with the tools of today that marks entities with surface constraints?**

List of figures

Table of Contents

Acknowledgements

From the beginning to the end of my research, I received a great deal of support, including academic support, material and operational support and, of course, a huge amount of care and love.

Supervisors

I would like to thank my advisor, Professor Ashley Hall. With his supervision, what began as a bit of curiosity, a naive inquiry of ‘what would happen if I did this?’, was able to blossom into several years of research process. I would also like to thank another advisor of mine, Dr Laura Ferrarello, for teaching me how to develop my own perspective in observation and a form of communication with readers and audiences: how to make valid inferences and transform my work into knowledge that I believe is worth reading and comprehending.

I would also like to thank Professor Craig Bremner and Dr Dan Lockton for their help at the beginning of my research. They gave me a great deal of guidance and showed me many possible directions when this thesis project had yet to find its path.

Project participants

When I think of the numerous people who have participated in my projects using 3D scanners and 360-degree cameras, I am reminded of Picasso’s statement that he only painted his friends so he could distort their images as much as he wanted without the fear of being punished. Therefore, I would like to thank these friends for allowing me to deform, reconstruct and duplicate their body images, for which I feel a tremendous amount of affection and friendship. They are as follows:

The Portraits Project

Tianyou Huang, Xiaoyi Nie, Xingyi Ou, Jingran Sheng, Bella Wang, ‘Chips And Yogurt’, Nini Zhou

The Her Project

Yao Wang

The Panorama Project

Tiger, Suki, Jiaqi Chen, Yujian Guo, Jie Jie, Cunming Sun, Emma Wang, Tiny Willow, Bubu Wu, Huahua Zhang

Art institutions and galleries

I was able to complete all the projects and exhibit them to the public with the cooperation of these organisations and their personnel:

Aranya Art Center, Qinhuangdao
Hive Center for Contemporary Art, Beijing
Mocube Gallery, Beijing
Power Station of Art, Shanghai
Tag Art Museum, Qingdao
The Closer Gallery, Beijing
UCCA Dune Art Museum, Qinhuangdao

And most of all,

I would like to thank my family and friends for all the help they have given me. I want to thank my grandfather, Huajie Dai, for giving me the drive to become a designer and for teaching me to find joy in creating from an early age.

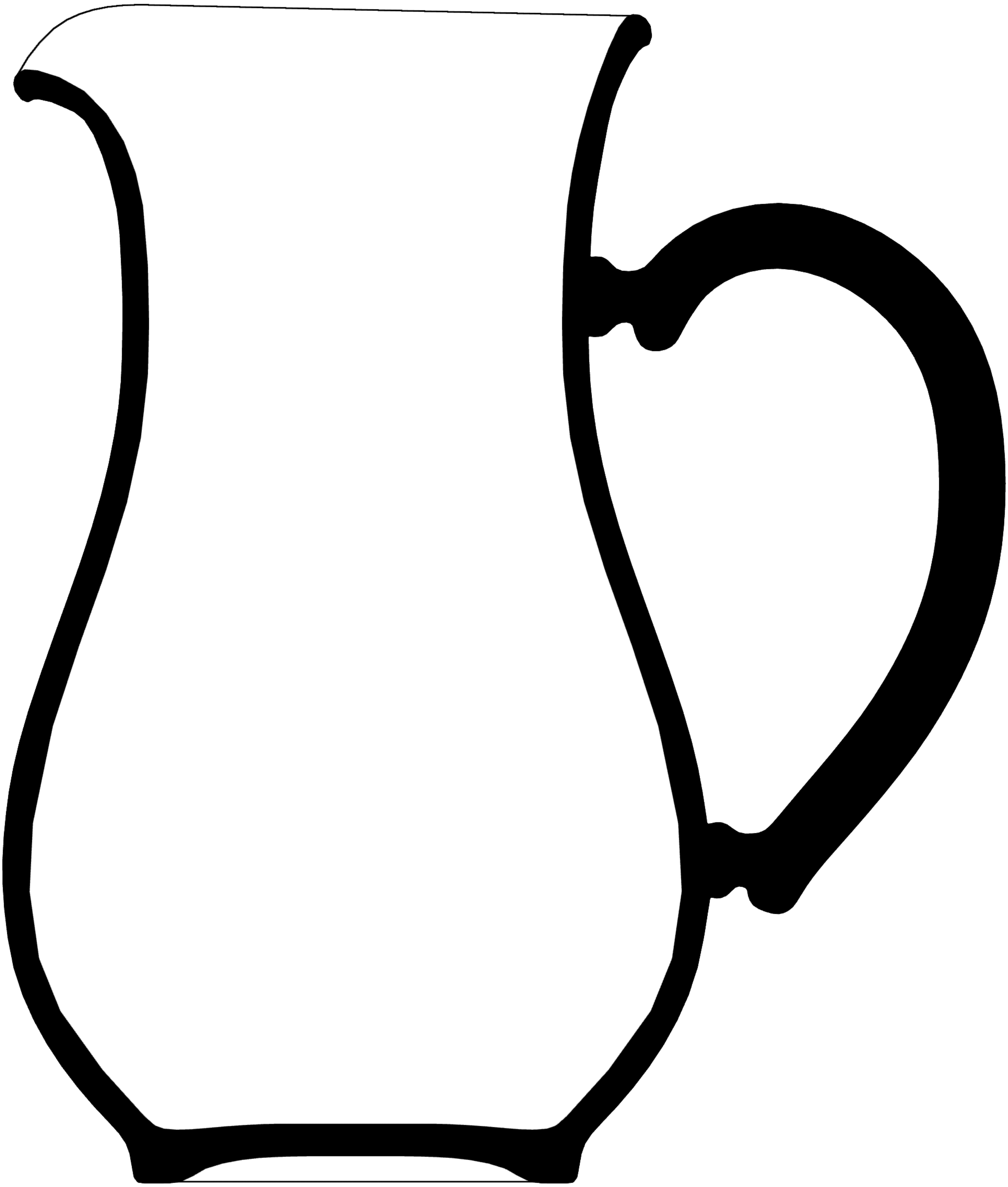


Fig.1 A hand-drawn section view of a jug and a clay jug with a ‘double void’ on a Rhino Software interface

1 Exploring the contribution space

When Heidegger said that a potter did not 'make a jug' but 'shaped the void' (Heidegger and Hofstadter, 1975, p.169), the void inside the jug was just a linguistic concept for us; however, in the process of computer-aided design (CAD), our perspective could be compared to that of a bug that has sneaked into the void inside a jug. The 'retinal journey' (Pallasmaa, 1996, p.14) provided by the computer may not allow the designer to experience the feeling of holding a weighty design product in their hands, but it can make them feel the transformation from abstract concepts to a visible spatial form as accurately as possible. With today's modelling software, designers can even penetrate the surface of a jug and reach the previously unattainable interior wall of the jug, which should be made of clay, to see another level of the 'void'. Thus, with the help of today's CAD software, the designer can see a double void [Fig.1].

As a designer and visual artist with many years of experience, it is hard for me not to notice a new method of visual representation that differs considerably from the real world. Here, the absence and presence of substance are directly equivalent. In the operation of a typical CAD program, the physical materiality is completely transformed into attributes of space and coordinates. Any entity simulated by the software is essentially a cavity wrapped in a thin film, completely devoid of thickness, whether it is a brick wall, a metal handle or a plastic cap for a toothpaste tube. This void, which does not exist in reality, is a space that is completely invisible to others and belongs only to designers and manufacturers. It existed before the computer. Ancient masons or potters may not have been aware of it, but the craftsmen who cast metal must have discovered this space long ago: to shape hot liquid copper, a cavity of the same shape must be created in advance. Since ancient times, we have shaped form by creating cavities.

However, the cavity is completely novel in terms of design representation. Prior to the widespread use of computer modelling programmes, the wall of a jug was typically depicted on hand-drawn designs as black blocks or filled with a group of dense lines to distinguish it from the actual space within the jug. As a result, I was curious as to what kind of artefact such a new illustration technique may inspire, which was the original impetus for this thesis.

Design representation and illustration are frequently correlated with design outcome. Design representation 'does not necessarily dominate but always interacts with what it represents' (Evans, 1997, p.199). For instance, the Renaissance facades 'were harmonized to create perspectives' (Lefebvre, 1974, p.47), which is closely related to the discovery (or rediscovery) of the principles of perspective at the time. Another example is the popular drawing method of the Developed Surface in the 18th century, which had a significant impact on the 'superficial' architectural style of the time, as well as the type of interior design that pushed furniture to the edges of rooms (Evans, 1997b, p.210). Representational tools are the path to the final construction and establish its predetermined boundaries. How the tools are viewed and utilised by their operators can result in vastly different outcomes. To avoid the accusation that most practitioners 'have simply replaced traditional media with new ones, without any substantial effect on their design process or outputs' (Bottazzi, 2020, p.vi), a dynamic tool operator must be able to recognise and respond to minor changes in tools and technology.

Through studying and reflecting on the new visual means of digital representational tools, as well as a series of practical projects, I seek to answer the following research question:

Is there a new method, or a new set of methods, of making things from the tools of today that marks entities with surface constraints?

1.1 Vision and approach

Tools serve as the foundation for this investigation. This study was inspired by the new visual characteristics of today's design and production tools. Technology has provided us with many 3D modelling tools for perception and production. Computer modelling software provides us with a highly abstracted way of describing the world, in which the process of making things is divorced from confrontation with physical materials and environments and instead becomes a simulation and speculation of what will be shaped in a purely Cartesian geometric space. Another effect of software is to bring the operator closer to the actual experience, at least in terms of the senses, through various visual simulation techniques to replicate the closest possible effect on various products and through virtual lens settings and lighting. This allows the designer to 'travel' with their eyes through a space defined by geometric coordinates or through interactive methods, such as touch screens, to simulate the feeling of realistic shaping and sculpting. As a result, the space in the tool becomes a hybrid of Cartesian and Merleau-Ponty spaces. Therefore, these tools can be considered design tools; they serve as a medium for combining the manipulative and predictive aspects of the design process. And this specific space, which combines pure geometric and perceptual space, allows for everything. Because of this, in addition to 'tools', another crucial topic of this research is 'space', to be more specific, the space displayed in the tool.

This study is not so much an exploration of issues within a specific academic or practical field as a starting point for exploring an approach that can be used in various fields, using the space presented in the tool as a starting point. This interdisciplinary approach to making is also an essential element of this study. 3D modelling tools are widely used in almost all creative fields. As a designer and visual artist for many years, I have frequently used modelling tools such as Rhino, Blender or the more popular SketchUp when completing personal art projects and commissioned design work. Most modelling tools now include an initial interface that includes templates with scales and units of measurement meant for a variety of tasks, such as architectural and product scales. Digital modelling is already required in all domains. As a result, this research does not initially focus on any one specific design domain; rather, it begins with tools and seeks to develop one or more methods of creation that can be applied to a variety of fields.

The widespread use of 3D modelling tools in various industries indicates a trend toward equating the creation of objects with the creation of space. The empiricist conception of space as the outer boundary of material form in the physical world is violated here. In his book *The Life of Forms in Art*, which discusses the formal evolution of man-made objects, art historian Henri Focillon describes the relationship between space and matter as follows: space is both an environment and a boundary (in so far as it is a boundary) in the matter of shaping material forms, and 'space more or less weighs on form and rigorously confines its expansion, at the same time that form presses against space as the palm of the hand does on a table or against a sheet of glass' (Focillon, 1992, pp.78–79). However, in today's computer interfaces, matter is presented as a closed space surrounded by a digital film. The layer of virtual film that separates space from the matter presented as space is the only boundary. And, through the software's scheduling of the virtual lens, these two spaces — the 'original' space and the matter presented as space — are transformed into visually navigable places. This 'spatialisation' of matter is where all shaping is possible. It is also this disregard for construction material, this undifferentiated treatment of everything as a film-wrapped envelope, that allows the same tool to function in multiple fields.

For in this case, the process of designing a bowl is the same as that of designing a car. Thus, studying the material spatialisation of tools allows us to use ‘space’ as a starting point to investigate a broader approach to the creation of human-made objects.

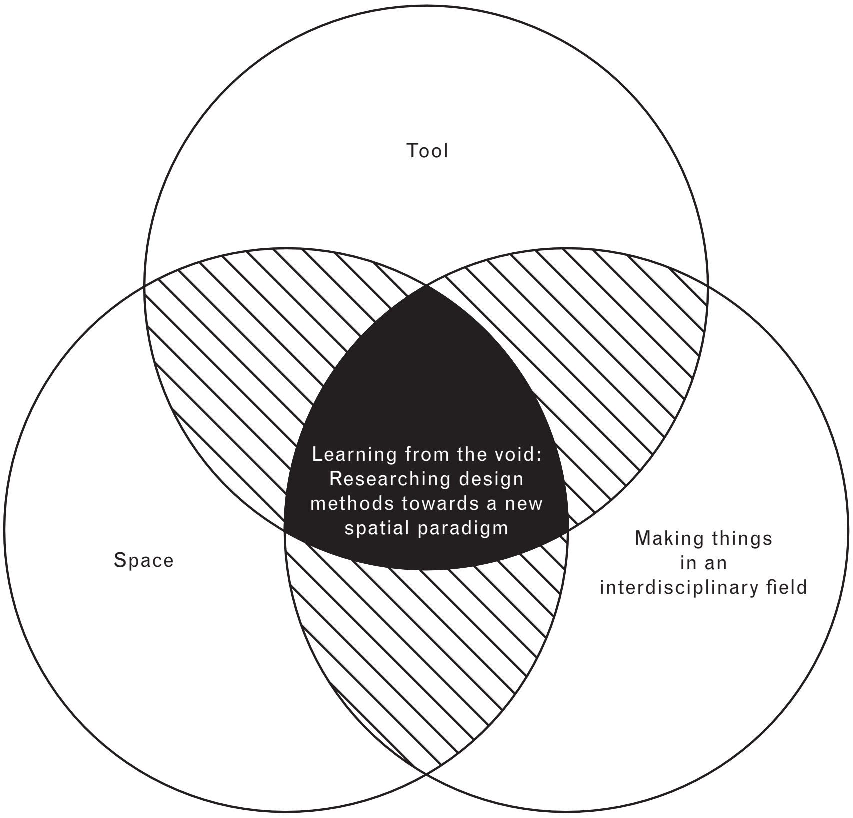


Fig.2 The convergence of three discussion stances

For this study, therefore, there are three coordinates of referential research: tool, space and making things in an interdisciplinary field. It is from these three perspectives that I commence my search for new methods of creation. Within the discussion of these three perspectives, numerous relevant research and projects have been conducted previously, which helps me to position my research parameters and approach more precisely and allows scope for further research and exploration [Fig.2].

1.1.1 Tool

1.1.1.1 Two types of criticism, and two types of instrumentality

Today's design tools have clear scientific origins, such as 'CAD solely relying on geometry and its Euclidean origins; and simulation software based on forces and behaviors inspired by Newtonian physics' (Bottazzi, 2020, p.11). Representational tools were designed with our understanding of how we perceive things. Obviously, geometry is an integral part of this. Humans have used geometry to generalise the world and 'capture' the unknown since the times of ancient Greece. Similarly, modern CAD software enables the design process by reducing everything to points, lines and surfaces on a coordinate axis. Designers design by manipulating these reduced objects to create things that are ultimately off the axis.

Through the way we perceive the world, we acquire a range of ways of marking and representing things, and by manipulating these marks and representations, we seem to be able to fully depict the things we want to put back into the world. In essence, this transformation can be regarded as a transformation from human cognitive ability to expressive ability. When Merleau-Ponty said, 'Everything I see is in principle within my reach' (Merleau-Ponty and Edie, 1964, p.162), he revealed the limits of the former. When Lefebvre explained that things encoded by language are not 'there' but only 'sayable' (Lefebvre, 1974, p.185), he underlined the limits of the latter. Tools exist at the crossroads of these two constraints. One of the challenges of designing with representational tools is to be aware of this double limitation [Fig.3].

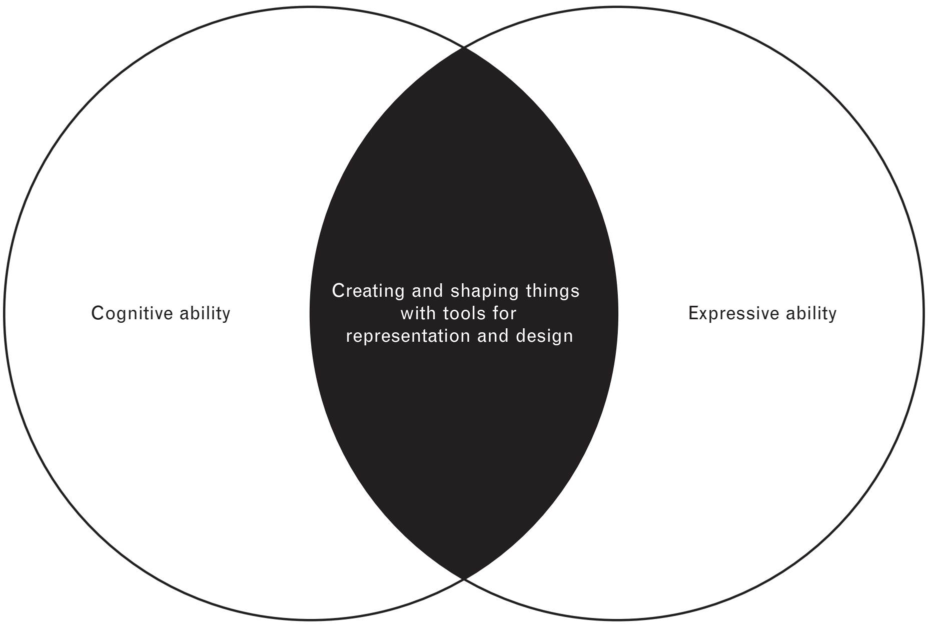


Fig.3 The double limit when using representational tools to design

Computer modelling software provides a highly abstracted way of describing the world, in which the process of making things is separated from direct contact with tangible material and an actual place, and in which things inevitably 'get bent, broken, or lost on the way' (Evans, 1997, p.154). In this context, some early practitioners criticised technology for its inability to fully align itself with the sensations and outcomes of the direct shaping of matter, such as Juhani Pallasmaa's statement in *The Eye of the Skin* that 'computer imaging...turns the design process into a passive visual manipulation, a retinal journey' (Pallasmaa, 1996, p.14). The lack of physical materials and physical environment is an undeniable disadvantage here: 'the computers create a distance between the maker and the object, whereas drawing by hand, as well as working with models, put the designer in a haptic contact with an object, or space' (Pallasmaa, 1996, p.14).

According to Pallasmaa, it is computers and software that lead to such a 'distance', while 'drawing by hand' and 'working with models' avoid this separation of the designer from the manufacturing process (Pallasmaa, 1996, p.14). But is this really the case? In fact, as early as 1986, Robin Evans discussed the fracture and difference between architectural drawings and physical buildings in his essay *Translation from Drawing to Building* (Evans, 1997). Today, however, there is a more positive view, totally contrary to Pallasmaa's, that ever-evolving CAD and computer-aided manufacturing (CAM) technology has 'the potential to narrow this gap between representation and building' (Iwamoto, 2009, p.4). Advancing technology means we, as designers, can see and do more on-screen than ever before — angles are more easily observable and tangible, details can be more precise and there is an abundance of 'materials' and lighting environments available for use. Additionally, the synchronous updating of CAD and CAM software makes the relationship between design and manufacturing apparently closer.

This seemingly growing relationship raises another criticism of technology. According to Latour, today's 'lack of space' is the result of a 'confusion of space with paper', and architects' 'manipulation of geometric forms' is 'intoxicating' (Latour, 2009, P.141). Designers, he claims, are overly skilled at projecting a purely geometric spatial code onto the real world.

These two criticisms of technology can be placed side by side because they share similarities. For instance, both types of criticism stem from the same underlying assumption, namely that the use of tools is viewed as a purely non-destructive translation process from concept to final product. For Pallasmaa, the tool is ineffective if it fails to perform this function. For Latour, on the other hand, the tool may not do this directly, but through its own convenience and deceptive nature in visual simulation, it can cause people (architects and designers) to misunderstand what they are doing or what they are supposed to achieve, which is this one thing: the exact equivalence of the palpable world and the world in the axes of coordinates.

However, we can see that even though both types of criticism of technology originate from the same source, the specific targets of their criticism are entirely different. The former explores the shortcomings of this technology in the sense that the computer-aided modelling system is not capable of allowing users to achieve the most complete sensory experience. The latter questions the adequacy of the technology: it is increasingly easy for people to learn, or even master, and even more convenient for them to simulate sensory effects, so that 'this manipulation is now at the fingertips of any dumb-downed user of CAD design software or even Google maps' (Latour, 2009, P.142).

This study first attempts to exonerate digital tools in the face of these two contradictory criticisms and then seeks new insights into their applications. The spatial representation of modelling software that interprets things as a unity of cavity and surface is the focus of my attention. This method breaks things down into the surface and the void beneath and applies the same rules in reverse to build new things. People like Pallasmaa, who value tactile sensation and physical experience, clearly criticised the crude simplification of things outside the screen. At the same time, it was concealed as a default digital reality under the over-convenient technical tricks that Latour pointed out. In my research, these two critical perspectives point precisely to people's efforts to advance the creation method under two pulling forces of mutually opposed tension, which I will elaborate on in more detail in a later chapter. One perspective is to try to get as close as possible to the final design product (at least visually) at the design and planning stage. The other is to try to maintain, as much as possible, its ability as a sketch, an inspiration and a 'vector of information' (Calvino, 1993, p.13) rather than a rich and complete preview. I will also describe these two directions as the essential attributes of all representational tools. Though the perceptibility and operability of tools seem to be conflicting attributes, they, in fact, support each other. Because of these two attributes, a tool can become a tool.

Once designers and practitioners understand this last point, we will come to the realisation that the question is not whether these computer-based tools are inadequate or too sophisticated but what can be created in the gap between the two. When the tangible material is completely transformed into space and coordinates, and when the physical space is replaced by vectors, can we also regard these transformations as an intrinsic part of our tools and make good use of them?

1.1.1.2 Between the thinkable and the touchable

From the standpoint of design tools, Robin Evans is someone who has had the most far-reaching impact on this research. In several papers related to architectural drawings, he discussed the relationship between various architectural drawing methods and architecture itself: ‘it would be possible, I think, to write a history of Western architecture that would have little to do with either style or signification, concentrating instead on the manner of working. A large part of this history would be concerned with the gap between drawing and building’ (Evans, 1997, p.185–186). The gap he mentions is the one that exists between what architects want to create and what they ultimately make. To some extent, my research can be considered an exploration of the digital version of this gap.

Evans’ essay *Translations from Drawing to Building* has always encouraged this research. In this essay, he argues, long before digital design tools became commonplace, for the inevitable loss before design ideas are gradually realised into a final product (Evans, 1997). Thus, long before Latour and Pallasmaa presented their critiques, he predicted that their comments largely stemmed from a false expectation of, or over-reliance on, the use of tools. When hand-drawn sketches were still the norm, there was little awareness, as Evans puts it, that the source of architectural drawing’s energetic power was ‘recognition of the drawing’s distinctness from and unlikeness to the thing that is represented, rather than its likeness to it’ (Evans, 1997, p.154).

As mentioned earlier in Lefebvre’s remarks, architectural drawings (or any design tool used for representation) can clarify only ‘sayable’ or ‘susceptible of figuration’, not ‘what is there’. Since the tool itself is a limitation, how can we still create with it? Evans answer was ‘lose control’ (Evans, 1997, p.180). In other words, in designing, we should give up some power exerted by architectural drawings or some power bred from drawings and geometric figures. He took the Royal Chapel at Anet, designed and built by Philibert de l’Orme, as an example: by comparing the architectural drawings with the final buildings, he found that de l’Orme chose to use the geometric form in the drawing only as the initial creative concept, rather than the final form, to guide the construction; therefore, ‘to fabricate would be to make thought possible, not to delimit it by making things represent their own origin’ (Evans, 1997, p.180). In this case, we once again see the conflict between perceptibility and operability, or abstraction and materiality, when architectural drawings are used as an intermediary. A drawing is a vehicle that ferries between ideas and final products. For Evans, the two are still in a repressive relationship. To create between the two, we must invent a means of reconciliation, which is why he said, ‘lose control’.

Maybe this is the actual creation. This kind of creation does not come from thought, nor does it come from the victory of thought over the material world, but just from the compromise and failure of thought over the world. Several of Evans’ papers have left me reflecting on agency. When we construct an agent between the idea and the final product, how much of the agent’s own qualities can be carried over into this final product? However, the path I have chosen during this research is not consistent with what he refers to as ‘losing control’.

Evans’ decision to ‘lose control’ stems from what he sees as a disadvantage of drawing on paper: too much ‘likeness’ (Evans, 1997, p.172). Excessive pursuit of an external depiction of things becomes a limitation in the design process. Today’s tools, however, have the potential to break this pursuit of external resemblance. When we use digital tools, we have a completely different perspective than when we look at an image on paper, and this perspective is a tool in and of itself. In my research, I hope to demonstrate the power of the new perspectives that digital tools provide.

That is, once I have identified the properties that make the tools work, if I continue to use them as mere imitation, I will fall back into the ‘likeness’ that Evans suggests. It is, therefore, critical to develop new ways of using them based on a corresponding perspective. Another task for my research is to find new ways of invoking the properties of tools to investigate new ways of making things inspired by new perspectives.

1.1.1.3 Learning from tools

There is considerable discussion of the impact of digital tools on the appearance of design products. I have noticed that many of these discussions have connected the attributes of such tools with the emergence of new styles. According to this line of thinking, the surface-based construction on which I am focusing, for example, is responsible for a fluid morphological style such as ‘Blob’ (Bechthold, 2003). Furthermore, according to architectural historian Antoine Picon, this surface-based logic of construction allows designers to break down ‘some of the fundamental binary structures that have characterized the discipline for a long time — for example, the distinction between exterior and interior’ because ‘surfaces do not define space by enclosing it; they generate it as layers following their various inflections,...that would lead, unbounded, to clear oppositions between exterior and interior, building and ground, object and subject’ (2010, p.89).

The distinction between these two statements is clear: the first, based on the actual functions and characteristics of the tools, investigates the kinds of design forms they can be used for generating directly. Much of the relevant practice in the design field explores the limits of tools from this perspective. For example, Audrey Large’s (b. 1995) furniture designs and sculptures are created using free-form digital modelling tools to create flowing forms, which are then manufactured using a 3D printer. You would be unable to tell the size of such sculptures or furniture from a photograph unless they were placed in a scene. This is a real-world rendering of the digital aesthetic of representational tools.

The second statement, on the other hand, draws its inspiration for creation from the intrinsic nature of the tool. Picon’s statement is clearly related to a Deleuzian theory of folds, not as a direct derivation from the tool’s function but as a statement made from the tool’s logic of construction, thus relating it to architectural practice and postmodern theory.

Exploration of a tool’s functions is important because it allows designers and practitioners to discover the limits of what the tool can achieve and create an efficient and stable design process. However, as Roberto Bottazzi puts it: ‘...architects have not been able to build or even imagine forms beyond what is allowed by the tools they employed’ (Bottazzi, 2020, p.vii). Simply experimenting with the function of the tool is, at the same time, a process of domestication by the tools themselves, for in training the tools, the tools train the designer. Especially as tools are now increasingly sophisticated and computerised, many designers’ education begins with learning the software for their corresponding field.

My perspective is closer to the second discourse mentioned above. Rather than investigating what designs can be created with digital tools, I am more interested in what designs can be inspired by these tools. This study is less concerned with the immediate functions of tools and more with the ways of knowing and expressing that are embedded in these tools through these functions. I attempt to start with the most basic way of knowing things, the way people understand concepts like ‘surfaces’ and investigate how this exists in virtual space and why it helps us shape. At the same, the role of the human being — whether designer or user — is introduced into the space created by the surfaces’ twists and turns.

The emphasis on understanding the nature of surfaces is to investigate why a simulated surface can be a tool that enables us to ferry between the worlds of thought and touch, identify its instrumental properties and redistribute its instrumental properties in practice to see if new ways of shaping objects and spaces emerge. The introduction of human characters into surface-generated spaces is an attempt to accommodate the new visual characteristics of today’s digital tools: the virtual camera in modelling software provides us with eyes that can travel through matter, allowing us to be inside cavities surrounded by digital surfaces in the simulation. When Lefebvre pointed out that the architect ‘ensconces himself in his own space’ (Lefebvre, 1974, p.361), the ‘space’ he was referring to is still a flat substitute for what is depicted on the surface of architectural drawings. Architects no longer think of space in terms of two-dimensional drawings with today’s tools; instead, they think of space in terms of space. They can at least ‘ensconce themselves in their own spaces’ in terms of their visual senses. One of the goals of this research is to determine what kinds of creativity can be stimulated by design illustrations that involve the perspective of real people.

1.1.1.4 From decoding tools to understanding their prehistory

There is another criticism aimed at today's representational technology, which is similar to Pallasmaa's point of view on practitioners. Although it does not advocate the direct material experience in the process of design and manufacturing, it points at the lack of this experience in the opposite direction and then mystifies the technology. This kind of criticism probably starts from Vilém Flusser's critique and prediction of technical images. On the one hand, this criticism also refers to the control that intermediaries and tools have over operators — yes, in Flusser's theory, the roles of tools and operators are completely reversed. He used the camera as an example: 'any image produced by a photographer must be within the programme of the apparatus' (Flusser, 1985, p.20), and when photographers, or anyone who uses any visual prostheses to produce images, get satisfactory results, they are merely winning a game of probability in all the results provided by the tool.

It should be noted that Flusser's seminal book *Into the Universe of Technical Images* was published in 1985, which was many years before my current research and the advent of most of the expressive design tools in use today. His impact on this thesis stems from two sources.

First, he gave this thesis a sense of accountability. While I was writing the first draft of this research, Facebook announced that it would be renamed *Meta*, focusing on the establishment of a 'Metaverse', that is, a shared virtual environment. Enveloping people in the same virtual 'cave' seems to be a necessary future, and there will be more and more visual acrobatics and magic related to it. For me, the most critical thing about Flusser's theory is that he made it clear that 'envisioners' (Flusser, 1985, p.19), those who know how to use technology, have the responsibility of disenchanting and decoding technology to the public. They should not be the touts of visual acrobatics and illusion but the people who expose it. Otherwise, the world built by technology will become a colourful world that is artificially controlled in an incomprehensible range.

Many projects included in this research are concerned with creating a perceptual bridge between the designer's space and the user's space by increasing the visible and tactile dimensions of feeling and by revealing the space that only the designer can see beneath the simulated surface. The purpose of making this invisible space visible, turning what was once only the tool's operational process into a method of creation, is to produce some new experiences for designers to refer to, as well as making 'the world tangible, conceivable, comprehensible again, and to make consciousness aware of itself once more' (Flusser, 1985, p.31). Therefore, this research aims at professional readers and hopes to help more people understand today's visual technology from such a perspective.

There is an apparent paradox in the book *Into the Universe of Technical Images* that caused me to carefully adjust my research methods. When Flusser mapped the history of image production and interpretation from a technical point of view, he carefully avoided the possible connection between each generation. For example, significant changes have taken place from the era of pure picture reading to the era of linear interpretation of images after the advent of written language. However, this was by no means a sudden change. The birth of language was a long process. Language, especially when fixed into written words, is only an upgrade of drawing in many civilisations with hieroglyphics. It is still a tool for receiving information through vision. From a relatively narrow perspective, the difference between image and text is just an efficiency-related solution. This development process is obviously omitted from the discussion in Flusser's book. Following this change, the technical image has ushered in the final upgrade in history, and various machines and programmes have appeared.

These machines are described as mysterious instruments that cannot be understood, and because of the production of these machines, technical images have become incomprehensible. But no technology is without its own history, and all technologies have predecessors. Flusser also mentioned that 'the technical process is itself informative' (Flusser, 1985, p.45), and that one of the tasks of the 'envisioner', the operator of these machines, is to decode technology. To decode technology, of course, is to decode the history embedded in it because this history contains all the logic behind the making of that tool. Flusser's paradox was that while clarifying the task of the 'envisioner', he mystifies technology and describes it as something that the 'envisioner' cannot touch and understand.

Realising such a paradox, I began to imagine the history of voids contained in artificial objects before the computer age. The space in the cast model I mentioned earlier is not an analogy. This space is indeed the predecessor of the cavity inside each object simulated within modelling software: a mould with a cavity is made, not for the cavity itself, but to create a finite surface for the final product.

The discovery of tool prehistory has been mentioned, to varying degrees, in many theories on representational tools. Two researchers have had a significant impact on this current thesis. One is Antoine Picon, whose numerous articles on architecture and virtual technology, as well as the book *Digital Culture in Architecture: an Introduction for the Design Professions* (Picon, 2010), are frequently cited in this thesis. His reflections on the distinction between 'Reality' and 'the Real' in the context of modern technology served as the foundation for the development of several spatial paradigms in this thesis, which I will highlight below. Roberto Bottazzi is another researcher to have an impact on me. In the book *Digital Architecture Beyond Computers*, he mentioned the importance of researching the prehistory of technology: 'software is too often considered as just a series of tools; this superficial interpretation misses out on the deeper concepts and ideas nested in it. What aesthetic, spatial and philosophical concepts have been converging into the tools that digital architects employ daily? What's their history? What kinds of techniques and designs have they given rise to? ...The answer to these questions will not be found in technical manuals but in the history of architecture and sometimes adjacent disciplines, such as art, science and philosophy. Digital tools conflate complex ideas and trajectories which can span across several domains and have evolved over many centuries' (Bottazzi, 2020, p.vi). This explains why he started with some specific concepts and functions in CAD tools to investigate their origins and evolution and the historical context behind each function, which often extended to before the emergence of computers. This history of technology has created the tools we have today.

The tracing of the prehistory ofh methods embedded in the tool itself runs throughout this research. This entails tracing these methods' origins and development in the history of philosophy in the early part of the project, while it is more focused on learning from specific cases from around the world in the latter part. In contrast to the two scholars mentioned earlier, my research is not concerned with building a complete and comprehensive collation of the history of technology, but I have found many cases in the history of manufactured objects that have inspired me to rethink technology and consider whether these technologies have other possibilities. In the process of reading and visiting museums and Chinese gardens, I have found many lively applications of 'surface' abstraction (operability) and materiality (perceptibility), especially from cultures outside the Western tradition.

1.1.2 Space

1.1.2.1 Space in tools

There are numerous interpretations of space. However, the space in the tools I am focusing on is worth investigating because it is a hybrid of two types of space, or more precisely, a hybrid of two types of our understanding of space. As previously stated, the digital modelling tools we use today are built on a Cartesian space defined entirely by three axes of coordinates.

In 3D modelling software, a visible substance does not mean an entity but a series of defined boundaries. Moreover, in the absence of matter, the location of an entity disappears. That means we lose the reference of scale and site — when we fabricate simple or complex blocks in software, we do not work in a studio room or a street. When this infinite space is displayed on the screen, its scale can be enlarged and reduced. When space becomes a vector, and distance is just a kind of annotation, what designers can see through the screen is nothing more than the images captured by 'cameras' set in virtual locations or a small human figure placed by the side of a model as a scale.

Or perhaps we should say that what modelling software can make people experience is not the lack of place but rather a kind of place that cannot be perceived in the real world: infinity. Space is maximised when using computer software to fit real matter onto surfaces without any tangible thickness. There are no tables or boundaries in the interface of Rhino or any other modelling software; it is Cartesian infinity supported by coordinate axes.

We are working in a space that is very different from the world we experience with our physical bodies: a concept visualisation. However, it is this visualisation that is worth investigating. We cannot continue to understand thought conceptually once it has a way of being seen. Herein lies the distinction of space in representational tools, which are built purely mathematically but are perceptible to our eyes. At the same time, it is perceptible to our bodies due to the rapid development and iteration of technology (for example, modelling in a virtual reality environment or modelling by touching an iPad screen). It is then mixed into a Merleau-Ponty-type space. Thus, the construction of space with tools is also the positioning of the person who uses the tool as the centre of perception within that unbuilt world. As Merleau-Ponty put it, 'our body is in the world as the heart is in the organism' (Merleau-Ponty, 1992, p.203).

Two opposing perspectives on space are welded together in the tool. But it is this welding and coexistence that allows the tool to be perceived and manipulated. And this coexistence is not a pure juxtaposition because the two elements coexist in a way that means they interfere with each other. The 'new materiality' mentioned in many tool theories occurs in manipulating purely mathematical space. Just as the lack of space on the screen creates a new infinite space that we can experience, the lack of matter in modern tools creates new materiality, such as texture maps that can be changed at will or surfaces that can be pulled at will without breaking. Picon describes this renewed materiality by comparing driving and walking: 'the automobile has not diminished our physical perception of the world. It has altered it. It has displaced the content and boundaries of materiality' (2011, p.108).

As a result, the thinkable and perceivable are mixed in this space, which is exactly what is required in a design process: enough space for thought and manipulation, but also some clear materiality of feedback and visualisation of expectations. In *Continuity, Complexity, and Emergence: What is the Real for Digital Designers?*, Picon wrote that the distinction between 'Reality' and 'The Real' is likely to be more complex than ever for a designer working with digital tools. He interprets the two concepts in terms of Kantian phenomena and noumena, with 'Reality' referring to 'about the world as perceived,' and 'The Real' referring to 'the world envisaged independently from us, or as the original source of what appears to us' (Picon, 2010a, p.147). For the practitioner, this distinction is increasingly blurred in today's tool interface as we mobilise the world we imagine in sensory form. In contrast, the world that was independent of our senses and could only be reached by imagining it is no longer independent.

This is the highly kneaded hybrid space that occurs at the interface of our tools. The practices I undertook in this research were based on identifying two properties in this space: those related to geometry and those used to enhance or stimulate our feelings. Simultaneously, I was motivated by the spatial mix itself. When considering how to bridge the gap between creator and user, one method I employed was turning the part most characteristic of geometric space into a real and tangible object. Our tools visualise a Cartesian space, and I increased this visibility from the original design process and presented it in a space beyond the computer screen. My point of reference for this practical approach was the work of the architect Peter Eisenman.

Eisenman's work can be distinguished by a variety of approaches to shaping form that emphasise geometric manipulation of space and solids, such as box stacking and penetration, or geometric form cutting. These approaches dominate the shaping of his buildings to the point where other prerequisites for architectural design, such as the daily needs of the users, generally give way to them. His partitioning of a couple's room is a well-known example. This geometric concept's invisible 'blade' cuts through a double bed and the floor, making it impossible for the couple to sleep in the same bed (House VI, 1975). This method of shaping, which relies solely on geometric manipulation, not only inspired me but also made me think more deeply.

Robin Evans, the theoretician mentioned earlier as an important influence on this thesis, has written an essay criticising Eisenman's architectural practice (Evans, 1997, p.119). Strictly speaking, his comments were not concerning the emphasis on geometric manipulation of design but about Eisenman's excessive use of writing as a defence of his architectural practice, and in this type of writing, language does not work to enhance but merely obscures what is supposed to be a 'rational' geometric modelling process. In the case of House X, for example, Eisenman describes one process as the 'pulling of a smaller cube through a larger one as if from a distendable mass' and presents a series of diagrams to explain this 'pulling out'. Evans describes them as a 'parody of rigour' because 'they are presented as series legitimisation... Once conscious of the material constitution of the object, once conscious of its being cardboard, timber, concrete, or glass, a morphology of this sort is conceivable but impossible' (Evans, 1997, pp.137–138).

It is easy to see why Evans would make such a statement, as he was someone who sought to create from the disparity between the drawing and the thing it was meant to represent (Evans, 1997, p.154). It was thus unacceptable for him to blur this distinction through language or concepts. I see a new kind of gap between Eisenman's architectural practice and Evans' criticism.

Firstly, my work is influenced by Eisenman's autonomous pursuit of form, as well as the belief that this can be a source of creativity, as Eisenman's own practice has demonstrated over many years. My quest, however, differs in that while I attempt to apply Cartesian laws of space to the real world, I focus on the intrinsic properties of digital tools. More precisely, my practical approach has always been to amplify and highlight processes that are embedded in tools that are otherwise classed as 'default' or hidden. Such processes contain geometric operations.

The most significant difference between this instrumental perspective and Eisenman's purely geometric one can be illustrated by one example: in Evans' critique of him, the process of 'pulling *a* through *b*' is no longer a purely conceptual description in today's software, nor is it necessary to add a series of explanatory models to illustrate the process. However, this animated process is realistically present in today's software. The final building is made of concrete or glass, but all the simulated surfaces are homogeneous in the software. I want to use this hybrid digital materiality as a creative practice and actively identify the geometric, abstracted parts of things, as well as the detailed, perceptible parts. This is an important part of my work and the new knowledge that I hope to contribute to this field.

1.1.2.2 The creator's space

My research focuses on the cavity wrapped by simulated surfaces in the modelling tool to investigate the tool and the way we think about and make things. To put this in more detail, the CAD tools we use are built around the logic of lines and surfaces. If this is true, why choose to start this research from the perspective of the void rather than the surface? The main reason is that the void represents the pure perspective of the creator; this space cannot exist in the real world. As soon as it enters the actual manufacturing process, it will be filled with actual components. Therefore, no one other than the creator possesses knowledge of it.

The emergence of this void is unprecedented in the history of design representation. It means that designers now have a perspective they have never had before. If in the past, when designers were sketching or modelling and found themselves unable to resist the urge to over-model the shape of the object that was being created and get lost in the 'confusion of space with paper,' as Latour claimed, then this perspective is a possible method for removing this potential pitfall.

Because of this, design representation can no longer be a simulation, as we are not merely sharing an external perspective with the user. We can even shape things from the inside, where they do not exist in reality. Consequently, describing the spatial relationship between the creator, the user and this cavity became the objective of this research. For if my objective is to find methods of creation under this new perspective, I must also determine how to locate it and describe:

what it was;
what it has become as a result of technology;
and whether I can describe it visually, just as the representational tool does to our minds today.

Beginning with Lefebvre and his book *The production of space* (Lefebvre, 1974), an equal number of forebears have pointed me in the direction of understanding and describing this perspective. Lefebvre's theory is a political discussion on spatial distribution. In this research, I do not touch upon the political attribute of space at any great length. The only discussion related to this is the distinction between space producers and users. When reading Lefebvre's theory, I paid particular attention to one thing: when he stated that 'the architect ensconces himself in his own space' (Lefebvre, 1974, p.361), I wanted to ask, 'where is such a space?'. It cannot be a simple abstract space because even in Lefebvre's own theory, space is always a 'concrete abstraction' (Lefebvre, 1974, p.27). One significant contribution of his theory is to break the tendency to treat space as a complete abstraction from Descartes to Kant. In our time, perhaps the space wrapped by a virtual surface in modelling software is the best place to represent this concrete and abstract space. Such a space is a digital agency for manufacturing real space and can be traversed through the computer screen.

However, even if one of my conclusions is that our tools give space makers a very different perspective from space users/observers, I am not advocating complete designer–user dualism. Under the functionalist domination, the opposition between designers and users, which Lefebvre declared, still exists today but in another way. First, because we own and use these modern tools, designers have long been shaped into becoming 'users' by digital tools. This shaping process has even become embedded in the education system. Many architecture students begin their professional studies with the learning of software. Therefore, the shaping of a designer and the shaping of a software user coincides. Correspondingly, the convenience of the tool highlighted by Latour also eliminates 'pure' users. Anyone can quickly deal with the surface of their environment, such as modifying the font and background colour of personal websites or using SketchUp to design their bedroom. If design is regarded as an act rather than a profession, all people living today are designers because they can make many more formal choices for themselves than before. The identity of users and designers has long become blurred. Second, I think the conceived space, which is seen and known only by designers, is precisely the tool to reconcile this binary opposition. In the age of designing and sketching on paper, for architects or designers, space prediction and potential user activities could only exist as lines and graphics on paper. However, when using computer programs like Rhino, we have a spatial equivalent to future users, and we can see and travel through it. In this perspective, the modelling of user space becomes the opposite of shaping the designer's own space. To design is not to picture a plan or elevation from a high place or a distance but to visit and experience a virtual cavity. And this suggests not the same but equal perspective with users.

In addition to Lefebvre, the theories of Plato, Heidegger and Sloterdijk have served as essential anchors in describing this shifting relationship between the role of humans and the virtual cavity. Their theories allowed me to establish a series of spatial paradigms that describe this relationship. These paradigms are the outcome of my practice's first phase, which will be discussed in detail in the second chapter of this thesis. My selection of these philosophers and their theories follows a visual approach. If one examines many philosophical treatises, one will find an abundance of dichotomous discussions on topics such as 'appearance' and 'essence.' The theories I utilised to construct spatial paradigms are not those classified as the philosophy of space but rather those whose discourse has a clear description of space. For example, Plato's Allegory of the Cave (Plato et al., 1985) expresses enclosing space. I visualised the spatial relationships that these philosophers have described in words. Simultaneously, these theories are all relevant to the way people perceive and construct the world and, thus, provided me with strong theoretical support for building this series of descriptive paradigms:

Plato's Allegory of the Cave (1985) is related to the use of design representation to simulate the appearance of the to-be-built object as closely as possible. It refers to a designer attempting to simulate the exterior of objects from the user's perspective.

The model based on Heidegger's theory is an enhanced version of Plato's, in which the world 'becomes picture' (Heidegger, 2002, p.69) and we are merely 'thrown into' the world (i.e. the description of the world is directly equated with the world itself, which can be thought of as 'the confusion of space with paper').

The world described by Sloterdijk's bubble theory (Sloterdijk, 2011) is identical to the spatial descriptions we can see in modelling software interfaces: the creator and the user each have their own space, separated by a virtual surface. This layer separates and connects the two within the same world, allowing them to coexist. This perspective is where creation takes place.

1.1.3 Making things in an interdisciplinary field

1.1.3.1 A perspective based on the history of manufacturing

In sifting through the fields of all the theorists influencing this thesis, I found a substantial number of theories emanating from architecture. This is primarily because the architectural industry has always been at the forefront of inventing and applying digital tools. Architectural historian Mario Carpo (2017) states that since the early 1990s, 'many key principles of the digital revolution — from digital mass customisation to distributed 3-D printing — have been interpreted, developed, popularised, if not outright invented by architects and designers' (p.96). This has led to a wealth of discussions within the industry about digital tools and a plethora of examples that can be cited. However, the abundance of theoretical grounding is just a surface phenomenon; the root lies in the working methods of the architectural industry. Evans (1997) highlighted the difference between architecture and other fields in the planning stage:'...nearly always the most intense activity is the construction and manipulation of the final artifact (painting and sculpture), the purpose of preliminary studies being to give sufficient definition for final work to begin, not to provide a complete determination in advance, as in the architectural drawing' (p.156).

Due to many factors, including the volume of architecture, the division of labour in the industry, and the lack of immediacy by architects in approaching their final work, architecture entered the field I am attempting to discuss earlier than other fields. Many scholars, from 'James Ackerman to Robin Evans to Mario Carpo,' have argued for 'the emergence of the modern definition of the architect during the Renaissance. The architect came to be defined as one who works through representations, who could pass judgment regarding architecture through drawing rather than by participating in physical construction' (Young, 2022, p.25). Thus, it can be asserted that this reliance on representational tools as a work method has defined the architectural industry and the identity of architects. Therefore, it is logical that this study on representational tools seeks its basis in architectural theory and cases.

However, this study examines all 3D modelling-related fields without favouring any one of them. Digital technology, primarily 3D modelling and rendering techniques, is often perceived as a 'paradigmatic revolution, a recurring theme in many fields', not just within the realm of architecture (Young, 2022, p.3). The widespread adoption of modelling technology in all areas studied makes it possible for this research to reach various domains. Furthermore, these tools describe all forms of creation as the same thing: an enclosing cavity of surfaces. This tool's character is central to this research, and the homogenisation and spatialisation of everything necessitate reaching out to all types and scales of artefacts, whether a bowl, a car, or a work of art.

At the same time, a thread in art history that runs from Henri Focillon (1992) to George Kubler (2008) to David Summers (2003) has also greatly influenced the kind of vision I am attempting to explore. Focillon initiates this discussion regarding emphasis on technique on the autonomy of the form of things. Discussing art history in terms of technique, of how things are made, he believes, 'affords an entrance into the very heart of the problem, by presenting it to us in the same terms and from the same point of view as it is presented to the artist' (Focillon, 1992, p.103). The shortcoming of an iconography-based approach to art historical research is that even 'the most attentive study of the most homogeneous milieu, of the most closely woven concatenation of circumstances, will not serve to give us the design of the towers of Laon' (p.103).

This perspective of exploring history from the standpoint of making itself is exciting for anyone who tries to create something. This line of thought is taken to another level by Focillon's student Kubler (2008), who includes all manufactured objects in the discussion of art history. It should be noted that Kubler's emphasis on manufactured objects needs to be dated from the Neolithic to the Renaissance; the mass production of the industrial age does not appear to be considered in his narrative, possibly due to his academic background in the prehistoric cultural study; this is where my work differs. However, his search for a form analysis method that could compete with Erwin Panofsky's iconography and Ernst Cassirer's symbolism at the time was lost in the postmodernist wave.

My research derives a historical perspective from their theories. Focillon's (1992) attempt to explore history 'in the same terms and from the same point of view as it is presented to the artist' (p.103) is a central goal of my work. I try to reveal the kind of space and method in which today's creators work. From this perspective, I believe that discovering new ways of creating can initiate a broader perspective, one inherited from Focillon and Kubler, of seeing all manufactured objects through the lens of making. These two scholars might not have predicted the day when the creation process would be homogenised and governed by the same tools and methods of creation. As a result, I believe now is the best time to pick up their words and reconsider them because technology allows us to discuss all types of artefacts in the same context.

Another scholar influenced by these two scholars, David Summers (2003), has significantly impacted this study in the cross-disciplinary and cross-cultural sections. He attempted to create a framework of art history applicable to a broader world because the existing semiotic and contextual methods were no longer applicable to the whole vision of art history, especially art outside the Western tradition. The tool he used was also space. In his theoretical framework, space is divided into two types: 1. Real space refers to the space we share with others and things; 2. Virtual space alludes to the space we can feel through 'the capacity to see three dimensions in two' (p.431).

According to this classification, all events in art history are just a round-trip process in these two spaces. Summers' theory has been criticised because, although his academic purpose is to provide a more useful framework for artistic creation worldwide, almost all the terms he used to establish the theory came from the history of Western thought. However, I believe that we should think the other way around. Why not consider why he chose space as the basis for constructing the theory? Is it not because space, or the discussion of space, has such carrying capacity? Reviewing Summers' work, O'Donnell (2017) said that 'far from being some hegemonic act of epistemic violence intent on re-colonializing the world's art in different terms, the sole goal of Real Spaces is to create an art historical vocabulary that is better than the formalist vocabularies it attempts to replace' (p.35). Although I do not attempt to establish a new art history, my research perspective is similar to his: transportation between real and virtual space; I can fully understand his pragmatic choice. Space is not necessarily the perfect angle to describe the world, whether Eastern or Western. No matter where people are, they cannot avoid the topic of space; their understanding and reflection of space, rejection and action show who they are and what kind of culture they have.

Therefore, besides decoding the tools in our hands, this research aims to prove that we can expand a broader view of the whole world from such an instrumental perspective. When investigating the history of digital technology, it is almost easy to find that these technologies can be traced back to the ideas and technologies in the Baroque period and the Renaissance (Bottazzi, 2020, p.viii). Their pursuit of surface treatment or visual illusion has deeply affected the tools we use today because they are the direct ancestors of these technologies. However, if we want to promote our tools or find other ways to use them, we may have to investigate them from a larger perspective.

Initially, my supervisor suggested that I watch the film *Zero Spaces* to discover architect Ranulph Glanville's adventure in Mexico and understand how another ancient civilisation, long before the computer age, discovered and named a space existing in physical matter. Another of my supervisors suggested that I find some cases in my own culture to see what sort of space I want to explore. I was thus inspired to look for more examples of this type of space throughout human history, to find traces of this approach to creation in a broader geographical and cultural context and to see how such a way of making can relate to different regions and cultures.

When I look for examples of space and fabrication in non-Western cultures, it's easy to see why many theorists are critical of Summers' use of Western spatial terms to describe indigenous artefacts. When artisans in Mexico or China created objects or architecture, they were unlikely to think of abstract extracts such as surfaces. Using such an angle to interpret is not to use a visual cultural power to annex other cultures. On the contrary, these cultures can supplement a new worldwide cultural perspective.

If the comparison between rhetoric and space practice established by Lefebvre (1974) is still applicable, we ought to expand it and connect space practice with literature. I would like to quote Deleuze et al.'s (2016, pp.18–19) discussion on 'minor literature'. He commented that Kafka, oppressed in Germany, wrote his novels in German: 'Only the possibility of setting up a little practice of major language from within allows one to define popular literature, marginal literature and so on. Only in this way can literature become a collective machine of expression and be able to treat and develop its contents.' We cannot say that the visual culture differs from the Western tradition and is a 'minor culture'. Still, in today's material and cultural production, various creation methods rooted in Western tradition have become powerful and mainstream. We should look for and learn from those practices excluded by the mainstream to fundamentally realise the tools in our hands and how many possibilities they could achieve.

Similarly, the space theorist Sloterdijk noted that to tell the arch-history of his life, the history before he acquired language, he could only do so with 'a voice that's precisely other than that of the maternal language' because 'the language your mother teaches you is the one that makes it impossible to express your relation to her' (Sloterdijk, 2005, cited in Ohanian and Royoux, 2005, p.224). Another reason I introduced non-Western cases is that they can more effectively describe the unspeakable parts of Western tradition. As I will show in the *Portraits* Project, lossless surface overlap and intersection can be viewed as a technical error in a video game or as a classical garden design language.

1.1.3.2 Questioning from other fields

I mentioned Latour (2009) and Pallasmaa's (1996) criticism of expressive tools to describe the tools' opposing and interdependent properties. Indeed, expressive tools that use surfaces as a spatial limit are universally applicable outside of the realm of designers and other types of creative workers. Perhaps it should be described the other way around: this method of spatially defined surface representation is universally used in various industries and upon which the tools of these industries have been created.

My work in this research has been equally concerned with expressive tools in fields other than art and design and the voices of some relevant industry experts who have questioned them. I recognise that experts from non-creative fields questioning these tools or representational methods contribute to our understanding of these methods because we share the same constructive principles of using cavities to model matter and surfaces to generate space. Furthermore, these inquiries lead us to conclude that in any discipline in which we construct a proxy between the idea and the final product, the qualities of these proxies are carried over more or less into the final product.

Geographer Doreen Massey (2005) cites various rigid understandings of space, one of which is how we currently depict the earth. Traditional maps, for example, make it easier to imagine space as a surface, transforming the world into a journey of conquest from one point to another. Latour et al. (2018), in a paper written in association with several designers and scientists, also question how the way we currently depict the earth as a blue spherical surface misses much of the depth of understanding of the planet. The earth is dynamic and multi-layered at the same time. Much information is lost by compressing what is happening on all levels at once onto a single thin surface.

The depiction of the earth, whether as a flat map or as a sphere affixed to a surface, is, in fact, the same thing. They are both concerned with the absence of solid matter and use the surface as a substitute. In this case, a map is nothing more than a specific state of the unfolding of a spherical surface. From a geographical standpoint, the key message that these two scholars emphasise for those of us who fiddle with images and models in software is twofold: first, that representing the world in this diagrammatic way is doomed to information loss; and second, that the result will be a more simplistic understanding of the world for those who use these diagrammatic ways.

In my research and practice, I would like to contribute in some small way to such a specific questioning of the diagrammatic approach. While scientists debate the relevance or danger of using the surface as a substitute for solids, I would like to suggest that now is the time to take a close look at these representation methods, to investigate what possibilities are left unfulfilled and whether the criticism is based on the fact that it has provided us with too much convenience. In the final phase of practice, I will go over this type of spherical texture mapping.

1.1.4 Summary: Possible contribution

My research has three keywords: tool, space, and making things in an interdisciplinary field. I attempted to define my starting point, vision, and approach using these three key categories. Many previous theories and practices in these three areas have influenced this research and allowed me to identify various unfilled gaps in the intricate intersections. These gaps in knowledge, i.e. the potential contribution of this research to the field of knowledge, are listed below.

Tool

1. My research topic begins with the representational method of using surfaces to simulate solids in digital tools. If new ways of making things are to be sought under this visual means, the first thing to identify is the surface's instrumentality. There are at least two critical perspectives on the digital tool at present, i.e. Latour (2009) and Pallasmaa (1996). If this visual approach has inherent flaws, why do we continue to use it in design? What are its tool attributes? Or, to put it more simply: how does it function?

2. Robin Evans' (1997) research shows how, prior to the development of digital tools, people used hand drawings as proxies for ideas and actual buildings and how they could build even when such proxies differed significantly from the final product. I want to then carry this line of thought forward into today's design process using digital tools. However, digital tools provide us with a different perspective than drawing on paper. As a result, I have taken a completely different approach to discovering new ways to create than Evans. I hope to demonstrate the power of the new perspective that digital tools afford us, and I also hope to find new ways of invoking the properties of tools to explore new methods of making things.

3. There are at least two ways to explore the path of creation using digital tools: directly using the tools to discover their limits and using the tools' functionality, intrinsic properties, etc., as a prompt for creation. I have decided upon the latter option. I began with the fundamental concept of the surface, investigated its instrumental properties and the spatial relationships it formed with people, and then applied this knowledge in practice. By doing so, the limitations imposed by the sole manipulation of tools were circumvented. A practical supplement is added to previous authors' philosophical and technical discussions (such as Evans (1997) and Picon (2010b) in the same field.

4. Flusser (1985) and Bottazzi's (2020) theory taught and prompted me to reflect that the methods embedded in newer iterations of technology can be traced back. In researching this visualisation of defining volumes by surfaces, am I able to find relevant examples from before the invention of this technology that will inspire the development of a new fabrication method?

Space

5. In digital tools, there is a hybridisation of Cartesian and Merleau-Ponty spaces. The combination of these two types of space is what enables digital objects to have new materiality that they could not have in reality. Can I utilise this hybridity to explore it creatively? In contrast to practitioners like Peter Eisenman, who attempt to apply the laws of Cartesian space to the real world, identifying the geometric, abstracted parts of things and the detailed, perceptible parts is an integral part of my practice and the new knowledge I hope to contribute.

6. When I point out the emergence of this void beneath the digital skin, designers and creators can see a new perspective on the evolution of design expression. Hence, why is it 'new'? Prior to that, what was the relationship between the creator and the surface they desired to build? For if my objective is to find ways

of creating from this new perspective, I must also determine how to describe and locate this perspective: what it was, what it has become as a result of technology, and whether I can describe it visually, just as the representational tool does to our minds today.

Making things in an interdisciplinary field

7. The ubiquity of digital technology makes it possible to reach out to all fields. These tools describe artefacts in all fields as essentially the same thing: an enclosing cavity of surfaces. I believe that the discovery of new creation methods opens a broader perspective, inherited from Focillon (1992) and Kubler (2008), of interpreting all manufactured objects through the lens of this creation method. Once the manufactured object is interpreted in a binary fashion as 'surface-internal,' we can find more examples on a larger scale, in more cultures, and in more locations to inspire the development of new creation methods. This perspective is also the knowledge that I attempted to develop, a response to Focillon's formalist approach to analysis with today's technical eye.

8. I hope this study will also shed some light on many scientific practitioners who have questioned the insignificance or harm caused by using surfaces as a substitute for solids. I take a cautious approach to such criticism, and I believe it is time that we take a close look at these visual approaches to determine what they are and what possibilities of use we have not exhausted.

While trying to respond to my research questions, I also tried to complete the above tasks one by one.

Some of the listed potential contributions are more relevant to my research questions than others, while others are secondary. Addressing some of them can also result in responses to others. However, in terms of the thesis's main aim, if a new approach is to be found, the primary issue is to address points 1 and 6. Point 1 enquires about the instrumental nature of the representational tool itself, and to find a new approach, the part of the tool that can work must be analysed and understood. Point 6 is a question about the research's positioning. I began my investigation because of the tool's new visual features; what does this 'newness' mean for the creator? What exactly changes in relation to the past's perspective? Responding to these questions is the first step in completing my research questions. This is where my practice's first phase begins.

1.2 Methods and structure

1.2.1 Methods

This investigation started with an intuitive visual observation. After many years of being involved in visual design, I noticed this particular graphical approach and began working on this research; the same background also led to the practice in this project being developed more from a visual perspective. This includes describing some specific issues I tried to address in the same manner, such as using a series of visual models to describe the spatial relationship between the creator, the user, and the virtual cavity at various stages. This intuitiveness is something I hope to develop as a visualiser, in contrast to predecessors with very close affinities to my research, such as Evans (1997) and Picon (2010b). They have explored related issues more through philosophical musings and case studies. In contrast, I would like to contribute by using my practical approach. As a result, the research based on my own experience and practice serves as a supplement to the relevant field of study.

This practice has posed challenges in articulating my research, as it does not align precisely with my research questions. It fails to address the questions I have posed directly and lacks applicable quantitative or qualitative measures for evaluation. While I have not defined these practices as 'artworks', they are almost exclusively exhibited as visual art projects in museums and galleries. However, my steadfast use of this method in my research is justified by its unique advantages incomparable to other approaches.

Kubler wrote that he was faced with the problem of choosing a 'token' when attempting to establish a vision of art history encompassing all manufactured objects. He noted that 'we may achieve sooner by proceeding from art rather than from use, for if we depart from use alone, all useless things are overlooked, but if we take the desirableness of things as our point of departure, then useful objects are properly seen as things we value more or less dearly' (2008, p.1). This passage is a source of motivation for me. Defining an 'artwork' may be challenging, but when my work is classified as an artwork, it somewhat escapes the functionalist preconception. I do not create all these visual practices to solve a functional problem; instead, they investigate how manufactured objects can be shaped. Positioning them as artworks ensures at least a minimal reading of the forms of things without projecting them onto an unmet need.

At the same time, the method I use is not isolated. On the contrary, such practices are prevalent in design or architecture. While they do not offer direct solutions to problems, they provide opportunities for reflection and interpretation, leading to valuable insights. In the concluding section of this thesis, I introduced examples of similar practices adopted by my contemporaries. These include not only examples of those who have successfully produced functional objects in the design or architectural world but also examples of work that is image-based. By comparing my work with theirs, I have placed my practice within a context of constantly updating trends for assessment. Some examples were executed around the same time and with tools similar to my project yet yielded markedly different outcomes. This contrast enhances the clarity and credibility of my practice's intentions and conclusions.

Establishing an effective research procedure for this type of practice initially presented significant challenges for me. I did not initially find a framework that suited my research; instead, I began my practice with some very direct trials and experiences with the tools at hand. Through these naive initial attempts, I discovered some questions I wanted to delve deeper into, guiding a new round of projects. As I deepened my exploration, I gradually realised that this approach to advancement might itself be a methodology.

In this situation, Schön's (1983, p.79) approach was an important reminder for me, for the process of design itself, as a typical reflective practice exemplified by him, is for a designer to 'shape the situation in accordance with his initial appreciation of it, the situation talks back', and he responds to the situation's 'back-talk' or feedback. He reflected on a deeper understanding of objects, materials, tools, and other factors gained through practice to advance to the next round. This iterative cycle is where the design takes place. My research is, first and foremost, a deeper examination of the design tools I have employed for many years. Through this reflection, I hope to discover additional methods for shaping objects and spaces. In addition, the process and outcome of this search, which is a reflection on a universal tool, will serve as a source of new methodological inspiration for other practitioners.

I have chosen to approach my research in a practical and experiential manner, documenting the feedback I receive and using it as a driving force for my research. To summarise my research process, I refer to David Kolb's (1984, p.51) 'experiential learning cycle', which is an iterative cycle of four steps: 'concrete experience, reflective observation, abstract conceptualisation and active experimentation'. I did not strictly adhere to these four steps to complete each loop. While completing my project, I realised that with such an emphasis on visuals, it is difficult to move directly from an intuitive visual experience to a process of reflection and then generalise it into a valid concept effectively. In such a project, the generalisation and reflection on the visual could easily devolve into a simplistic evaluation of 'the style that the tools tend to generate,' which runs counter to the research's primary objective.

One method that worked well for me was advancing through the questions that my practice generated. In this research, practice and theory interact in this manner. I accomplished this by creating practical projects, compiling the parts of the process that elicit questions into questions, and then discovering revelations through reading or other means. These revelations prompted me to practise for the next round. Therefore, I would describe the progression of my work as a four-step process: making, questioning, reflecting and active making. Each project generated new questions that will inspire new projects once pondered and answered [Fig.4].

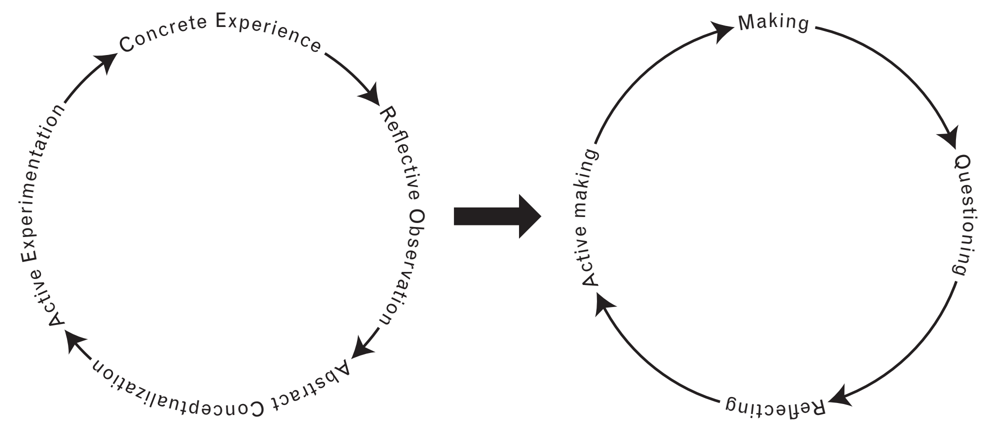


Fig.4 The thesis research cycle, as modified from Kolb's Experiential Learning Cycle

1.2.2 Three practical phases

I divided my practice into three phases, each of which is also triggered by some specific questions. Again, at the end of each phase, new feedback and questions emerged after exploring and responding to these questions through practice, which inspired the next practice phase until I could finally answer my research question. At times, these leading questions were modified as the practice progressed and specific findings were uncovered. Alternatively, sometimes a project's reflection could not answer a question entirely, and then this question would be split into more discerning questions to consider. At the summary of each practice phase, I compiled the answers to these questions as a knowledge base for the next phase. This research is a journey of discovery with constant questions and summaries.

Practical phase I: Through a Surface

This practice phase begins with two key questions from the introduction, which I made more precise:

This research began with a new visual means in today's digital tools: to simulate entities by closed surfaces. If this new visual approach contains a new creation method, the first thing to determine is what the tool attributes of this visual approach are. What makes the surface effective?

When I referred to the emergence of this cavity as a new perspective in the history of design representation, I was describing my first-hand experience as a practitioner: I observed this cavity that was not visible before computers in my daily use of digital tools. Therefore, how should I precisely define and conceptualise this perspective?

As an initial learning phase for the tool, I picked a 3D scanner as my initial object of study. This machine interprets what it sees naturally as a sinuous surface, dividing space into the visible portion above the surface and the obscured portion below. During this phase, I utilised the 3D scanner to explore two tool attributes of the virtual surfaces: perceptibility and operability. Using perceptibility to simulate the real world and operability to shape form is a more conventional way of employing tools. We design based on these two attributes. These two valid characteristics then became the tools I used for my subsequent practice phase.

At the same time, I proposed a series of spatial paradigms based on people's ever-changing image of the world as a hollow structure in terms of the history of human thought. In fact, these 'hole' models, extracted from various philosophical theories in different periods, do not mean the same thing. They can be interpreted from various angles, but I chose them because they reflect a common perspective: they are all about how we can perceive and understand the world. When these paradigms are observed from a purely spatial perspective, it can be seen that all three basic elements are incorporated: a subject of observation, a perceptible surface and something beneath this surface. The difference between these paradigms is the hierarchical relationship between the three. At the end of this stage, I put forward a final space model, which came from the bubble theory of philosopher Sloterdijk (Sloterdijk, 2011). For designers, if Plato's allegory (Plato, Sterling and Scott, 1985) of the cave implies a typical method of manufacturing and casting illusions — the person who makes or transforms the surface and the person who observes and experiences the surface are on the same side of the surface (even the person who returns from outside of the cave to inside will be executed). The bubble theory proposed by Sloterdijk will allow both the interior and exterior of the cave to be seen and occupied; this may become an inspiration to our designers from the design perspective.

Practical phase II: The creator's space

In the previous phase, I visualised four spatial paradigms before settling on the Sloterdijk Paradigm as the new guide. In this phase, I needed to investigate this model in greater detail to clarify what practitioners could see and feel within this paradigm and what specific operations could be carried out based on it. I have reduced such considerations to three questions that must be addressed during this phase:

If today's designers can see behind the surface and thereby obtain a 'new' visual experience, what distinguishes this new experience from the one it replaces? What are we gaining from this change?

According to the latest Sloterdijk paradigm that a creator and user coexist, and each has his own space and is separated and connected by a surface; the constructed surface has two sides: one facing the creator and the other facing the user. What does the surface's double-sidedness imply in terms of design?

According to the previous discussion, the link between a designer and a user is a constructed surface. The process of invoking the surface's tool attributes is the process of creating based on the surface. So, how does this process manifest itself in the actual tool manipulation? And how can this process, which appears to have been born entirely under the influence of today's technology, according to Bottazzi outputs' (2020) in the introduction, be traced back to a time when things were made without computers?

In this phase, the leading questions are more detailed and precise than in the previous phase. I attempted to shed more light on this digital void by investigating its characteristics and the history it once concealed. I developed three projects addressing these three questions. In the first practical project, *Fruit and Hamburger*, I analysed the visual differences between existing tools and previous design drawings in the section view. In the second project, *Cairn*, I investigated the relationship between the interior and exterior surface of a model that highly simulates natural stone. In the third project, *Her*, I consciously related the perspectives of the designer and non-designer, real and virtual, by transposing the 'head texture' unfolding procedure from the digital modelling process to the physical world. This stage made me realise that the designer's and the user's perspectives can be switched and that perhaps designers ought to request a more flexible role in the design process.

Moreover, this series of projects is accomplished through an unusual pairing of surfaces' dual properties. The collaboration between operability and perceptibility is no longer about producing refined previews of design outcomes; rather, the irrationality of combining the two produces conflict; this may be a novel, scalable method for creating objects and spaces evaluated in the subsequent phase.

Practical phase III: New methods

This is the final stage of practice, and the questions to be answered at this stage are the thesis's research questions: **Is there a new way of making things, or a new set of ways of making things, under the tools of today that mark entities with surface constraints?**

Based on the previous phase of practice, I learned that the spatial configuration between a designer, user and surface can be flexible and that the dual properties of digital surfaces can be manipulated without imitating the appearance of a specific outcome. With these two premises in mind, I attempted to develop three different approaches to creation. The strategy for developing all three approaches is to make explicit a pre-existing procedure embedded within the modelling tool:

In the *Panorama* project, an unfolding texture map of a finite 3D model becomes the way to generate space. This project also attempts to respond to Latour (2009) and Massey's (2005) critiques of existing visual methods of describing the earth mentioned in the introduction.

The *Sooner or Later* project explores the nesting of multiple layers between surface structures (operationality) and textures (perceivability). Instead of a single level of structure-texture correspondence, they can develop a complex, multi-layered relationship.

I used blender software to create a correlation between two blade-shaped artefacts and to animate this morphological correlation for the *Green Blades* project. This animation emphasises the interaction between the inner and outer spaces of the simulacrum's surface and the relationship between positive and negative forms. If we extract a specific form from this animation process, we can use it to make new things. This method is simultaneously a response to Evans' criticism of Eisenman.

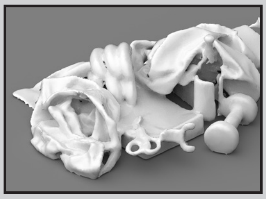
1.2.3 Two primary concepts

This research has always centred on a few primary concepts, one of which is the operability and perceivability of surfaces. These two properties form the basis of today's tools that are used to construct and operate the surface.

The other concept is four spatial paradigms for describing the relationship between people and surfaces: the Greek paradigm, the Plato paradigm, the Heidegger paradigm and the Sloterdijk paradigm. These four paradigms were extracted from the history of thought. However, there is no evolutionary relationship between these spatial models, nor is there a linear timeline for their evolution from ancient Greece to modern times. The final paradigm, the Sloterdijk (2011) model, is not a future prediction. This development history is more like the discovery journey of the researcher, from the outside to the inside of the surface, and then to realise that the surface is an interface and connection between people. For the creators and practitioners of space, these four paradigms are unlikely to be four stages of development in time. One of the purposes of this research is to let readers know these four modes to achieve the best call: when we need to hide in Plato's cave to cast an optical illusion and when we have to disenchantment the magic of technology.

These two key concepts were also the earliest outcomes of the practice and were present as tools in subsequent practices. All practical projects were accomplished through the uncommon invocation of the dual properties of the surface and the flexible distribution of the spatial relationship between people and surfaces. All the construction behaviour around surfaces is the combination of these two clues: choosing a position for oneself, knowing the position of others and knowing how to use surfaces to create.

The entire research's practical process can be represented by the following diagram [Fig.5], which combines the three phases described in the previous section:

	Phase I: Through a Surface			Phase II: The Creator's Space
				
	Project: Landscapes	Project: Still Lifes	Project: Portraits	Project: Fruit and Hamburger
Surface Attributes	Separation of surface and The Real	Perceptibility	Realistic texture	Realistic texture; Virtual lighting system
		Operability	Lossless surfaces overlap and intersection	Section cut of virtual surface
Spatial Paradigm Shifts: Relationship between People, Surface and The Real	The ancient Greek model	From the Plato model to the Heidegger model	The Sloterdijk model	Locate the designer the Sloterdijk model

Leading questions

1. This research began with a new visual means in today's digital tools: to simulate entities by closed surfaces. If this new visual approach contains a new creation method, the first thing to determine is what the tool attributes of this visual approach are. What makes the surface effective?

2. When I referred to the emergence of this cavity as a new perspective in the history of design representation, I was describing my first-hand experience as a practitioner: I observed this cavity that was not visible before computers in my daily use of digital tools. Therefore, how should I precisely define and conceptualise this perspective?

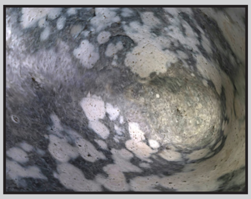
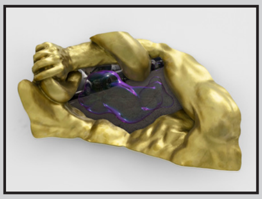
1. If today's designers can s
thereby obtain a 'new' visua
es this new experience fron
we gaining from this chang

2. According to the latest S
user coexist, each has his c
and connected by a surface
two sides, one facing the cr
What does the surface's do
of design?

3. According to the previou
designer and user is a cons
of invoking the surface's to
creating based on the surfa
manifest itself in the actual
can this process, which app
under the influence of today
Bottazzi in the introduction
things were made without c

Fig.5 Structure of three phases of practice

Phase III:
New Methods

				
Project: Cairn	Project: Her	Project: Panorama	Project: Sooner or Later	Project: Green Blades
Realistic texture; HD 3D Scanned mesh surface	Realistic texture	360° moving image	Realistic texture; HD mesh surface	HD mesh surface
Flippable normal direction	Texture mapping	Unfolding texture map into seamless image	Convertibility of texture and surfaces	Surface fluidity and sculptability
Locate designer and user in the Sloterdijk model	Between designer and user there is a surface	Designer and user are on the same side of the surface; the designer unfolds and articulates the surface into a continuous space	Designer and user are on the same side of the surface; the relationship between surface and The Real is nested and multi-layered	Designer and user are on different sides of the surface; it is the internal and external thrust from the surface that jointly form the shape

see behind the surface and
al experience, what distinguish-
n the one it replaces? What are
e?

loterdijk paradigm (creator and
own space and is separated
e), the constructed surface has
reator and one facing the user.
uble-sidedness imply in terms

s discussion, the link between
structed surface. The process
ol attributes is the process of
ace. So, how does this process
tool manipulation? And how
pears to have been born entirely
y's technology, according to
, be traced back to a time when
omputers?

Research Question:

Is there a new method of making things, or a new set of methods of making things, under the tools of today that mark entities with surface constraints?

2 Practical phase I: Through a Surface

During the initial phase of my practice, I began with the two essential questions mentioned in the introduction. Since my goal was to find new ways of making things, it was necessary to gain a deeper understanding of our tools first; therefore, in this initial stage of practice, I sought answers to these two questions through practice and observation:

This research began with a new visual means in today's digital tools: to simulate entities by closed surfaces. If this new visual approach contains a new method of making things, the first thing to determine is what the tool attributes of this visual approach are. What makes the surface effective?

When I referred to the emergence of this cavity as a new perspective in the history of design representation, I was describing my first-hand experience as a practitioner: I observed this cavity that was not visible before computers in my daily use of digital tools. Therefore, how should I precisely define and conceptualise this perspective?

I used a 3D scanner as a learning and practical tool to complete three projects in this phase: *Landscapes*, *Still lifes* and *Portraits*. These three projects were accomplished with the help of a 3D scanner, which was not simply a tool used for the studies but also formed the core of the projects; the scanner represented how humans observe the world. If a 3D scanner is pointed out into the world, it will neither recognise every single object in its view nor record them as groups of individuals. A 3D scanner, by its nature, 'sees' or 'reads' the world around it as a surface; thus, it considers the world a void and rebuilds the world as an artificial cavity; this makes it the most appropriate tool to facilitate this research.

The 3D scanner used in this study was a Structure Sensor developed in 2014 by the start-up company Occipital. This scanner was one of the earliest consumer 3D scanners. The idea of such a scanner is very suggestive of Sontag's (1977) critical analysis of photography from the 1970s, which was written soon after cameras entered the consumer market: 'to collect photographs is to collect the world' (p.3); thus, the world is thus reduced to something collectable. Nowadays, 3D scanners have moved on from standard camera abilities and pushed the boundaries of this notion; the world can now not only be collected but also physically duplicated. As the promotional video for the Structure Sensor says, 'if you point the Structure Sensor out into the world, you are capturing the world.' Moreover, 3D scanners are often advertised alongside 3D printers, and these machines are used together to allow people to take a small piece of the real world and recreate it to hold in their hands.

The *Landscapes* project was inspired by my desire to capture the world.

2.2 *Landscapes*

Single channel video loop
3’00’
2017

Fig.6 Image still from the *Landscapes* project, 2017

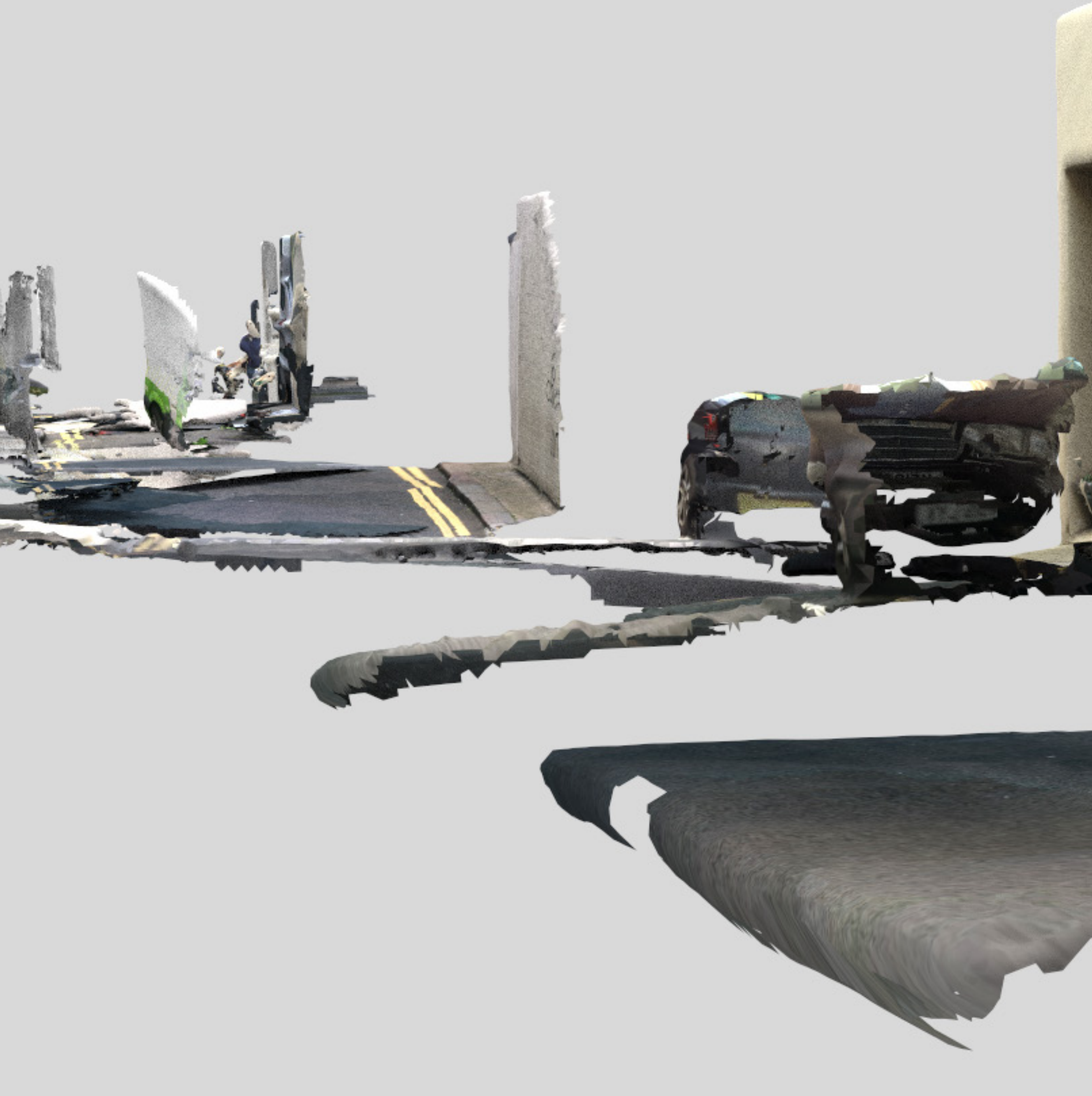


Fig.7 Image still from the *Landscapes* project, 2017

2.1.1 Practice

This was the first project I worked on after purchasing the 3D scanner. This project was more of a learning phase to become acquainted with the tool than subsequent projects are deliberately undertaken. Without trialling the 3D scanner on small objects as recommended by the tutorial videos, the scanner was turned immediately on acquisition out into the streets. I 'shot' a whole block of scenes in my neighbourhood.

The scanner has several limitations, such as the inability to detect transparent or reflective materials or fast-moving objects. Consequently, the pedestrians and vehicles on the street become a hazy, suspended mass, transforming dynamic matter into static. Similarly, to wander through these suspended masses on a computer screen is to observe the static from a dynamic perspective.

In this project, I did not make many adjustments to the results of the 3D scanning process. Integration was the only action taken. I integrated the scanned models of the entire neighbourhood into a looping tour video (https://vimeo.com/188427407). As I scanned, I also recorded the sounds of the scene, including the sound of passing cars, pedestrian footsteps and conversations. I combined them all into this looping video. I attempted to capture the scene of the scan through images and sounds at the time, but it was fragmented [Fig.8].

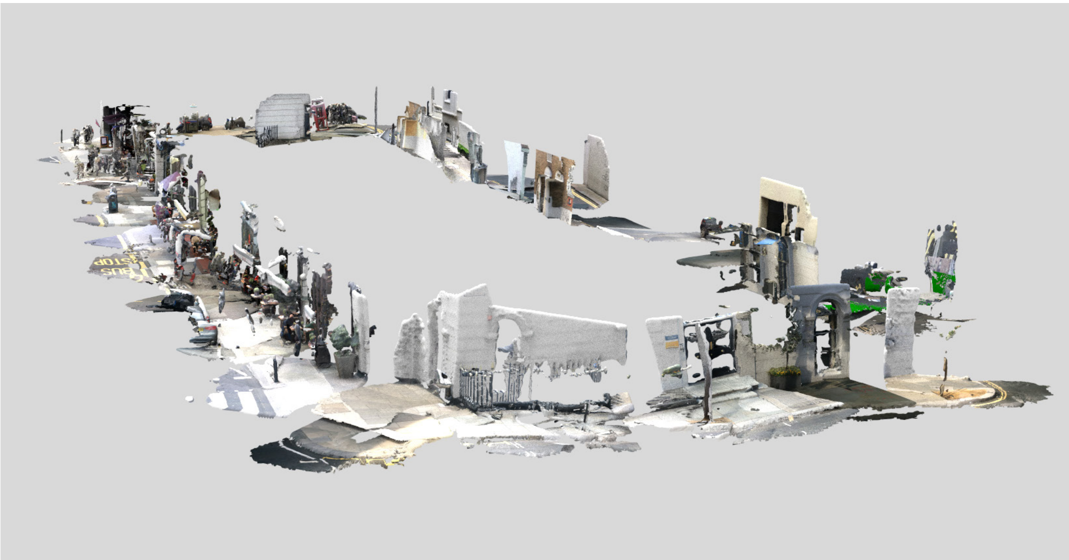


Fig.8 The building block models scanned in the *Landscapes* Project

Fig.9 Installation view, the *Landscapes* project, 2017

I learned how the machine interprets the world on these broken surfaces, which have not been perfectly scanned because of technical limitations. Ideally, the machine would interpret all the objects it could detect as a complete surface. However, it was the broken surfaces that allowed me to see the void beneath these surfaces. A 3D scanner can capture something in a space that is not a solid but rather a thin layer of the surface. Here, my observations and reflections commenced, and I began to explore:

What does it mean for an object to be stripped of all its matter, leaving only its surface?

2.1.2 Reflection: Separation of surface and The Real

When and why did human beings begin to notice the appearance of each thing and decide to 'peel' it off, so to speak? The Chinese character '表' (biao), which means 'surface', originally refers to the hair on the external surface of animal skin people wear. The character's meaning refers to materiality with rich texture. It is much easier to recognise that there is hair on the surface or peel on an apple than to see a visible quality that only appears outside from a pile of gravel. However, human beings have long extracted the abstract surface from all things, as Lucretius wrote (2008, p.102):

> There exist what we call image of things,
> Which as it were peeled off from the surfaces
> Of objects, fly this way and that through the air…
>
> I say therefore that likenesses or thin shapes
> Are sent out from the surface of things
> Which we must call as it were their films or bark.

These words prove that the object's appearance was already a thing of lightness that could be stripped as early as the ancient Roman period. As the distinction between 'Reality' and 'The Real' articulated by Picon (2010a) and mentioned in the introduction, the Western philosophical tradition typically distinguishes between 'the part of a thing that we can perceive' and 'the part of a thing as it truly is,' as if 'The Real' of a thing is always wrapped and sealed in a crust or shell that protects and conceals it. Kant (2018) pointed out a distinction between the observable world and the world. Heidegger (1975, p.35) also used an ancient Greek word, 'aletheia', to clarify that truth is the state of not being hidden from this idea, a paradigm of 'The Real' can be created whereby 'The Real' is located and hidden in a void; to touch 'The Real' thus requires digging a hole in its external surface [Fig.10].

Fig.10 *Paradigm 1*, the ancient Greek model of the world

Realising the distinction between appearance and essence and consciously creating this separation are two different things. We can directly see the roughly stripped exterior from the image scanned by the 3D scanner. However, the intentional separation of surfaces and the things beneath them did not begin with the development of 3D-modelling software. If any transfer of the surface of things can be considered a stripping, then we already have too many means to peel off the surface from The Real. In the age of the camera, a photographic image represents the crust removed from The Real World. Sontag (1977) argues that the ultimate wisdom of the photographic image is that 'there is the surface. Now think — or rather feel, intuit — what is beyond it, what the reality must be like if it looks this way'(p.23). Whenever people print photos onto mugs, make movies, draw or paint, this conscious separation occurs. This separation can be difficult to comprehend for someone new to the idea. Gayford (2016, p.10) related a relevant story:

'In the 1720s, William Cheselden, a London surgeon, removed cataracts from the eyes of a thirteen-year-old boy. The latter gradually came to associate the objects he had known only through touch with what he now saw. One of the last puzzles he solved was that of pictures. It took two months, as "to that time he considered them only as Party-coloured Plans, or surfaces diversified with Variety of paint."'

The logic embedded in this paradigm is not only used widely in terms of perceiving and understanding things but also in making and creating things. For example, all 3D-modelling software is designed using the following logic: the user starts by building a structure and then adds texture. There are numerous different textures available for people to choose from. Still, no matter what a person intends to create using the software, whether it be a bowl, a car or even a skyscraper, they always start modelling using the same default texture.

The so-called texture in the world outside the computer is just a graphic layer of non-thickness attached to surfaces in the digital world. This method of giving forms from the physical properties of matter has given way to this method of shaping in the digital void. Nevertheless, such a process is not new in the history of creation. Alberti (1955) defined the origin of architecture as building first and then decoration. For Gottfried Semper, architecture is a kind of clothing or masking of the original structure. His theory came from discovering remains of colour left on the marble relief surface in classic temples. He then concluded that the Greeks used marble to build temples because this material 'provided a good base for paint' (Semper, 1863, cited in Frei, 2003, pp.43-49). Therefore, architecture is merely a structure whose surface hides the physical material.

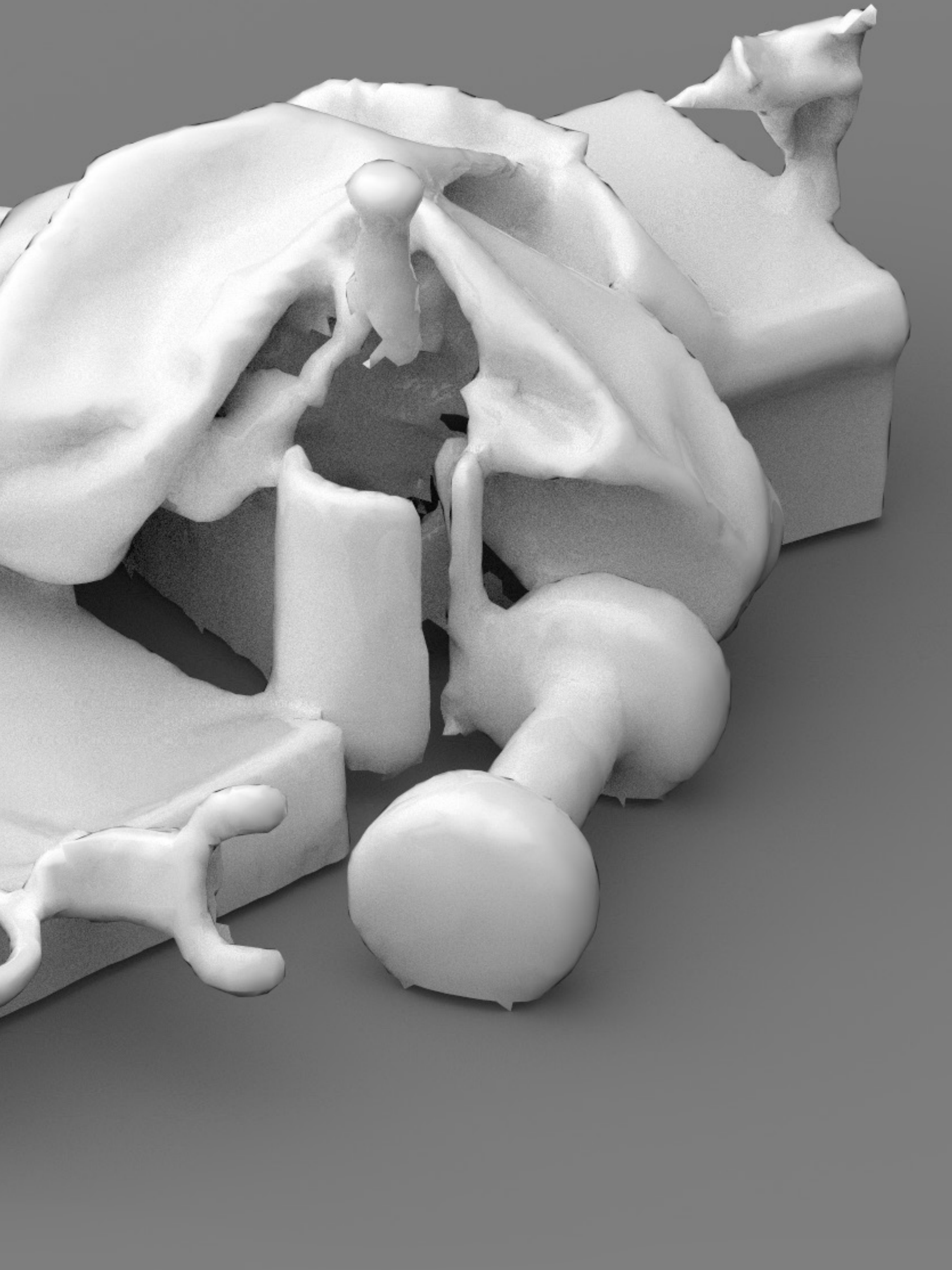
Although it is not new, the creating process is the superposition of construction and coverage. However, in computer-aided design (CAD), the two processes of modelling and mapping become suspicious because there is almost no correlation between them. Even now, a lot of modelling software has imitated the method of physically shaping with fingers to the greatest extent, such as the application *nomad 3D*, which can be used on the iPad, where building shapes and adding materials are still independent processes. If we want to simulate a process in a digital tool like creating things in the real world, such as using hands to shape mud or carve wood, then the last step should correspond to the action of polishing, colouring or carving delicate patterns. In short, it should be about the final fabrication and decoration for those things exposed to the outside. But in fact, what we give to a digital model after completing its basic structure is to add materiality to it, whether it is glass, marble or metal.

If the design process in computer software was once just a preview or rough simulation of the manufacturing process, then this simulation has overflowed the computer screen and appeared in our physical world. By 2018, 3M™ company had launched over 1000 DI-NOC™ adhesive film products. This film can be attached to most physical structures, is firm and durable, and has the external and tactile feeling of materials of various natural substances, including wood, metal, textiles, ceramics, stone and leather. This product, like the rendering software's shader, has been moved to the real world for architects and interior designers. People can first determine the shape of an object and then decide whether it should be wood or metal. The law of creation based on the performance of physical materials has been overturned in this workflow.

Then, what does 'surface' mean in such a process? Is it Alberti's 'decoration' (1955) ? Or is it Semper's 'clothing' or 'masking' (2003)? It looks like neither because it seems to result from reordering a traditional workflow. However, from another point of view, it is both. From a visual point of view, adding materials to a digital mesh is equivalent to covering up the fact that it is a digital creation. The purpose is to simulate the final product's appearance on the screen. Once the material changes from the basic condition of constructing objects to an attachment like tattoos or stickers, we should reconsider the definition of 'decoration'. The equivalence between 'ornament and crime', proposed by Loos (1908), is no longer applicable because the material in the modelling software is the final polish after constructing all structures. The material will not be covered up by ornament; the material is the ornament.

2.2 ***Still-Lifes***
Epson ultra giclée print
42 × 66cm × 8
2017

Fig.11 *Still Lifes*, 2017



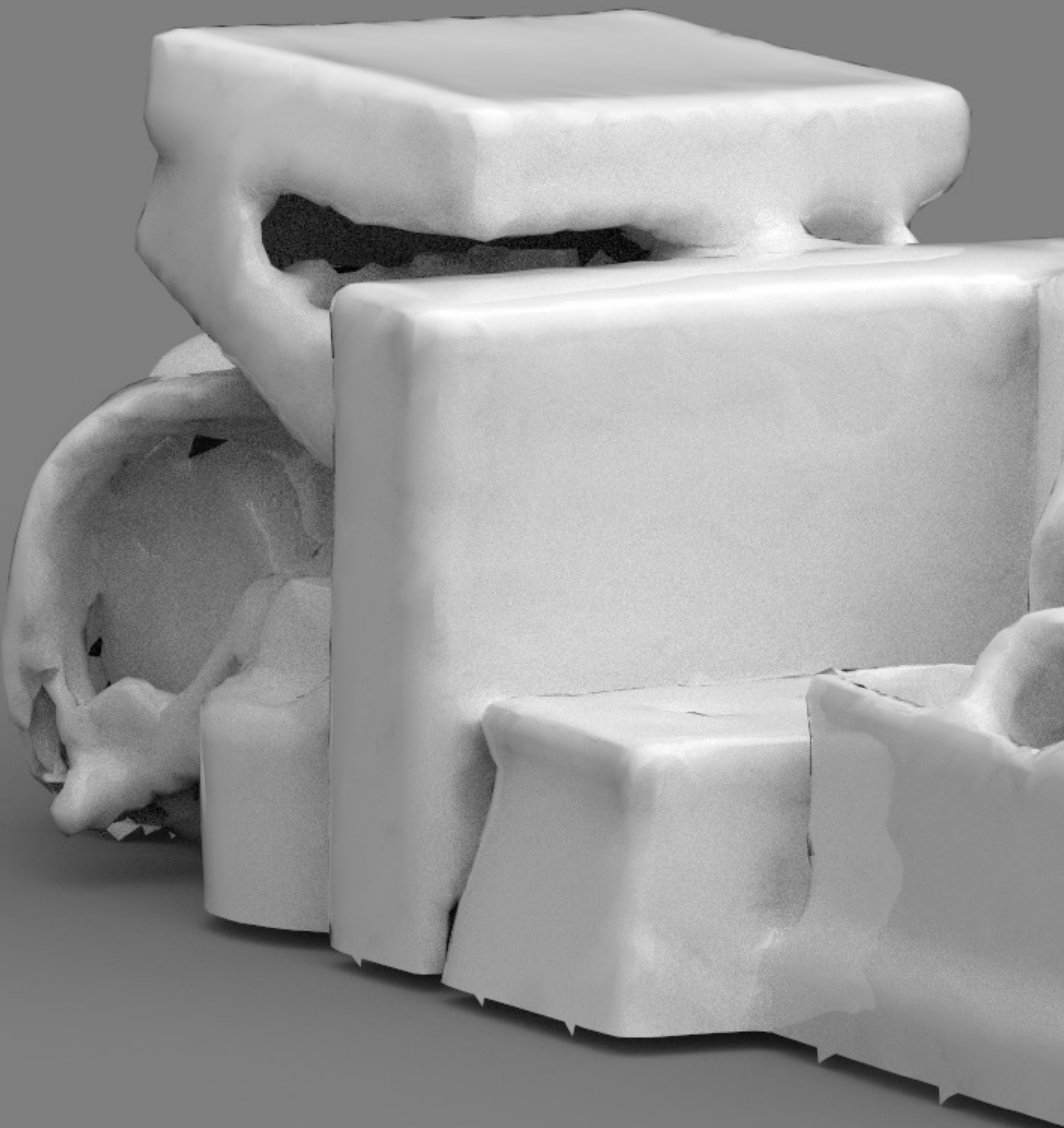


Fig.12 *Still Lifes*, 2017

2.2.1 Practice

The second project in this phase, *Still Lifes*, continued my exploration of the separation between surfaces and The Real. The Structure Sensor is ‘the world’s first 3D sensor for mobile devices’ and must be attached to a smartphone or tablet to be used. Throughout the scanning process, the image displayed on the iPad screen looks like snow falling or a type of white substance that gradually solidifies on the surface of the object being scanned, finally covering it [Fig.13]. The image created is immediately reminiscent of Teppei Kaneuji’s (b.1978) sculpture of a pile of mundane objects covered with a gloopy white resin, which together form a monstrous contour. The 3D scanner works similarly by enclosing each object within a single basic substance, eventually joining all objects together. The word ‘adhesion’ is used in medical science to refer to the creation of fibrous bands between tissues and organs, often after an injury or during surgery. It is a process that disrupts the functioning of the individual organs within the newly-formed mass. Similarly, a 3D scanner ‘adheres’ objects, thus destroying their isolation and functionality and replacing them with an indescribable mass. This is an assemblage described by Antoine Picon (2010a, p.151) as ‘reminiscent of Gilles Deleuze’s rhizomes or Bruno Latour’s hybrid networks’, and ‘Whereas traditional objects had a tendency to stand in splendid isolation, these new entities are never completely separable from their surrounding conditions’. The final product created by the scanning process is, in fact, a piece of a surface rather than a group of individual objects. The world is interpreted as a homogenous entity, and the only differences between the objects in a scan come from their so-called textures, which in reality are only different colours and graphic patterns that have been attached to their external surfaces.

Fig.13 Image of the 3D scanning process on the iPad screen

For the Still Lifes series, piles of garbage were scanned, and the lighting was reset. The original textures were removed in the 3D rendering software to make the surfaces look like snow, porcelain or similar material with a slight gleam. The aim was to materialise the surface without thickness generated by the 3D scanner, and the series of images is thus an archetype of still-life photography. It highlighted that a photographic image is nothing but a transferral of an object's surface to a paper or screen. I hope to apply this visual agency of data materiality and give it volume and weight in a realistic lighting environment. The empty interior underneath these digital shells can also be seen in the cracks formed by scanning failures.

I began experimenting with basic model alterations in this project, such as switching materials and lighting. These are frequently employed functions when dealing with 3D modelling software. There were two things I thought about while I was executing these tasks:

I realised that the imaginary items essentially defied common sense. On the one hand, they possessed realistic-appearing materials; on the other, these realistic-appearing materials could be altered at will. I realise that this contradiction embedded in the virtual surface may be its most useful quality. So, what are these tool attributes exactly? How do they operate?

The fact that 3D scanners use surfaces to 'adhere' to objects also caught my attention. That would mean that an ideally complete scan of the world around us would be a closed cavity around the person holding the scanner. It seems, then, that my view of the structure of this scanned surface should not be that of an 'outside' of something; instead, it should be a structure that envelops the observer. Is the spatial paradigm model I visualised in the previous project no longer accurate?

2.2.2 Reflection I: Perceptibility and operability

Designers are designing with the virtue of such contradictions nowadays. It can even be said that our real tools are the coexisting operability and perceptibility on the digital surface. The software is just the function refinements of these two tools. We can always see how the two contain and exclude each other in the history of creation. When we try to record and understand those rich and changeable truths by purification and abstraction, or when we try to use geometric means to plan and build a new world, we experience these two opposite forces. All creation, if our ultimate pursuit is solid, results from swinging and gradually stabilising under these two joined forces. It is said that the split of design (manipulating the geometry) and actual building (facing the materiality) probably began in the Renaissance, ‘most likely, the drawing skills of architects of the epoch and their eagerness in relation to authorship recognition contributed to such separation’ (Marcos, 2001, p.352). The interesting point of this view is that it describes such a thing. At that time, architects did not choose to use geometric projection and other drawing techniques for efficiency or the division of labour but their mastery of skills and personal ambition. They needed to prove that they had the ability to grasp the material world in their hands and arrange a new world that could be realised from the drawing. Abstract tools, such as orthographic projection, may have many shortcomings, but at least the world it promises is ‘predictable’, so ‘consequences can be foreseen’ (Evans, 2000, p.xxvii). In the Renaissance, the mastery of abstract tools even became a criterion to define the identity of creators. In *The First Book of Architecture*, Sebastiano Serlio (1611) proposed that only by mastering ‘the principles of geometry’ an architect or workman ‘may not be accounted among the number of stonespoilers’. (p.6)

In modelling tools, surfaces that are volume-bound only ‘appear’ to withstand the richness of material properties; in fact, they lack thickness and serve as a form marker. A similar thing is the contour line in a hand-drawn design sketch. The contour lines do not exist. They are just where the surface turns. The contour line will change as long as someone moves the subject slightly. Therefore, the contour line only exists in a two-dimensional drawing. It is just a drawing method of framing the subject. What about the surface? According to this logic, can we say that the surface does not exist? Because it is just the upper limit of a substance without separable volume or the partition or junction of adjacent substances. Therefore, can we conclude that the layer of a visible digital surface with no thickness is the most honest and correct manifestation of a ‘surface’ while modelling with a computer?

The two concepts, the upper limit of matter and the interface between adjacent substances, have been discussed by the philosopher Avrum Stroll (1988) in his book *Surfaces*. The most interesting part of this book is that it does not summarise the surface as a single concept. According to the author, the definition of a ‘surface’ can be discussed from at least four different levels: as the upper limit of matter and the interface between substances, there are only two of them, and the other two are the depth that can be scratched and left as traces and the outermost atomic layer of an object. The latter two definitions of a ‘surface’ are obviously separated from the purely conceptual field. Under these two definitions, the surface of things is also a tangible material entity: the birthplace of all friction, scars and inscriptions.

This means that the conceptual term ‘surface’ itself has the dual properties of abstraction and perceptibility. If the original meaning of the Chinese character ‘表’ mentioned earlier — the hair on the outside of the animal fur — is a perceptible side of the surface, then the ‘films’ mentioned by Lucretius, which can fly in the air, are the abstract side of the surface. If we look at the computer-aided modelling software built around the surface logic from this perspective, we can almost find that these two attributes correspond with the two criticisms of computer-aided design tools mentioned in the introduction.

On the one hand, to meet the abstract requirements of geometry and operation in Cartesian space, the surface functions as a 'vector of information' (Calvino, 1993, p.13), which can be operated, flipped, stretched and deformed, intersected with other surfaces, reduced and enlarged arbitrarily. Such operability is at the expense of experience in the traditional sense; for example, it is impossible for us to flatten or elongate a stone by hand. This sensory gap is what Pallasmaa criticised.

On the other hand, to make up for this defect, the realistic detail is increased through the surface material, lighting effect and other factors to look as if it were the same as in reality (although still a 'retinal journey'). Efforts in this direction could lead to what Latour calls 'the confusion of space with paper' (Latour, 2009, P.141).

In the design process, the difference between operability and perceptibility is noticeable. At the beginning of the article *Between surface and substance*, Mark Burry discusses a model of a part of the Sagrada Familia Church nave roof designed by Gaudi, on a scale of 1:25. This model reflects such a contradiction: even if Gaudi designed the church roof strictly according to the geometric hyperboloid, the inner side could not show the same mathematical 'perfection' due to the thickness of the material, as long as the outside surface of the roof follows the shape of the hyperbolic paraboloids. Burry wrote, 'pure geometry is, of itself, becoming a misrepresentation of the facts' (Burry, 2011, p.8). This example illustrates the difference between our touchable, gravitational world and the conceptual, calculated world. As long as the perfect geometry in the architect's mind requires realisation by actual material, they must make different degrees of compromise. In this case, we might ask, which one is the architect's work: the architectural drawings or the physical realisations? Is the drawing the actual work of the architect? Because the drawing is an ideal state, and the building itself is only the flesh dragged down by its noisy environment and heavy materials.

The two conflicting properties complement each other when used as tools. As Lefebvre said in his *Production of Space*, the reason why space can be constructed or produced depends on our two illusions: 'The illusion of transparency' and 'The realistic illusion'. 'The illusion of transparency' means that the light of thought can illuminate all spaces, and all spaces can be understood, encoded and designed (1974, pp.27–30). In contrast, the 'realistic illusion' shows that every property of everything in the world can find an equivalent in the language, and in turn, the language in which they are compiled has some materiality. Lefebvre pointed out that these seemingly opposite illusions actually 'embody and nourish the other' (1974, p.30).

At the practical level, all computer-aided modelling software is designed to balance 'the illusion of transparency' and 'the realistic illusion' or balance the operability and perceptibility. In other words, before having design software, as long as we do not create things facing the material but choose an indirect agent to convey our ideas, we must find a balance between 'the quest for verisimilitude' and 'the desire to preserve margins of indeterminacy' in the agent (Picon, 2011, p.115). In *Translation from drawing to building*, Robert Evans (1997) almost expressed both opposing views from Pallasmaa and Latour before them. In this article, he mentioned a conventional 'partisanship': 'in the present climate the tendency is generally to place the abstract and the instrumental within the orbit of a suspect, culpable professionalism, allowing the direct and experiential presence only within a covert architecture which can never be revealed fully in the former, and which shows up as so many sporadic episodes of resistance. In consequence the direct and experiential appears far more ethical and far more interesting, far more at risk and far more real than the indirect and abstract approach' (p.161). This 'partisanship' is similar to Pallasmaa's position. In the following article, Evans talked about the advantages and disadvantages of architectural drawing: the advantage of architectural drawing lies in 'the ease of translation', while the disadvantage 'stemmed from the same source: too close a likeness, too cautious a liaison, too much bound up in the elaboration of frontalities' (p.172). This view that the visual similarity between 'drawing' and 'physical realisation' is a disadvantage can almost be equated with Latour's words.

Therefore, we can infer that perceptibility and operability exist in any communication medium between thought and entity. Whether it is hand-drawn lines or surfaces in modelling software, the wisest attitude towards both may not be to choose one side and suppress the other but to match the two appropriately. In many fields, we can see that authors have stated the dual nature of tools. For Lefebvre (1974, p.30), this opposition is 'The illusion of transparency' and 'The realistic illusion'. For architectural historian Antoine Picon, they are 'materiality' and 'abstraction' (Picon, 2011, p.115). Even in areas outside design, such as writing, the medium of conveying ideas, we can see both of these examples. Calvino (1993) used both as essential tools for writing. In *Six Memos for the Next Millennium*, he described that his writing was branching out in two directions: 'On the one side, the reduction of secondary events to abstract patterns according to which one can carry out operations and demonstrate theorems; and on the other, the effort made by words to present the tangible aspect of things as precisely as possible' (p.74). Calvino then cited a scene from his novel, *Invisible Cities* (1997): Kublai Khan finally reduced all the cities described in detail by Italian traveller Marco Polo to a chessboard. But Marco Polo guided the emperor to carefully look at the ring of a trunk and tree knot on the chessboard and guess the origin of every detail. A chess board is an abstract surface, but at the same time, it has a physical entity.

2.2.3 Reflection II: A fully immersive cave

As mentioned earlier, a 3D scanner interprets the world as a continual surface. Ideally, each scanned space is a sheet of a surface that fully wraps around the person holding the scanner to create a completely enclosed cave. All of The Real is hidden by the appearance of the world and is thus located outside the cave. Sontag (1977) used the cave from Plato's *Republic* as a metaphor to explain human dependence on images and representations of things. Today, however, the escapable cave is no longer considered an accurate metaphor, as human beings recognise images as a true reflection of the world. The modern view of the cave is that it is encircling, immersive and unbroken. Virtual reality technology has always been considered a gift of scientific development, but it can also act as a prison for the senses. Paradigms previously used to express the relationship between surfaces and The Real no longer work in the age of virtual reality, and it is important to develop a new one. In this new paradigm, the surface and The Real are transposed; the surface remains in the same position, but the locations of the viewer and The Real have switched. People are thus inside the surface, and The Real has moved outside [Fig.14]:

Fig.14 *Paradigm 2*, the Plato model of the world

The second paradigm updates the first paradigm by turning it inside out, creating an inside-out cave of The Real. This is not a completely new notion, and its roots can be traced back to a period long before virtual reality techniques were developed. The mural *Villa dei Misteri* (60 B.C.) [Fig.15] in Pompeii, the illusionistic ceiling paintings created during the Renaissance, Baroque and Rococo periods, and Robert Barker's more recent *Panorama Rotunda* (1801) [Fig.16] at Leicester Square are attempts at creating closed environments, isolating visitors from The Real. The technique of the one-point perspective that was discovered, or perhaps rediscovered, in Renaissance Italy is an idealistic tool for creating illusionistic space and offers the perfect model for the idea of the inside-out cave. With this technique, a sphere of sight is created, with the viewer located in the centre. The world becomes a single huge image, which can be scaled down and projected onto the surface of a sphere, even as the viewer becomes a fixed centre-point, i.e. the ultimate centre of the world [Fig.17]. According to Heidegger, 'that the world becomes picture is one and the same process whereby, in the midst of beings, man becomes subject'(2002, p.69).

Fig.15 *Villa dei Misteri*, Room 5, Pompeii, Roma. 60 B.C.

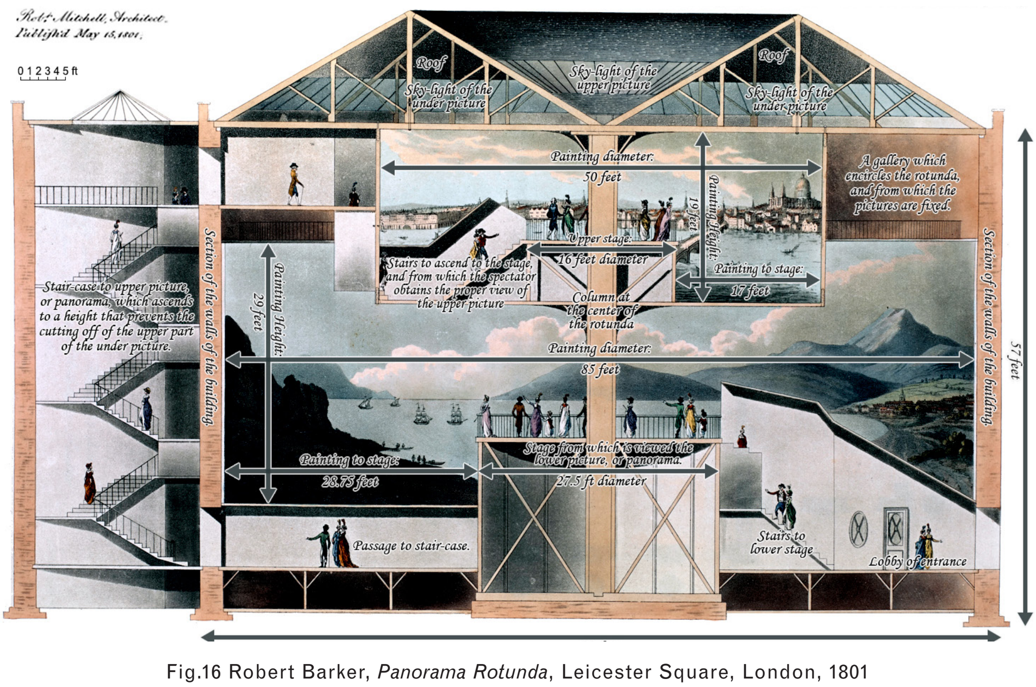


Fig.16 Robert Barker, *Panorama Rotunda*, Leicester Square, London, 1801

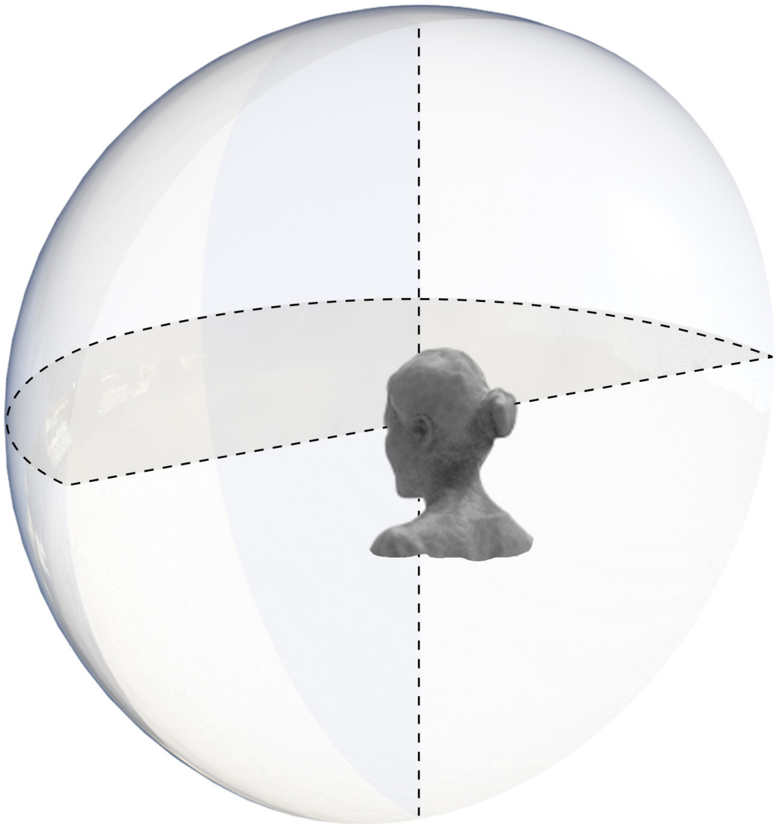


Fig.17 A sphere of sight in the one-point perspective system

According to this, the Plato paradigm can be developed into an even more complete and radical version. The cave in Plato's allegory was not inherently depressing because it had an outlet; prisoners in the cave had a chance to escape from it. According to Plato, the ultimate goal of human beings is to leave the cave. Only in this way can they see the outside world (Plato et al., 1985). However, the exit to this cave was finally closed by Heidegger [Fig.18]. In Heidegger's philosophical system, the world becomes a closed spherical image, symbolising the completion of the modernisation process: 'the fundamental event of modernity is the conquest of the world as picture' (Heidegger, 2002, p.71).

Fig.18 *Paradigm 3*, the Heidegger model of the world

Human beings have always tried to build perfect illusionistic spaces independent of reality. For a long time, even with the help of perspective drawing techniques, people had to compromise in their work due to the substantiality and materiality of the world. There are many limitations to using the law of perspective in a real space. For example, Andrea Pozzo's (b.1642) famous Baroque ceiling painting, located in the nave of the Sant'Ignazio Church in Rome [Fig.19], merges real space with a painted illusionistic structure; however, it cannot completely display its glamorous scene of heaven unless the observer stands directly atop the marble circle in the middle of the church floor. This location provides the best view of the illusionistic ceiling panorama, and the fixed viewpoint is required for the perspective technique to work; a physical space that allows people to move around acts in opposition to this, and as a result, perspective drawings are not always effective in practical terms. The history of constructing caves of illusion is the history of constantly compromising with ideal models and physical space. Once again, we return to the discussion of the conflict between materiality and abstraction. If the conflict between materiality and abstraction existing in Gaudi's roof is reflected between the geometry and thickness of matter, then in this example, it is reflected between the law of perspective and a space large enough for people to move around in and change their perspective.

Fig.19 Andrea Pozzo, the Nave of *Sant'Ignazio Church*, fresco, Rome, 1688–1694

Nowadays, virtual reality headsets represent the most complete illusionistic environment created by humans, placing the user as the focal point of an artificial surface. Each user is at the centre of the artificial space, acting as the axis and is surrounded by human-made imagery. No matter where they are and how they move their bodies, they remain at the centre point as the headset moves with them through the artificial space. This leads to the question:

When humans have succeeded in creating a near-perfect artificial space, what will the next step be? Furthermore, what can be done with this type of artificial void and should humans remain the centre point of such illusionistic systems? What will happen if humans try to escape from them?

2.3 ***Portraits***
Epson ultra giclée print
67.5 × 120cm × 16
2017

Fig.20 *Portraits*, 2017

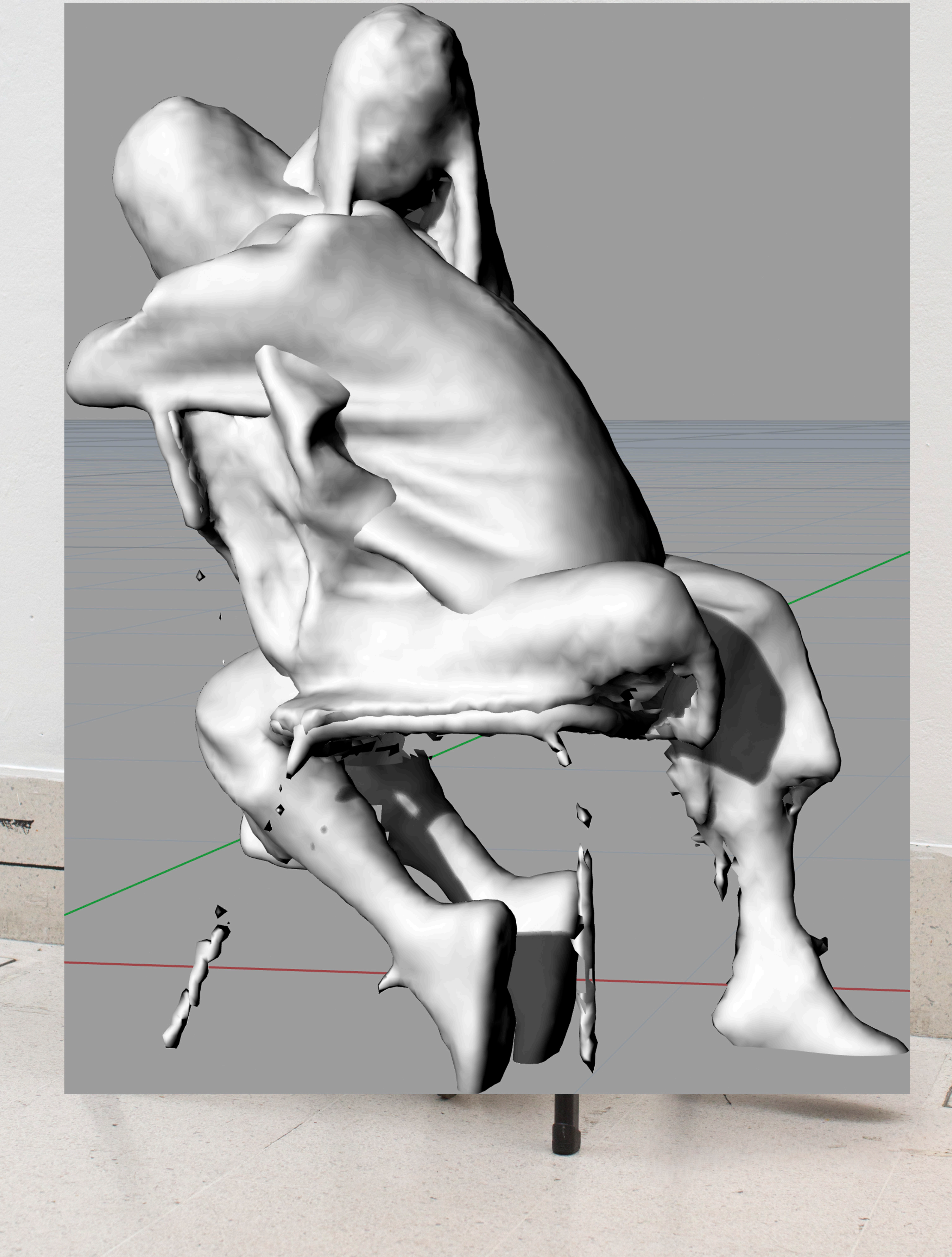
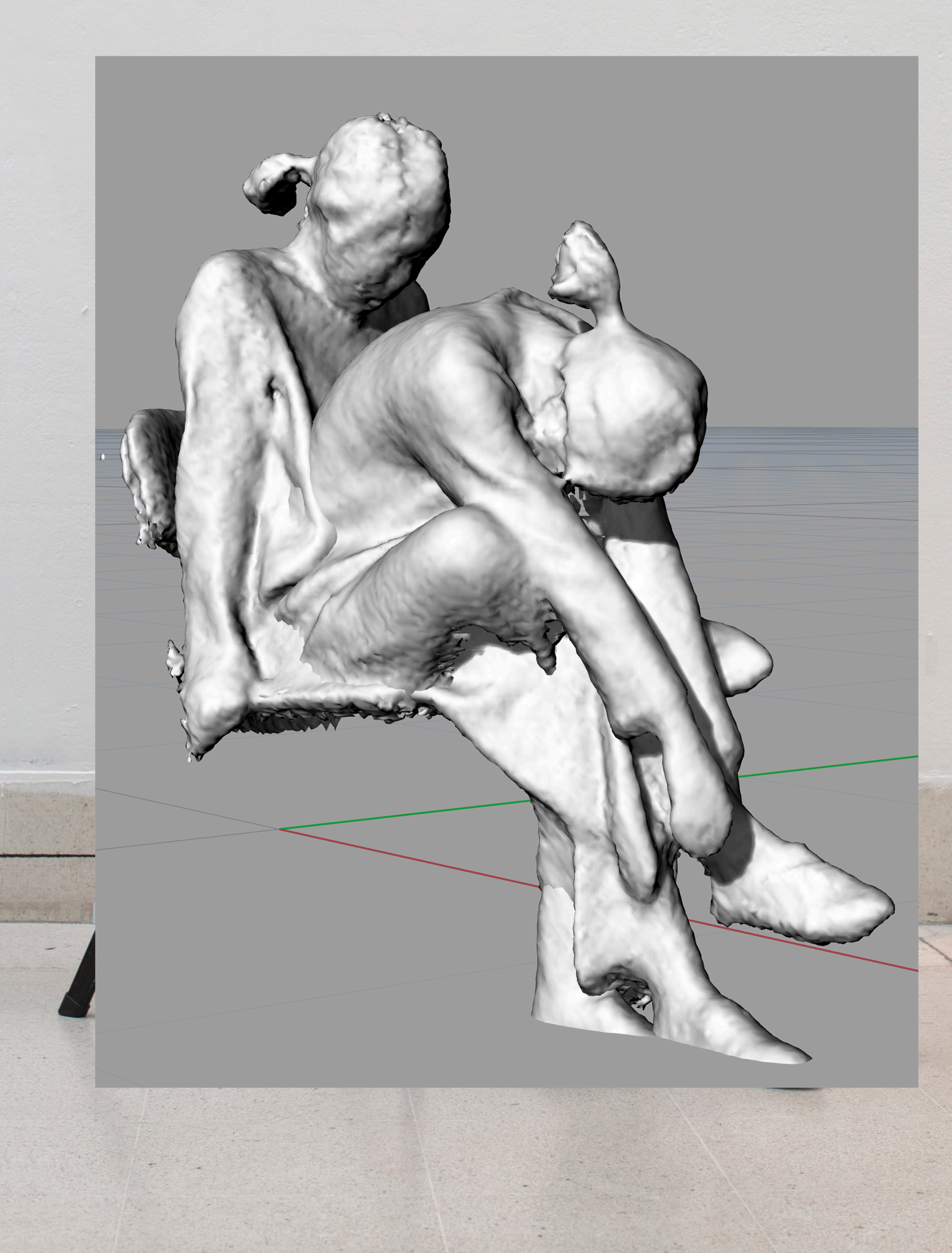


Fig.21 *Portraits*, 2017



2.3.1 Practice

The third attempt I made with the 3D scanner centred on the unanswered question from the previous practice. I tried to find out whether or not there were any new possibilities in this completely enclosed immersion paradigm. The practice of Cubism in art history has provided me with much inspiration. Cubist artists bring several different views of their subjects together in the same picture, breaking the shackles of the one-point perspective, and creating paintings that appear fragmented and abstracted. This leads to the thought: what would have happened if a 3D scanner had been given to a Cubist painter, such as Picasso? This question inspired me for the *Portraits* series, which used a 3D scanner to mimic the process of photographic double exposure.

I invited several friends and asked them to pose randomly. I scanned their images and then superimposed multiple scans. I used Photoshop as much as possible at the project's onset to fix all scanner errors and broken models resulting from failed scans. However, I ultimately kept the majority of these flaws. It was not my intention to present a freakish figure; rather, I intended to demonstrate spatial overlaps and repetitive occupations.

At the same time, I began to understand the importance of these errors. I believe that many people who are keen to study and present technical defects are not pursuing the unexpected 'beauty' brought by uncertainty. On the contrary, technology defects can best explain what this technology is, what its operation logic is and where its boundaries lie. That is why I think it is essential to keep the holes in the model and the unsmooth joints. In fact, it was the technology's failure when using the 3D scanner that exposed the holes that allowed me to discover the space beneath the virtual surface.

This project references two types of practice: first, numerous attempts were made to find a middle ground between still and moving pictures (strictly speaking, the Cubist artists mentioned above could also be classified in this category) around the time that moving pictures were first created. A classic example is Duchamp's painting *Nude Descending a Staircase* (1912). It is now possible to ask what kind of 2D image can be produced by these techniques following recent significant developments in the motion picture industry and the introduction of new techniques for generating quality 3D models. The *Portraits* series thus attempted to answer this question.

David Hockney's (b.1937) photo collages are also a reference for this work. Hockney uses collages to combine photographs of different perspectives within a particular space. Hockney's work and *Nude Descending a Staircase* are similar in that they both involve the repetition of a particular image within the picture. Nevertheless, they are fundamentally distinct. The image in *Nude Descending a Staircase* results from a fixed perspective, in which the observer is immobile, and the observed descends the stairs. In contrast, Hockney's work depicts a stationary object of observation and a constantly moving observer.

The distinction between the two also indicates two methods for escaping the cave of a perfect visual illusion. The first method consists of a constantly changing object and repeated superimposed time, while the second consists of a constantly changing observer and repeated superimposed time. In my project, I opted for the former, as I discovered early in my first project at this stage, Landscapes, that one of the tool's flaws was that it blurred out fast-moving objects, turning them into indistinguishable clumps. That movement was captured due to the machine's limitations, and I wanted to represent it more proactively this time.

I intended to destroy a completely immersive illusionistic environment with this project. The purpose of superimposing multiple simulations of the real world was to destroy this simulation. The effect of this lossless superimposition cannot occur in the tangible world; I have therefore tried to contemplate the following:

What is the nature of this non-destructive superimposition?

Concurrently, a question concerning the observation of the surface itself emerges. Whether intentionally destroying this simulated world or accidentally seeing the space beneath the surface in previous projects, we can be certain of one thing: the perspective of those who can view and manipulate these virtual surfaces differs from the perspective from which things are viewed in a physical reality. We cannot insert one object into another outside of the computer screen, such as we cannot penetrate the skin of an object to locate a cavity beneath it. If I continued to describe this perspective using a spatial model, the previous Heidegger paradigm would be inapplicable.

What kind of spatial model, then, can match this 'beneath the surface' perspective?

2.3.2 Reflection I: Unusual tool attribute matching

We often see lossless surfaces overlap in video game scenes, and it exists as a technical error or at least a technical error under the compromise. The incorrect model intersection happens in many 3D games due to the wrong set of collision volumes. When there are too many model faces in a game, continuous collision detection consumes too much central processing unit performance. The collision of objects can only be simulated with an approximate shape, so this error will occur. In addition, if it is an online game, it also involves the issue of data synchronisation, so the model intersection has become an allowable error.

We regard this model intersection as a mistake because it is inconsistent with what we see and feel in the physical world. When I attempted to overlap multiple human forms in a project, I actually created a new logic combining operability (lossless stretching, scaling and overlapping) and perceivability (mapping and lighting). In other words, I am using a design language that was once regarded as an error in the design process.

When we mention architectures similar to digital objects, we usually think of many constructions with hyperboloids or so-called 'Blob' architectures. These architectures are often regarded as typical simulations of virtual objects and are praised for their free shaping. However, there was another type of construction that falls into this category that predates the computer age by a considerable margin.

The Master of the Nets Garden in Suzhou, founded in the Southern Song Dynasty, is one of the most famous Chinese gardens in the world. In the centre of the garden is a small lake. On the west side of the lake is a small pavilion called 'Where the Moon Meets the Wind' [Fig.22]. One side of the pavilion faces the water, and the other is against a low wall. If we detour behind the low wall, we see that the eaves of the pavilion pass through the wall and stretch out. There is no functional reason for the eaves of the pavilion to pass through the wall. This is a purely formal choice based on a unique understanding of materiality. The row of slender eaves exposed outside the wall is like a sign telling people what is happening behind the wall.

I realised that to find a certain way of creating, it is possible to look at the processes that are treated as mistakes in the tools. I realised that the two attributes of the surface could be invoked in this unusual way. They can work together in a way that is not just taken as a realistic simulation of the object to be built. In the subsequent phase, I would conduct additional experiments of this nature: combining two tool properties in an unusual way.

Fig.22 Eaves of the pavilion, *The Master of the Nets Garden*, Suzhou

2.3.3 Reflection II: An operable world

In the previous reflection of Project *Still Lifes*, I compared contemporary virtual reality to a fully enclosed envelope structure. I believe the significance of the placement of this structure is that it provided us with a reference point in relation to virtual reality technology, or even other creative industries, requiring solid visual representation. We inhabit a world with a highly developed visual culture where images are proliferating. What Heidegger referred to as 'the conquest of the world as picture' (2002, p.71) occurs in every facet of life and production. Our design culture is also dominated and conquered by imagery.

Under the Heideggerian paradigm, the distance between man and The Real becomes unclear. This model divides us from the world and causes us to misunderstand the world around us. While wearing a virtual reality mask or stepping into a room with walls covered by illusionistic murals, we can see things that could not be seen before and go places that could not previously be reached. That is why the panorama painting *The Battle of Sedan* (1883) by Anton von Werner (b.1843) was so highly thought of in the 1880s. Before that time, only soldiers had ever been so close to war. The picture brought ordinary people to the scene of a violent battle from the front line. Modern computer war games are small pieces or fragments scattered from this illusionistic cave.

This type of illusory cave allowed us to see the world at an unprecedentedly close distance. When I tried to use the medical expression 'adhesion' to describe a world connected by a surface through the lens of a 3D scanner, I was thinking of Walter Benjamin's analogy of a surgeon to a cameraman standing behind the lens, 'the cameraman penetrates deeply into its web' (Benjamin, 2008, p.35), and gives this unusual image close to the viewer. This paradigm changes the distance between us and The Real and also the scale of the world, transforming it into a picture that can be projected onto the surface which surrounds us. This suggests that all kinds of realities in the world can be shrunk or enlarged to the necessary, appropriate scale for people's participation. This lack of location and scale is indeed fully reflected in today's computer-aided design software.

Heidegger offered us an ultimate encapsulated model of the world, which means that it is without exit or exterior. This means that there is no longer any space for The Real. The idea that the world itself becomes an image (2002) pushes the relationship between the surface and The Real into an extreme state of rupture that suggests that either The Real disappears, and the surface can exist by itself, or that the surface has become The Real; These two statements perhaps represent the same thing. If there is nothing that can be regarded as inherent Real, then the surface is the only element through which to construct a real environment.

Heidegger's student Peter Sloterdijk (2011) criticised this method of equating the world with its projection. When Sloterdijk proposed his bubble theory, some of the problems he was trying to solve included the absence of The Real and the unreasonable scale of the surface in the Heidegger paradigm. Sloterdijk noted, 'if man is a fish, the world as a pool is simply oversized' (Sloterdijk, cited in Melik Ohanian and Royoux, 2005, p.223). He restored the concept of the space outside where The Real had once taken place. However, to him, the world was not a giant confined space, but a foam made up of linking bubbles. Each bubble is the small world of one person's own experiences, and between these myriad worlds are shared surfaces that both separate and support the bubbles. This updated model of the world leads to the final paradigm in this study: people remain in their spaces, and everyone has their own space. The formation of space has thus become more complicated than ever before because there is no clear distinction between internal and external spaces: people live inside their own spaces and yet are outside other people's spaces.

This final paradigm [Fig.23] separates The Real and the surface bonded together by Heidegger. This is particularly important for practitioners trying to create things because the surface is completely inoperable in Heidegger's paradigm. According to Lefebvre, Heidegger's view of the world was an 'obsession with absolute space', which 'pushes us back towards a purely descriptive understanding, for it stands opposed to any analytic approach and even more to any global account of the generative process in which we are interested' (1974, p.122). Humans lose their ability to sense direction and distance in relation to the world when a given projection of the world is equivalent to the world itself. According to Latour, Sloterdijk once asked Heidegger, 'When you say Dasein is thrown into the world, where is it thrown? What's the temperature there, the colour of the walls, the material that has been chosen, the technology for disposing of refuse, the cost of the air-conditioning, and so on?' (Latour, 2009, p.140) The surface becomes no longer sensible, and the world becomes a completely abstract model. Sloterdijk's new 'foam' model is more reliable because the distance between each person and the surface of their small world is determined.

Fig.23 *Paradigm 4*, the Sloterdijk model of the world

2.4 Summary

In this phase, I completed three projects using the 3D scanner: *Landscapes*, *Still Lifes*, and *Portraits*. These three projects represented a progression in the operation of digital tools. In the first project, *Landscapes*, I made more visual observations, but from these observations, I realised that perceiving and comprehending things as a unity of surface and interior is a common method. I envisioned the first spatial model to describe this unity, which was the ancient Greek paradigm.

In the second project, *Still Lifes*, I began experimenting with minor alterations to the digital surface, such as modifying the lighting and texture. During this manipulation, I became aware of the oppositional and interdependent relationship between the operability and perceptibility of surfaces. We can add textures to a digital surface to increase the realism of the analogue, but the process of adding and replacing textures undermines this realism we seek to achieve. At the same time, the operation of the 3D scanner in this project made me realise that this method of describing and recording the world involves the creation of an entire surface centred on the individual holding the scanner. This meant that the spatial paradigm I had developed in my previous project was no longer applicable, so I updated it with the Plato paradigm (the spatial structure of a person surrounded by a surface) and its extreme form, the Heidegger paradigm.

In the third project, *Portraits*, I experimented more with the scanned surfaces and tried to superimpose them. This process of non-destructive superimposition made me realise two things. First, in addition to creating something more convincing and similar to how the real world would appear, the invocation and matching of the operability and perceptibility of surfaces can also be used to undermine the simulation of the real world. Second, the perspective from which a person manipulates digital surfaces differs from the perspective people view things in real life. Beyond the computer screen, we cannot insert one object into another, nor can we penetrate an object's surface to locate a cavity beneath it. The first three paradigms I deduced could not be used to describe this perspective beneath the surface, so I developed a fourth paradigm: the Sloterdijk paradigm.

I developed these three projects using the 3D scanner to answer the two questions posed at the beginning of this phase. The first question pertained to the tool attributes of the virtual surface, and the second related to the spatial relationship between people and the constructed surface. I answered these two questions throughout my practice by dismantling them with my reflections and assembled them at the phase's conclusion. The following are the answers I discovered and the lessons I learned from this phase:

Through their dual tool attributes, perceptibility and operability, virtual surfaces become our tools. Perceptibility encompasses mapping, illumination and other attributes that bring an object closer to the physical world. Operability includes cutting, deforming, stretching, and other attributes that defy the physical laws of the real world but allow us to shape the surface easily. Perceptibility is utilised to simulate the appearance of the object to be built, and operability to help shape it is a conventional method of employing the tool. I discovered that there might be alternative ways to invoke these two properties that do not require a simulation of the real world. This could be an opportunity for me to discover a new means of making things.

I proposed a series of spatial paradigms based on people's ever-changing image of the world as a hollow structure in terms of the history of human thought: from the Greek paradigm to the Plato paradigm to the Heidegger paradigm to the Sloterdijk paradigm. They are all about how we can perceive and understand the world, and it can be seen that three basic elements are incorporated: a subject of observation, a perceptible surface and something beneath this surface. The difference between these paradigms is the changing position of the relationship between the three. At the end of this stage, I put forward a final space model, which came from the bubble theory of philosopher Sloterdijk. If Plato's allegory of the cave implies a typical method of manufacturing and casting illusions, then for designers, the person who makes/transforms the surface and the person who observes/experiences the surface are on the same side of the surface (even the person who returns from the outside of the cave to the inside will be executed). The bubble theory proposed by Sloterdijk will allow both the interior and exterior of the cave to be seen and occupied. This may become an inspiration to designers from the design perspective.

In the next phase, based on these milestones, I will be more proactive in discovering new ways to use the two tool attributes of virtual surfaces and investigate in depth what designers see and experience under the Sloterdijk paradigm.

In the former stage, the virtual cavity we see through a layer of digital skin, gradually disappearing in design and manufacturing, is the space known only by creators and makers. On the computer screen, they are cavities defined by the analogue surface, while in the real world, they are filled with matter and no longer known. One reason is probably that today's 'productive operations tend in the main to cover their tracks' (Lefebvre, 1974, p.113). However, it is perfectly acceptable to pose the question: Is there a method of creation that is more unambiguously explicit about the existence of this constructed space?

In this stage, I focus on whether the disappearance of the creator's space is a double disappearance. The non-existent cavities in the wall of architecture were once hidden in the architectural drawings. Today, the modelling software shows these spaces in front of their builders in an evident state. This must mean something, which is the focus of this chapter.

The space in the casting mould mentioned in the intro chapter is the direct ancestor of the digitally conceived space. The space in the mould exists as the knowledge transmitted in potters' and goldsmiths' hands. However, in Mexico, it is actual knowledge of space. While travelling to Mexico, design theorist Ranulph Glanville (b.1946) came across a pavilion in an ancient Mayan city (Mavignier, 2015). The walls of the pavilion were one metre thick. However, such a thick wall was not needed structurally. A local told him that the Mayan people had a space called the 'zero space'. In the local's words, the interior and exterior of a building were negative and positive spaces, respectively. And that this thick wall was just the 'zero space' when crossing from the inside and outside. This ceremonial space indicated an understanding beyond materiality. Here, matter was no longer a space occupier or obstacle but the space itself. This one-metre thick wall may have been an excellent case of how to build a link between virtual and touchable spaces. It was entirely different from our process of 'productive operations tend in the main to cover their tracks'. It emphasises it.

Under the Sloterdijk paradigm, practitioners can see and experience this void. Not only does The Real exist beneath the surface, but also the user. In this phase, I investigated this new perspective for designers in greater depth. The three projects in this phase were centred on these three questions. Through them, I attempted to comprehend the specific experiences and concrete operations of the designer under this paradigm, from which I hoped to glean something that could be distilled into the new creative approach I was pursuing:

If today's designers can see behind the surface and thereby obtain a 'new' visual experience, what distinguishes this new experience from the one it replaces? What are we gaining from this change?

According to the latest Sloterdijk paradigm (creator and user coexist, each has his own space and is separated and connected by a surface), The constructed surface has two sides, one facing the creator and one facing the user. What does the surface's double-sidedness imply in terms of design?

According to the previous discussion, the link between the designer and user is a constructed surface. The process of invoking the surface's tool attributes is the process of creating based on the surface. So, how does this process manifest itself in the actual tool's manipulation? And how can this process (which appears to have been born entirely under the influence of today's technology, according to Bottazzi in the introduction) be traced back to a time when things were made without computers?

In the previous phase, I gained tools that I can use in future projects (two surface tool attributes) and a series of spatial models that describe the relationship between the human and the virtual surface. In this phase of the project, I will be more conscientious of calling on these two properties and will seek out new ways in which they can be combined.

3.1 ***Fruit and Hamburger***
Epson ultra giclée print
77.2 × 102.6 cm × 2
2018

Fig.24 *Fruit*, 2018

Fig.25 *Hamburger*, 2018

3.1.1 Practice

In this project, I chose to depict the space beneath the simulated surface in the most visual way possible. I chose to combine two types of common images: the still life image typical of painting and photography and the section drawing typical of design. I combined the characteristics of these two images to create a section view of still life: *Fruit and Hamburger.*

I used the most detailed and realistic material mapping and ambient lighting to simulate the details found in traditional still-life photography (perceptibility) while using Rhino's cross-section feature to slice through the surface of these simulated objects (operability). Rather than simulating the real world, the two properties of this surface work together to create a sense of conflict and dissonance.

A noticeable hollow can be observed under the cut surface. When you cut a lemon, you get its aroma and juice; when you cut a polyhedron with a high-quality lemon-like texture, you get broken surfaces and emptiness inside it. This is the new perspective available to designers today. What I must consider moving forward is:

If today's designers can see behind the surface and thereby obtain a 'new' visual experience, what distinguishes this new experience from the one it replaces? What are we gaining from this change?

3.1.2 Reflection: Visible interior

This project seeks to reveal the space concealed beneath the surface of digital construction. The section plane is the rhetorical device of this series of images. Here, the paper functionated as a blade that cuts the content. What do we observe through such cutting? Once, a wall cut by an invisible blade will be blackened and hidden in a traditional architectural drawing. The word poché in architecture refers to this blackened part. Poché, as a method of drawing, originated in fifteenth-century Italy and for architects, its most fundamental function is to 'render "space" sensible as figure and ground' (Young, 2022, p.11). Making the poché is an 'act of differentiation', an act of 'putting in a bag and covering up all that is mysterious and unpredictable' (Ghosh, 2001, p. 61). It is politics in cartography: blackening one part of the facts to highlight another. Among all types of architectural drawings, section drawing is the most closely related to material and architectural structure. This kind of drawing shows the front or outer surface of things; the cut wall may not be solid, and it is selectively blackened.

In digital construction currently, all the poché have changed from dark and mysterious substances to cavities. At the same time, designers can be in the poché through the screen. It has been said that the section drawing has two origins: 'the observation and subsequent depiction of Roman ruins' and 'the physical dissection of human remains' (Lewis et al., 2016). The former means that this method of observation or narration is inspired by the damage to things originating from the destruction of matter. This destruction of matter can be extracted as the most abstract way of destruction. As Evans pointed out, a front view of architecture is based on sufficient affinity between paper and wall (1997), so the section view is based on the damage created by paper to the building surface. In the former chapter, I clarified the abstraction and materiality of the surface. If we look at these two types of architectural drawings from this point of view, we will know that the front view drawing uses the materiality of the paper surface to directly fit the abstraction, while, on the contrary, the section view's materiality destroys the abstraction.

Currently, we operate using a computer interface as opposed to a paper interface. The previously concealed poché is now exposed. When I compare this viewpoint to the Sloterdijk paradigm, I do so because this straightforward visual presentation of a poché is a novel viewpoint and because it enables designers to comprehend their own position.

All paradigms before the latest Sloterdijk paradigm, from the Greek paradigm to the Heidegger one, have a default factor: there is no distinction between the maker and user of space. This means that the maker and user of space are on the same side of the surface and face the surface with the same perspective. The extreme case in this state, Heidegger's giant sphere, means that when a person faces any point on the sphere's surface, the line of their eyesight always coincides with a spherical diameter. In other words, no matter where the person looks, there is the front view. The auxiliary lines of the perspective law all converge at the centre of their field of vision. Everything gets smaller and disappears there.

To shape space from this perspective has always been under the same illusion for space makers and designers, no matter how the technology is updated: the space to be constructed is entirely equivalent to the space to be experienced. The 'sufficient affinity between paper and wall' (Evans, 1997, p.172) leads to this illusion. Lefebvre also mentioned 'the delusion that 'objective' knowledge of 'reality' can be attained by means of graphic representations' (1974, 361).

However, digital construction, within the surface as the core, is always a technology of casting. It is not to directly shape the space or matter but to obtain its surface by establishing a virtual space and then using the surface to turn the entity into reality, with the dual attributes of operability and perceptibility. This process means that the actual creation is only a cast or stamp of the mind's creation, not a direct copy.

Today, digital technology provides designers and makers with a new perspective. We can look from the interior of a product to its surface. What does this perspective mean? It means we have obtained a distinguished perspective from the user/observer. In this perspective, the surface is no longer regarded as an imitation of a real thing waiting to be built but as a real interface. The junction surface of each bubble separates the makers' space and users' and connects them, as in those closely connected bubbles in Sloterdijk's foam. All marks left by the maker on this surface will pass through this surface to the user.

This is a very specific and figurative perspective. Although it can only be experienced through the screen, it is more specific and closer than any drawing to an environment that can be visited. In the era when Lefebvre put forward the concept of 'conceived space' (1974, p.361), computer-aided design tools were far less potent than today. Therefore, for him, the agent of space in which an architect 'ensconces' is usually only architectural and planning drawings. What do we get if we carefully distinguish the perspectives displayed in these abstract spaces? For the front view drawing, the architect stands infinitely far away from a building and looks at the gorgeous facade of the building. For the plan or section, the architect is in the position of God, overlooking all living beings. These perspectives may be closely related to Lefebvre's political view of space. For Lefebvre, the user is always more vulnerable than the space designer, constantly being attacked by the functionalist domination transmitted by the space designer, and all they can do is bear or counterattack it. Today's architects and designers see a completely different new perspective inside the cavity of the simulated object. When they place themselves inside the digital object, when they know that the user is standing outside the object, and when they realise such a head-up rather than a top-down view, the design process becomes a game of mutual shaping across a layer of film with the user. Realising this perspective inside the virtual object may bring designers more equal space politics. This awareness is a fundamental 'newness'.

3.2 *Cairn*

Virtual reality installation
Size variable
2018

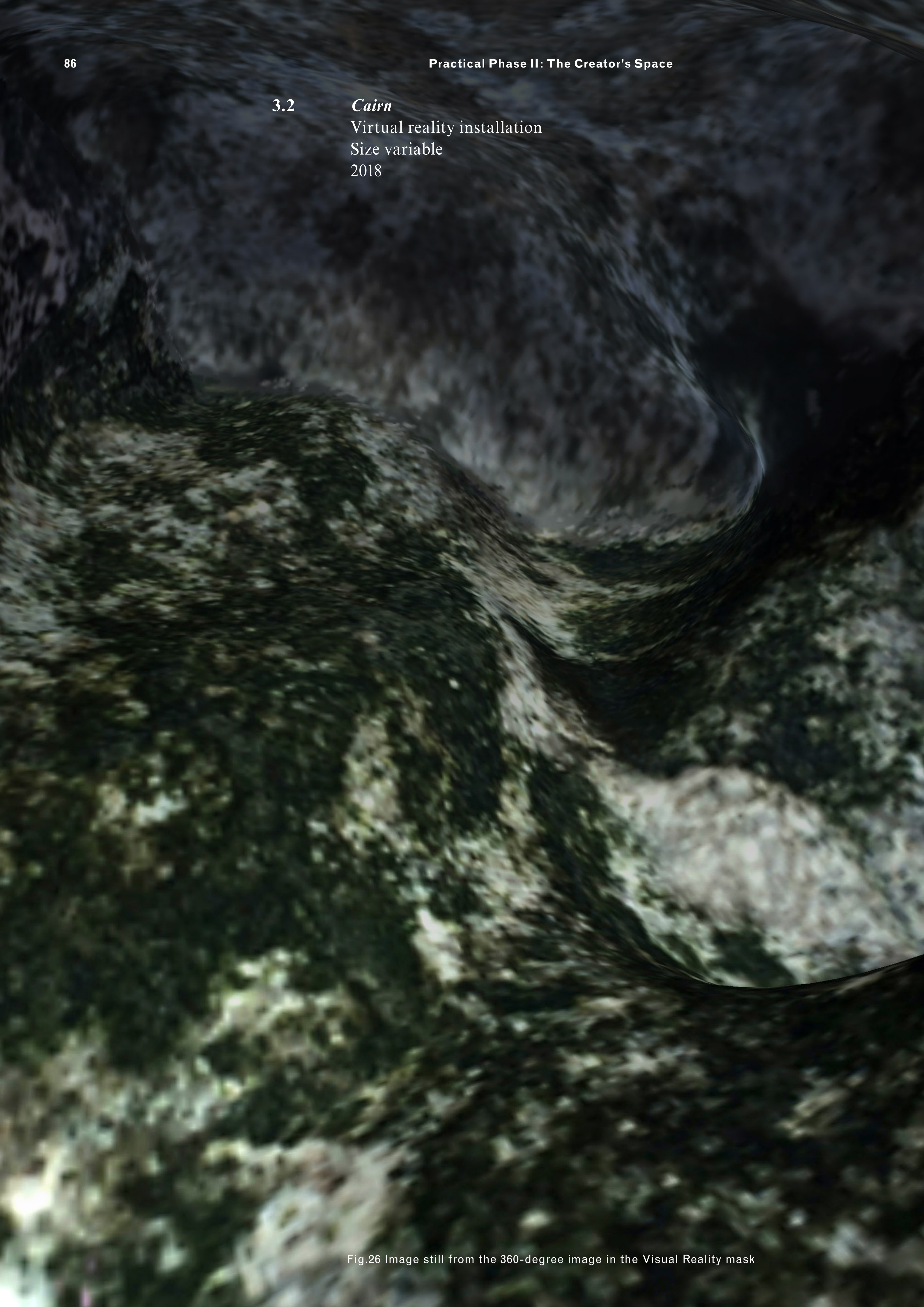


Fig.26 Image still from the 360-degree image in the Visual Reality mask

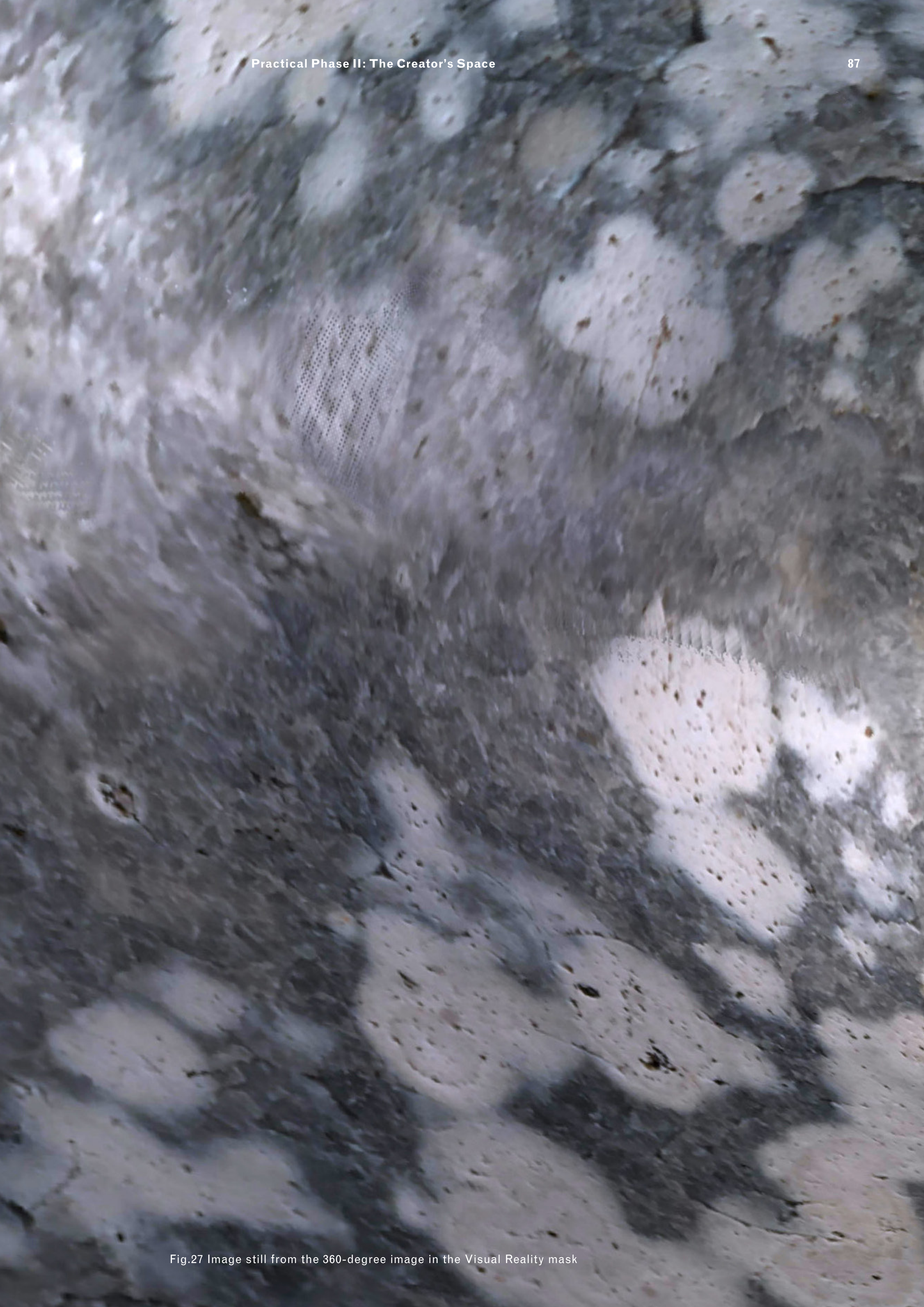


Fig.27 Image still from the 360-degree image in the Visual Reality mask

3.2.1 Practice

The goal of the former project was to expose the space under the digital skin. This taught me that the designer and user could be on the opposite side of a simulated surface. Consequently, the surface has an orientation. The *Cairn* project investigates this orientation.

In the 3D software, I simulated four stones as much as I could, coming from the Thames, Dungeness, Jökulsárlón, and Athens's Acropolis [Figs.28 and 29]. I do not want people to feel the outside of the simulated object. I want people to be inside the surface. I intended to make the designer's and creator's perspectives visible to the public. To reveal that which is unseen by others.

I used a 3D scanner to get the surface of these stones and then put them into the Visual Reality (VR) program. I put the viewpoint inside the stone in the VR program instead of outside. This way, when people wear the VR mask, they can be placed in these simulated stone cavities. The technology distorts the material, and the stone is hollowed out, so people can stay inside.

Fig.28 Four simulated stones of the *Cairn* project

Fig.29 One of the rocks and its digital simulation

Fig.30 Installation view, the *Cairn* Project, UCCA Dune Art Museum, Qinhuangdao, 2018

The portion of this project directly related to the vision is the high-precision stone material mapping (perceptibility), whereas the normal orientation of the digital surface is the applied operability. Once I reversed the surface's normal orientation, the colour and texture of the stone surface, which had been facing outwards, were now facing inwards. I was curious about what possibilities this reversible surface orientation could trigger in a design process, so my question for this project was:

According to the latest Sloterdijk paradigm (creator and user coexist, each has their own space and is separated and connected by a surface), the constructed surface has two sides: one facing the creator and one facing the user. What does the surface's double-sidedness imply in terms of design?

3.2.2 Reflection: Flippable space

We can get the relevant reference from another similar process, a typical decorative process: first manufacturing physical structures and then painting patterns. What does it mean to draw a pattern on an enclosed surface? Art historian Meyer Schapiro pointed out that the most significant difference between cave paintings and paintings on objects lies in the surface limitations (1972). Painting on the surface of a cave means that one can paint endlessly, which is not the case for painting on an object's surface. A wholly closed surface defines and limits the drawing as a prepared base. Simultaneously, the space of the object itself also determines the function of the graphic pattern on it. If we compare a Greek vessel [Fig.31] in the Metropolitan Museum with a Chinese porcelain plate [Fig.32] in the Victoria and Albert Museum, we will witness this distinction. The artisans who draw patterns wanted to maximise the spatial illusion created on such an enclosed surface. Both of them used the same kind of spherical projection. One craftsman chose to project outward, and the other was the opposite. We can say that the use of the surface of the Greek vessel is similar to the use of mounting the world map on a sphere to make a globe. It is more similar to modelling an object while drawing a Chinese porcelain plate is more similar to setting a spherical high dynamic range background in rendering software, and the direction of projection is inward. In other words, it is more approximate to build an environment.

Fig.28 Terracotta lekythos (oil flask), Greek, Attic, ca. 550–530 B.C.

Fig.29 Famille rose plate, China, Qing dynasty (1644–1911)

The actual material is always thick. Therefore, drawing a pattern on the container will differ between the inner and outer surfaces, whereas drawing on the virtual surface lacks this difference. Creating objects and creating environments are identical due to the absence of solid matter in a logic of construction that centres around surfaces. The only distinction between the object and the environment is the viewpoint from which it is observed. If the observer is inside a constructed cavity, the construction is the environment; if the observer is outside the constructed cavity, the construction is the object. For instance, when I simulate a stone with a surface and then enter it, the stone becomes a cavern.

What if we add 'designer' and 'user' as observational subjects to the surface-orientation relationship? Thus, if the 'designer' is inside the cavity, the structure is their environment, whereas, for the user, who is outside the surface, the structure is the object (and vice versa). Surface-based creation in this manner equates to the creation of space and objects.

In addition, it is essential to recognise that this surface orientation is flexible and can be reversed. This flipping can also be used to create objects and environments. I simulated the stone in the modelling software and then let people observe it from the inside of the model. This was actually to let people see the outer surface of the stone from the inside. Because the digital surface has no thickness, the so-called 'inner surface' is the complete reversal of the 'outer surface'. Therefore, I have flipped the inside and outside of a stone [Fig.33].

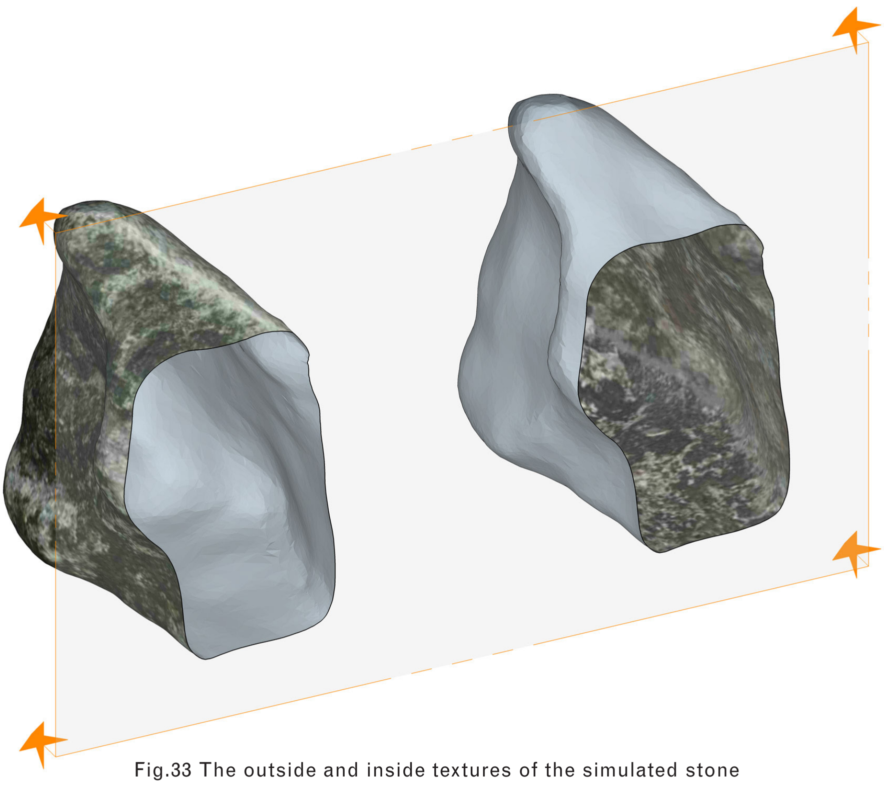


Fig.33 The outside and inside textures of the simulated stone

How would this treatment of space manifest itself in the real world? In one of his lectures, art historian Wu Hung mentioned Zhang Wenzao's tomb, Liao Dynasty (Wu et al., 2018). The interior walls of the space, encased underground, depict the exterior of a wooden house, some plants and the sky. By drawing on the inner surface of the tomb, the craftsman reversed the interior–exterior relationship. If everything can be reduced to a surface-wrapped interior, then the tomb effectively seals off the living space above the earth. The space within the chamber contains the cranes, grass, courtyard and universe.

3.3 ***Her***
Digital printing on silk, 90 × 90cm
Double-channel video, 1'18', 0'42'
2017

Fig.34 Image still from the *Her* project

Fig.35 Image still from the *Her* project

Fig.36 The scarf of the *Her* Project

Fig.37 The scarf of the *Her* Project

3.3.1 Practice

In the former project, I focused on the orientation of the surface of the digital cave. In this project, I intended to investigate issues relevant to the precise sculpting of surfaces. We already know that the computer gives us a very specific and figurative perspective. Although it can only be experienced through the screen, it is more specific and closer than any drawing to an environment that can be visited. Today's designers no longer imagine space through a drawing but through space. Today's designers experience this space inside the cavity of the simulated object. If they place themselves in it and know that the user is standing outside, the design process becomes a game of mutual shaping with the user across a layer of film, like the erotic game of touching through a veil layer in the film *The Last Emperor* (1987). Before we had these digital tools, speculation about user behaviour was more like drawing a circulation line on a plan view from a top-down perspective. Realising this perspective inside the virtual object could at least bring designers a more equal space politics.

In my work, I wanted to discuss this kind of 'touching through a veil', so I made the project *Her*. I wanted to represent the state of 'creator and user on opposite sides of the surface' more explicitly and physically; to construct a physical thing that allows someone other than the creator to experience the creator's perspective. I obtained the surface texture of my head through 3D scanning and photography, stretched it into a square picture, and then made it into a silk scarf that can be used to cover people's heads. Through this process, I completely copied the mapping process of a typical 3D character from a video game. First, I grind all the things on the human body surface into a square picture indifferently and then wrap them on the simulated human body. If we search the keywords 'head texture' in Google, we can find countless similar images [Fig.38].

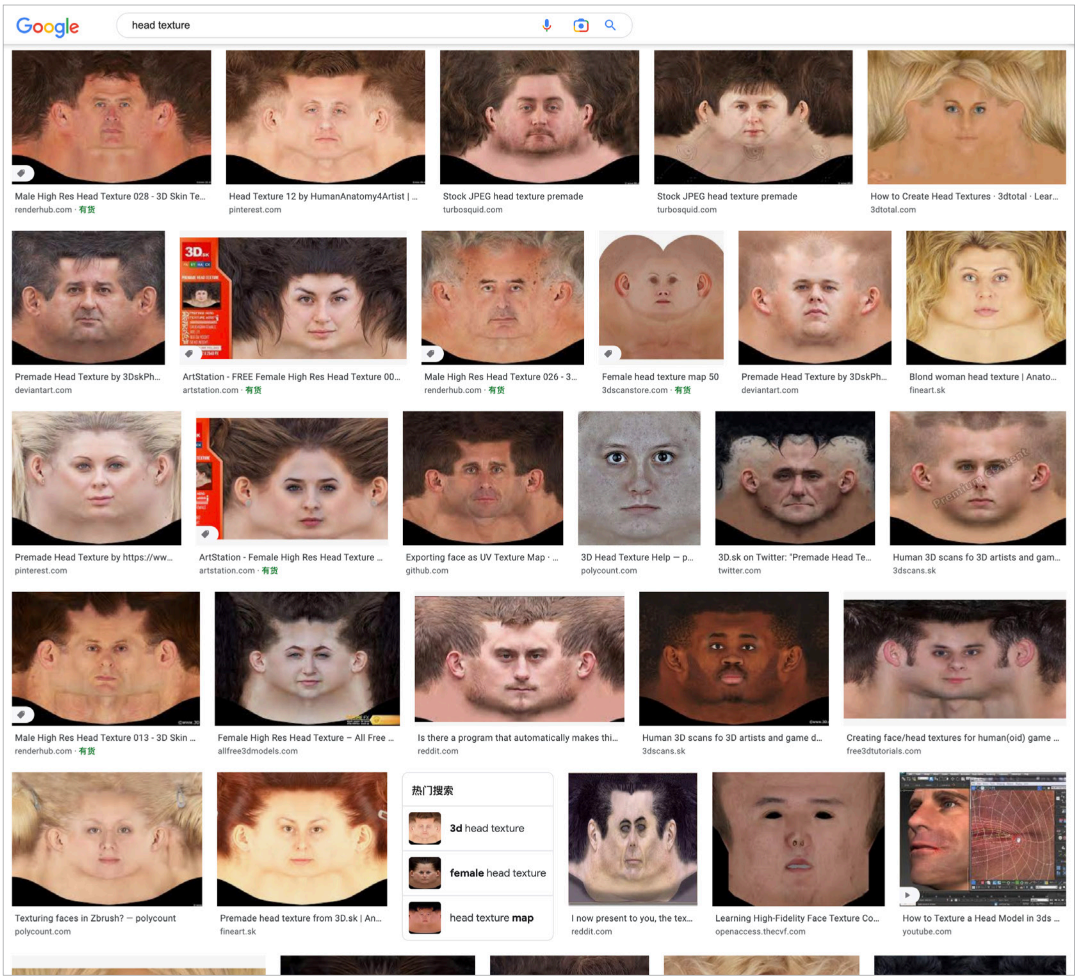


Fig.38 Typical face textures

Fig.39 Image on the scarf

Fig.40 Installation view, the *Her* project, Hive Center for Contemporary Art, Beijing, 2017

After making such a scarf [Fig.39], I invited a couple to wear these scarves and imitate two of René Magritte's (b.1898) paintings [Fig.34 and 35]. I shot them standing together and kissing each other and made a continuous loop video. Today's space makers contact users through a simulated surface, and users feel this touch and give feedback through the same surface. However, there is a production cycle delay between this touch and the feedback process.

Although my initial intention in this work is to present the relationship between designers using CAD tools and users in a sensible or even touchable way, I found another part of the virtual surface was worth exploring during the process of production: the two parts of the surface, structure (operability) and texture (perceivability), and how they are combined. It is, therefore, the most difficult project in terms of surface manipulation, requiring a lengthy and painstaking process of constantly adjusting the structure and texture of the 3D model to finally unfold it and obtain an accurate and high-definition image. The question posed at the beginning of this phase:

According to the previous discussion, the link between designer and user is a constructed surface. The process of invoking the surface's tool attributes is the process of creating based on the surface. So, how does this process manifest itself in the actual tool manipulation? And how can this process, which appears to have been born entirely under the influence of today's technology, according to Bottazzi in the introduction, be traced back to a time when things were made without computers?

Therefore, this question is broken down into two parts of reflection: concrete operationalisation and historical retrospection.

3.3.2 Reflection I: Structure and texture

When I create my own body mapping, or when anyone else creates a model mapping, one thing to consider is what features on the surface can be classified as a structure and what can be classified as just a texture. For example, when I made the texture map of my head, I set the ear (actually a structure with rich details) as a graphic pattern according to the conventional method of making body texture, and all hair and pores were also processed into flat patterns.

This is a coordination between the perceptibility and operability of the virtual surface. We can make a rough division. The shape and structure of the surface are closer to its geometric essence and more involved in the process of 'shaping', so it is closer to operability, while the mapping process is closer to a preview of the finished product, which is closer to perceptibility. However, when making a digital-analogue object, we must choose among various things on the surface and determine their classification. This choice can shape things entirely differently.

In many cases, from before computers, we can find the difference brought by such a choice. For example, a Buddha statue from northern India typically treats the folds of clothes as a pattern [Fig.41]. Therefore, artisans created a round and smooth body, and the part describing 'clothes' is only shallow stripes carved on the surface. In contrast, Michelangelo (b.1475) regarded all pleats as 3D structures, and each pleat occupies its own space. Therefore, his *Pietà* is 'fuzzier' in the space occupation [Fig.42].

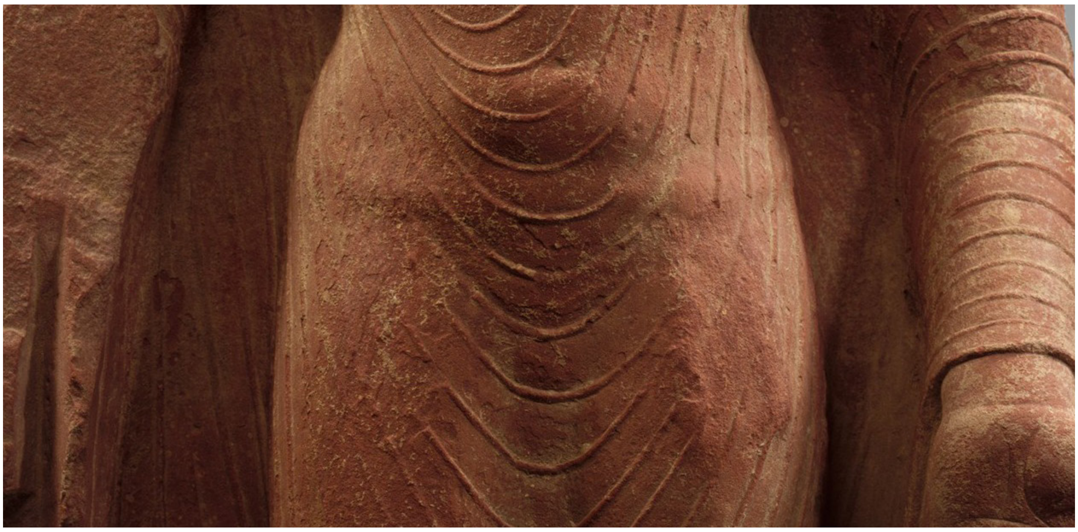


Fig.41 Detail of a Buddha statue from northern India, 4th– 6th century

Fig.42 Detail of Michel-Ange's *Pietà*, St. Peter's Basilica, Vatican City, 1499

Another example came from Evans's research on the Developed Surface in the 18th century. According to him, 'folding out the adjacent surfaces of a three-dimensional body so that all its surface can be shown on a sheet of paper is called developing a surface' (Evans, 1997, p.202); it was a popular drawing technique for interior design during that time. Evans also pointed out what kind of design style had emerged under such a drawing method's influence, 'use of the developed surface induces facile, specious, superficial architecture that sucks as much of the world as it is able into flatness' (1997, p.210). This pursuit of 'flatness' even affected the layout of furniture: 'furniture is pushed back to the wall and dwindles into a series of modest extrusions out of the mural surface'.

This example shows what kind of design may result from modelling around the virtual surface. An 18th-century room designed under this method is consistent with a model built in Rhino because they shared a consistent construction logic. Under such logic, there is no matter but empty shells. There is no core either because all the core content is pushed to the surface. Even the thickness of this surface is infinitely close to zero, and the enclosed structure and the degree of folding are information. Things become a cavity closed by dense information. Things are easier to be shaped into a mass full of surface details when all operable events are concentrated on the surface of things and when such a surface lacks a scale reference and limitation. 'There is always the temptation to add detail beyond the scope of what is appropriate as one zooms in and out of a drawing plane' (Moe, 2008, p.540), which was the result observed by architect Kiel Moe when observing the way his students work.

3.3.4 Reflection II: Surface manipulation in ancient objects

At the beginning of this chapter, I mentioned the story of design theorist Ranulph Glanville's trip to Mexico. The pre-Columbian civilisations had a unique view of space, volume and surface. Art historian David Summers cited many cases from South America when composing his monumental work *Real Spaces*. One of the reasons he wanted to discuss art history from a space perspective rather than other angles was that he found that practitioners outside the Western world had a completely different understanding of space: 'the principal features of modern Western coordinate space are homogeneity, divisibility and infinity, relative to which more primordial spaces are qualitative, continuous and unified, and, as wholes, heterogeneous with respect to one another' (Summers, 2003, p.21).

The ancient civilisation in Mexico also had its own way of solving the problems of constructing the surface and creatively building space based on the surface. I want to talk about two different stone carvings from the British Museum as examples to illustrate more surface structure possibilities.

There is a stone skull [Fig.43] in the Mexican Gallery of the British Museum, and according to the official description, it may be 'a mould to make leather objects or a ball-court marker.' What I found interesting is the construction method of this object. The stone skull, produced from 300 to 1200 AD, was designed under a similar method to manufacturing shape in today's digital modelling, that is, 'lofting.' An unknown craftsman directly extracted the shape of a human head's profile and then added thickness to it to make a three-dimensional skull. Here, extreme prudence is reflected in the use of material and the modelling technique: when a person's head is understood as a pure thickness, and when the two eyes are connected as a single hole, the flashing beams in both eyes come from the same light.

Fig.43 Skeletal head made of stone, Mexico, 300-1200 AD

This stone skull is not the only example of using the surface to catalyse the volume. Another example is the Mayan altar of death [Fig.44] in the same room as the stone skull. If we can recognise the relationship between cheekbones, auricles and occipital bones from its front, we can know that this is a 360-degree plane expansion of a head. Such an expansion method is almost identical to the technique I mentioned earlier in today's character modelling. The only difference is that this altar shows the shallow structure of the body surface as a relief.

Fig.44 Death Altar, Mexico

3.4 Summary

During this phase, I worked on three projects, each of which began with the concept of revealing the space I discovered beneath the surface. In the first project, *Fruit and Hamburger*, I used a graphic approach to compare the once-common section view in the design representation with today's digital cavities by 'cutting' highly realistic, still-life images to expose the internal void of these seemingly real objects.

In my second project, *Cairn*, I intended to examine the digital surfaces' orientation by inviting the audience to enter the void within the four simulated rocks. I consciously exposed this perspective to all exhibition attendees, which was once only visible to the designer.

In my third project, *Her*, I attempted to transform the space beneath the surface of digital objects into a tangible object by printing a skin texture on a silk scarf that people could wear. I was trying to transpose a standard mapping procedure from modelling software to the real world.

My learning outcomes at this stage and responses to the three questions asked at the beginning of this stage were as follows:

The 'new' perspective today's tools offer us is to expose the once blacked-out parts of the poché. The designer can no longer merely imitate things from the outside but can now shape things from the inside. Concurrently, this implies that the artist gains a position concerning the user.

When the designer and user are on opposite sides of a virtual surface, the surface has an orientation. At this stage, I consciously related designers' and non-designers' perspectives, for instance, by inviting the viewer to explore the stone's interior space. I then realised that the virtual surface's orientation could be reversed, and the designer's and user's perspectives could be switched. Perhaps designers ought to request a more flexible role in the design process.

The relationship between surface operability and perceptibility is constantly in flux. Furthermore, determining what is operable and perceptible (for instance, determining what structure and texture are) results in alterations to the overall design's shape. Simultaneously, this technique of constructing volume from a surface devoid of thickness has a long history, as evidenced by examples in ancient Mexican culture.

In this phase, I gained a deeper understanding of the dual properties of surfaces and perspectives within a new spatial paradigm. In the next stage, I put this knowledge to use to find new ways of creating.

4 Practical phase III: New methods

Based on the previous practice phase, I learned that the spatial configuration between designer, user and surface is flexible and that the dual properties of digital surfaces can be manipulated without the presumption of 'imitating the appearance of the design outcome.' Both were crucial indicators in the search for a new method. In the final phase of my practice, I aimed to complete my research question:

Is there a new method, or a new set of methods, of making things under today's tools that mark entities with surface constraints?

I attempted to discover a new method through three separate projects, and they all built upon what I had learned and explored in the previous phases. In addition to extracting two key concepts (two properties of the tool and the creation of a series of spatial paradigms) in the preceding phases, I discovered that there are some established or default processes in tools that can be extracted and developed into a new approach of making things:

The *Panorama* project is a continuation of the discussion on the process of unfolding texture maps.

The *Sooner or Later* project is a continuation of the discussion on structure–texture correspondence.

The *Green Blades* project is a continuing exploration of the homogenisation and spatialisation of things in representational tools.

4.1 *Panorama*
Multiple projection installation
Size variable
2021

Fig.45 Image still from the video installation

Fig.46 Installation view, the *Panorama* project, Aranya Art Center, Qinhuangdao, 2021

4.1.1 Thoughts before practice

In the project *Cairn*, in the last phase, I discussed the process of mapping on a closed surface. Texturing on a completely closed surface without edges means developing a limited image with no starting or endpoint that cannot go beyond the surface.

Texturing a three-dimensional, closed surface is utilised in various 3D technologies and 3D modelling in design. In a VR headset, for instance, the 360-degree video is a dynamic image added to a complete sphere, and this technology also shapes the space for users and designers. If we are inside a 360-degree video, such as wearing a VR eye mask, we are typically in a Heidegger's cave and trapped in the centre of a typical linear perspective. However, if we are outside of it, we see a closed space wrapped in dynamic images and will clearly understand how this spherical surface creates its visual illusion for internal viewers. In this case, the creator's space is outside the surface.

This sounds like a reversal of previous research results because before writing this paragraph, I clarified that the conceived space, which only belongs to makers and designers, is under the analogue surface. However, as I mentioned in the project *Cairn*, the surface texture can be turned over, so the person who watches or creates the surface can be either inside or outside. Inside and outside is just a relative, positional relationship.

Being in a 360-degree video means being surrounded by an optical illusion. However, if we want to use 'decoding technology,' as Flusser mentioned, we must leave the illusion and stand outside. Then this spherical video is no longer the result of illusion but just a graphic pattern that can be unfolded and closed. Once we realise this, we may shake the idea of the limitation of the pattern on the closed surface. Therefore, I wanted to explore this contemporary image of the cave of illusion as it unfolds to see if there are new possibilities yet to be explored.

4.1.2 Practice

In the *Panorama* project, I photographed a group of friends playing circle games on the city's public lawn with a 360-degree camera. I learned the game in a dance workshop; the participants form a circle, and each tries to imitate the actions of the previous person. So, the queue gradually becomes a resonant organism between imitation and delay. I flattened and recorded the spherical image of the queueing people and spliced these friends into a team extending infinitely along the horizon through multiple projectors in a 14-meter-long space.

The surface perceptibility evoked by this project is a high-precision, 360-degree moving image, while the operability is to unfold the surface, similar to the *Her* project in the last phase. I subsequently connected the unfolded surfaces horizontally. Here, I extended the viewer's space encased in a sphere by connecting its surfaces to the side of the building, thereby creating a larger space. Although still limited, I could stretch this space further out with sufficient length and projectors [Fig.47].

I discovered this possibility during the *Her* project when I created my head material scarf. For a material to be seamless on a closed 3D model, it must be seamlessly connected to the same image when unfolded into a single image. Thus, this unfolding creates, in essence, an infinitely continuous pattern.

I regard the panorama, or spherical projection, as a reusable visual vocabulary, not just the result of illusion. The information contained in a 360-degree video does not so much create a closed world as it opens a series of continuous worlds.

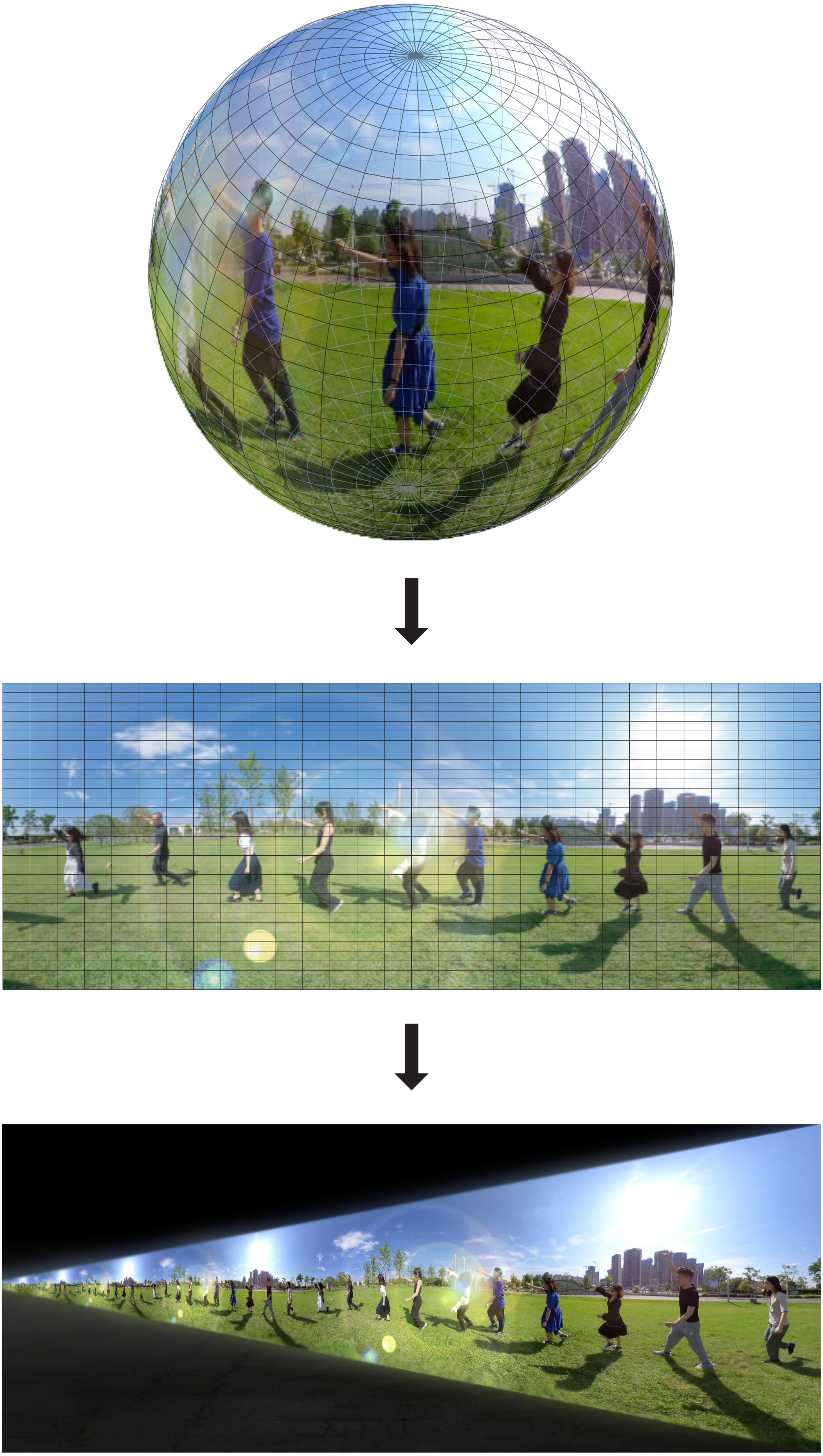


Fig.47 The process of unfolding and repeating the spherical texture

4.1.3 Method I: Finite image and infinitely expansive space

The first method I devised involved unfolding a closed surface with image texture attached to it to obtain a pattern that could be stitched together to create an infinitely extendible space. Unfolding a texture map is a typical step in 3D software design and production, and this method extracts this process and transforms it into a technique for shaping space.

This approach is also an attempt to respond to Latour and Massey's criticism of the introduction of the visual approach, which consisted of flattening the Earth's surface. This graphic method used in geographic fields may have several disadvantages. For instance, information loss and, consequently, a more simplified understanding of the world by those who use this type of map. Perhaps technological advancements in the future will permit us to have better graphic tools. Information will always be lost if the tools remain a simulation rather than the world itself. According to Evans, we must acknowledge the difference between the simulation and the real world, be inspired by it, and determine what we can do with it. I decided to attempt the *Panorama* project because I also wanted to try not to think of this 'unfolding texture map' as a real-world simulation or as the final step in the construction process. Instead, I wanted to see what else it could do.

As Hito Steyerl said in her article *In Free Fall: A Thought Experiment on Vertical Perspective*, we are now in an era where the horizon has disappeared because more advanced technologies, such as aerial photography, have given us a perspective of overlooking the Earth from a very high place (Steyerl, 2011). The horizon disappeared, and the Earth became an object suspended in the universe. This disappearance may explain the new perspective brought by technology from another angle and the change from the Heidegger paradigm to the Sloterdijk paradigm. The horizon is the product of a typical linear perspective, suggesting an indifferent view from a distance. From this perspective, everyone sees the same scenery: things change from large to small and gradually disappear at the edge of the Earth. On the contrary, today's technology brings a view directly toward the Earth's surface, and the Earth appears as an operable surface rather than a horizontal line in an infinite distance.

Let us examine what this operable surface of the Earth looks like, not from a paper map but a Google map. At this time, another operability of the surface appears. In addition to the flippable orientation and scalable attributes mentioned above, in Google Maps, we can scale down the Earth's spherical expansion to the extreme, then the Earth that once was a sphere with limited space becomes a pattern that can be extended infinitely [Fig.48].

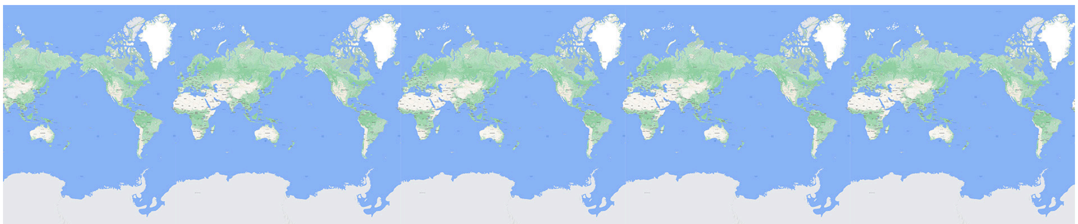


Fig.48 The scaled-down Google map view

4.2 ***Sooner or Later***
Gold-plated stainless steel, Epson ultra giclée print
110 × 103 × 20cm, 40 × 58 × 19cm, 142 × 62 × 21cm
65 × 45 × 13cm, 32 × 49 × 11cm, 42 × 73 × 18mm
2020

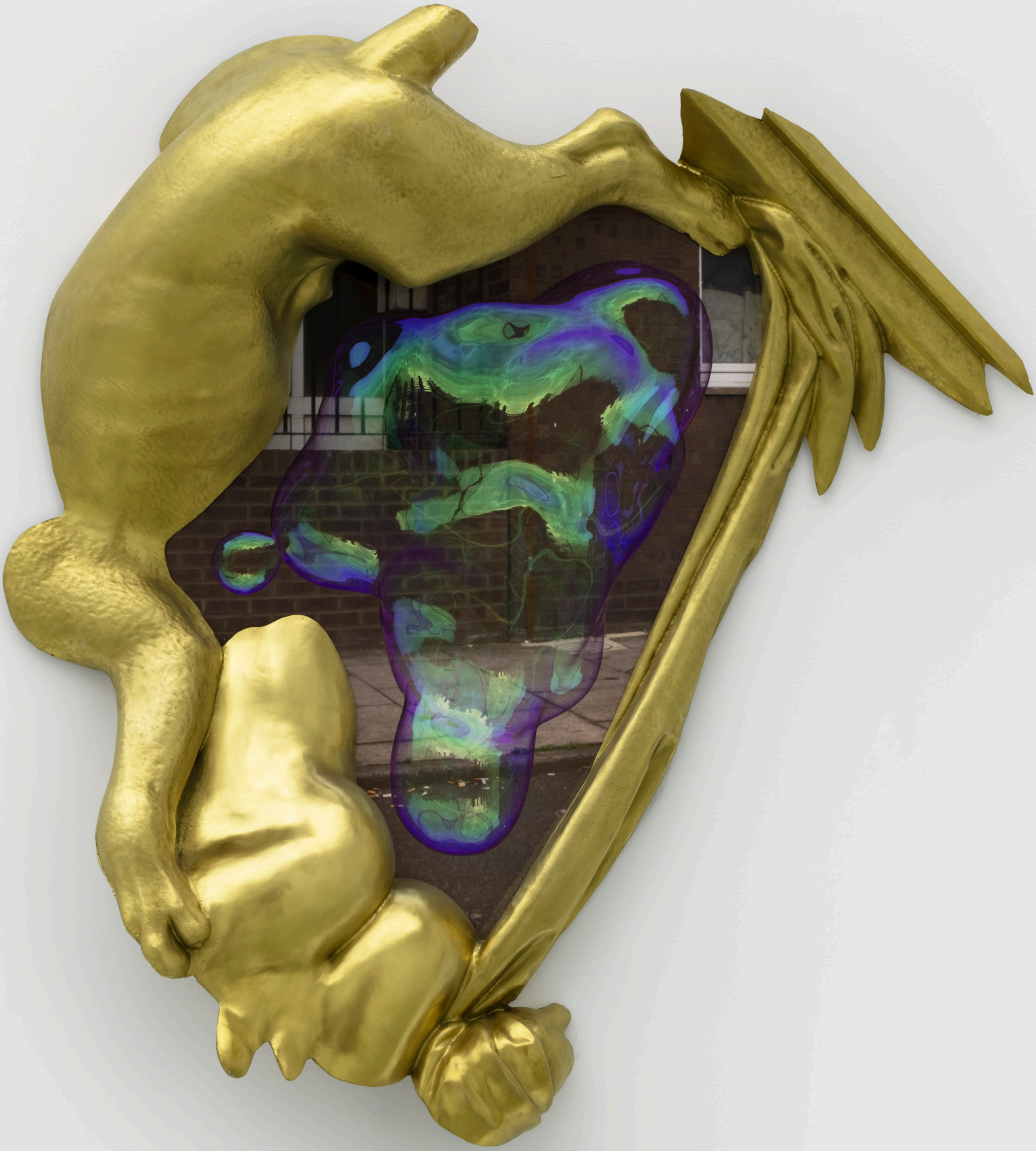


Fig.49 *Sooner or Later*, 2020

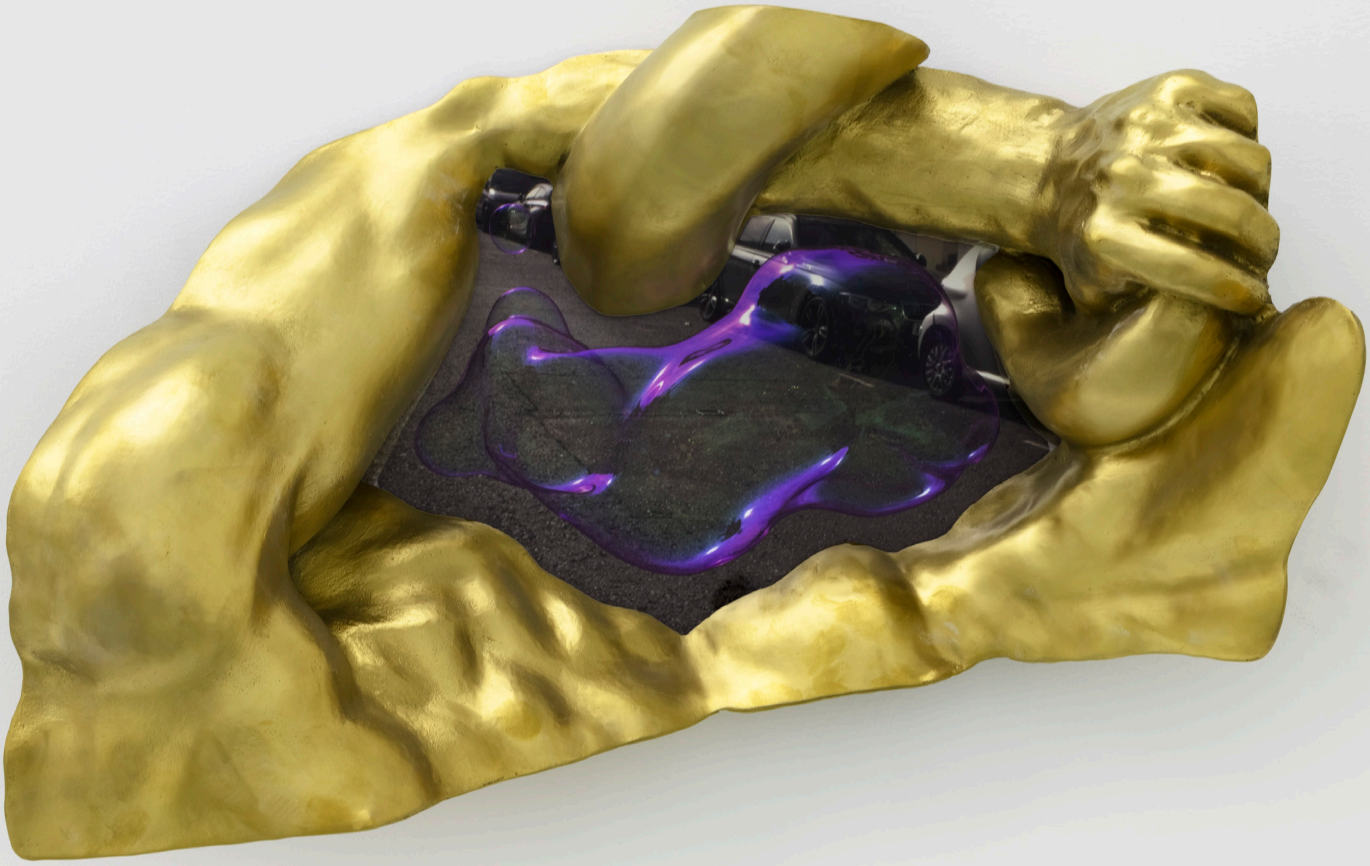


Fig.50 *Sooner or Later*, 2020

Fig.51 *Sooner or Later*, 2020

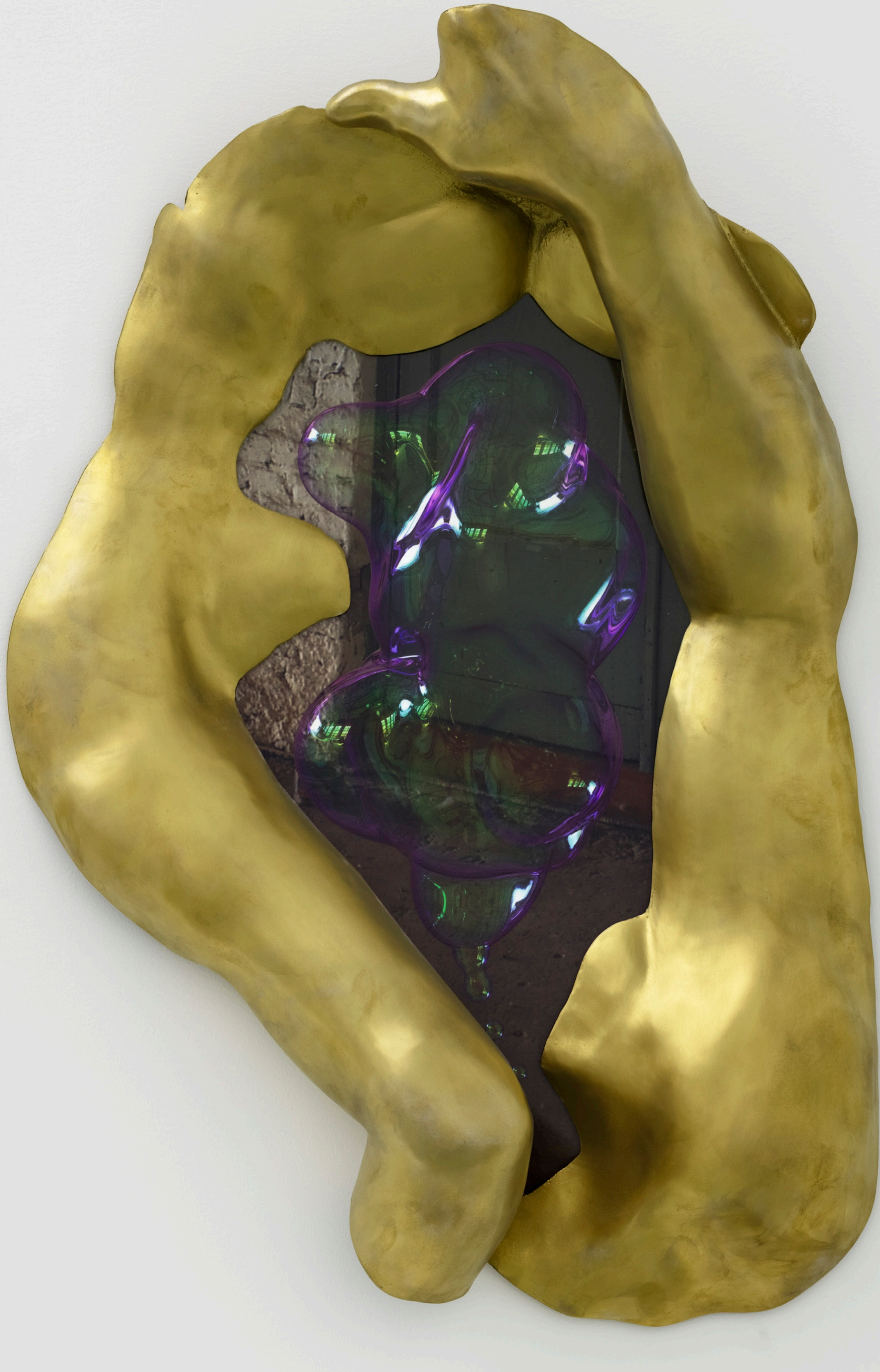


Fig.52 *Sooner or Later*, 2020

Fig.53 *Sooner or Later*, 2020

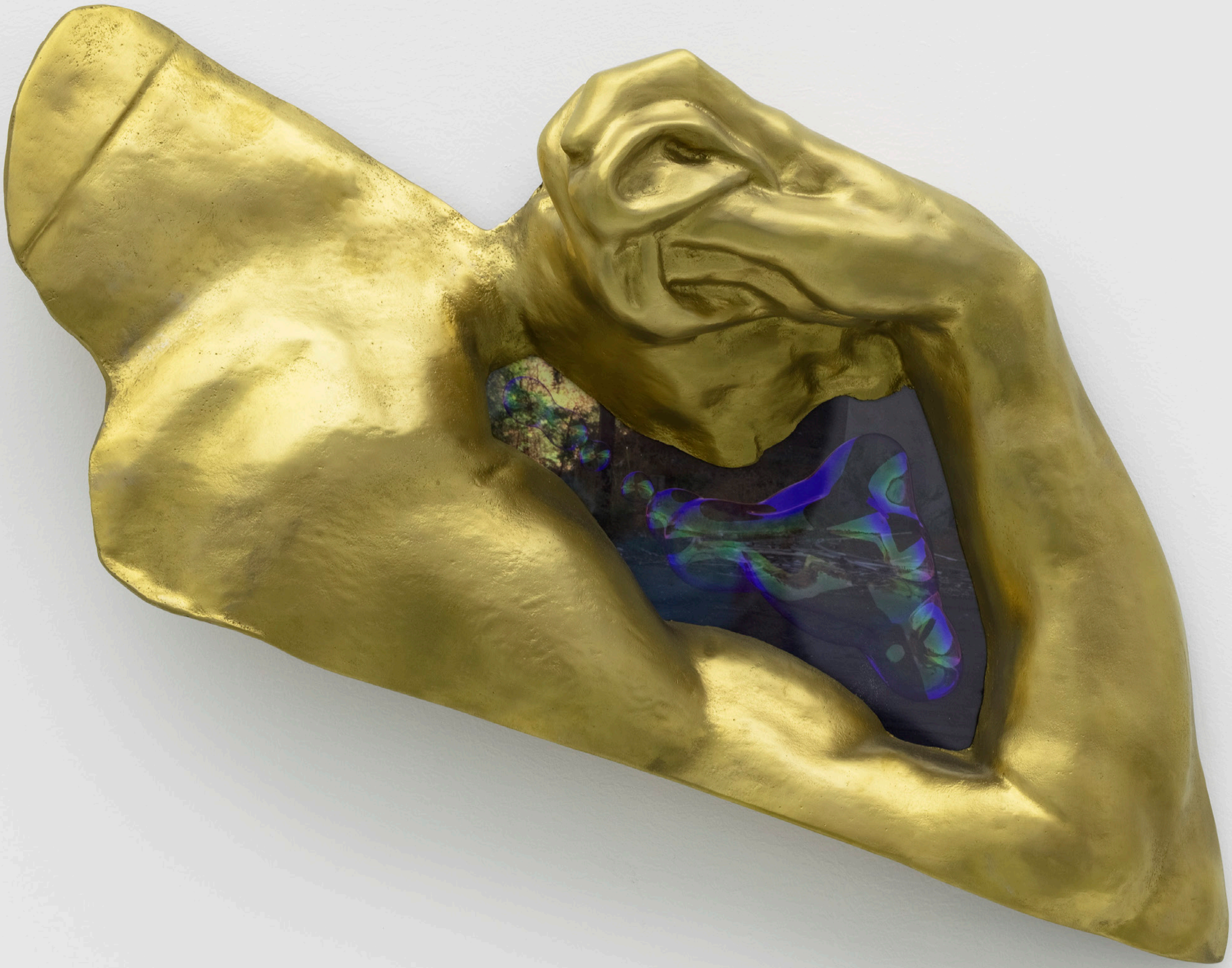


Fig.54 *Sooner or Later*, 2020

4.2.1 Thoughts before practice

In the *Her* project of the previous phase, I discussed the transformation between the surface structure (operability) and its attachment, the texture (perceptibility). In this project, I discuss a more complex relationship between the two. The transformation between them is far more accessible than I have previously described, and the relationship between the two can also be more complex. Before describing my practice, I would like to describe this complex relationship through a few distant examples.

In *The production of space*, Lefebvre used Chinese characters as examples several times to illustrate that 'whether the East, specifically China, has experienced a contrast between representations of space and representational spaces is doubtful in the extreme,' and 'Chinese characters combine two functions in an inextricable way' (Lefebvre, 1974, p.42). He even quoted a very long paragraph of text from a Japanese philosopher to demonstrate his doubt. According to this text, the Chinese character '田' (tian), also used in Japanese, is an abstract concept. At the same time, its visual appearance points out the landscape of the fields and the principle of spatial organisation in agricultural civilisations (Lefebvre, 1974, p.152).

For such comments, as a Chinese, I first admire Lefebvre's sensitivity, but I do not think this is a good example because there must be many examples for any civilisation in which the characters in use originated from hieroglyphics, which cannot be classified as an attribute belonging to the East. However, there seem to be some more appropriate examples to illustrate this. First, if we look at the existing Chinese gardens built in the Ming and Qing Dynasties, we will find many fan-shaped windows [Fig.56] and vase-shaped doors [Fig.58]. We can easily find their relationship with the famous fan painting [Fig.55] and bottle painting [Fig.57] of the same period. Li Yu, a writer in the late Ming Dynasty to early Qing Dynasty, even wrote this design method in his book, *Casual expressions of feeling of leisure*. He wrote, 'the lake and the mountains, the temples, the clouds, the bamboo, the trees, the woodcutters and shepherds, the drunken old men, the women playing, the horse riders passing by, all can be seen on the surface of the "fan" and become my natural paintings' (Li Yu, 2005, p.186). In the design of the window, Li attempted to evoke the image of the fan painting. Whether it is a fan painting or a window in the shape of a fan, the relationship between content and carrier remains the same. Whether a painted landscape or a real one, the landscape has always been the content conveyed; they are always a 'texture.' Similarly, the fan has always been either the entity that transports the landscape or a form that makes the actual landscape visible. There was no difficulty in the mutual transformation of objects and media for the Chinese people in the Ming and Qing Dynasties.

Fig.55 Chen Jichun, Chinese fan painted with landscape, 1635

Fig.56 Fan-shaped window, The Humble Administrator's Garden, Suzhou

Fig.57 Painted vase, China, Qing dynasty (1644–1911)

Fig. 58 Vase-shaped door, Couple's Retreat Garden

Another more extreme example is the painting *Double Screen* [Fig.59] by Zhou Wenju, a painter in the Southern Tang Dynasty. This painting shows Li Jing, the leader of the Southern Tang Dynasty, and Jing Sui, his second younger brother, watching two of their younger brothers play chess. There is a screen in the painting and another screen painted on it. There are many discussions about this painting. The most famous one, by art historian Wu Hung, concerns its spatial analysis: 'the designer deliberately confuses and puzzles the viewer, who is led to believe that the domestic scene painted on the screen is part of the real world portrayed in the painting' (Wu, 2005, p.81). There is another way to interpret this painting, which has never been mentioned in my limited reading. For practitioners using the surface as a building method, the most exciting part of this painting is that if the three screens can be considered three spatial layers, each layer is equivalent in virtual or artificial degrees. The image on the innermost layer (picture in picture in picture) is the natural landscape (with no people in it), the middle layer (picture in picture) is daily human activities and the content of the outermost layer (picture) is a game of chess — the most abstract and conceptualised human activity. The higher the degree of virtualisation and artificiality of the painting's media (the screen), the more separation from human participation in the content (the image). In this sense, the three layers are entirely equivalent.

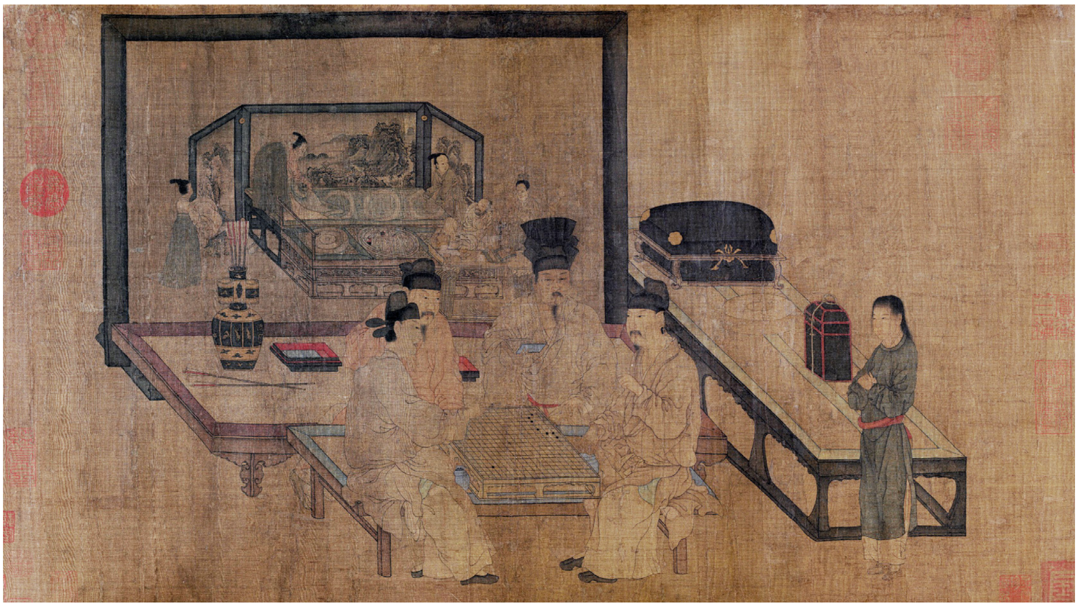


Fig.59 Zhou Wenju, *Double Screens*, ink and color on silk, Five Dynasties Period (907–960 AD)

4.2.2 Practice

A screen in a picture is almost the same as a rectangular surface on a computer monitor, and the pattern drawn on the screen is similar to the digital surface's texture. The enlightenment I gained from these two examples is that if the virtual hierarchy can be nested and layered and the actual structure and the attaching texture can be transformed so freely, what can we do with today's technology? This question is the original intention of my project, *Sooner or Later*. In this project, I wanted to discuss the conversion between frame and content, like the examples of fan-shaped windows and double screens. However, in the final form choice, I referred more to the framework history of Western artwork.

The frame of a painting or photograph makes people understand and believe what is happening inside the frame in an established way. They distinguish works of art from coloured surfaces. Although they are more secondary than the framed content in sense and metaphor, they define what is framed and delegate power to it. However, compared with the things within the frame, the evolutionary history of the frame itself is more closely related to the external things. As a tool to connect the interior environment and works of art, the evolution of frame style has been closely related to architectural and interior decoration. The frame was also related to the ownership of the painting. After the painting was sold, the frame could be replaced. For a long time before the 12th century, a picture frame was integrated into the wood panel on which the image was painted. They were carved of the same wood, and the picture was just a deeper indentation than the frame. The tray-shaped wood is carved first, and the painting is the last step in manufacturing.

Preparing the frame first and then filling in the content is similar to today's creative/manufacturing industry. Such a process means that the limits of all creative forces are set in advance before releasing them. It also means the creator knows their creation's attribution and classification beforehand, along with where it could be located.

I followed this process this time, first making the frame, then the content, and it was obedient. I used parts cut from some famous classical sculptures to make the frame: the space surrounded by the body, usually between the armpits, the legs, or two hugging people's bodies. Then, according to the space enclosed by such a framework, I made content, which was many bubbles.

None of these bubbles were real. Instead, they were all digital products simulated by software. Nevertheless, the essence of classical sculpture and bubbles is the same; they are just a layer without thickness. The surface of classical sculptures reproduced by 3D scanning is the same as the bubble blown by digital mesh. The Impressionists used particles to understand and even reconstruct the world. Similarly, in our era of surfaces, if we do not tear them off piece by piece, the whole world is just a surface attached to pigment.

I attempted to create a nested structure–texture form for this project. I began by creating a closed, flowing structure (operability) with the software blender. By affixing a transparent material to this structure and arranging the light and scene, the entire scene is transformed into a picture (perceptibility) shot by a virtual camera. This image was then framed within the cut-off part of the human body form (another structure, i.e. operability), created by a 3D scanner [Fig.60].

The choice of the bubble image as the content object for the frame was initially influenced by Sloterdijk's bubble theory, which is a visual description of an object wrapped in an air membrane. Also, whether it is '幻梦泡影' (all phenomena are like a dream, an illusion, a bubble and a shadow) or 'Homo bulla,' bubbles are a symbol of fragile and perishable life in different cultural and religious contexts. However, I think more of the game we used to play in the bathroom as children, ringing our fingers and watching a thin film of bath soap form between them. This game is the most intuitive display of the relationship between the frame and the content. The smaller the ring our fingers form, the smaller the bubble. When we close or open our palms, the bubbles break.

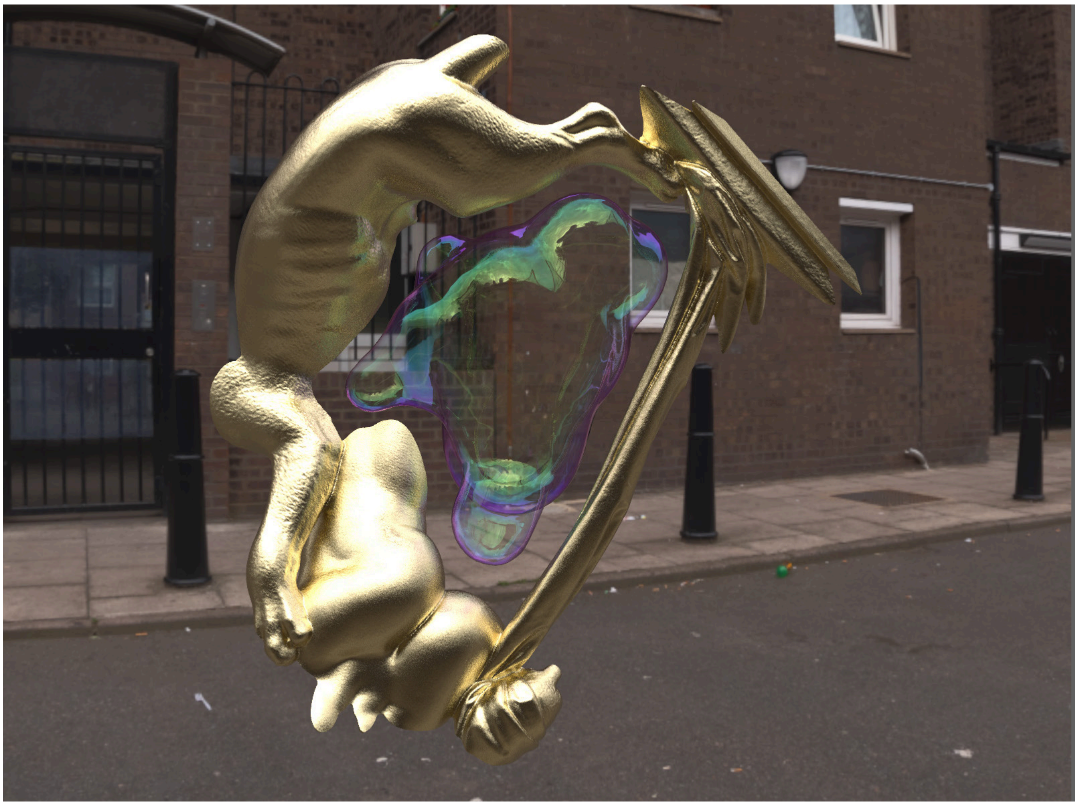


Fig.60 Image still from the rendering process, the gold frame was then fabricated from stainless steel, and the soap bubble part was inkjet-printed on paper

Fig.61 Installation view, the *Sooner or Later* Project, Hive Center for Contemporary Art, Beijing, 2020

4.2.3 Method II: Multiple nesting of textures and carriers

I developed a nested approach for this project by visualising structures as textures, which can then be related to new structures. From the previous project, *Her*, we knew that identifying structure and material (operability and perceptibility) can significantly impact the design outcome. The new method I am investigating goes one step further: operability and perceptibility can be transformed, referred to, and nested within one another. Instead of a single level of structure–texture correspondence, they can develop a complex, multi-layered relationship.

This nested relationship is not only possible in the tool software but also the real world. For instance, my project's final product is a collection of real-world sculpture-photograph hybrids. Another example is the painting *Double Screen*, mentioned in the previous section, which consisted of a series of screens appearing in nested space. According to art historian Wu Hung, this painting was originally framed by an actual screen that has since disappeared. Consequently, this nested relationship adds a layer of physical dimension. Wu Hung provides a sketch illustrating that the screens and furniture in this painting are arranged on an axis perpendicular to the screen, creating the illusion that the spaces inside and outside each screen are connected (Wu, 2005, p.82).

This is Wu's argument from the perspective of artistic composition. I suggest that if we consider each screen layer a surface, this can be viewed as a unified normal direction along the axes [Fig.62]. The unified normal direction toward the screen's edge tends to be 'real,' whereas the opposite tends to be 'virtual.' The relationship between the 'real' and 'virtual,' as it is often called, is not an either/or dichotomy but a progressive one. Similarly, in today's practice, the space presented on the simulation surface is not a certain outcome or a complete prejudgement of the outcome but an elastic state of continuous transition between the world of ideas and the world of touchable.

In this study, the ongoing investigation into operability and perceptibility is an attempt to determine when this technology is closer to the real world and the conceptual world or what characteristics of this technology cause it to converge closer to the real and conceptual worlds.

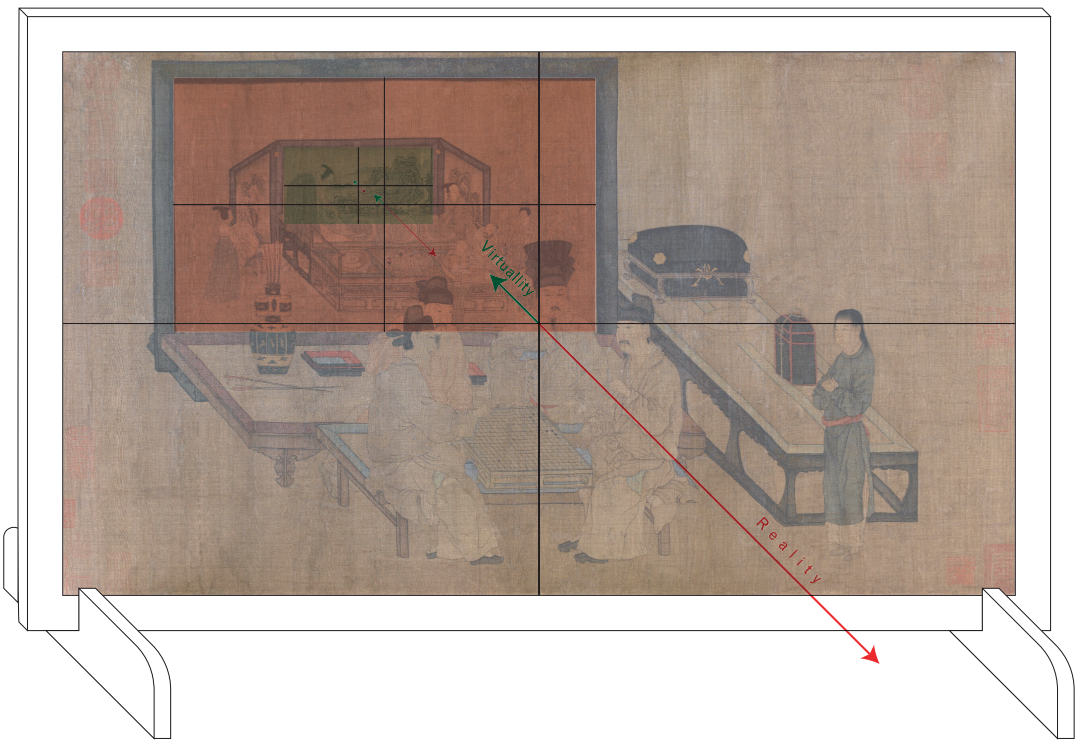


Fig.62 Virtuality analysis model, as modified from Hung Wu's Drawing

4.3 *Green Blades*

PLA 3D Printing, copper powder
100 pieces in total, each around 160 × 20 × 3mm
2021

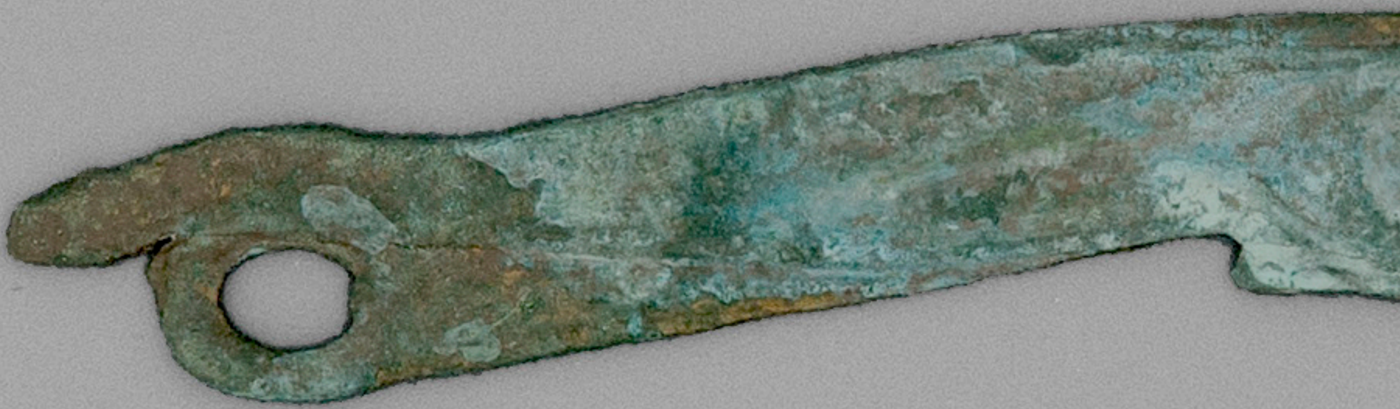


Fig.63 Detail view, the *Green Blades* project, 2021

Fig.64 Installation view, the *Green Blades* project, Tag Art Museum, Qingdao, 2022

4.3.1 Thoughts before practice

As mentioned earlier, surface-centred construction is a technology of casting space. There is no doubt that casting technology is a great invention because the history of casting is a critical factor in the progress of various civilisations. If we consider why every significant prehistoric age was named after the prevailing metal of that era, we will understand how important this way of creating is. However, casting is not only a way of manufacturing but also a way to understand and disassemble things. With all kinds of rapidly updated, computer-aided technologies, manufacturing seems to have eliminated materials' physical limitations, and we can finally shape freely. Therefore, we will no longer hear such naming methods as the 'Bronze Age.' However, the recognition method embedded in casting technology has been used continuously into the modern era. Perhaps one day, our era will be named 'digital casting.' In the project *Green Blades*, I used the idea of 'casting' as the project's starting point. This project included at least three types of casting: bronze casting in ancient China, plastic casting now and digital casting with the virtual surface as the core.

In this project, I also investigated the linguistic description of morphology in the design and modelling process. In the introduction, I referred to Evans' criticism of Eisenmen's morphological descriptions as the 'pulling of a smaller cube through a larger one as if from a distendable mass' cannot be constructed in reality. However, the entire morphing process can be rendered with modern representational tools, whose homogenised, soft surfaces make this possible, visible and animated. Moreover, it is possible to realise it with the appropriate CAM procedure.

4.3.2 Practice

I forged 100 ‘Green Blades’ and semi-fictionalised the transition process from a Starbucks plastic table knife to a pre-Qin knife coin [Fig.65]. It does not matter to me which of the two occupies an earlier time point in real history. What matters is ‘morphing,’ the way of describing the change. I mentioned the plastic table knife before the pre-Qin knife coin because I want to make this sequence start from a more familiar form.

The Starbucks table knife is used for cutting but is made of plastic because of cost considerations. To increase its strength as a knife, it is edged with tiny serrations. The Starbucks table knife is green in colour, mainly to match the brand’s overall marketing and promotion strategies. This knife is a part of the daily operations of a vast modern catering company.

The Yanyi knife of the pre-Qin Dynasty was made of hard metal, but it was not a tool that could be used for cutting. Although it imitated the form of a concave copper scraper used by nomads, it intended to realise the most abstract function in human society as a currency. Its colour was not green originally—the patina we see now is just a rusty colour due to age.

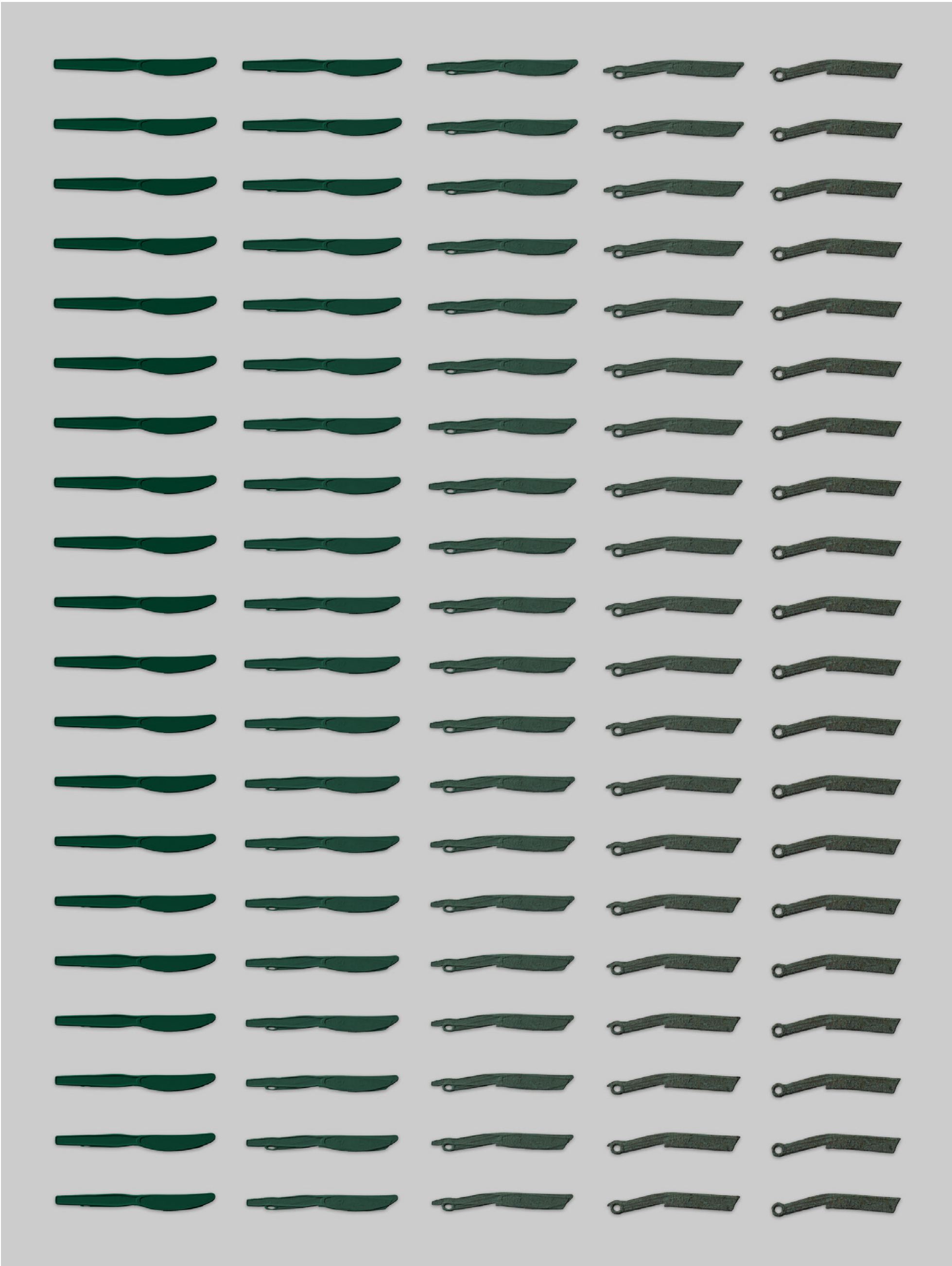


Fig.65 One hundred blades, the *Green Blades* project, 2021

From the perspective of the history of creation proposed by Kubler (2008), all manufactured objects are no more than a vast network woven from a sequence of forms. A particular specific form of a manufactured object is passed, drifted or lost in history, and this kind of change never stops. The form of manufactured objects is ever-changing, whereas a specific object in our hands is just a moment pulled from this continuous movement. The forms of many manufactured objects, especially those convenient objects, such as knives, have remained unchanged for thousands of years. Maybe this is because their forms fit too precisely with people's needs. However, these stable forms of objects may influence other types of objects. The knife coin originated from a living utensil used by nomads around the middle and lower reaches of the Yellow River. Many of the earliest coinages originated from certain forms of manufactured objects. There is a theory that the nomads once directly used the copper knife as physical currency, while the knife-shaped coin was only a conversion product of this custom. Whether this conjecture is correct or not, the knife had been converted into money. Alternatively, the form of currency could have been influenced by the form of a knife. Just as, thousands of years later, the desire for money and transaction was transformed into an emerald green colour and incorporated into the form of a plastic table knife. The various form elements of manufactured objects, such as size, shape and colour, always affect each other. In the sequence of forms constituted by blades and handles, the table knife and the knife coin must be distant relatives.

As mentioned above, the table knife and knife coin hybrids I created constitute a 'semi-fictional' sequence. The non-fictional part is precisely the relationship between them in terms of colour, size and structure, while the fictional part is the morphing process strictly derived by computers.

In this project, I utilised a high-precision 3D scanned surface (perceptibility) and the computability and sculptability of this surface (operability). Using a high-precision 3D scanner, I obtained the digital surface of a Starbucks knife and a knife-coin and then used Blender software to calculate the intersection of the two spaces closed by the surface. Then, two gradients were animated: the one from the knife model to the intersection model and the one from the intersection model to the knife-coin model. (Gradient process animations: http://weiyi.li/greenblades.gif).

During the animation generation, the entire morphing process is visible, as is the gradual transfer of a constantly swaying, deforming surface from one object to another. Eisenman is not the first to express this. Focillon, in his book *The Life of Forms* in Art, not only describes (external) space pressing against the form as 'as the palm of the hand does on a table or against a sheet of glass' (Focillon, 1992, p.79), but also refers to '...the baroque state of all styles presents innumerable examples of this. The skin is no longer merely an accurate mural envelope; it is quivering under the thrust of internal reliefs that seek to come up into space and revel in the light and that are the evidence of a mass convulsed to its very depths by hidden movements' (Focillon, 1992, p.80).

From his language, things seem simultaneously subjected to internal and external thrusts, generating the final form shape. However, this is merely a linguistic metaphor. While creating this animation, it appears that by adjusting the virtual lens' perspective, I can observe this synergy from both the inside and outside. For instance, several animation frames show a slow contraction of the internal space [Fig.66] and a slow expansion of a small external space from nothing [Fig.67]. At this point, the hollow at the end of the knife coin is formed. The creation and expansion of this small void come at the expense of the internal void, which is the counterbalanced relationship between the inside and outside of things, between the creator's and user's spaces.

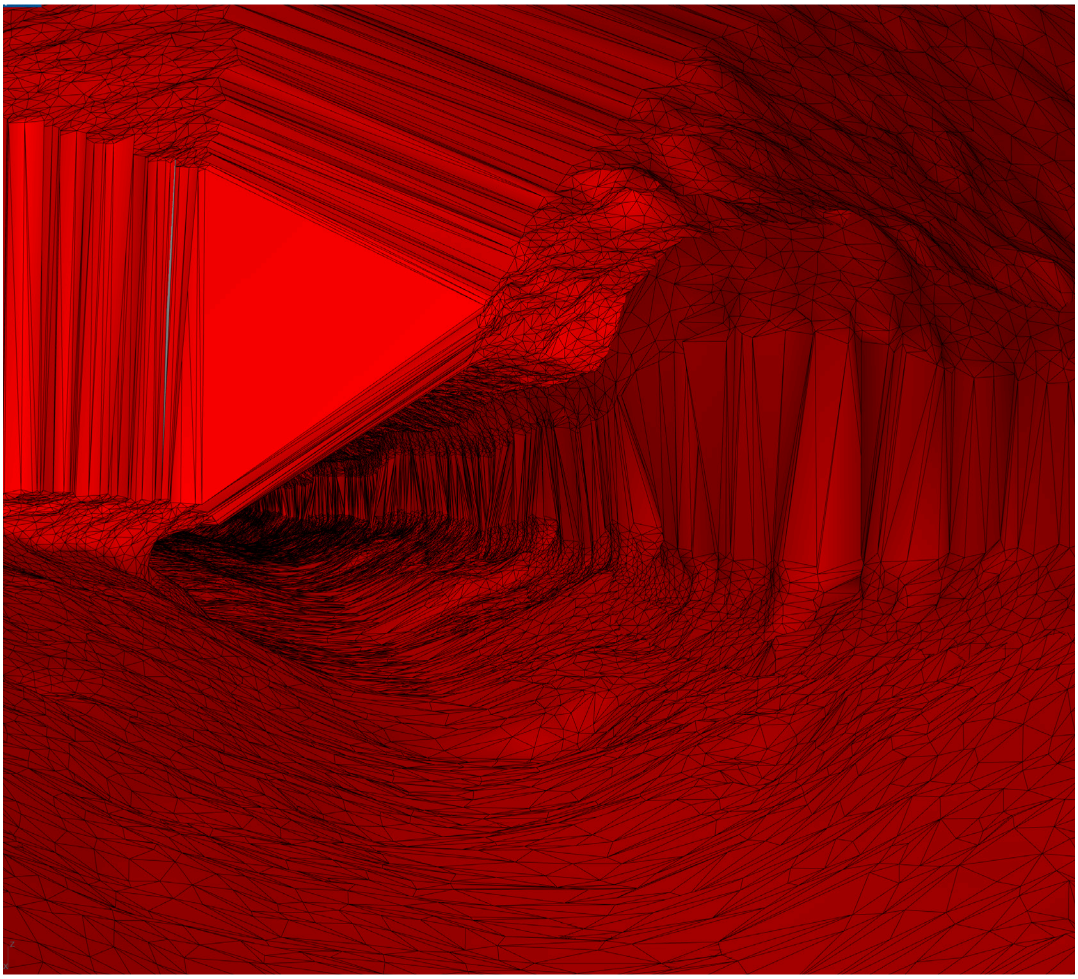


Fig.66 Shrinking interior of the model

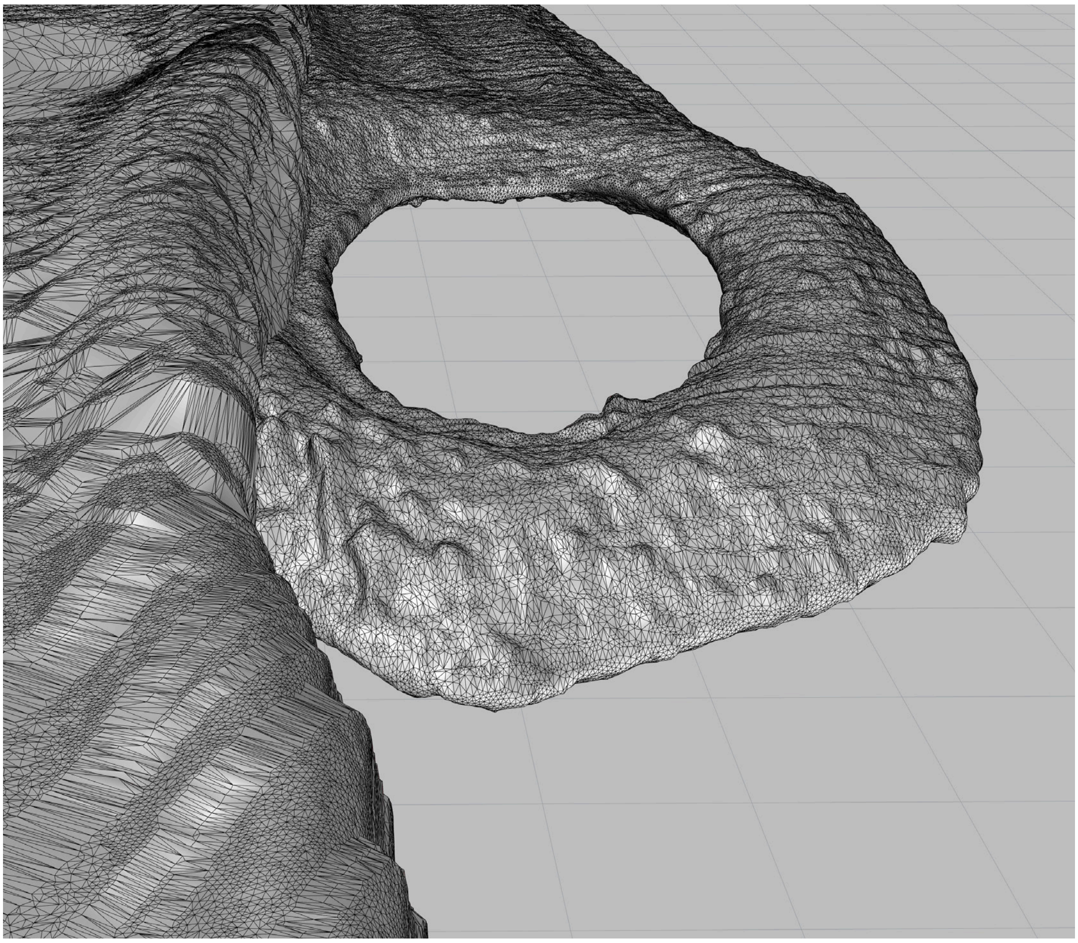


Fig.67 Expanding exterior of the model

I exported 100 blade models from this morphing animation process. With the help of high-precision 3D printing technology, I could ‘cast’ these 100 green blades in reality. Computer-aided modelling technology bridged ancient bronze casting and modern plastic injection moulds in this project. It ‘liquefies’ the surface of the two moulds to make them soft so they can be transformed into each other. Thousands of years ago, the nomads living in the area north to the middle and lower reaches of the ancient Yellow River learned to forge knives and then used the same method to forge coins. Today, I used the same method to forge hybrids between two manufactured objects separated by thousands of years.

In this work’s subsequent exhibition, the small space at the end of the knife-coin, which was previously mentioned, also resonates with the audience. I arranged and displayed these blades in chronological order in the exhibition. According to a news article, ‘...visitors couldn’t resist circling the podium multiple times, eager to determine which knife had the first small hole’ (Li, 2022).

Fig.68 Installation view, the *Green Blades* project, Tag Art Museum, Qingdao, 2022

4.3.3 Method III: Infinitely subdivided animation and infinite hybridisation possibilities

In the *Green Blades* project, I attempted to develop a digitally based method for visualising the 'morphing' process. This process could not be depicted in detail in the past but can now be animatedly depicted. In addition, this animation makes the interaction between the inner and outer space of the simulated surface clear. If we pick a specific form from this animation process, it can become a means of production. That would imply that we could 'hybridise' many existing objects globally, so long as we understood all created objects as surfaces. Since the animation timeline is infinitely divisible, this also implies that we could theoretically create an infinite number of intermediate models between the two object types.

This method is also a response to Evans' criticism of Eisenman. He argues that a literary description of the morphology and the actual construction should not be conflated, but I would suggest that modern technology permits the morphing process to be combined with ultimate fabrication. Here, I would like to discuss morphing as a pictorial technique in greater detail, as this has always been how we describe 'change.' The tracing of it can explain why I wanted to create this work at this moment in time.

In computer image processing, 'morph' is an interpolation technique that creates a series of continuously changing intermediate objects between two entities to transition from the source to the target smoothly. Morphing is also a standard processing method when parameterising the digital surface. For scholars like Antoine Picon, surface fluidisation and space animation are features of digital materiality: 'space can no longer be apprehended as a passive container. Far from being passive, it appears animated by fields, gradients and flows in a way that tends to blur the distinction between the nonorganic and the organic. In today's reality, continuity goes with a pervasive animation that is no longer the monopoly of organic life' (Picon, 2010a, p.151). However, why do we invent such image processing technologies? Why do we desire to fill in a smooth transition process between two images and two forms?

Before the advent of computer technology, the natural history painter Rudolf Zallinger (b.1919) created the famous illustration *The March of Progress*, which was widely used to describe the theory of evolution. In a certain sense, this illustration is arguably the most famous scientific image in history. It has been copied, modified and parodied in large numbers and has also attracted countless criticisms. In addition to those scientific facts that have been falsified, many criticisms were aimed at simplifying evolution into a linear process — the beasts seem to want to be human beings as their ultimate goal, one after another, moving forward step by step. One of the most famous criticisms came from Stephen Gould: 'but life is a copiously branching bush, continually pruned by the grim reaper of extinction, not a ladder of predictable progress' (Blake, 2018).

Let us turn our attention to the more distant past, not only before the invention of computer technology but before the emergence of the entire scientific system. The Chavin site in the Peruvian Andes was formed around 1200 BC, where archaeologists discovered huge stone tenons embedded in the walls. Assuming nothing is missing, the sequence of more than 40 tenons depicts the process of a shaman's transformation from a human face to a leopard god's face. The position of the eyeballs gradually recedes, the nostrils turn up and the fangs stick out [Fig.69]. Perhaps Bataille's comments on the prehistoric humans depicted in the Lascaux petroglyphs also apply here. For people at that time, beasts were closer to gods than human beings, so they wanted to hide behind the masks of beasts. Ultimately, we are 'human beings who disguise themselves with the glory of beasts' (Bataille, 1955, p.116).

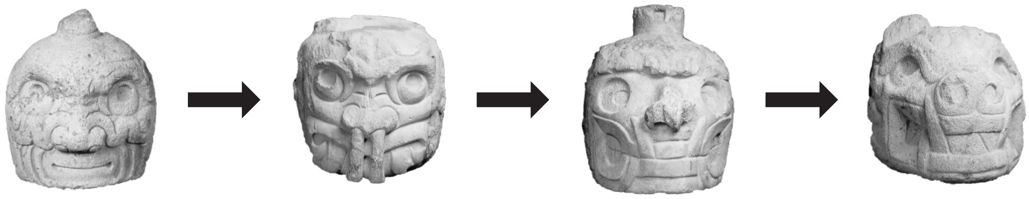


Fig.69 Stone tenons from the Chavin site in the Peruvian Andes

In these two examples, we can see an apparent common feature. The direction of progress described in the scientific illustration is to turn beasts into humans, while the prehistoric, non-scientific statues describe that humans must be re-naturalised into beasts to reach a higher level of existence. If we follow the deductive rules of the image, we can completely integrate the two into a closed loop of transformation between beasts and humans. What connects this closed loop is not a specific depiction style but the way of interpreting changes and the logic we use to create images. We may think that the images rendered by this logic have grasped the world and the rules of its operation. Why do we have to find more 'transitional species' between monkeys and humans to describe the process of evolution even if it may lead to false implications? Why must the process of a shaman transforming into a beast through hallucinogenic drugs be depicted in more than 40 images? Why do we desire to insert one or a series of imaginary intermediate forms between two different forms to create a smooth transition? The logic behind this resembles the reverse operation of Gestalt. The Gestalt proves that people can sense the connection in discontinuous forms. However, the way we describe objects is the opposite — we are constantly making things up; sometimes, what we make up is more than what we need.

This diagrammatic method we have been employing is a visual representation of purely linguistic logic. Before we had digital tools, this visualisation depended more on imagination (like the stone tenons in the Peruvian Andes). In contrast, this process is now automated: an infinite number of transitional images can be inserted between two images. While the project was still in progress, I realised it was essentially stringing together the observations of many of the scholars I had cited in my research. For example, this morphing process is a visual representation of language's linear nature ('texts are concepts strung together like beads on an abacus, and the threads that order these concepts are rules'; Flusser, 1985, p.9). It also visually represents the technique intellectuals use to deal with reality, as Focillon describes: 'the intellectual…tends necessarily to make every activity conform to the processes of rational discourse' (Focillon, 1992, p.120). In this morphing process, spatialisation is equivalent to textualisation. Doreen Massey, the geographer mentioned in the introduction, also notes the concern with this type of spatial imagination, which is the opposition of space and time, where time becomes all but linear and space becomes a completely static thing on the timeline: 'you hold the world still in order to look at it in cross-section.' (Massey, 2005, p.36) Furthermore, Evans mocks Eisenman's use of morphology as a 'parody of rigour.' I compared all this discussion to the tools we used and concluded that while our tools are not necessarily the best predictive medium, they largely present the extreme linearity of our thinking in an explicitly visual way.

In a project like *Her*, I was attempting to present in the physical world a process that was previously only an unfolding process of texture mapping in software. However, in this project, I attempted to present a more complex physical process: a frozen, subdivided process of morphing animation, a visualised linguistic structure. I intended to create a history of evolution that is so smooth that it appears unnatural, as if every change between two objects looks like a frame drawn from a fast-flashing film. That is why I believe there is no better time than now for presenting this work. The time was ripe for everything because the frame-by-frame calculation in image technology already perfectly matched the rhetorical metaphor, as well as the maturity and popularity of computer 'forging' technology.

This project highlighted the most significant difference between my research and Evans' theories. His theory taught me the difference between what is presented in the tool and what is built in reality. He emphasises that the importance of geometry and mathematics for the actual construction is not a preconceived and complete set-up but rather a hint for the final construction. Moreover, I would like to suggest that, in addition to geometry and mathematics, language and metaphor are essential tools in how we understand the world as humans. They should be able to compete with mathematics in terms of importance. Today's tools meticulously visualise them and their potential limitations (e.g. linear expression). However, as with geometry and tools, we must identify them and determine how they differ from the actual world and where and how they can be utilised. For instance, to describe a fictitious evolution of manufactured objects.

4.4 Summary

This is the final practical phase of this research, and in this phase, I investigated three methods for creating things using digital representational tools. Here, I provide a more comprehensive summary of how I derived these three methods from the first two phases.

Practical Phase I: Through a Surface

In the first practical phase, I developed three projects using a 3D scanner to complete my initial exploration of digital surfaces. The scanned street facade fragments from the *Landscapes* project [Fig.70] enabled me to discover a way of understanding and representing things with a surface separated from them. Digital tools today are built on the idea that the surface works as an agency.

In the *Still Lifes* project [Fig.71], I learned how digital surfaces merge those perceptible features of surfaces with the operable, and a design outcome was the result of these two properties working together. In addition to using the surface and the void beneath it to define entities, I also learned that our tools form a spatial relationship between these surfaces and the practitioners. A more traditional approach to using tools is to view and construct objects from their outer parts, with the goal of tool operation being a complete preview and accurate simulation of the object to be built. However, this simulation method does not account for the losses incurred when using the surface as a substitute for solid, and it also limits the results of manipulating the tool to an ensemble of tool performance limitations. To avoid these issues, I continued investigating the tool's visual properties, and *Portraits*, my third project, was born.

I deliberately attempted to break a perfect digital simulation in the *Portraits* project [Fig.72]. This intentional disruption granted me at least two benefits: a new way to describe the spatial relationship between people and the simulated surface and a new possibility of invoking surface attributes. This new spatial relationship is achieved not by rearranging the position of the person, the surface and The Real but by differentiating the perspectives of various individuals. The designer and user of an object can occupy different positions on the same surface and observe it from various angles. This tool's new perspective enables designers to view and manipulate surfaces from the interior of objects. This perspective also allows designers to avoid the limitations of predictions and assumptions made from the same perspective as users, and the simulation of the appearance of things is no longer the sole function of the tool. At the same time, I found that the unconventional use of the dual properties of the surface is how this simulacrum can be broken down. In this project, the realistic texture (perceptibility) and the unbroken interpolation of surfaces (operability) worked together to produce the impossible overlap of human body forms.

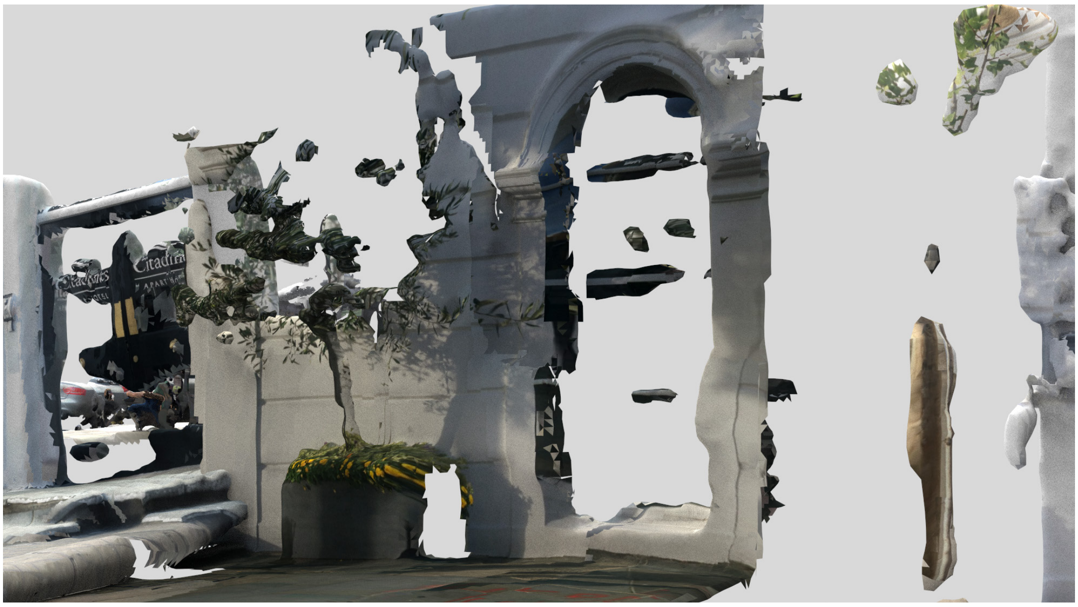


Fig.70 *Landscapes*, 2017

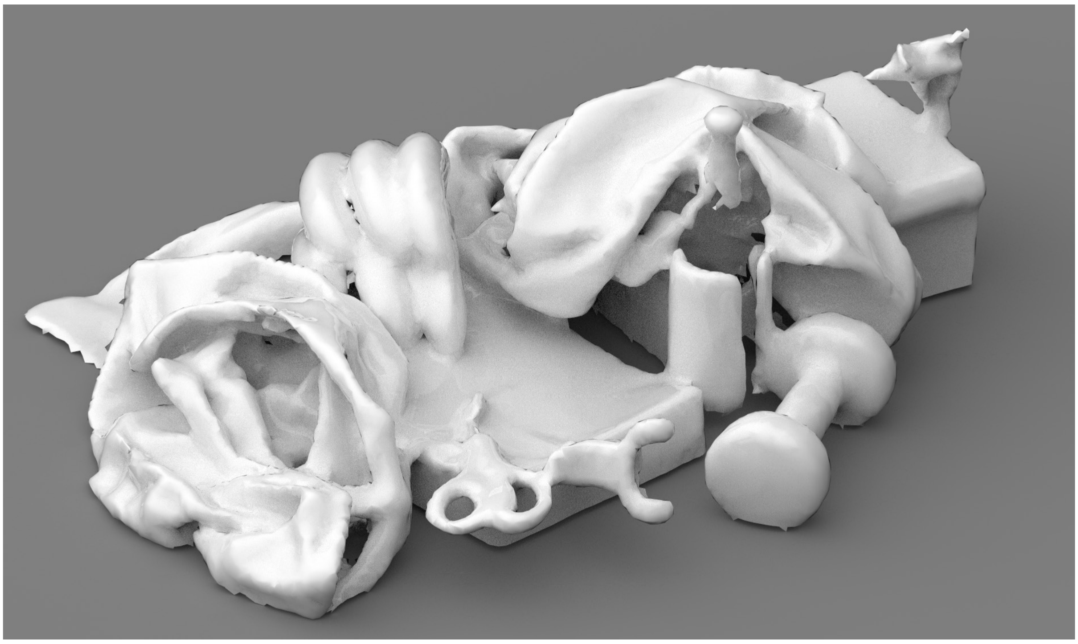


Fig.71 *Still Lifes*, 2017

Fig.72 *Portraits*, 2017

After this phase, I acquired two tools: one for manipulation (i.e. the sensitivity and operability of surfaces) and the other for describing the spatial relationship between people and constructed surfaces (i.e. a series of spatial paradigm models) [Fig.73]:

Paradigm 1 (the ancient Greek world model) is the initial model used to describe how people define things in terms of the surface and The Real.

Paradigm 2 (the Plato world model) represents a conventional method of constructing surfaces that arose after discovering that surfaces could be separated from The Real. In this paradigm, the designer and the user occupy the same position, and the surface is conceived from a single viewpoint. Here, all visual forms in the design process are created to simulate a perspective and feeling identical to the user's.

Paradigm 3 (the Heidegger world model) refers to the situation in which the to-be-built object is identical to the conceived surface. When designers equate what is presented on the interface of a representational tool with what is in the physical world (consciously or subconsciously ignoring the distinction between these two worlds) or attempt to trap the user in a virtual reality helmet permanently, they are attempting to build the Heidegger paradigm. This model is not a practical way to use the tool but rather an expectation, which is where Latour (2009) and Pallasmaa's (1996) criticism originates.

In contrast to *Paradigm 3*, *Paradigm 4* (the Sloterdijk world model) allows the designer to have an independent space and perspective. Thus, the sole purpose of surface modification is no longer to model the appearance of objects. Additionally, the dual properties of surfaces can be utilised more freely. Instead of being constrained by strict visual expectations, the designer can experiment with unconventional means of invoking these properties, thereby positively shaping the surface.

Based on what I learned in phase I, I hypothesised that the breakthrough in exploring new creation methods might lie in the unconventional invocation of surface properties based on *Paradigm 4*. In practice, this model corresponds to the same void within a digital object from which the designer can see and construct. This is a designer's perspective like never before and a new way of illustrating what digital tools have given us. To prepare for the eventual exploration of new methods, in my second practice phase, I sought to examine this new perspective in greater detail and investigate the relationship between the two surface properties and how they can be invoked under this perspective.

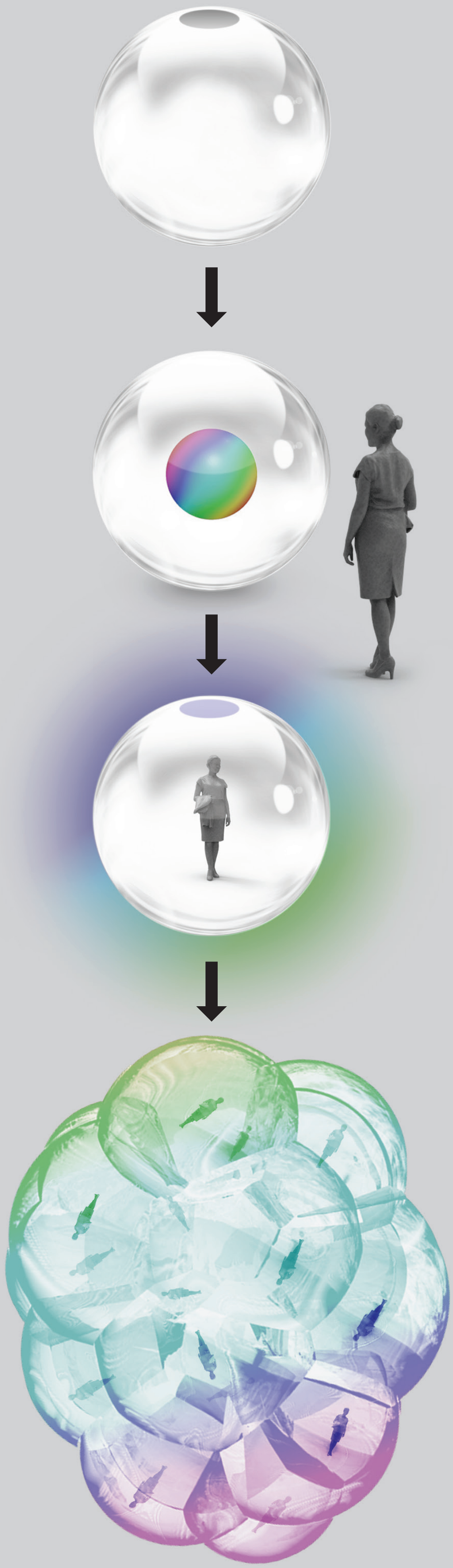


Fig.73 Models of the four spatial paradigms

Practical phase II: The creator's space

During this phase, I worked on three projects, each beginning with a revelation of the space I discovered beneath the surface. These three endeavours represent three distinct levels of revelation.

In the first project, *Fruit and Hamburger* [Fig.74], I compared the section view before computer graphics to the digital voids of today, presenting the new perspective in a highly visual manner. However, the comparison was still based on a familiar perception to designers, who are likely the only individuals familiar with the visual presentation of the former section view.

In the second project, *Cairn* [Fig.75], I invited the viewer to step inside the void of four simulated rocks. I consciously exposed this perspective, which is only visible to the designer, to all the exhibition visitors. I was simultaneously aware of the digital surface's orientation in this project. In the Sloterdijk paradigm, the design of the object and the environment are identical. When the designer is on a closed surface's exterior, they design the object; when they are on the interior, they construct the environment. This is how surface-based creation equates space creation with object creation.

In the third project, *Her* [Fig.76], I attempted to transform the void beneath the surface of a digital object into a manipulable space in the real world by printing a digital texture map on a silk scarf that people could wear. Doing this transposed a standard mapping procedure from a modelling tool into the real world. This project taught me that surface operability and perceptibility are transferable. Moreover, the designer's choice between operability and perceptibility can result in various design outcomes.

In phase II, I investigated the designer's perspective within the Sloterdijk paradigm in greater depth. In each project, I consciously selected and invoked the dual attributes of the object surface. Completing these projects made it abundantly clear that avoiding accurate visual simulation of the to-be-built object and conventional surface property invocations was feasible. During the *Her* project, I realised that making a routine process in design software more explicit could be a way to encourage new creation methods. Many of the specific tool process steps I encountered during this phase served as a springboard for the subsequent phase, which involved exploring new methods.

Fig.74 *Fruit*, 2018

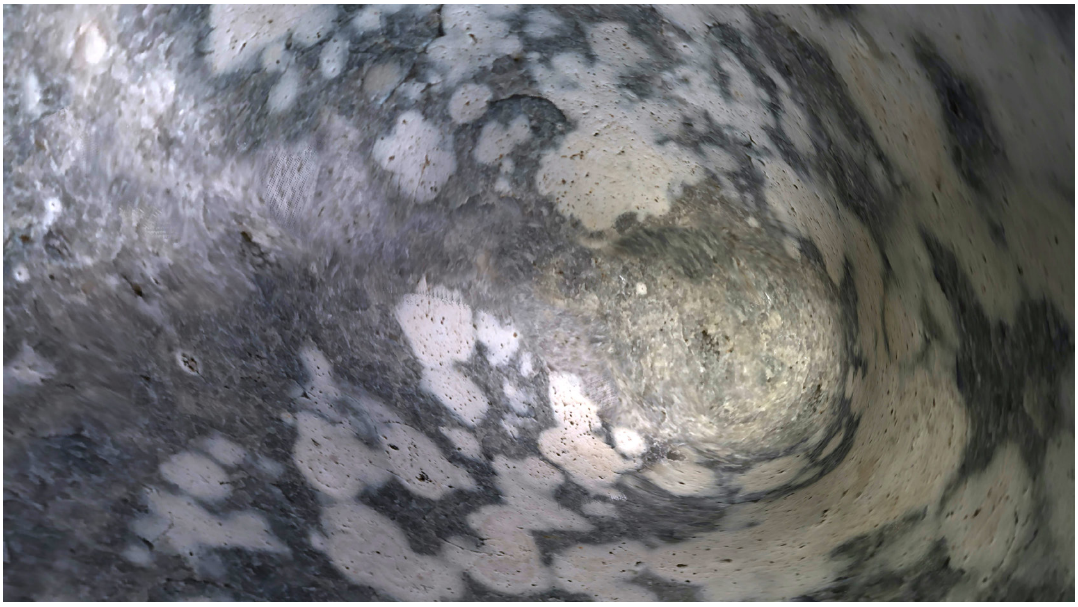


Fig.75 *Cairn*, 2018

Fig.76 *Her*, 2017

Practical Phase III: New Methods

This phase verified the knowledge I learned in the previous chapters. I tried to maximise the use of the surface's two tool attributes, not by balancing them but by promoting their conflict, highlighting the virtual surface attributes in the actual material construction, and treating the material as a permeable, fluid and infinitely extensible thing. While working on these projects, I also paid extra attention to the spatial relationship between myself, as the creator, and the simulacrum surface.

I tried to develop three different approaches to creation through three projects. All three methods were a manifestation of some established processes in digital tools:

In the *Panorama project* [Fig.77], the method I devised involved unfolding a closed surface with image texture attached to it to obtain a pattern that could be stitched together to create an infinitely extensible space. This approach is also an attempt to respond to Latour and Massey's criticism of the introduction of the visual approach.

In the *Sooner or Later* project [Fig.78], I developed a nested approach by visualising structures as textures, which could then be related to new structures. Surface operability and perceptibility in tools can be transformed, referred to and nested with one another. Instead of a single level of structure – texture correspondence, they can develop a complex, multi-layered relationship.

In the *Green Blades* project [Fig.79], I developed a digitally based method for visualising the 'morphing' process. This animation makes the interaction between the inner and outer space of the simulated surface clear. If we pick a specific form from this animation process, it can become a means of production. This method is also a response to Evans' criticism of Eisenman. He argues that a literary description of the morphology and the actual construction should not be conflated. I suggest that modern technology permits the process of morphing to be combined with ultimate fabrication, and this process is also an essential tool for imagining and creating forms.

Fig.77 *Panorama*, 2021

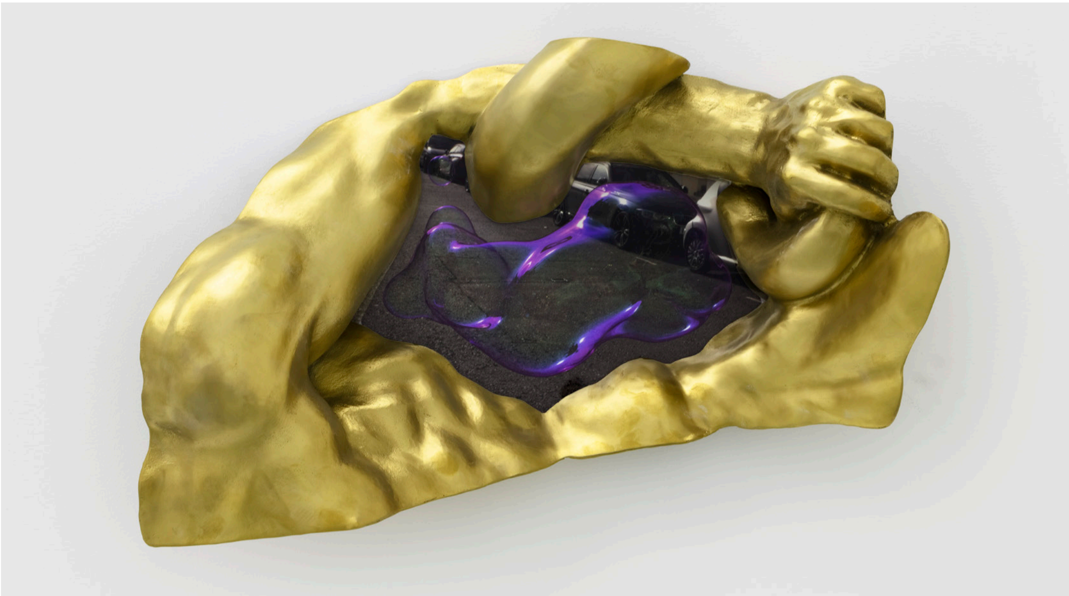


Fig.78 *Sooner or Later*, 2020

Fig.79 *Green Blades* project, 2021

5 Conclusion

5.1 Contemporaneous practices

Before formally concluding this research, I would like to present a few examples of practices from my contemporaries to provide some side-by-side comparisons and analyses of my practice. In the previous discourse on the three practical phases of this thesis, the cases used for comparison with my projects were ancient and even predated the existence of computers. The purpose of citing them is to highlight ideas that may have been overlooked by contemporary designers but are actually ingrained in digital software, thereby tracing our origins and fostering inspiration for novel creations. Some scholars, such as Mario Carpo, acknowledge that 'contemporary digital techniques in many respects are closer to some pre-mechanical age cultural technologies than the mechanical era we are now leaving behind' (Carpo, 2011, p.118). Many solutions inherited from the Industrial Revolution may no longer be relevant to our present technologies. Examining previous instances, however, could provide us with valuable direction.

This chapter aims to showcase the practical projects of creators from my generation. I engage in a comparative analysis of my work with theirs, primarily due to its intricate nature and focus on visual exploration. This complexity can pose challenges when analysing and evaluating my work within the framework of academic research. This is because it does not directly align with my research questions. To give a simple example, in the *Landscapes* project, I am unable to explain the rationale behind my decision to utilise 3D scanning on a specific block rather than another. This project's visual themes do not correlate one-to-one with particular research questions, nor can it generate precise data for evaluation purposes.

Nevertheless, the approach I employed is not isolated. On the contrary, this type of project exists in abundance in architecture and design. They do not emerge to solve specific problems or achieve immediate and certain answers, but the manipulation, observation and analysis of such projects can stimulate new thinking. In this chapter, I begin with a selection of similar projects. In addition, I also present examples of buildings or products that have already been created to demonstrate that the methodology I have developed in this thesis has the potential to be applied in the practice of others and its practical implementations. I continue to evaluate these works using my three stages of practice as a framework:

Practical Phase I: Through a Surface

During the initial stage of my practice, my project focused on my experience and observations regarding using a 3D scanner. Here, I would like to juxtapose these practices with a project with visual outcomes similar to my projects at this stage. *Interiors Matter: A Live Interior* is a practical project accomplished in 2019 by Ulrika Karlsson, Cecilia Lundbäck, Veronica Skeppe, Daniel Norell, and Einar Rodhe. They used a 3D scanner to document the interior environments of apartments in Stockholm. The choice of equipment and the visual results of this project closely resemble my work with a 3D scanner, mainly my 2017 project *Landscapes*, utilising a 3D scanner to capture substantial volumes, such as buildings. Nevertheless, I conducted my scanning and recording exclusively from outside buildings rather than from inside.

From the paper about the project, authored by the creators, it is evident that our projects not only share visual similarities but also a common awareness of the distortive nature of 3D scanners. For instance, they describe how the surfaces created by 3D scanning exhibit a 'continuity across objects' (Karlsson et al., 2020, p.13), with the interior items firmly attached to the walls and floors of the structure, forming a vast unified surface. They utilised such observations to discuss 'how the cloud drawings developed in the project can open for new ways of understanding and conceptualising the interior' (p.2). A cohesive surface allows the space originally designed for living to be reinterpreted as 'environments, assemblies, and materialities' (p.1). They also noted the gaps created by the scanner's inability to 'see' certain areas (p.14), yet they did not delve deeply into them. However, in my practice, the openings in the surface revealed the space beneath, and it was this discovery that my practice subsequently increasingly revolved around. This reaffirmed my realisation during my *Portraits* project: at times, the discoveries made in the process depend on the constraints imposed by the equipment being used.

Another correlation between their practice and mine pertains to the orientation of digital surfaces. In a series of images, they presented the interior surfaces of a room from the outside, turning the space into a volumetric block [Fig.80]. I was unaware of this characteristic of surfaces being reversible during the first practice phase with a 3D scanner. Instead, in the second phase of my practice, during the *Cairn* project, I came to recognise and deliberately utilise this feature.

Fig.80 Ulrika Karlsson, Cecilia Lundbäck, Daniel Norell, Einar Rodhe, Veronica Skeppe, isometric view of *Interiors Matter: A Live Interior*, 2019

Comparing my work with their outcomes, the most intriguing point is that their visualisation of the 3D scanning results still follows a traditional architectural drawing notation. They continue using standard plans, elevations, and isometric views to present their work [Fig.81], which aligns with their project's close ties to the architectural industry. In contrast, I followed a more general software user experience involving the dynamic preview of space on the screen [Fig.82]. Much literature discusses the need to treat architectural plans and renderings differently. For example, 'A plan drawing requires training and knowledge to be properly interpreted. A realistically rendered image is treated differently, however' (Young, 2022, p.5). In other words, plan drawings are supposed to be a more professional architectural representation, while rendered images are more like advertisements aimed at clients. In this regard, my practice distances itself from an exploration focused explicitly on the architectural industry. I never emphasised the distinction between these two types of images throughout the current and future stages. From the standpoint of this thesis, these are merely two display modes that can be seamlessly toggled on the screen at any given moment. They only vary in terms of the level of perceptibility and operability. Plans are more conducive to architects for delineating, altering, and scrutinising; rendered images allow people to preview what a building will look like before it is built.

Fig.81 Ulrika Karlsson, Cecilia Lundbäck, Daniel Norell, Einar Rodhe, Veronica Skeppe, section view of *Interiors Matter: A Live Interior*, 2019

Fig.82 Image still from the *Landscapes* project, 2017

The *Landscapes* project predates *Interiors Matter* by two years. However, comparing the two, I can better understand why I made certain choices whose intentions were not clear to me at the time of creation, as well as evaluate their eventual effectiveness from a side perspective. *Interiors Matter* stands because all its visual choices adhere to rules typical of architectural imagery. By contrast, *Landscapes*, as a visual exploration, has a more mixed set of elements. I attempted to recreate a journey on screen recorded by a 3D scanner. Although the objects captured by the scanner were static and fixed, I inserted a moving virtual camera position in the software to mimic the journey of the person holding the scanner. I added the soundtrack recorded at the time as a voiceover, trying to simulate a living person's walking experience as much as possible, with the machine's 'eyes' and 'ears'. However, within the final work's imagery, the fragmented architectural surfaces and pedestrians, misinterpreted by the scanner as a series of blurry masses, narrate the difference between digital representation and human experience. This contrast between a world recreated with surfaces and the tangible world we interact with propels me to continue my exploration.

Practical phase II: The creator's space

The second piece I would like to analyse is the *Still Life Interventions* project [Fig.83] by Michael Young and Kutan Ayata. The two architects incorporated a digitally created peculiarly shaped object into a traditional still-life painting from the Dutch Golden Age. The newly created paintings were reproduced and coated with glazes to imitate the visual characteristics of conventional still-life works. Therefore, an unusual item abruptly materialised in the most classical of settings. The texture and colour of this unique object perfectly complement the overall tone of the original scene despite being an item that is impossible to exist in reality.

I introduce this piece to compare it with my second phase of practice, where I endeavoured to connect the designer's space with the user's. My objective was to enable the audience to encounter the virtual void typically exclusive to the creator. In the initial series of this phase, *Fruit and Hamburger*, I merged images of still life on the table with architectural section drawings [Fig.84]. The software-rendered objects, appearing remarkably lifelike, unveiled their empty interiors to the viewers beyond the frame, thus exposing their inherent nature as mere digital simulations.

Fig.83 Michael Young, Kutan Ayata, *Still Life Interventions*, 2014

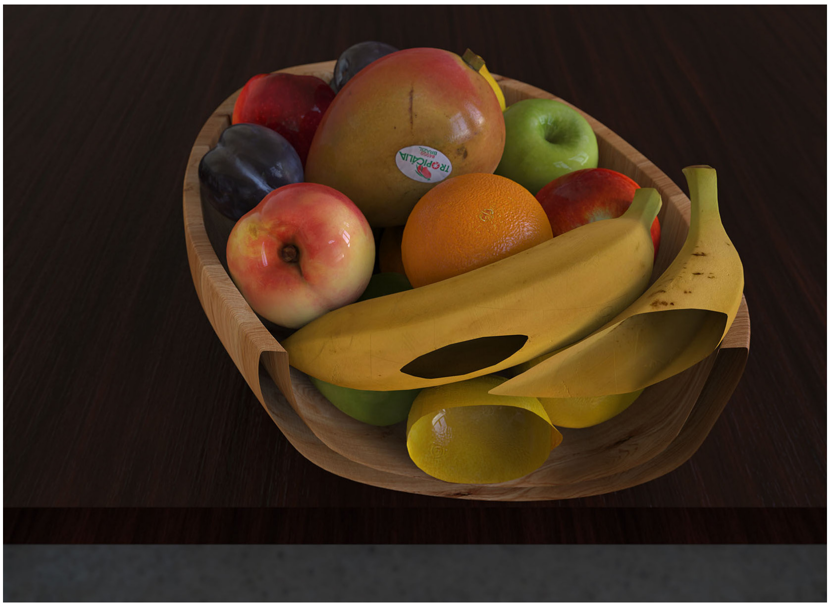


Fig.84 *Fruit*, 2018

Fruit and Hamburger can be compared with *Still Life Interventions* as they employ a similar approach to engage the viewer: they make a typical, familiar image into something alien and bizarre to elucidate their message. However, in terms of strategy implementation, *Still Life Interventions* places a digital object into a classical setting, where 'a digitally rendered intrusion can allow an observer to experience an existing background in new ways' (Young & Ayata, 2014). *Fruit and Hamburger* combines two distinct visual representations targeted at diverse audiences: a meticulously detailed, lifelike portrayal of food arranged on a table and a cross-sectional view commonly recognised by designers and architects. Blending these two images, a bizarre scene emerges that is neither aimed at designers nor non-designers. The other projects from this phase, *Cairn* and *Her*, can be considered products of this strategy. In the previous stage's comparison, I mentioned that I never distinguished between professional images (elevations, sections, and isometric views) and more general images (renderings) during this research. In this phase, I deliberately mixed the two, and this blend of professional and non-professional perspectives validates the project.

In his book *Reality modelled after images: architecture and aesthetics after the digital image*, Michael Young, one of the authors of *Still Life Interventions*, establishes a connection between Poché and labour by stating, '...the hollow cavity is where you hide the technological labour of the building' (Young, 2022, p.30). Although he does not discuss this point in the project mentioned, he is aware that concealing the Poché also means concealing the professional and technical work involved, whereas revealing it makes the efforts of designers and makers known to the public. During the second phase of my practice, after exposing this hidden space, which only belongs to designers and makers, the next stage was to seek creation methods based on its characteristics.

Practical Phase III: New Methods

The practice phase is the concluding stage in addressing the ultimate research question and identifying the creation methods. Hence, the examples I present at this phase hold greater practical importance than the preceding two categories; they are objects and architectures fabricated for human utilisation. I would not say these items were already manufactured using the methods I discovered in this thesis. If that were true, then this research would be rendered insignificant, as it would suggest that others had already implemented the techniques I discovered. The practitioners of these examples did not consider or develop their work from the perspective of this thesis, such as the dual nature of digital surfaces or the spatial relationships formed between designers and digital surfaces. However, comprehending the design process from these viewpoints implies that the techniques I have identified may apply to the design methodologies of others.

I would like to reference two works by the architect Greg Lynn. The first is the *Korean Presbyterian Church of New York*, which he designed; however, I do not wish to discuss the final built structure, but rather a diagram he used to describe the form-finding process of the structure [Fig.85]. The drawing illustrates how he used a software called Blob Modeler to construct a series of ellipsoids representing different functions. These ellipsoids can attract and merge by setting specific parameters until they form a complete, enclosed shape.

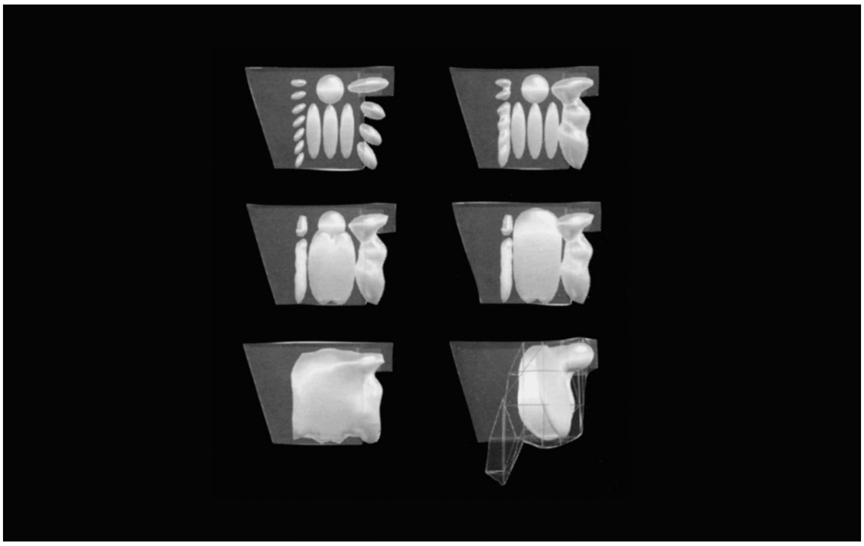


Fig.85 Greg Lynn, diagram of generations of the Blob form transformation, *Korean Presbyterian Church of New York*, 1999

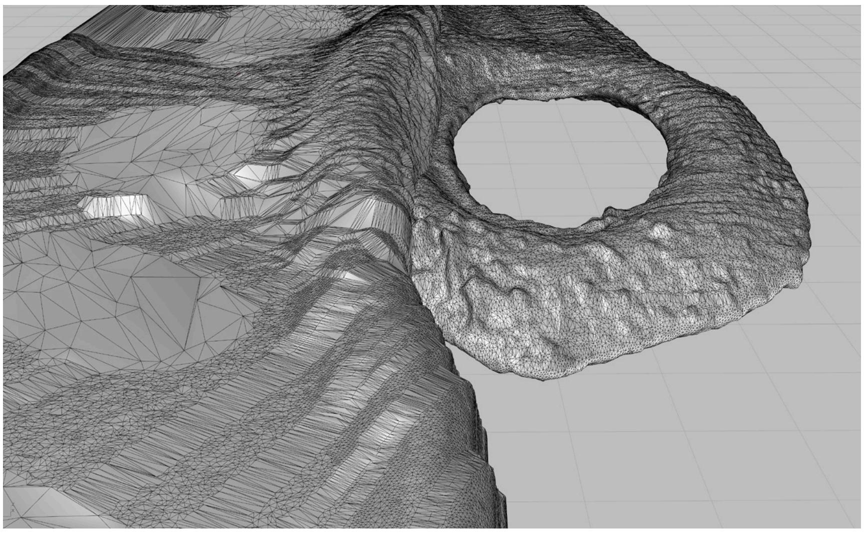


Fig.86 Expanding exterior of the model, the *Green Blades* project, 2021

In the critique of Eisenman by Evans that was mentioned earlier, Eisenman employed a sequence of images illustrating the act of extracting a smaller cube from within a larger one, as if it were being pulled from a malleable substance (Evans, 1997, pp. 137–138). Upon reflection, it becomes evident that Evans's critique is subject to historical constraints. These charts should not be seen as a defence or theoretical validation of a work. Instead, they should be viewed as an illustration of the interdependence between a tool and a design style. This is similar to the examples discussed by Evans himself, such as the relationship between the drawing method of the Developed Surface and the architectural style of the eighteenth century (Evans, 1997b, p.210). Architects such as Greg Lynn and Peter Eisenman view the architectural product as a static representation taken from a continuous and evolving process, akin to Eisenman's interpretation of Deleuze's concept of the Fold: 'Folding is a process, not a product' (Carpo, 2011, p.87).

My fascination with Greg Lynn's diagram stems from its representation, not merely a simulation of materiality. In the diagram, each ellipsoid represents a functional unit within the church. The merging of ellipsoids embodies the integration of different functions. This reflects what I witnessed while creating the *Green Blades* project [Fig.86], where a handle intended for human grip was stretched and extended to become a hole suitable for hanging. Previously, I discussed how the 3D scanner indiscriminately interprets everything as surface; here, conversely, surfaces form everything without distinction, and the transformation of surfaces enables all things to morph into one another. This is the idea behind my assertion that this research is about a cross-disciplinary method of production: a plastic dining knife can transform into an ancient coin, a transformation caused simply by the manipulation — pushing, pulling, extruding, and merging — of surfaces.

Another project I wish to discuss is also from Greg Lynn: his *Recycled Toy Furniture* series [Fig.87]. Lynn used a 3D scanner to capture the surface data of a collection of recycled plastic toys. In the software, these toys were interlocked and merged, with precise calculations and markings for the intersections and seams between adjacent toys. Following these data, the physical toys were cut and reassembled to create new pieces of furniture. Even though I did not employ a similar method in the method-finding phase, we can still interpret the design approach of this furniture series using some of the fundamental viewpoints mentioned in this thesis. This practice essentially applies the lossless intersection characteristic of digital surfaces to actual production. This design language is the same one I used in the *Portraits* project in the first phase, and the language of the small pavilion in the *Master of the Nets Garden*.

Fig.87 Greg Lynn, *Duck Table*, from *Recycled Toy Furniture* series, 2008

5.2 New knowledge

This research focuses on computer-aided design tools built around the logic of the surface today. Through many projects, it examines aspects of the 'digital casting' process, including recording (such as 3D scanning and 360-degree photography), reproduction (such as VR technology) and manufacturing (such as 3D printing). Simultaneously, an investigation into the 'prehistory' of these technologies was conducted to discover new creation methods.

The immediate response to my research question (**is there a new method, or a new set of methods, of making things with the tools of today that marks entities with surface constraints?**) is a particular set of methods. These specific methods are as follows:

1. By unfolding a closed digital surface with image texture attached, it is possible to obtain a pattern that can be stitched together to form a new, infinitely extensible space.
2. The operability and perceptibility of surfaces in tools can be transformed, referred to, and nested with one another. Instead of a single level of structure – texture correspondence, they can develop a complex, multi-layered relationship.
3. Besides visualising a Cartesian space, surface construction-based digital tools allow the morphing process to be combined with the final fabrication. This metamorphic process is also essential for realising imaginary and manufactured objects. If we pick a specific form from this animation process, it can become a means of production. That would imply that we could 'hybridise' many existing objects worldwide, so long as we understood all created objects as surfaces. Since the animation timeline is infinitely divisible, this also implies that we could theoretically create an infinite number of intermediate models between the two object types.

In addition, the ability to extrapolate these methods is based on two significant concepts that have proven effective through the progressive completion of many projects. These concepts are methods that inspired the following:

1. It is essential to identify digital surfaces' dual properties — operability and perceptibility — and to understand that the use of these two properties is not limited to simulating the real world. The boundary between the two properties is blurred, and as demonstrated in the *Her* project, the distinction between the two can create completely different forms. Moreover, as demonstrated in the *Sooner or Later* project, the two can be transformed into each other.
2. Always be aware of the relationship between oneself, the surface one is constructing and other people (e.g. users and viewers). The practitioner places themself and others on the same side of the surface to visualise a simulation object, which is the conventional method of employing representational tools. Today's tools provide a new perspective by placing a surface between the practitioner and the user. This new perspective, where the simulation object is not viewed as a construction to be built but as a penetrating, enclosing digital surface, is the premise of my series of projects and the practitioner's ability to analyse the surface's tool attributes.

These methods offer the most direct responses to my research questions, defining the primary beneficiaries of this thesis as those who utilise digital representation tools. I believe those who frequently employ these modelling and rendering tools, be they artists, designers, or architects, have likely encountered or manipulated the core subject discussed in this thesis — the void within the digital surface. The essence of this thesis lies in how we should deal with this cavity once we become aware of it.

When I initially described one of the goals of this research as exploring what Evans referred to as the digital version of the void between what architects aspire to create and what they ultimately construct, I was making a rough analogy. The transition from drawing to digital software tools alters the nature of constraints for creators. With drawings, constraints predominantly arise from conventional drawing notations, whereas software imposes limitations through an invisible author behind the software and its programming.

Today, any software user encounters the situation of the 'two levels of authorship' mentioned by Carpo in his discussion of parametric software and its users (Carpo, 2011, p.126). Before the final product is created, at least two authors are involved. One is the software itself (and its designers), which determines what can be created using the program. The other is the person using the software, who performs the specific delineation of the given task. As practitioners using such tools, we face the question: How do we engage with this hidden author?

This thesis advocates for a more conscious engagement with the tools we use rather than accepting them as default settings when conveying our ideas. I also disagree with the simplistic approach to criticism and praise (as typified by Latour and Pallasmaa). It is the responsibility of the tools' users to understand what they can do and what we can see through them. Therefore, when I set the goal of discovering a new method, I believed it was more important to discover a way of viewing the tools we have today than to find an actual method for using them. For this reason, I have two response levels for my research question. The three specific production methods are direct responses to the research question and, simultaneously, three examples. The dual characteristics of surface and the four spatial paradigms I propose are more in-depth methods for practitioners to discover ways to use digital tools. At the very least, I anticipate they will provide practitioners with a more cautious perspective on tool usage.

Providing examples serves to corroborate the methods. They demonstrate that designing and fabricating objects based on the dual nature of surfaces and the spatial relationship between the software operator and the surface is indeed feasible. Moreover, none of the three specific ways of making things is a subversive modification to manipulating the tools. Instead, they have amplified examinations and re-invocations of some specific processes within the tools and the application of the digital surface attributes to places outside the digital space. This path of exploring new design approaches by learning from the tools themselves can, therefore, serve as an inspiration to a broader range of designers and practitioners than just those who use digital tools.

We should approach the tools in our hands with caution while recognising the new possibilities they offer us. The fresh perspective of moving beyond the simulated surfaces of objects to viewing their interiors is unprecedented before the advent of digital modelling software. Nor has it ever been possible for a designer to land on the inside of a drawing from outside the drawing or from infinitely high above the floor plan. We have entered the very blueprints we sketched. Evans' (1997) critical theory of architectural drawing before the digital age remains a crucial anchor for this thesis. In his theory, 'losing control'(p.180) — not treating the drawing as the ultimate goal for the final built form, but merely as a prompt for creation or a conceptual model — serves to liberate from the constraints of pursuing visual 'likeness' (p.172) between sketches and constructed outcomes. Today, our tools inherently provide us with a perspective to avoid this 'likeness,' observing and shaping from within the simulated object. From this vantage point, design becomes a shaping process that is not solely concerned with simulating appearance.

The technological shift we have experienced has transformed spaces that could not possibly exist into experiences that are tangible to us. It has been over forty years since Lefebvre proposed the concept of the architect's 'own space' (1974, p. 361). Throughout the writing of this thesis, I have repeatedly pondered the meaning of this term, which could indeed be a favoured metaphor used by philosophers, a play of language. However, as my research progressed, I realised that our technology's present goal is to concretise these abstract, verbally expressed concepts into experiences we can engage with. From drawings on paper to a digital simulated cavity, we may be closer to the kind of 'concrete abstraction' Lefebvre mentioned (1974, p.27). Imagining and analysing such a space is my contribution to the evolution of such spatial concepts in our era. To fully describe this space, I have done what today's digital technology does: I have visualised it.

I visualised a series of spatial paradigms based on people's ever-changing image of the world as a hollow structure in terms of the history of human thought: from the Greek paradigm to the Plato, Heidegger and Sloterdijk paradigms. For the creator, choosing a different paradigm to work on can lead to different ways of manipulating the tool. The Plato paradigm implies a typical method of manufacturing and casting illusions—the person who makes/transforms the surface and the person who observes/experiences it are on the same side of the surface. The Heidegger paradigm is an enhanced version of the Plato one. The bubble theory proposed by Sloterdijk allows the cave's interior and exterior to be seen and occupied, so making an object under this paradigm shapes it from within the object. Unlike Lefebvre's discussion of power and politics in space, I hope that this series of models will be more informative for practitioners, advising them when to hide in Plato's cave to cast an optical illusion and when to disenchant themselves from the magic of visual simulation. However, when it comes to the actual design, all these paradigms are alternatives to be considered, and there is no best option. This thesis focuses on the Sloterdijk paradigm because it corresponds to the tools we have today and a new designer's perspective. It compensates for some of the shortcomings of earlier models.

My other endeavour in this research, which I hope will help the practitioners, is using the surface-defined-volume approach in digital software to analyse and interpret ancient examples from non-Western civilisations. These examples are not the direct ancestors of modern digital tools, like the illusionary Baroque ceiling painting illustrated in practice Phase II. Instead, they demonstrate another understanding of matter and surface that would be an error during a typical design process. For instance, the pavilion in a Suzhou garden passed through a wall. My search for a new creation method lies in such an 'error,' which is a particular understanding of materiality and an unusual pairing of the dual properties of surfaces. Consequently, these cases from non-Western cultures are extremely significant indications that we may be able to find new approaches for matching the tool attributes of surfaces beyond their traditional application.

The reason things can be viewed and interpreted this way is also due to the quality of the digital tool's homogenised and spatialised understanding of things. A plastic dinner knife can be transformed into a coin, a human head can be unfolded to become a silk scarf, and different parts of a building can gradually merge. Under this perspective, everything becomes the same thing. We have ushered in an era where creation no longer starts from the materiality or the field in which it works. This concept could potentially encourage broader collaboration among designers from various fields and give rise to a more contextually ambiguous, interdisciplinary creation method applicable across a broader range. In the *Green Blades* project, I attempted to hybridise a modern industrial product with an ancient artefact. However, this may just be a simple and preliminary exploration of the possibilities. I believe many more opportunities merit our exploration.

Beyond the aspects mentioned above that I hope will benefit practitioners, this research could also open new spaces for discussion among scholars engaged in studying the philosophy of technology. At the beginning of this thesis, I defined it as an intersection of three discussion stances: tool, space, and making things in an interdisciplinary field. After much consideration, I still chose to use the term 'tool' rather than alternatives like 'technology' or 'digital technology'. I needed a more fundamental word to describe the relationship between people and the objects they operate, a concept I learned from the philosopher Heidegger. When Heidegger uses objects like hammers to describe tools, 'he is more concerned with a general ontology than with a theory of tools or technology' (Harman, G, 2009, p.17). Similarly, with this thesis, I hope to respond to a generalised critique of emerging tools from a practitioner's perspective.

Criticisms and fears about tools often stem from their mystification. One of the things I believe this thesis can counter is some parts of the legacy left by Flusser. It can do so as he hoped for, that is, by 'envisioning' technology to decode it (Flusser, 1985, p.19). By acknowledging that every technology has its historical and intellectual origins, we can dispel the myth that portrays technology and technological imagery as incomprehensible.

Although decades have passed since Flusser's theories, his influence is still very far-reaching. For instance, philosopher Byung-Chul Han, in his recent work 'Non-things: Upheaval in the Lifeworld' (Han & Steuer, 2023), makes a rigorous distinction between 'things' and 'non-things.' He uses the term 'non-things' from Flusser's language: 'Non-things are currently entering our environment from all directions, and they are pushing away the things. These non-things are called information' (1993, as cited in Han & Steuer, 2023, p.1). The doubt that this thesis casts on such a view lies in the distinction between 'things' and 'non-things' in the strictest sense does not exist. At the very least, all those who use 3D modelling technology, be they designers, artists, or architects, understand that there is a vast transitional range between 'thing' and 'non-thing.' From concept to final product, from the weightless cavities on the screen to the tangible materials in real life, there is no clear demarcation between them. Instead, technology itself serves as a device that shuttles between the two. When practitioners create something using digital representational tools, their operation object always lies between 'thing' and 'non-thing'. As they gaze at the screen, they can always find in the analogue of the digital surface both the perceptual aspect of the 'thing' and the operational aspect of the 'non-thing'.

At the same time, I hope this study will also shed some light on many scientific practitioners who have questioned the insignificance or harm caused by using the surface as a substitute for a solid. I take a cautious approach to such criticism, and I believe it is time to take a close look at these visual approaches to determine what they are and the possibilities of use we have not exhausted. Information loss is inevitable in any field where the representational tool remains a simulation of the world rather than the world itself. Moreover, what we must do in response to this loss is perhaps not to adopt an utterly pessimistic outlook but to recognise the difference between the tool's world and the real world and draw inspiration from it.

5.3 The way forward

This research was merely the start of an investigation into the methods inspired by representational tools. The three approaches I eventually discovered were derived from the same concept: the manifestation of a pre-existing process embedded within the original tools. In this sense, they were a set of methods within the same mindset. Nevertheless, with today's tools, many additional processes or functions could be investigated, such as the sectioning of profiles and flipping surface normals, which were covered in this study but not used as the final development method. They are all avenues that could be investigated further.

At the same time, there were unexpected things in my path of exploration that are integral to future exploration. For example, I have noticed that the imaginings of morphing in design shaping, which Eisenman describes graphically, have been fully realised in today's tools. Before I practised on this point, I had been aware of this tool-induced change and understood it as one of the ways in which digital tools present the homogenised, spatialised visual character of things. However, when I completed the *Green Blades* project, I realised that this visual representation actually reflects a linguistic structure. Digital tools accurately reflect the linear characteristics of this structure. Language and metaphor are crucial tools for understanding the human world and should be able to compete in importance with mathematics and geometry. Due to the topic and length of this thesis, I have not conducted additional research on this topic. Nonetheless, I believe that the characteristics of language and imagination reflected by the tools are also worthy of study, complementing a study of tools based solely on geometric space.

In addition, one of this project's limitations was what I mentioned in the introduction: all my projects currently exist in museums or art galleries as visual artworks. It is advantageous to ensure a minimal reading of the forms of things without projecting them onto specific needs that must be met. The drawback, however, is that even though I have identified some existing cases that have been put into production and have interpreted and analysed them using the perspectives and methods of this thesis, these methods have not yet been truly applied in the design process of everyday objects. As a method of form-making, they are supposed to be universal and interdisciplinary. As a designer, I will determine if they can serve as a practical idea and source of inspiration for a commissioned design project in the future.

Bibliography

Alberti, L.B., Lessing J., Rosenwald Reference Collection (Library of Congress) DLC and Internet Archive (1955) *Ten books on architecture* [Online], Internet Archive, London: A. Tiranti. Available at http://archive.org/details/tenbooksonarchit00leon (Accessed 18 Aug. 2022).

Arènes, A., Latour, B. and Gaillardet, J. (2018) 'Giving depth to the surface: an exercise in the Gaia-graphy of critical zones', *The Anthropocene Review*, vol.5, no.2, pp.120 – 135. Available at doi:10.1177/2053019618782257.

Bataille, G. (1955) *Prehistoric painting: or the birth of art*. Skira.

Bechthold, M. (2003) 'On shells and blobs: structural surfaces in the digital age', *Harvard Design Magazine*, No. 19. Cambridge, MA: Harvard University Graduate School of Design, pp.168 – 175.

Benjamin, W. (2008) *The work of art in the age of its technological reproducibility, and other writings on media*, London: The Belknap Press of Harvard Univ. Press.

Blake, K. (2018) *On the origins of 'The March of Progress'* [Online], Washington University ProSPER. Available at https://sites.wustl.edu/prosper/on-the-origins-of-the-march-of-progress/.

Bottazzi, R. (2020) *Digital architecture beyond computers: fragments of a cultural history of computational design*, London: Bloomsbury Visual Arts.

Burry, M. (2011) 'Between surface and substance', *Architectural Design*, vol.73, p.8 – 19.

Calvino, I. (1993). *Six memos for the next millenium*. New York: Vintage Books.

Calvino, I. (1997). *Invisible cities*. London: Vintage Books.

Carpo, M. (2011) *The alphabet and the algorithm: Form, standards and authorship in times of Variable Media*, MIT Press.

Carpo, M. (2017) *The Second digital turn: Design beyond intelligence*, The MIT Press, p.96.

Carus, T.L. and Melville, R. (2008) *On the nature of the universe*, Oxford: Oxford University Press.

Deleuze, G., Guattari, F., Bensmaïa, R., Polan, D.B. and University of Minnesota Press (2016) *Kafka: toward a minor literature*, Minneapolis; London: University of Minnesota Press.

Evans, R. (1997) *Translations from drawing to building and other essays*, London: Architectural Association.

Evans, R. (2000) *The projective cast: architecture and its three geometries*, Editorial: Cambridge, MA.: Mit Press, Cop.

Flusser, V. (1985) *Into the universe of technical images*, Minneapolis: University of Minnesota Press.

Focillon, H. (1992) *The life forms in art*, Translated by G. Kubler, New York: Zone Books.

Frei, H. (2003) 'Masked matter and other diagrams', *Surface consciousness*, London: Wiley, p.43 – 49.

Gayford, M. (2016). *A bigger message : conversations with David Hockney.* London: Thames And Hudson, p.10.

Ghosh, S. (2001) 'Poché parisienne: the interior urbanity of nineteenth century Paris', *Oriental Occidental: Geography, Identity, Space, 89th ACSA Annual Meeting* [Online]. Available at https://www.acsa-arch.org/proceedings/Annual%20Meeting%20Proceedings/ACSA.AM.89/ACSA.AM.89.13.pdf.

Han, B.-C., & Steuer, D. (2023) *Non-things: Upheaval in the lifeworld*, Polity, p.1.

Harman, G. (2009) 'Technology, objects and things in Heidegger', *Cambridge Journal of Economics*, 34(1), 17–25, p.17. Available at doi:10.1093/cje/bep021.

Heidegger, M. (2002) *Heidegger: off the beaten track*, Translated by J. Young. and Translated by K. Haynes, Cambridge, UK; New York: Cambridge University Press.

Heidegger, M. and Hofstadter, A. (1975) *Poetry, language, thought translations and introduction*, New York: Harper & Row.

Iwamoto, L. (2009) *Digital fabrications: architectural and material techniques*, New York: Princeton Architectural Press.

Kant, I. and Meiklejohn, J.M.D. (2018) *The critique of pure reason*, Middletown, DE: Pantianos Classics.

Karlsson, U., Lundbäck, C., Norell, D., Rodhe, E., & Skeppe, V. (2020) 'A Live Interior: Environments, Assemblies, Materialities', *ATHENS JOURNAL OF ARCHITECTURE*, 6(3). Available at doi:10.30958/aja_v6i3.

Kolb, D.A. (1984) *Experiential learning: experience as the source of learning and development*, 2nd ed. Upper Saddle River, New Jersey: Pearson Education, Inc.

Kubler, G. (2008) *The shape of time: remarks on the history of things*, New Haven Conn.: Yale University Press.

Latour, B. (2009). Spheres and networks: Two ways to reinterpret globalization. *Harvard Design Magazine*, No. 30. Cambridge, MA: Harvard University Graduate School of Design, pp.141–142.

Lefebvre, H. (1974) *The production of space*, Oxford: Blackwell.

Lewis, P., Tsurumaki, M. and Lewis, D.J. (2016) *Manual of section*, New York: Princeton Architectural Press, Cop.

Li, W. (2022) 'The art promenade in Qingdao' [Online], www.sohu.com. Available at https://www.sohu.com/a/545106270_151792 (Accessed 26 Aug. 2022).

Loos, A. (1908) *Ornament and crime* [Online], depts.washington.edu. Available at http://depts.washington.edu/vienna/documents/Loos/Loos_Ornament.htm.

Marcos, C. (2011) 'New materiality: ideation, representation and digital fabrication', *eCAADe Conference*, vol.1, pp.351–360.

Massey, D.B. (2005) *For space*, London: Sage.

Mavignier (2015) *ZERO SPACES – Portrait of Ranulph Glanville* [Online]. Available at https://vimeo.com/131408983 (Accessed 16 Aug. 2022).

Merleau-Ponty, M. (1992) *Phenomenology of perception*, London: Routledge.

Merleau-Ponty, M. and Edie, J.M. (1964) *The primacy of perception, and other essays on phenomenological psychology, the philosophy of art, history and politics. Edited, with an introduction, by James M. Edie*, Evanston: Northwestern University Press.

Moe, K. (2008) 'Translations from (digital) drawing to building, *seeking the city', Seeking the City, 96th ACSA Annual Meeting* [Online]. Available at https://www.acsa-arch.org/proceedings/Annual%20Meeting%20Proceedings/ACSA.AM.96/ACSA.AM.96.63.pdf.

O'Donnell, C.O. (2017) 'Revisiting David Summers' real spaces: a neo-pragmatist interpretation', *World Art*, vol.8, no.1. Available at doi:10.1080/21500894.2017.1292947.

Ohanian, M. and Royoux, J. (2005) *Cosmograms*, New York: Lukas & Sternberg.

Pallasmaa, J. (1996) *The eyes of the skin*, Chichester: Wiley.

Picon, A. (2010a) 'Continuity, complexity, and emergence: what is the real for digital designers?', *Perspecta*, vol.42, pp.147–157.

Picon, A. (2010b) *Digital culture in architecture: an introduction for the design professions*. Basel: Birkhäuser.

Picon, A. (2011) 'Architecture and the virtual towards a new materiality?', *Praxis: Journal of Writing + Building*, vol.6, pp.107–111.

Plato, Sterling, R.W. and Scott, W.C. (1985) *The republic*, New York: Norton.

Schapiro, M. (1972) ‘On some problems in the semiotics of visual art: field and vehicle in image-signs’, *Simiolus: Netherlands Quarterly for the History of Art*, vol.6, no.1, p.9. Available at doi:10.2307/3780400.

Schön, D.A. (1983) *The reflective practitioner: how professionals think in action*, London: Temple Smith.

Serlio, S. (1611). *Five bookes of architecture: translated out of Italian into Dutch and out of Dutch into English* [online], Internet Archive, Robert Peake. Available at: http://archive.org/details/firstbookeofarch00serl/page/6 (Accessed 4 Jan. 2022).

Sloterdijk, P. (2011). *Spheres. Volume 1, Bubbles : microspherology*. South Pasadena, Ca: Semiotext(e).

Sontag, S. (1977) *On photography*, New York: Dell Pub. Co., ©, Printing.

Steyerl, H. (2011) ‘In free fall: a thought experiment on vertical perspective’, *E-Flux*, no.24 [Online]. Available at www.e-flux.com/journal/24/67860/in-free-fall-a-thought-experiment-on-vertical-perspective/.

Stroll, A. (1988) *Surfaces*, Minneapolis: University of Minnesota Press.

Summers, D. (2003) *Real spaces: world art history and the rise of western modernism*, London: Phaidon.

Wu, H. (2005) *The double screen: medium and representation in Chinese painting*, Chicago: The University of Chicago Press.

Wu, H., Wenyi Qian, Jiu, Y. and Beijing, I. (2018) *Space in Art History*, Shanghai: Shanghai People’s Fine Arts Publishing House

Young, M. (2022) *Reality modeled after images architecture and aesthetics after the Digital image*, Routledge, Taylor & Francis Group.

Young, M., & Ayata, K. (2014) ‘Still life interventions’, YOUNG & AYATA [Online], Available at https://www.young-ayata.com/ (Accessed 11 Aug. 2023).

Li Yu (2005) *Casual expressions of feeling of leisure*, Translated by Yong Shen, Shanghai: Shanghai Classical Literature Publishing House.