LIMES.
A DESIGN PLATFORM FOR URBAN RESPONSIVE BEHAVIOR

Dr Laura Ferrarello / Suramya Kedia
Royal College of Art

Keywords: boundary, data manipulation, interaction, voxel, behavior

Abstract

This paper describes the urban design platform Limes, which uses data interaction and data manipulation as design techniques to build systems of responsive infrastructure. The platform is a current research that the authors, tutor and student, are developing at the Royal College of Art. In this paper we illustrate early stage simulations that intend to show the possibilities the platform can offer on the topic of responsive cities via engaged citizens. By employing voxels as information placeholders, we describe a series of simulation models that, on the base of Transport for London data, interact and create response. The platform addresses the necessity to include local information in global networks and proposes methodologies that combine them together in a flexible and adaptive territory of informational exchange, which, for us, is urban space. We, indeed, use the resilient aspect of each territory as core information the voxel uses to interact with its neighbourhood. Nonetheless the platform is drawn upon the aspects of human creativity and interaction with technology to envision design opportunities for the urban environment. How can space react, facilitate and respond to the flux of information between humans and the environment? Through simulations this paper intends to design responsive spaces, in which interactions constitute the network of responsive cities.

1. Introduction

Contemporary daily life is a twofold combination of events that take place between the digital and the physical domain. Technological advancements, and the human interaction with it, shape people's time and space in the form of complex networks, which overlapping relationships constitute the connected age. To dwell our time equals to: "be connected", "create value" and "create experience". Interfaces support and facilitate such a system by intertwining the materiality of the physical real with the engaging experience created by digital content. It then follows that space (physical and digital) becomes a 4D experience of information; physical infrastructure (objects) wires digital information to reveal, unpack and perform human experience. Objects are informational gateways, which tag and link their aspect and/or functionality to digital information, humans produces value through the interaction with information. Nonetheless people's interests are the trigger that enables any transition of data; human creativity needs to drive any data exchange in order to produce content, hence value. The engagement of communities in creative processes of dynamic exchange of information is pivotal, as people's imagination fosters growth and innovation. The act of sharing information and editing feedbacks forms a creative cycle where technology becomes a service provided to society, and communities benefit of these processes.

In this light contemporary cities are dynamic systems of vectors, which shape modifies in real time between the physical and the digital space; the urban environment is indeed a complex territory made of agents, like services, people and materials, which constitute a system of input data. The mutual interaction of these agents shapes society, i.e. a network of human-not-human agents whose mutual collaboration generates textures like value, desires, ambitions, etc. Textures vary both in relation to the agents' proximity and the nature of the surrounding threshold, which ignite variations of existing conditions when agents interact with the neighbourhood.

People dwell in spaces that behave as interfaces of communication. Such spaces provide the stage and the context that make any kind of social interaction happen via interaction; hence the city can be described as a dynamic framework that performs social, political and economical events through infrastructure. It is a system of many neighbourhoods populated by agents, through which interaction transforms information into communication.
It then follows that contemporary urban everyday is an intertwined topography built around the exchange of information. Proximity and agents' behaviour activate phenomena, which enable changes of different impact. Can urban space adapt to such continuous flux of information? Can technology be a framework of social relations that, through interaction, facilitates creativity and innovation at the scale of the urban environment?

This paper describes a design platform, Limes, that enables responsive behaviour through the boundaries that inscribe each thematic territory. Boundary-to-boundary interaction exchanges information through osmotic like relationships, which are driven by a design-thinking attitude. Boundaries act as a membrane; the design-thinking approach helps with develop urban strategies out of territorial responses, obtained from boundary-to-boundary interactions. Responsiveness is indeed understood as design feedback; it drives urban transformation out of neighbourhoods' resilient assets, i.e. the peculiar features contained in any social environment. To manipulate boundaries, i.e. data migration for design operations, means to deal with an entropic behaviour where information finds a common and flexible territory to navigate. Proximity and voxels enable the platform (i.e. information placeholders). The manipulation of voxels makes the network respond in relation to the data (resilient information) collected from the environment. As data belong to people, our intention is to engage citizens in the construction of the urban environment via the flux of data they create, to adapt space to daily changes. The platform is at an early stage of experimentation, however we believe the methodology can support urban strategy design constructed upon a system that can change and adapt to the real time conditions developed from human-machine-human interaction.

2. Conceptual framework: culture, resiliency and osmotic processes.

Resiliency is a factor that in urban analysis proportionally distributes information – like mobility, health, etc. On the topic Kenneth Frampton wrote in 1983 the essay "Towards a Critical Regionalism". The essay argues against the universal and flattening strategy of global urban design, which makes each city of the world obey the same kinds of territorial and aesthetic rules. In the essay Frampton describes an alternative design route that includes, and embeds in it, the features of specific places: materials, construction techniques, habits, etc. According to Frampton, Critical Regionalism is a mediation process that helps deconstruct the overall spectrum of world culture [...] in the second place it has to achieve, through a synthetic contradiction, a manifest critique of universal civilization (Frampton, 1983, p. 20). Critical Regionalism is a platform of dialogue that engages diversity; it enables different cultures to meet within a shared territory. It opposes the logic of the tabula rasa, which, from a common ground, applies universal systems to any part of the world. Through a local/global culture there is the opportunity to grow a kind of society where macro and micro scales are in a direct and flexible relation, so that changes can perpetuate and adapt to different kinds of territories.

Hence the boundary of each territory plays a pivotal role: by borrowing Heidegger's words, Frampton defines the boundary as a meeting space; it is a place where diversities enter in contact (Heidegger, 1954 in Frampton). The presence of a boundary creates the possibility of establishing contact, i.e. to generate an event; nevertheless by being present the boundary causes resistance. The boundary is a spatial entity that encompasses at the same time the sense of being and not being. By embodying the opposites, the boundary allows information to trespass borders via osmotic processes. Indeed, like an osmotic transformation, the differential between the parts enables the flow of content. It is important to retain resistance to activate transformations over time. Resistance is the resilient character of the territory. The boundary transmigrates differential events, thus constituting communication. The boundary declares the state of any related territory and enables dialectic relationships among neighbourhoods via osmotic exchanges. There is no need of a particular state of being; proximity, i.e. the range of distances that separate territories, stimulates the osmotic process.

In this light, the human body is a kind of territory, whose system of senses makes it react to the environment. The human body has the same presence and "scale" of the urban environment; they are two different kinds of systems that react and respond to stimuli in a different way. Local behaviour, surrounding conditions and proximity diversify the exchange of information; proximity is nonetheless the activator of territories' interactions. Human senses, for instance, are the reactors that make us aware of the environment; light, dark, humidity, hot, cold, etc are all factors that we acknowledge as sensorial responses to the environment, which we call experience, i.e. a memorable event recorded in our brain (Frampton, 1983). The environment is not a mere set of information. It is an experiential milieu our body senses by reacting to it. A human being feels the presence/resistance of the environment via the boundary of the skin; it reacts to exterior conditions through osmotic relations which intensity varies in relation to proximity. The sense of space is a complex reaction our body creates when it gets in contact with environmental stimulations, which returns what we call a "sense of being". Such a sense is not a linear process, but a paradoxical set of events that, define a new different whole resulting from boundary interactions.

2.1. Territorial voxels of information

In contemporary urban strategies the understanding of data is a pivotal skill. Alphabet, the parent company of Google, recently founded the Sidewalks Lab, which is, to some extend, the Google of physical space. The Lab's aim is to connect people to the urban environment through a system that works like a digital search engine. For instance, by working with Uber, Sidewalks Lab is currently helping the city of Columbus Ohio create a feasible network for driverless cars (Harris, 2016) in order to understand the impact on urban design and mobility. Via artificial intelligences, which learn from patterns of data collected from people's behaviour, the system is intended to predict citizens' needs. With fast wireless technology, Sidewalks aims to connect the physical space to the digital, thus interweaving an infrastructure of data that interfaces with the technology Google has already in place, like Maps and Street View. It envisions a new kind of infrastructure, which behaves in relation to the data it registers from the physical environment.

However, Sidewalk is missing a qualitative analysis of the environment; quantitative analysis, based on patterns created by algorithms, is its main focus. Through Flow, the cloud software platform that enables its computing system to operate, Sidewalk Lab is envisioning a responsive infrastructure that operates before demand (quantity), on the base of artificial intelligence computations. Sidewalk thus conforms to the current vision of "smart city", which focuses on efficiency and control over information. Within it humans are integer values, and relationships are formed by predictions of data sets. Nonetheless, data are part of our everyday. They are collective information created by human-machine-human interaction, regulated by algorithms and displayed through interfaces. The value of data is still understudied. To recognize any value data can take to human life requires comparative studies that acknowledge the impact of qualitative effects in the everyday.

For this reason, data are valuable elements for design. If integrated in urban strategies, which aim is to predict behaviour resulted from human interaction with information and the environment, data can help with design territories of physical/digital information that understand the human dynamic relationships with the built environment. The challenge is using the complexity of the networked society as a system of territorial information, in which boundaries facilitate interactive urban design strategies. The intention is to establish a platform that interfaces territories, in which liminal resistance/reaction computes resilient information that senses and designs the environment via responsive behaviour. Osmotic responses between boundaries enable information to dynamically trespass territories. The platform produces an endless loop of interaction that returns feedback variables, result of responsive behaviour.

Data is a local set of information; it is geolocated. By using real geo-coordinates we consider a kind of physical information that escapes the logic of the abstract. We intend to take into account the diverse properties of the physical world; data is collected from local specific interactions that happen in a specific time. Data becomes a series of space/time dynamic events, as they frame a specific behaviour or gesture; hence space is no longer perceived as physical but as gestural (Bratton, 2009).

As spatial gestural events that facilitate the interactions of neighbouring systems via proximities boundaries create a dynamic and responsive sense of place. According to Varnelis we witness the development of a mobile sense of place, through the emergence of popular virtual worlds, the rise of the network as a socio-spatial model, and the growing use of mapping and tracking technologies" (Varnelis, in Bratton, 2009, p. 92). Each single territory, including buildings and human beings, shares such a condition to the extent that territories become behavioural fields which content is transmitted to the surrounding as voxel variable. Voxels are volumetric informational placeholders which inflections create an environmental response. What we understand as environment is nonetheless response, and reflection, of behaviour. A human being is an actor in such a system, whose body is another kind of territory. By exchanging information amongst them through proximity and a set of rules voxels create these volumetric informational gradients and patterns. As the process of exchange progresses to reach targets and gradients, the gradient itself gets modified. The process continues until the voxel system has achieved the desired informational distribution. The voxel methodology enables us to generate new forms by using information as distributed in the three dimensions. By inputting data from an urban environment, and specifying one or more target informational gradients and rules of voxel interaction, we can shape new forms at any scale of design.

3. Methodology: The boundary as a design territorial event

In the simulations the concept of the voxel helped with manage complexity of flows, relationships of matter and information in the urban landscape (Verebes, 2014). The voxel inner structure embodies the 'network' paradigm. Voxels are the diagrammatic representation of the territory. According to Verebes the voxel space is space being formed from informational forces where spatial and experiential effects can be recorded, analysed and mapped. (2014, p. 75).

We simulated complex behavioural responses and information flows using data from Transport for London (TFL) collected from London Datastore website. We customised VSpace, a voxel manipulation software designed by Alexandros Tsamis, to collect and order data sets that are assigned as information type to the voxel in the voxel space. The voxel relationships are lead by different mathematical equations, which we used in this paper for the purpose of illustrating how the platform works.

The mutual collaboration of three data sets - road length, number of bicyclists, and number of cars on the road - forms a single information system (one voxel) that embraces both humans and the built environment.
In the VSpace simulation, each data type is represented by a colour:

- TYPE A: road length Red (255,0,0);
- TYPE B: number of cyclists per year Green (0,255,0);
- TYPE C: number of cars per year Blue (0,0,255);

As a combination of three data sets, each voxel holds three types of information, which are recorded at the same time and location. In our modified version of VSpace, we specified the data we wanted the voxel space to be ordered with. In Figure 1, the voxel space is ordered by TYPE B.

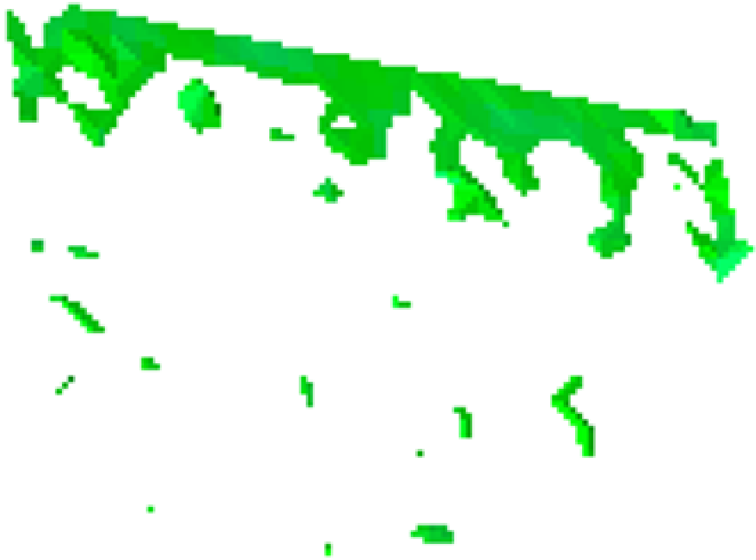


Figure 01. The graphic displays the result of posing a query.

The figure above renders the result given by querying the software for the boundaries that surround the voxels, which contain between 50% -100% concentration of information TYPE A. The figure is a visual representation of a statistic analysis; it does display how boundaries are spatially relational to the data by which the voxel space is ordered, hence in this example all boundaries are spatially relational to information TYPE B.

4. Results

I. Voxel behaviour and boundary querying without applying any reaction diffusion equations, and without applying manual transformations

The figures below show the boundaries generated after querying VSpace for different concentrations of A and B. The boundaries are physically relational to TYPE B.

By querying for the boundaries of A in relation to B, we have a spatial relationship of TYPE A (road length) and B (number of cyclists) before we manipulate information flows through boundaries.
When we query the voxels or simulate a reaction within the voxel space, the voxel space will react differently, resulting in very different forms. As the figures below show, when we query the program we are querying the voxel space to show us a specific form determined by the distribution of information we are querying.

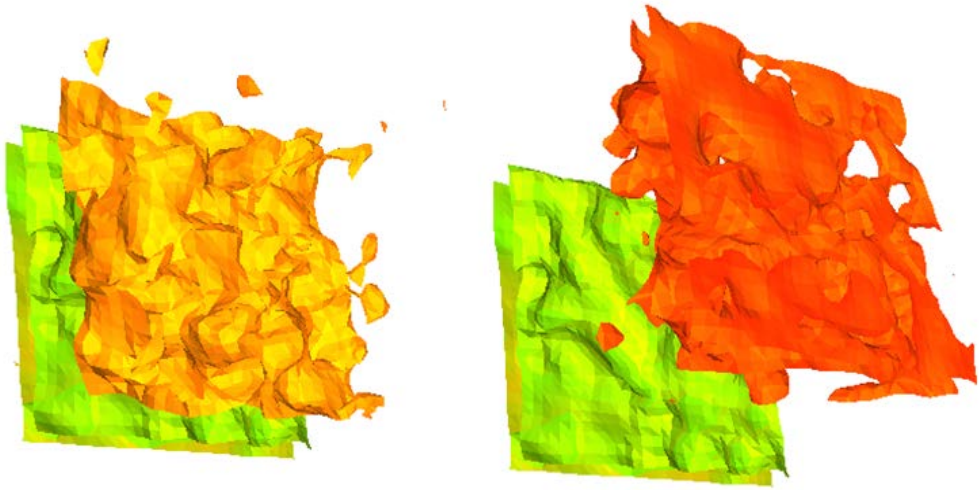


Figure 1. showing boundaries for voxels containing between 50-100% of information type A and B

Figure 2. showing boundaries for voxels containing between 50-100% of A and 25-100% of B

II. Voxel behaviour and boundary query after applying BZ reaction diffusion equations, and without applying any manual transformations

In this example we applied the BZ (Belousov–Zhabotinsky Reaction) reaction diffusion equation to test how an osmotic behaviour (as described previously described conceptually) might be applied to urban analysis. The BZ reaction diffusion is a family of oscillating chemical reactions in which the oxidation of reactants is catalyzed by metal ions in an acidic water solution (Ma, Wang, 2010). In a closed system, such as the one we use for this simulation, a BZ reaction can generate up to a thousand oscillating cycles, going from one state to another. In these examples, the states oscillate between a completely homogenous concentration of either A, B or C. What is most interesting, however, is how the elements A, B and C 'react' and diffuse through the voxel system over time, as this is fundamentally a representation of environmental information reacting and diffusing through a common complex system.

The system in which the information 'reacts' and diffuses through the boundaries is function of the equation entered in the software. Data behave in relation to it. By increasing the accuracy of the equation (related to the topic of investigation) we can achieve more precise spatial distribution of information. To shape an open platform for co-designing new forms we intend to use as input live and crowd-sourced data sets from the urban environment. Nonetheless for common clarity we need to interface visual and formal changes to the data sets contained in the voxels. These are the next steps of the project.

Figure 3. The images show successive changes to the boundaries (50%<A,B<100%) as we step through the BZ equation.

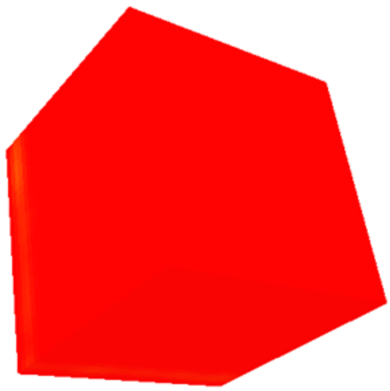


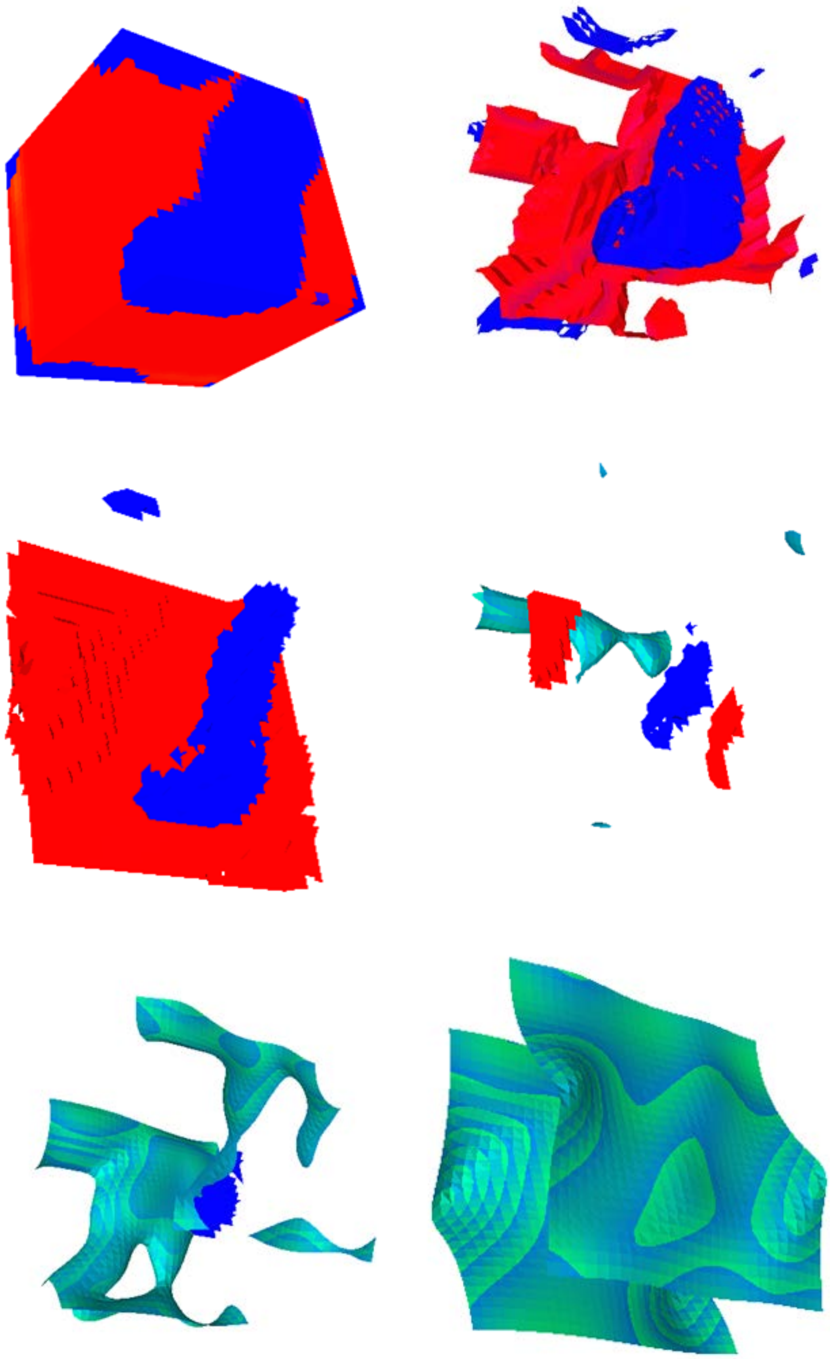
Figure 4. The images shows the first 'final state' of the BZ-equation, where the boundaries disappear, and all voxels contain only 100% A, 0% B and 0% C.

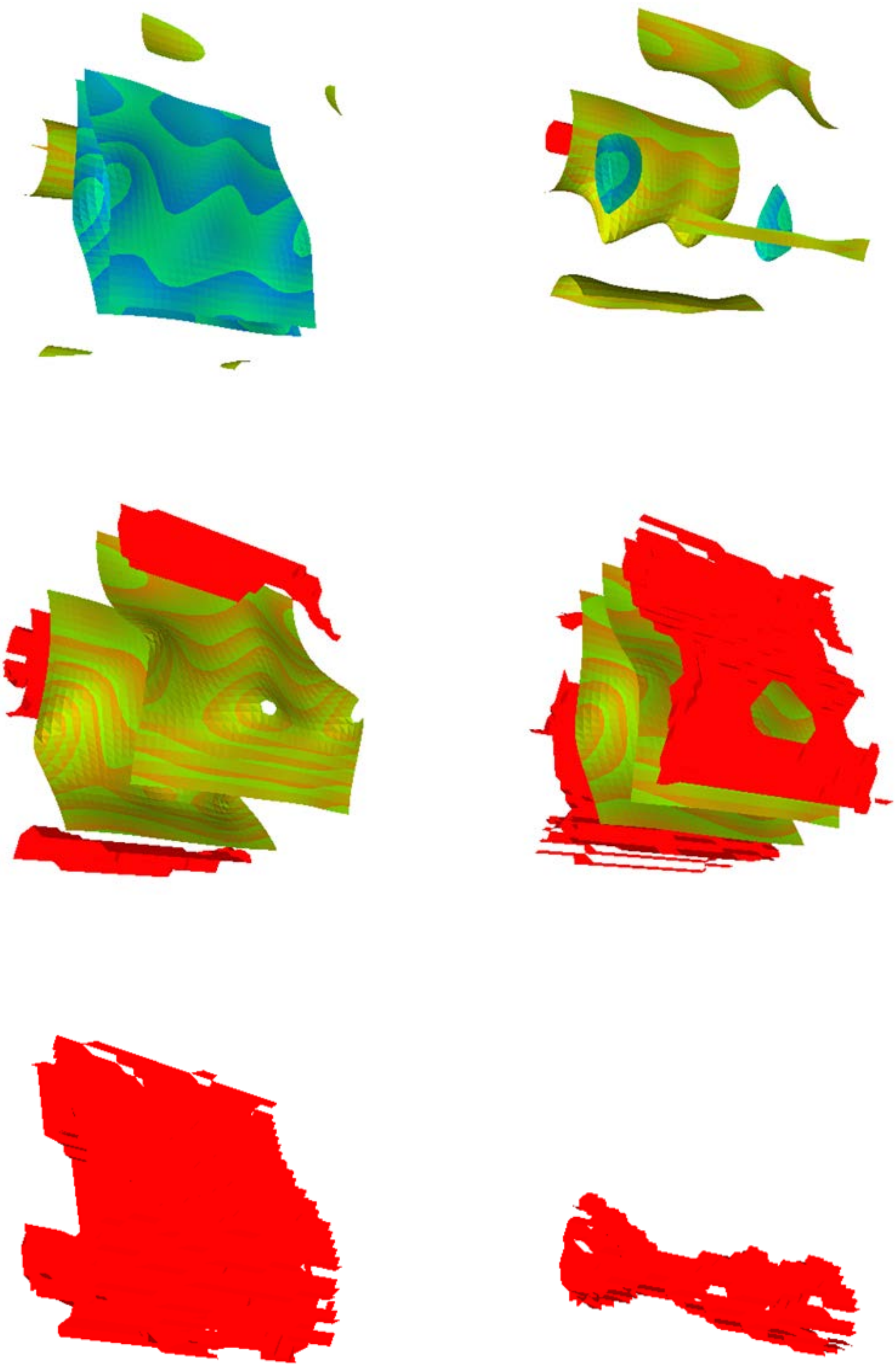
III. Voxel behaviour and boundary query after applying BZ reaction diffusion equations, and one manual transformation

The BZ equation can produce up to 1000 oscillations without introducing any further chemicals into the closed system; given enough steps, the system would begin to form boundaries of different concentrations once again.

In this simulation we focused on responses from environmental information and how we can manipulate it. We wanted to try a deliberate gestural 'painting' for the engagement of the human body; a VSpace 'paintbrush' allows us to select the colour, which means to select the proportions of A, B and C that we decide to apply. It is also possible to select the opacity, which allows us to define the impact the paint stroke will have on the voxel space, and the size of the paint-brush, i.e. the number of voxels that will be painted on the cube. Alternately we can intentionally introduce a specific value of information to a specific part of the voxel space, which means it is possible to "gesturally" manipulate the information of the environment.

The images below show the effect of one paint stroke (size 8, colour (0,0,255), opacity 8), and the subsequent steps of the BZ equation. The first image shows the voxels, and the following images show the boundaries.





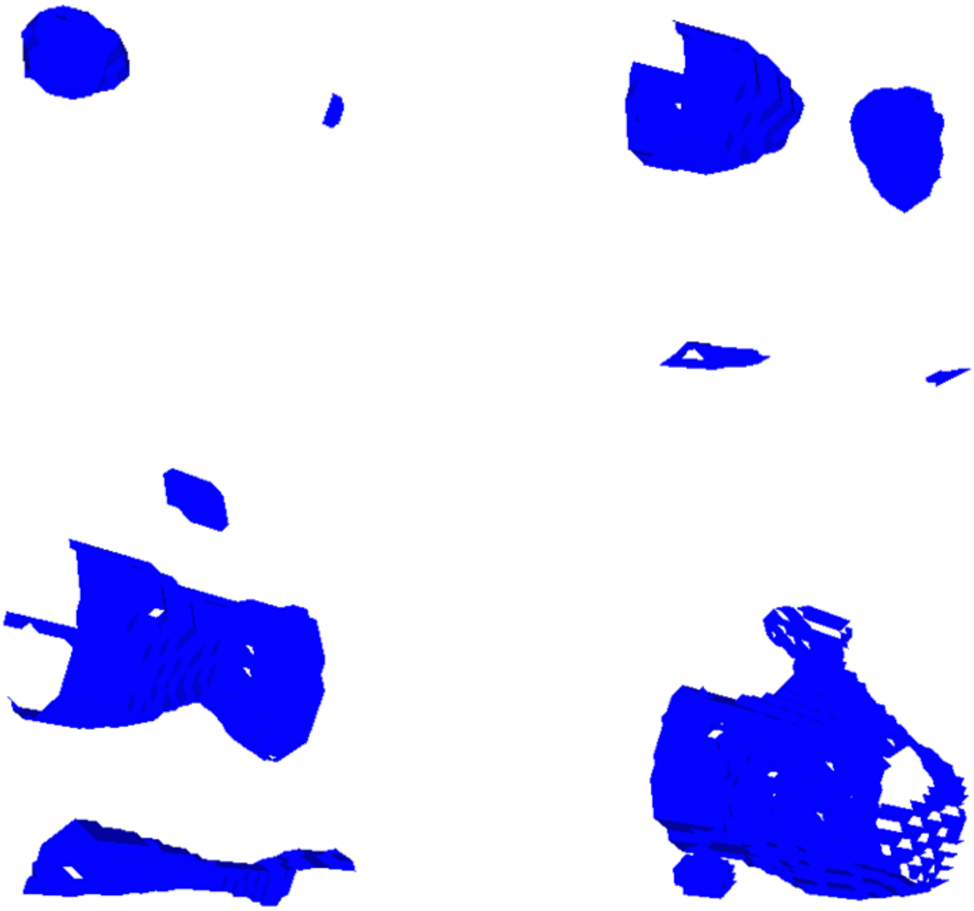


Figure 5. After homogenous state #2

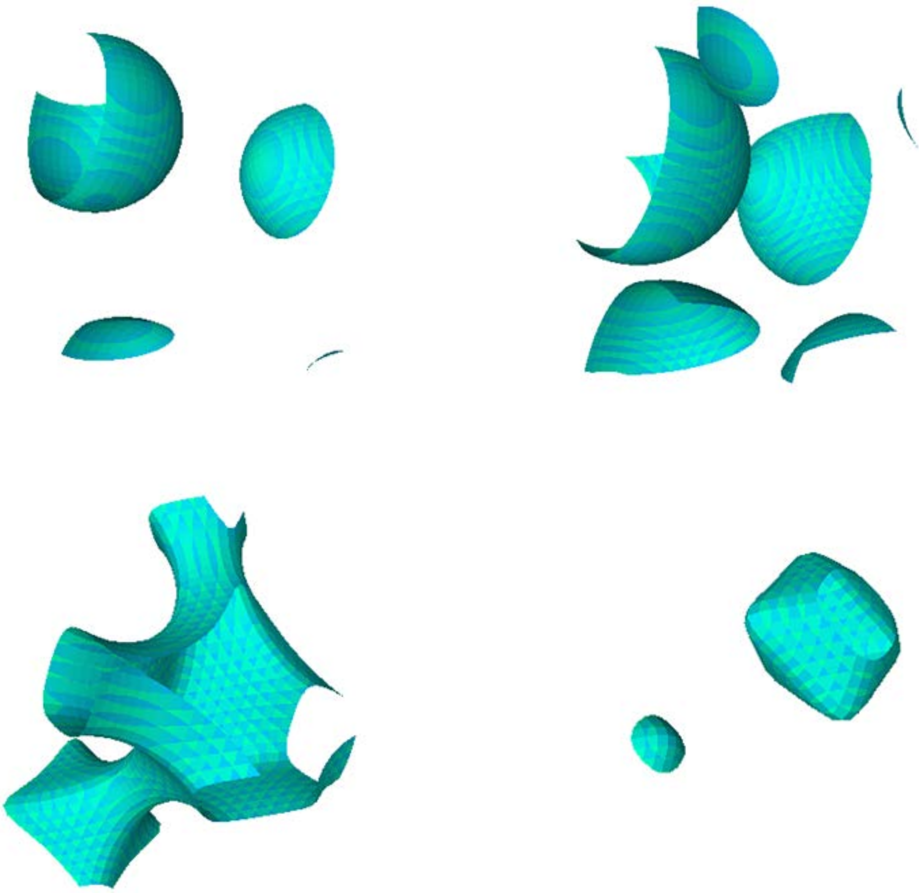
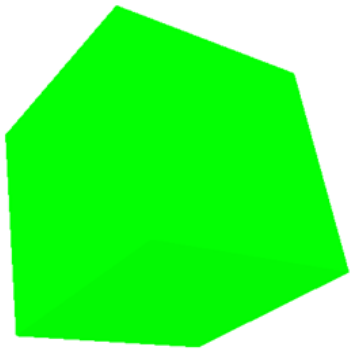


Figure 6. Homogenous State #3



IV. Voxel behaviour and boundary query after applying BZ reaction diffusion equations, and two manual transformations

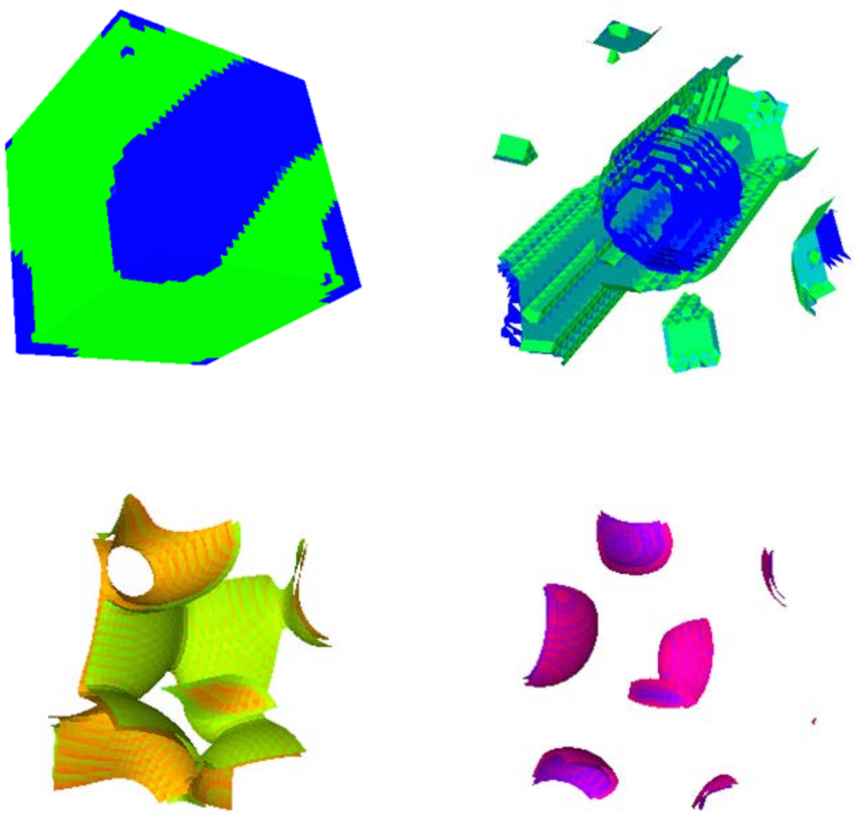


Figure 7. (0,0,255), opacity 8 and size 8 applied to the homogenous voxel space

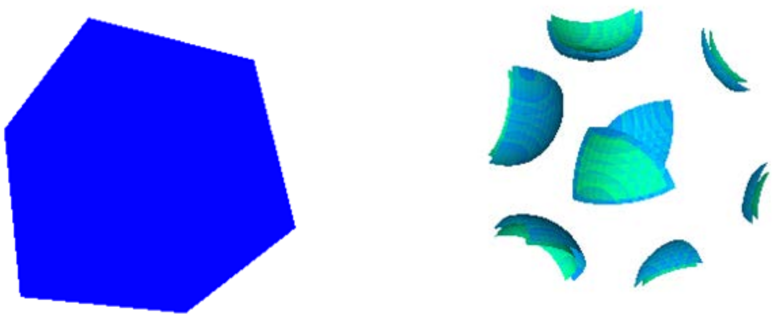


Figure 8. Homogenous State #4

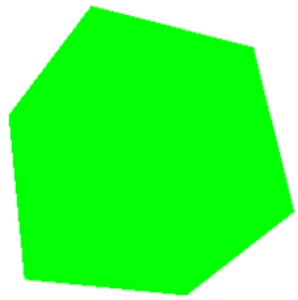


Figure 9. Homogenous State #5

This simulation shows how the length of the road and the use of cycles and cars can be extracted from an urban environment and fed into the voxel space to simulate how information is spatially related, and reacts and diffuses over boundaries via the representation of textures and forms.

6. Conclusion

In this paper we illustrated a design platform, Limes, which simulates responsive environments via the interactions of neighbourhoods. Our intention is to use responsive behaviour as design tool for urban strategies. Through voxel manipulation we ran a set of simulations, which employed the VSpace software. We displayed how data interaction can trigger responses via different methods that employ data from Transport for London. Nonetheless the equations that govern the interaction of data can be changed to obtain a much more specific result. Our goal, which has been illustrated via different kinds of simulations, is also to look at the value data produce in terms of resilient information that identifies different kinds of contexts. Limes is a platform that we hope defines a dynamic infrastructure that makes people drivers of urban innovation. By participating in the process of urban design, people create value through sharing data and working as a whole complex community.

References

- Bratton, B., 2009. iPhone City. In: Leach N., ed Digital Cities, AD volume 79, issue 4, London: Wiley Press, pp. 90-97.
- Frampton, K.,1983. Towards a Critical Regionalism: Six Points for an Architecture of Resistance. In: Foster, H., ed, Postmodern Culture. London: Pluto Press, pp.16-30.
- Harris, M., 2016. Secretive Alphabet Division Funded by Google Aims to Fix the Public Transit in US. In The Guardian [online]. Available at <https://www.theguardian.com/technology/2016/jun/27/google-flow-sidewalk-labs-columbus-ohio-parking-transit> [Accessed on July 2016]
- Ma, T., Wang, S., 2010, Phase Transitions for Belousov-Zhabotinsky Reactions, in Cornell University Library [online]. Available at <http://arxiv.org/abs/1008.1109v1> [Accessed on August 2016]

- Verebes, T., 2015. Towards a Distinctive Urbanism, in Verebes, T.. In: Verebes, T., ed Mass-Customised Cities, AD Vol 85, issue 06, London: Wiley Press
- Public Transport Accessibility Levels, 2016. London datastore, [online]. Available at < http://data.london.gov.uk/dataset/public-transport-accessibility-levels> [Accessed on July 2016]