Data Driven Urban Design

Justyna Karakiewicz
University of Melbourne, Australia
✉ justynak@unimelb.edu.au

ABSTRACT

Increasingly, interest in urban design challenges is being tied to research agendas in which data are generated of relevance to design intent. This paper addresses consequent opportunities for those engaged in urban design and discusses opportunities in parametric urban design to move beyond common engagement in description. The paper describes how parametric systems have been used to help students to bridge the gap from conceptual design to propositions and describes models used to develop diagrams of site potential. The paper illustrates the power of diagram in both mapping existing conditions as well as in projecting possible urban futures.

KEYWORDS: diagrams, parametric design, urban design, emergence, adaptive systems.

There is extensive discussion on diagramming or use of the diagram as a tool in the design processes in architecture. The introduction to architecture of ideas like Foucault's panopticism (2001), Deluze and Guattari's abstract machines (1987), or de Certeau's top down view (1984), greatly influenced the way architects address design processes. This paper will be predominantly concerned with role of diagram in urban design and the role diagrams may play in replacing traditional master planning and simple deterministic plans.

In the studio, when we are dealing with mapping of existing conditions in anticipation of a conceptual engagement of site potential, our main concern is in finding ways of illustrating emergent qualities of these maps. We believe that when data is spatially organized it can be held in dialogical tension that enables emergence to appear in these diagrams. It is this emergent quality of mapping that we seek to develop in our students work. Emergence here we understand as "production of innovative, unanticipated effects that cannot be explained in terms of properties of the constituent parts of the system" (Turnbull, 2003). Another way of approaching this is from the idea of two types of knowledge: "knowledge of", and "knowledge for". The "knowledge for" is all about how things are. It usually comes from research and data collection. In our diagrams will be looking how to represent the "knowledge for", or the potential.

Diagramming emergent knowledge is particularly difficult when it comes to cities. Castells (1996) believes that cities are open, complex, self organizing systems, unpredictable and uncontrollable and inherently unplannable. During our work with students (Karakiewicz, Schnabel 2007) , we have found a variety of problems arising when diagramming urban conditions as complex dynamic systems. Most urban projects tend to offer solutions through rigid scenarios in perfect conditions, conceptualized at a final outcome when the completed project works to an optimal potential without any further opportunity to change or adapt. By contrast, even a small project will influence surrounding sites over time (Degen, 2008; McKinnon, 2008); any attempt to optimize one element of the design will have consequent impact on the surrounding areas. Furthermore, those properties which derive from the project will have subsequent impact on other pre-existing elements. The characteristics and properties of the resultant system will be different to the sum of the parts. This is the first fundamental principle of *emergent property*: "'A system is a set of interrelated entities, of which no subset is not related to any other subset'. This means that a system as a whole displays properties which none of its parts or subsystems has" (Kramer & De Smit, 1977).

In much popular literature and common vocabulary, this is also known as "synergy", an overused and often misunderstood concept. The second fundamental principle is *subsystem interaction* and *systematic behavior*:

> *A systems approach is the application of synthetic (i.e. "integrative") thought to systems problems.*
> *This way of thinking is based on the observation that when each part of a system performs as well as possible, the system as a whole will seldom perform as well as possible.*
> *This follows from the fact that the sum of the functioning parts is seldom equal to the functioning of the whole. (Ackoff, 1974, 2010)*

When each part of the system is optimized, or each subsystem is designed to be as efficient as it can be, it is likely that the system will underperform. Such a *"reductionist" approach* in system design and planning can undermine the system's emergent properties. Master plans can be compared to representations of simple systems, were the chain of causes and effects between elements have a stopping point. In contrast to simple systems, complex systems have chains of causes and effects that do not have stopping points, using instead feedback loops at such points. These feedback loops are connected interactions of various sub-elements of the system. When these components interact, there may result a change in the behavior of one of the elements or the input from one element may generate a response or output in another element, and this will automatically leads to consequent changes in overall behaviors, since, in such a system, all the elements are interconnected and interdependent on each other. These feedbacks may be both positive and negative. The challenge in such a system is to test the level of feedback embedded to establish an open system, one that is in a constant process of self-correction and adaptation through changing elements or introducing new connections through self-learning, while avoiding the problematic outcomes of information overflow, noise and destabilization. The challenge for us, as designers, is to establish how these systems can be understood and communicated.

When it comes to mapping existing condition or coming up with proposals, we usually start with asking students to define system boundaries, system elements and relationships between the elements. We have explored rule-based programs to define relationships between different elements of the systems (Karakiewicz, 2007, Herr, 2007). We have sought to establish interdependency models that guide, not determine, the development and change of the urban systems. In this investigation we have directed students to ask the question: what strategy creates better answers – a dependence on planned system changes or anticipating new properties and behavior which can emerge from unpredicted interactions within the system and with external environments?

The Melbourne Experience 2009: University Station

In 2009 we ran a parametric urbanism studio at the University of Melbourne which dealt with proposal for the new metro line and station close to our university campus. The station has been proposed by government as part of a new 17 km metro tunnel to link the growing western suburbs to the city. At the edge of the CBD, the station is intended to link three separate communities: the university, the adjacent medical precinct, and the residential /commercial precinct. By focusing most narrowly on station functions, the opportunities for breaking barriers have been ignored.

In Melbourne residential, pedestrian, and built form densities are extremely low. Introduction of some extra densities to the site by way of residential, commercial or even recreational facilities maybe useful, but how do we make sure that intensification will be beneficial to the area and not only benefit the train station?

Higher densities and compact developments can promote casual, unstructured interactions, but they can also create barriers end exclude possibility of interactions with outside. Hillier (1989) believes that spatial organization plays a very important role on the way people move through the space and interact with each other, suggesting that spatial form can either promote or discourage interaction. How then do we create a form that can promote interaction, dismantle the barriers and create an urban system which can learn?

Students were asked to look at the stations through a system thinking framework and identify the system itself, its boundaries, the main elements of the system, and the rules which determine system survival. This exercise led to findings that some of the stations operate very much as closed isolated systems, having very little impact on the surrounding areas and, while removal of the station might cause some inconvenience, the larger area around the station will not be affected.

Complex adaptive systems exist by absorbing energy from external environments through the system boundary. This energy is used to maintain the system. The system also needs to get rid of energy that is no longer desired or have negative effect on sustainability of the system. Therefore the boundaries of the system need to be flexible and porous enough that this two-way process can be maintained. This process allows the system to adapt to changes and therefore to learn. Students were asked to identify the environment and the external links of the system that were most important to maintaining system life.

One student decided early on to increase the catchment area to redefine the boundary of the system. A quick exercise of the catchment area within a 5 minute walk illustrated that the catchment area diminishes from 502,654m^2 to 177,205m^2. Further analysis showed that existing land uses around the station determine a predominantly health precinct employees (over 15,000) and the sizeable student population (approximately 35,000) (Fig. 1).

This population is split geographically by a major road and the largest catchment population will also be absent for during non-teaching periods (up to 5 months of the year). The proposed catchment area also includes predominantly day-time

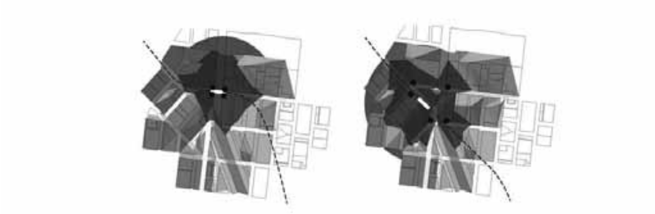

Fig.1 Station catchment analysis (Leanne Hodyl).

activities suggesting that the potential catchment population will not support the operation of train services into the evening. Some parametric testing led students to believe that proposed location for the new station may not be the best for its successful operation.

The Melbourne Experience 2010: Docklands

Melbourne Docklands are just to the west of central city grid. This new housing and office development has one the highest residential densities in Melbourne. Attached to the housing there is extensive an shopping centre, a sports complex and many other activities. The attractions of a water edge with a variety of restaurants and attractions have not, however, managed to connect this area to the existing urban structure. The Docklands remains separated and isolated, even though the distance from the CBD edge is less than 300 meters. Our studio in 2010 addressed this disconnection problem. Although students found variety of exciting ways to map and diagram existing conditions, such as through an analysis of sound landscapes, pedestrian densities or activity patterns (Fig. 2), when it came to proposals, most of the students found it necessary to build over the railways lines, or to provide multiple bridge connections over the rail to connect CBD and Docklands (Fig. 3). Nevertheless few students managed to come up with fascinating diagrams which dealt with small interventions which created far bigger impact than other mega-structure projects (Fig. 4; Table 1).

Conclusions

From these outcomes, it is clear that parametric tools have the capacity to support urban diagramming. Parametric systems revealed the diagrammatic nature of data and students acquired capacity to sketch through data and parametric relationships. Most importantly, students learned that parametric systems can be applied to diagramming, not only form making or BIM modeling.

After working with students for several years in the exploration of urban diagramming through parametric systems, we are still facing similar problems. Most of our students managed to demonstrate a capacity for abstraction and diagramming techniques using variety of tools, but a major stumbling block remains: the students' limited understanding of parametric potential and inability to define relationships that could guide their design beyond a literal mapping, in other words, seeing potential beyond that which they have been taught in their digital media classes. In our earlier studios, when we offered an elective digital media class in parallel with the studio which showed that driving skill acquisition through design purpose was effective. In this, students tested what they learned in the digital media class through their design, and the knowledge they gained was reinforced through studio experience. Also the possibility to test design ideas through pushing a conceptual underpinning of computational potential can go much further. Studios that included parametric modeling teaching as part of the studio were a little bit less affective. It became obvious to us that students need much more time just to learn skills; time designated to studio did not allow them to push their design as far as we wished this to happen.

Another problem that we have encountered over several years is the students' inability to distinguish between the diagram and its reinterpretation into design. Too often diagrams end up as proposed built form, a problem evident if the profusion of blob architecture as an outcome of parametric design. There is considerable learning to be accomplished in this field in order for us to see the diagrams for what they are or are not.

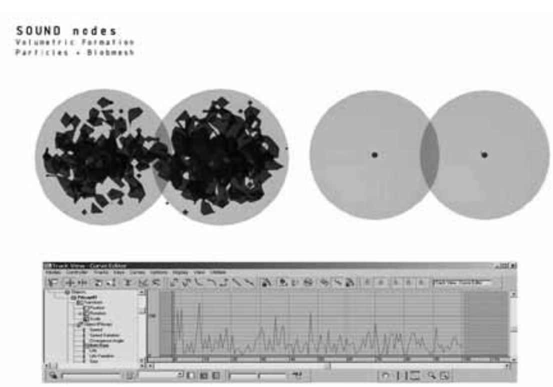

Fig. 2 Soundscapes (Chee)

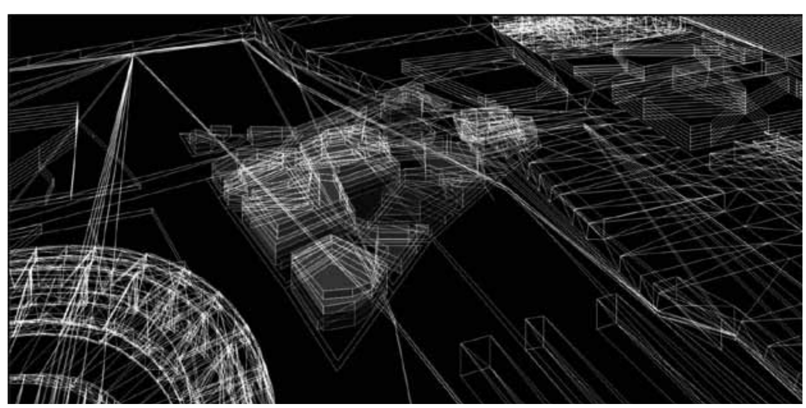

Fig. 3 Multi- connections (Xiao)

The power of the diagram is especially strong in urban design, even more than architecture. Urban design proposals could, and often should, stay in the diagram stage for considerably longer, instead of using them to illustrate over-deterministic and often over-designed propositions.

References

Ackoff, R. (1974). *Redesigning the Future: Systems Approach to Societal Problems*. New York: John Wiley & Sons.

_____(2010). *Systems Thinking for Curious Managers: With 40 New Management f-Laws*. Triarchy Press Ltd.

Castells, M. (1996). *The Rise of the Network Society* (The Information Age: Economy, Society and Culture, Volume 1). Malden, MA: Blackwell Publishers.

Certeau, de M. (1984). Walking in the City. In *The Practice of Everyday Life*. University of California Press.

Cuthbert, A. R. (2003). *Designing cities: critical readings in urban design*. Oxford: Blackwell.

Degen, M. (2008). *Sensing Cities: Regenerating Public Life in Barcelona and Manchester*. New York: Routledge.

Delanda, M. (1995). *Homes: Meshwork or Hierarchy?* Special: Home issue. Retrieved Dec. 4, 2004, from: http://www.mediamatic.net/article-200.5956.html

Deleuze, G. & Guattari, F. (1987). *A thousand Plateaus: Capitalism and Schizophrenia*. Minneapolis: U. of Minnesota Press.

Foucaut, M. (2001). *Order of Things: An Archeology of Human Sciences*. New York: Routledge Classics.

Hall, P. (2010). Diagram and their Future in Urban Design. In *The Diagrams of Architecture*. Chichester, UK: John Willey & Sons.

Herr, C. & Karakiewicz, J. (2007). Algogram: Automated Diagrams for Architectural Design Studio. *Computer-Aided Architecture Design Futures*, Springer.

Hillier, B. (1989). *The Social Logic of Space*. Cambridge: Cambridge University Press.

Karakiewicz, J. (2004). City as a Megastructure. In *Future Forms for Sustainable Cities* (pp. 137-151). Architectural Press,

_____(2005). Is Hong Kong transport sustainable? In *Sustainable Development and Planning II* (vol. 2, pp. 969-979). WIT Press.

_____& Schnabel, M. (2007). Rethinking Parameters in Urban Design. *International Journal of Architectural Computing* (IJAC), 5 (1), 84-98.

Kramer, N. & De Smit, J. (1977). *Systems Thinking: Concepts and Notions*. Leiden: Martinus Nijhoff.

McKinnon, M. (2008). *Urban Acupuncture*. Living Lab Publishers.

Turnbull, D. (2003). *Masons, Tricksters and Cartographers: Comparative Studies in Sociology of Scientific and Indigenous Knowledge*. London: Routledge.

Wootton, B. (2004). Cities as Complex Adaptive Systems. Retrieved November 13, 2009, from: http://www.generation5.org/content/2004/complexCities.asp.

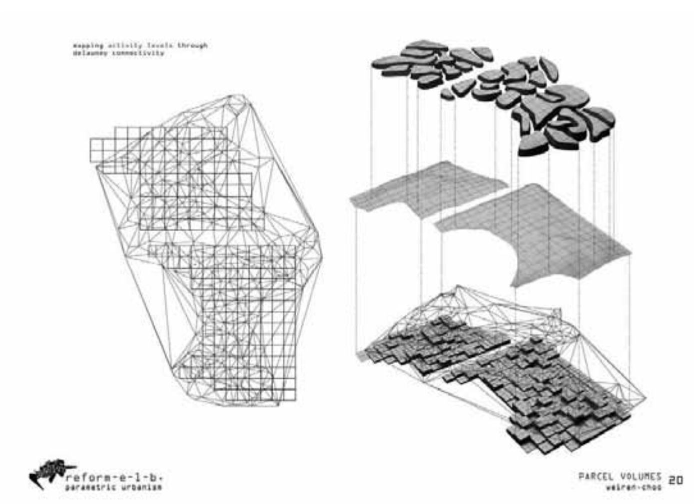

Fig. 4 Final Diagrams(WeiRen)