B. Dave, A. I. Li, N. Gu, H.-J. Park (eds.), *New Frontiers: Proceedings of the 15th International Conference on Computer-Aided Architectural Design Research in Asia CAADRIA 2010,* 327–336. ©2010, Association for Research in Computer-Aided Architectural Research in Asia (CAADRIA), Hong Kong

URBAN MICRO-INFORMATICS

A test case for high-resolution urban modelling through aggregating public information sources

A. BURKE, B. COOREY
University of Technology, Sydney, Sydney, Australia
Anthony.burke@uts.edu.au, Benjamin.coorey@student.uts.edu.au

D. HILL and J. MCDERMOTT
dan.hill@arup.com.au, Jason@jasonmcdermott.net

Abstract. Our contention is that the city is a rich collection of urban micro-ecologies in continuous formation that include information types outside the traditional boundaries of urban design, city planning, and architecture and their native data fields. This paper discusses working with non-standard urban data types of a highly granular nature, and the analytical possibilities and technical issues associated with their aggregation, through a post professional masters level research studio project run in 2008. Opportunities for novel urban analysis arising from this process are discussed in the context of typical urban planning and analysis systems and locative media practices. This research bought to light specific technical and conceptual issues arising from the combination of processes including sources of data, data collection methods, data formatting, aggregating and visualisation. The range and nature of publicly available information and its value in an urban analysis context is also explored, linking collective information sites such as *Pachube*, to local environmental analysis and sensor webs. These are discussed in this paper, toward determining the possibilities for novel understandings of the city from a user centric, real-time urban perspective.

Keywords. Urban; informatics; processing; ubicomp; visualisation.

1. Introduction

Our research tests the possibility of publicly available information sources and the resolution of this data towards novel forms of urban analysis. Our contention is that the city is continuously developing a rich field of disarticulated information types and sources that operate as an ecology of information outside the traditional boundaries of urban design, city planning, architecture and locative media practices and their native data fields. These new data resources include social networking sites, environmental systems and monitors, individual and institutional information sets of various kinds, RSS news feeds, and so on, and are understood as non-standard in urban terms. Working across a multitude of heterogeneous data types requires the development of novel methods of collection and visualisation appropriate to developing urban understanding. Equally it is our contention that by virtue of their heterogeneous and non-standard nature, these information sources promote new questions of urban environments.

1.1. CONTEXT OF URBAN INFORMATICS

The desire to understand and systematise the city for management, planning and analysis purposes was explored by Jay Forrester in the Urban Dynamics movement of the 1960's and underpins the development of contemporary urban information systems such as GIS, simulation and satellite mapping technologies. Laurini (2001, 1), underpins a typical formulation the city as a system, noting, "A city can be described as a general system with different interconnected subsystems." The development of complex geospatial databases has also enabled combined geospatial data platforms or Spatial Data Infrastructures to be established such as those developing under the EU INSPIRE directive and the US National Spatial Data Infrastructure (NSDI) protocol. Interestingly, the ecological metaphor has been used to describe urban situations (for example Jacobs, 1961) but only recently has it begun to be implemented as a means through which analysis and testing are possible (Batty, 2005). In contrast to Laurini, Watt describes a system in ecological terms as "An interlocking complex of processes characterised by many reciprocal cause and effect pathways." (Watt, 1966, 2) Watt notes "that a principal attribute of a system is that we can only understand it by viewing it as a whole." The ecological foundation to Watt's description offers a more complex and strictly non-lineal formulation of urban relationships in contrast to the computational hierarchy model of Laurini. For our purposes, the ecological model serves well to articulate a bottom up approach to urban issues, where the boundaries to causes and effects cannot be assumed and therefore cannot be systematised in a general systems model.

GIS and agent based simulations are common foundations to contemporary urban planning and urban design strategies. These rely on large database sets in the case of GIS, or specialised code based environments for agent simulation. GIS offers a layered overview of the urban realm, while agent based simulations attempt to capture the dynamic qualities of urban environments in action. Both of these approaches require the formulation of an abstract intellectual model of urban space based within the planning disciplines and employ disciplinary specific frameworks for identifying and incorporating appropriate data sources. A variation to this is the citizen reporting methods as discussed by Paulos (2008).

Urban informatics has begun to be tested in design practice also, typically in projects employing parametric systems and specialised disciplinary information for the creation of city information models (CIM). These models operate in the same mode as Laurini's, through structuring hierarchies of relationships in order to develop a balanced urban position according to the authors range of interests and information sources. CIM offers the possibility to test and refine urban models through versioning and analysis of a very high order, but suffer from a necessary abstraction in information translation and the need for complex hierarchical models.

Locative media strategies that tie location based information typically to a single user experience through personal media devices and their application within the city are also not new ideas to urban design, being discussed in media, art and architecture circles since at least 1996 (Townsend, 2008; Paulos, 2007; Foth, 2008; Mitchell 1996, 2004; Hill 2008). Location in this sense activates the availability of information to a single user.

1.2. THE RESEARCH

This research explores a distinctly different path to those forms of urban research described above, based on the premise of uncovering non-hierarchical cause and effect relationships at a very small scale. Through capturing a range of non-traditional information sources, the intention is to gather user centered, non-simulated information types through hybridising various formats. An example of the granularity and dynamic possibilities of this kind of urban mapping was captured by in the project *Cabspotting* by Stamen Design (2005) who used a high resolution GPS trackers to visualise the invisible dynamic of San Francisco through the movement of their yellow cab fleet. Another more recent example of this strategy is the New York Talk Exchange study conducted by the Sensible Cities Lab at MIT. Through looking at high resolution patterns of phone use in New York, a startlingly different picture of the urban and social fabric and its relationship to telecommunications was possible (Ratti, 2008).

This research seeks to build on these kinds of initiatives by establishing a broader cross-section of information types that range across physical, social, and material orders so as to provide novel urban analysis opportunities. *We feel fine* (http://www.wefeelfine.org/) is an example of an application that visualises written statements of emotion along with contextual information regarding the time of writing (temperature, rainfall patterns), becoming a barometer of the emotional state of people on the Internet. The immediate impact of cross-comparing disassociated sets of data to gain new insight into the 'lived' properties of places has been demonstrated (Harris and Kamvar, 2009); with one shared element in all examples being the presentation of locative feedback of the data collected.

Our critique of existing urban planning models is with the relatively narrow bandwidth of information sources and types used to develop urban analysis, in an age of massive information expansion. Responding to urban environments through urban based systemic models also presupposes the questions involved in urban understanding and decision making. In this research, no planning or computing model was 'strategised' as a whole, rather, our interest is in emergent understandings through developing combinations of publicly available information at the highest resolution possible. This research began with an open enquiry into the range and nature of public information broadly linked to the precinct of study. Other questions about information handling across information types, methods of information gathering and techniques for hybridising and visualising data to maintain an urban analytical focus are also raised.

This research specifically aimed to test the following questions:

- What alternative formal and informal information sources are publicly available for mapping the city?
- What is the quality of these sources and at what resolution is it possible to understand the city?
- What visualisation techniques and possibilities present themselves with new forms of information when they are aggregated?
- What does this mean for urban design?

The remainder of this paper discusses the design research studio created to explore these questions.

2. The street as platform project

The intensive studio comprised of instructors from planning, architecture, interaction design and media design and students of a post professional advanced architecture degree in 2008. The goal was to explore the limits of information fidelity of a very small urban area, a pedestrian bridge over a busy 5-lane inner city road at UTS in Sydney, and 'paint the fullest picture' possible for a public audience. Of particular interest was discovering what alternate sources of information of the city were available, and what issues were raised when transcoding many and various sets of information towards more complex informatic assemblies. The project required designing techniques for visualising real time data, and methods for evaluating information feeds that were found to be freely available and numerous. The data collection methods used included web-scraping algorithms, RRS feeds, purpose built and third party environmental sensor networks and online open data sharing communities services (Pachube, 2009). The sources of information included local urban planning statistics, Australian interest rates trends, new feeds, social media networks, published institutional and governmental timetables and highly specific local, regional and global environmental data. Issues such as methods for collection, sources and evaluation of data were raised in this urban informatic context, as was the role of visualisation and the interpretation of data as information (Whitelaw, 2008). The project was presented to an audience of approximately 1000 people as part of an exhibition event as a projected animation.

3. Data sources

Most data sources provided large amounts of highly granular dynamic data that required converting into information through several stages of processing. Collecting, parsing and formatting information from dynamic and static data sources such as RSS feeds, data logging websites or by decoding raw HTML code raised issues of update intervals, reliability and format. Once acquired, the data needs to be parsed and converted into a format that is suitable for visualisation, which may involve delimiting the data into CSV files or applying pattern-matching techniques to extract and format the data. Once formatted, the data needs to be filtered to extract the relevant information to understand the specific layer of the urban fabric and temporal correlation to other data sets. In this way the collection of data can be seen as an accumulation of individual sources, growing over time and not limited by top-down requirements that all variables be known at the start. In this process a view to an 'ecology of techniques' was developed over the development of specific tools.

A series of visualisations were developed around the specific urban environment, with the data being categorised by the particular temporal and geographic scale to which it related. Visualisations were constructed from local sensors detecting real-time activity, web data indicating suburb activity and global data including news feeds and financial movements.

3.1. STREET SENSING

The setup of a system to gain an understanding of the actual use and context of pedestrian movements over the footbridge allowed site-specific localised data to form part of the information ecology. A series of sensors were located on and around the footbridge, measuring ambient environmental changes in temperature, light, and humidity. These sensors logged to centralised data locations, available for use as live data in the information visualisations. The sensors were an experimental remote location setup, utilising a new prototype board which reported its' data wirelessly over a radio protocol (designed and produced by David Lowe of CRIN at UTS). These sensors were used to relay data from the bridge to a nearby receiver computer and aside from a relatively short battery lifespan, were robust and active throughout the full period of measurement.

To visually analyse the street a camera was placed within the DAB building, simultaneously observing both the roadway and footpath in a single image. This camera was programmed to save an image every minute. These images were saved to a local storage location, which was also available for image processing and analysis. These images were analysed to outline patterns of motion from the street, including human, plant and vehicular movements. These images were saved with date and time stamps, allowing the images to be considered and used in context with the other sets of data being collected. To measure ambient sound levels a microphone was installed facing the street. The analog microphone signal was translated into a digital audio signal and converted into an audible range by a simple audio mapping algorithm. These levels were collected as an average level each minute and logged with the other sensor data.

To observe and visualise the invisible aspect of on-street activity, a number of ambient radio frequency scanning techniques designed to detect and report on radio activity (such as WIFI, mobile activity or Bluetooth) were explored. Eventually a piece of dedicated Bluetooth scanning software was selected which was able to passively scan for visible Bluetooth devices, within a range of 10-20m. This software would also log the detected devices to a centralised location, for use in the visualisations of the street. This technique was later refined and used in a site-specific data visualisation project in Sydney, *Smart light fields.*

In addition to the street sensing techniques employed for the project which were understood to be only one part of the informational e-cology, remotely accessed data was incorporated into the live visualisations. Information sources were drawn from three different scales of relevance: local, regional and global. These scales required specific translation both in time period and data format, but also in terms of context, since traditionally isolated sets of data were being drawn in parallel to observe their overlap.

3.2. LOCAL SCALE

Local data was measured by the sensors, cameras and Bluetooth loggers discussed above. Wherever possible this data was published in real-time to online data sources (Pachube, Twitter), contributing to the community with our data feeds. The use of web cameras and Bluetooth loggers were most successful at this scale of detecting dynamic information such as human activity in the space. The collected visual logbook was analysed by custom software algorithms, which applied a threshold filter to each image, converting the base images to outlines based on the amount of light in each pixel. The silhouette of each image was then pieced together as an animated video of the street – as seen through the filtered process of abstraction (Gachadoat, 2008).

Manipulating the fade time and speed of playback allowed a vivid construction of the spatial dynamics under the bridge. Movement in the tree foliage provided an alternate description of local wind patterns (figure 1). Traffic and car movement was easily detected, and by focusing pixel analysis on the road area of the image, we could determine traffic patterns through light intensity variations on a 24-hour basis. It also allowed monitoring of student access patterns into the building.

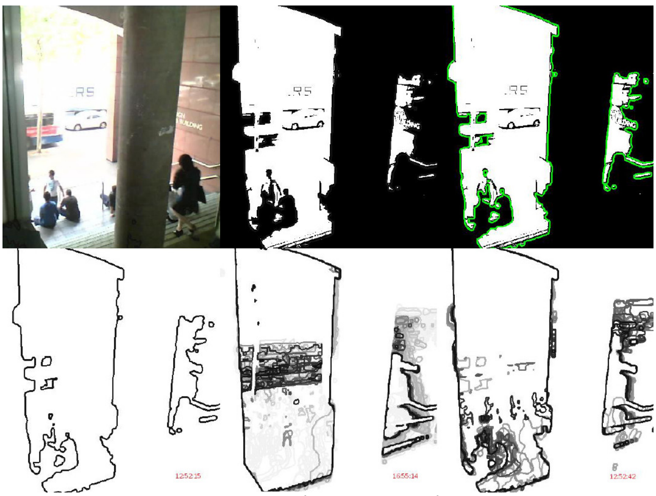

Figure 1. Web camera analysis.

3.3. REGIONAL DATA

Web-scrapping techniques were used to collect information at the regional level, with the easiest method to extract data being through readily available RSS feeds. The data comes preformatted and the text can quickly be read into Processing by loading the data as text and splitting it line by line directly from the webpage. The direct link to the website means that any updates will automatically be registered in the visualisations. Designing for this required an understanding of the type of data and ability to strategise for error checking. Understanding the format of the data allows the information to be organised as it is parsed, making it available more readily for visual analysis.

At a suburban level, it was possible to extract data from the local planning authority website in regards to development applications including lodge dates, status, address, descriptions and staff member responsible. Data was also available in regards to local weather, university class timetables and traffic flow. This information was not as readily available as the local sensors, being updated daily or weekly. Construction of an overall visualisation for the area required the extrapolation of values for this data or the display of a visual cue within the visualisation process when new data arrives. This technique was experimented with the suburb wind data, which updated every 15 minutes with scripted particles bursting on the screen and flowing across the visualisation in the direction of the wind each time new data was retrieved. The data was also represented historically through a feather like time graph indicating wind strength, direction, gust, humidity and temperature (figure 2).

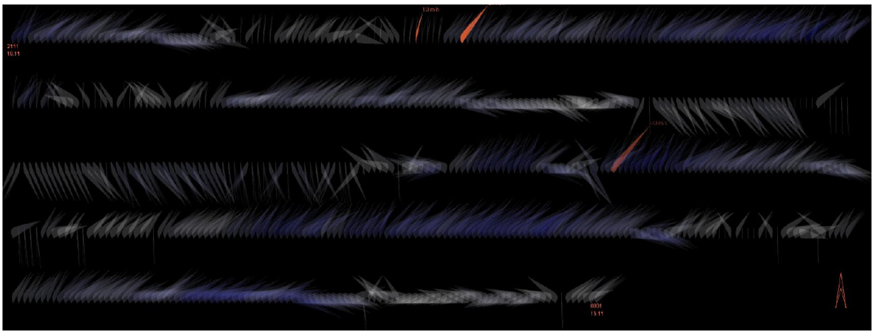

Figure 2. Historical wind graph.

3.4. GLOBAL DATA

At the global scale, there was an opportunity to extract news feeds and economic data into visualisations. Stock exchange data can be read simply as a line graph that fluctuates over time. The interesting applications occurred when we were able to parse through the financial fluctuations over time whilst correlating other data over the same time period. This was explored by connecting the financial variations over the last four years with development applications in Ultimo. We were able to map a complex relationship between the global economy, lodge and completion dates for building applications along with their approval status, down to the responsible planning officer performance records. Constructing a visualisation that provided useful data required innovative graphic techniques that allowed animation and user interaction to extract and display relevant information.

4. Conclusion

This project revealed several ways in which real time public data can be visualised, prompting us to explore two modes of visualisations; integrated data correlations (such as interest rates and housing approvals), and non-integrated or collaged information such as 15-minute wind-bursts that would pop up while viewing a different data source. In other cases such as interest rates and housing approvals being plotted simultaneously, the vastly different scales of information in combination with the depth of the local council information allowed us to speculate, down to the state of mind of a particular planner during a period became startling.

We also speculated on two immediate effects in planning and urban design as a result of this research. One is the untapped capacity of non-specialist and local participation in providing valuable and forceful local information without the need to employ expert systems. In this sense citizen agency is made highly potent in collecting and distributing data. The other impact on urban design is the overlapping of dynamic states of qualitative and quantitative data which reaches beyond traditional urban metrics, and interestingly opens speculations on possible new forms of urban indexes or metrics. We note our ability to correlate university class times with an out of synch bus schedule which may speak to "institutional fit" as a possible metric for future exploration, which is of immediate interest to local traffic planning and ambitions to foster 'campus life'.

By using publically accessible information streams from a variety of sources, it is possible to begin to visualise new forms of urban dynamics that would not be visible through traditional urban visualisation systems. Understanding the urban condition as a continuously developing rich field of disarticulated information types and sources that operate as an ecology of information offers the potentials for low cost high gain urban information of a unique type. Non-traditional urban information sources are capable of being used for urban analysis processes, if new methods for incorporating scrapping, RSS feeds, sensor webs etc in complex assemblages can be developed.

By approaching urban informatics not as an urban system but as a broad and emergent information ecology, and by virtue of their heterogeneous and non-standard nature, these information sources promote new questions of urban environments.

Acknowledgements

The authors would like to acknowledge Mitchell Whitelaw of CU, for his contributions to the studio and David Lowe at CRIN, the Center for Realtime Information Networks at UTS, Faculty of Engineering for his generosity and guidance with sensor equipment. We would also like to thank Bert Bongers of the UTS Interactivation lab for his generous use of the lab for both sensing and presenting the work.

References

Batty, M.: 2005, *Cities and complexity,* MIT Press, Cambridge, Mass.
Foth, M. (ed.): 2008, *Handbook of research on urban informatics: the practice and promise of the real-time city,* Information Science Reference, New York.
Gachadoat, J.: 2008, BlobDetection library, available from: V3ga.net http://v3ga.net/processing/BlobDetection/ (accessed 20 November 2008).
Greenfield, A.: 2006, *Everyware: the dawning age of ubiquitous computing,* New Riders Publishing, Berkeley.
Harris, J., Kamvar, S.: *We feel fine: an almanac of human emotion,* Scribner, New York.
Hill, D., 2008: The street as platform, available from cityofsound.com, < http://www.cityofsound.com/blog/2008/02/the-street-as-p.html> (accessed 11 February).
Jacobs, J.: 1961, *The death and life of great American cities,* Random House, New York
Laurini, R.: 2001, *Information systems for urban planning: a hypermedia co-operative approach,* Taylor & Francis, London.
Mitchell, W.: 1996, *The city of bits: space, place and the infobahn,* MIT Press, Cambridge, Mass.
Mitchell, W.: 2004, *Me++: the cyborg-self and the networked city,* MIT Press, Cambridge, Mass.
Pachube: 2009, Pachube:: connecting environments, patching the planet, available from: Pachube.com <http://www.pachube.com>.
Paulos, E., Honicky, R. J. and Hooker, R.: Citizen science: enabling participatory urbanism, in M. Foth (ed.): 2008, *Handbook of research on urban informatics: the practice and promise of the real-time city,* Information Science Reference, New York: 441–436.
Ratti, C.: 2008, *New York Talk Exchange,* Sensible Cities Lab, Cambridge, Mass.
Stamen Design: 2005, *Cabspotting,* project sponsored by the Exploratorium San Francisco, http://cabspotting.org/ (last accessed 14 November 2009).
Townsend, A.: 2009 Preface, in M. Foth (ed.): 2008, *Handbook of research on urban informatics: the practice and promise of the real-time city,* Information Science Reference, New York, xxviii.
Watt, K.: 1966, *Systems analysis in ecology,* K. E. F. Watt (ed.), Academic Press, New York.
Whitelaw, M.: 2008, Art against information: case studies in data practice, *Fibreculture* **11** (Jan. 2008).