A Mobile Sensing Kit for Urban Analysis

For more legible, quantifiable intangible and temporary data

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This paper describes the design and testing of a mobile sensing kit for real-time urban site analysis. It aims to contribute to a discussion on the importance of sensing-based mapping of urban phenomena following our assertion that current delivery of urban analysis methodologies, with their emphasis on visuo-spatial analysis only, fail to create maps that reflect the nuanced and layered interrelationships between the people and the physical environmental space they live in. In essence, the paper will bring to light the set up components and deployment of a mobile sensing kit that allows for usually mapped static invisible data (air quality, temperature, humidity) to be mapped as visible data. In other words, we want to explore how real-time geo-referenced data collection can enhance traditional data mapping and visualization methods enabling designers to understand better the urban space.

Keywords: *Environmental data collection, mobile sensing, intangible data collection and visualization, city modeling, site surveying with open hardware, DIY electronics*

INTRODUCTION AND BACKGROUND

This paper highlights the marginalisation of intangible and temporary data in conventional urban analysis. Even though extensive and extremely valuable research has been put into sensory analysis in the urban space (Degen, Monica Montserrat and Rose, Gillian 2012) these analogue mapping approaches lack in visual and dynamic visualization of their findings. This paper also addresses the limited GIS techniques in spatial design that tend to be weighted heavily toward visual, surface-based data (land use, pedestrian flows, slope analysis, exposure, viewshed, etc.). Within this domain, our goal is to transform aspects of the intangible world into a form that is legible and quantifiable. This paper aims at setting out a sensorial base analysis framework that allows for the use of electronics and sensory nodes (temperature, light, air quality, bio-feedback data) that can allow for an informed design that is able to provide design responses that have relationship to sensor parameters. A long-term aim is an increased critical understanding of local spatial characteristics and design implications for students of urban planning and architecture.

We propose that a design framework based on sensory information can enhance traditional walk-

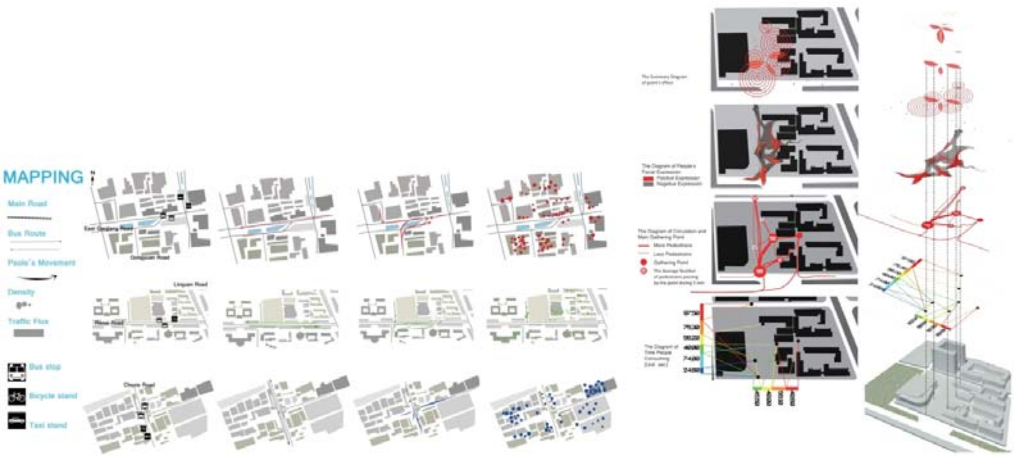


Figure 1
Examples of traditional site analysis visualizations on flow (of people, buses, cars, bicycles).

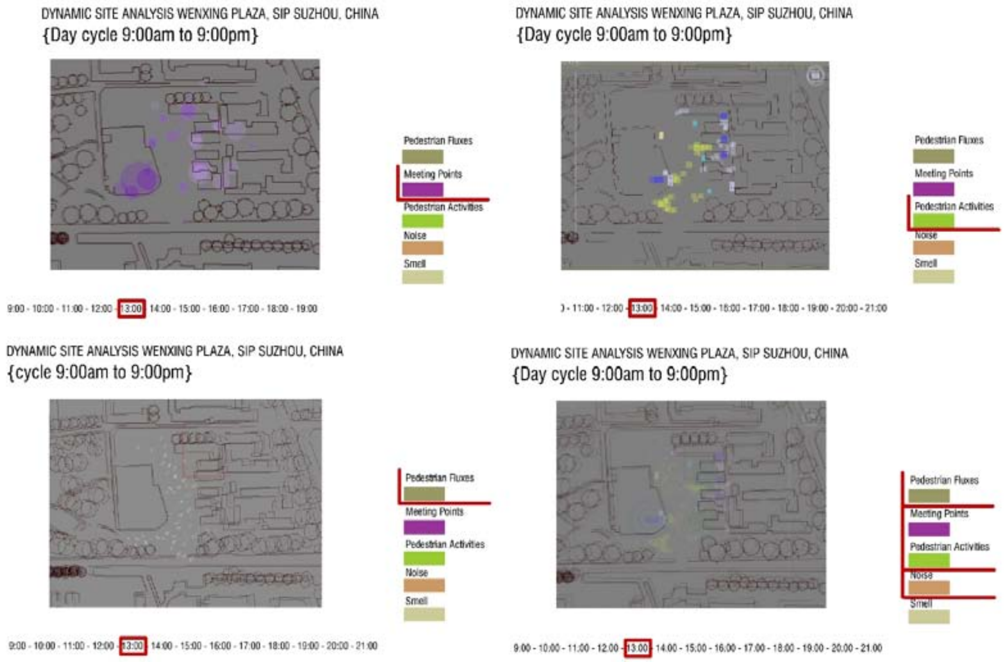


Figure 2
The Snapshots of animated visualizations display time-dependent information with emphasis on sensorial and proxemics experiences.

along and surveys methods (Degen at al 2012) and GIS data vizualization methods and increase our visual understanding of urban interrelationships. Hence, in our research we place primarily a deliberate emphasis on the invention of novel methods for understanding the site through sensing-based data collection. This emphasis on data collection, interpretation, and manipulation is a direct reaction to the perceived risk posed by a "limited" understanding of a place or a context, in which designers react predominantly to existing physical features and culturally based design goals. The common issue in spatial design potentially fails to acknowledge specific site conditions that would remain undetected by our senses alone and therefore new supporting tools are needed to capture and represent the undetected data. The conceptual depth of the conventional 'site visit' in architecture and urban design is called into question. Alternative methods for site recognition form the context of this exercise, including "time-based" mapping paradigms using animation techniques to visualize data (Diniz et al 2012) and "emotional mapping" by measuring the sweat on the palm hands of users exploring the space resulting in a series of bio-maps (Nold 2009) demonstrate how different ways of mapping space by leveraging perceptual and other sensorial understanding, leads to the formation of variables (or parameters) which at the same time turn themselves as catalysts for other variables. The potential for a constantly evolving reinterpretation of the perceptual experience and for associated paradigm to shift suggest a multiplicity of design possibilities for urban areas that also need to adapt to the new requirements of contemporary living.

PREVIOUS EXPERIMENTS USING TIME-BASED URBAN MAPPING VISUALIZATION

This paper build on previous research (Diniz et al 2012) supporting the idea of mapping urban space experience in real-time incorporating people's fluxes, activities, smells and densities in space. We did an exercise using animation techniques in an attempt to provide practical tools and techniques to communicate temporal sensorial information to assist in the analysis and design of urban sites. From our study, we used three simple techniques: animation, traditional site analysis drawings and parallel small multiples or layered visualizations. Animation was used as an easy-to-implement and intuitive way to communication time-dependent data. In more traditional visualizations, they rely heavily on the use of arrows, colour contrasts, and simple shapes as visual highlights (Fig. 1). On the right, the maps make use of layering of information to highlight relationships. With this kind of mapping is difficult to incorporate animation into them, especially as a post design feature. In contrast, Fig. 2 was conceptualized with animation being an integral part. Simple polygons describing the urban morphology were used in the background to deemphasize the information (so as to highlight the other, foreground information). Finally, parallel small multiples differed from layered visualizations, with each one having varied benefits. Given access to both during the analytical process can bring forth their complementary benefits.

EXPERIMENTAL SET UP FOR A MOBILE URBAN SENSING PROTOTYPE

Drawing on a previous sensor kit named "Ambient Sensor Kit (ASKit)" by (Melsom, J.; Fraguada, L.; Facklam, F.; Pecegueiro Curado, F. (2011) and 'Citizen Sensor'; [1] as precedents to our project, the project develops a sensor pack and data contextualization system that allows users to collect readings of real time data from their immediate surroundings using sensors by recording the environmental conditions (air quality, temperature, light, and heart-rate). The main components of the hardware prototype implementation are an Arduino-based controller board, sensors (air quality sensors, light, noise, temperature and heart-rate) and a smart phone as an interface (Fig 3). The project has also developed an online interface that maps people's routes within the environs they live; recording the data in real-time (Fig 4).

We use an Arduino mega board, as this version

Figure 3
The mobile sensit kit components on the left, the smart phone interface and screenshots of the prototypes being developed and tested by users.

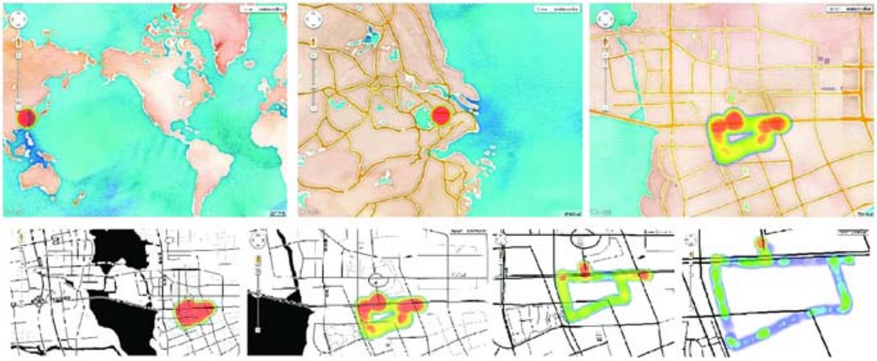


Figure 4
Screen shots of the geo-referenced online visualization platform.

has enough analogue and digital ports for the many sensors to work together. Analogue signal from the sensors is received via the IO port , and our program runs on the Arduino control board to translate and sample them into digital information. The power management and other additional services are provided by our program.

Next we will detail the smart phone application and online mapping platforms in all its components as illustrated in (Figs 5 and 6)

A Service is an application component representing either an application's objective to perform a longer-running operation while not interacting with the user or to supply functionality for other applications to use. An activity is a single, focused thing that the user can do. Almost all activities interact with the user, so the Activity class takes care of creating a window for you. A Fragment is a piece of an application's user interface or behavior that can be placed in an Activity, as we see in the various menus and interactive steps in the smartphone interface application (Fig 3). We have 3 services in our application: Bluetooth, GPS and Cloud services. The Bluetooth Service, it receives data from Bluetooth and unpacks it, and trims it, so we get data correspond to the different sensors. In order to spreads the data to all other components. The Bluetooth service packs the data into a broadcast message. All other components have its Broad-

Figure 5
Diagram of the sensing kit prototype components.

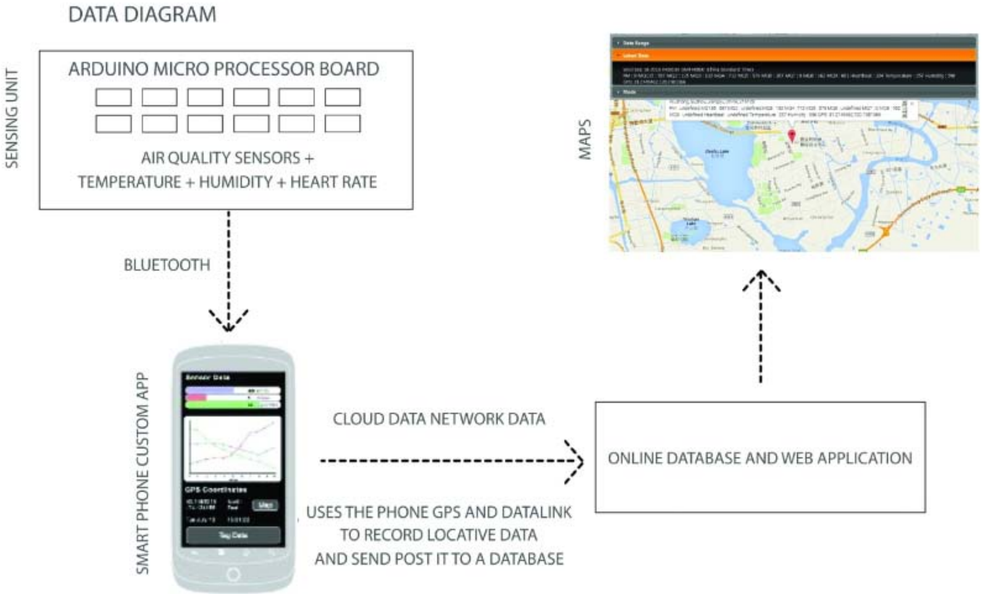
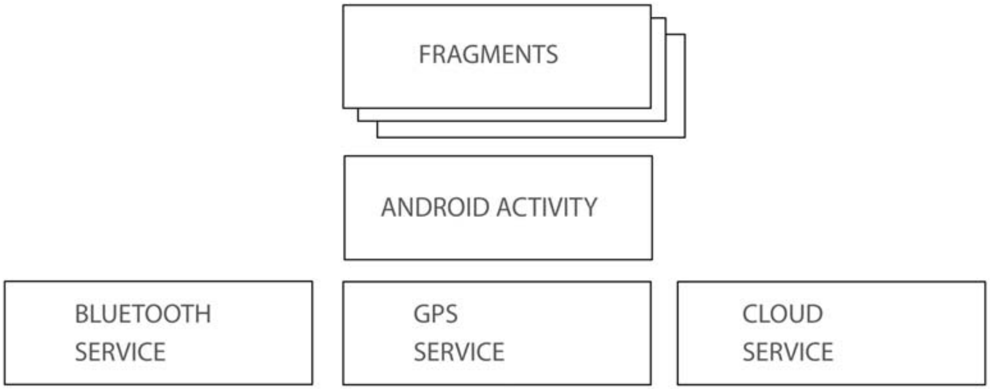


Figure 6
Smartphone API and online mapping platform architecture



cast Receiver, it is asynchronous and event-based, it is triggered as the same time as the data is being received. The GPS Service provides the location information to the phone, it called 'Google Play Service API' to control the inner GPS chip to get the GPS data. These data consists of Latitude, Longtitude, Accuracy, Altitude, Speed and Local Time. When the location is updated, this service writes the data to the context for the application for global access. The Cloud Service is connected with Yeelink.net server. Yeelink is a distributed realtime computation platform. It can process unbounded streams of data, doing real time data processing. We just use it to store our data. After the Cloud Service receives the broadcast, it sends the sensor data and the GPS information with a timestamp via http protocol. Because sensor data is a kind of stream, it is associated with time, episodic smoothly continuous. The Yeelink merges all the streams at the entrance point in their system and splits it into various streams by stream id. The advantage of stream management system as opposed as a normal relationship Database is that we can process the data like a stream even it has been put in the warehouse. Finally, we explain the online mapping feature. We use google map as the base WebGIS system. And we use jquery to build a friendly user interface browser. Then a significant amount of JavaScript visualization libraries are written and imported to show the data in the form of heat maps. The application gets the stream via the Yeelink Application Programming Interface (API), and presents the latest location and data or historical data for the sensor kit. The stream use json as the format and http protocol. The application sets a timer for five seconds as an updating period. Then it requests the Yeelink every five seconds for new updated data. Therefore the stream data is based on a timeline range previously programmed, in this case every five seconds.

DATA COLLECTION TESTING AND FUTURE WORK

The data was captured in different measurement sessions; the kit incorporates a GPS chip to determine the position on earth and the orientation of the sensors in each data collection session. Each data capture session lasted for about 15 minutes, they happened in different cities in China (Suzhou and Shenzen) and in two consecutive days in the morning and afternoon in the same position and orientation. This paper takes the potential of real time mapping and visualization as a point of departure to discuss and rethink traditional urban site analysis and design. The aim and scope of this paper is to provide new visualization tools which could be implemented with widely available open source software and low cost DYI electronics and hardware. The assumption is that real time mapping can allow for different analysis and evaluation of existing urban conditions and therefore support different interpretations and simulations of urban spaces to enhance urban spatial experience. To test our assumption, we described the design, the hardware and software methodologies involved in the prototypes implementation and the results of data collection with the sensing kit. In the future we want to conduct systemic testing and evaluation of the prototype by setting up an exercise of dynamic mapping in a task for urban site analysis by architecture students and explore how this methodology may provide opportunities for different design process approaches, as opposed to traditional, static and compartmentalized urban design site analysis. The online visualization application (Fig. 8) needs further development to allow a translation of the quantifiable data at the moment only visualized on the Yeelink platform (Fig 7). We are in the early stages of understanding the potentials of dynamic mapping and the many aspects of their creation, and encourage others to conduct further research in this challenging application domain. A recurring question for future development of our research remains: will we be able do we design differently by capturing, and visualizing unquantifiable and intangible data?

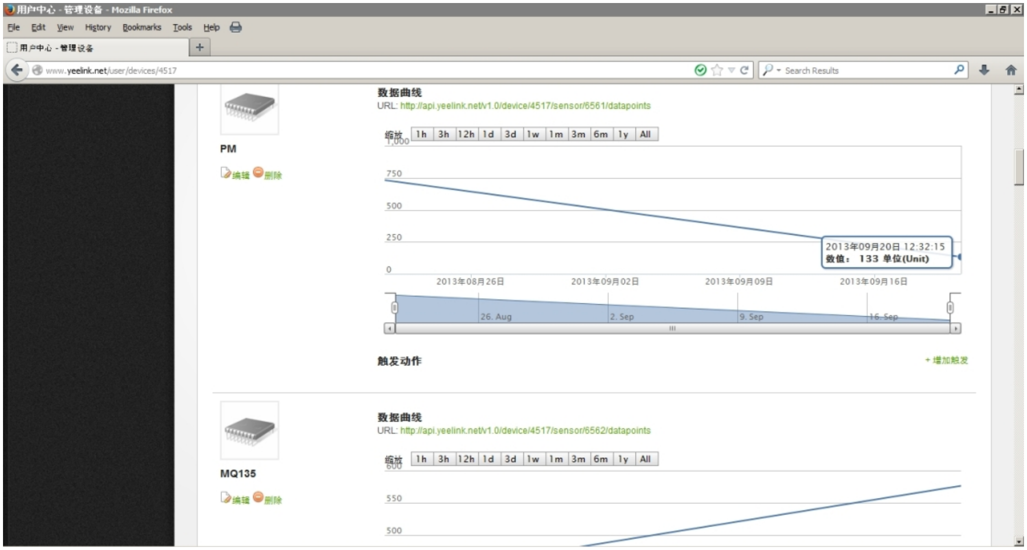


Figure 7
Screenshots of the Yeelink application where we can visualize all historical data captured by the sensing kit..

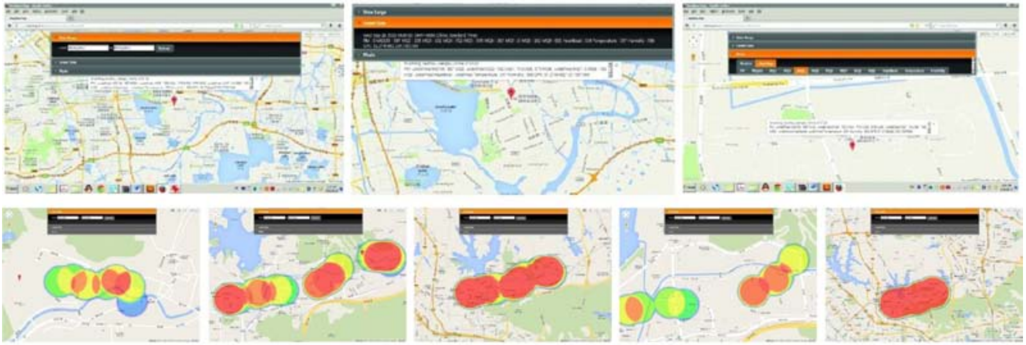


Figure 8
Screenshots of user tests on the online visualization platform.

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