Sensing digital co-presence and digital identity

Visualizing the Bluetooth landscape of the City of Bath

Angelos Chronis¹, Prarthana Jagannath², Vasiliki Aikaterini Siskou³, Jonathan Jones⁴
¹,²,³,⁴ University College London UK
¹ http://www.cityware.org.uk
¹ angelos.chronis.09@ucl.ac.uk, ²http://processing.org, ³vasiliki-aikaterini.siskou.09@ucl.ac.uk, ⁴ucftjcj@ucl.ac.uk

Abstract. The impact of ubiquitous digital technologies on the analysis and synthesis of our urban environment is undoubtedly great. The urban topography is overlaid by an invisible, yet very tangible digital topography that is increasingly affecting our urban life. As W. J. Mitchell (Mitchell, 2005) pointed out, the digital revolution has filled our world with “electronic instruments of displacement” that “embed the virtual in the physical, and weave it seamlessly into daily urban life”. The mobile phone, the most integrated mobile device is closely related to the notion of a digital identity, our personal identity on this digital space. The Bluetooth is the mainly used direct communication protocol between mobile phones today and in this scope, each device has its own unique ID, its “MAC address”. This paper investigates the potential use of recording and analysing Bluetooth enabled devices in the urban scale in understanding the interrelation between the physical and the digital topographies.

Keywords. Pervasive systems; digital presence; urban encounter; digital identity.

BACKGROUND

The impact of ubiquitous digital technologies on the analysis and synthesis of our urban environment is undoubtedly great. The urban topography is overlaid by an invisible, yet very tangible digital topography that is increasingly affecting our urban life. As W. J. Mitchell (Mitchell, 2005) pointed out, the digital revolution has filled our world with “electronic instruments of displacement” that “embed the virtual in the physical, and weave it seamlessly into daily urban life”. The mobile phone, the most integrated mobile device is closely related to the notion of a digital identity, our personal identity on this digital space. The Bluetooth is the mainly used direct communication protocol between mobile phones today and in this scope, each device has its own unique ID, its “MAC address”. Based on previous research (Fat-tah et al et al, 2006 and O’Neill et al, 2006 among others), this paper investigates the potential use of recording and analyzing Bluetooth enabled devices in the urban scale in understanding the interrelation between the physical and the - overlaid - digital topography of the City of Bath.

DATA COLLECTION

The project looks at the use of Bluetooth Wireless Technologies as a means for detecting the presence of people at a particular point in an urban context and tracking their movement between several such points.
by tagging their unique mobile phone ID’s, their MAC addresses. In order to develop a macro scale study of the chosen urban context, data was collected during four half hour sessions of Bluetooth scanning at 9 specified ‘gates’ (O’Neill et al, 2006) in the City Centre of Bath using the Cityware software [1].

Bluetooth technology has two very strong characteristics that pose both restrictions as well as potentials in this study. One is the short range of detection, which is useful for local analysis but more restrictive in the urban scale and the other is the unique but not personal character of the MAC address, which is very useful in tracking devices, but cannot be linked to personal characteristics (with an exception to the friendly name of the Bluetooth device, which is out of the scope of our research). Although the effectiveness of the Bluetooth scans in identifying human behavioural patterns was questioned, our research generally aimed on identifying the patterns of flow and activity in the City, through the analysis of the data we collected, and in relation to spatial and social criteria. Thus this data was also supplemented by a physical survey on the number of people entering and exiting these gates during the allotted half hour slot.

**METHODOLOGY**

The project aimed to identify patterns of flow and activity in the city through the analysis of the Bluetooth data collected. To succeed in that the approach had to be supplemented with various additional data related both to the physical and the digital layer. Mapping these properties is important in identifying and explaining the potentially detected flow patterns in our collected data. The generation of several maps of the City helped in visualising these patterns, such as street categorizations, higher and lower density areas, built and non build plan and attraction maps on the physical layer, as well as wireless hotspots and internet cafes in the digital layer [Figure 1]. Places of interest, like a Cathedral which acts as a social attractor, or a wireless hotspot, that affects the activity of Bluetooth devices were mapped and further investigated since they were considered as important drivers of the captured “dynamic field” of the city.

Data visualisations have also been a key factor to the analysis throughout the project. Simple projections of the scanned data over the physical topography in relation to time proved to be effective in identifying patterns of flow [Figure 2]. With the aid of sketches developed in the Processing[2] programming environment we were able to visualize not only the levels of Bluetooth activity on each gate but also track the path of a particular MAC address through several of the gates. In terms of relating the scanned data to physical paths, the methodology included an “agent simulation”, part of the Space Syntax Group methodology, which was performed using the city map as a substratum and
the Bluetooth data as the parameters defining the movement. The simulation aimed to propose possible paths taken by individual Bluetooth devices between their timed appearances at gates. The motion was mainly controlled by the time difference of each device’s appearance at each gate.

Moreover, we considered implementing the attractors we mapped on this simulation, as well as “weight” the paths according to the axial map of Bath. The paths of the agents represent people moving throughout the City, and are generated according to the data set and moved according to the attraction field, therefore giving an essence of the potential real flow of people around the City, which also constitutes a direct relation of the otherwise “abstract” field of scanned Bluetooth devices to the “concrete” field of physical space.

**DISCUSSION**

The urban flow analysis is twofold in the scope of this research. It investigates, on one hand, the patterns of activity in the local area of the gates described as a persistent layer, and on the other, the patterns of movement flow between the gates, as a transient layer. (Fatah et al 2006). The distinction between persistent and transient is based on the user’s view, when the impression of the space is derived from a static field then it is referred to the persistent layer and when the impression derives through a movement it refers to the transient one. The overall nature of a gate as persistent or transient was analysed by various graphs based on the characteristics mentioned above in order to identify various aspects of the nature of the gates.

**Persistent Layer**

The activity of the gate accumulated over a particular time session was represented with dynamic visualizations as 3D “activity spheres” [Figure 4]. An “activity sphere” is growing bigger according to the number of hits shown in the area; busier places tend to have a bigger radius than places which do not have many active Bluetooth devices. On the overall “Bluetooth activity” table several patterns were identified such as the displacement of activity between gates at different time slots, or the alteration of the activity on a specific gate which drops or rises at specific times [Figure 3].

To define the overall character of each gate, those data were also enriched by some qualitative characteristics given by the people at each gate, who verbally described their subjective experience of the space (e.g. busy, transient, quiet, well-integrated, traffic, boring). The answers were then mapped and correlated to the quantitative analysis.

Some of the findings strongly correlated with the empirical observations however it became clear that although the overall character of a gate was easily identified, there were certain properties of space that were difficult to name based only on the quantitative analysis. For example, the level of
activity can be the same between two gates, but there is no way to identify the type of activity through the data analysis.

**Transient Layer**

The visualization for the transient layer consisted of a path graph between gates and a 3D representation of Bluetooth paths as straight lines. The significant difference from our earliest visualizations was the use of time as the third dimension. The values on the z-axis were provided by the time at which the device was scanned at the gate. The MAC addresses were also colour coded depending on the time they first appear. This difference was critical in understanding the significance of the time length of each path. The slope of a path is depending on the amount of time passed before a MAC address reappears in another gate and thus the slope is a measurement of how fast a path is. Using this feature of the visualization sketch, an interesting observation came about, that the slopes of the paths provide information on the specific transient character between gates. Comparing the distance of the gates to the prevailing slope of the relevant path shows that there is a great difference on the speed of movement on different paths throughout the City. The slope of the paths, for example, between gates 8 and 9 is generally very slight, suggesting that this path is a direct transitional one, while the paths between gates 5, 6 and 7 have generally steeper slopes that suggest that movement flows between these gates are slower transitional paths. This correlates also with the number of local attractors present around these gates and the fact that they are closer to the city centre. Again specific patterns of flow in relation to time were identified through the path graphs [Figure 5].

In that case the movement of the people between the gates is being perceived as a straight line without taking into account any alterations in the direction people are moving. Therefore the survey tried to implement a model used by the Space Syntax group, which is trying to mime people's behaviour in space based not on the straight connections of diverse points but on locations which act as attractors for peoples' movement, an agent simulation program [Figure 6].

The agent simulation was an attempt to simulate the physical urban flow of the City through the Bluetooth data. For each MAC address, an agent is generated and pointed to its destination gate which is provided by the subsequent gate which records the presence of the same device. Its speed is altered within allowable range so as to reach that gate within a specific amount of time. What we aimed at was the projection of the “abstract” Bluetooth field on the actual topography of the City.

Quantitatively, although we can identify for example that the level of activity is the same between two gates we cannot identify the type of activity
taking place. These arguments supported the qualitative supplement necessary to a holistic urban study that accounted for the fact that a physical path around the City is much richer in information and that the urban flow is generated by a vast amount of spatial and social parameters that we are not able to identify through the quantitative visualisations alone.

We should also mention that there are several problems which can occur during the survey, coping mainly with technological limitations in the software that could lead to false results, as for example the fact that there is an alteration of the Bluetooth scanning capacity while moving from one place to another or in busy places, where the software is unable to scan all the devices.

**Agents simulation**

Since the Bluetooth data is collected at nine pre-specified gates, it provides discrete slices of information as a representation of a continuous urban flow. It lets us know how many people with handheld devices enter and leave a detectable zone around a gate at a particular time. Additionally the unique MAC IDs allow the recognition of a particular handset. But in order to reconstruct from this sliced information, a dynamic urban flow, bridges must be constructed for the space in between the gates. The projection of the “abstract” Bluetooth field on the actual topography of the City was what was aimed for.

For this purpose a simple agent system was considered as a possible method by which movement could be generated in the space between the gates. Each agent represents an active and detectable Bluetooth device with a unique MAC address. It has a starting location given by the gate it first appears at. Sifting through the whole set of data reappearances of particular addresses are grouped as sets and linked to an agent. Each agent is then able to collect a series of consequent gates it must appear at, at specific times, in order to generate a representation of the entire flow possible within the limits of the data set. The route that it must follow is made of a series of gates it was detected at in succession. A large number of devices were seen to be detected successively at the same gate over a long period of time. This shows up in previous visualisations as persistence. In such cases the routes of these agents would be marked by long series of similar gate numbers ensuring that the agent keeps appearing at the zone of the gate during that time.

Intrinsic to the nature of agent systems is the emergence a certain level of unpremeditated motion that allows the bridging of gaps between gate data to not be defined entirely. As the flow is situated within an urban context consisting of choices to be made between physical routes, this methodology allows for a model which converges on a probable representation of the dataset as opposed to requiring a deterministic prediction of what the flow could be. The only parameters that then shape the resulting flow are the start and end points, provided by the data set, the period of time in which this journey has to be made and the obstructions produced by the built environment. The agent’s speed within set limits is indirectly proportional to the amount of time the agent has left in reaching its destination. A numbered grid radiating from the destination gate is the medium of attraction the agent responds to. Using the number gradations along valid routes ensured that the agents would avoid stagnating at dead ends.

The primary distinction this mode of dynamic representation has to offer over the previously tested visualisation models is its embedment within the spatiality of the built environment. This enables it to be easily read as an impression of urban flow. Although it is able to situate itself after lending itself to certain approximations, patterns generated by the simulation could then be assessed by comparison to the other visualisation models. This may reveal whether the emergent pattern points to a pattern within the data collected as opposed to being largely caused by the bridging between data sets.

Alternative methodologies that could have been explored in order to bridge between the gates...
could have been shortest metric distance route choices or shortest angular distances paths. However the deterministic nature of these alternatives would have lost out on the possibility of generating similar yet non-same representations of the same data which can be achieved by repetitive execution of the agent model. The setting up of a numbered grid to control movement however, unexpectedly exerted more control over the motion of agents in open spaces than was desired.

CONCLUSION
In understanding how pervasive technologies can be used to analyse the urban flow of a city we see the limitations in simulating urban flow through a modelling of the great variety of spatial, social and environmental factors as opposed to visualising a previously documented flow. Nevertheless, the sensing and mapping of this urban flow with the use of the Bluetooth technology is limited, yet not totally restricted, meaning that it can provide useful conclusions regarding the movement and activity of the people in the urban topography, but it cannot provide meaningful interpretations on subjective and empirical aspects of the urban life. Finally one could also argue that a further analysis of larger data sets would set in a denser resolution of gates through this methodology and possibly yielding even more interesting results on this interweaving of digital and physical urban flow.

Although Bluetooth pervasive technologies may display limitations when compared with more accurate tools like GPS tracking, there is one key advantage to the former. Bluetooth activity as scanned passively in this exercise signifies a real and growing digital presence overlaying the physical realm as opposed to an active intervention that may sometimes be required of other technologies when used as tools. The main contribution of this data to a model of movement is a unique identification of the device which may be attributed to the presence of a single individual. When compared to qualitative analyses these data models may fall short in richness but one may argue that larger sets of scan data and simulation of more contextual attractors may help bridge that gap.

REFERENCES
