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MUMMY, I NEED A WEE!

The Integration of Space Syntax, Internet of Things (IoT), and Self Tracking Technologies to Design for Pedestrians in Smart Cities

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ABSTRACT

City and town planners are accounting for Internet of Things (IoT) at different scales of applications. Planning for pedestrians has attracted practitioners and researchers overarching different domains and addressing various problems. This paper explores the re- use of self-tracking technology to have a human-centric planning for pedestrian whilst integrating this with the urban layer and agent-based modelling (ABM) technique. This study is a part of an on going research; it presents a part of its overall methodology to obtain interim findings. We focus on the comfort qualities the pedestrian demands in the walking pathway and in particular when they are walking with a child. An ABM is proposed to represent the phenomenon and analyse it. This study covers the development of the model, emphasizing how it would reflect the integration of the re-use of self-tracking technology and the syntactic measures to assist with planning for pedestrian in smart cities. The outcome of the research should interest city planners and make a concrete business case that would interest technology providers.

KEYWORDS

Agent-based modelling, Design For Pedestrian, Self-Tracking, Location-Allocation Problem, Spatiotemporal, Walkability

1. INTRODUCTION

Over the past few years, the definition of a smart city has evolved to mean many things to different people. Yet, one thing remains constant is the utilisation of information and communications technology (ICT) and the Internet to address cities challenges. Smart city concept is materialised as a problem-solving technological instrument to urban problems. The Internet of Things (IoT) is coming to a city near you, it is a crucial tool for digital citizens of the future (Walden, 2015; Kortuem et al., 2013). Cities stand to benefit the most from connecting people to big data. Cities are repositioning themselves to play a pivotal role in the development of humanity; however, because of the rapid population growth and the soaring urban expansion, cities are facing a variety of challenges related to urban life (e.g., urban planning, traffic management, urban safety, resource sharing, energy efficiency, and recreation). Letting down to cope with any of these aforesaid challenges may threaten the city's prosperity and quality of life (Mitchell et al., 2013).

1.1 PEDESTRIAN WALKABILITY_ ACCESS TO SERVICES

Urban designers are interested in the spatial qualities of spaces that create pedestrian – friendly cities. Launching traffic calming schemes, refining the quality of pedestrian environment, and public realm are various initiatives to improve town centres viability (Begg, 2002). Planning-for-pedestrians is an evolving design problem as with IoT, living and mobility technologies, more requirements arise. Pedestrian movement was categorised by Gehl, (1987) into three main types: *functional walking*, *social walking* and *optional walking*. This study focuses on the latter where pedestrian is out under favourable weather conditions to convenient public places. There are unmet ICT and spatial-planning design requirements in pedestrian environments (Guo. et al., 2013; Sisiopiku & Akin, 2003; Shriver, 1997). The design requirements become more crucial when young children are involved. Attention is always given to child-friendly design in functional urban spaces. Pedestrians need to be well informed about the routes prior to their walk. Open sources (OpenSource, 2016) are very limited to inform about the qualities of the routes and the facilities being offered (South, 2012). Expanding upon this case, when children are away-from-home and they announce that they need to go to the toilet, or if the parents notice that their body signals are indicating a need to go, it raises an urgent matter that needs to be solved. In this research we are focusing on young children and referring to this demand as *Toddler Toilet Demand*-ttd.

1.2 THE RESEARCH QUESTION

The research addresses the current common practice of pedestrians and interrogates the benefit of integrating IOT and spatial configurational models in smart cities design. The research question is: how can smart spatial planning techniques meet what the pedestrian demands in future cities?

2. BACKGROUND

Stonor et al. (2003) discussed 17 various factors of walkability (i.e. the time of the day, footpath dimensions, and qualities), and created a walkability index taking London as a case study. Pedestrian needs were identified by Alfonzo (2005) as in order to decide to walk or not to walk; the walk has to be feasible, safe, comfort, and pleasing within an accessible route or space. Mehta (2008) expanded the walkability models in Main Street to include the sensing of belonging, pleasure, comfort safety, accessibility, feasibility and usefulness as the walking needs, whilst categorising the street characteristics as physical, social and land use. To this end, we focus on the comfort qualities of the surroundings and in particular the pathway itself. Comfort is a positive emotional reaction to the walking environment, which is affected by various factors; thermal, visual, acoustic, smells, air pollution…etc. In particular, we focus on the comfort associated by accessing services, which are perceived as fundamentals; as well as, the size and location of pathway-facilities.

2.1 SELF TRACKING

Many individuals use wearable devices, for tracking, quantifying, and documenting everyday life activities, gadgets, and self-tracking applications (Klauser & Albrechtslund, 2014). Self-tracking and social sensing devices gained attention from medical and public health professionals due to the potentials these devices have benefiting clinical decisions (Sharon, 2016). Among the most popular electronic gadget categories last year is the motion tracker, Fitbit (Mackinlay, 2013). Fitbit is used for physical fitness purposes; however, the data gathered can be re-used in a different analytics context. While the majority of activity trackers are recommended for adults and kids (+13), the same device can be attached to a toddler to track a certain behaviour.

2.2 THE URBAN CONTEXT

We take Bishop's Stortford as the case study to analyse the pedestrian demand in the main pedestrian corridor of the city, see fig. 1. Some shots are taken to show main segments. This study is taking the inner urban core of the town, the area around South and North streets (BSTC, 2015). Many studies have deployed configurational models to predict pedestrian movement (Lerman et al., 2014); such models are based on the topological features of the space which are deployed for both vehicles and pedestrian (Hillier et al., 1993). Via axial map (62 axial lines) and the connectivity graph, see fig. 1, while taking South Street (street 1), as the graph root. Integration values were calculated using Depthmap (Turner, 2004), see fig. 3

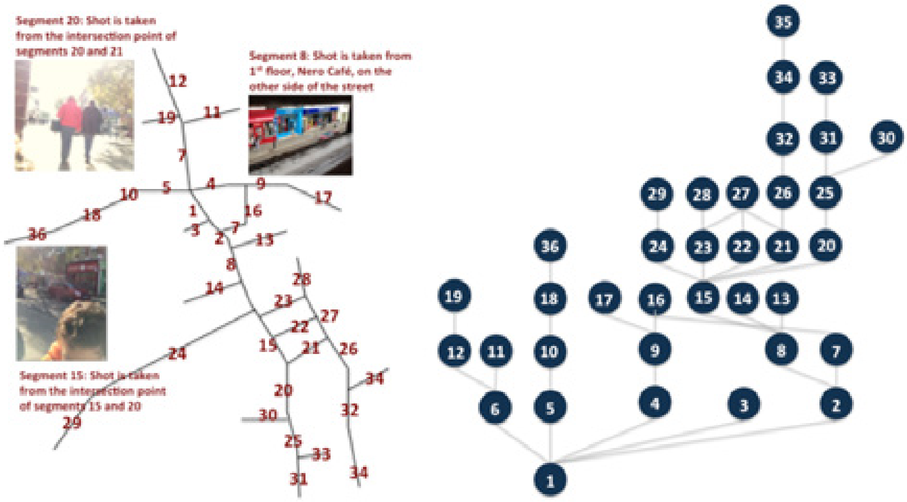

Figure 1 - Town_Main Street_axial map and connectivity graph

2. DATASETS AND METHODS

The study explores the potential re-use of self-tracking technique to predict the pedestrian demand in outdoor urban spaces. It integrates network's spatial attributes deploying agent-based modelling (ABM) approach. Integrated ABMs and space syntax have been used by (Shelton, Pereira et al., 2012) and (Jiang & Claramunt, 2002) in the context of pedestrian movement. Studies proved successful in predicting pedestrian movement and evacuation in the case of emergencies. This study deploys the same method addressing the planning for pedestrian. With a human-centric approach, it proposes a pedestrian planning model, which amalgamates integration values and ABM technique.

2.1 THE STUDY

In August 2015, a pilot study (n=2) was conducted. The recruitment of participants was done via word-of-mouth and posting in town centre nurseries that we are looking for volunteers to have the device attached to their toddler/ young child for one week. In September, a device (Fitbit- Zip model) was given to two families who have 2-year-old healthy toddlers. The whole trial was explained to them, and upon their consent, we asked the parents to ensure that the device is attached to the toddler whenever they are going to a walk in the city centre, and once the toddler demands a toilet or to rest, they take a record of the number of steps being made (reading the count, stating the location, and document it on what we called it '*My ttd Monitor*'. The documentation is done using a smartphone. A parent who is taking a child for a walk, will be having a stroller, diaper bag, toys, water/ juice and snacks, and potentially a handbag. We realised that on-the-go documentation on a piece of paper, is not handy and it will be inconvenient. So we asked the parents to audio record the ttd event and we transcribe it, see Fig. 2. There was no minimum number of walks, but we explained to them that the more they record, the clearer and reliable the outcomes would be. Each of the toddlers had an account with their names (Fitbit profile), through which we accessed their data log and retrieved the 7-day record. Devices were collected alongside the diaries, *My ttd Monitor*, from the parents on the 8th day.

2.2 THE MODEL DEVELOPMENT

The data collected was analysed and correlated to the urban area's spatial attributes. An ABM was designed to depict the *ttd* behaviour (normal distribution of the data collected) deploying a step-based-demand agent architecture. In the simulation environment, there are two main layers: 1. *Urban layer* is the pedestrian pathways and 2. *Behavioural* layer is the spatial values and movement prediction technique.

3. RESULTS

A log of the seven-day tracking was retrieved from the two gadgets and the audio recordings and visualised in the urban context. Figure 2 illustrates a sample of three-day visualisation showing: the starting points, the route taken (distance and time), and the ttd details.

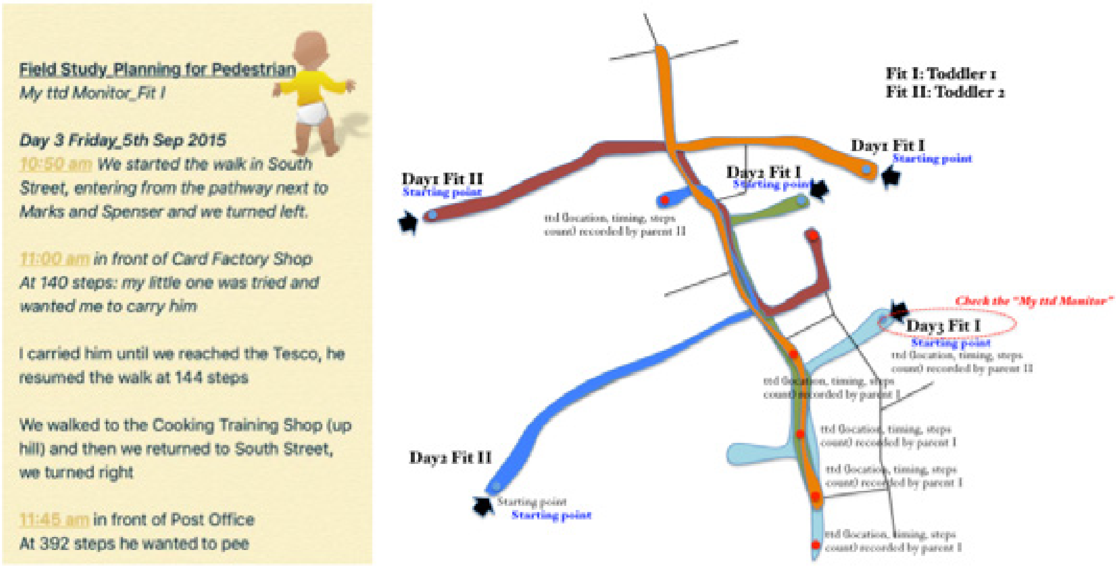

Figure 2 - ttd-urban network visualisation and a transcribed "My ttd Monitor" of Fit I, Day 3.

We observed the fit-for-purpose of using tracking devices for planning for pedestrian as: 1.the toddler does not understand what this device is for, hence the behaviour is not affected (no biasness), 2.the device does not count the steps if the baby is on the buggy, bus, or carried by an adult (accuracy), and 3.potential to use the retrieved data for planning purposes of other facilities (e.g. public seats' location). For instance, 1 kilometre equals to 5,000 toddler's steps. Fit I toddler after 100 steps (0.2km), was tired and sat on the ground (as noted by the parent in the My ttd Monitor).

3.1 THE MODEL

Each toddler was presented as an anonymous agent (agent a, b, n). The agent randomly enters the urban network (various entry points). The *ttd measure* is a function of (the amount of liquids the toddler had, last time the toddler used the toilet, the activity, the distance walked, and time spent before reaching the Main Street). These elements form the initial state (InValue_ttd) which in order to be simulated, each agent is assigned to InValue_ttd on a random distribution basis.

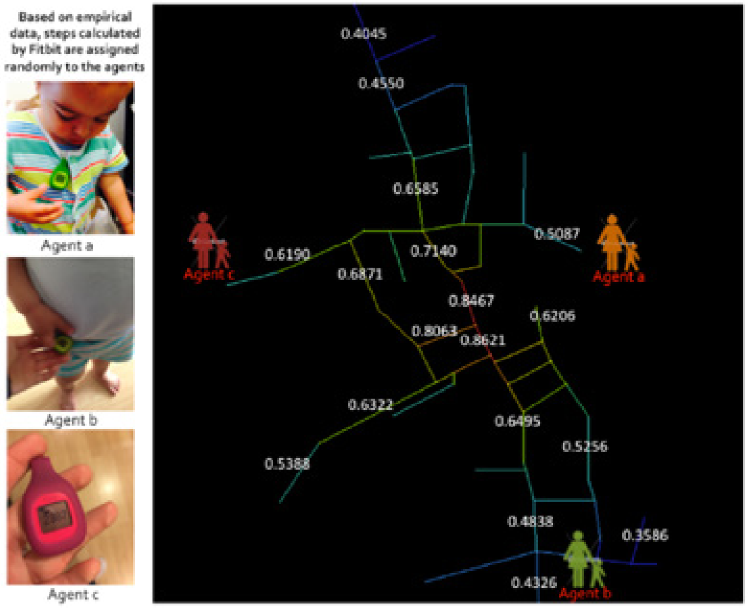

Figure 3 - Town_Main Street_axial map with integration values, entry points, and anonymous agents

4. CONCLUSIONS

The proposed approach depicted the pedestrian demand in Main Street area via integrating IoT, and spatial and behavioural layers of the urban space. This is a part of on going research; the interim outcomes reveal potentials of a smart integrated planning tool. The study proposed an innovative idea to improve the comfort of walkability via the re-use of self-tracking collected data to assess and predict the candidate locations of pedestrians' facilities especially for adults with young children. The use of tracking devices managed to inform the design-for-pedestrian with individual demands and provide smart human-centric solutions. The deployment of ABM managed to denote the pedestrians and their various demands throughout their walk paths. It provided a framework within which an alternative approach to self-tracking for pedestrian planning can be developed. The next step is to increase the sample size and to expand the urban area. In addition, a wearable camera, same notion of the wearable designed by Mehta et al. (2016) is to complement the tracking device, which may refer to as the (ttd Kit) to capture the surroundings and the facial impressions.

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