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ScienceTalk

Urban living in the age of the smart city

Data from devices can allow real-time fine-tuning of traffic flow, for example

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A commuter checking out interactive "smart boards" at a bus stop. Such boards offer information such as bus timings, the weather and street directory. There are physical books to browse, as well as e-books to download too. Commuters can also use mobile phone charging points and free Wi-Fi. ST FILE PHOTO

Across the globe, cities like Singapore are investing heavily in smart city infrastructure, which is generating unprecedented amounts of data. Such information has huge potential to help governments, residents and businesses make smarter choices in areas such as urban transportation, healthcare, logistics as well as policy and planning.

Technologies that enable easy generation, storage and sharing of such diverse data streams allow for large-scale studies on urban mobility and collective behaviour.

In Singapore, through government-led open data initiatives such as Data.gov.sg and the Land Transport Authority's DataMall, a wide variety of information has been made available for public use. For example, cameras along expressways upload real-time images of traffic, and taxis report their current position and availability. Also, buses servicing the 5,000 bus stops island-wide report their occupancy levels once every two to three minutes.

Besides such infrastructural sources, city residents continuously share, often publicly, text, videos and images of their surroundings via popular social media platforms such as Twitter and Instagram.

University-led initiatives such as the LiveLabs Urban Lifestyle Innovation Platform at the Singapore Management University (SMU) have developed mobile computing technologies to understand behavioural traits of individuals via their smartphones and wearable devices such as smartwatches.

All this data helps reveal the mobility-driven dynamics and preferences of people both indoors and out, at different scales.

UNDERSTANDING SOCIAL BEHAVIOUR

In our work, we have been exploring the extraction and uses of such multi-scale mobility dynamics and insights.

Indoor positioning systems that rely on Wi-Fi infrastructure within buildings to locate smartphone users are becoming mainstream. This could unlock the answers to questions on individual and social human behaviour that may affect the well being of people and businesses.

Through a series of preliminary studies involving hundreds of students on campus, we found that this technology-assisted, passive sensing of locations does, in fact, confirm many of our intuitions about how people behave.

For example, in a study we conducted with other SMU colleagues on the mobility-driven social interaction patterns of students, we found that they tended to use their phones less when they were in formal groups like meetings, whereas the behaviour was quite the opposite in the presence of close friends. Similarly, they spent more time at the food court when eating with friends compared to when they grabbed a bite alone.

These examples illustrate the true power of passive, unobtrusive Wi-Fi-based sensing in capturing human behaviour.

PUSHING RESEARCH FRONTIERS

Such large-scale indoor movement analyses, capturing the movement of thousands of tenants or visitors to indoor public spaces, are enabling novel applications.

For example, by anticipating how crowded different rooms are, 15 minutes to an hour in advance, smart energy solutions can predictively adjust the cooling or heating level of rooms, saving energy costs and offering optimal comfort levels.

We can use such technologies to research human behaviour. For instance, we extracted the students' sleep patterns based on their smartphone app usage (with the sleep duration extracted by observing the periods of continuous non-use of the smartphone).

We then extracted the "quality of sleep" by deriving specific items on the Pittsburgh Sleep Quality Assessment scale, such as overall sleep duration and interruptions during sleep.

By correlating such sleep quality measures with their socialising behaviour, captured from their on-campus movement patterns, we found that students who interacted with social groups during the day showed better sleep quality compared to those who did not.

In a separate experiment, we replicated a classic psychology experiment which studies the "implicit bystander effect" by surveying students either in their social groups or those on their own through an app about how much they were willing to donate to their respective schools.

We found the former felt less charitable, thereby validating the phenomenon where one's tendency to help is reduced due to the presence of others.

In social science studies, the experimenters show up in person to hand in the questionnaires to groups of people or invite them to their labs, running the risk of the subjects feeling biased, due to the physical presence of the researchers.

Our technology-assisted experimental methodology allowed us to classify students as either being alone or with their group of friends while leading their natural daily lifestyle, leading to more credible field studies.

UNDERSTANDING THE CITY

We have also been exploring the use of mobility and social media traces to understand the collective dynamics of a city. People leave digital breadcrumbs of their movements each time they make a call, send a text or use the Internet.

Each ride they take on a train, a bus or a taxi is a brick helping to build the collective understanding of urban mobility. Transportation infrastructure managers and land use planners have traditionally relied on such information, typically through surveys, to answer questions such as where to add the next train station or which area to develop as the next food hub. With smart nation initiatives in place, urban mobility information, suitably anonymised to tackle privacy concerns, is made available at much finer granularity and faster rate, making real-time decision making possible.

The Internet of Things is transforming everyday objects, such as phones, taxis and buses, into connected and communication-ready devices. Analytics applied to these diverse information streams is making smarter living a possibility, across our homes, workplaces and community spaces.

In a recent study, we analysed a set of advertised events that were held in and around the Central Business District. We found we could locate an event's venue, with less than 1km error, in more than 40 per cent of the cases, relying solely on crowd estimation using aggregated, anonymised records of consumer phone calls, SMSes and data usage.

Urban planners are aware that, as large events draw to an end, the sudden emergence of large crowds tends to cause traffic congestion not only at the event location, but also in adjoining areas.

Using real-time geospatial information about the location of, and user demand for individual transport resources, we expect to be able to mathematically model the impact of such events on the transport system.

Such predictions will allow urban planners to dynamically re-route traffic before the onset of congestion, and to better plan traffic diversions for future events.

HELPING BUSINESSES THRIVE

Finally, such transportation and social media information can reveal the demand patterns and economic vibrancy of individual businesses.

Our ongoing project, in collaboration with researchers from the University of Cambridge, explores the use of data from location-based social networks, along with urban transportation data that helps profile the commuters coming and going from different neighbourhoods, to predict the health of individual retail businesses.

Check-in volumes and comments on such social networks provide a sampling of the visitor interactions at individual venues, while the social media presence of such venues helps reveal the distribution of retail outlets across different neighbourhoods. By combining such venue-oriented data with neighbourhood-scale traffic flows, derived from taxi and bus data, we have been able to predict the likelihood of individual retail businesses – especially restaurants – failing, over the next six months, with over 80 per cent accuracy, for 10 different cities.

With retail being a notoriously competitive business, our techniques open up the possibility for urban planners to predict the vibrancy of retail businesses in different sectors and neighbourhoods, as well as uncover the impact that transportation resources, such as availability of parking garages, have on such economic vitality. Urban planners can then perform policy-level interventions – such as rental rebates or reduced parking rates.

Similar analyses might in future give urban planners insight into the likely traffic impacts on the neighbourhood, and more, from shops – even before they open.

The Internet of Things is transforming everyday objects, such as phones, taxis and buses, into connected and communication-ready devices. Analytics applied to these diverse information streams is making smarter living a possibility, across our homes, workplaces and community spaces. However, challenges lie ahead as more sensors and data become available.

In particular, we will have to find a balance between the benefits we get from such information and the need to preserve people's privacy.

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