Simulating Urban Flows of Daily Routines of Commuters

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Abstract. Forecasts of the ambient population, the actual location of people throughout the day, could have different applications in fields that need to know how many people are at risk or in need of something at any time. These include crime science, transport research, or modelling exposure to air pollution. Recently, human movements can be tracked thanks to a diverse range of 'big' datasets having a high spatial and temporal resolution. Examples are mobile phone locations, footfall cameras, geolocated social media updates or transport smart cards. In this presentation, we discuss the development of an agent-based model of the ambient population at an individual level in an urban environment. Ultimately, the goal is to calibrate the model with different big data streams in real time by using dynamic data assimilation techniques. At the moment, we have developed a model of recurring activities of individual commuters (working, shopping, leisure, etc.) that we calibrated with a recent British time-use survey and validated with hourly Wi-Fi sensor footfall data in the town centre of Otley, West Yorkshire, UK. The validation dataset captures mobile phones passing by at different well-chosen crossings and buildings. The results show that modelling the behaviour of commuters only is not sufficient to capture the evolution of the ambient population.
Keywords: Agent-based modelling, Big data, Ambient population

1 Introduction

The 'big' data revolution has an impact on the scale, applicability and calibration options of numerous urban models [1]. Agent-based models are most suitable to quantify the location and behaviour of an urban population [2]. The aim of our ongoing work is to build an agent-based model of the ambient population, the number of people at any location in an urban environment at any time of the day. Several studies in other disciplines can benefit from such population forecasts with a detailed time scale, including crime research [3, 4] and modelling exposure to air pollution [5]. This presentation focuses on the development of the agent-based model, an application to commuting in a town in Yorkshire, calibration of the model parameters with a time-use survey, and validation with a large dataset of footfall.

2 An agent-based model of the ambient population

In our model of the ambient population, agents are driven by intensities to do different daily routines. We break these intensities up in time intensities and background intensities. Time intensities are about the time of day and day of week when it is more likely that agents do specific activities. Background intensities change depending on the recurrence pattern of every activity. Generally, they slightly increase when an agent does other activities and decrease faster when the activity is actually being performed.

At present, we model the behaviour of individual commuters. They can be home, work in their office, visit restaurants for lunch or dinner, go shopping, or do leisure activities (going out or sports). We have applied this model to the town of Otley, West Yorkshire, UK, and its surrounding suburbs.

3 The UK Time Use Survey 2014-2015

The intensity parameters of the model are calibrated with the UK Time Use Survey 2014-2015 [6, 7]. The survey has 8278 full records of respondents who have kept diaries of all their activities per 10 minute interval during two days. We extracted time intensities and recurrence patterns for the activities of commuters on workdays.

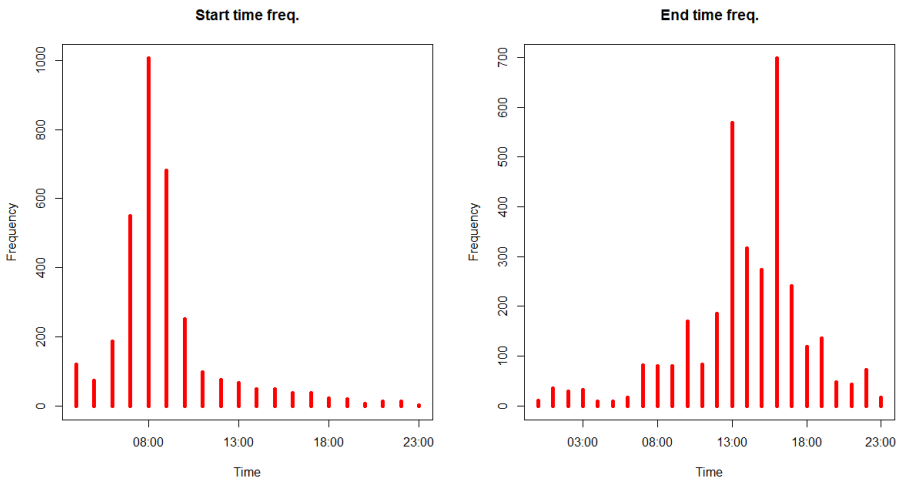

Fig. 1. Distribution of start and end times of working at the office in the UK, according to the UK Time Use Survey 2014-2015.

Not surprisingly, many commuters begin their workday at the office between 7 and 9 in the morning (see Fig 1), and stay on average for 8 hours. Part-time working seems to be much more popular in the morning than in the afternoon. Around 30 % of the commuters go shopping on an average workday (up to 40 % on Friday), and around 20

% do sports (only 15 % on Friday). Only a limited group (6.5 %) goes for lunch in a restaurant or cafe.

4 Validation with Wi-Fi footfall data

We obtained a dataset with hourly footfall for a period of two years (August 2015 –July 2017) at different key locations in Otley. The data has counted every Wi-Fi enabled mobile phone passing by. As such, although activities of commuters are only a subset of the recorded mobility, we expected peaks in the model and the validation dataset to be similar. But except for one footfall device (with *id* 14, see Fig. 2), no clear morning or evening rush hour peaks could be detected. This leads to the observation that a general model of the ambient population needs a much bigger effort to capture the behaviour of different groups with more unpredictable travel patterns, like unemployed or retired people, and employees with highly variable schedules.

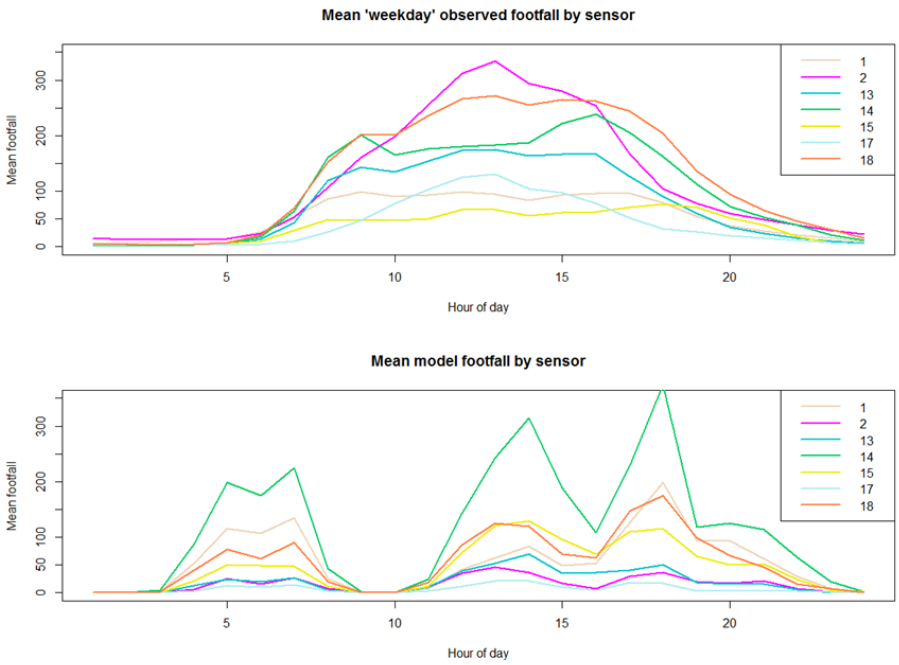

Fig. 2. Comparison between observed and modelled footfall at seven locations in Otley on an average workday (Monday and Friday were excluded).

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