Modelling of mobility patterns of large urban populations

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ABSTRACT

Urbanization leads to the rapid population growth in many cities worldwide, resulting in increased demands on the transport system. This has given rise to traffic congestion and challenged the stability of urban mobility systems and the liveability of urban environments. Moreover, changing demographic conditions are also altering the contemporary urban mobility patterns. The increasing complexity of urban structures and the unknown mobility behaviour of such large populations make it difficult to determine optimal transport plans. There is growing demand for tools to assist decision making for travel planners. In this context decision making could be improved with detailed information on mobility behaviour at high spatial and temporal resolution. It is of high importance to understand the state of the transport system by analysing individual activities.

Conventional approaches to describing individual behaviour like aggregate statistical methods [1-4], and differential equations based methods [5] can be used to describe the certain aspect of the complex system. But such models do not fully explain the real human systems as they usually treat the individuals as largely homogenous entities, that is populations are modelled using same characteristics. They are not able to realistically describe the mobility behaviour of individuals. Besides, differential equations are much better suited to modelling smoothly changing systems rather than sporadic and discontinuous travel behaviour. Agent-based modelling (ABM) offers an effective solution to modelling social systems that are composed of decentralized individual 'agents' who interact with and influence each other according to localized knowledge, and adapt their behaviours according to the environment [6]. The populations are modelled as a collection of autonomous agents that make decisions based on their own perspective and decision rules. Agents may perform various behaviours appropriate for the system they represent, for example producing, consuming and selling [7]. An agent possesses a set of attributes and behavioural characteristics. The attributes constitute an agent's identity and the behaviour characteristics represent the activities that the agent

carries out, which reflect the heterogeneity of the populations. The benefits of ABM compared to other modelling techniques are: 1) ABM can capture emergent phenomena that are resulted from the interactions between the constituent agents. For example, the emerging collective behaviour can be predicted while each agent follows the rules associated with defined attributes; 2) ABM can construct a model that is closer to reality. For example, traffic jams can be formulated as a group of agents that are modelled individually, rather than described using the distribution density of population [7]. The construction of a synthetic population is essential to the modelling and can facilitate the dynamic analysis of individual behaviours, as well as addressing potential bias and misrepresentation within crowd-sourced datasets.

As part of a project researching the use of new technology in smart-journey-planning, the research presented in this paper aims to develop an ABM to describe citywide population mobility patterns. The model predicts the daily activities for populations on the basis of individual behavioural characteristics. This involves information on the applied transport modes, types of activities, times spent and duration of the activities. This model can be trained using movement data that is provided by a journey-planning app, and analysed to estimate travel patterns to work and other locations, taking into account demographic characteristics including age, gender, physiology, geo-demographics and socio-economic status and the occasionally random nature of human movement. Furthermore, the constructed model is applied to the detection of mobility patterns in the transport system. The objective is to identify where segments of the populations are likely to be and the activities they may be involved in at different times of the day. The routes that recur frequently in the transport network can reflect activities such as commuting, shopping trips and other travel purposes. It should be possible to analyse the temporal dependence, i.e. days of week and distinct seasons and to compare the patterns associated to different weather conditions.

The work has the potential to advance understanding of activity spaces and the interactions of the whole set of individuals in a metropolitan area, and improving the evidence-base for decision-making for trip-based activities.

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