Modelling Movement in the City: The Influence of Individuals

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Modelling Movement in the City

Within the urban context, collective patterns of human behaviour are fundamental in shaping the nature and function of the city. Patterns and systems of movement through the city are shaped by individual choice and knowledge. It is the actions of individuals, in this sense, determine the appearance of damaging phenomena such congestion and crowding. Naturally, it is these phenomena that are of most concern to those that maintain the function of the city, and seek to ensure that transportation systems operate in the most efficient way possible.

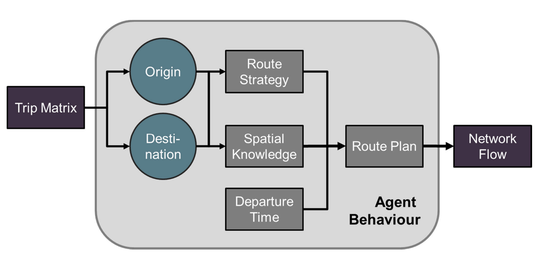
Yet, in seeking to develop an understanding into these patterns, traditional approaches towards the modelling of individual movement in the city remain relatively simplistic in their approach. While numerous researchers in the fields of spatial cognition and urban planning (Golledge 1999, Wiener & Mallot 2003, Hillier et al. 1993, Kuipers 1983) have sought to more comprehensively describe the human route selection process, many conventional modelling approaches continue to simulate individuals as though fixed to the shortest distance route, knowledgeable and rejecting of all alternatives as they travel between origin and destination.

Reasons for the continued utilisation of the shortest path approach may be boiled down to two key principles – one, the approach is intuitively approximate (despite contradictory evidence), and two, it doesn't matter very much. For, in a city with a static transport network, given set of origins and destinations, and given set of individuals travelling at predetermined times, how much variation in behaviour is feasibly possible?

This work seeks to reassess the importance the individual route selection process in establishing a prediction of city-wide dynamics. This work looks at two elements of human behaviour in the city – first, how individual route-choice strategy influences network patterns, and second, how heterogeneity in spatial knowledge may also prove to hold an important influence.

Method

This work utilises multi-agent simulation (MAS) to realistically explore a range of alternative scenarios. The MAS focuses on an area of almost 20000 road links in Central London. The time period chosen for this simulation is 30 minutes during a weekday morning peak period, during this time 15000 agents are dispatched within this area of London. The relationship between agent behaviour and macroscopic processes is described in the image below (Manley et al 2012):



References

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Hillier B, Penn A, Hanson J, Grajewski T, Xu J. 1993. Natural movement: or, configuration and attraction in urban pedestrian movement. *Environment and Planning B: Planning and Design* 20:29-66.

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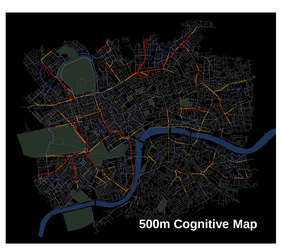
The Base Case: Shortest Distance Path, Complete Knowledge

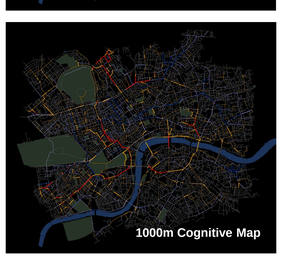
This map visualises traffic flow across the study area, where each individual agent selects their route between origin and destination according to a principle of shortest distance path. All individuals are knowledgeable of the complete road network, selecting only that which best achieves this specification. Data from this simulation will be used as the base case in comparing against alternative representations of agent behaviour.

The Influence of Spatial Knowledge

Spatial knowledge is investigated through simple reduction of the network route search space for each individual. Rather than all agents holding complete knowledge of the road network, knowledge is restricted to only 500 metres around the origin and destination points, with additional knowledge of only the main routes outside of these zones.

From the results it is clear that the restriction agents' cognitive maps is important determining network flows. Further, the extent of knowledge plays an additional role in influencing traffic flow, suggesting the need for consideration of the latent heterogeneity in spatial knowledge.





The Influence of Route Choice

The influence of individual route choice on determining the distribution of traffic flows across the study area was conducted through three scenarios. In each scenario, the method by which individuals select their route is altered from the shortest distance path utilised in the base case. All other attributes – those relating to origin-destination distribution, knowledge of the road network, simulation time period – remain the same as in the base case simulation.

The maps to the right show the differences observed from the original in response to this change in behaviour. The colours in each image represent standard deviations away from the mean change in flow on every link, where the mean for all links is near to zero. A stronger red shows an increase in flow, with respect to the base case – up to 2.5 standard deviations above the mean – and a stronger blue shade shows a reduction in flow – down to 1.5 standard deviations below the mean. A grey colour indicates little variation around the mean (-0.5 to 0.5 standard deviation).

The results indicate that a simple change in individual routing behaviour leads to some significantly altered distributions in traffic flow. The key findings may be summarised as follows:

- In the case of the least time routing strategy, there is a clear shift onto the faster routes, indicated in red, with a reduction in traffic flow in subsidiary routes.
- The least angular deviation scenario demonstrates an apparent stronger redistribution of traffic around the network, albeit to a different selection of routes.
- Finally, the results from the least turn strategy again show a different type of traffic redistribution, albeit at a reduced scale. This reduction may be accounted for by the inclusion of distance within the choice function.

The Influence of Individuals

The results from these simulations illustrate the impact that changes in individual routing behaviour can have on network flows, despite the presence of static conditions and trip distributions. While it is not yet known the full range of behavioural heterogeneity in respect to spatial knowledge and routing strategy. it has been possible to demonstrate the importance of fully considering alternative representations of individual behaviour. Simple alterations to the way in which individuals act in completing their journey within the city can significantly alter our understanding and predictive power. Further work will consider travel time and road congestion, specifically how congestion forms in space and time according to the definition of the agent behaviour.

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