Understanding Route Choice using Agent-based Simulation

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1. Introduction

In traffic analysis and simulation, it is usually assumed that all individuals hold a complete knowledge of the road network and a homogenous preference in route choice, either via the shortest (in time or distance) or least cost path. These modelling assumptions do not, it is argued, truly represent human preference in relation to route choice. Rather, the shortest path strategy is viewed as one factor influencing choice. Golledge describes revealed use of first noticed path, fewest turns and shortest leg first (Golledge 1995). Conroy-Dalton (2003) also demonstrated how individuals primarily seek to minimise the number of turns as they proceed along their route. In a recent study, in investigating real path correlation with shortest path, Papinski and Scott (2011) demonstrated that movement does not follow shortest length or least time paths. It has also been found that the shortest path method performed worse than least angular change and least turns in predicting the movement of vehicles through four small test areas in London (Hillier and Iida, 2005).

This paper seeks to add to this growing literature on route choice methodology by testing these measures within an agent-based simulation environment. The model, described in Section 2, simulates the movement of multiple individual agents across the London road network between given origin and destinations. The movement patterns created by these agents will be compared to real movement data (described in Section 3), with initial results documented (Section 4) and discussed (Section 5) herein. This work represents an initial yet contributory step towards establishing a realistic route choice model for use in traffic simulation.

2. Model Development

An Agent-based Simulation was developed to simulate the movement of individuals around the complete London road network. The model is an extension of that described in Manley and Cheng (2011) – a Java-based application developed using the Repast framework – with inter-agent variation contained within the route choice mechanism applied in wayfinding. Between a given origin and destination (restricted to those selected for testing, described in Section 3), agents minimise their path cost according to one of four measures, these are as follows:

- Metric: The shortest length path between origin and destination.
- Angular Change: The least cumulative angular change between origin and destination, where deviation at each junction is accumulated.
- Turns: The least number of turns between origin and destination.
- Angular Choice: Minimising the ‘Angular Choice’ value associated with each segment. This measure is a betweenness value scored for each segment when it falls

on the shortest angular path between any origin and destination. This value is calculated for all possible origins and destinations (see Turner 2001).

The former three measures described here represent an extension of the work carried out by Hillier and Iida (2005), while Angular Choice has also been recognised as a possible predictor of route choice (Turner 2007). Agents proceed towards their destination at a given speed and coordinate at junctions according to a set of priority rules. Traffic regulations are implemented also to ensure a parallel with real data, with most-notably Oxford Street – a key road in central London – being closed to all through traffic. The resulting paths are then exported by the simulation into an ArcGIS shape file for comparison with movement data.

3. Test Data

The test dataset is drawn from a database of taxi driver traces provided by Addison Lee Taxi Company. This dataset contains the GPS traces of some 1.5 million trips between locations in London over a three month period spanning December 2010 to February 2011. For the purposes of this initial study, four test scenarios were extracted representing a range of routes within central London. The scenarios used were as follows:

Scenario 1: Knightsbridge (SW7) to Herne Hill (SE24) on 15th February 2011 between 18:03 and 18:43.

Scenario 2: Saville Row (W1) to Highbury and Islington (N1) on 16th February 2011 between 16:01 and 16:28.

Scenario 3: Islington (N1) to Chelsea Royal Hospital (SW3) on 15th February 2011 between 20:26 and 21:01.

Scenario 4: Abbey Road Studios (NW8) to Bermondsey Wall (SE1) on 16th February 2011 between 14:16 and 15:35.

For each scenario, the corresponding GPS traces were matched to the ITN road network. This process yielded polyline data that can be seen in the result maps below. The origin and destination points for each scenario are passed to the agent-based simulation for the production of test routes according to each agent's rules.

4. Results of Simulation

The simulation yields a total of 16 datasets exhibiting the movement of agents defined using each of the four routing mechanisms in each of the four scenarios. Maps of these results are presented below in Figure 1, with further analysis of route similarity presented below:

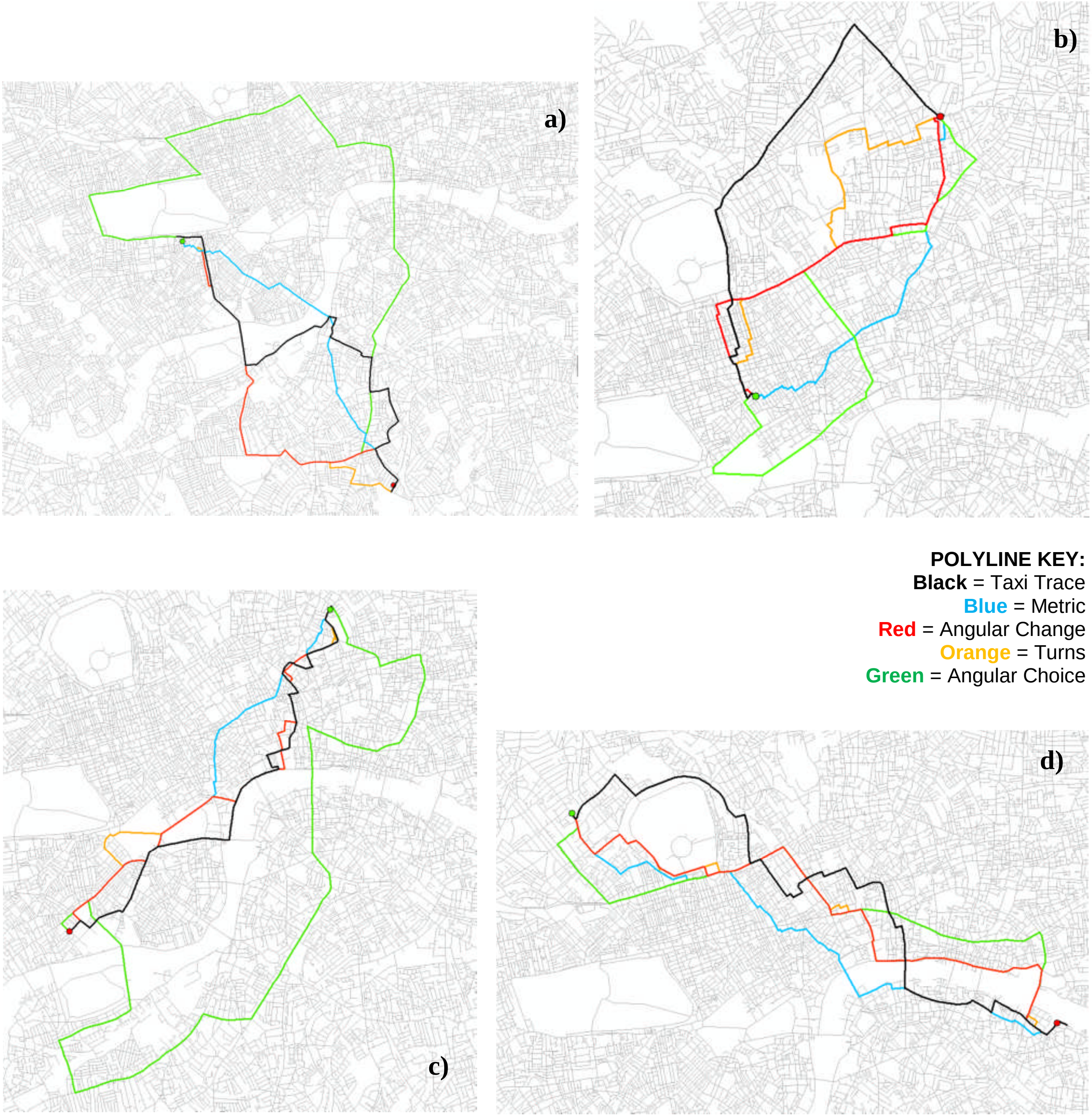

Figure 1: a) Scenario 1: Knightsbridge (Green point) to Herne Hill (Red point)
b) Scenario 2: Saville Row (Green point) to Highbury and Islington (Red point)
c) Scenario 3: Islington (Green point) to Chelsea Royal Hospital (Red point)
d) Scenario 4: Abbey Road Studios (Green point) to Bermondsey Wall (Red point)

Using the route datasets yielded from the simulation, it is also possible to calculate the extent to which the real taxi driver route is predicted by the routes of each agent. These results are calculated on a segment by segment basis and are as follows:

Route Choice Measure	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	Segments Matched	%	Segments Matched	%	Segments Matched	%	Segments Matched	%
Length	17/136	12.5	1/123	0.8	21/141	14.9	28/169	16.6
Angular Change	25/136	18.4	10/123	8.1	41/141	29.1	14/169	8.3
Turns	20/136	14.7	8/123	6.5	30/141	21.3	7/169	4.1
Angular Choice	16/136	11.8	5/123	4.1	2/141	1.4	14/169	8.3

5. Discussion and Conclusions

The results generated from the simulation suggest that none of the four metrics employed to route agents between two locations provide a full answer to the route choice conundrum. However, as has been also noted by others, the results from these scenarios demonstrate a clear difference between reality and the shortest path algorithm. In three of the four scenarios, least cumulative angular change and least number of turns represented better models of movement than simply shortest path. Where the shortest path algorithm did score favourably (in scenario 4) this may be put down to the point at which the individual driver decided to cross the River Thames en route to the destination. The results indicate that, in extension to the work of Hillier and Iida (2005), angular change and number of turns are also employed as heuristics in guiding longer journeys within the urban environment. The selection of these measures, understood as 'most direct' (least angular) and 'simplest' (least turns) paths, align more with human preference than expressed by existing transport models.

The performance of Angular Choice as a predictor was demonstrated to be variable during these investigations. In the cases of scenarios 1 and 3, the agent appears to travel some considerable distance away from the target before converging upon it. Yet equally, in the case of scenario 4, its performance surpasses that might have been expected. The answer perhaps lies in the distribution of high scoring segments as defined by the Angular Choice measure. The location of these highly-attractive roads – albeit those which appear to correlate with high traffic flows – in relation to the origin and destination appears to influence the quality of these results. For instance, three of these higher scoring sections are Euston Road, Woburn Place/Southampton Row and Holborn Viaduct (all featuring within the top 5% of Angular Choice values in the London road network), all of which fall between the origin and destination of scenario 4.

There are, of course, a number of caveats that must be offered alongside these results. Firstly, the small sample size presented cannot be representative of the complete variation in route choice that may be observed. In the case of scenario 2, there is a vast difference between the actual route and those predicted by all four measures. For this piece of work no further investigation behind the dynamic influences upon route choice (such as congestion avoidance, knowledge of a road closure etc.) has been carried out. Furthermore, the extent to which local traffic regulations impact on these results is equally not fully incorporated, with only basic rules implemented at this stage. Finally, the influence of local knowledge should not be discounted in assessing correlation. While taxi drivers may generally be expected to have a good knowledge of the road network, this is by no means confirmed in this situation. Scenario 2, for example, may represent a driver wishing to avoid the busy Upper Street road (chosen by the driver agents) yet not having knowledge of a more direct route to the final destination.

In conclusion, this work presents an opportunity for further investigation into the prevalence of such factors during the process of route choice. The drawbacks of this investigation should be tackled at the next iteration and the study extended to account for individual variation and traffic dynamics. Other measures, relating also to the city configuration, should also be investigated for correlation with these data. Of particular note may be that of travel time, an improvement upon shortest metric path and also widely employed within transportation modelling. By extending this work it may be possible to begin to draw clearer trends with regard to the most important measures employed by drivers and how the influence of these parameters vary with space and time.

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