Human behaviour modelling using gaming software

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HUMAN BEHAVIOUR MODELLING USING GAMING SOFTWARE

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ABSTRACT

An important aspect of urban sustainability is concerned with the provision of urban transport systems that are 'inclusive' in that they allow full participation in society for older people and people with disabilities. Much can be achieved by improving the design of individual aspects of the transport system such as access into public service vehicles, but equally important is the appropriate design of transport interchanges where crowded situations add an extra dimension to the problems experienced by older and disabled people. Simulation of passenger flows is clearly a benefit in this respect but there is a need to understand and represent individual human behaviours that together form a dynamic interaction between individuals in crowded spaces. Behaviours have been studied and used in the generation of behavioural rules that have been incorporated in a simulation system based on software originally intended for creating computer games. The simulation has been used to study passenger flows at a major railway station and interchange.

1 INTRODUCTION

This research has its origins in a major research project known as AUNT-SUE (**A**ccessibility and **U**ser **N**eeds in **T**ransport for **S**ustainable **U**rban **E**nvironments) the aim of which was 'to develop a comprehensive "toolkit" that can be used at different scales, from city-regions down to the micro-level of streets, vehicles and facilities such as bus stops, signage and ticket machines. Central to its approach is the integration of policy, design and operations throughout the whole journey environment' (AUNT-SUE 2011). Within this broad project Loughborough University was responsible the creation of tools to assist in inclusive design from a physical perspective (HADRIAN – Human Anthropometric Data Requirements Investigation and Analysis (Marshall et al. 2010)) and I-Journey, a journey planner focused on the needs of the older or disabled passenger (Davis et al. 2009).

Many researchers have published work related to human crowd modelling where the objective is to study how a crowd of humans exhibit behaviours as a single entity rather than as individuals. This could be considered to be similar to the behaviour of a flock of birds or a shoal of fish responding to external stimuli. The crowd dynamics work of Still (2000) is typical of this area and has found use particularly in emergency evacuation situations. However, the main focus of the work reported here is the behaviour of individual human beings in crowded situations, where the interactions between individuals in localized situations is the focus.. Badler and Allbeck's (2002) use of 'agents' to represent human spatial behaviour based on age, gender, status, roles, culture and personality is typical of this approach.

A substantial part of the research is concerned with gaining knowledge of some of the characteristics of human behaviour that can be modelled in a virtual environment. The important aspect of this is that human behaviour is a significant issue when for example understanding how a disabled person in a wheelchair reacts to a platform while boarding a bus or how an elderly man manoeuvres while balancing his walk with a walking cane. This approach applies to the design of common facilities for ordinary people in their everyday life. For older people as an example, there is a need to know how they respond to the facilities offered such as disability toilets and lifts, procedures for boarding and alighting from public transport, access to shops and climbing staircases. In this way, it will be possible to gather information on the difficulties that they are facing and to investigate how the design of facilities might be undertaken to minimize these difficulties.

The research described here is concerned with observational studies to understand individual behaviour in crowded situations and building this acquired knowledge into behavioural rules that can be used within computer simulations based on commercially available gaming software. The outcome is illustrated with a case study based on a new situation at Paddington station in London.

2 OBSERVATIONAL STUDY

A major observational study was undertaken (Syed Shazali 2010) to understand and record the parameters affecting human behaviour in crowded situations. Security issues precluded such a study at transport interchanges such as railway stations so the study was undertaken at two shopping centres in Loughborough (Figure 1). At each centre weekday and weekend video observations were conducted on Wednesdays and Saturdays with hourly sessions to cover early mornings, lunch hours and late afternoons. Subsequent analysis of the video recordings resulted in information on a total 17,062 individuals. These were classified into nine categories: older people (8%), disabled older people (1%), adults (63%), disabled adults, adolescents (18%), disabled adolescents, children (5%), disabled children and toddlers (under three years old) (3%). The characteristics examined were walking speed (average, slow, fast, very fast), behaviour (passing through, window shopping, going to store, U-turn) and the relationships between the categories of people and speed/behaviour.

Figure 1: Lunchtime crowd, Carillon Court Shopping Centre, Loughborough

3 BEHAVIOURAL RULES

The observational data was used in constructing behavioural rules which are aimed at the individual reaching some objective whilst avoiding objects in the environment (static obstacles) and other people moving about the space (dynamic obstacles). The avoidance behaviour was characterised as consisting of four phases: *traversing* (walking at various speeds), *looking* (for obstacles ahead), *thinking* (decision-making) and *action* (the movement executed).

4 SIMULATION

The rules generated from the observational studies were implemented in DarkBasic Professional (Harbour et al. 2003) a commercially available game programming system. This software is object-oriented and allows agents (individual humans in this instance) to be given individual speeds, behaviour characteristics, starting points and end objectives. Initially avoidance rules were also implemented in the software but eventually these were replaced by the system's own procedures (part of the DarkAI system). Testing was conducted by building models of the physical environment and observing the behaviour of the virtual humans. Figure 2 shows a simulation of a shopping centre with the different coloured objects representing humans with different characteristics.

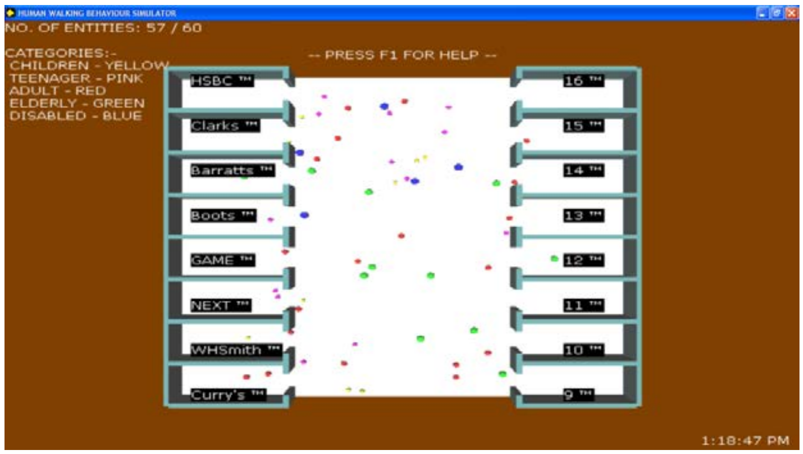

Figure 2: DarkBasic Simulation of Carillon Court Shopping Centre

5 CASE STUDY

A more substantial case study was based on London Paddington station which has high traffic, problematic areas, bottlenecks and the potential for layout re-design. During December 2009, work was completed on major modifications to the Circle Line which have had a dramatic effect on passenger usage of Paddington's multiple underground stations. As the main underground station, located at the front of London Paddington no longer accommodates Circle Line trains eastbound further than Edgware Road, passengers must alight and change trains to continue into the centre of the city. This has encouraged passengers to instead use the much smaller underground station to the far end of the rail station which used to accommodate Hammersmith & City Line trains only. This station now provides Circle Line trains both west to Hammersmith and east into the city centre alongside the existing Hammersmith & City Line. This underground station is accessible by the bridge that spans the station width at the far end of the platforms and is ill-equipped to accommodate the increased level of passenger activity in both directions. As such there are major bottleneck issues getting into and out of the station from the limited barriers available on and off of the platform via the bridge.

Work is also due to commence on the construction of the new Crossrail station under London Paddington in September 2011. The new underground line will again influence the layout of the building and the movement of people within. Such major changes within the station highlight the potential requirement for such a simulation to make observations of crowd flow and to ensure the safe management and welfare of the public using the building.

Figure 3 illustrates the area modelled within the simulation environment and a schematic produced in the Solid Edge CAD package. The red and blue sections indicate the station walls and obstacles within the model respectively; representing retail/food outlets and ticket/rail services. The dark grey areas indicate the rail tracks, also treated as obstacles with the remaining light grey sections within the environment indicating the areas in which entities can move and interact.

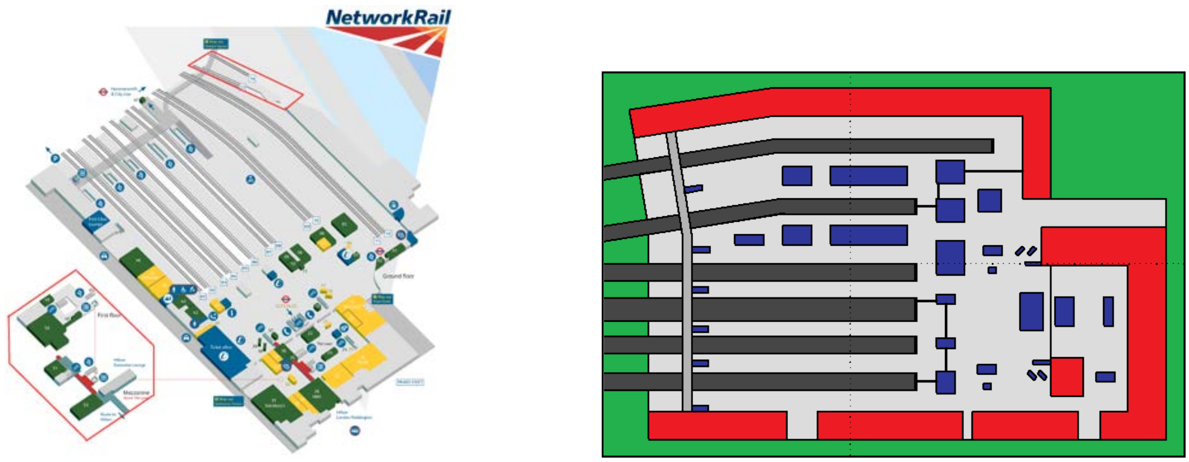

Figure 3: Paddington Station Map (Network Rail 2010) (left) and Solid Edge schematic (right)

Between April 1st 2009 and March 31st 2010, London Paddington recorded 29,104,198 passenger entries and exits (Delta Rail 2011). This equates to approximately 79,700 passengers per day assuming an even distribution over the year. In order to ensure a valid simulation statistics were gathered from the National Rail Travel Survey (Department for Transport 2011). Data from this survey were used to provide percentages for passenger journey purpose separated into different scenarios; Commuting (69%), Business (12%), and Leisure (19%). As commuting journeys occur at specific periods during the day (Figure 4) and leisure journeys more predominantly between these periods, these formed two separate and distinct scenarios for the simulation. Business journeys were grouped together with commuting journeys to create a new distribution of 81 per cent to 19 per cent. Figure 4 illustrates the distribution of rail journey purpose by departure times.

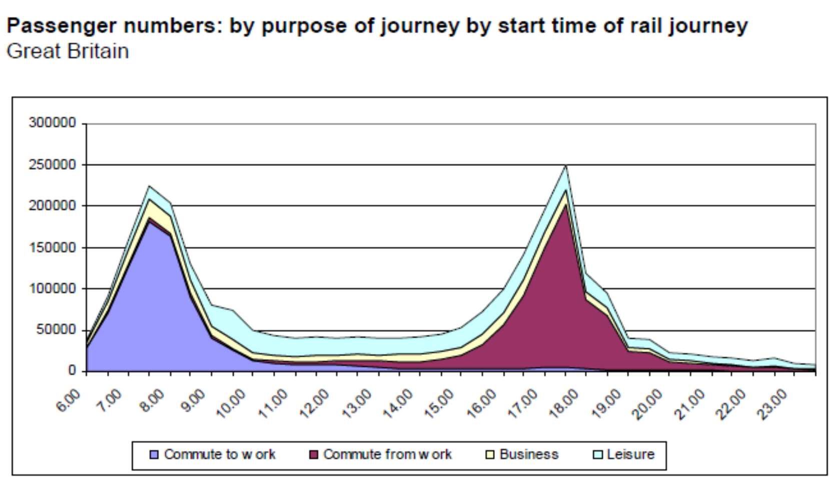

Figure 4: Rail travel journey purpose by departure time. Taken from the National Rail Travel Survey, Overview Report (Department of Transport 2010)

By using the value of 79,700 entries and exits through London Paddington per day, rough numbers of entities could be calculated for the simulation. Dividing the value by 18 would give an approximation on the number of passengers in the station over an hour; this is based on the sample obtained in Figure 4. This equates to over 4400 passengers over the course of one hour. In order to ensure that the simulation would run smoothly, efficiently and as quickly as possible, that the snapshot of entities in the station at one time were narrowed; the final number of entities within the simulation were 1500 for the commuting and business journey scenario and 1000 for the leisure journey scenario.

The four different groups were represented within the simulation based on the data available; adults, young persons, older people, and the disabled or adults with infants. The final group unfortunately cannot be based on any statistics within the survey as it is not based on age but on mobility. Due to the lack of information available for the volume of passengers using trains with reduced mobility; disabled travellers using a wheel chair or adults with children and/or infants in pushchairs this group were added to the system as a small percentage. The percentage were selected to reflect the small volume of travellers with reduced mobility but it was significant enough to represent the group realistically within the simulation.

The volume of entities for each group within each simulation was selected and finalised based on the data collected in the previous tables taken from the National Rail Travel Survey. The number of entities in each group is outlined in Table 1. Behavioural characteristics of the four groups were represented by the speed range of the entity (Table 2) (Syed Shazali 2010).

Table 1: Number of entities per group for each scenario

Group	Commuting	Leisure
Adults	1365	740
Young Persons	105	80
Older People	15	170
Disabled and Adults with Infants	15	10
Total	1500	1000

Table 2: Walking speed by classification

Classification	Walking Speed km/h
Slow	< 4.5
Average	4.5 – 5.6
Fast	5.6 – 7.2
Extra Fast	7.2 – 14.76

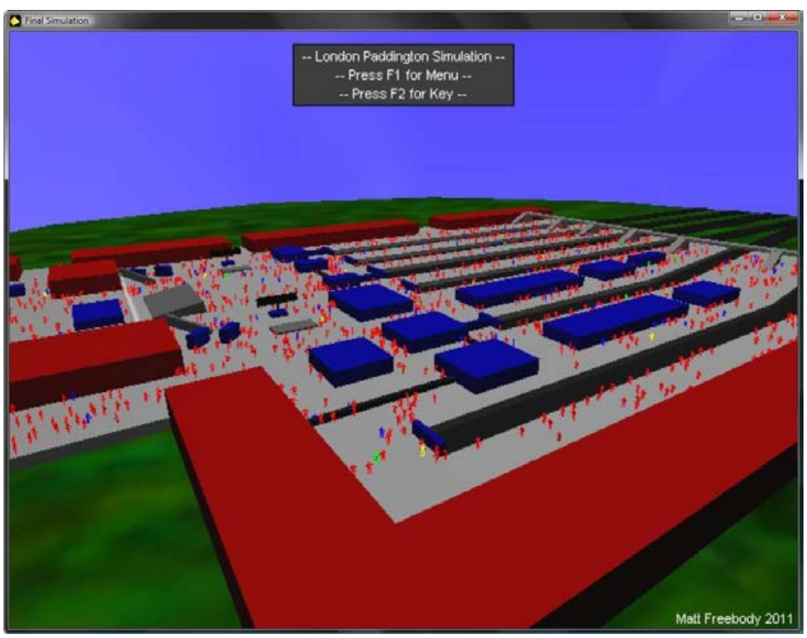

Figure 5: Screenshot of Final Simulation running.

It was considered very important that the final simulation (Figure 5) incorporated the following:

- A realistic environment which could be related to a real-world example.

- Obstacle and collision avoidance.
- Realistic entity destination selection and route decisions.
- A user interface to select either a peak or an off-peak simulation scenario.
- Incorporation of realistic behaviour rules to different groups of entities.
- Introduction of a realistic number of entities for the simulation scenario selected.

6 CONCLUSION

The simulation provides a pictorial and dynamic representation which gave qualitative assurance that the real situation was being represented to a reasonable degree. No formal verification has been possible although earlier work involving simpler and more controllable scenarios provide convincing evidence that with fine-tuning these simulations can provide valuable information to planners and designers. Again, it has not been possible to vary the physical environment of Paddington station so that comparisons can be made between predicted and actual outcomes. However ongoing work is concerned with transferring the observation and simulation approach into a more controllable environment which is much more like a laboratory scenario.

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Department for Transport. 2010. *National Rail Travel Survey – Overview Report.* Figure 2 - *Passenger numbers: by purpose of journey by start time of rail journey*. Available via *http://www.dft.gov.uk/pgr/statistics/datatablespublications/railways/nrtsupdate.pdf* [accessed May 15, 2011].

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