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Pedestrian Behaviour Modelling:An Application to Retail Movements using a Genetic Algorithm

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This paper introduces pedestrian movement modelling which incorporates ideas about agent-based systems and utility-maximization theory. The approach used in modelling is a simulation based on *Genetic Algorithms (GA)* which represents retail movements of shoppers in a large shopping centre. The aim of this simulation is to examine the applicability of one of the basic assumptions in existing models of spatial behaviour; the route with the shortest distance maximizes the utility of each pedestrian's travel.

Although *shortest-path* models have been widely used in traffic management to predict routing behaviour, there is considerable erratic behaviour in urban areas; shopping migration behaviour, for instance, can not be easily explained by such models. Thus, it is important to identify other possible influential factors on their utility maximization process in order to develop more explicable models for pedestrian movement. GA is a suitable measure to generate optimum solutions and for spatial structure, can be adopted for *learning and adoption* process in agent-based model (Iba, 1999). In this study, we implement a simulation model using the *shortest-path* model as one evaluation criteria of GA and test the accuracy of the routes estimated. This simulation system will be used as a platform for further modelling. We then suggest several requirements for new models through comparisons between the computed routes based on this simplified assumption and the actual routes that shoppers take. The modelling process is summarised in Figure 1 below.

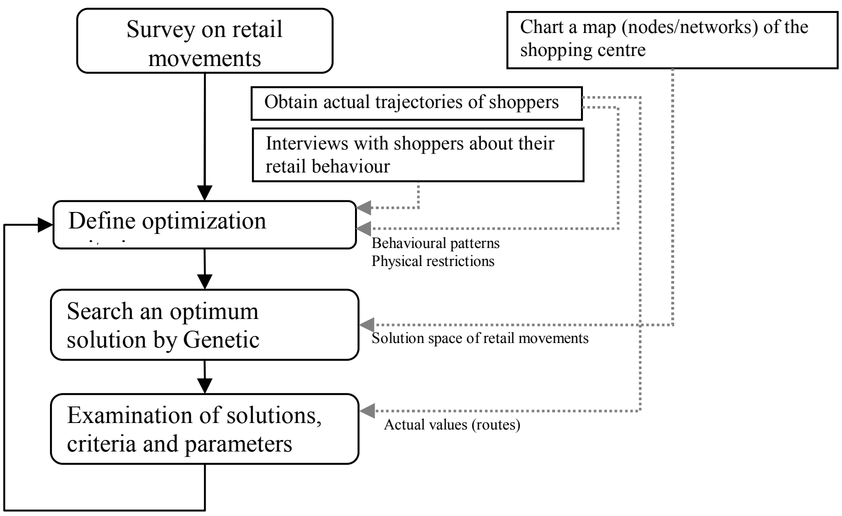

Figure 1 Flow chart of the modelling process

The test samples were from a series of surveys on retail movements undertaken at a large shopping centre in Tokyo, Japan. The centre is composed of more than 140 young-women-oriented shops, and this allows us to simplify the analysis by eliminating the influence of age and gender on behavioural patterns. 18 female shoppers were then asked to shop around for 2 hours and the routes they took were tracked and recorded. In order to obtain as much detailed data as possible, digital video cameras were used as the main sensors in this study. Figure 2 shows how retail movements are represented as a genome sequence in the GA simulation associated with the map of the shopping centre which is described as a collection of nodes and links, each of which has its unique ID number. From the video images, the node that is closest to the shopper's location was identified every 30 seconds so that the route could be reconstructed. This time resolution is fine enough to cover 90% of nodes that were visited. Every survey was followed by an interview with respect to the spatial knowledge of the participants and, if any, schedules or plans for shopping. The same surveys were conducted once every two weeks from 18/11/2002 to 10/01/2003.

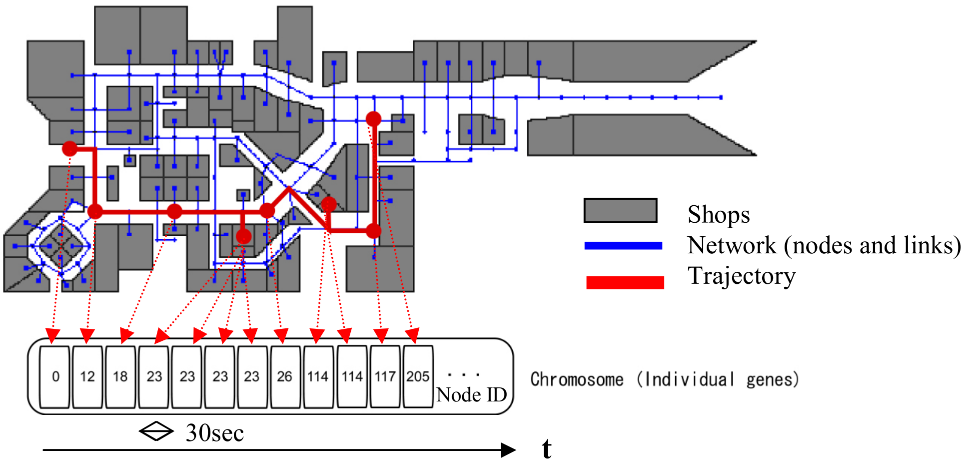

Figure 2 Representation of shoppers' spatio-temporal location by Genetic algorithm

The basic structure of GA simulation system implemented in this study is an expansion of integrated spatial data representation systems developed by Sekimoto(2001) and Tanaka(2003), which reconstruct pedestrian's trajectories from fragments of location data, aggregated data of traffic volumes, and common knowledge about human behaviour. The total value (*V*) is expressed as weighted linear sum of all evaluation functions and the solution and parameters which optimize *V* are searched by the system where the objective function is defined as:

$$\max V = \sum_{i=1}^{N} a_i \cdot x_i \qquad (x_i: \text{Evaluation function for model } i \quad a_i: \text{weighting parameter for } x_i)$$

The evaluation standards in the system include:

- Physical restrictions of movements (walking speed, rotation angle, limited vertical movements)
- ID of nodes which were actually visited by shoppers
- Origin and Destination of the travel
- Travel distances (the shortest-path model)

We conclude the paper with a critique of the model and proposals for future research.

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