MovementMapper: the movement simulation of visitors in nature areas

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Introduction

The movement of visitors in nature areas is influenced by a variety of factors that consist of collective characteristics such as the average number of visitors to a park, different types of visitors, and their typical destinations, as well as individual characteristics of an individual visitor's expectations, motivations, activities, duration of stay, and trip itineraries inside a park. Therefore, it is important to simulate an overall picture of a visitor movement (macroscopic level) in accordance to the individual physical mobility and cognitive capabilities (microscopic level). In the first case, movement is represented similar to that of gases or fluids at a macroscopic scale, where partial differential equations describing density and velocity change over time are used to characterise streams of pedestrians as analogous to river beds (Henderson 1974). However, these equations are usually complex and computationally intensive. On the other hand, research has also been focused on modelling pedestrian movement as a set of individuals. In this case, the models are considered microscopic since the movement emerges from the complex interactions between many individuals with their surrounding environment. Some examples include models using social forces (Helbing & Molnár 1995), gravity measures (Ubøe 2001), utility calculus based on personal preferences (Taczanowska et al. 2008), floor fields (Burstedde et al. 2001), prisms (Miller 2004) and agents (Batty 2003). Most of recreational simulation models have been developed to deal with one specific level in particular (Skov-Petersen 2005).

This paper describes the MovementMapper tool that encompasses a synergetic approach in the prediction of visitor movement in nature areas. At the macroscopic level, a visitor movement is represented by a movement surface which follows the analogy of the flow of water in gravity models. In contrast, our tool also belongs to the microscopic model category, where visitors interact with their surrounding environment by making a sequence of decisions according to utility measures, which in turn, generates individual trajectories. This synergetic approach has been founded on three modelling phases as previously proposed by Peuquet (1994) and Kavouras (2001). These phases are exploration, reasoning and prediction.

During the exploration phase we have focused on the abstraction of acting classes in visitor movement. They represent the visitors and their preferences, the physical environment where their movement takes place, and the time period when their movement occurs. In the reasoning phase we have inferred the behaviour of these classes through a prediction reasoning task that considers whether certain conditions hold at a certain time after the occurrence of a particular event. An interaction function tries to systematically capture the continuity of movement in the neighbourhood space where interactions between a visitor and the environment are taking place over time.

Finally, in the prediction phase, our model forecasts the movement surface? at the macroscopic level as well as individual trajectories at the microscopic level. The movement surface defines the most probable regions (i.e. cells) to form part of a visitor movement considering a pre-defined origin, destination and time budget. In contrast, an individual trajectory is the result of the simulation of the decision making process carried out by a visitor as he moves around a nature area. The actual displacement of visitors recorded in the Dwingelderveld National Park in the Netherlands were used to validate the simulated trajectories generated by the proposed tool.

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