

Chapter 5

Developing an Interactions Ontology for Characterising Pedestrian Movement Behaviour

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ABSTRACT

Since the introduction of Time Geography, the literature has witness a growing interest in representing and understanding human movement and its relationship with the environment. Although recent technology in personal tracking devices brought new potentialities in collecting and representing individual movements, methods to deal with the complexity and dynamism of collective movements are still lacking. This chapter introduces a spatial knowledge representation for the conceptualisation of pedestrian movement as a complex system based on the interactions. Movement interactions are defined and classified to represented global characteristics of the movement as emergent properties other than as a set of individual properties. The devised approach is exemplified through a case study on characterizing visitor behaviour in the Dwingelderveld National Park in The Netherlands.

INTRODUCTION

The interest in representing the movement of people in order to understand their relationship with the environment dates back to the '70s, when Hägerstrand posed the basis of Time Geography. He studied the space-time path of individuals to identify the spatial and temporal constraints that characterise human movement (Hägerstrand, 1970). This idea has proved very suitable to represent the

individual movement as an essential relationship between an individual and the environment, as well as between individuals. Moreover, analysis of pedestrian movement has been widely recognised to be essential in understanding human behaviour (Blythe, Miller & Todd, 1996). The space-time paths used by Hägerstrand (i.e. trajectories) have become the most common representation for human movement, due in part to its intuitive visualisation and interpretation, but also to its feasibility to directly represent data from tracking technologies. As a result, several technologies and tools have

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been developed for the collection, storage and recovery of large trajectory data sets (Güting & Schneider, 2005; Manco et al., 2008; Ortale et al., 2008; Pfoser & Jensen, 2001; Renso et al., 2008), analysis (Andersson, Gudmundsson, Laube, & Wölle, 2008) and visualisation (G. Andrienko, N. Andrienko, Kopanakis, Ligtenberg, & Wrobel, 2008). Although trajectories have proved to be useful in representing the movement of individuals, they seem to be an inadequate representation to deal with the complexity and dynamism of collective movement and the interactions that are the cause and the consequence of it. For example, the spatio-temporal path of an individual would have different meanings depending on the presence or absence of other individuals as well as the relationship of the individual with the environment; the trajectory-based representation is not enough sophisticated to represent these different meanings. This idea will be further developed in the next sections.

Our research assumption is that this limitation arises from an underestimation of the representation's roles and implications. Davis stated in (Davis, Shrobe, & Szolovits, 1993) that a "knowledge representation" has five roles that should be taken into account: a surrogate for the real world, a set of ontological commitments, a fragmentary theory of reasoning, a medium for efficient computation and a medium for human expression. We believe that the broad use of the trajectory-based representation has led to an underestimation of some of these roles. Mainly, the ontological commitments of this representation (i.e. what is represented and what is not) have been undervalued. For example, there is a commitment that the movement of an individual starts at the first point of the trajectory and ends at the last point, and that the whole movement can be represented as an interpolation of the intermediate points, which is not necessarily true. Another commitment is that intermediate points would represent either stops or moves, but this distinction, although intuitive, is not always precise, since individuals are hardly ever still and

therefore the conceptualisation of stops depends on the scale. Consider for example, a commuter's trajectory: It would have long stops (i.e. home, office) and short stops (i.e. kiosk, traffic lights), but the people are not completely static in these places and it would even be interesting to represent the movement inside those "stops". As we can see, these commitments limit the possibilities of the representation.

The main contribution of this chapter is the description of a Spatial Knowledge Representation for conceptualisation of pedestrian movement. Indeed, pedestrian movement can be conceptualised as a dynamic complex system based on the interactions that happen between individuals as well as between individuals and the environment in which they move. This conceptualisation becomes useful since it allows for the representation of some global characteristics of the movement as emergent properties rather than as a set of individual properties. Moreover, it emphasises the feedback effects of the movement of a pedestrian on other pedestrians and the environment. These characteristics and effects are the basis of the interactions based representation.

This representation is formalised according to the five previously mentioned roles. However, special emphasis will be placed on the first three roles, which allows us to answer the following questions:

- What are the movement interactions?
- What elements and relations are important to consider?
- How can we interpret them?

On the one hand, we propose a simple taxonomy of pedestrian interactions and we show how this taxonomy can be part of an ontology of interactions, where concepts like Context, Behaviour and Patterns are combined to offer a more general understanding of the essence of pedestrian movement behaviour. On the other hand, we have developed an ontology of pedestrian behaviour

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