Chapter VIII
Towards Simulating Cognitive Agents in Public Transport Systems

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ABSTRACT

In this chapter, the authors present a methodology for simulating human navigation within the context of public, multi-modal transport. They show that cognitive agents, that is, agents that can reason about the navigation process and learn from and navigate through the (simulated physical) environment, require the provision of a rich spatial environment. From a cognitive standpoint, human navigation and wayfinding rely on a combination of spatial models ("knowledge in the head"), (default) reasoning processes, and knowledge in the world. Spatial models have been studied extensively, whereas the reasoning processes and especially the role of the "knowledge in the world" have been neglected. The authors first present an overview of research in wayfinding and then envision a model that integrates existing concepts and models for multi-modal public transport illustrated by a case study.

1. INTRODUCTION

In transport planning, simulation is an established tool and traditionally comprises four sequential steps: trip generation, trip distribution, modal choice, and traffic assignment (Ortuzar, 2001). These macro-models were critiqued, mainly for the strict sequence of the steps (re-planning is not possible)
Towards Simulating Cognitive Agents in Public Transport Systems

and the strong focus on individual motor car traffic (Meier, 1997). In contrast, simulations of public transport systems require an integration of different modes of transport, where each mode has specific properties and peculiarities.

The current trend in traffic simulation is towards activity oriented micro simulations and the inclusion of other modes of transport besides private cars (Widmer, 2000; Nagel, 2001; Raney et al., 2002a). Raney et al. (2002b) simulate the navigation of many travelers at once, which is needed to forecast the load on the transportation networks (Nagel, 2002). The focus in these simulations is on properties of the whole system (traffic loads, traffic flows), not on the individual traveler. However, when more than one mode of transport is involved, the cognitive processes of the individual traveler clearly matter. Hence, there is a need for models that handle the details of transfers between different modes of transport and provide agents with minimal cognitive processing capabilities.

We simulate the navigation process from the perspective of the user of the public transport system. The focus is on the user as a cognitive agent, i.e., an agent who can reason about the navigation process and navigate through and learn from the environment. From a cognitive standpoint, human navigation and wayfinding rely on a combination of spatial models (“knowledge in the head”), (default) reasoning processes, and knowledge in the world. There is a consensus in the spatial cognition community that many different models exist, but that there is a need to integrate them before the whole navigation process can be adequately described. Up to date, no integration effort has been undertaken because of the diversity of the existing models and theories.

Our goal is to design a modular system/framework in which different theories (and their resulting models) can be tested. The idea is that the system will allow the exchange of modules (implemented models) according to which theory currently prevails and for the purpose of comparing different approaches. Currently, many theories of spatio-temporal knowledge processing are known from research in psychology, geography and robotics, but they exist in separate models or even separate research communities. There are computational models for navigation or aspects thereof, which were built for the purposes of either proving psychological theories or for the purpose of robot navigation. As we will discuss in section 3, none of these models can be used for our specific case, although we build on insights from the TOUR (Kuipers, 1979) and NAVIGATOR models (Gopal et al. 1989). A multi-agent simulation system where each agent has cognitive and spatial processing capabilities seems to be an ideal basis for integrating models of navigation and test their effectiveness.

We will thus use a multi-agent methodology to simulate the complete navigation process, i.e. the wayfinding and the locomotion processes for a public transport system. This is different from other approaches where either the wayfinding aspect alone is modeled for a single agent (Raubal, 2001; Frank, 2001; Pontikakis, 2006) or the research is focused on pure locomotion described as physical models (e.g., Helbing & Molnar, 1995; Raney et al., 2002a). The integration of existing models will be a challenge in itself – thus we will work with a case study of navigation in a public transport system and especially with a study of the transfer process. The need to transfer from one means of transport to another at a specific time and place is mentioned as stressful by 70% of public transport users in our case study; 50% admitted to being annoyed by the need to transfer and 63% would rather travel a longer route than transferring (Heye, 2002).

The spatial and spatiotemporal reasoning processes during the transfer situation are rather complex (Raubal 2001; Heye & Timpf 2003). Formally modeling the basic process is possible and revealing (Rüetschi 2007). Such a model forms the basis for a multi-agent model of public transport. Navigation is an integrative process and requires many different sub-processes, which are well researched. An in-