Shortest Path in a Multi-Modal Transportation Network

Agent Simulation in a Product of Two State-Transition Networks

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Location Based Services that assist travelers in wayfinding are a prime application for expert system techniques. The use of public transportation leads nearly always to a combination of different services from different transportation companies (multi-modal transportation). Information systems must combine data for the different services and produce advice to navigate in space and to obtain the right tickets, reservations, etc. This information can be seen as the combination of two (or more) state-transition diagrams: one for the spatial navigation and one for the business (ticketing, validation, reservation) rules. A (categorical) product combines two state-transition diagrams. The implementation is immediate using an intuitionistic logic reasoner built into the programming language, which infers typing for second order, polymorphic functions and allows their safe execution. The shortest path algorithm in this combined network produces sound advice and reminds the user to acquire tickets and plans the necessary navigation to ticket vending machines, etc. The analysis shows how to specify the connections between the two graphs optimally. The approach combines typical expert system technologies like inference engines with object-oriented programing; recent advances increase the level of reasoning possible during compilation. The use of a high-level programming language with substantial inference power facilitates the formalization of domain knowledge and is a viable alternative to the classical expert system architecture.

"(Playing Chopin's etudes) taught me a lifelong lesson: that phenomena perceived to be magical are always the outcome of complex patterns of nonmagical activities taking place at a level below perception. In other words, the magic behind magic is pattern." Douglas Hofstadter, SCIENTIFIC AMERICAN, April, 1982, p. 17.

1 Improve the Quality of Mobility with Advice to Users of Public Transportation

It is widely accepted that individual car transportation is not a viable solution to increase and improve mobility in European cities, but to entice people to use public transportation is notoriously difficult. The standard argument is that public transportation is not available when and where it is required, which is certainly true for some mobility demands, but investigations show that many potential passengers do not use public transportation even when it is available. The simple reason: potential users do not know when and where public transportation is available and how they could use it; they lack information about schedule and the–often complex–tariff and ticketing rules. Location based services provide the information when and where it is necessary.

In most cases, the information is available and can be found on the web; most public transportation companies publish their schedules and line maps with stops. Public transportation combines in all but the most simple cases several services from different providers. I considered recently a trip from Vienna to Tangier and a combination of a direct flight to Malaga, a bus to Algeciras, and the ferry to Tangier seemed more attractive than the unreliable multi-stop flight to Tangier. I realized quickly that combining the different schedules and rules was nearly impossible. The schedules and line information for the different transportation companies involved in a trip are not coordinated and the effort to collect the information and patch the trip together is a complicated task. An intelligent method to combine the available data and produce the information necessary for the user for the whole trip–door to door–and including ticketing rules, reservation system, etc. is a perfect application for artificial intelligence.

The scientific goal of Pontikakis [Pon06] was to understand how to combine spatial navigation (Figure 1) with the "navigation" of the state-transition diagram of the public transportation business rules (Figure 2). An agent simulation demonstrated the typical problems; e.g., how to plan locomotion such that travelers stop at convenient places to buy tickets they need later. Travel agents, railway information staff are the experts that know how to paste together the various data pieces found in published schedules. Some expert systems exist for such applications, for example the widely used web pages of European national trains services, which use a European knowledge base of scheduled transportation. The knowledge base includes hints about distances and time necessary to change between stations, etc.–lacking are mostly the reservation and ticketing rules.

To construct an intelligent advisor for multi-modal, public transportation requires data about schedules, ticketing, connections between services, etc. and a method to combine these data for use by a shortest path algorithm. The contribution here focuses on an abstract description of the method to combine navigation and business graph; and how it is accessed by the shortest path algorithm. Descriptions of the form in which the data must be provided, or specifica-

Auszug aus: Künstliche Intelligenz, Heft 3/2008, ISSN 0933-1875, BöttcherIT Verlag, Bremen, **www.kuenstliche-intelligenz.de/order**