Adding BDI Agents to MATSim Traffic Simulator (Demonstration)

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ABSTRACT

MATSim is a mature and powerful traffic simulator, used for large scale traffic simulations, primarily to assess likely results of various infrastructure or road network changes. We have coupled MATSim with the BDI system GORITE to provide additional valuable functionality within MATSim, and have demonstrated this with an application combining BDI taxis with standard MATSim traffic agents. Although standard MATSim agents all have individual plans regarding their behaviour, this is fixed in advance, and cannot be modified during the simulation of a single day, depending on emergent situational phenomena. This limits its usability for a range of applications, such as evacuation planning. In addition, the plans of MATSim agents are very simple, being limited to sequences of activities at different locations. In this work we extend the capabilities of MATSim to allow agents to respond intelligently to emergent environmental phenomena.

Categories and Subject Descriptors

I.6.8 [**Simulation and Modeling**]: Types of simulation—*Combined, Distributed, Traffic simulation*

General Terms

Design, Algorithm, Experimentation

Keywords

Distributed Simulation, Model Integration, Agent-based Simulation, Traffic simulation, Intelligent reactive agents

1. MOTIVATION

MATSim is an agent based simulation tool which models traffic scenarios[1]. It is designed for finding stable traffic patterns over many iterations/days. In order to achieve this, its framework contains four successive processes:

- Demand modelling, i.e. taking travellers (agents)' daily activities (plans) such as "at work" and "at home" attributes as the input to set up the simulation,
- Simulating each agent independently during each one day iteration,
- Scoring plans based on their quality, giving low marks for things such as arriving at the destination too late, and
- Replanning by gathering all of the low-scored plans and modifying them at the end of the iteration using genetic algorithms.

It terminates on upon reaching a stable state, when all agents are no longer finding any improved plans.

Based on its current framework, MATSim is very good for analysing traffic patterns for large-scale scenarios. For instance, it was used for the analysis of the placement of a new Berlin airport. However, it cannot be used for exploring problems such as evacuation in an emergency, which requires immediate response or replanning during an iteration, because the current MATSim replanning process is conducted at the end of a one day iteration.

Also, while each MATSim agent has its own individual plan, these are very simplistic sequences of activities and routes between those activities. In many applications, it is desirable to be able to represent at least some simplified reasoning of the agents, particularly if they are to be able to react to the dynamically changing situation. The capability to explore these problems (called within-day replanning in MATSim) would allow MATSim to be used to address a wider range of issues.

In this work we have taken the MATSim component that runs one iteration of the simulation (typically a day), and coupled it with a BDI platform, GORITE [2] for representing and executing the decision making of (some of) the MATSim agents. We have then developed a simple demonstrator where some of the agents do not have fixed daily plans, but are taxi agents, responding to requests arising, and determining their ongoing behaviour, depending on the situation. The demonstration shows how we have integrated these two systems to provide a powerful generic new functionality to MATSim.

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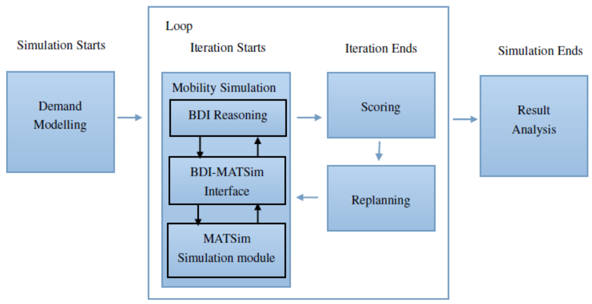

Figure 1: The enhanced framework which integrates the BDI reasoning during the MATSim simulation

2. INTEGRATION OF BDI INTO MATSIM

Firstly we explain the enhanced MATSim framework incorporating the BDI agent model, and then we describe the implementation of a taxi service which applies this enhanced framework, as our demonstration system. The BDI system allows an agent to decide what to do as the situation unfolds. We have modified MATSim so that the decisions made by the BDI agent system can change the agents' behaviours in MATSim during the execution.

Each BDI agent (in the BDI system) receives relevant information (percepts) from the environment (either MATSim based information, or information introduced from elsewhere such a requests for taxis), and determines what it should do. Actions (such as driving to a particular location), are then passed to the MATSim system, where the MATSim plan representations are edited to incorporate the newly made decisions. The basic architecture used for the communication and synchronisation between the two processes is based on that described in [4], where the JACK BDI system was integrated with Repast Simphony, a popular Agent Based Modelling and Simulation platform [3]. The BDI agent model is embedded into the Mobility Simulation process of the current MATSim framework, while the rest of the MATSim framework remains the same, as shown in Figure 1.

3. THE TAXI APPLICATION

To use this framework in an application, the percepts required by the BDI agents and the actions to be modelled in MATSim must be identified. To obtain the percepts and to execute the actions, we may need to add some functionality. In our developed taxi service example, we have implemented the action `DriveTo` for taxi drivers to obtain a route and drive to a given location for picking up or dropping off passengers. The route planning and route following functionality required for this already exists within MATSim.

In order to reason about whether to take an advertised job, the BDI agent needs to know whether he is close to finishing the current job. Consequently we implemented a small function in MATSim for a taxi to recognise when he is "close" to the destination (where "close" is configurable), and provide this as a percept. An additional percept is when a destination has been reached. Depending on the reasoning desired, recognition of slow moving traffic, or communication of temporary roadblocks, could also be defined as percepts, although for this demonstrator we kept things simple.

The Gorite BDI module contains the individual taxi agents, as well as the radio operator which dispatches jobs. This latter agent may well affect the simulation, based on such things as policies for assigning jobs. However, there is no need for any representation of this agent in MATSim, as it does not do any actions directly affecting the agents MATSim is simulating (the traffic). In our demonstrator, the taxi module is very simple, with a single operator and a constant number of taxis and distribution of arriving jobs. However, it would be straightforward to model a range of taxi specific policies and configurations, such as multiple competing companies, density of taxis at various times, time related fares, etc. that could impact and be impacted by the rest of the traffic simulation. The ability to keep this separate from the MATSim component supports and facilitates modularity, with all its known advantages.

4. CONTRIBUTION AND FUTURE WORK

The direct contribution of the work demonstrated here, is that it provides a clean and generic mechanism for two key improvements to MATSim:

- It allows agents to change their plans during a simulation iteration, rather than have these fixed for a day.
- It allows for more complex modelling of agents behaviours and decision making around these, using an intuitive representation of goals/subgoals and associated plans/recipes to achieve these.

These enhancements make MATSim suitable for use in a much wider range of applications than it was originally developed for.

Our future work is oriented towards a platform for integrating multiple components, and towards techniques for appropriate modelling and understanding of human behaviour in simulations.

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