Traffic simulation environment for Multi-Agent systems based on GIS

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1. Introduction

The main aim of this paper is to describe the simulated, simplified traffic simulation environment, where the particular methods are tested and developed. Since it is necessary to control the agents operating in space and time, a special field of interest is geo-informatics, which processes space-structured temporal data (also called geodata).

We concentrate on the development of the platform that affords a fine-grained natural-language analysis, specified in a formal language, which enables us to represent knowledge in the multi-agent world adequately. The external representation of the particular pieces of knowledge will make it possible to design intelligent and relatively autonomous systems that can and must communicate with each other in a (pseudo-) natural language.

Last, the analysis and synthesis of intelligent systems that can derive useful conclusions under incomplete or imprecise knowledge is also studied.

2. GIS data and demands on it's structure

In order to verify simulated behaviour of the agents in the real traffic flow it is necessary to create sufficiently precise model of the traffic infrastructure. Requirements on the model depends on the planned task for mobile agents e.g. overtaking, lane changing, crossroad priority etc. Because of such demands we have to design a data structure describing the road network up to the level of traffic lanes. Afterwards we need some geodata complying required data structure.

For our purpose is the best way to use data from the car navigation systems. This kind of data has both road elements geometry and detail attribute description of roads and crossroads. There is an information about number of lanes, road segments, lane types, traffic signs, restrictions, bridges, tunnels and many others. The navigation data storage is based on the GDF standard. For needs of our purpose at the first phase we use MultiNet data according to standard GDF version 4.0. This data isn´t fully suitable for the application in the area of the intelligent transport systems.

On the standard GDF concur NEXTMAP project, which extends description of the road infrastructure into the detail level such as the lane description. On that ground we try to use the ideas of NEXTMAP project for our application. Because the data corresponding with NEXTMAP structure doesn’t exist, it was necessary to complete

MultiNet data. There was a testing area of transport infrastructure selected, which was extended of the necessary data and is being used for the simulation now. There should not be a problem to use our simulation in other cases in the future.

Unfortunately, today's data does not fully contain all information defined in GDF 4.0. So we filled in missing attributes on the small testing road network around our university and this area is used for testing purposes of the simulation. There should not be a problem to use our simulation to other areas in the future.

Beside providing data for the simulation environment, the GIS is also a visualisation platform for results of simulation. These days, we already connected our traffic simulation with two GIS applications. The first one is open source GIS applications written in Java language and second one is commercial, broadly used applications ArcGIS of ESRI corporation.

Results of simulation are dynamically displayed on background 2D data layers

3. Simulation environment

The environment serves as a simulated world for the mobile agents representing the regular cars, trucks and other vehicles which can be found on the roads. They are able to move from one place to another and can perceive the environment and other mobile agents. The environment also provides information about the current traffic situation, congestions, traffic signs, number of lanes and their directions and other to the mobile agents. They are subsequently able to decide what to do and can adapt their current behavior according to the current traffic situation.

By a multi-agent simulation we mean a microscopic simulation that models each vehicle as an individual (mobile agent) with it's own unique behavior and properties. Each agent can thus have it's own strategy and driving style, which allows us to perform more realistic simulation. These agents are intelligent (they have long term objectives and strategies to achieve them) and they also have an internal representation of the world around them.

The simulation environment provides the mobile agent with all information needed to achieve their goals (shortest/fastest path finding, dynamic navigation, accidents warning etc.). So in this case the environment takes an active role in the simulation.

The system architecture is completely distributed. Each vehicle is represented by separate autonomous agent capable of communication with other agents in the system.

Because of demand on distributed architecture the simulation environment is designed to be agent. This approach allows us to deploy the environment and the mobile agents independently anywhere in the computer network.

The overall architecture of the simulation environment and the creation process is depicted at figure 1. Information about real world (roads, crossroads etc.) is stored as GIS data (Shapefiles or geographic database), subsequently transformed into internal object representation using programming language like Java or .Net. This object representation serves as virtual world for mobile agents (vehicles) moving through the road network.

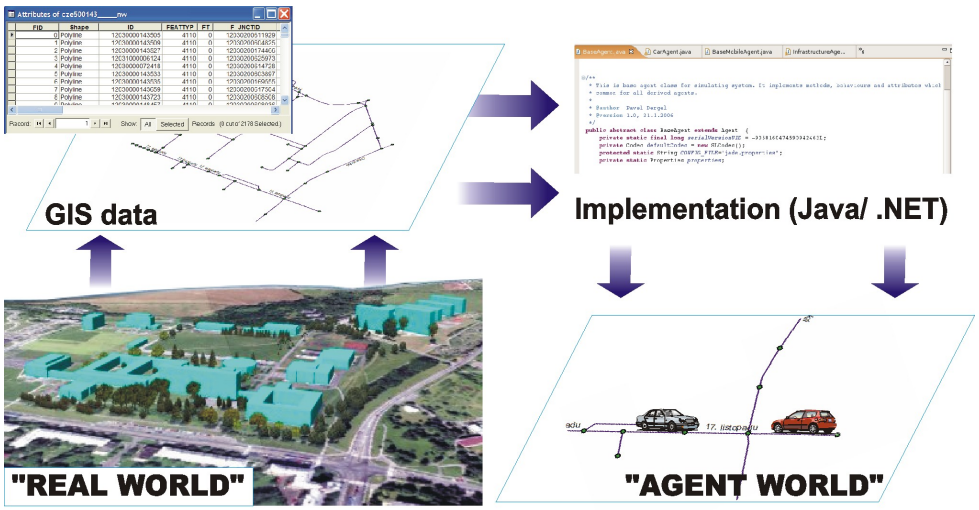

Figure 1: Simulation environment creation process

4. Practical applications

During the last decades, high growth in car use has resulted in a rapid increase of the traffic congestions. Congestion wastes fuel and increases air pollution due to increased idling, acceleration, and braking. Since driving time is a non-productive activity, congestion reduces regional economic health by increasing drive times.

Without better control road transport will be less effective and more dangerous especially in the big agglomerations. We already have some systems today that inform drivers about the situation on the road. But today's information systems only react to situations which already happened. When we improve the systems with some kind of predication we will be able to inform drivers and police in advance and avoid traffic collisions and accidents.

Intelligent traffic systems based on the MAS can be successfully used in following areas:

- **Rescue systems -** advanced navigation through the road network which will be able to avoid congestions and dynamically find the optimal route which can minimize the time needed to get to the place of an accident and help to save human lives.
- **Transportation of goods** - goods transportation and delivery in urban areas represents a significant problem for the majority of cities. The key to success for the delivery companies is to transport goods at the right time, as fast as possible and for the lowest possible price. Wrong timing and coordination results in increased expenses, higher traffic intensity etc. Intelligent navigation systems can help to improve this situation.
- **Security systems** - Preventive safety applications help drivers to avoid or mitigate an accident through the use of in-vehicle systems which sense the nature and significance of the danger, while taking the driver's state into account. Preventive safety makes use of information, communications and positioning technologies to provide solutions for improving road safety. With such technology, which can operate either autonomously on-board the vehicle or co-

operatively based on vehicle-to-vehicle or vehicle-to-infrastructure communication, the number of accidents and their severity can be reduced, leading to a decrease in the number of accidents.

5. Conclusion and future work

We have developed the multi-agent traffic simulation that allows us to solve simple tasks connected with road movement and navigation. The model represents a parallel world to the real road network which allows us to study the complexity of the traffic flow.

Computer simulation is a very useful tool for planning and predication of all kinds. If we collect enough data from the road sensors we will be able to simulate parallel traffic system. This virtual world can show traffic bottlenecks and other traffic problems. Moreover we may combine traffic information with for example weather forecasting, or other information sources to simulate the environment impact on the traffic situation.

Our future work includes the following tasks:

- Developing new agent coordination and cooperation methods which will allow agents to negotiate during the difficult traffic situations and find an appropriate solution.
- Improving navigation system for mobile agents by taking into the account factors like actual (and expected) traffic situations, surface conditions, accidents, throughput etc.
- Developing 3D visualization and a control system which will be used as the user interface.
- Improving the system performance to be able to run the simulation in real-time.

6. Acknowledgements

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