The Open Source Traffic Simulation Package SUMO

Daniel Krajzewicz[1], Michael Bonert[1], Peter Wagner[1]

[1]German Aerospace Centre, Institute of Transportation Research
Rutherfordstr. 2
12489 Berlin, Germany
{Daniel.Krajzewicz, Michael.Bonert, Peter.Wagner}@dlr.de

Abstract. Since the year 2000, the Institute of Transportation Research (IVF) at the German Aerospace Centre (DLR) is developing a microscopic, traffic simulation package. The complete package is offered as open source to establish the software as a common testbed for algorithms and models from traffic research.
Since the year 2003 the IVF also works on a virtual traffic management centre and in conjunction with this on traffic management. Several large-scale projects have been done since this time, most importantly INVENT where modern traffic management methods have been evaluated and the online-simulation and prediction of traffic during the world youth day (Weltjugendtag) 2005 in Cologne/Germany.
This publication briefly describes the simulation package together with the projects mentioned above to show how SUMO can be used to simulate large-scale traffic scenarios. Additionally, it is pointed out how SUMO may be used as a testbed for automatic management algorithms with minor effort in developing extensions.

1 Introduction

SUMO is the acronym for “Simulation of Urban MObility” and the name of an open-source microscopic, multi-modal traffic simulation package which is developed since the year 2000 by the Institute of Transportation Research at the German Aerospace Centre. The idea behind developing an open source traffic simulation was to support the traffic research community with an open simulation in order to a) make the results of investigations more comparable and b) ease the testing of algorithms developed within traffic research.
SUMO uses a very fast but still valuable (see [1]) traffic simulation model which allows us to run simulations of large areas faster than real-time. This capability was used within several projects which had been done in the last years to simulate large city regions such as the city of Magdeburg or the city of Cologne together with a larger area around it (see figure 1). The main topics of these projects were traffic management and traffic forecasting. These topics are the main research interest areas of a larger-scale project of the IVF, the TrafficTower, a virtual traffic management centre, and the TrafficTower project is meant to be a host for other projects that deal with traffic management in the future. We want to mention, that one of the sub-projects of the TrafficTower is training of human operators of real traffic management centres.

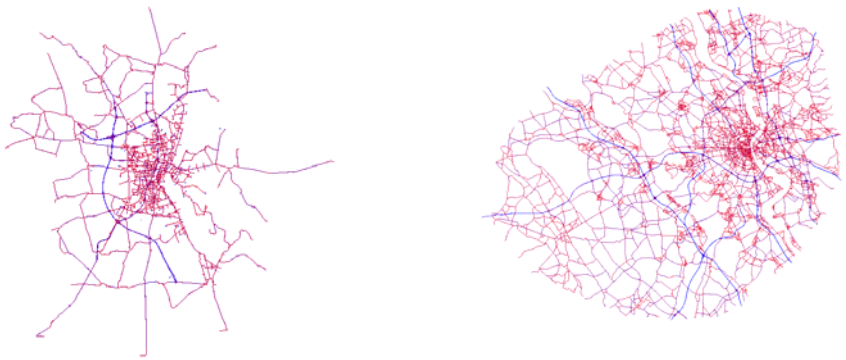

Fig. 1. Two example networks as simulated by SUMO; left: the city of Magdeburg from the INVENT-project; right: the area around the city of Cologne from the WJT-project

This paper is organized as follows: First, the SUMO-package is described and then the two of our large-scale projects which uses the software to show its capabilities. Then, we would like to describe ideas how SUMO could be used within the RoboCup community to simulate rescuing of persons and the reachability of places for rescue teams.

2 The SUMO-Package

SUMO is a microscopic and space-continuous simulation of vehicular traffic. That means, that each vehicle has an own route and is simulated individually. To simulate the vehicles' movements on the network, a model developed by Stefan Krauß ([2]) is used, a very fast but still good (see the comparisons of different models in [1]) model. This model uses discrete time steps of 1s. SUMO is very fast, around 100.000-200.000 vehicles can be simulated in real time on a desktop PC, including simulation of traffic lights, right-of-way rules and lane changing.
The package includes a set of applications used for different parts of preparing a traffic simulation. There are two different simulation programs, one running at the command line for in order to allow faster simulations and a second one which can show the simulation using the openGL-API. Two applications which allow generating networks in the format used by SUMO are included; one importing other formats such as NavTeq-databases or TIGER-maps, and one generating abstract, geometrical networks. Furthermore, the package contains a set of applications which allow computation of vehicle routes within a network, each being based on a different routing paradigm (see also [3]).
In accordance to the goals stated in the introduction, SUMO is available as open source at the open source development portal "sourceforge" (http://sumo.sourceforge.net). Also, the software was developed using standard c++ only making it portable among almost all systems, including MS Windows, Linux and MacOS.

3 Traffic Management Projects

The SUMO traffic simulation package has been already used within different projects including small-sized simulations for testing the possibilities of new traffic control systems (see [4]), and some simulations of larger areas. We want to point out two applications where whole cities have been simulated, in order to present SUMO's capabilities to be used as a testbed for rescue scenarios.

3.1 Simulating the City of Magdeburg and Munich

Within INVENT, our part was the simulation of the city of Magdeburg and the highway ring around Munich together with development and testing of modern traffic management scenarios. Besides implementing new types of traffic lights systems which adapt to the current traffic (see [4]), a traffic rerouting system based on dropping loads from the streets, a method formerly used within electrical engineering (power supply of large electricity networks), was implemented. The implementation required an extension of the simulation tool and one of the routing applications by the possibility to cooperate via a connection while running simultaneously.

During the simulation runs, the simulation part was sending information about the current state on the network to the routing application, which used this information to reroute certain vehicles and sending back the changed routes to the simulation. We could show, that an a-priori rerouting of vehicles around sudden incidents can highly reduce the amount of jams (see figure 2) and travel times.

Fig. 2. Comparison of the effects of an incident without an intervention (left) and two levels of load drop. (Red: high occupancy/jam; green: low occupancy)

3.2 Simulating the City of Cologne with Surrounding

The WJT (Weltjugendtag / world youth day) was a large happening organised by the catholic church which took place in the area of the city Cologne in Germany in August 2005. Together with the pope, over 1.000.000 participants took part at the ending ceremony which was located some kilometres apart from the city. A large part of these participants were using public transport systems, but it was unclear until the ceremony's beginning whether the situation on the streets can be handled.

The IVF was using about 1.000 highway detectors, about 100 city detectors and a zeppelin to collect data about the current traffic and used an extended version of SUMO to predict the situation in half an hour in the future. The situation was presented to the local authorities, police and the local traffic management centre, over a network.

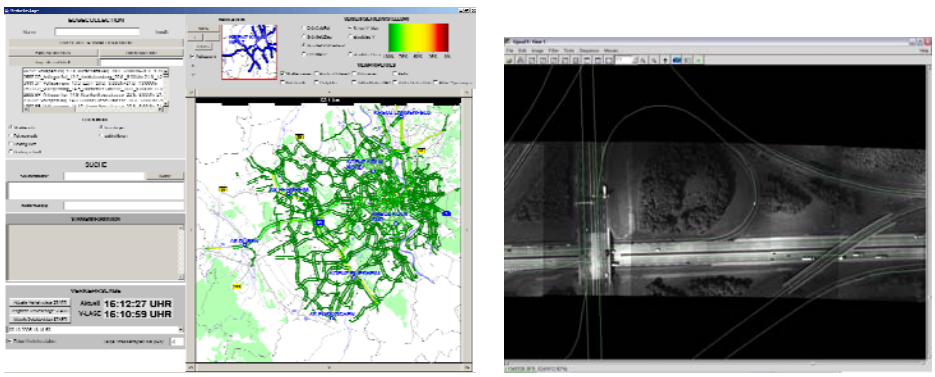

Fig. 3. Left: Visualisation of the area around the city of Cologne; Right: a mosaic generated form images collected from the zeppelin

4 Usage of SUMO for Rescue Simulation

Traffic management and simulation of catastrophe scenarios are meant to become the main topics within the IVFs internal project group “TrafficTower” – a virtual traffic management centre. While the SUMO package has proven its usability as a tool for plain traffic simulations in the past projects, we suppose further extensions will become necessary in order to make it usable for rescue and catastrophe simulations. We would now like to briefly describe what we think is needed for simulating rescue or catastrophe situations and present features already implemented in SUMO which should be needful these purposes. These “requirements” are rather meant to be a list of our ideas, describing what an application should be capable to do and should be used as a base for further discussions.

4.1 Requirements

Our idea of a catastrophe simulation is based on the simulation of normal traffic. Additionally, an incident must be modelled which yields in a reduction of the network. Such a reduction may be a discrete closure of streets in order to simulate smaller problems, such as the break of a pipeline, but may also be growing over time in order to simulate large catastrophes, such as flood situations.
In order to achieve his goals, the solver – either a human operator or an algorithm – should be able to perform actions on the simulation such as guiding special purpose vehicles to certain locations, closing or openings streets in order to control traffic, for example. The work of the solver should be rated by certain measures, such as the number of rescued persons, the number of still open roads etc.

4.2 Implemented Structures

Several needed things are already implemented. The simulation is capable to reroute vehicles by assigning them a new path to their destination or a completely new destination. Rerouting of vehicles can be triggered by an external application or at the graphical user interface. The simulation can also handle road closures, so that in conjunction with rerouting, situations where streets are blocked may be simulated.
The current work on SUMO concentrates on an implementation of multi-modal traffic, introducing trains and public busses into the simulation. Using such structures will allow simulating rescuing of pedestrians.

4.3 Missing

What is needed, are further interfaces to other applications, which should simulate the catastrophe itself and change the situation of the road network we use. On the other side of the process, the solver should be able to enter his actions. As said, this may be done for a large variety of actions already, but links to effects beyond the simulation of traffic are missing. If, for example, someone would like to simulate the usage of sandbags within a critical area during a flood, one would have to insert vehicles into SUMO and after they would reach their destination, SUMO would have to pass the information to another application which then changes the model of the flood.
Also missing are internal measuring methods to rate the performance of a solver.

5 Conclusion

Traffic management and simulation of catastrophe scenarios are meant to become the main topics within the next couple of years. Due to this, we are looking out for others who have already an expertise in these topics, wanting to share knowledge and technology.
Hopefully, it has been demonstrated that the traffic flow simulation package SUMO is a very interesting tool for simulating large traffic scenarios. Our own work with the software has proven that it is easily extendable, which makes it very interesting for other applications as well.

6 Further Work

The next extensions to the software will concentrate on finishing the work on simulating multi-modal traffic including trains and other public transport and on opening the source in order to ease implementation of own algorithms.
Although we are not yet working on explicit projects that deal with catastrophes, we suppose that some further work will be done in extending the model by a definition of goals and methods to determine how good they have been solved. This is meant to be an important aspect in training of human operators.

References

1. Brockfeld, E., Kühne, R., Wagner, P.: Calibration and Validation of Microscopic Traffic Flow Models. In: Transportation Research Board, Nr. TRB2004-001743, TRB Annual Meeting (CD-Rom), January 2004, Washington, USA, 2004
2. Krauß, S.: Microscopic Modelling of Traffic Flow: Investigation of Collision Free Vehicle Dynamics. DLR (Hauptabteilung Mobilität und Systemtechnik), 1998, ISSN 1434-8454
3. Krajzewicz, D., Hartinger, M., Hertkorn, G., Nicolay, E., Rössel, C., Ringel, J., Wagner, P.: Recent Extensions to the open source Traffic Simulation SUMO. In: Proceedings of the 10th World Conference on Transport Research (on CD), WCTR04 - 10th World Conference on Transport Research, Istanbul (Turkey), 2004-07-04 - 2004-07-08
4. Krajzewicz, D. Brockfeld, E., Mikat, J., Ringel, J., Rössel, C., Tuchscheerer, W., Wagner, P., Woesler, R.: Simulation of modern Traffic Lights Control Systems using the open source Traffic Simulation SUMO. In: Krüger, J.; Lisounkin, A.; Schreck, G. [eds.]: Proceedings of the 3rd Industrial Simulation Conference 2005, EUROSIS-ETI, S. 299 - 302, 3rd Industrial Simulation Conference 2005, Berlin (Germany), 2005-06-09 - 2005-06-11, ISBN 90-77381-18-X