The "Simulation of Urban MObility" package: An open source traffic simulation

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KEYWORDS

traffic simulation, road traffic, open source, car-driver model, traffic research

ABSTRACT

SUMO is the acronym for "Simulation of Urban MObility" and is an open source project concerned with the development and usage of a traffic simulation. The project is a part of our scientific work concerned with the verification of different microscopic models of traffic, and their comparison ([1]). Further, the traffic science community often involves ideas where each of them needs a traffic simulation to be validated. Over the time, many more or less sophisticated simulations have been developed to do this job. They mostly stay unknown. This approach is not only very inefficient as a traffic simulation has many things to regard; also, the results are often not replicable or at least hard to compare. When a common platform is supplied, such problems should not occur.
Within this publication, we would like to introduce our package to the public in the hope to gain some further interest.

INTRODUCTION

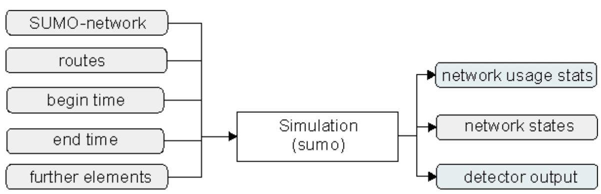
The development of SUMO began in 2001. With some experience in building simulation packages, namely FastLane ([4]), the main concepts were already known at the begin of the work. The simulation is based on the space-continuous, microscopic car-following model invented by S. Krauß. It is very well described and investigated in [8] and [5]. Other models that describe the movement of vehicles should be easy to implement. This is one of our main interests as one of our scientific topics deals with the comparison of traffic models regarding both their efficiency (execution time) and their ability to replicate the reality.
For a more detailed description of different models and model types, the reader is referred to [2] or to our internet pages, where you can find some models at the pages of the Clearing House for Transport Data and Transport Models [12] or some further SUMO-documentation describing it ([6] or [7]).
During the development two guidelines were followed. Firstly, the simulation has to be as fast as possible in execution. The current implementation is capable to simulate about 1 million of vehicles in real time on a 1GHz PC. The graphical user interface which uses the industry-standard library openGL [10] for visualisation is capable to deal with large city areas made up of several ten thousands streets on a normal PC without any problems and staying smooth. Further, the simulation shall be as portable as possible. Using the standard c++ language and open source or free libraries only, allows us to compile and run the package both under MS Windows and Linux and it should also be compilable when using SunOS or MacOS.

THE SUITE

The package consists of six main applications and some further helping programs. We will describe the main components.

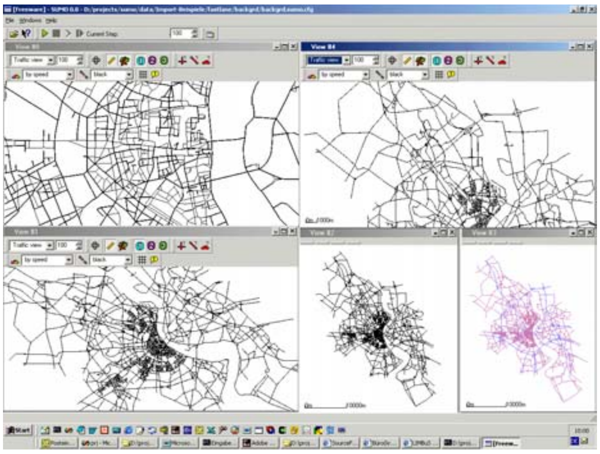
The simulation and its graphical version

The main application of the suite is of course the simulation itself. Two versions exist, a command line version without any visualisation, which is meant to be used during iterations when optimising networks without the need of interaction with a user. The graphical version is a little bit slower due to visualisation itself. As the graphical version is just an extension of the command line version, both applications use the same input and generate the same output.
Beside a network description, which has to be converted into a proper format using the net-conversion application, the routes the vehicles use and the vehicles themselves must be supplied to the simulation. As output, the simulation may generate aggregated street values such as the flow, the mean speed or the usage rate, discrete information about vehicles' positions and speeds, or simulated detectors such as induct loops known from real life or some more sophisticated detectors that cover longer surfaces of a street's part.



Data flow through the simulation module

The simulation handles multi-lane traffic with lane changing. No vehicle collisions occur under normal circumstances.



A screenshot from a simulation of the city of Cologne, the Centre of Applied Information Science is located at, showing different zooming scales and coloring schemes (down right: streets colored by the maximum speed allowed)

The network generator

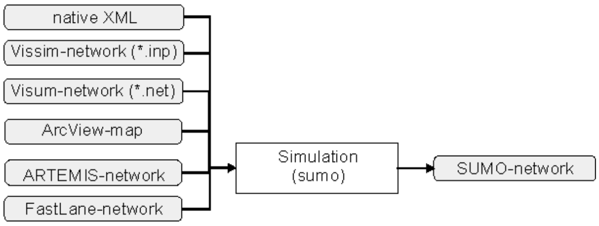
When dealing with large urban areas, no one likes to implement them street by street using an editor - beside the roads themselves, connections between them have to be specified and information about the traffic lights and right-of-way rules have to be set. To avoid such manual editing, our approach is to import digital maps and to automatically generate all information needed to describe the network.

This process is quite complicated, involving about ten steps for the computation of dependencies between the roads only. Further, right-of-way rules and traffic lights have to be computed. Still, the building of large cities such as Munich's network takes less than five minutes on a normal PC. Doing the same by hand would need several weeks. Surely, the heuristic we use do not cover all possible ideas road designers may have. They will be validated in future, but do they prove their quality during our current projects already.

Currently the network converter handles the following file types:

- Maps stored in the Arc View-format
- Networks from FastLane
- Networks from Artemis (in work)
- Networks from Visum (version 7.0 up to version 8.0)
- Networks from Vissim (version 3.6 up to version 3.7)
- An easy to generate native-XML-format

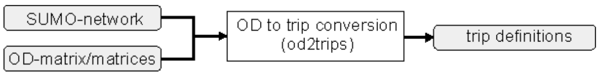
Different types of junctions are supported and computed: priority junction, right-before-left junctions and traffic light junctions. Traffic lights may both have a fixed switch plan or be controlled using different, simulated detectors.



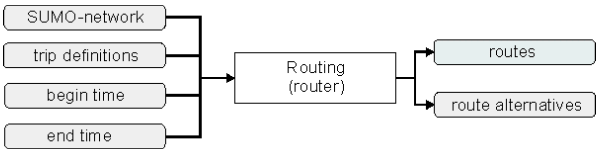
Data flow through the network conversion module

The traffic assignment - OD-matrices and routes

Detailed descriptions of a cities' mobility patterns are at least as needed for valid simulations as a detailed road network description is. To fill the network with traffic in SUMO, one may either use existing OD-matrices and convert them into route descriptions using the od2trips-tool or specify the routes themselves by hand. The first approach is the one used mostly within the traffic science when dealing with large real-world scenarios as such matrices are often available. The second one is needful when one is interested in agent-based simulations where each agent has its own wishes about his mobility.



Data flow through the od-to-trips converter



Data flow through the routing module

The loaded routes, being mostly described by their starting point and their ending point, have to be laid into the network. When all people are using the shortest path, this road will get jammed and other roads will stay free. To gain a realistic behaviour of the flow, SUMO uses the Dynamic User Equilibrium approach developed by Christian Gawron in his PhD thesis [4]. It assumes that the driver tries more promising (faster) alternative routes with decreasing probability over iterated simulations. Although a simulation has to be performed several times to achieve it, this approach yields in a realistic behaviour of the flow.

CURRENT USAGE WITHIN THE IVF

SUMO is already being used within several projects at the Institute of Transport Research (IVF) at the German Aerospace Centre where it was developed with the participation of the Centre for Applied Information Science.

To name only the important ones, it is now used to simulate the benefits of the optical information sensors (OIS) developed at the IVF. This is done by simulating a small area around our institute using information about the traffic amount gained by a measurement campaign this year. After the verification of the simulation, the traffic lights currently used which do have a fixed time interval, will be replaced within the simulation by traffic lights with a new intelligence based on the information that may be gained by the OIS. Both, the OIS detectors and the traffic lights' intelligence will be implemented in SUMO and used to predict whether and how the traffic may be positively influenced – mainly reducing the waiting time on the traffic lights – when OIS systems are used. Final results will be available at the late summer of this year (2003). Within the second step, the network will be enlarged and simulated again to gain further information about the possible benefits.

Within another project, INVENT, we use the simulation to validate traffic management approaches. Herein, to gain the most exact information about the networks to be considered, we work together with the german traffic engineering company "ptv". INVENT itself is a large project leaded by most of Germany's road vehicle manufacturers and other companies concerned with traffic. The traffic management approaches we deal by now with, are mostly based on the optimisation of traffic lights. Later this year, other approaches from telecommunication networks, physics or biology shall be tested, too.

FUTHER PARTICIPANTS

By now, a few groups work on the package. It is used at the IFS, another institute for traffic research at the German Aerospace Centre for some projects by now and gains increasing interest there. Also, some interest comes from the University of Laval, Canada where it shall be a part of a multi-agent system including own software and another traffic simulation package, Paramics.

FUTURE WORK

As the software is stable by now and does contain everything needed to perform professional simulations of road traffic, the main work in the future will concentrate on the implementation of some more sophisticated data processing and visualisation. Further, some methods must be rechecked, such as the computation of junction shapes.

To achieve one of the major goals, the possibility to integrate different car movement models, a programmer interface for this part will be implemented.

CONCLUSIONS

With SUMO, we do offer a well designed, complex and modern simulation package for free, which does cover all steps needed to perform own simulations of large areas for free. As described above, we do already use it in some industry-near projects and it should be surely interesting for industry due to its extensibility and portability.

By doing this, we hope to gain some participation which allows to increase the software's abilities and usability. Beside this, we hope SUMO to be a shareable standard platform for models of any kind of algorithms needed within traffic simulations to make them more comparable.

You may find the projects web sites at:

http://sumo.sourceforge.net

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