SIMULATION OF TRAFFIC LIGHTS CONTROL

Krzysztof Amborski, Andrzej Dzielinski,
Przemysław Kowalczuk, Witold Zydanowicz
Institute of Control and Industrial Electronics
Warsaw University of Technology
Koszykowa 75, 00-662 Warszawa, Poland
Email: ambor@isep.pw.edu.pl

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ABSTRACT

Simulation of traffic control is very important nowadays for dealing with increasing urban traffic. It helps to construct the strategy of traffic lights switching and determine alternative path in the case of an accident or traffic jam. In the paper we present the application of simulation tool DYNASIM being used by French company DYNALOGIC. It has big number of alternative possibilities in modeling of crossings and conditions. In the paper will be described exemplary simulation of chosen crossings in Warsaw with choice of several different conditions. The simulation package can be free available for universities for educational use.

INTRODUCTION

Control of street traffic in urban conditions is nowadays crucial problem in majority of developed countries. Rapid increase of number of vehicles – before all personal cars and pick-up's – creates in many cities the situation which is difficult to manage. It is important not only to assure fluent movement of cars in chosen directions in specific time periods, but also determination of alternative ways in the situations in which original main communication ways are blocked - by road accident or cars being out of order. Basis for planning of control algorithms is gathering information about the traffic and traffic history on given crossing or/and series of crossings conjugated with a given one. But it is not enough. There is also a need to observe the situation and adapt realized strategy to the changing road situation (Gaca 2008). For this purpose a number of various devices is used – such as induction loops, infrared sensors, radar sensors, photo and video cameras and others. Signals from these sensors are sent mostly through radio transmitters (for short distance) and further by fiber optics (for longer distance).

SIMULATOR DYNASIM

Simulator Dynasim (Citilabs 2005) is a software application that models and simulates the operation of transportation infrastructure. It includes a graphical editor, a simulation engine, and tools for viewing and analyzing simulation results. In fact there are three simulation engines inside:

- microscopic — the simulation considers in details each moving vehicle according to its behavior and immediate environment
- stochastic — the simulation obtains many of the parameter values, like those describing behavior, from statistical distributions
- event-driven — the simulation alters vehicle behavior as a result of simulation events, e.g. change of traffic signal from green to red.

Simulator DYNASIM offers two tools for viewing and analyzing simulation results: the animator and the data viewer. The animator reproduces the vehicle movements calculated by the simulation engine in animations. The data viewer displays the statistical results as graphs according to criteria measured during the simulation, such as the travel time or flow. To support iterative studies, simulator Dynasim organizes data into projects.

A project groups all the related simulation alternatives. A single simulation alternative, called a scenario, is defined by up to four individual components.

Projects reflect an existing condition and then test and compare a number of alternative scenarios. Possible scenarios include:

- change of transportation infrastructure — this can include adding lanes, changing a road's geometric configuration, altering the traffic control, and so on.
- change of transportation infrastructure — this can include evaluating traffic volumes forecast for future years or for changes in the environment.
- change of timing plans or the operation of traffic signals
- change of public transport routes, frequencies, schedules, or vehicle fleets.

A simulation scenario consists of four independently managed components:

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1. flow scenario
2. network scenario
3. signal scenario
4. public transport scenario.

Flow scenarios quantify the vehicle demand for the modeled transportation system. Origin-destination matrices specify vehicle demand by vehicle type and time period. You can define flow scenario*s* that change by time of day, forecast year, or land-use development.

Initial assumptions

Input data for simulation are divided on several categories:

Geografical data:

- movement trajectory – determines the way on which vehicles are moving
- crossings – they have traffic lights, can also have some sensors
- input and output vectors – together with trajectory they determine flow of vehicles

Vehicles data:

- determine dimensions (length), maximal velocity and acceleration.
- Movement of vehicles is modeled by the equation:

$$A2(t+0.25) = a[V1(t) - V2(t)] + \\ +b(X1(t) - X2(t) - t\,V2(t) - L) \qquad (1)$$

where:

- o $Ai(t + 0.25)$ — Acceleration of vehicle i at the moment "t+0.25"
- o $Vi(t)$ — Speed of vehicle i at the moment t
- o $Xi(t)$ — Position of vehicle i at the moment t
- o a, b, t — Parameters that describe three types of acceleration for vehicle 1
- o L — Length of vehicle

For every area of simulation we can measure following values:

- Flow of vehicles
- Transition time between crossings (mean and maximal values)
- Number of vehicles, moving between crossings
- Speed of vehicles (mean and maximal values)

Output data are delivered in Excel files. Structure of these files should be carefuly analysed before interpretation.

Simulator DYNASIM can also deliver analysis of various detail degree (scenarios). One can consider only vehicles flow without data from the sensors. One can also take into account privileged public transport, etc.

Example of application

As an example of application let us consider one of typical crossings in Warsaw – the crossing which is next to Warsaw University of Technology, Nowowiejska and Al. Niepodległości (Fig. 1).

Fig. 1. Air view of the crossing of Al. Niepodległości and Nowowiejska

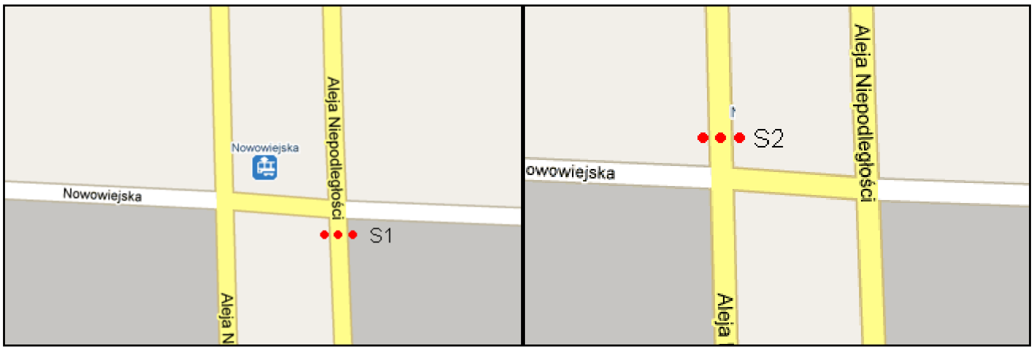

Fig. 2. Simulation of traffic lights on the crossing of Al. Niepodległości and Nowowiejska.

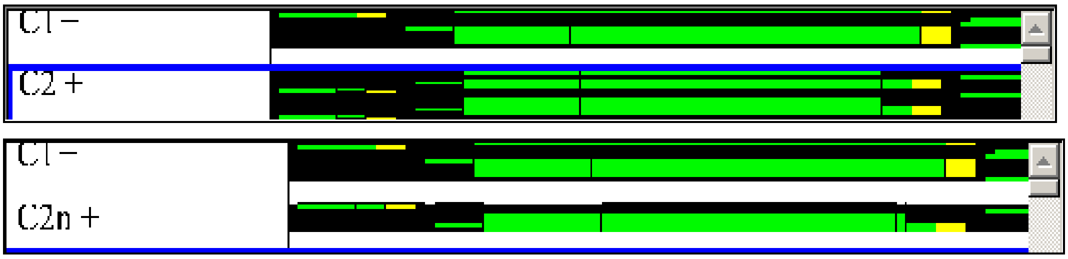

Fig. 3. Scenarios for controllers in simulation of traffic lights on the crossing of Al. Niepodległości and Nowowiejska.

Simulator DYNASIM enables import of maps in various formats – as bitmap of vector presentation. The main street - Al. Niepodległości - has 6 lanes, three on each side. Nowowiejska, the smaller one, has 2 lanes in each direction. It is pretty complicated, although not penultimate. Complication results from the fact that besides cars there are also public transport buses and streetcars. Moreover the streetcars (or tramways) can turn right and left, so separate traffic lights for them can be installed and used. There are also some constraints in turning on this crossing – namely turning left from Al. Niepodległości into Nowowiejska is forbidden for cars, but not for tramways.
In the simulation program the traffic lights are synchronized for all lanes in given direction (Fig. 2). Traffic lights S1 and S2 are controlled by controller C1, traffic lights S3 and S4 (east-west direction) are controlled by controller C2. Controllers C1 and C2 work with different scenarios (Fig. 3).
Simulation package Dynasim enables defining of:

- Traffic lanes for every direction,
- Sources of vehicles and the target of their way
- Trajectories
- Traffic lights with controllers.

Simulation conditions assumed traffic on the level of 20000 vehicles per day (data from General Traffic Measurement Office, forecast on the year 2010) taking into consideration peaks at hours 8:00 i 16:00. Measurement period, to which sequential data are taken, is 1h.

Results of simulation.

Simulation has been performed 100 times for traffic in every possible direction. After averaging of results we got visualisation of the traffic in North-South direction (Al. Niepodległości) presented on Fig. 4.

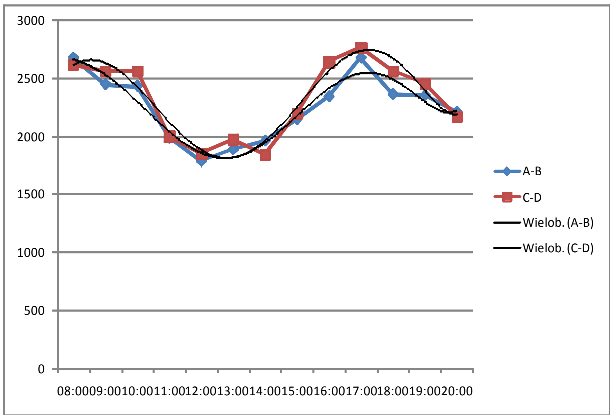

Fig. 4. Results of simulation of traffic in North-South direction (Al. Niepodległości)

It shows the flow (number of cars per hour) passing the crossing in given direction in relation to the time of a day. In the simulation package DYNASIM we can also check what will be changed after introducing some changes in traffic organisation, e.g. by introducing bus lane on every side of main street – Al. Niepodległości.

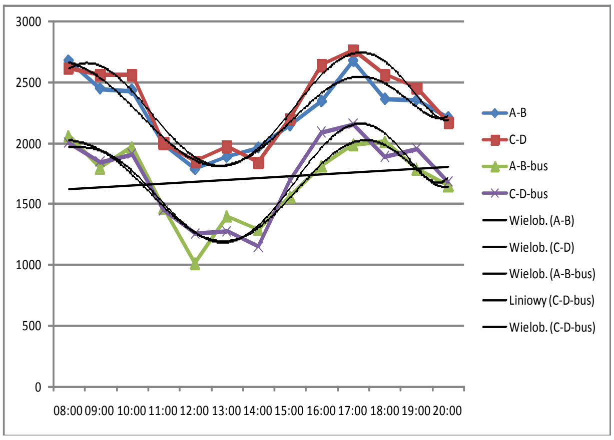

Fig.5. Results of simulation after introduction of bus-lane on Al. Niepodległości.

After changing simulation conditions we get simulation results as presented on Fig. 5.

Output data from each simulation are stored in three kinds of files:

1. RAW files with all simulation data,
2. STAT files with aggregated statistical data (calculated from RAW files)
3. Excel files.

An example of STAT file for one of the simulation runs is presented below on Fig. 6. The stat file lists a value measured at a data collector for each time sample in each iteration. In addition, the file lists statistics—mean, standard deviation, confidence interval, maximum, minimum, 25th percentile, 50th percentile, and 75th percentile—for the measured value during each iteration across all samples, during each time sample period across all iterations, and across all time samples and all iterations.

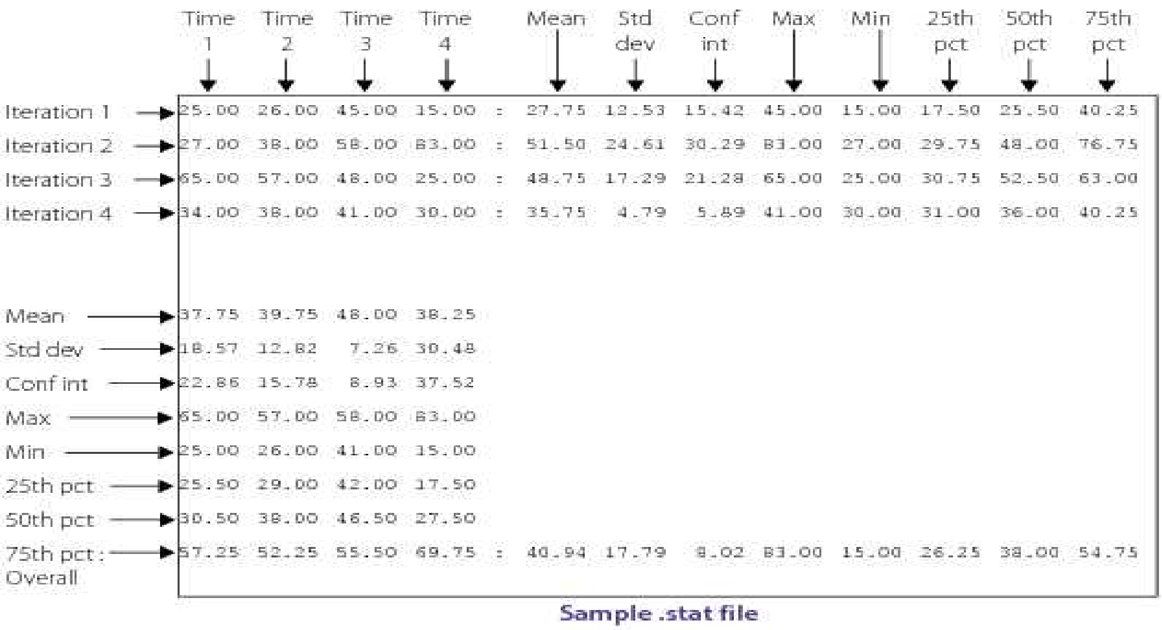

Fig. 6. Example of STAT-file with explanation of data structure.

CONCLUSIONS

Simulation presented in the paper is based on professional simulation program used for commercial purposes. It is well structured, relatively easy to operate and efficient in everyday work. Simulation scenarios record the data specified by the output groups associated with the network scenario's layers. Therefore, one does not need to specify output parameters for each simulation scenario; instead, you simply specify the data collected for each unique network. The combination of output group and layer have to be unique. One can use the same output group name in different layers. This corresponds to two different configurations of the same transportation system.

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AUTHOR BIOGRAPHIES

KRZYSZTOF AMBORSKI was born in Lublin, Poland. He received his M.Sc. in Telecommunications (1964) and Ph.D. in Control Systems (1972) from Warsaw University of Technology. In 1971 he received also M.A. in Mathematics from the University of Warsaw (Poland). Since then he was with the Institute of Control and Industrial Electronics at Warsaw University of Technology, now as associate professor. In 1994-2002 he was active as an expert in Multimedia Broadband Services at Telekomunikacja Polska S.A. In 1998/2004 he was professor at the University of Applied Sciences in Darmstadt (Germany), in 2003 he was visiting professor at the University of Wisconsin-Platteville (USA).
E-mail: ambor@ee.pw.edu.pl

ANDRZEJ DZIELINSKI is a professor at the Warsaw University of Technology. He received M.Sc. in 1983 in electrical engineering specialising in Control Systems, Ph.D. in 1992 and D.Sc. in 2002. His main professional interests are in computational intelligence, modelling, simulation and automatic control. He is all the time with the Institute of Control and Industrial Electronics, now as Deputy Director for Science.
E-mail: adziel@ee.pw.edu.pl

PRZEMYSŁAW KOWALCZUK is with the Warsaw University of Technology. He is specializing in databases, database management, simulation in logistics and computer science, working towards his Ph.D.
E-mail: pkowalczuk@ee.pw.edu.pl

WITOLD ZYDANOWICZ received his M.Sc. in Telecommunications (1964) and Ph.D. in Control Systems (1972) from Warsaw University of Technology. He is co-author of several textbooks on control systems. He is now adiunct there.
E-mail: witek@isep.pw.edu.pl