An Accelerated-Time Simulation for Traffic Flow in a Smart City

José Luis Galán; Gabriel Aguilera; José Carlos Campos; Pedro Rodríguez

Department of Applied Mathematics.
University of Málaga - Spain

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Motivation

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- Different cities are nowadays involved in the design and implementation of smart traffic control.
Motivation

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- Different cities are nowadays involved in the design and implementation of smart traffic control.
- Since the cost of the physical installation of such systems is very high, accelerated-time simulations of traffic flow using smart traffic lights and signals are welcome.
Background

- Cellular automaton
Background

- Cellular automaton
- GRAM Model
Background

- Cellular automaton
- GRAM Model
- ATISBAT Model
Cellular automaton

- Conway’s Game of Life
Cellular automaton

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Rule 184

Direction of traffic →

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Direction of traffic →

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Model of Nagel-Schreckenberg (NS)

- A section of highroad is divided into $N$ cells.
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- At time $t$, each cell can be:
  - Empty.
  - Busy by a car with velocity $v \in \{0, 1, v_{\text{max}}\}$. 
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- At time $t$, each cell can be:
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  - Busy by a car with velocity $v \in \{0, 1, v_{\text{max}}\}$.
- At any step the state of a cell is updated in parallel by using 4 rules:
  - **Acceleration**: Each car increases its velocity until the maximum allowed is reached: $v_0(t + 1) = \min\{v(t) + 1, v_{\text{max}}\}$
  - **Braking**: Each car adapts its velocity to the gap $b$ with the previous one: $v_1(t + 1) = \min\{v_0(t + 1), b\}$
  - **Random braking**: With a probability $p$ the velocity is reduced by 1. ($p = 0 \Rightarrow$ deterministic model): $v(t + 1) = \max\{v_1(t + 1) - 1, 0\}$
  - **Updating**: $x(t + 1) = x(t) + v(t + 1)$
GRAM model: ACA 2011
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- It allows to essay some different motorway conditions and traffic rules obtaining both macroscopic and microscopic traffic parameters.
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- It shows real traffic characteristics such as: waves, collapses, low traffic, ... 
- It allows to essay some different configurations of the handling systems: change the number and distributions of the entries and exits, security parameters, etc.
ATISMART model
General ideas

- ATISMART combines ideas from cellular automaton methods and neural networks. So cells are considering but special characteristics of each item in the cells (cars) are stored in its state vector.
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General ideas

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- Parameters of the system are flexible and completely configurable.
General ideas

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- At every step, each cell changes its value depending on the neighbour cells values and the individual characteristic of the item.

- Parameters of the system are flexible and completely configurable.

- Maps can be easily adapted to the characteristics of the city.
Configurable parameters

- Input distributions.
Configurable parameters

- Input distributions.
- Street directions.
Configurable parameters

- Input distributions.
- Street directions.
- Timing of traffic lights.
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- Street directions.
- Timing of traffic lights.
- Maximum number of cars within the system.
Configurable parameters

- Input distributions.
- Street directions.
- Timing of traffic lights.
- Maximum number of cars within the system.
- Setting a car in the system with specific input and output streets.
Computing the path of a car

Cars can be both: randomly introduced in the system with random input and output or set by the user with a given input and output.
Computing the path of a car

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- The car decides its path by using Dijkstra’s algorithm.
- Since the characteristics of the map (graph) can be dynamically changed, the car recomputes the path in each crossover.
Interface Human - Java - Maxima
Random distributions using a CAS

In ACA 2009 we presented a Derive utility file to simulate different random distributions.
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- Now we are implementing in Maxima algorithms for:
  - Generating random numbers of an uniform distribution (with a very large period).
  - Generating samples of random variable distributions.
  - Generating samples from any particular density function.
Random distributions using a CAS
Random distributions using a CAS
ATISMART model
Conclusions

- The use of cellular automata together with individual information is a good tool for simulating traffic in different environments.
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The use of CAS (Maxima) in the simulations allows obtain exact distribution functions even from the density function.
Conclusions

- The use of cellular automata together with individual information is a good tool for simulating traffic in different environments.
- The use of CAS (Maxima) in the simulations allows obtain exact distribution functions even from the density function.
- Many characteristics of the car traffic in a smart city can be simulated in order to improve the design of the parameters of the system in an easy and cheap way.
The application has been implemented using independent modules which allow to adapt ATISMAKT to any specific requirement.
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ATISMART can be used both as an aid during the smart signal design process and to optimize the use of an already built smart traffic lights and signals in a specific map.
Conclusions

- The application has been implemented using independent modules which allow to adapt ATISMART to any specific requirement.
- ATISMART can be used both as an aid during the smart signal design process and to optimize the use of an already built smart traffic lights and signals in a specific map.
- The graphic interface produces important visual information about the simulation. This graphical approach is very useful, since the effects of making any change can be visually shown immediately.
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