

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

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FEMTEC 2013
4th Intern. Congress on Computational Engineering and Sciences
Las Vegas, May 19 - 24, 2013

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- Traffic control is nowadays one of the most important problems related with the urban development. New trends are based on the use of smart traffic lights and signals as a part of smart cities projects

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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

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- **Cellular automaton**
- **GRAM Model**

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Conway's Game of Life



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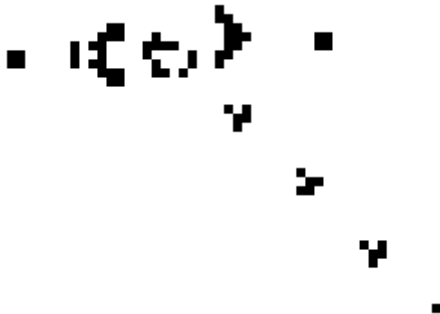
Conway's Game of Life



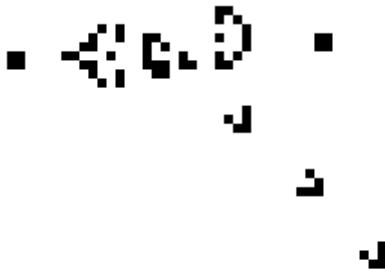
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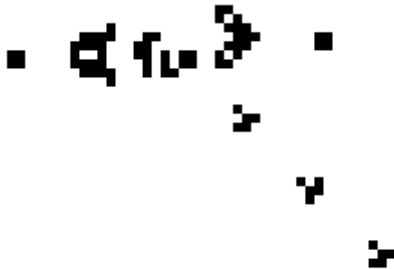
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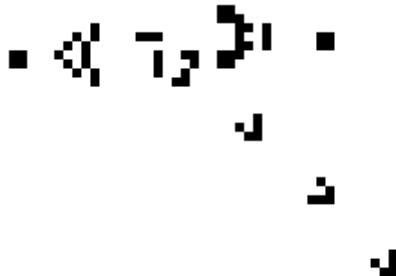
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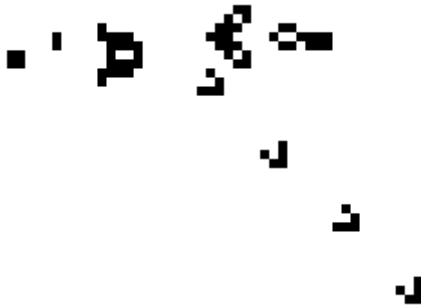
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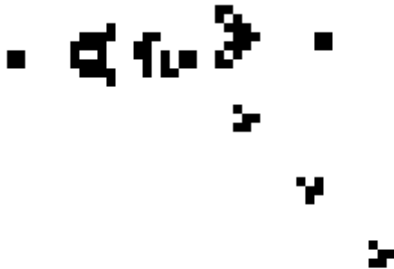
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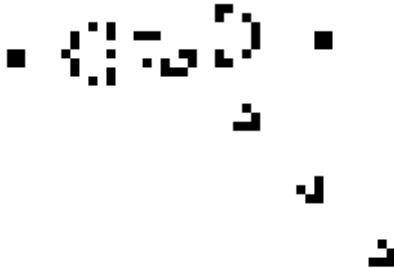
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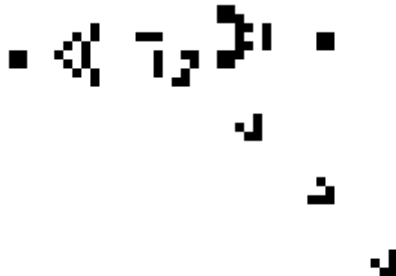
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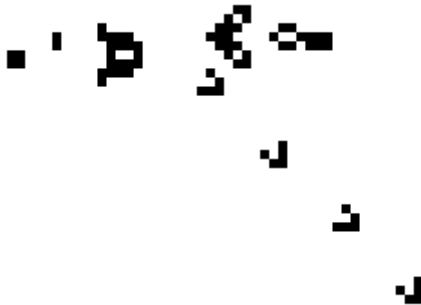
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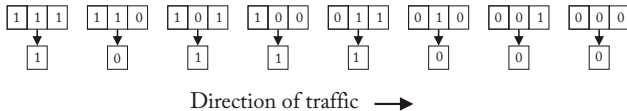


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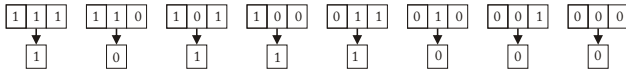
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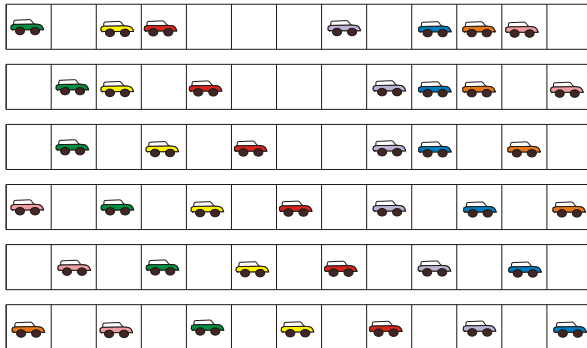


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Direction of traffic →



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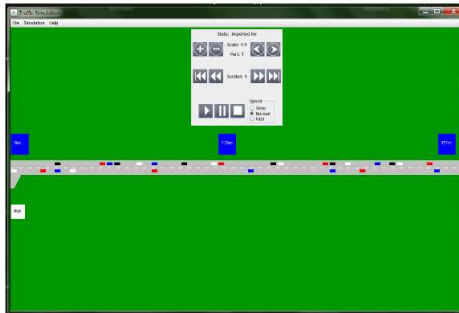
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 - Busy by a car with velocity $v \in \{0, 1, v_{max}\}$.
- At any step the state of a cell is updated in parallel by using 4 rules:
 - **Acceleration:** Each car increases its velocity until the maximum allowed is reached: $v_0(t+1) = \min\{v(t) + 1, v_{max}\}$
 - **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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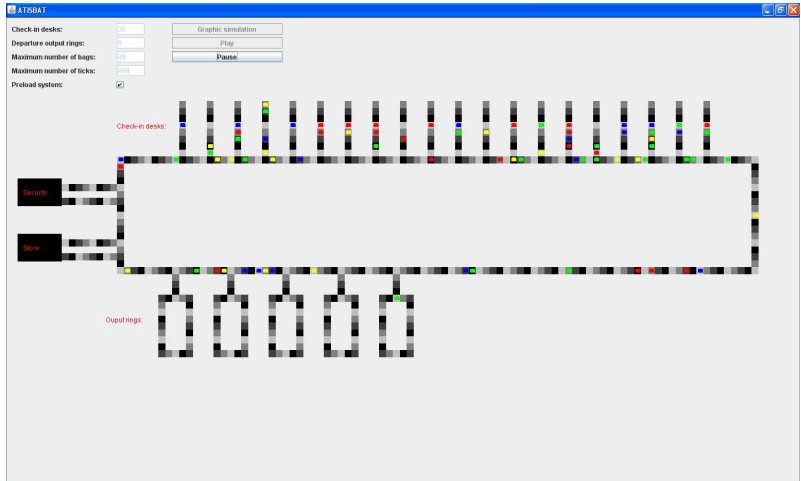
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- It shows real traffic characteristics such as: waves, collapses, low traffic, ...
- It allows to essay some different motorway conditions and traffic rules obtaining both macroscopic and microscopic traffic parameters.

ATISBAT model: ACA 2012



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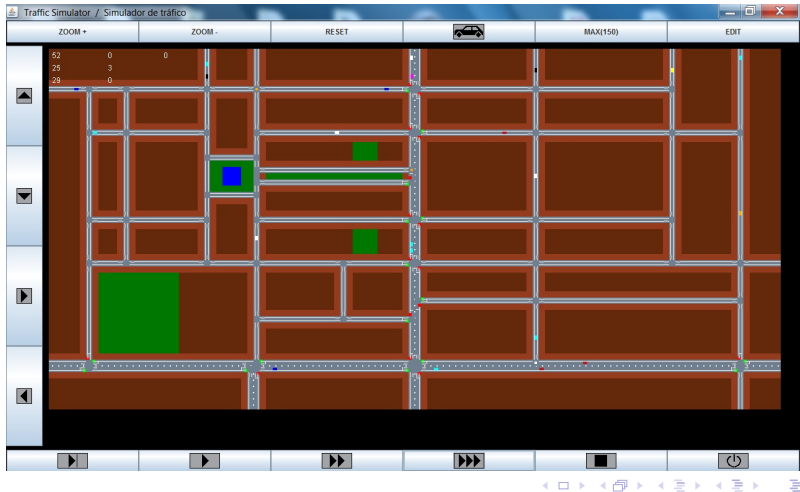
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- It shows real traffic characteristics such as: waves, collapses, low traffic, ...
- It allows to essay some different configurations of the handling systems: change the number and distributions of the entries and exits, security parameters, etc.

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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- 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.

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- 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.

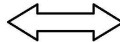
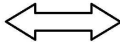
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- The car decides its path by using Dijkstra's algorithm.
- Since the characteristics of the map (graph) can be dynamically changed, the car recomputes the path in each crossover.

Interface Human - Java - Maxima



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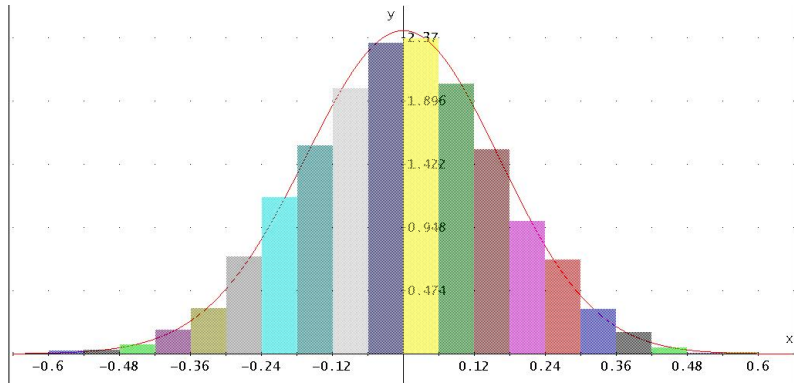
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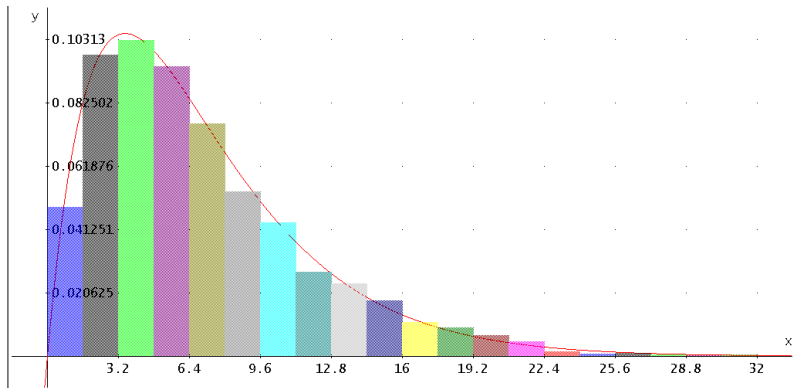
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 - Generating samples of random variable distributions.
 - Generating samples from any particular density function.

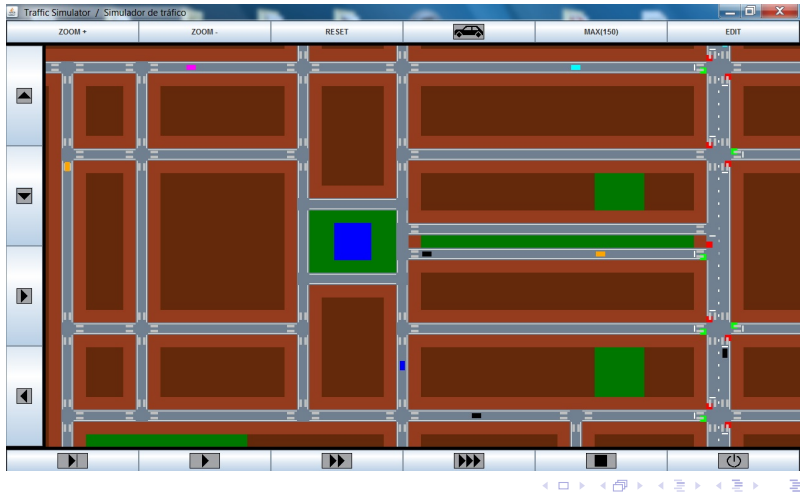
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ATISMART model



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- 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.

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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.
- 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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