Kierunek: Informatyka i Systemy Inteligentne
Semestr: IX
Rok akademicki: 2021/22
Przedmiot: Agent Systems

Temat:

Nagel-Schreckenberg extension

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Introduction

This project aims to create a Cellular Automata model to simulate traffic on two-lane road. It is based on the Nagel-Schreckenberg model and extends it with some extra conditions to make the model more realistic. Some of the proposed extensions are creating different types of agents (cars), adding exits and entries, as well as adding a faster lane (left) for overtaking.

Nagel-Schreckenberg

Is a model to simulate one-way road traffic flow. It was developed by 2 German physicists: Kai Nagel and Michael Schreckenberg. It uses a simple automata cellular model to reproduce this behaviour. It has few assumptions:

1. **Acceleration**: If a car does not move with maximum velocity, its speed is increased by one unit. For example, if the velocity is 4 it is increased to 5.
2. **Slowing down**: All cars are checked to see if the distance between it and the car in front (in units of cells) is smaller than its current velocity (which has units of cells per time step). If the distance is smaller than the velocity, the velocity is reduced to the number of empty cells in front of the car – to avoid a collision. For example, if the velocity of a car is now 5, but there are only 3 free cells in front of it, with the fourth cell occupied by another car, the car velocity is reduced to 3.
3. **Randomization**: If a car is moving (it's speed is 1 or greater), it's speed can be reduced by one unit with a probability of p. For example, if p = 0.5, then if the velocity is 4, it is reduced to 3 with probability of 50%.
4. **Car motion**: All cars are moved forward the number of cells equal to their velocity. For example, if the velocity is 3, the car is moved forward 3 cells.

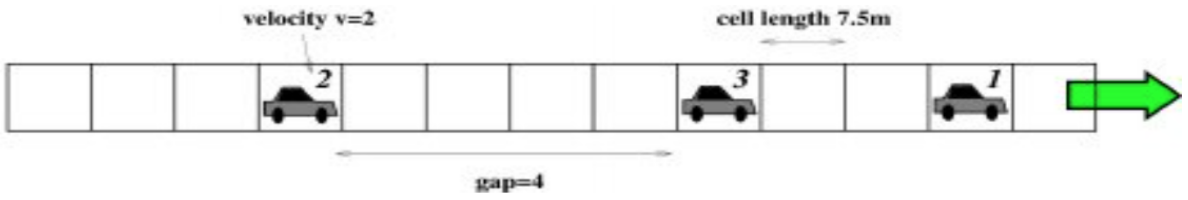

Fig. Nagel-Schreckenberg model visualization
[*Selection of Information Types Based on Personal Utility a Testbed for Traffic Information Markets*]

Nagel-Schreckenberg - proposed extensions

In our project we want to extend the classical Nagel-Schreckenberg model with some extra conditions and properties. It should allow us to create a more realistic model to simulate traffic flow on highways.

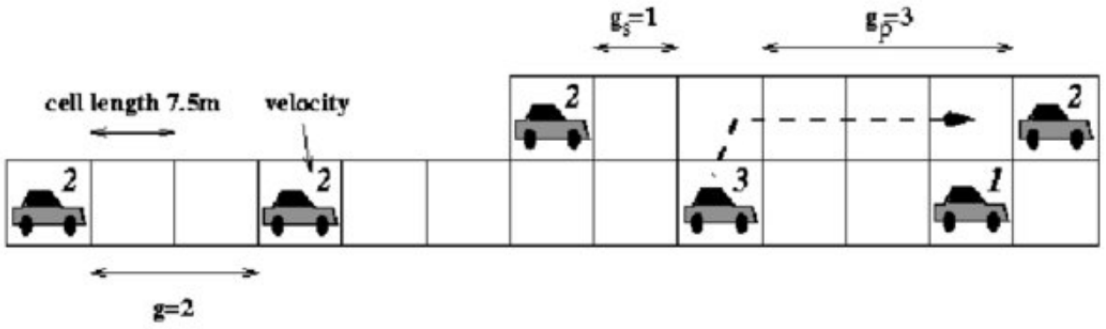

Fig. Two lane Nagel-Schreckenberg model visualization
[*Online Traffic Simulation with Cellular Automata*]

Proposed extensions:

1. Create different types of agents (cars) with different properties (maximum speed and length):
    a. Family car (max speed: 8 units)
    b. Sports car (max speed: 10 units)
    c. Truck (max speed 6 units)
2. Different types of road:
    a. regular road
    b. constructions (cars need to change lane)
    c. exit (cars can with probability *p* leave highway)
    d. entry (cars can with probability *p* enter highway)
3. Two lanes:
    a. right lane is preferable (slow one)
    b. cars can overtake change lane to left (fast one)
4. Cars can drive faster than road limit with probability *p*

Actions connected to extended model:

Changing a lane is split into to sub-steps, which do not happen parallely:

1. Check the exchange of vehicles between the two lanes according to the new rule set. Vehicles are only moved sideways. They do not advance. Note that in reality this sub-step regarded by itself seems unfeasible since vehicles are usually incapable of purely transversal motion. Only together with the second sub-step our update rules make physically sense.

   This first sub-step is implemented as strict parallel update with each ve- hicle making its decision based upon the configuration at the beginning of the time step.

2. Perform independent single lane updates on both lanes according to the single lane update rules. In this second sub-step the resulting configuration of the first sub-step is used.
3. Cars try to go back to the right lane.

   A vehicle i changes to the other lane if all of the following conditions are fulfilled:
   - $gap(i) < l$ (**T1**),
   - $gap_o(i) > l_o$ (**T2**),
   - $gap_{o,back}(i) > l_{o,back}$ (**T3**)
   - $rand() < p_{change}$ (**T4**)

Implementation details - to do

Github
Libraries
Tools
Start coding ?

Simulation

Conclusions

References

[1] Two lane traffic simulations using cellular automata

[2] Investigating Traffic Flow in The Nagel-Schreckenberg Model

[3] Modeling traffic flow on two-lane roads with traffic lights and Green Cities 2018 Green Cities 2018 countdown timer countdown timer

[4] Crossover transitions in a bus–car mixed-traffic cellular automata model

[5] A modified Nagel-Schreckenberg model with overtaking strategy and its effects on traffic flow

[6] Estimating the Probability that a Vehicle Reaches a Near-Term Goal State Using Multiple Lane Changes