Multi-Agent Systems

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Exercise Sheet 1

Due: May 8, 2017, 10:00

Please note: Submissions are to be made to the folder `ex01` of your group's repository. While all theoretical questions have to be answered in one single `pdf` file, you're allowed to submit multiple Python source files (just make clear in the header of each source file, to which exercise it refers to). A brief explanation of the simulation framework is given in the file `README.md`, which you can find in the repository. For more detailed information on how the framework's components work, you can look directly into the documented source files.

Exercise 1.1 (Nagel-Schreckenberg Model, 3+3)
Nagel and Schreckenberg employ cellular automata to model traffic flow.[1] Your task is to represent a concrete traffic situation within the Nagel-Schreckenberg model and to predict the system's future behavior based on the model.

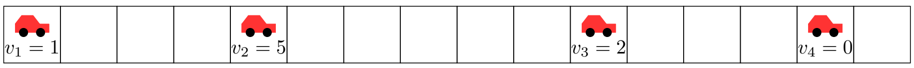

Figure 1: Some traffic situation in the Nagel-Schreckenberg Model

(a) According to the model, what are the possible values for the velocity v_3 of car 3 in the next iteration? Consider the cases $p = 0$, $p = 0.25$ and $p = 1$ (given $v_{\max} = 5$).

(b) Illustrate the most probable successor state for the next two iterations, given that $p = 0.1$, $v_{\max} = 5$, and that car 4 (due to randomization) remains on its cell for the first iteration.

Exercise 1.2 (Nagel-Schreckenberg Model, 3+3+3)
Your task for this exercise is to implement the Nagel-Schreckenberg model within our multi-agent framework. You can find a documented implementation of a simpler traffic simulation in your repository (`ex01/trafficexample.py`).

(a) Implement the cars' behavior by implementing the four steps each car performs in each iteration. Your simulation is supposed to take the values of $v_{\max}$ and p, as well as the number N of cars (which are to be placed randomly on the track), as command line arguments.

(b) In this task you are asked to run the simulation with different values for the parameters N, $v_{\max}$, and p. Describe in your own words how you think that the variation of these parameters effects the shape of the fundamental diagram of traffic flow (see lecture slides). Compute the fundamental diagrams of traffic flow for at least 9 different combinations of $v_{\max}$ and p. Discuss your observations. Does the result agree with your hypotheses? For plotting, you can for example use Pyplot or Gnuplot. Add the computed diagrams and your discussion to your `pdf` submission file.

(c) Velocity-Dependent Randomization (VDR) is an extension of the original Nagel-Schreckenberg model. VDR models the observation that it takes longer to re-accelerate at low speed than to accelerate at high speed. Implement VDR with two different probabilities of random deceleration, p_0 for $v = 0$ and p_+ for $v > 0$. Write down in your own words how you think the fundamental diagram with VDR will differ from the fundamental diagram without VDR (all other parameters held constant). Run simulations and compare your prediction with the observed results.

[1] Check out the original article: `http://www.pd.infn.it/~agarfa/didattica/met_comp/lab_20140108/1992_origca.pdf`