Computational Physics

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Project 4, due November 3, 2021 at 11:59 p.m.
to be uploaded to https://elearning.jacobs-university.de

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4. One-dimensional cellular automata [100 points]

a) Write a code to solve the iteration of a one-dimensional Boolean cellular automata. The code should work for N sites and one should be able to select between finite grids or periodic boundary conditions.
b) Determine the properties of a rule for which the value of a site at step $t+1$ is the sum modulo 2 of the values of its neighbors plus its own value at step t. This rule is equivalent to 10010110 or rule 150. Start with a single seed site and test both kinds of boundary conditions. As an example you can take $N = 100$ but can also experiment with other sizes.
c) Choose a random initial configuration for which the independent probability for each site to have the value 1 is $p = 1/2$; otherwise, the value of the site is 0. Determine the evolution rule 90, rule 150, rule 18 , rule 73, and rule 136. How sensitive are the patterns that are formed to the initial conditions? Does the nature of the patterns depend on the use or non-use of periodic boundary conditions?
d) Implement the traffic rule 184 which we discussed in class and employ periodic boundary conditions. Simulate the following scenarios of a ring-shaped street of 100 cells: First simulate a traffic jam with 6 of 18 cars. The rest of the cars are to distributed randomly with a random initial velocity. In a second test, double the number of cars and then triple them.

General remarks for all Projects

You will have to (i) analyze the problem, (ii) select an algorithm (if not specified), (iii) write a Python program, (iv) run the program, (v) visualize the data numerical data, and (vi) extract an answer to the physics question from the data.
Which checks did you perform to validate the code? State the results you got for these tests.
For each project you will submit a short report describing the physics problem, your way of attacking it, and the results you obtained. Provide the documented Python code in such a form that we can run the code. A Jupyter Notebook including the code and report is fine but not necessary.