Report Document: Lab 4

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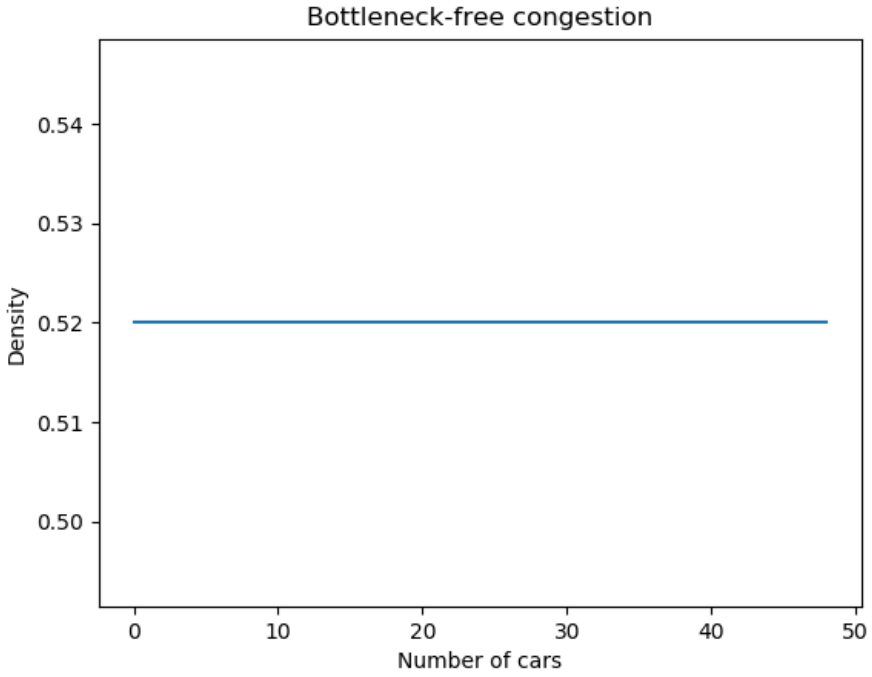
1 Vraag 1

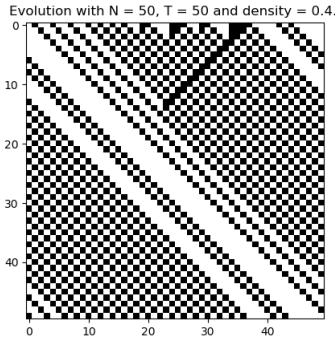
Explain in what way rule 184 models bottleneck-free congestion by looking at its state transition table.

By looking at the state transition table of Rule 184, you can see that for any finite set of cells with periodic boundary conditions, the number of cars (1s) and thereby the number of 0s in a pattern remains invariant throughout the pattern's evolution. No matter what the initial state is. So this shows that rule 184 models bottleneck-free congestion since there occurs no bottleneck.

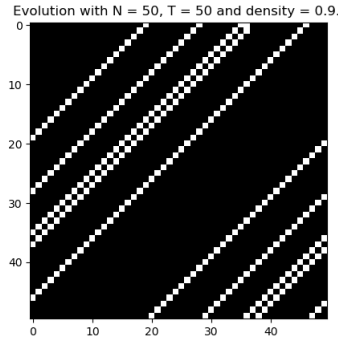


2 Vraag 2

Show the evolution of a CA of size N = 50 cells for 50 time steps for the 'car' densities 0.4 and 0.9. Describe briefly what you see.



(a) Evolution of the CA with a density of 0.4.



(b) Evolution of the CA with a density of 0.9.

As you can see in the two evolutions above, the evolution of a density smaller than 0.5 (a) eventually converges into all 0's, the white cells. Conversely, the evolution of a density greater than 0.5 (b) eventually converges into all 1's, the black cells.

3 Vraag 3

Name as many advantages as you can think of for simulating these experiments as opposed to using real cars, drivers, and roads.

ADVANTAGES:

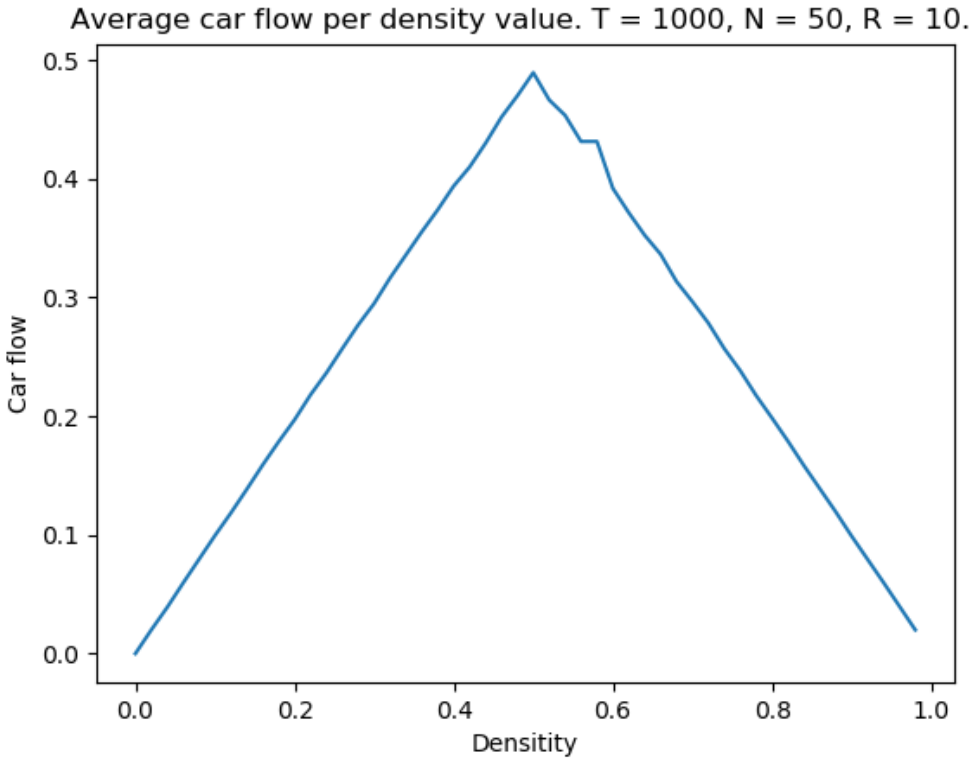
- Real cars, drivers, and roads are not always available.
- When doing an experiment with real cars, drivers, and roads, there is always a risk. Driving with inexperienced drivers, unsafe cars or roads can be dangerous.
- When doing an experiment with real cars, drivers, and roads, the economic costs are higher since the need of cars, drivers and roads. Think of the usage of the cars, gasoline, hiring drivers etc.
- Not only the economic costs are higher, the environmental costs are higher too, since the emissions from cars.
- When doing an experiment with real cars, drivers, and roads, the time scale of the system is much longer than with a simulation.

4 Vraag 4

Is there a clear phase transition, and if so, at which density value?

Yes, there is a clear phase transition as you can see in the graph below. This phase transition happens at a density value of 0.5.

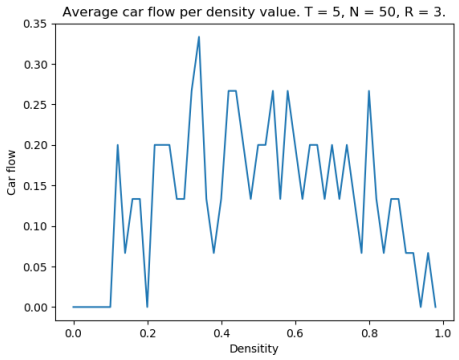
If the density of the initial state is less than 0.5, the pattern converges in time to a state of all 0's and moves rightwards. If the density of the initial state is greater than 0.5, converges in time to a state of all 1's and moves leftwards. If the density of the initial state is exactly 0.5, the CA's behavior is undefined. The initial pattern slowly stabilizes to a pattern that can equivalently be viewed as an alternating sequence of 0s and 1s.

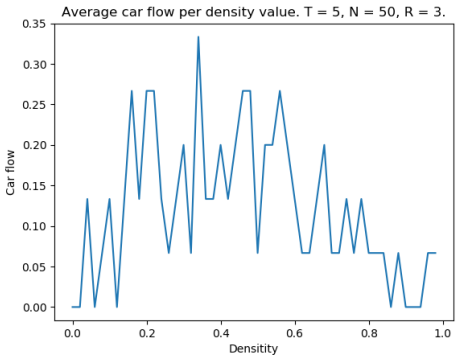


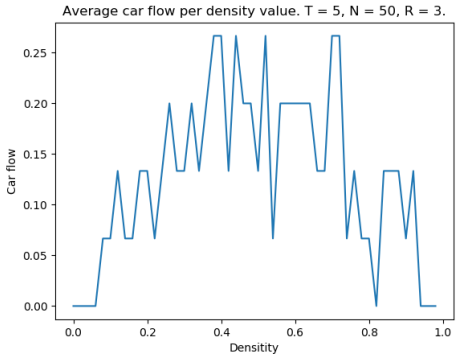
5 Vraag 5

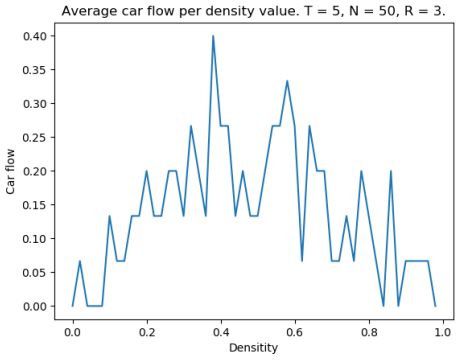
What is the effect of such 'undersampling'? Show a plot with undersampled results.

Undersampling is the effect of having too large sample sizes and a too low sample density. As you can see in each of the graphs below, the data in the graph is described more accurately than in the graph with more data from question 4. However, every graph looks significant different. This effect of such 'undersampling' happens because there is less data by the lower T and R values, which makes the data more random since the average of less data is less reliable.









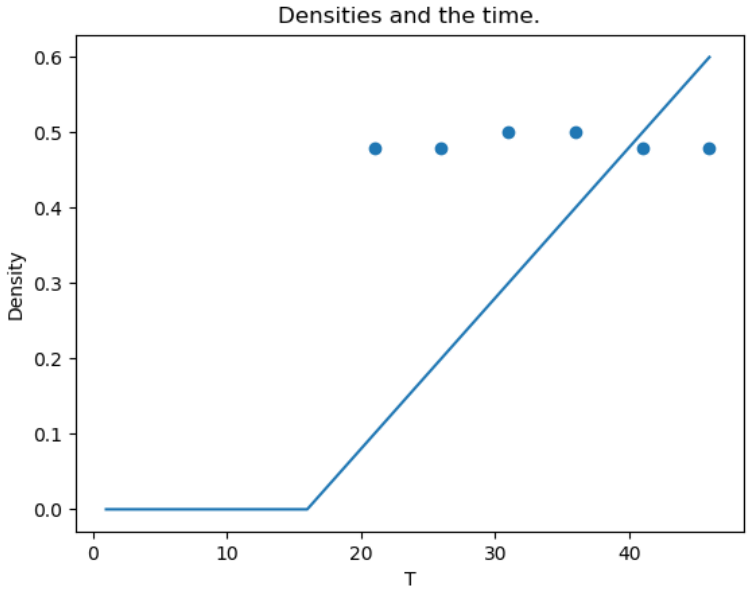
6 Vraag 6

6.1 Implement a function which takes the "car flow versus density" data points1 of exercise 4 as input and returns an automatically estimated 'position' (density value) of the phase transition as output (termed 'critical density', a scalar). Mention briefly how you implemented this.

The implementation of the function which returns the critical density is as follows:

1. get the max car flow and the index of this car flow
2. with this index, get the corresponding density of this car flow
3. return the max flow and max density as a tuple

6.2 At which value for T = Tmin do we have at least 90 percent probability of inferring the correct critical density? Show a plot of "probability correct" as function of T from which it is easy to estimate Tmin by visual inspection.



The Y-as needs to be 'Probability that density estimated is correct' .

As you can see in the graph above, the value for Tmin, where we have at least 90 percent probability of inferring the correct critical density, is 18 in a total range of 50.

7 Vraag 7

What can we conclude about the importance of other possible ingredients, such as the gender of drivers or the sizes of their cars, for explaining the existence of the phase transition? Explain why.

We can conclude that other possible ingredients (as the gender of drivers or the sizes of their cars) do play an important factor for explaining the existence of the phase transition.

In the 'free phase' (till the critical density at the maximum flow), all cars traveling at the maximum allowed speed. The other phase occurs when the average speed of cars is less than the speed limit. The phase transition happens between the free flow and the congested traffic. Reasons for happening are also caused by other possible ingredients than merely collision avoidance. Maybe it is the case that male drivers drive faster than female drivers causing faster congestions in the traffic. This could be a reason of a sooner phase transition.