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Project proposal

Question and motivation

There is a referendum coming up in Switzerland where the people are asked to vote on weather or not a third lane should be added to certain parts of the main motorway going through the country. Many people think that increasing the number of lanes will solve the traffic crisis, others believe that the problem will only be solved partially and that in a few years the situation will be back to where it is today. Simply viewed, more lanes must equal more capacity. However this reasoning leaves out the human element of lane changing. More lanes will lead to more lane changing which creates acceleration and deceleration of cars and typically slows down traffic. The question at the heart of this project is therefore:

How is motorway fast lane flow affected by lane changes ?

After ample research on modelling and different strategies of analysis, I alighted on cellular automata (CA). This particular kind of modelling appealed to me because its elegance and simplicity took my liking.

Objective and scope

The broad aim of this project is to understand the overall effect of adding a lane to a motorway. However, such situations require complicated models with many human unknowns. Hence, I will limit the scope to single lane changes.

The objective of this project is to construct a model using cellular automata to simulate traffic flow, in particular to examine the effect of cars transitioning from a slow lane into a fast lane. In particular, we want to provide simulation data on the dependency of traffic flow on the quantity of incoming cars. Finally the results will be presented graphically.

State of the art

One of the most famous traffic flow models using cellular automata was engineered in 1992 by Kai Nagel and Michael Schreckenberg. This model (NaSch) is discrete in time and in space and has synchronous updates. It implemented for the first time a stochastic element regarding random acceleration and deceleration of drivers. It is to this day a benchmark in CA modelling and is referenced in countless papers regarding traffic models. In 1999, Wu and Brilon added rules to the NaSch model regarding lane changes and how lanes interact with each other.

Regarding actual code, many cellular automata have been implemented in C. Most notably perhaps is the classic Game of Life by John Conway (link to such a code from GitHub below). Also referenced is a one-dimensional CA in C. There also exist Python librairies related to cellular automata such as CellPyLib, but for this project the CA will be implemented in C.

Approach

The idea for the project will be to use Nagel and Schreckenberg's work as the theoretical basis for the model and adapt it to answer our question. As a first step, I will implement the NaSch model in C. This will already give an idea of what happens in an unperturbed one-lane situation.

Ideally this would be followed by adding rules to the existing CA to account for other lanes. Designing a CA for several lanes could be rather difficult and time consuming due to the large amount of rules that need to be implemented. The aim here is to mimic a two lane situation while only having one lane in the model (and crucially the code). Briefly, the idea is to allow a new car to appear in our CA lane if the space between two cars allows it. This way we imitate what would happen had we coded a slow lane where cars would transition into the fast one, all the while maintaining a one-dimensional CA. The appearance of new cars can occur with a given probability and we can examine different situations (simulation runs) for different probabilities and observe the effects.

Once the model in C is implemented, I will use a python code to organise simulations runs of the model and process the resulting data. I can then modify parameters and observe which variations yield the most efficient traffic flow and present graphically the results.

Schedule

	Holiday week	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
Research	🟥	🟥							
Proposal		🟦							
Midterm			🟦						
Implement NaSch			🟥	🟥	🟥				
Complete model (lane change)					🟥	🟥			
Write python code						🟥	🟥		
Modify parameters/ analyze							🟥	🟥	
Write up project								🟥	🟥

References

Nagel, K., Schreckenberg, M. (1992): A cellular automaton model for freeway traffic

Ning Wu and Werner Brilon (1999): Cellular Automata For Highway Traffic Flow Simulation

Patrik Christen (2024): Programming of Cellular Automata in C and C++

Chris Webb (2019): github.com/CodeDrome/cellular-automaton-1d-c
using code from codedrome.com/one-dimensional-cellular-automata-in-c

Isaac Cobb (2024): github.com/CobbCoding1/gol (game of life in C)