Development of a Traffic Cellular Automaton Model for Highway Traffic

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Background

With the increasing traffic demand on the Belgian road network, the need for a better usage of the existing road infrastructure (i.e., the supply) arises in order to counter the forthcoming congestion. Within this context, our research is aimed at improving the current and future traffic conditions.

To this end, we develop a flexible testbed environment that is capable of providing us with a simulation model of a real-world road network (in this case, the Flemish primary highway network and its secondary road network) [4].

This testbed is constructed in three stages : building a traffic flow model, simulating the road network and performing control and prediction of traffic flows. At this moment, we are focussing on the first stage.

Traffic Flow Models

Traffic flow models can traditionally be classified as being either macroscopic or microscopic in nature. The former considers a traffic flow as a compressable fluid and uses fluid-dynamical partial differential equations to propagate flow and density between large discretized time/space sections. The latter however, considers each vehicle in a traffic flow individually, resulting in a more detailed description of the dynamical process behind a traffic flow.

Within our framework, we are concentrating on using the cellular automata programming paradigm as a discrete dynamical system for the modeling of traffic flows. The system's state is changed through synchronous position updates of all the vehicles (i.e., the cells).

Traffic Cellular Automaton Model

Our traffic cellular automaton (TCA) model is able to handle simplified highway traffic, meaning that we initially only focus on the car-following dynamics and ignore the lane-changing dynamics (we'll allow for multi-lane traffic once the basic setup is done). Both dynamics are modeled as rule-sets that reflect the rule-based behaviour of a cellular automaton evolving in time and space [1,3].

Our motivation is largely driven by the fact that classical TCA models (i.e., CA-184, NaSch's STCA, …) suffer from several deficiencies and therefore are more suited for theoretical studies. We remedy this situation by constructing a new TCA model that alleviates the problems of the aforementioned TCA models and at the same time includes advanced traffic characteristics (such as metastability, hysteresis, time-based headways instead of space-based headways,…) [2].

Several generic tests are performed that assess the validity of the developed TCA model (as well as the classical TCA models). These tests include histograms of lead gap distributions, measuring the time needed to travel a congested section or to completely dissolve mega-jams, measuring the life-time and size of congestion waves, …

In the end, calibration and validation are required in order to apply our model to an existing road infrastructure. At this stage, we need a rigid mathematical description for the calibration process, a fact that is most of the time neglected in literature [5].

References

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