Avoiding phantom jams in traffic

- Simulations with agent-based models

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Abstract

Det här är en sammanfattning. Test of reference to [2].

1 Driver model

Several driver models have been developed to simulate different traffic situations. These models describe the position and velocity of each car in the simulation and can then much easier be compared with empirical data than in macroscopic models. Intelligent Driver Model (IDM) is a car-following model and belongs to the deterministic kind of microscopic models.

The IDM control the position of the car on a single-lane road. The position depends on the velocity and acceleration of the car. Acceleration is described by the velocity v_α and distance to the car in front s_α. These two parts are related to the desired velocity v_0 and effective desired distance s^*. The equation for acceleration then becomes: $\dot{v_\alpha} = a(1 - (\frac{v_\alpha}{v_0})^\delta - (\frac{s^*}{s_0})^2)$ Desired distance between the cars is calculated from minimum distance s_0, time headway T and difference in velocity Δv. $s^* = s_0 + max(v_\alpha T + \frac{v_\alpha \Delta v}{2\sqrt{ab}})$

2 Methods to reduce jams

A technology to increase safety for drivers in traffic is Adaptive Cruise Control (ACC) which is the next generation of cruise control. This kind of system is able to measure the distance and speed to the car infront and then adapt the speed so a certain time gap is maintained between the cars. ACC is already commercially available on the market and there is much research going on to see the effect in traffic flow when more and more vehicles are equipped with this system [1]. The biggest advantage of the system is the increased comfort of the driver but also safety is increased. A human driver is mostly not good at estimating the distance or the velocity to the car in front which can cause unneccessary brakes or accelerations in the traffic flow. Also because of some drivers behaviour the time headway between the cars is even shorter than the reaction time of a normal driver which reduces the ability of a driver to adapt to changes of traffic flow. Since ACC is able to measure the distance and velocity with good precision and adapts the speed to always keep a safe time headway to the car in front there isn't neccessary to do as much braking and acceleration. (FIXME: ref till not)

One ability that human drivers have but not ACC is the possibility to look ahead in traffic. One example is the braking light that can be seen through several cars and this ability increses both safety and in some cases traffic flow. A problem with this method is the difficulty to estimate the speed of the cars ahead. The only information available is that the cars further ahead are breaking. We have thought of system that have the advantages of the ACC and the possibility to look further ahead in traffic. This enhanced model could be realized by communication between the cars that are travelling in the same direction. There has been some research on communication between cars and (FIXME: Kesting et al.) have tested the connectivity of such a system. The enhanced system can then adapt the speed to the cars further up in line depending of position and velocity and then possibly reduce stop & go-traffic.

3 Simulator setup

In the simulator created there was a one-lane circular road with a length of 800 m. Different amount of cars could be placed on the track corresponding to a certain traffic density. During one simulation this meant that the density was constant since no cars could be added or removed during one run. Initially all cars were positioned equally spaced on the circle, but then every car was moved forward randomly between 0 and 1 metre to create some initial perturbation that speed up the upcoming of phantom jams. The design of the simulator can be seen in Figure (FIXME: picture of the simulator).

4 Implementation of mathematical models

The three systems described in Sections (FIXME: ref till dessa tre modeller) were implemented as described below. Since the simulator used a circular road position of the car was transformed into an angle from 0 to 2π but since the acceleration and velocity were not affected by this, the car was only aware of a straight road where the car going out in one end started over from the beginninning in the other end.

4.1 Normal driver

The IDM is developed to describe a normal behavior of cars in traffic and hence we have implemented the model in our simulations with only one difference. A delay of the acceleration has been added which represents a reaction time. For human drivers it takes about 1 s to react to changes in traffic [3]. Our model is then implemented as equations (FIXME: eq) but with a time delay T_r which affects the acceleration.

4.2 Adaptive cruise control

The purpose of the ACC is to keep a constant time gap to the car in front and since IDM already has this ability only the reaction time of the model has been changed between the normal driver and ACC-driver. The ACC system is electronically controlled and we believe that the system has a reaction time of about 200 ms.

4.3 Enhanced adaptive cruise control

How to implement a system that can adapt to changes further ahead than the car infront is not obvious. In our model we have assumed that the system can get the exact information about the position and velocity of the cars further ahead. The dynamics that should be considered from the car in front is the difference of velocity between the two cars. This is implemented in the effective desired distance equation (FIXME: ref till eq IDM s*) from the IDM. The enhanced model was then realized by changing the equation of the desired distance and also include the difference of velocity of the car further ahead. The new effective desired distance then looks like:

where Since the enhanced model is controlled similar to the ACC system we also used the same parameters in both systems.

5 Results

5.1 Compairison of Performance

6 Discussion Conclusion

References

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[3] D.Helbing M. Treiber, A. Hennecke. Congested traffic states in empirical observations and microscopic simulations. *Physical Review*, E 62:1805–1824, 2000.