Traffic Modelling – Speed Controls

Description:

It is commonly observed that traffic jams and other similar traffic issues occur 'for no obvious reason'. These effects have also been observed in simple, one-lane models of traffic, where cars 'look ahead' to determine whether to speed up or slow down. Leeds Traffic Management are responsible for determining things such as speed limits, traffic calming measures, and the location of traffic lights. They have seen some results of simple models and are interested in understanding if and how they can be applied in more realistic situations. In particular, they are hoping to determine how such models work when vehicle speeds are determined by factors other than their interaction with other vehicles. They would like to use the results to determine the optimal way to implement speed and traffic flow controls, leading to smooth flow across the network.

Aims:

The Perthshire Road Agency wish to understand some/all of the following:

- Can the model treat roads with variable speed limits?
- If so, what does it tell us about the formation of traffic jams in regions where speed limits change?
- How can the model be extended to(wards) including traffic lights, or other road-users such as cyclists or pedestrians crossing the road?
- Again, what does the model tell us when applied to such a system?
- Can the model predict the effects these interventions on the overall flow through a real road network? Can it be used to determine an 'optimal' strategy for, e.g., enforcing speed limits or installing traffic lights?

An initial model:

Environment:

A one-dimensional road (array) of L sites with open (or periodic?) boundary conditions;

Agents:

Vehicles, with integer velocities between zero and $v_{\max}$.
Each road site may be occupied by one vehicle, or be empty.

Algorithm:

The motivation for the algorithm is that vehicles will accelerate towards a maximum speed limit, as long as this will not lead to them crashing into the vehicle in front. If they would do so then they decelerate. Also, drivers are not perfect at doing this, so some random deceleration is included in the model.

For an arbitrary state, one update of the system consists of the following four steps, performed in parallel for all vehicles:

1. **Acceleration:** if the velocity v of a vehicle is lower than $v_{\max}$ and if the distance to the car ahead is larger than $v+1$, increase the speed by one $[v \mapsto v+1]$.
2. **Deceleration:** if a vehicle at site i sees the next vehicle at site $i+j$ with $j \leq v$, it reduces its speed to $j-1$ $[v \mapsto j-1]$.
3. **Randomisation:** with probability p, the vehicle's velocity is decreased by one to a minimum of zero $[v \mapsto \max(v-1, 0)]$.
4. **Motion:** each vehicle is advanced v sites.

You'll need to decide what to do at the boundaries of your domain (i.e., how to add/remove vehicles).

Reference:

'A cellular automaton model for freeway traffic', Kai Nagel and Michael Schreckenberg, Journal de Physique 1, **2**(12), 2221-2229, 1992