

A Computer Simulation Algorithm About Traffic Flow

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Abstract. We bring in the simple model-NaSch Model to simulate the traffic conditions where people drive their car and obey the basic traffic rules using the Cellular automation and Monte Carlo algorithm. We establish five basic laws of the traffic flow and give an example of a simple road condition.

Introduction

Cellular automation is a modeling method which assumes that time, space and state are all discrete. the basic idea of cellular automation is that defining the law of the interact of adjacent cells for each time step, than let the time going step by step ,and the state of each cell for each time will be calculated ,so that a simulation model could be formed . In this paper we mainly discuss its application in traffic system. In order to optimize the simulation making its behavior more Authentic, we apply the Monte Carlo algorithm in it.

Cellular automation by traffic system

Basic idea. The basic idea is so called NaSch Model . NaSchModel is a typical one-dimensional model of single-line road. It is suitable to simulate the traffic flow of freeway.[2]

In this model, one lattice represents a single-line road. It divides the road into n small sections(cellular) whose length is L . The location of one point of the lattice represents one cellular. Each location is idle or accommodates one car.

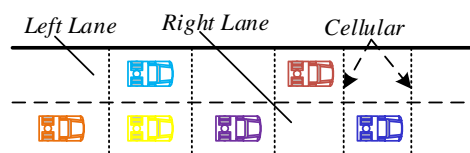


Fig.1 Cellular automation division

As is described in Fig.1 we could define which cell a car will take in the following time step. and which lane it will take ,as all the car in the road has been defined, we could change the every cells' states. Then repeat the calculation above. (Fig.2)

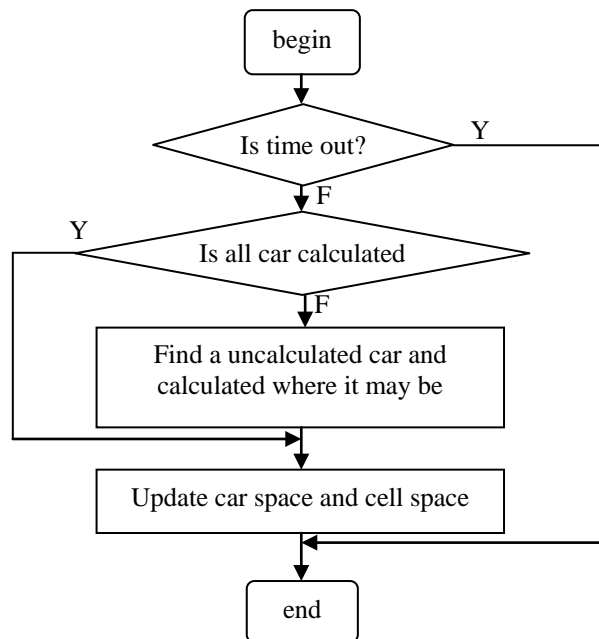


Fig.2 the flow chart of Cellular automation

The accelerate law. It's widely recognized that a driver could tend to accelerate for many aspects. for example, when a driver find that there are fewer cars ahead, he may has a higher ambition to accelerate .to sum up a driver's ambition of acceleration could be defined by the sparse degree of current state of road.

The decelerate law. As the same of acceleration law the tendency of deceleration could be the same motivation that the sparser the lane be ,the lower the deceleration will happened.

The lane change law. When a fast car will overtake a slow one ,the lane change happened .we could describe the situation like that, a fast car find there is a slow car ahead ,and only a few cell away from itself, then it will decide whether to deceleration all change lane.

The car input law. This law defines generating of the car space in the beginning of a road or there will be none cars in the road, obviously the speed of the cars to generated is different .

The crash law. It is unlucky that if the road suddenly get a crash ,in the simulation a crash could be described like a cell is taken by a certain car whose speed is zeros for a long time.

Monte Carlo algorithm by the simulation of traffic system

Basic ideas. Because the traffic flow is a display of human's behavior there must be a plenty of uncertain events .there needs to use Monte Carlo algorithm.

The accelerate law. It could be only be described that the sparser the lane is, the driver is more likely to accelerate, he may accelerate, may not .And even there is no changes of the road state, it's always possible to accelerate.

The decelerate law. As the same of acceleration law, we could only let the possible of deceleration high when the road state becomes dense.

The lane change law. In order to find the will of change lane, we should evaluate many aspects, first the difference between the speed for each other, second, the distance between two cars, third the lane occupancy of every lane, and then we could describe the possibility of a car's lane changing will.

The car input law. The probability of generating cars obviously obeys the Poisson distribution .And the speed of cars could also obey the Poisson distribution.

The crash law. The probability of a crash is a small probability event, while the cars running obey the law above, there has been a small probability that two cars crash into one cell which means the crash accident has happened.

Simulations

Basic idea. The process of the simulation is a process of iteration , in that case ,we need to save the state in current time as well as the state at next step .which could be discussed as the following formula:

$$\begin{cases} cellspace_{nextstep} = f(cellspace_{current}, carspace_{current}) \\ carspace_{nextstep} = g(cellspace_{current}, carspace_{current}) \end{cases} \quad (1)$$

The cellspace is formed as a road, which is divided into several patterns ,every patterns calls as cellspace_{i,j} in order to distinguish the location of each cell.

The carspace records every car's information, including the cars' ID, which cell the cars take, the speed of cars.

The accelerate model. The process could be described as follow:

Search the cell space find a cell which are taken as (i_a, j_a)

$$num_{ahead} = \sum_{i_a}^{i_a+20} cellspace_{k,j_a} \quad (2)$$

$$P_{accelerate} = \frac{\varepsilon_{acc}}{V_a \times num_{ahead}} \quad (3)$$

where ε_{acc} is an accelerate coefficient; $P_{accelerate}$ is the probability of acceleration.[3]

The decelerate model. The process could be described as follow:

Search the cell space find a couple of cell which are taken as $(i_a, j_a), (i_b, j_b)$

If $V_a < V_b$ and $1 \leq i_a - i_b \leq 6$

$$P_{decelerate} = \frac{\varepsilon_{dec}(V_b - V_a)}{V_b \times (i_a - i_b)} \quad (4)$$

where ε_{dec} is an accelerate coefficient; $P_{decelerate}$ is the probability of deceleration.

The lane change model. The process could be described as follow:

$$num_{left} = \sum_{i_a}^{i_a+20} cellspace_{k,j_a+1} \quad (5)$$

$$num_{right} = \sum_{i_a}^{i_a+20} cellspace_{k,j_a-1} \quad (6)$$

$$P_{changelleft} = \frac{\varepsilon_{overtake} \cdot P_{decelerate}}{\varepsilon_{dec}} + \frac{\varepsilon_{left} \cdot num_{ahead} \cdot num_{right}}{num_{left} + num_{right}} \quad (7)$$

$$P_{changeright} = \frac{\varepsilon_{overtake} \cdot P_{decelerate}}{\varepsilon_{dec}} + \frac{\varepsilon_{left} \cdot num_{ahead} \cdot num_{left}}{num_{left} + num_{right}} \quad (8)$$

where $\varepsilon_{overtake}$ is the coefficient of overtaking; ε_{left} is the coefficient of changing the left lane; ε_{right} is the coefficient of changing the right lane; $P_{changelleft}$ is the probability of changing the left lane; $P_{changeright}$ is the probability of changing the right lane.[4]

The car input model. The process could be described as follow:

$$cellspace_{1,j} = \begin{cases} 1 & rand(0.5 + \partial \sim 1.5 + \partial) > 1 \\ 0 & rand(0.5 + \partial \sim 1.5 + \partial) < 1 \end{cases} \quad (9)$$

If $cellspace_{1,j} = 1$

Then $V_{car-id} = poisson(v_{ave})$

where $cellspace_{1,j}$ is the beginning of every lane; V_{car-id} is the speed of a certain car; v_{ave} is the average speed of cars in the road; ∂ is a parameter of the probability of car generating.

The crash model. The process could be described as follow[5]:

If $cellspace_{i,j} \geq 2$

Search the cars in (i, j) find their ID

$$V_{car-id} = 0$$

Numerical example

We simulate a simple road which is straight and only has two lane .The average speed in the road is 80km/h, and we set the road rule that if you driver at a speed higher than 80km/h your must run in left, or you must run in right ,only if you would like to overtake the car ahead. In that case ,the The density distribution of the two lanes could be show in fig3.

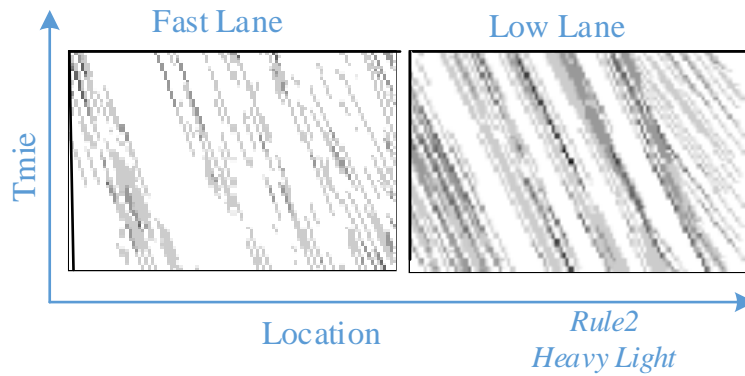


Fig 3. The density distribution of two lanes

Conclusion

A simulation system of traffic road is formed by Cellular automaton Monte Carlo algorithm .there are also many problem have not been solved ,such as the corner and the cross roads.

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