2P-09

Expressway Congestion Simulation Involving Lane Changing

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1. Introduction

Recent years, studies regarding congestion on expressway has been done. The expressway congestion caused by a few factors. One of the factors is lane changing. The level of confidence to do lane changing and method to change lane for each driver are different. These differences lead to chaos in traffic flow that could cause congestion. A situation where lane change often occurs on an expressway is at the lane drop [1]. When a lane drop exists, the time taken by the driver who drives on the disappearing lane to act affects the traffic.

Therefore, in this paper, we designed a traffic simulator of an expressway that can construct lane drop. Then, we originate the congestion on the expressway that caused by the lane drop.

2. Overview

Travelling to a distant place using land transportations would be convenient if the traffic flow is smooth and the travelling route is uncomplicated. In this situation, travelers might think using expressways will be one of the good choice to reach the target point. It is because expressways do not have much obstacles such as traffic lights, pedestrian crossings, traffic intersection etc. and expressways have systematic routing system. However, these do not guarantee that there would be no congestion happen when travelers using expressways.

Whenever congestion happens on an expressway, it would be inconvenient for the travelers as their travelling time will be longer. Besides, congestion on expressway will snatch away the excitement of driving on a wide long road from the travelers too as drivers have to break and move their vehicles repeatedly.

The causes of congestion on expressway is on several reasons such as huge number of vehicles on roads, traffic accidents, lane closure due to utility work, and drivers' lane changing behavior. At first, we believe the number of vehicles is the main reason of expressway congestion. However, when we include drivers' behavior in our study, we can conclude that congestion could happen regardless the number of vehicles on the road. Therefore, in this paper, we focused on expressway congestion caused by one of drivers' driving behavior which is lane changing.

When a lane changing occurs, the following vehicle will reduce speed to avoid collision with other vehicles. Then, once the lane changing is over, the following vehicle will accelerate to its former speed. Unfortunately, the speed recovering will take time. Thus, a chain of decelerating vehicles will make the congestion [2] by lane changing to happen.

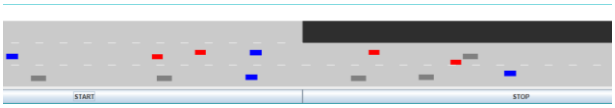

Figure 1. Example of simulation screen

A scene where a lane changing usually occur is at the lane drop. Lane drop is where the number of lanes is decreasing from *n* to *n-1* due to the bottlenecks, accidents, construction etc. [1]. In this scene, the vehicle that is traveling on the disappearing lane inevitably move to the next lane. Furthermore, each driver change lane at different distance from the end of the road. In the same time, the following vehicle on the targeted lane could not predict the behavior of that lane changing vehicle. This would force the following vehicle to slow down earlier than the needed time. Thus, delay in the driving time often occurs.

As mentioned above, lane drop on expressway is one of the factors of traffic congestion. However, there are few studies on congestion caused by lane drop. Therefore, in this study, we designed a model that involves the behavior of the drivers at the lane drop on the simulator and originate the congestion.

3. Designing the Expressway Congestion Simulation

3.1 Designing the expressway model

In this paper, to study the behavior of lane changing and the effect of lane drop on expressway congestion, we designed a model. In this model, we created road agents and vehicle agents. These agents have different values of parameters. Thus, in the future, we can conduct wide range of experiments by setting up any parameters as the manipulated variable. Beside that, these agents were created by constructing four classes, which are *Traffic* class, *Road* class, *Lane* class and *Vehicle* class. As the result, *Figure 1* shows the example of a lane drop on our expressway simulation. Whereas, F*igure 2* shows brief explanation of agents and classes constructed in our model.

3.2 Road agents

As road agents were constructed in this model, we are able control the structure of the roads and we can gather information needed during the experiment easily. The structure of the road can be control by

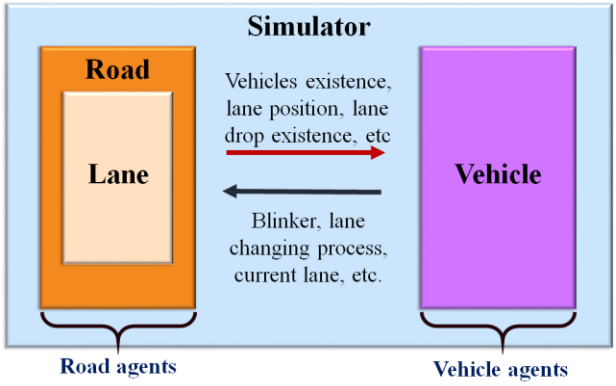

Figure 2. Agents used in our proposed model

changing the road parameters so it can suit a particular situation. For instance, to create the road structure as shown in *Figure 1*, we created two parts of road consists of three lanes and two lanes respectively. Then, we joined both of the road parts. Plus, as shown in *Figure 2*, the road agents provide the vehicle agents with information such as lane number, existence of lanes on the right, left, or front of the vehicles, and distance from the lane drop.

3.3 Vehicles agents

Like road agents, vehicle agents were constructed so that we can control the behavior of the vehicles and collect information of the vehicles for each frame. We constructed vehicles with different speed controlling behaviors and sizes. This is because we try to create variation of vehicles in our model to resemble sedan, trucks, sport cars etc. that usually runs on the real expressways. Besides, we gather the information of position, speed, size, blinker, etc. of each vehicles. Then, as shown in *Figure 2*, and we transfer the information to the roads agents. Therefore, vehicles able to judge the situation around them and takes action prior to the situation.

4. Observation on the Implication of Lane Changing Using Proposed Model

On the expressway, the density of the traffic will be higher after if a part of the road is narrowed down [1]. Therefore, in this paper, we conducted observations on lane changing behavior using our proposed expressway model. As mentioned on chapter 2, we focused on lane changing at the lane drop, so we used a simulator quite similar as shown in *Figure 1* to conduct the observation. The result of a simple observation was shown in *Figure 4(a), (b)*.

Following is the method used in this paper to conduct an observation on the congestion at the lane drop using the proposed model. First, we set up a simple straight line that does not involve lane drop. There is a constant in the number of lanes for that particular simulator as shown in *Figure 3*. Then we run the simulator for a minute and jot down several information based on the outcome. Then, we repeat the same process on lane drop simulator (*Figure 4(a)*).

Figure 3. Observation on effect of lane changing (without lane drop)

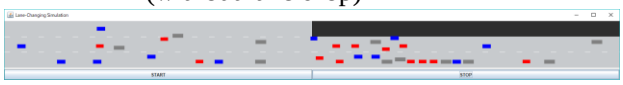

Figure 4(a). Observation on effect of lane changing at lane drop simulation

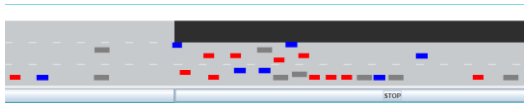

Figure 4(b). Close up of the lane drop part

After one minute the simulator runs, we took the number of the vehicles appear on the screen and calculate the number of the vehicle on each lanes of the simulator. The simulator without lane drop (*Figure 3*) shows a mean distributed vehicles. Meanwhile, in *Figure 4(a)*, the right half of the screen especially at the region right after the lane drop, shows a high density of vehicles compared to the left half of the screen. This is because at the half right of the screen, the number of the lanes has been decreased from three to two.

Besides, from *Figure 4*(*b*), we can see that around the lane drop region, distance among the vehicles is the shortest. Based on this, we can conclude that lane drop caused a delay as vehicles have to recover their speed after changing a lane and it is harder when the traffic becomes narrow.

5. Conclusion

In this study, we developed a simulator to originate congestion at the lane drop on expressway. Particularly, the purpose was realized by using multi agent system with vehicle and road as agents.

The future work is to find the approximate value of vehicle speed control related parameters and road structural parameters. In addition, the investigation on the congestion mechanism should be conduct using improvised model. Then, using the results, the solutions for traffic congestion can be propose.

References

[1] Yasuhiro, Shiomi., Tomoki, Taniguchi., Nobuhiro, Uno., Hiroshi, Shimamoto., Toshiyuki, Nakamura.: Simulating Lane-Changing Dynamics towards Lane-Flow Equilibrium Based on Multi-Lane First Order Traffic Flow Model. *Transportation Research Procedia 6*, 128- 143, (2014).

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