CSE 6740 Project 1 Checkpoint 1

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1 Description of our project

1.1 Problem statement

Not surprisingly according to INRIX, a transportation analytic firm [1], the Atlanta metro ranked the top eighth congested cities in the world, highlighted with the average commuter spending 70.8 hours each year. Congestion is not just time consuming from drivers on the road. Based on the index of INRIX, traffic congestion cost Americans $124 billion in direct and indirect losses in 2013.

The congestion costs include the external costs of road transport such as accident costs, noise, and pollution, which are various by location. Also, it leads to travel delay which is valued by wage rates and value on their free time, added fuel usage like waste fuel, and adverse environmental impacts such as greenhouse gases and criteria pollutants as engines idle while drivers are caught in traffic. Traffic congestion has impacts not only on just those elements consisting of the congestion cost, but also the possibility of another vehicle collision triggered by the traffic congestion. Resulting in longer travel times, adverse environment impacts and triggering other vehicle collisions, traffic congestions is a big problem for everyone living in cities.

In this project, we would like to discover how traffic flow simulations can be applied by Cellular Automata (CA) on the traffic network system, we focus on 1) simulating normal condition of traffic flow on the interstate highways around the city of Atlanta, 2) simulating incident condition on highway, following incident occurrence timeline to handle a vehicle collision, and 3) calculate the vehicle capacity loss of the congestion costs with average traffic, crash duration, probability of lane closure, and reduced capacity, due to lane closures intentionally or unintentionally.

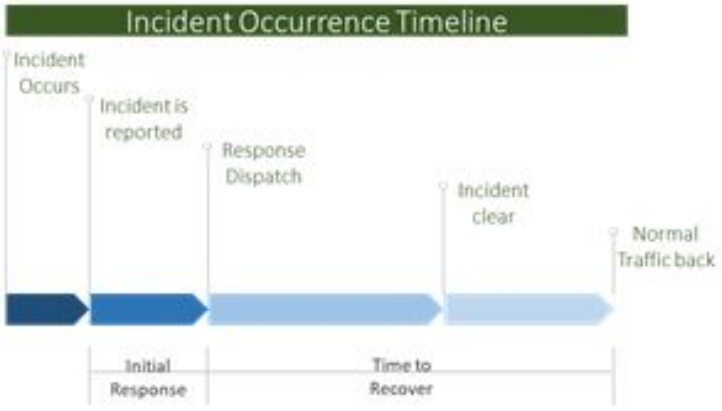

Figure 1. Incident occurrence timeline

1.2 Cellular automaton

Traffic stream or phenomena is complex and nonlinear and defined as multi-dimensional traffic lanes with flow of vehicles over time. Vehicles follow each other on each lane, and they can choose lane changing when the former position on different lane is empty. CA model is one of the microscopic traffic models. In this model, a segment of roadway is made up of cells like the checkerboard and time is also discredited. Vehicles move from one cell to another. The first research using CA model for traffics simulation was conducted by Nagel and Schreckenberg (1992), who simulated the single-lane highway traffic flow by a stochastic CA model. [2] By using CA model, we will develop a traffic flow simulator to evaluate dynamic traffic flow. We extend the existing CA models to describe the influence of a car accident in highway of five travel lanes of traffic flow model. We also add the lane changing rules to simulate the reality traffic condition. By simulation, we analyze all possible situations. The simulation will be implemented in C programming language.

1.3 Literature review: Microscopic traffic flow modeling

Microscopic traffic flow models simulate single vehicle-driver units, based on driver's behavior. The dynamic variables of the models represent microscopic properties like the position and velocity of the vehicles. There are two modeling approach are known as Car-following model and Cellular automaton model. Newell (2002) establish the Car-following models which was used to determine how vehicles follow one another on a roadway. [3] Kanai (2006) propose a stochastic CA model for traffic flow and show the availability of CA modelling for the complex phenomena that occur in real traffic flow. [4] CA models describe the dynamical properties of the system in a discrete setting.

1.4 Case study

Assuming Police officers/Highway Emergency Response Operators (HERO) can handle a vehicle collision happened especially on the interstate 285 in the city of Atlanta for 63.98 mi in Figure 1, when any accidents happen on I-285, any available team of Police/HERO will be called to the scene and handle the vehicle accident.

Figure 2. Interstates map in the metro of Atlanta

1.5 Vehicle collisions

There are lots of details in handling a vehicle collision by different cases, but we simply indicate a few steps for the project purpose. When a vehicle collision happens, drivers will face different steps (activities/events) as followings.

(1) A vehicle collision happens. It is recommended to call the police to the scene and move to a safe area if possible. When a vehicle collision happens, one or more lanes are blocked, causing a congestion queue backward from the collision.
(2) When Polices / HEROs arrive, they check the scene of the vehicle collision.
(3) After checking, collision-involved vehicles are escorted to the shoulder of the road in a safe way.
(4) After moving to the shoulder, all the traffic is released as normal and filing an accident report is conducted with the police and then leave the scene of the accident.

2 Current state of the project and initial results

2.1 Labor division:

Han Gyol Kim: Literature review, data analysis, report writing;
Ruxu Zhang: Mathematical model building, model coding, report writing;
Ciyuan Yu: Mathematical model building, model coding, report writing.

2.2 Current state:

From the submission of the proposal to now, we have specified our direction, decided the model and finished the first stage of the traffic simulation model. Our time line is shown as below:

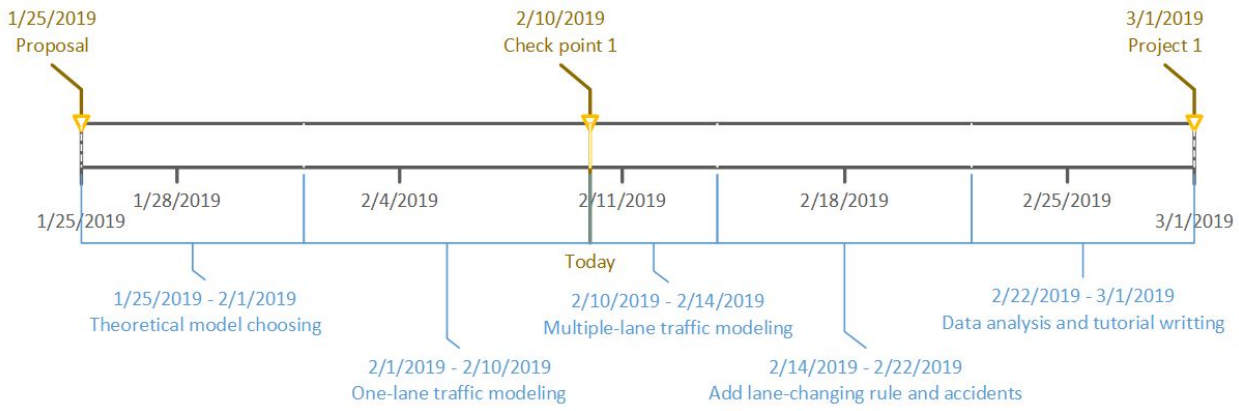

Figure 3. Timeline of the project

The time for the project is nearly over half, and we have achieved a initial result which is the most basic one-lane traffic flow on CA Model. Latter on, this prototype model could be extended to a multiple-lane model. Then, lane-changing rule of cars will be added into the model, enabling cars to switching between lanes. Finally, the "accidents" functions will be integrated into the model, the impact of accidents to the traffic flow will be recorded and print out to a file that would be used to do data analysis.

2.3 Initial results

Following is a part of the working code of the CA model that simulates movement of cars on the road.

```
1.  // move cars to the next position
2.  void NextPosition(){
3.      struct Car *node = car_list->first_car;
4.      struct Car *pre_node = car_list->first_car;
5.
6.      int count = 0;
7.      while(node != NULL){
8.          //Acceleration process
9.          node->speed = node->speed + 1;
10.         if(node->speed > MAX_SPEED) node->speed = MAX_SPEED;
11.
12.         //Deceleration process, if there is not enough space
13.         if ((node->speed) > (node->front_space)) {
14.             node->speed = node->front_space;
15.         }
16.
17.         //Randomization process, reduce speed with prob p
18.         if (node->speed > 0) {
19.             double prob_decelerate = (double)rand() / RAND_MAX;
20.             if (prob_decelerate <= 0.25) node->speed = (node->speed-1)<0 ? 0 : node->speed-1;
21.         }
22.
23.         node->space = node->space + node->speed;
24.
25.         //Move this car to new position, Xi -> Xi + Vi
26.         if (node->next_car == NULL && node->space >= MAX_SPACE) {
27.             pre_node->next_car = NULL;
28.             NewCarGenerator(node);
29.             break;
30.         }
31.
32.         node = node->next_car;
33.         if(count != 0) pre_node = pre_node->next_car;
34.         count++;
35.     }
```

Code 1. How cars move in one lane

Following is the simulation results after the 46th movement of cars on the highway segment, space = the ith cell that the car is in, front space = the interval space between cars. With these data, we could easily work out the traffic density and average speed etc.

```
---time: 46---
car:1  space:20  front space:2  speed:3
car:2  space:23  front space:5  speed:2
car:3  space:29  front space:4  speed:3
car:4  space:34  front space:10  speed:3
car:5  space:45  front space:0  speed:2
car:6  space:46  front space:4  speed:0
car:7  space:51  front space:2  speed:1
car:8  space:54  front space:5  speed:2
car:9  space:60  front space:8  speed:3
car:10  space:69  front space:4  speed:3
```

Figure 4. Part of simulation result of the one-lane model

A FIFO queue link list was built to simulate the one way highway, and accordingly, there are functions to add new cars and delete cars leaving the highway segment.

3 Github link

https://github.gatech.edu/rzhang418/Project1.git

References:

[1] AJC, “Atlanta traffic among worst in the world, study finds” http://www.ajc.com/news/local/atlanta-traffic-among-worst-the-world-study-finds/C6JR110E1z9xZeGGmjJ2HM/, accessed 2/10/2019

[2] K. Nagel, M. Schreckenberg (1992). A cellular automaton model for freeway traffic, Journal de Physique I 2(12), 2221-2229.

[3] Newell G.F. (2002) A simplified car-following theory: a lower order model, Institute of Transportation Studies, University of California, Berkeley.

[4] M. Kanai, K. Nishinari, T. Tokihiro (2006) Stochastic Cellular-Automaton Model for Traffic Flow, International Conference on Cellular Automata, pp 538-547