Design of Traffic Flow Simulation System to Minimize Intersection Waiting Time

Jang, Seung-Ju
Department of Computer Engineering,
Dongeui University

***Abstract*—This paper designs a traffic simulation system for minimizing intersection waiting time. We use SUMO simulator which is widely used as a traffic flow simulation tool for traffic flow simulation. Using the SUMO simulator to set the route from the source to the destination and measuring the time required when using the existing intersection signal system. Through this simulation, we want to measure how much the proposed system can minimize the waiting time. In order to minimize the intersection waiting time, it is assumed that there is a loop sensor that can recognize whether there is a waiting vehicle in each direction of the intersection. Using this information, a signal lamp is used as a waiting signal in the case of a direction in which there is no waiting vehicle, and a driving signal is given in the case of a waiting vehicle or an entering vehicle. In this paper, we try to reduce the time required for vehicles to arrive at their destination by making the traffic flow smoothly without any expense such as road expansion through the limited system.**

Keywords—Traffic flow simulation; SUMO simulator; reduce traffic time; intersection traffic flow; simulation design

I. Introduction

Advances in vehicle technology have provided people with convenient and safe transport. However, the rapid increase in the number of vehicles has intensified traffic congestion, and physical solutions such as road extension are no longer a good solution. It is no longer possible to physically construct roads and extend buildings.

In recent years, Intelligent Transportation Systems (ITS) have been studied in an effort to solve these problems by using existing facilities more efficiently through advanced IT technology. ITS is a convergence of IT technology and transportation. It is a next-generation transportation system that integrates intelligent advanced technologies such as electronics, control, and communication with components of existing transportation systems such as roads, vehicles, and signal systems.

In advanced foreign metropolises, a traffic control system that manages only urban highways and safety management measures are introduced and operated separately from general highways. Recently, the importance of intelligent transportation system as a strategic target facility has been increasing. The actual situation of the traffic congestion including the expressway and the main road is not a mutually independent system but an organically integrated system such as system operation and influence due to individual control strategy.

Research on the integrated control model, which is an approach to this system worldwide, is actively being conducted. In Korea, there are no cases that have been studied from this point of view. Due to the development of Intelligent Transportation System (ITS), it is possible to collect data, and dynamic and intelligent traffic signal control becomes possible. Despite these technological advances, the problem of traffic congestion in urban areas is still not resolved.

The urban area consists of a network of multiple intersections with a very high traffic volume. Therefore, if a part of the traffic network is congested, it can affect not only the traffic flow of the following road but also the traffic flow of the other intersection. ITS is a system that maximizes the efficiency of transportation facilities and provides transportation convenience and safety, and the infrastructure is being established under the leadership of the government and local governments. The ITS system is converged or integrated with Geographic Information System (GIS), Global Positioning System (GPS), LBS, and telematics element technologies to provide traffic information to users.

II. Related Research

A related study for minimizing the intersection waiting time has been to efficiently schedule the green signal to reduce the average waiting time and the total travel time at the intersection, assuming that the intersection signal has the final destination information of the vehicle. Algorithms for controlling the traffic lights to provide services to the vehicles with the shortest route remaining from the intersection to the destination are being studied [1, 2].

Another signal control method to improve traditional signaling using fixed-time scheduling is being studied to analyze the pattern of vehicle flow through an intersection during the day. A study on the algorithm that adjusts the signal pattern for each signal cycle by controlling the vehicle flow at the intersection according to the predicted vehicle pattern or by using the statistical value of the traveling direction of the vehicle leaving the intersection during the previous signal cycle [3, 4, 5].

However, research to reduce the waiting time of intersections is not very active. Most of them are operated in a simple form in which the signal pattern is firstly determined in consideration of the traffic conditions of the surrounding roads [6, 7, 8].

In recent years, research has been shifting from fixed signal control to active control to reduce waiting time at intersections in urban areas. The active control method collects the flow of the vehicle in real time and performs traffic control based on this information. Recent studies have been conducted to control signals using reinforcement learning algorithms. It is possible to see the waiting queue length of the vehicle waiting at the intersection and set the signal flexibly [9].

Reinforcement learning is a method in which a defined agent recognizes the current state and selects a behavior or sequence of actions that maximizes compensation among selectable behaviors. A study on signal control using Q-learning algorithm, which is one of the reinforcement learning algorithms, is being conducted. The reinforcement learning algorithm is one of the research fields of machine learning. It is a learning theory that accumulates the feedback obtained from the surrounding environment through repetitive search and takes the optimal selection based on this feedback. The following is the operation process of the reinforcement learning algorithm (Fig. 1).

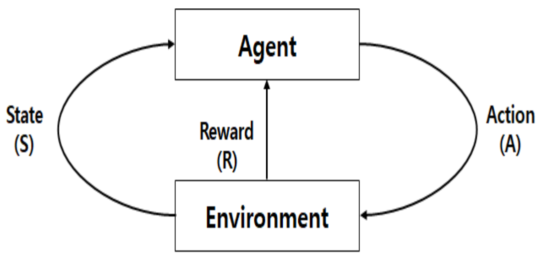

Fig. 1. Process of the reinforcement learning algorithm

III. Traffic Flow Simulation Design

This paper designs a traffic flow simulation system to minimize the intersection waiting time on the road. Simulation of Urban Mobility (SUMO) simulator is used for traffic flow simulation system design.

The SUMO simulator tool is an inter- and multi-modal, space-continuous and time-discrete traffic flow simulation platform. The SUMO simulator tool was developed in 2002 for anyone to use in open source form. The SUMO simulator is a publicly available traffic simulator tool that follows the GPL policy. The SUMO simulator also supports the ability to use it in conjunction with existing simulators.

SUMO is a traffic simulator dealing with a wide range of road networks based on open source developed since 2000 at ITS of German Aerospace Center.

The main features of SUMO are as follows.

- Free collision avoidance of vehicle nodes
- Various vehicle characteristics information applicable
- Multiple lane and lane change function
- Interacting with other applications
- Application of intersection characteristics such as actual road environment

SUMO is capable of handling traffic network node information of 10,000 large-scale environments, and has the advantage of generating node topology using files of various formats such as Visum, Vissim, ArcView, and XML. The following Fig. 2 shows the GUI interface of the SUMO traffic simulator.

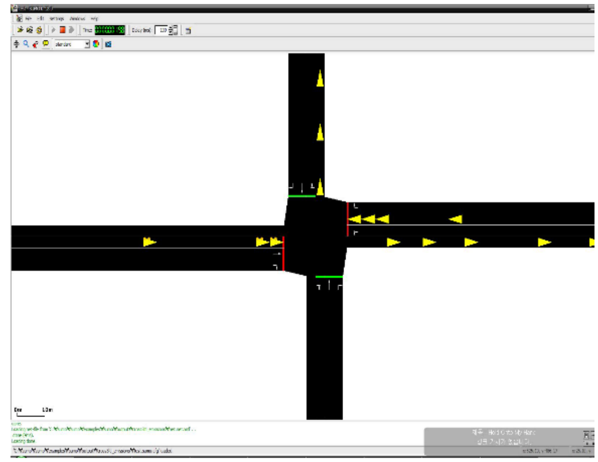

Fig. 2. SUMO Traffic simulator GUI

In this paper, we simulate traffic flow of intersection system using SUMO simulator. First, it is necessary to identify the problems with the existing traffic flow system. Most intersection signaling systems provide a certain amount of waiting time at the intersection, and when this time passes, they can pass through the intersection with green signals. These systems have advantages, but they also have several disadvantages. The advantage of a system that controls the flow of vehicles at regular time intervals can be the most optimal method for busy intersections. However, in the case of a no busy intersection, there is a fatal disadvantage of waiting for a certain period of time, even though the vehicle is not in the other lane. This causes a problem of delaying the running time of the vehicle at an intersection which is not much troublesome.

This paper simulates actual road traffic situation by using SUMO simulation tool to find improvement direction of existing intersection traffic signal system. In order to practice the road traffic situation using the SUMO simulation tool, we set the starting point and the end point of the actual road. In this paper, the actual starting point for the simulation of the traffic situation is the Busan Metropolitan City Dong Eui University. The terminal point is set at the entrance to the Hwangryung Tunnel of Busan Metropolitan City. To establish the actual road configuration for these two points, we construct road information linked with eWorld.

3.1 Link with SUMO Simulator and eWorld

In this paper, the actual starting point for the simulation of the traffic situation is the Busan Metropolitan City Dong Eui University. The terminal point is set at the entrance to the Hwangryung Tunnel of Busan Metropolitan City. To establish the actual road configuration for these two points, we construct road information linked with eWorld.

The following Fig. 3 shows the result of linking with the SUMO simulator tool on the starting point location and the ending point location using eWorld.

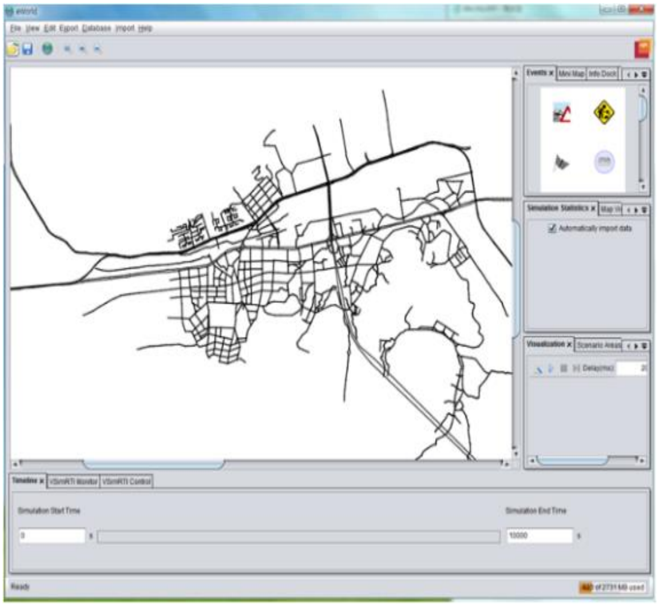

Fig. 3. Road map created using eWorld

Fig. 3 shows the path from the start to the end of the road to be simulated. In this way, an environment similar to the actual road situation is constructed to simulate the traffic flow.

3.2 Simulation Environment Design using SUMO Simulator

We design environment to measure intersection waiting time in actual road environment using SUMO simulator. We use the SUMO simulator to design an eWorld map for the same environment as the actual road situation. To simulate actual road conditions using the SUMO simulator, set it from Busan Metropolitan City Dong Eui University to the entrance of the Hwangryung Tunnel. After designing this environment, the designed files are as follows. : deuu123.add.xml, deuu123.edg.xml, deuu123.evt.xml, deuu123.flows.xml, deuu123.net.xml, deuu123.nod.xml, deuu123.poi.xml, deuu123.sumo.cfg

The deuu123.rou.xml file is described as follows. The deuu123.rou.xml file contains the following declarations for simulating the source to destination. Fig. 4 shows the declaration of these attributes.

```
<?xml version=”1.0” encoding=”TUF-8”?>
<routes>
<vType accel=”3.0” decel=”6.0” id=CarA” length=”5.0” minGap=”4.5”
maxSpeed=”50.0” sigma=”0.5”/>
<vType accel=”2.0” decel=”6.0” id=CarB” length=”7.5” minGap=”4.5”
maxSpeed=”50.0” sigma=”0.5”/>
<vType accel=”1.0” decel=”5.0” id=CarC” length=”5.0” minGap=”4.5”
maxSpeed=”40.0” sigma=”0.5”/>
<vType accel=”1.0” decel=”5.0” id=CarD” length=”7.5” minGap=”4.5”
maxSpeed=”30.0” sigma=”0.5”/>
```

Fig. 4. Declaration of the simulation attributes

Table I shows the contents of the attribute definition for Fig. 4

TABLE I. PROPERTIES AND FUNCTIONS FOR SUMO SIMULATION

Attribute Name	Value Type	Default	Description
id	id(string)	-	The name of the vehicle type
accel	float	2.6	The acceleration ability of vehicles of this type(in s/m^2)
decal	float	4.5	The acceleration ability of vehicles of this type(in s/m^2)
sigma	float	0.5	Car-following model parameter
tau	float	1.0	Car-following model parameter
length	float	5.0	The vehicle’s netto-length(length)(in m)
minGap	float	2.5	Empty space after leader[m]
maxSpeed	float	70.0	The vehicle’s maximum velocity(in m/s)

The deuu123.rou.xml source code above is designed to define automotive properties for simulation. You can specify the name of the car and the length of the car, as well as the distance between the front and back of the car and the maximum speed. The SUMO simulator supports the ability to simulate through the specification of these attributes. You can specify a route here. This function specifies the path the car should go during the simulation. The route id specifies the name of the route through which the car to be simulated passes.

Next is the information configuration for edges. This is the edge where the car travels from one junction to another. If the junction is not correctly set between one edge and the other, an error will occur. Detailed configuration of edges is shown in the following file deuu123.edg.xml.

Fig. 5. deuu123.edg.xml Configuration File

In Fig. 5, the edge id is set, and from to is also set. This indicates that from one junction to the next junction from “From” and “To”.

In this paper, we are designing a system for minimizing the intersection waiting time. I explained the current research contents. In the future research direction, we try to implement similar to the actual environment with the designed contents.

IV. Experiment

In this paper, we design a simulation method to reduce intersection waiting time. Experiments were conducted on the proposed design contents. Experiments were conducted using the SUMO simulator, linking the eWorld map to specify the starting and destination locations to be similar to the actual road conditions.

The following figure is a map of Busan Metropolitan City with Dong Eui University as the starting point and the destination with the Hwangryung Tunnel. The following shows how to simulate the actual start and destination through SUMO settings.

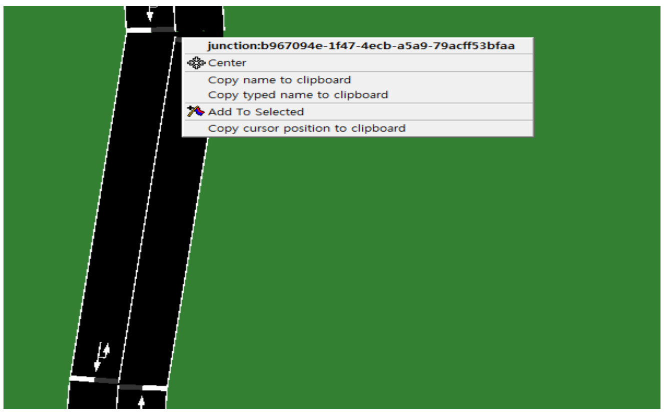

Fig. 6. SUMO Environment Setting

As shown in Fig. 6, simulation can be performed similar to the actual environment through SUMO setting. Fig. 7 shows the process of initial simulation starting place of Dong Eui University.

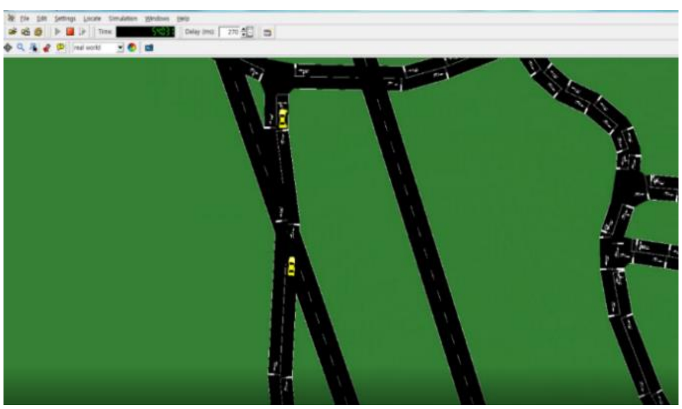

Fig. 7. Simulation initial process

Fig. 7 shows the initial process of simulation using SUMO. And the road situation is not complicated. Fig. 8 shows the process of the middle step to some extent using the SUMO simulator.

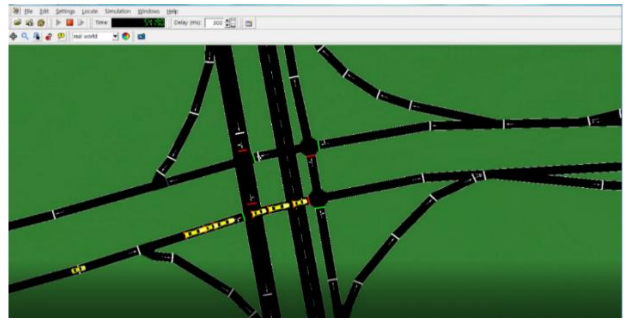

Fig. 8. Simulation middle process

In the case of Fig. 8, it can be seen that the vehicle is gradually increasing and proceeding to complicated road conditions. In this way, the simulation proceeds to the destination. As a result of this experiment, it can be confirmed that the design works normally. We will extend the simulation environment constructed in this paper to estimate the actual time required for future research.

V. Conclusions

This paper designs a traffic simulation system for minimizing intersection waiting time. We use SUMO simulator which is widely used as a traffic flow simulation tool for traffic flow simulation. Using the SUMO simulator to set the route from the source to the destination and measuring the time required when using the existing intersection signal system.

In this paper, we use SUMO simulator to simulate intersection waiting time. We try to find various solutions through simulation. We use the SUMO simulator to design in conjunction with actual road conditions. We work with eWorld maps to connect with real roads. In this paper, the actual starting point for the simulation of the traffic situation is the Busan Metropolitan City Dong Eui University. The terminal point is set at the entrance to the Hwangryung Tunnel of Busan Metropolitan City.

We design a system to simulate the time required for the route to the destination using the SUMO simulator on actual roads. To design such a system, the SUMO environment is set and constructed. Once the SUMO environment is established, we will experiment with the environment in which the cars run for the simulation. As a result of this experiment, it can be confirmed that the design works normally. We will extend the simulation environment constructed in this paper to estimate the actual time required for future research.

References

[1] Sung Yoon Young, Lee Sook Young, Lee Mee Jeong, “A Survey on traffic light control algorithm for vehicular traffic flow optimization based on real-time traffic information and contraflow lane”, Proceedings of Symposium of the Korean Institute of communications and Information Sciences , pp. 618-619, Jan. 2017.

[2] Y. K. Chin, N. Bolong, A. Kiring, S. S. Yang, K. T. K. Teo, "Q-Learning Based Traffic Optimization in Management of Signal Timing Plan," International Journal of Simulation Systems Science & Technology, vol.12, no.3, pp.29-35, 2011.

[3] Y. K. Chin, W. Y. Kow, W. L. Khong, M. K. Tan, K. T. K. Teo, "Q-Learning Traffic Signal Optimization within Multiple Intersections

Traffic Network," UKSim-AMSS 6th European Modelling Symposium, pp.343-348, Valetta, Malta, 2012.

[4] Jinseop Cho, et al., "Multiple-Intersection Traffic Signal Control based on Traffic Pattern Learning", Journal of KIISE, JOK, No. 20, Vol. 3, Mar.2014.

[5] YoungTae Jo, et al., "Intersection Traffic Signal Control based on Traffic Pattern Learning for Repetitive Traffic Congestion", Journal of KIISE, JOK, No. 20, Vol. 8, Aug.2014.

[6] Kwang-baek Kim, "Intelligent Traffic Light Control using Fuzzy Method", Journal of the Korea Institute of Information and Communication Engineering, No. 16, Vol. 8, May 2012.

[7] Won-Kee Hong and Woo-Seok Shim, "Traffic Signal Control Scheme for Traffic Detection System based on Wireless Sensor Network", Journal of Institute of Control, Robotics and Systems (2012) 18(8):719-724

[8] Jin-Tae Kim, "Diagnosis of Local Traffic Controller for Effective", JOURNAL OF THE KOREAN SOCIETY FOR RAILWAY VOL.18

[9] Hun Choi, et al., "Business Model of U-Intelligent Traffic Information and Control Services in U-City Environment", The Journal of the Korea Contents Association, Vol. 10 No. 5, Apr.2010.