Speeding Detection and Time by Time Visualization based on Vehicle Trajectory Data

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ABSTRACT

The speed of vehicles has remained a significant factor that influences the severity of accidents and traffic accident rate in many parts of the world including South Korea. This behavior where drivers drive at speeds which exceed a posted safe threshold is known as 'speeding'. Over the past twenty years, the Korean National Police Agency (NPA) has become aware of an increased frequency of drivers who are speeding. Therefore, fixed-type ASE systems [1] have been installed on hazardous road sections of many highways. These system monitor vehicle speeds using a camera. However, the use of ASE systems has changed the behavior of the drivers. Specifically, drivers reduce speed or avoid the route where the cameras are mounted. It is not practical to install cameras at every possible location. Therefore, it is challenging to thoroughly explore the location where speeding occurs. In view of these problems, the author of this paper designed and implemented a prototype visualization system in which point and color are used to show vehicle location and associated over-speed information. All of this information was used to create a comprehensive visualization application to show information about vehicle driving. In this paper, we present an approach detecting vehicles moving at speeds which exceed a threshold and visualizing the points those violations occur on a map. This was done using vehicle trajectory data collected in Daegu city. We propose steps for exploring the data collected from those sensors. The resulting mapping has two layers. The first layer contains the dynamic vehicle trajectory data. The second underlying layer contains the static road networks. This allows comparing the speed of vehicles on roads with the known maximum safe speed of those roads, and presents the results with a visualization tool. We also compared data about people who drive over threshold safe speeds on each road on days and weekends based on vehicle trajectories. Finally, our study suggests improved times and locations where law enforcement should use monitoring with speed cameras, and where they should be stricter with traffic law enforcement. We learned that people will drive over the speed limit at midnight more than 1.9 times as often when compared with rush hour traffic at 8 o'clock in the morning, and 4.5 times as often when compared with traffic at 7 o'clock in the evening. Our study can benefit the government by helping them select better locations for installation of speed cameras. This would ultimately reduce police labor in traffic speed enforcement, and also has the potential to improve traffic safety in Daegu city.

Keywords

Speeding, Camera, Visualization, Enforcement, Vehicle Trajectory Data.

Ⅰ. INTRODUCTION

Speed has been identified as a key risk factor in road traffic injuries as well as the severity of the injuries that result from driving at speeds which exceed the posted safe threshold. According to WHO report [2] the deaths by road user category in the Republic of Korea comprise 37% "Pedestrians", 26% "Driver 4 wheeled vehicles", 21% "Riders motorized", and 5% "Cyclists", Consequently, Korea government (Korea National Police Agency: NPA) [1] is attempting to increase drivers' compliance to posted speed limits and has started to operate an Automated Speed Enforcement (ASE) program, yet road traffic crashes still pose a major public health problem. The aim of the ASE vehicle monitoring system is to reduce the proportion of speeding vehicles on roads, but this system also causes changes in drivers' speeding behavior. Specifically, drivers now often reduce speed when they know cameras are present, or they avoid the routes where the cameras are mounted altogether. Furthermore, the information from the National Transport Information Center about the reported number of speed camera devices such as CCTV and VDS show there are about 3,000 devices, which are installed in national highways and local roads. The using camera ratio is 0.029 per square kilometer. Thus, these incidents mean the collected data not be completely representative of the real behavior of drivers who are not being monitored. The selection of appropriate locations suitable for deploying speeding cameras is the one interesting topic to explore. For example, [3] suggested randomly placed installation of cameras within a larger region of high risk. [4] presented a method used by police who have used aggregate data from commercial products to install speed cameras at places where drivers tend to exceed the speed limit. [5] suggested the location to install a speed camera is between historical accident locations. However, based on related information about driver's changed behavior, there is no evidence to prove that such locations continue to be locations where drivers tend to exceed the speed limit.

A vehicle monitoring and visualization system is one solution for solving these traffic problems. Use of such systems is getting more interesting in this era as cost for the equipment has decreased. So Many research projects have proceeded to install IoT systems in public transportation vehicles. This helps researchers to understand problems which are identified by observation, and the results of this research yields visualization software which shows the facts about vehicle data in a convenient way. [6] built a system based on a real-world trajectory dataset generated by 424,036,598 records of data covering their travels for one month. The system provides visualization of the dynamic taxi movement trajectories. However, most existing visual analysis approaches are focusing on only the spatial visualization and are simple. Space and time are actually inseparable in visual analysis of the dynamics of traffic mobility. From study of the current research situation mentioned above, we can obtain a conclusion: the current location where cameras are mounted can be made more effective. Current locations of mounted cameras may not be appropriate places for speeding detection, at least in the common case when the behavior of the driver has changed as a result of knowing where the camera is. Thus, these incidents mean collected speeding data may not accurately reflect real life decisions of drivers when they have no knowledge of being monitored. Therefore, in this paper, in response to that fact, we propose an approach for analyzing more realistic data and a tool for visualizing that information. We are careful to factor in the time and occurrence frequency for speeding incidents based on vehicle trajectory data.

Ⅱ. MAIN APPROACH

In order to visualize trajectory data at speeds exceed a posted safe threshold, we need a solution to clearly display incidents time by time and their location. Our approach consists of three phases; the data preprocessing, layer matching and visualization.

2.1 Data preprocessing

Our vehicle trajectory data is accumulated by the sensing devices which are installed on top of vehicle [7]. During operationing times, engine turn on / turn off events or climate have an impact on data accumulation. Thus data cleansing is important to removes trajectory inconsistencies or duplicated points. The structure of each record of the data is shown as follows: node_id, GPS locations, speed and timestamp. Each record stores latitude and longitude as a GPS location, speed indicated by the movement information and retrieved from the engine system, a timestamp saved as a string and node id which is used to identify the vehicle. Meanwhile, other data came from "Open Data" called road network data. This be fetched from Open Street Map API and the basic format is JSON. The original files have 41 fields, but for our research we used only 5 fields including full_id, osm_id, name_en, highway, and maxspeed.

2.2 Layer Matching

For the layer matching phases, our method performed a merge of two pieces data and imported these into QGIS. First data was vehicle trajectory data. Second data was road network data which used 'Overpass Query' for selecting 4 types of highway roads consisting of primary, secondary, residential, and trunk roads. Fig. 1 (a.1) depicts a vehicle trajectory data layer and (a.2) depict a road network data layer. After importing both layers, we did a spatial joint by using QGIS’s function called 'Jointed attribute by location'. The spatial join is used for joining or transferring attributes of two vector layers based on their spatial relationship. The result is a Merged Layer which is show in Fig. 1 (b.1).

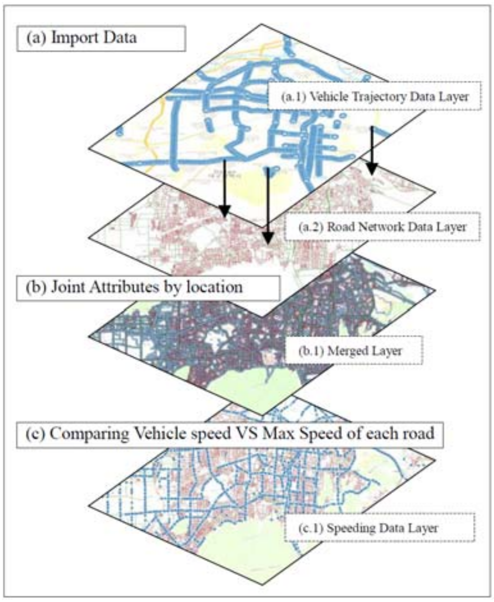

Fig. 1 Matching Layers Procedure

III. EXPERIMENT RESULTS

3.1 Vehicle Trajectory and Road Network data

The vehicle trajectory data contains a lot of route information. These records cover 4 months of data accumulated 24 hours a day and are stored in time ascending order. There are 1,865,746 records in total and after remove duplicate the total of data are 1,805,638 . On the other hand, the road network data extracted from OpenStreetMap which consists of all roads in the spatial range from 35.9318N to 35.7999N and from 128.4814E to 128.7438E. After that, we extracted the information about 4 types of highway and this yielded 8,159 records.

3.2 Posted speed limit and Speeding Detection

The Korean society has set a posted speed limit for each category of road. Most city streets and rural two-lane roads are 60–80 km/h, 80km/h for roads over 5 lanes, 30-90km/h for motorways, and the limit on expressways ranges between 100 km/h and 120 km/h. In this preprocessing step, we compared driving speed of vehicle and posted speed limit of each category of road. Speeding data = [Driving Speed] > [Posted speed + 10] The number of speeding incidents detected was 45,318 records, representing 2.5% of all data. The fig1. (b.1) shows a point and location of speeding data. A new layer after ‘Jointed attribute by location’ was also created, called the Merged Layer.

3.3 Visual Analysis of Traffic Data

The visualization of 'Points' on the map at different hours show the speeding of all vehicles. Our result shows that at midnight, which is shown in Fig. 2, there are many speeding vehicles on many roads and few vehicle are speeding data at 15:00 on the main road. All the points on the map are different colors which indicate that the Points come from a variety days.

Fig. 2 Vehicle Speeding at 00:00:00 (top) and Vehicle Speeding at 15:00:00 (bottom)

IV. CONCLUSIONS

In this paper, we propose an approach for ‘Speeding detection' and present a time by time visualization using a web based application. In addition, our system can visualize the 'speeding' data in two ways. First, the 'Speeding' points are visualized time by time and day by day, from which we learned that people will drive over the speed limit at midnight more than 1.9 times as often when compared with rush hour traffic at 8 o'clock in the morning, and 4.5 times as often when compared with traffic at 7 o'clock in the evening. Second, the location where 'Speeding' occurred also lets our study suggest improved locations where law enforcement should use monitoring with speed cameras, and where they should be stricter with traffic law enforcement.

In the future, we would like to explore the further potential of the system by making it real-time. We would like to help the government by helping it select better locations for installation of dynamic (movable) speed cameras. This would ultimately reduce police labor in traffic speed enforcement, and also has the potential to improve traffic safety in Daegu city.

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