A System for Visual Exploration of Caution Spots from Vehicle Recorder Data

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ABSTRACT

It is vital for the transportation industry, which performs most of its work by automobiles, to reduce its accident rate. This paper proposes a 3D visual interaction method for exploring caution areas from large-scale vehicle recorder data. Our method provides (i) a flexible filtering interface for driving operations such as braking or handling operations by various combinations of their attribute values such as velocity and acceleration, and (ii) a 3D visual environment for spatio-temporal exploration of caution areas. The proposed method was able to extract caution areas where some accidents have actually occurred or that are on very narrow roads with bad visibility by using real data given by one of the biggest transportation companies in Japan.

1 INTRODUCTION

Traffic accidents are still troubling society. In 2013, 629,021 traffic accidents occurred in Japan according to recent transportation statistics[1]. Many local governments in Japan have made potential risk maps of traffic accident spots to reduce such tragedies.

It is vital for the transportation industry, which performs most of its work by automobiles, to reduce its accident rate. The industry has started to introduce dashcams or vehicle recorder systems to retrieve information of accidents and to increase drivers' safety awareness. Collected information helps drivers to look back their daily driving at the end of the workday. Moreover, if we collect many drivers' records over a long time, the data will allow us to find caution spots for driving. Extracting such spots helps to create a new risk map on the basis of many facts about risky areas. The map will be able to cover a wide area and reflect both spatial and temporal information.

There has been some research on spatio-temporal analysis and visualization of mobility data collected by tracking technologies such as GPS [4, 3, 1, 2]. However, most studies have focused on analyzing traffic jams or movement patterns. As far as we know, no research has explored caution spots for driving on the basis of real vehicle recorder data using 3D spatio-temporal visualization and coordinated multiple visualization techniques.

This paper proposes a novel visual exploration interface to explore the wide range of spatio-temporal caution spots from vehicle recorder data including braking and handling operation logs. Our major contributions are as follows:

- We design a visual interface to flexibly filter driving operations in accordance with various combinations of their attribute values.
- We present an exploration interface using 3D spatio-temporal space to discover caution spots using huge amounts of driving operation records.

We demonstrate the possibilities and usefulness of our novel visual exploration environment by describing case studies using real data given by one of the biggest transportation companies in Japan.

2 EXPLORATION OF STANDARDS FOR CAUTION DEGREE

We provide an exploration interface to calculate caution degrees for driving operations to filter them using relationships between attribute values of the driving operation logs and accident information in a specific area.

2.1 Datasets

For the experiments, we use large scale real driving records collected by Sagawa Express Co., Ltd., which is one of the biggest transportation companies in Japan providing a door-to-door delivery service, in cooperation with Datatec Co., Ltd. The records consist of about one month's worth of data (21 July to 20 August 2014) for about 80 drivers assigned to Bunkyo ward, Tokyo. Data is recorded by a multifunctional vehicle recorder that has a longitudinal accelerometer, lateral accelerometer, gyro compass, and GPS. The drive recorder automatically detects some basic driving operations such as braking and handling. Several statuses are recorded: speed, longitudinal acceleration, and jerk during the braking operation, and speed, yaw velocity, yaw angular acceleration, and lateral acceleration during the handling operation.

2.2 Standards Exploration View

We provide a mechanism for exploring appropriate standards for calculating caution degrees on the basis of attribute values of braking or handling operation records. For this purpose, we consider the places where traffic accidents have occurred as dangerous places. We then explore a standard to have a high correlation coefficient between the sum of calculated caution degrees and the number of accidents in the same region.

We utilize five years' worth of accident place records, totaling around 500 records, plotted on the map provided by the local government of Bunkyo ward[2]. We counted the number of accidents in every 100-meter grid in the map.

Figure 1 (I) shows a Scatter Plot Matrix based visual exploration interface for caution degree standards called Standards Exploration View (SEV). Each scatter plot in the SEV has two axes selected from attributes of operations. SEV plots operation records included in the same regions as those on the map provided by Bunkyo ward. SEV measures the distance of each operation plot from a standard-line as a caution degree (Figure 1 (I-a)). The caution degree for each plot changes in accordance with the slope of the standard-line. Users can interactively rotate the standard-line to determine the slope of the standard-line to have a high correlation coefficient between the sum of caution degrees and the number of accidents in every 100-meter grid[3].

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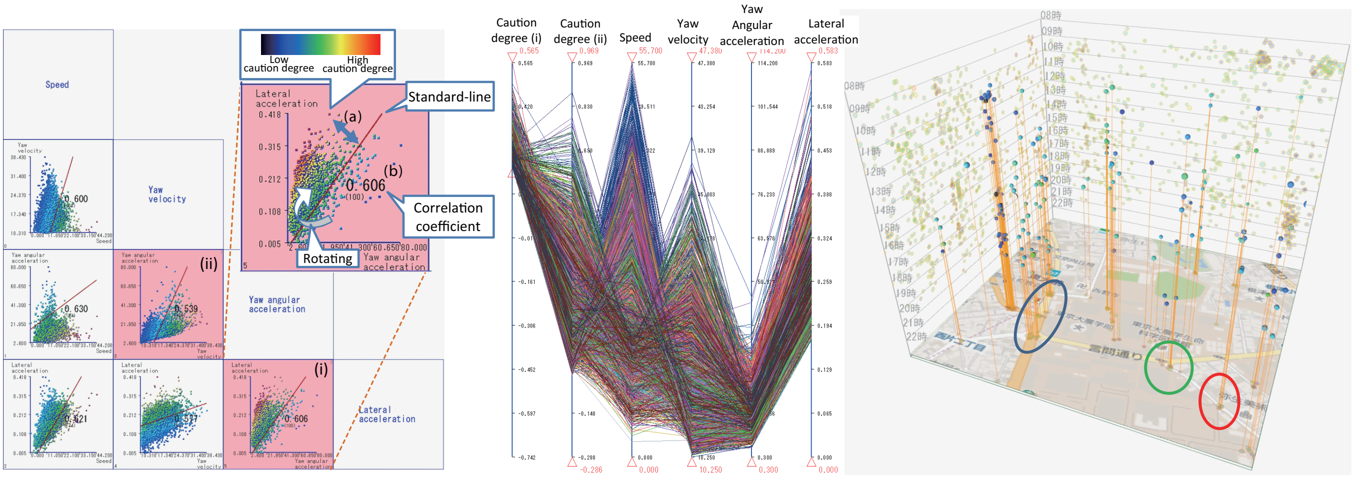
[1]Ministry of Internal Affairs and Communications in Japan: http://www.e-stat.go.jp/SG1/estat/List.do?lid=000001117549 (in Japanese)

[2]http://www.city.bunkyo.lg.jp/var/rev0/0094/4688/hiyari.pdf (In Japanse)

[3]Users can also define the standard-line as they like.



(I) Standards Exploration View (II) Filtering View (III) Spatio-temporal View

Figure 1: (I) Standard Exploration View (SEV): Scatter Plot Matrix based exploration interface for caution degree standards. (a) Measuring the distance of each driving operation from a standard-line as a caution degree. (b) Rotating and determining the slope of the standard-line to have a high correlation coefficient between the sum of caution degrees and the number of accidents. This example shows SEV for handling operation that includes four attributes: speed, yaw velocity, yaw angular acceleration, and lateral acceleration. (II) Filtering View: Exploring caution spots by filtering driving operations, such as braking or handling operations, on the basis of caution degrees defined by (I) and/or attribute values using parallel coordinates view (PCV). Filtered results are shown in (III) 3D Spatio-temporal View. In this example, extracted results are almost the same spots as the actual accident places.

3 Spatio-temporal Exploration Environment

We utilize a 3D spatio-temporal visualization space to visualize caution degrees of operations (Figure 1 (III)). In our Space Time Cube implementation, its base represents geography, and its height represents time, with later times at the bottom. Each operation record is represented as a sphere and mapped on the 3D space in accordance with its longitude, latitude, and time. The size and color of each sphere are defined by its caution degrees or attribute values. Users can arbitrarily define the mapping of them. Users can interactively zoom in/out of, rotate, and pan the 3D space to observe plots from various viewpoints. Users can also pan and zoom in/out of a map on the base.

We can explore caution spots by filtering driving operations, such as braking or handling operations, on the basis of caution degrees and/or attribute values using parallel coordinates view (PCV) for dynamic queries as shown in Figure 1 (II). Axes in PCV represent caution degree standards specified in Section 2 and attributes of operation. Line graphs in PCV represent operations. Users can interactively define selection ranges for axes.

We can visualize movement trajectories of driving as lines as shown in Figure 2 to understand moving directions of drivers. Red lines represent 10-second trajectories before braking or handling operations occurred, and black lines represent 10-second trajectories after operations occurred.

4 Case Studies

Figure 1 (III) shows caution spots filtered by Figure 1 (II). We confirmed that these results are almost the same spots as the actual accident places, which are plotted on the map provided by Bunkyo ward. It is difficult to extract such spots through filtering only by attributes on PCV without using caution degrees because distributions of operations are tilted as shown in Figure 1 (I).

Figure 2 visualizes the explored caution spots in detail. These results show that out system enables us to find caution spots even on the very narrow roads in places with bad visibility.

5 Conclusion

We proposed a novel visual exploration system that enables us to explore caution spots for driving from wide range of spatio-temporal space using drive recorder data. Caution spots explored by using our system are useful for drivers' safety education and urban development to reduce the traffic accidents. We plan to utilize more long-term data, other kinds of operation data, weather data, elevation data, and photos taken by dashcams to gain deeper insights into caution spots.

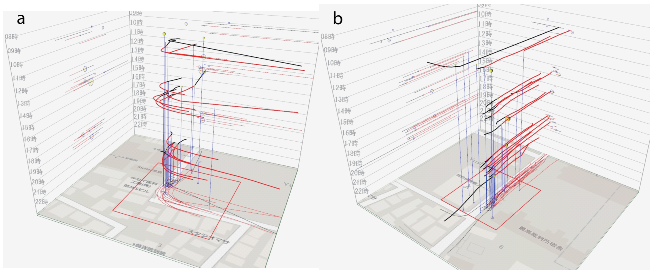


Figure 2: Exploration examples: (a) is in a place just after the corner of the narrow road. (b) is in a place in front of the gate of an official residence.

Acknowledgements

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