

Automatic Classification of Motorcycle Motion Sensing Data

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Abstract—Motorcycles are cost-efficient transportation but regarded as unsafe. To build safer motorcycle, the vehicle motion of motorcycles should be clarified. The motion depends on that of a rider much more than that of the body of a motorcycle, and thus motorcycle companies do not have enough motion data. Our research group has researched a sensing network with motorcycles and a vehicle-motion corpus of motorcycle. In this paper, we propose a method to attach an appropriate label to sensed data from the sensing network.

I. INTRODUCTION

Motorcycle riders are generally much more likely to have a death or heavy injury than car drivers at a traffic accident because the body of a motorcycle does not protect its rider and its structure cannot be self-standing. Although many intelligent transport systems (ITS) are being researched and developed, there are no ITS dedicated for motorcycles. To develop a ITS for motorcycle safety, it is important to comprehend the vehicle motion of a motorcycle. The vehicle motion of a motorcycle is much different of that of a car, and it depends on each rider and each vehicle type.

Our research project, Bikeinformatics[1], focuses to build a sensing network for motorcycles with mounted sensors and to create a vehicle-motion corpus of motorcycles. In this paper, we propose a method to attach an appropriate label to the part of sensed data that is straightforward. In our project, enormous amount of sensed data will be gathered through the sensing network and it should be processed automatically in order to build the corpus. The related work including human activity sensing[2] labels data by hand because such activities are complex and it is difficult to be automated. Since the motorcycle motions are simpler than that of human, it is possible to classify them automatically. In our project, the labeled data by this method will be utilized as supervised data in order to label the other part of the sensed data, which is complex, with the machine learning[3] in the future work.

II. PROPOSED METHOD

In this paper, we propose a method for sensed data to attach an appropriate label to them. To comprehend the motion of a motorcycle from crowd sensing data, we need to classify the data by the situation where a rider and a motorcycle are in and to analyze the data statistically. The following two motions: turning right/left on an intersection and going along right/left

curving road, can lead similar sensed motion data but they should be distinguished. The labels indicate such a situation. We utilize the location information with a GPS receiver and the digital map in order to estimate the situation.

A. Sensing Environment and Device

We use a rider's smartphone as a mounted motion sensor for their motorcycle. The smartphone is fixed on the body of a motorcycle. It includes the following sensors: 3-axes acceleration sensor, 3-axes gyroscope (angular rate) sensor, 3-axes geomagnetic sensor and a GPS receiver. We can obtain the 9 axes motion data and the location of a running motorcycle. We have developed an application software to log the data[4]. The motion data are measured with 200Hz rate and the location data is sensed with 1Hz rate.

B. Detection of Curving Point

Significant vehicle motions usually occur in a situation where a motorcycle is not on a straight road and goes on it. We utilize the trajectory and derive where the motorcycle is turning in order to pick up such situation.

We calculate the curvature of each three consecutive location from the motorcycle's trajectory measured by GPS, and we detect the turning points of the motorcycle by the derived curvature data. The curvature ρ is calculated as follows: Given three points A, B and C, their circumradius R is calculated by $R = |BC| \sin \angle BAC$ using the sine theorem; ρ is the inverse of R .

We regard a road segment that includes a higher curvature point than a given threshold. Furthermore, it is possible to distinguish an intersection and a curving road by using a digital map. If a higher curvature point is within the 20 meters from the center of an intersection, we regard the sensed data as obtained in the intersection. When a higher curvature point is found, we pick the time-series sensed data from three seconds before and after the point (1200 samples), in other words six seconds includes the point at the center, as a data segment. Additionally, we distinguish the picked data by each direction of a road.

C. Correction of Data Segmentation

In the previous subsection, we have sectioned each sensed data that include a higher curvature point than a threshold

TABLE I
CORRELATION OF SENSED DATA SEGMENT

	Mixed (Fig. 1)	toward SE (Fig. 2)	toward NW (Fig. 3)
Correlation	0.567	0.857	0.916

by time scale. However, such motion sensed data is widely varying depending on the speed of a vehicle. For example, a vehicle at 60 km/h finishes a turning action with a half of the duration time where the vehicle at 30 km/h. In this case, the moving distance of the former segment is two times longer than that of the latter. Moreover, since the location information is sampled each second, the starting and ending points of a sensed data segment can be differ in individuals.

In our method, we convert the sensed data into that with distance-scale calculating the moving distance. We calculate and add the offset to the starting point of each sensed data segment. After the processes above, we obtain the set of sensed data to be labeled.

III. EXPERIMENT

We have conducted an experiment to evaluate our proposed method. To obtain multiple motion sensing data of a certain curving road, we have run the same road seven times and have collected sensed data. The location of the experiment was conducted near Hamamatsu Campus of Shizuoka University, Hamamatsu City, and the smartphone was a SHARP AQUOS PHONE SH-01D with Android OS. The motorcycle was a YAMAHA FZ6 (600 cc standard model) and the rider was a 24 year-old man and his riding experience was about 3 years.

In the sensed data, the yew-axis gyroscope gives a positive (negative) value when turning right (left). Similarly, the roll-axis gyroscope gives a positive-to-negative (negative-to-positive) value when turning right (left).

To extract motion sensing data of a certain curving road, we have given 2/km ($R=500\text{m}$) as the threshold of the curvature. Figure 1 shows the corrected motion sensed data at a curving road with distance-scale. In this paper, we adopt a noise reduction method with an optimized FIR filter by Kaiser window and its number of order is 50.

There are two types of peaks around the distance between 0.15km to 0.3km in Fig. 1. One of them is positive peak, and the other is negative peak. In this graph, we do not distinguish the sensed data between the moving directions, and both turning-right motions and turning-left motions at the same intersection are indicated in the graph.

The moving direction is able to detect by the trajectory with GPS easily. Figures 2 and 3 shows the results after the sensed data have been distinguished by the moving direction.

We calculate the correlation of the sensed data above and Table I shows the result. After the distinct of the moving direction, the correlation is larger than 0.8. Through the experiment, it has been confirmed that the sensed data can be classified into turning right and left, and it is possible to generate labeled data for the supervised machine learning.

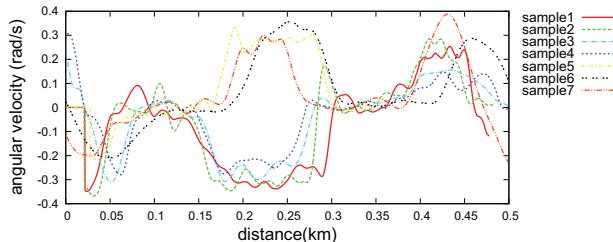


Fig. 1. 7 samples from experiment

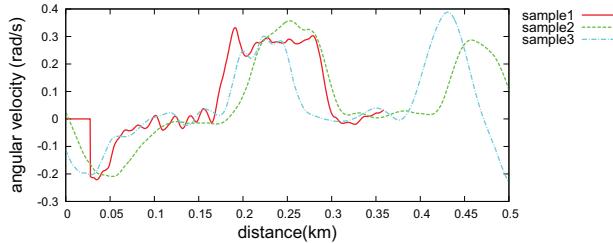


Fig. 2. 3 samples toward SE

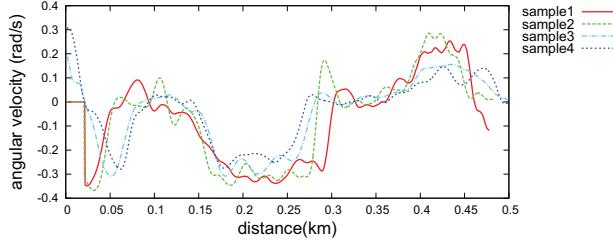


Fig. 3. 4 samples toward NW

IV. CONCLUSIONS

In this paper, we have proposed a method to classify sensed motion data by using the location information and digital map. The classified data can be attached the label indicating a vehicle motion after this processes.

To evaluate the proposed classification method, we have conducted an actual running experiment with a motorcycle and a smartphone mounted on the motorcycle. As a result, we have confirmed that it is possible to classify turning motion on a intersection automatically.

In future work, we will process more amount of data and utilize the machine learning technique to raise the precision of the classification.

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