An Evaluation Method of Obstacle Avoidance Behavior on Bicycle Trip Using Rider's Gesture

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***Abstract*—This paper proposes a method for evaluation of obstacle avoidance behavior on bicycle trips in videos using rider's gesture based on OpenPose. Since a bicycle is a vehicle which is ridden by rotating a wheel with load transfer of a rider, there is a high correlation between bicycle behavior and rider's gesture. Therefore, we evaluate the obstacle avoidance behavior based on rider's gesture. In the proposed method, features about rider's gesture are obtained by utilizing OpenPose. In addition, support vector machines (SVMs) are constructed based on the features. Our method detects the obstacle avoidance behavior and classifies that to a degree of danger. Experimental results show the effectiveness of our method.**

***Index Terms*— rider's gesture, obstacle avoidance behavior, OpenPose, machine learning, deep learning**

I. Introduction

According to the investigation by National Public Safety Commission and National Police Agency, the composition ratio of bicycle-related accidents to total traffic accidents in 2018 was around 20% and around 83% of them were accidents with cars in Japan [1]. Therefore, it is important to reduce bicycle-car accidents. The obstacle avoidance behavior on bicycle trips is a cause for the bicycle-car accident. This accident is mainly attributed to avoid any obstructions on the shoulder of a road. An example case of the obstacle avoidance behavior is indicated in Figure 1. During this case, since the distance between the bicycle and the car is nearer than a standard traveling situation, a possibility of the bicycle-car accident is increased. Therefore, an evaluation of traveling behavior of a bicycle is important in order to reduce the bicycle-car accidents. Also, in recent years, dashcams have been equipped on many vehicles making it easy to acquire a view ahead of a vehicle. Therefore, various methods have been proposed which evaluate the accidents in videos [2][3]. Specifically, these methods focus only on the occurrence of the accidents. However, in order to reduce the accidents, the evaluation of the object's behavior is also necessary.

From the above background, we propose a method to evaluate the obstacle avoidance behavior on bicycle trips in videos. In our method as shown in Fig.1, the obstacle avoidance behavior is defined as a situation where a bicycle does not travel straight. The degree of danger is a basis of classification, referring to the distance from a straight travel. Figure 2 shows an outline of the proposed method consisting of 2 steps. In the first step, features about rider's gesture are obtained from videos by utilizing OpenPose [4]. In the second step, such behavior is detected and classified to the degree of danger by using trained SVMs [5]. We confirm the effectiveness of the proposed method by 2 experiments.

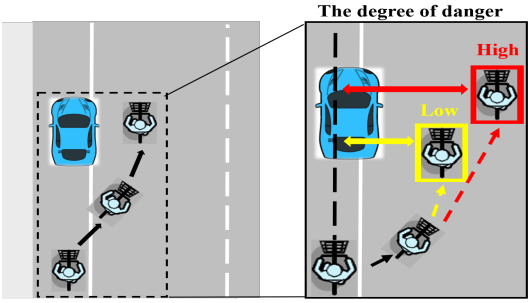

Fig. 1. The example of the obstacle avoidance behavior and the degree of danger.

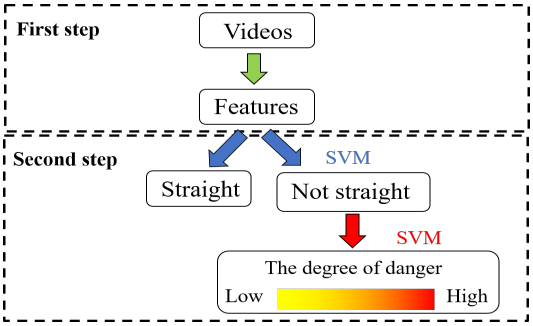

Fig. 2. The outline of the proposed method.

II. Evaluation of Obstacle Avoidance Behavior

The proposed method consists of the 2 steps. The detailed procedures of each step are as follows.

A. First Step : Feature Extraction

In this step, 3 types of features are extracted from each video clip consisting of 3 consecutive frames with a frame rate of 30fps. First, the proposed method detects a rider in a video clip and 2 dimensional coordinates of rider's joints in each frame are taken by utilizing OpenPose as shown in Figure 3. Second, the 2 dimensional coordinates are expressed by the relative coordinates with "MidHip" and then are normalized. Finally, the proposed method obtains 3 types of features which are shown as follows.

- Mean of relative coordinates [50 dimensions]
- Difference of relative coordinates [100 dimensions]
- Mean of joint angles [10 dimensions]

B. Second Step : Detection and Classification

In this step, the obstacle avoidance behavior is detected and classified to the degree of danger in each video clip. First, the

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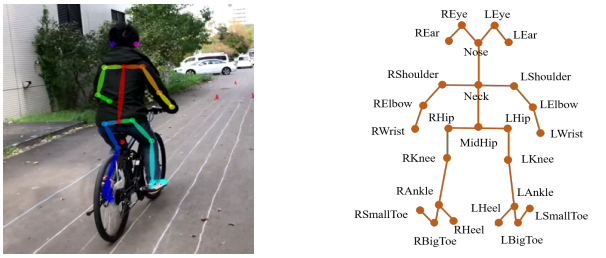
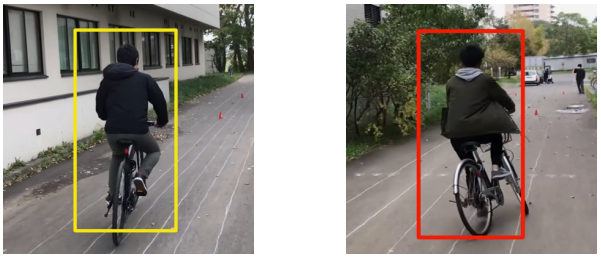


(a) (b)

Fig. 3. The feature extraction: (a) the obtained joints by utilizing OpenPose, (b) the definition of the joints.



(a) (b)

Fig. 4. The detection and classification: (a) Level 1, (b) Level 2.

TABLE I
THE NUMBER OF THE VIDEO CLIPS.

	Label	Train	Test
First experiment	Straight case	8,570	1,280
	Meander case	8,570	1,280
Second experiment	Level 1	5,304	1,998
	Level 2	5,304	1,998

obstacle avoidance behavior is detected. Specifically, whether the bicycle travels straight or not in each video clip is identified by using SVM which is trained on straight traveling and obstacle avoidance behavior. Next, the detected behavior is classified to the degree of danger. Specifically, the detected behavior is classified to the degree of danger by using another SVM which is trained on the degree of danger.

III. Experimental Results

In this section, the results of 2 experiments are shown to confirm the effectiveness of the proposed method. For these experiments, we prepare video clips of bicycle traveling which are Straight case and Meander case. These video clips are recorded from behind the bicycle. In these experiments, we define Straight case as the straight traveling and Meander case as the obstacle avoidance behavior. Also, as shown in Figure 4, we assume that the degree of danger is divided into 2 types called Level 1 and Level 2. Therefore, the video clips of Meander case are labeled into 2 labels. In the first experiment, we identify whether the video clip is Straight case or Meander case. In the second experiment, we classify the video clips of Meander case to the degree of danger. The above 2 experiments are performed by applying the proposed method to the video clips. The number of video clips in these experiments is shown in Table I .

For the performance evaluation in these experiments, we calculate Precision, Recall and F-measure, which is harmonic mean of Recall and Precision. Precision and Recall are defined as follows.

$$\text{Precision} = \frac{\text{Num. of correctly estimated video clips}}{\text{Num. of all estimated video clips}}, \quad (1)$$

$$\text{Recall} = \frac{\text{Num. of correctly estimated video clips}}{\text{Num. of correct video clips}}. \quad (2)$$

In order to confirm the effectiveness of the proposed method, we use 2 comparative methods explained below.

Comparative method 1)
: The 2 dimensional coordinates of the rider's joints are directly used.

Comparative method 2)
: A color-based feature which is hue around the rider in the image is used.

The experimental results are shown in Table Ⅱ and Ⅲ. In identifying whether the video clip is Straight case or Meander case as shown in Table Ⅱ, the proposed method outperforms the comparative methods in F-measure. Also, in the comparative methods, there is the method which reaches around 0.97 in Precision and Recall. Thus, using the multiple features should be considered in the near future. In classifying to the degree of danger as shown in Table Ⅲ, the proposed method outperforms the comparative methods in F-measure. From the above results, the effectiveness of the proposed method can be confirmed.

TABLE II
THE RESULTS OF THE IDENTIFICATION WHETHER THE STRAIGHT CASE OR THE MEANDER CASE.

	Straight case			Meander case		
	Ours	Comp.1	Comp.2	Ours	Comp.1	Comp.2
Recall	**0.8758**	0.6492	0.8023	0.9219	0.9195	**0.9781**
Precision	0.9181	0.8897	**0.9735**	**0.8813**	0.7239	0.8319
F-measure	**0.8964**	0.7507	0.8797	**0.9011**	0.8100	0.8991

TABLE III
THE RESULTS OF THE CLASSIFICATION TO THE DEGREE OF DANGER.

	Level 1			Level 2		
	Ours	Comp.1	Comp.2	Ours	Comp.1	Comp.2
Recall	**0.6542**	0.5490	0.1741	0.8243	**0.8423**	0.8158
Precision	**0.7883**	0.7769	0.4860	**0.7044**	0.6513	0.4970
F-measure	**0.7150**	0.6434	0.2564	**0.7597**	0.7346	0.6177

IV. Conclusion

In this paper, the method for evaluation of the obstacle avoidance behavior on bicycle trips in videos was proposed. The proposed method obtains the features about rider's gesture by utilizing OpenPose and constructs SVMs. Our method detects the obstacle avoidance behavior and classifies that to the degree of danger. The effectiveness of the proposed method can be confirmed by the experimental results.

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