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Evaluation of Driver's Cognitive Distracted State Considering the Ambient State of a Car

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ABSTRACT

The effectiveness of considering the ambient state of a driving car for evaluating the driver's cognitive distracted state is evaluated. In this article, Support Vector Machines and Random Forest, which are representative machine learning models, are applied. As input data for the machine learning model, in addition to a driver's biometric data and car driving data, an ambient state data of a driving car are used. The ambient state data of a driving car considered in this study are that of the preceding car and the shape of the road. Experiments using a driving simulator are conducted to evaluate the effectiveness of considering the ambient state of a driving car.

KEYWORDS

Ambient State, Cognitive Distracted State, Driving Simulator, Eye Movement, Features, Machine Learning, Random Forest, Support Vector Machines

INTRODUCTION

One of the main causes of traffic accidents is that drivers get distracted, such as carelessness. To prevent such accidents, it is important to evaluate driver distraction. There are several types of distraction, one of which is cognitive distraction. Cognitive distraction is difficult to assess because the driver may not exhibit any external changes. Therefore, in this study, we estimate the driver's cognitive distraction while driving a car using various data generated during driving.

To estimate cognitive distraction, one can use driver biometric data such as eye movement, head movement, and pulse as well as driving data such as steering angle, acceleration, and braking. Eye movements and head movements are affected by the ambient state of the car. For example, when looking at the right side while driving a car, the meaning of that action is different in cases in which there is another vehicle on the right side and there is no other vehicle on the right side. Therefore, in this study, we aim to improve the evaluation accuracy of driver cognitive distraction by considering

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the ambient state of the car. Parameters of the ambient cars and road shape (curvature) are used as data for the ambient state. Then, using Support Vector Machines (SVM) (Cortes & Vapnik, 1995) and Random Forest (Breiman, 2001) machine learning algorithms, the driver's cognitive distracted state is evaluated. A driving simulator experiment is also conducted to evaluate the effectiveness of considering the ambient state of the car.

BACKGROUND

There are many studies that have used driver biometric information such as eye movement to evaluate the cognitive distracted state. Eye movement is the primary sign of life in neuropsychology and cognitive science (Wang, 2014).

Yoshizawa, et. al. discussed the influence of nonvisual secondary tasks on driver's pedestrian detection to eye movement (Yoshizawa & Iwasaki, 2015). Miyaji, et al. detected driver cognitive distraction by using the eye movement and head movement data (Miyaji, Kawanaka, & Oguri, 2010). Liu et al. have also detected the distracted state by using the eye movement and head movement data obtained while driving (Liu, Yang, Huang, & Lin, 2015; Liu, Yang, Huang, Yeo, & Lin, 2016; Liu, Yang, Huang, Lin, Klanner, Denk, & Rasshofer, 2015). Mizoguchi et al. extracted complex rules appearing in cognitive distracted state from various driver characteristics such as eye movement, steering angle, and pedal pressure, using inductive logic programming (Mizoguchi, Ohwada, Nishiyama, Yoshizawa, & Iwasaki, 2015). In addition, Mizoguchi, et al. combined the driver rule in the cognitive distracted state generated by inductive logic programming and the classification result of the SVM, and then detected the cognitive distracted state with a higher precision than other existing methods (Mizoguchi, Nishiyama, & Iwasaki, 2014). We evaluated the cognitive distracted state using the eye movement data acquired while driving and the eye movement data acquired from visual experiment tasks on a personal computer display (Harada, Iwasaki, Mori, Yoshizawa, & Mizoguchi, 2014; Harada, Mori, Yoshizawa, & Iwasaki, 2015; Harada, Kawakami, Yoshizawa, Iwasaki, & Mizoguchi, 2015; Koma, Harada, Yoshizawa, & Iwasaki, 2017).

This shows the way eye movement data is used for evaluating the cognitive distracted state. However, the eye movement is affected by the ambient state of the car being driven. Therefore, by evaluating the cognitive distracted state in consideration of the ambient state of the driving car, more accurate results are expected compared with evaluation without considering the ambient state.

Several studies have described the relationship between the eye movement and the ambient state. Sato et al. analyzed the state of a driver's eyes at the time of occurrence of accidents such as the relationship between the sudden appearance of a bicycle and the driver's eye movement (Sato, Katsumata, Ito, Madokoro, & Kadowaki, 2015). However, this study did not evaluate the distracted state. There are also studies that evaluated the cognitive distracted state by considering the ambient state. Hirayama et al. analyzed the ambient car situation in scenes where the eye movement direction changed significantly, and compared how the eye movement changes between attentive state and distracted state (Hirayama, Sato, Mase, Miyajima, & Takeda, 2014). However, this study employed a method that evaluates the cognitive distracted state only when eye movement shifts significantly from the front to the side or rear of the car. Therefore, it is insufficient to evaluate the cognitive distracted state when driver's eye movement is less pronounced.

APPLICATION OF SUPPORT VECTOR MACHINES AND RANDOM FOREST

Input Data Generation

In this study, SVM and Random Forest are applied as machine learning models to evaluate driver cognitive distraction. SVM is a machine learning algorithm based on classifiers. In SVM, the