Title	自転車の危険な挙動認識と録画映像による web マップ型運転記録システムの提案および評価
Author(s)	原田, 力伎
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Description	Supervisor: 金井 秀明, 先端科学技術研究科, 修士 (知識科学)

Abstract

In this paper, we propose a web-based map-driven driving record system that detects hazardous behaviors during bicycle riding, integrates them with recorded video footage and location data, visualizes dangerous driving situations, and enables user sharing. Furthermore, we evaluate the effectiveness of the proposed system.

In recent years, bicycle use has been encouraged from the perspective of reducing environmental impact and promoting health, and its adoption has been increasing, particularly in urban areas. However, along with the rise in bicycle usage, traffic accidents have become a significant issue, and ensuring the safety of cyclists has emerged as a social concern. Consequently, efforts have been made to collect traffic data to enhance bicycle safety. Existing data collection methods mainly rely on interviews with cyclists and accident reports compiled by police officers after actual traffic incidents. However, information regarding near-miss incidents (where an accident was narrowly avoided) has not been adequately collected. Although some attempts have been made to gather such information, these efforts are often qualitative, subjective, and based on retrospective reports, raising concerns about data reliability.

One potential method for collecting information on various hazardous situations, including near-misses, is using in-vehicle dashboard cameras (dashcams). However, similar data collection using existing bicycle dashcams is challenging primarily because conventional bicycle dashcams do not possess features akin to automotive dashcams, such as detecting sudden braking or erratic swerving and recording the corresponding footage.

Therefore, a system with functionalities similar to automotive dashcams is required to collect information on near-misses and other dangerous events during bicycle rides without relying on conventional qualitative data. Previous studies have demonstrated that sudden braking and erratic swerving are helpful in identifying various hazardous situations, including near-misses and poor road conditions. Thus, developing a system that captures footage of such behaviors can contribute to the efficient collection of a wide range of hazard-related data beyond mere near-misses.

In response to this necessity, this study proposes a bicycle driving record system that links hazardous behaviors (e.g., weaving, sudden braking) with video footage and integrates this data with location information to provide accessible ride records. The proposed system consists of the following five steps:

1. Data Collection: Sensor data from a smartphone (acceleration, angular velocity, GPS) and video footage from an action camera are recorded.

2. Uploading Sensor Data: Collected data is transmitted to a web application, where a machine learning model classifies behaviors.

3. CSV File Modification and Video Extraction: The web application generates a CSV file cross-referenced with the recorded video from the action camera. The labels in the CSV file are manually corrected, and the corrected data is used to extract video segments corresponding to hazardous behaviors.

4. Uploading Videos: The extracted videos are uploaded to YouTube and stored in a viewable format.

5. Map Creation and Sharing: Google My Maps integrates behavior data, video footage, and location information to visualize data.

The proposed system employs a classification model based on the Random Forest algorithm, using the following features: mean acceleration on the y-axis, composite mean acceleration, directional change mean, number of positive directional changes, and negative directional changes. The model classifies behaviors into five categories: braking, meandering, right, left, and straight. A ten-fold cross-validation was conducted to evaluate the classification accuracy, achieving an average accuracy of 92.1%. This result indicates that the proposed model can effectively recognize hazardous behaviors with a certain degree of precision.

An experiment with eight participants was conducted to evaluate the proposed system's effectiveness. The quantitative evaluation focused on the classification accuracy of the trained behavior recognition model embedded in the system. Additionally, a qualitative evaluation was performed using the System Usability Scale (SUS) to assess the proposed system's usability.

The experimental results revealed that the behavior recognition model accurately classified straight but tended to misclassify meandering, right, and left. Notably, differences in handlebar operation among participants may not have been adequately accounted for in the sensor data and features used for model training, suggesting that this discrepancy contributed to misclassification. Furthermore, participants reviewed their generated maps and verified whether the detected behaviors were accurately reflected. The verification process confirmed that, except for two out of eight participants, sudden braking was detected and appropriately registered on the map. Additionally, meandering was accurately detected and correctly registered for all participants.

The usability evaluation using SUS revealed an average score of 62.5, indicating the need for usability improvements. Specifically, the burden of data collection and editing and the necessity of manually synchronizing the start of data acquisition between the smartphone and action camera were identified as challenges. Furthermore, free-form comments from participants suggested a demand for automation in data processing and improvements in system intuitiveness.

In conclusion, the experimental results demonstrated that participants could utilize the system to integrate detected hazardous behaviors with video footage and location data, enabling them to provide and share riding information.

As a key contribution, this study introduces a novel approach for recording and sharing hazardous cycling situations based on objective data. While previous methods for collecting data on bicycle accidents and near-misses relied on police reports and subjective user accounts, the proposed system functions as a bicycle-oriented dashcam, integrating hazardous behaviors with video and location data to facilitate objective data collection and analysis. This system not only allows cyclists to review their ride history but also provides a platform for sharing hazard information with others, contributing to establishing a safer cycling environment.

Nevertheless, several challenges remain in the current system. Notably, the manual correction of labels assigned by the machine learning model is labor-intensive, and there is no mechanism for automatically synchronizing sensor data acquisition with video recording. Moreover, enhancing classification accuracy requires data collection across more diverse environments and the design of additional features. Future work will focus on automating data collection, developing more accurate behavior recognition algorithms, and improving the intuitive usability of the proposed system.