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# Fatigue Driving Detection Methods based on Human-computer Interaction

Guanzheng An

College of Software, Jilin University, Changchun, China

angz5521@mails.jlu.edu.cn

**Abstract.** Drivers' fatigue driving detection is very important to traffic safety, and is closely related to the safety of human life and property. It is a key research topic for researchers. Effective fatigue identification technology can effectively reduce the traffic accidents caused by fatigue. This paper provides a systematic review of the detection methods for driver fatigue driving. The concept of driver fatigue and its necessity for detection are introduced, and the characteristics of fatigue driving behavior are described and classified. This paper summarizes several of the widely used public data sets for fatigue driving in detail, and analyzes the characteristics of each data set to compare its applicability and limitations, providing a valuable resource for subsequent research. Finally, the driver fatigue driving detection method based on facial features, physiological signal features, vehicle features and multiple features fusion is comprehensively analyzed. By comparing the advantages and disadvantages of various methods, this paper summarizes the problems and challenges faced by drivers in the field of fatigue driving detection, and prospects the future development direction.

**Keywords:** Fatigue Driving; Physiological Parameters; Visual Features; Multimodal Fusion.

## 1. Introduction

With the progress and development of society, people's quality of life is improving year by year, and the amount of cars in the country is also increasing year by year, followed by gradually increasing traffic accidents.Statistics show the death toll of road traffic accidents in 2023 is 13,800 [1]. About 20% of these traffic accidents are caused by fatigue driving the [2]. Fatigue driving has a huge impact on the safety driving of drivers, so the fatigue driving detection is of great significance to prevent and prevent the occurrence of traffic accidents. Traffic accidents can not only endanger life, but also cause major property losses. This paper summarizes the methods and research status of fatigue driving detection, points out the existing problems and discusses the future research direction.

## 2. Detection Method for Fatigue driving

### 2.1. Detection Method for Fatigue Driving based on Driver Physiological Signals

Currently, fatigue detection methods based on physiological characteristics include electroencephalogram (EEG), electrocardiogram (ECG), photoelectric plethysmography (PPG), and surface electromyographic signals (sEMG). Because brain electrical signals can directly reflect the activity of human brain and have good accuracy and reliability, this method has been praised as the measure of fatigue detection. For the EEG signal, the discrete wavelet transform can extract the wavelet log energy entropy features of the EEG signal, and the limit learning machine can accurately classify the features and compare them with the extracted classical fuzzy entropy features [3]. The modified algorithm can accurately extract the,, and four rhythms of EEG signal. Whether the brain is in fatigue is determined based on the eight features of the four rhythm-related energy ratios and the variance of the wavelet packet coefficient in each subband [4]. Convolutional neural network and transfer learning can judge fatigue on the electrode-frequency distribution map of EEG signals [5]. Ma et al. captures the ECG and cardiac impact tracing (BECG) through an adaptive filter [6], which can be used for fatigue analysis according to the data heart rate variability and heart rate. The PPG is suitable for real-time signal detection through a smartphone or a wearable sensor. Polynomial fitting

and Savitzky-Golay (SG) filtering were used to remove the baseline drift and smooth waveform of the PPG signals [7]. Zeng et al. studied the sensitivity of sEMG and type A ultrasound (AUS) to muscle fatigue [8]. These physiological signals can directly reflect the real condition of the brain and the body, and have the advantages of high detection rate and strong anti-interference ability.

### 2.2. Fatigue Driving Detection Method based on Driver Facial Features

Driver facial feature detection is a non-invasive detection, which requires camera and computer vision technology to obtain the driver's facial position, and then measures the driver's driving status through the characteristics of the driver's eyes, mouth and head. In order to realize the real-time detection of driver fatigue state, Li Zhao et al. proposed an embedded on-board fatigue detection system based on the optimized Adaboost algorithm combined with eye characteristics. The system still achieved good detection accuracy under the dark night or strong light [9]. Yang Zi Xun based on PCN algorithm according to the eye and mouth characteristics and fuzzy reasoning algorithm to obtain the fatigue index and then measure the driving state of the driver's test [10], in the embedded development board experimental test, can realize the function of fatigue detection and early warning. Wang Xiu et al. calculated the number of blinking, yawning and nodding based on Dlib library and HPE algorithm [11], and achieved good results in different environments [12]. Based on the improved local binary feature method, calculate the human eye closure degree and the sight direction of the human eye to determine whether the driver's attention is distracted, so as to measure the driver's driving state. The test results show that the average accuracy of this method reached 93.9%. Biswal et al. continuously locate the eye area through the camera, calculates the eye aspect ratio to measure whether the driver's fatigue [13]. If it is in a fatigue state, the system will have a warning, and the test results show that the accuracy of the system is 97.1%.

### 2.3. Driver Fatigue Detection Method based on Vehicle Behavior

When the driver is tired, the driving state of the vehicle is very different from the driving state of the normal vehicle. By monitoring the rate of the vehicle, the driving direction, the rotation Angle of the steering wheel, the relative position of the road marking and the vehicle and the movement of the foot brake, the determination of fatigue driving can be realized. The DAsZ000 developed by Ellison Research Lab Laboratory in the United States uses infrared detection technology to monitor the lane information in real time, and the computer will alarm the driver when the lane departure is caused by some reason. The safe TRAC driver detection system developed by Assist ware in the United States identifies the yellow and white lines on the road through the camera in the cab. When the vehicle starts to shift the lane, the driver's steering wheel operation parameters can quickly judge the driver's fatigue state. The S.A.M fatigue monitoring system developed by Digital Installations monitors the rotation Angle of the steering wheel in real time, and determines whether the driver is tired through the regular analysis of the rotation Angle of the steering wheel.

In China, Shi Jian et al. judged the driving state of the driver by detecting the parameters such as the steering wheel and pedal, and analyzed the correlation between the two parameters and the fatigue degree [14]. At present, there are many studies on the correlation between the change of throttle and steering wheel rotation parameters and fatigue in China. Figure 1 showed the safe TRAC fatigue reporting device.

**Figure 1**. Safe TRAC Fatigue reporting device [14]

### 2.4. Driver Fatigue Detection Method based on Multimodal Information Fusion

At present, the fatigue detection method based on single feature has low accuracy, which cannot meet the actual use requirements. The fusion of multiple features can reduce the limitations of single feature and effectively improve the accuracy of detection, which has become a focus of current research. Nowadays, multi-feature fusion is manifested in two aspects of multi-feature fusion and feature fusion of different types. In addition, in recent years, deep learning technology has been continuously applied to various aspects, and many researchers have applied deep learning to fatigue driving detection, which has brought the development of fatigue driving detection to a new level. Xie Zhi uses multiple physiological features to integrate, including the driver's pulse, respiratory signal and skin electrical signal [15]. After collection, it is analyzed and processed and establishes a detection model to determine the fatigue status. Li Lingling uses multiple cameras to obtain the characteristics of eyes, mouth and head movements respectively [16], and then integrates the features to analyze the fatigue state of drivers. Xu Weijing et al. obtained driver images through the camera [17], and extracted multiple characteristics of eyeblink frequency, pupil changes and head movements from the images, so as to analyze the fatigue state of drivers. MA et al. proposed a multi-feature detection system including eye movement, electromyography, electrocardiogram and steering wheel grip strength [18]. It is necessary to determine the detection indicators of each feature, in the application of principal component analysis to determine the weight of each feature, and build a fatigue detection model for detection. Dai Shiqi deep learning applied to fatigue driving detection [19], first use HOG algorithm determine whether driver face in the image, then use the feature point model alignment face, and segmentation eyes mouth area, reuse depth of convolution neural network to extract the characteristics of the mouth area, finally complete the feature fusion fatigue driving detection. This fatigue detection method is to integrate various features to effectively improve the detection accuracy. Therefore, this paper collects physiological signals and facial images of drivers, and extracts features for fusion, so as to realize the detection of fatigue driving.

## 3. Discussion

At present, fatigue driving detection is divided into the above types of methods. In each type of method, the fusion strategy of each characteristic parameter can more effectively and accurately detect the fatigue state of drivers. Physiological signal acquisition is to obtain the objective and true data through various sensors, with higher reliability, can continuously record the physiological signal changes of the driver in real time, and can more accurately analyze and evaluate the fatigue state of the driver. However, drivers need to wear physiological signal detection equipment for a long time, which is easy to cause driver discomfort, which will also have a certain impact on the safety of drivers, and has a certain invasive nature to the driver and the equipment cost is high. Visual detection, which collects the driver's face image through the camera, has the advantages of low cost, non-invasive, and has been widely promoted and applied. However, in the face of different lighting environment and external conditions such as mask occlusion, the performance of the fatigue detection system will also be affected to a certain extent. By collecting the relevant parameters of the vehicle movement data, detecting and comparing the gap between the motion parameters of the vehicle under the tired driving and the normal driving, we can judge whether the driver is tired. However, the detection process is affected by environmental factors such as drivers' driving habits and complex driving road sections, which will interfere with the data. For the detection method of multi-mode information fusion, different characteristic parameters are extracted, analyzed and integrated, which makes the fatigue driving detection model more perfect.

To detect driver fatigue through multi-modal information fusion, we need to collect the characteristic parameters of different modes for fusion and establish the model comprehensive judgment, which improves the accuracy of fatigue driving detection.

Summarize the fatigue driving detection method and make the following outlook: The collection of physiological signals is mostly aimed at simulated driving scenarios. In actual driving, physiological

signal detection equipment will affect the normal driving of the driver to a certain extent. The testing equipment should be designed based on ergonomic characteristics, considering user friendliness, convenient for drivers to wear and without affecting safe driving. The improvement of equipment invasive and cost effectiveness will be the future research direction, so that the detection of fatigue driving through physiological signals can be further promoted and applied. In the process of driving, the driver will be affected by light factors and facial occlusion. Uneven light may occur during the day and can be affected by insufficient light when driving at night. When drivers wear masks and sunglasses, it will cause some interference to the extraction of facial image feature parameters. In further research, considering the above factors, further improve the fatigue identification model, so as to further improve the comprehensiveness, identification rate and accuracy of fatigue driving detection. Some of the detection methods for fatigue driving are based on simulated driving scenarios, and they are not verified in the data set in the real driving environment. However, the actual driving will be affected by various factors, such as vehicle temperature, emergency road conditions and other factors, which may have certain fluctuations on data such as physiological signals and vehicle movement parameters. In the subsequent research, combined with simulated driving data and collected data sets in the real driving environment, a more perfect model was established to improve the model performance, so as to improve the detection effect in the actual driving environment. For the test objects of fatigue driving detection, the influence of individual differences should also be considered, which can be comprehensively considered for the different ages, different driving ages and driving habits of drivers. In other words, a more perfect data set can be established according to the collection of the data set under different conditions, and the model trained on the rich and comprehensive data set can be complete and reliable in the detection of fatigue driving.

## 4. Conclusion

In this paper, the different methods of fatigue driving detection are summarized according to their categories. Many studies have been carried out in the field of fatigue driving detection, and great progress has been made at present, but there are still unsolved problems. In the detection method of fatigue driving, the method of multimodal fusion will become the focus and focus in the future. By collecting different modal characteristics and using different methods to establish the model, the detection of fatigue driving will be more convincing and accurate. At the same time, for the test of physiological signal acquisition on the driving simulator, the model of fatigue detection algorithm should be improved according to the actual driving environment and applied to the actual driving, so as to make the test results reliable and robustness, which is of great significance for driving safety. With the promotion of the actual demand and the efforts of the researchers, it is believed that the fatigue driving test will achieve further development and breakthrough in the future.

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