ISSN 2616-5767 Vol.6, Issue 7: 24-29, DOI: 10.25236/AJETS.2023.060705

Analysis and Exploration of Automotive Fatigue Driving Detection Technology Based on Multimode Fusion

Luoluo Wang*, Hao Zhang, Junliang Chen, Jiexin Zhou, Xiyu Luo

Zhuhai City Polytechnic, Zhuhai, Guangdong, China
**Corresponding author: Wangll0375@gmail.com*

Abstract: *This article studies a multimodal fusion based vehicle fatigue driving detection system. This system comprehensively utilizes multiple signals such as EEG, EMG, and facial features for fatigue driving detection, and uses recognition algorithms for signal processing and feature extraction. With the support of hardware circuits and IoT technology, the system has higher accuracy and practical value. The experimental results indicate that the system can achieve good performance in accuracy and stability, and can play an important role in practical applications. Therefore, the multi-mode fusion vehicle fatigue driving detection system has broad application prospects and promotion value, which can provide drivers with a safer, more convenient and comfortable driving experience, while also reducing the incidence of traffic accidents.*

Keywords: *Information fusion; Internet of Things; Fatigue driving*

1. Introduction

Fatigue driving is one of the main causes of serious accidents during transportation. Statistical data shows that traffic accidents caused by driver fatigue account for about 20% of the total number of traffic accidents. According to further research by experts, driving problems caused by fatigue may actually have a higher proportion in traffic accidents. Frequent driver fatigue driving causes heavy burdens on society and families due to road traffic accidents, serious injuries, and property losses. Therefore, it is very important to accurately and effectively detect driver fatigue.

2. Background of vehicle fatigue driving detection

With the rapid growth of car ownership, fatigue driving has become an important issue in traffic safety. Long hours of driving, intense work pressure, and insufficient sleep can all lead to driver fatigue, thereby increasing the risk of traffic accidents. Therefore, the detection and warning of fatigue driving is of great significance for traffic safety.At present, facial recognition is the most commonly used method for detecting fatigue driving in automobiles. This method is based on changes in the driver's facial expressions to determine whether they are fatigued. However, a single facial recognition method has certain limitations. For example, facial recognition can cause recognition errors when wearing glasses, masks, hats, and other obstructions, and some drivers' expressions mask fatigue symptoms. Therefore, using multiple types of information fusion can improve the accuracy and reliability of fatigue driving detection. One possible multimodal fusion method is to comprehensively analyze facial features, electromyographic signals, and electroencephalographic signals.

Electromyography signals can reflect the degree of fatigue by detecting the electrical activity of muscles, while EEG signals can reflect the driver's fatigue state by detecting changes in brain waves. By combining this information with facial features, the fatigue status of drivers can be more comprehensively evaluated, thereby improving the accuracy and accuracy of detection [1]. In addition, multimodal fusion methods can also be processed using machine learning algorithms. By integrating multiple types of information, more accurate fatigue driving assessment results can be obtained, thereby improving the accuracy and efficiency of early warning. The multimodal fusion method based on machine learning algorithms can also be adjusted according to different driver characteristics to improve the personalized level of early warning.

In short, the detection and warning of fatigue driving is crucial for ensuring traffic safety. Traditional

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facial recognition methods have been widely used, but their accuracy and reliability have certain limitations. Therefore, the multimodal fusion method has important research value, which can improve the accuracy and reliability of fatigue driving detection, thereby effectively preventing traffic accidents.

3. Fatigue detection technology based on facial features

The principle of facial recognition fatigue driving detection is based on facial feature extraction and analysis methods. Generally, this technology requires the use of high-resolution cameras to capture facial images of drivers, and then process and analyze the images through computer vision technology and machine learning algorithms to determine whether the driver is fatigued.

In the image processing stage, commonly used techniques include feature extraction, facial localization, pose estimation, facial recognition, and expression recognition. Among them, feature extraction is one of the most crucial steps, as it can extract important features from facial images and convert them into digital representations so that computers can process them. In general, the feature extraction techniques used include Haar features, LBP features, HOG features, etc. In the analysis phase, it is necessary to input the extracted facial features into machine learning algorithms to train the model and predict whether the driver is fatigued [2]. The selection of machine learning algorithms includes traditional classifiers such as support vector machines and decision trees, as well as deep learning models such as convolutional neural networks and recurrent neural networks. Specifically, facial images captured by the camera will be transmitted to the computer for processing. The processed image is transmitted to the feature extraction module to extract key facial features of the driver. These features will be transmitted to the machine learning module for training classifiers or deep learning models. In the prediction phase, new facial images will be transmitted to the already trained model to predict whether the driver is fatigued.

The formula for detecting fatigue driving is usually based on the output results of machine learning algorithms. Classifiers or deep learning models typically output a probability value between 0 and 1, indicating the probability of whether the driver is fatigued. If this probability value exceeds a pre-set threshold, it will be considered that the driver is driving fatigue. This threshold can be adjusted according to different situations to achieve higher accuracy.

There are also some challenges and limitations in facial recognition fatigue driving detection technology. For example, the quality and resolution of facial images can affect the accuracy of the algorithm, and changes in the driver's facial expressions and posture can also affect the performance of the algorithm. In addition, the real-time performance of this technology is also a challenge, as the detection process needs to be carried out in real-time stream data, and algorithms need to be optimized and accelerated to ensure the timeliness of detection results [3].

In summary, facial recognition fatigue driving detection technology is a method based on computer vision and machine learning, which can analyze facial features to determine whether the driver is tired. This technology has achieved certain results in practical applications, but further optimization and improvement are still needed to improve its accuracy and real-time performance, as well as adapt to a wider range of scenarios and applications.

4. Fatigue detection technology based on physical electrical signals

4.1 Overview of Physical Electrical Signal Detection Technology

Physiological electrical signal fatigue detection is a technology that utilizes internal electrical signals of the human body for fatigue detection. Mainly detected from EEG, EMG, and ECG aspects.

EEG fatigue detection is based on changes in EEG signals to determine a person's fatigue state. When the human body is fatigued, a series of changes in EEG signals occur, such as α Wave β The change of wave equal frequency and the change of coherence between different brain regions. By analyzing these changes, one can determine a person's fatigue state. At present, EEG fatigue detection has been applied in multiple fields, such as driver fatigue detection and worker fatigue detection.

Electromyography fatigue detection is the use of muscle electrical signals to determine a person's fatigue state. When muscle fatigue occurs, the electromyographic signal undergoes a series of changes, such as a decrease in signal amplitude and an increase in frequency. By analyzing these changes, one can determine a person's fatigue state. Electromyography fatigue detection has been widely applied in the training and competitive processes of athletes, as well as in some work scenarios that require long-term

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muscle exercise.

ECG fatigue detection is the use of electrocardiogram signals to determine a person's fatigue state. When a person is fatigued, the heart rate changes irregularly and slows down. By analyzing these changes, one can determine a person's fatigue state. ECG fatigue detection has been applied in fields such as driver fatigue detection, sports competition, and worker fatigue detection.

In recent years, with the development of artificial intelligence and machine learning, physiological electrical signal fatigue detection technology has also been rapidly developed. Machine learning based methods can automatically extract features and establish models, achieving more accurate and stable fatigue detection. At the same time, technologies such as deep learning and neural networks have also been applied in this field. For example, some studies have achieved good results in using convolutional neural networks to classify and recognize EEG signals. In addition, some new technologies such as headwear devices and wearable devices have also brought more convenient and accurate methods for detecting physiological electrical signal fatigue.

4.2 Exploration of the Principle of Electromyography Fatigue Driving Detection

Myoelectric fatigue refers to the degree of fatigue of muscles in motion or at rest, and is an indicator to evaluate the degree of muscle fatigue. Myoelectric fatigue detection is mainly carried out by measuring the electrical activity of muscles. Muscle contraction is caused by potential changes within muscle cells. When muscles contract, the potential inside muscle cells changes, producing a bioelectrical signal called EMG signal. This signal can be detected by electrodes and converted into a digital signal for processing.

For the detection of electromyographic fatigue, it is mainly achieved through the potential frequency of electromyography. Median frequency (MDF) refers to the median of the electromyographic signal spectrum, also known as the 50% point of the frequency spectrum. MDF is considered one of the most commonly used data for treating muscle fatigue, as it can be used to evaluate the degree of muscle fatigue and predict the occurrence time of muscle fatigue. During muscle contraction, the electromyographic signal spectrum usually presents as a peak, and the frequency of this peak is called the dominant frequency. As muscle fatigue intensifies, the dominant frequency gradually decreases and the peak becomes blurry, so MDF can be used to evaluate the degree of muscle fatigue. When the MDF value is low, it indicates that muscle fatigue is more severe. As shown in Figure 1, during muscle exercise for a certain period of time, the EMG MDF value of the tester produces acidic substances due to biochemical reactions, which can reduce the conduction velocity of MUAPs on the muscle membrane. During the testing process, the MDF value will gradually shift to the left [4].

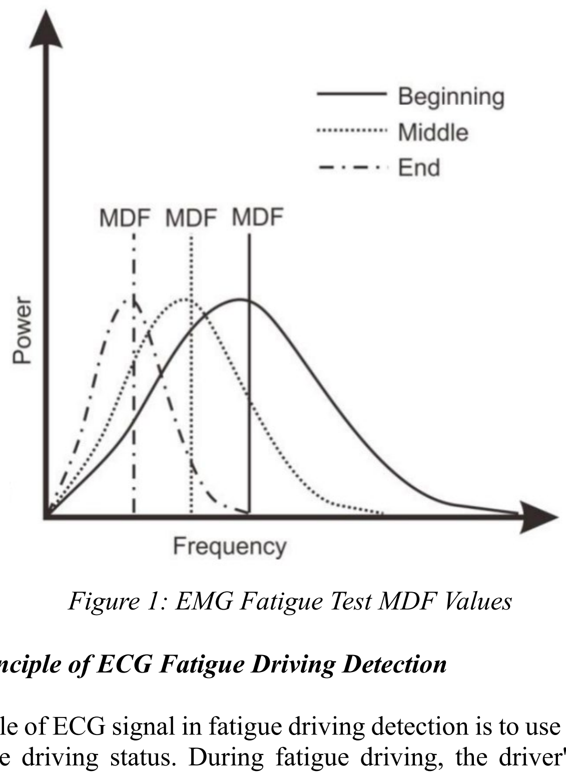

Figure 1: EMG Fatigue Test MDF Values

4.3 Research on the Principle of ECG Fatigue Driving Detection

The technical principle of ECG signal in fatigue driving detection is to use the characteristics of ECG signal to identify fatigue driving status. During fatigue driving, the driver's physiological state will change, and the characteristics of ECG signal will change accordingly. These changes include changes in heart rate, arrhythmias, ST-segment changes in ECG, etc.

The most important function of the heart is to pump blood through the blood vessels in the circulatory system to the whole body, to supply the body with oxygen and nutrients, and to play an important role in the removal of metabolic waste. Because these three substances are closely related to the occurrence of fatigue, the heart is critical in the study of fatigue [5]. Heart rate (HR) is defined as the number of beats the heart produces in a minute, while heart rate variability (HRV) is a physiological phenomenon used to describe uneven time intervals between consecutive heartbeats. Fatigue is associated with disturbances in electrolytes and acid-base balance that affect heart rate, which can be measured by electrocardiogram (ECG). Extreme exercise increases HR values, while excessive fatigue can lead to fatigue, which rarely occurs in driving fatigue. Therefore, most studies on driving fatigue using ECG focus on the consequences of drowsiness, which reduces HR. Therefore, in the ECG fatigue indicators, we can conclude that the HR value will decrease under fatigue.

Based on the above principles, it can be confirmed that the ECG signal has important application value in the detection of fatigue driving. The fatigue driving status can be identified by analyzing the characteristics of the ECG signal, so as to provide timely warning and warning for drivers and reduce the occurrence of traffic accidents.

4.4 Exploration of EEG Fatigue Driving Detection Principle

The electroencephalogram (EEG) signal is a weak non-linear chaotic signal with strong randomness in observation, but some basic features can still be found in the EEG, the most important of which is the frequency domain characteristics of the EEG. Therefore, the EEG signal is generally divided into different bands according to the frequency, and the brain activity status is analyzed according to the characteristics of different bands. Generally, the frequency range of EEG signals studied ranges from 0.5 Hz to 30 Hz. Generally, EEG signals are divided into four bands by frequency:

δ Waves, frequencies between 0.5 and 4 Hz, usually with an amplitude of 20 μ Below V, they occur mainly in the frontal and occipital lobes, mainly during deep sleep, so they are also called sleep waves.

θ Wave, frequency 4-8 Hz, amplitude 20 μ V to 400 μ Between V, mainly in the temporal and parietal lobes, occurs when people are depressed or tired. θ Waves, when the brain system goes into hibernation θ The energy of the wave increases.

α Wave, frequency 8—13Hz, amplitude 20 μ V to 100 μ Between V, they occur in all areas of the brain, and people look at themselves with their eyes closed. α Waves occur in a relaxed state that is not affected by the external environment α The waves will be more pronounced.

β Wave, frequency 13—30Hz, amplitude 5 μ V to 30 μ Between V, they occur mainly in the frontal lobe and generally in the exciting state of the brain, which is evident when maintaining a high concentration of work.

The electroencephalogram (EEG) signal contains a large amount of information which can accurately reflect the state of human mental state and brain activity. Therefore, it is also called the "golden standard" for fatigue detection. It extracts linear or non-linear features and frequency or time domain features from different frequency bands of EEG signal. These characteristics can be modeled and analyzed to determine the current mental state of the human body.

4.5 Research on Fatigue Detection System Based on Physiological and Electrical Signals

The system combines electromyogram (EMG), electrocardiogram (ECG) and electroencephalogram (EEG) signals to accurately detect fatigue. EMG signals reflect muscle contraction and fatigue, ECG signals reflect heart activity, and EEG signals reflect brain activity. Therefore, the fusion of these three signals can provide a more comprehensive and accurate fatigue status assessment [6].

The system design includes three main parts: signal collection, signal processing and fatigue assessment. The signal collection part uses electromyographic sensors, electrocardiographic sensors and electroencephalographic sensors to collect physiological and electrical signals of muscle, heart and brain. The signal processing part processes the collected signal, including filtering, noise reduction, amplification and digitization. Then, the feature extraction algorithm is used to extract the related feature parameters from three physiological electrical signals, such as muscle fatigue, heart rate and heart rate variability. Finally, the characteristic parameters are input into the fatigue evaluation model, and the

ISSN 2616-5767 Vol.6, Issue 7: 24-29, DOI: 10.25236/AJETS.2023.060705

fatigue index is calculated according to the preset evaluation method. The specific system design is shown in Figure 2 below.

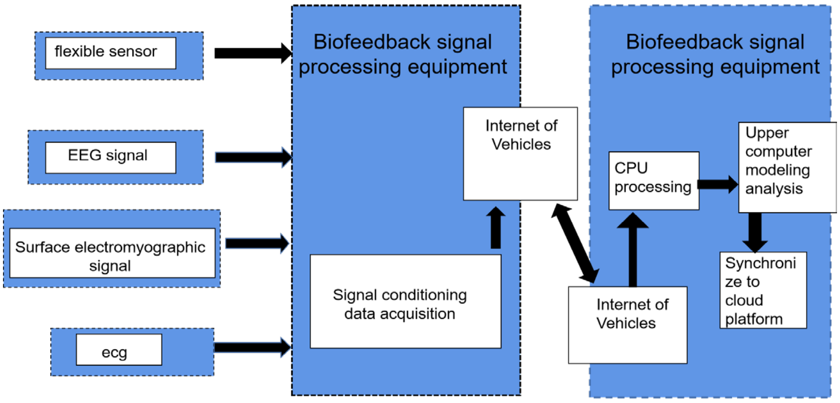

Figure 2: Main structure of fatigue detection system

5. Internet of Things Platform and Hardware Equipment Setup

The input and output part is composed of flexible sensors, display screen and operation keys. Arduino is used as the hardware part of the Internet of Things to transmit CPU, to realize WIFI network and MQTT communication upper computer cloud platform. Achieving networked collection and real-time transmission provides the basis for further networking with vehicles.

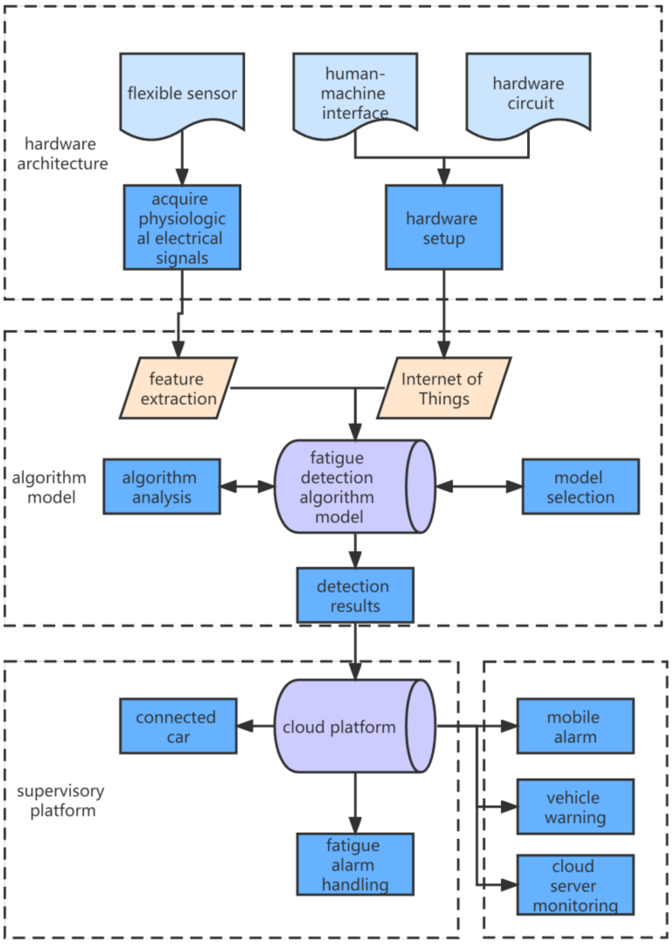

Figure 3: A diagram of the Internet of Things platform and hardware architecture

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6. Conclusion

In this paper, the automobile fatigue driving detection technology is studied. First, the fatigue detection method based on facial feature recognition technology is analyzed. Then, the fatigue characteristics and identification methods of three physiological electrical signals, skin electrical signal, electroencephalogram signal EEG and electrocardiogram signal ECG, are studied. A comprehensive multi-mode bioelectrical signal fatigue detection method is proposed. At the same time, considering the advantages and disadvantages of different fatigue identification methods, a multi-mode fusion fatigue driving detection scheme is formed. The hardware architecture of fatigue detection system based on cloud platform, Internet of Things module and flexible sensor is designed and developed, which provides a new idea for vehicle fatigue driving detection and has certain research significance.

Acknowledgements

This research is supported partly by Province Characteristic Innovation Project of common College (2022KQNCX234), Zhuhai City Polytechnic Technology Innovation Team Project (KJCXTD202003), 2022 Zhuhai City Polytechnic Quality Engineering Project (JY20220107). 2022 Zhuhai City Polytechnic Scientific Research Project (KY2022Y032Z), Zhuhai Urban Vocational and Technical College University Student Innovation and Entrepreneurship Training Program(CXCY 202207), Zhuhai Urban Vocational and Technical College University Student Innovation and Entrepreneurship Training Program(CXCY202211).

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