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Research Status and Development Trend of Drunk Driving Safety Detection for Drivers

Zonglin Li [1], Zhenzhong Shen [2], Bo Chen [1, *], Chuanjin Cui [1]

[1] School of Electrical Engineering, North China University of Science and Technology, Tangshan Hebei, 063210, China
[2] College of Science, North China University of Science and Technology, Tangshan Hebei, 063210, China

*** Corresponding author:** Bo Chen

Abstract: With the increase of motor vehicle ownership, drunk driving has become a major threat to road traffic safety. This paper comprehensively studies the current situation and development trend of drunk driving safety detection, emphasizes the serious impact of drunk driving on traffic safety, and deeply discusses the development of drunk driving detection technology. About 100,000 people die in drunk driving accidents in China each year, research shows, underscoring the need for effective prevention measures. In terms of detection technology, this paper describes in detail a variety of traditional and innovative drunk driving detection methods. This includes in-vehicle drunk driving detection based on artificial olfactory system, multi-modal signal deep fusion of the detection method combining infrared thermal image and electronic nose technology, and the use of multi-sensor information fusion in-vehicle drunk driving detection system. In addition, the design and implementation of car anti-drunk driving system based on Internet of Things technology are also discussed. In particular, this paper presents an innovative concept-a driver monitoring device design based on sweat biosensor and reflective photoplethysmography (rPPG) technology. While this technology has yet to be implemented, its potential applications are predicted and discussed in the paper, including non-contact heart rate monitoring and real-time monitoring of alcohol levels. The proposed concept aims to improve the accuracy and real-time detection of drivers' drinking status and reduce the accidents caused by drunk driving. Finally, the paper looks forward to the future development trend of drunk driving safety detection technology, and points out that the application of Internet of Things technology in the field of driver condition monitoring has great development potential. The further development and application of these technologies will make an important contribution to reducing road traffic accident rates and improving public transport safety.

Keywords: Drunk Driving Test; RPPG Technology; Single-chip Computer; Heart Rate Detection.

1. Introduction

With the rapid development of society and the improvement of the degree of motorization, road traffic safety has become an important public health problem. Globally, the death and disability caused by traffic accidents remain high, seriously affecting the quality of human life and social stability. According to the World Health Organization, nearly 1.2 million people die in road traffic accidents every year, while millions more suffer injuries. Under this background, it is urgent to discuss the causes of traffic accidents. Drunk driving, as one of the main causes of traffic accidents, has attracted worldwide attention. Alcohol can significantly reduce the driver's reflexes and judgment, increasing the risk of traffic accidents. In the United States, for example, drunk driving is involved in about one-third of all traffic fatalities. In China, accidents caused by drunk driving account for a considerable part of the total number of traffic accidents, many of which result in serious injury or even death. In view of this, it is of great significance to carry out research on the safety detection of drunk drivers. This paper will focus on the current research status and development trend of driver drunk driving safety detection. First, we will analyze the harm of drunk driving to traffic safety, then summarize the traditional methods of drunk driving detection, and focus on the design and development of driver monitoring devices based on sweat sensor and reflective photoplethysmography (rPPG) technology. Finally, this paper will look forward to the future development trend and research direction in this field.

2. Research Background

2.1. The Problem of Drunk Driving is Getting Worsens

China has a huge motor vehicle ownership and driver base. In 2022, the number of motor vehicles in the country will reach 417 million, including 319 million automobiles. The number of motor vehicle drivers reached 502 million, of which 464 million were car drivers. This brings severe test to the road traffic condition of our country, with which the traffic accident rate rises year by year. According to incomplete statistics, the number of people killed in drunk driving traffic accidents in China every year is as high as about 100,000 and continues to rise, how to prevent drunk driving has become a research topic in the country and even the world. 30% of road traffic accidents are caused by drunk driving. Fifty-nine percent of driver deaths were related to drunk driving.

The problem of drunk driving has always been a headache, and data released by China News Network show that in the first half of 2019, 901,000 drunk driving behaviors were investigated and punished, and 1,525 drunk driving traffic accidents were killed, and 1,674 people were killed. According to the national court trial and execution data released by the Supreme People's Court in 2019, the crime of dangerous driving ranks first in criminal cases.

2.2. The Current DMS has Defects

SAdvanced driving assistance systems (ADAS) continue to affect the driver's driving habits, such as automatic parking

system, many novice drivers can also be a good vehicle parking space: for example, lane departure warning system, can allow the driver in the high-speed long-term driving process, when the vehicle deviates out of the lane can be reminded in time, the driver can make adjustments to the vehicle. Avoid the occurrence of danger; For example, the head-up display function allows the driver to view the required vehicle data directly through the front windshield without looking down at the combined instrument when necessary in the process of driving the vehicle.

Extreme convenience will also bring a lot of disadvantages. The emergence of advanced driving assistance system (ADAS) not only changes the driver's driving habits, but also loosens the driver's driving process. In many high-speed scenarios, many drivers will directly turn on the automatic cruise function, so as not to supervise the running state of the vehicle in the whole process. Even many drivers rely on advanced driving assistance system (ADAS) to monitor vehicle information, relax their vigilance, direct long-term driving, and even fatigue driving, according to incomplete statistics, 50% of traffic safety accidents are caused by the driver's unclear consciousness, in order to solve this problem, driver monitoring system (DMS) came into being.

DMS has three technical solutions: indirect monitoring of driver status by monitoring vehicle steering information; Physiological indexes of drivers were obtained by biosensor for direct monitoring. The driver's behavior information is obtained by visual sensor for direct monitoring. Vision sensor-based schemes, supplemented by indirect monitoring based on vehicle steering information, are currently the mainstream DMS schemes. Although there are several years of technical accumulation, but still face many difficult to solve difficulties.

3. Overview of Traditional Detection Methods

Bai's research identifies drunk driving behavior by designing an artificial olfactory system that uses multiple sensors to detect alcohol gas inside a car [1]. This research breaks through the limitations of traditional drunk driving detection methods, realizes the high accuracy detection of alcohol concentration in the car, and reduces the cost and volume of the system by optimizing the sensor array, and improves the practicability. Liang Haoquan's research has proposed a method of drunk driving detection that combines infrared thermal imaging and electronic nose technology [2]. The method uses infrared thermal image to capture the temperature change of the head and neck of the human body after drinking, and combines the electronic nose odor data for deep fusion analysis, and realizes the efficient identification of drunk driving behavior. Wang Yanbo's research is based on multi-sensor information fusion technology to build an efficient on-board drunk driving detection system[3]. By optimizing the sensor array and data processing algorithm, the system improves the classification and recognition effect of alcohol gas and the detection accuracy. Tian Dawei's research combined with the Internet of Things technology to design a new type of car anti-drunk driving system[4]. The system can not only accurately detect the breath alcohol concentration of the driver, but also realize the real-time notification of drunk driving information through the Internet, which effectively improves the ability to prevent drunk driving. Liu Yanhong's research proposed a new way to identify drunk driving by combining gas alcohol sensors with vehicle steering Angle, acceleration and other characteristics detection[5]. Using D-S evidence theory as the information fusion algorithm, the system realized efficient and accurate identification of drunk driving state. Zhao Xia's research focuses on the status detection of drunk driving and in-car air quality [6]. In this paper, an integrated system is proposed, which realizes the accurate detection of the driver's alcohol concentration through various sensors and data fusion methods, and realizes the auto parking function through the relay control circuit. Li Jushang's research puts forward a design of anti-drunk driving system based on single chip computer[7]. The system can control the start and stop of the car engine by detecting the alcohol concentration of the driver's breath, so as to effectively prevent drunk driving behavior.

4. Design and Development of Driver Monitoring Device based on Sweat Sensor and rPPG

This study investigated the feasibility of using sweat biosensor to monitor drunk driving behavior. By using remote photoelectric volume pulse wave (rPPG) technology combined with advanced algorithm, the non-contact detection of driver's heart rate is realized. At the same time, combined with the MQ-3 alcohol sensor based on the STM32 microcontroller, the alcohol level is effectively monitored. In addition, through the integrated application of embedded technology and Internet of Things technology, an integrated driver real-time status monitoring device is developed. The device can effectively prevent the driver's drunk driving and other dangerous behaviors, and has important practical value for reducing the serious traffic accidents caused by drunk driving.

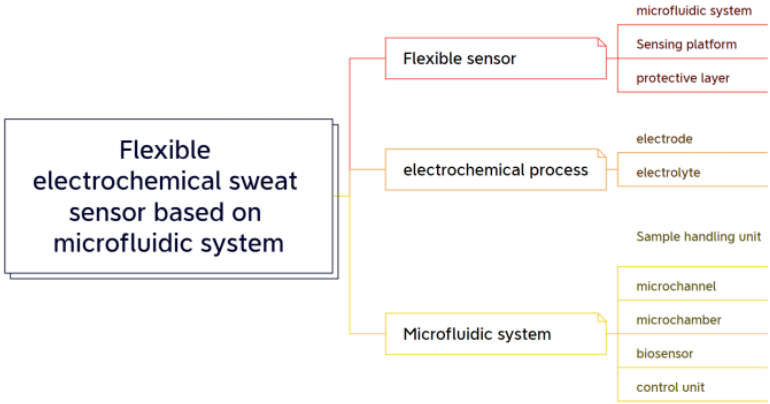

Figure 1. Sweat sensor research route

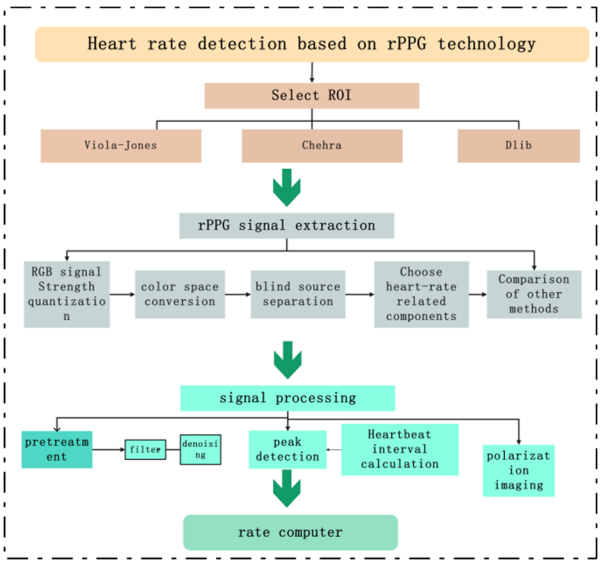

Figure 2. rPPG research route

4.1. Fully Flexible Electrochemical Sweat Sensor

4.1.1. Eliminate Drunk Driving at its Source

At present, the mainstream anti-drunk driving technology in the world is to complete the driver's alcohol detection through the on-board breath alcohol detection system. However, most of the traditional on-board alcohol detection systems are based on a single mode design, and the detection accuracy is not high, and the humidity and air flow of the interior environment are not taken into account, so it is difficult to make accurate drinking judgment on the driver. It is easy for drivers to cheat. In addition, the current single-mode technology also has a delay in alcohol detection, that is, the driver cannot be immediately processed in a timely manner.

Domestic and foreign automobile drunk driving prevention system mainly starts from the car cannot start after drinking, so as to prevent the behavior of drunk driving. However, there is no effective solution to the problem of vehicle failure to start caused by excessive indoor alcohol concentration caused by passengers in the co-driver's position after drinking. Therefore, it is necessary to conduct specific research on the location and accuracy of alcohol concentration detection and the processing work after the car fails to start.

Figure 3. Intelligent steering wheel

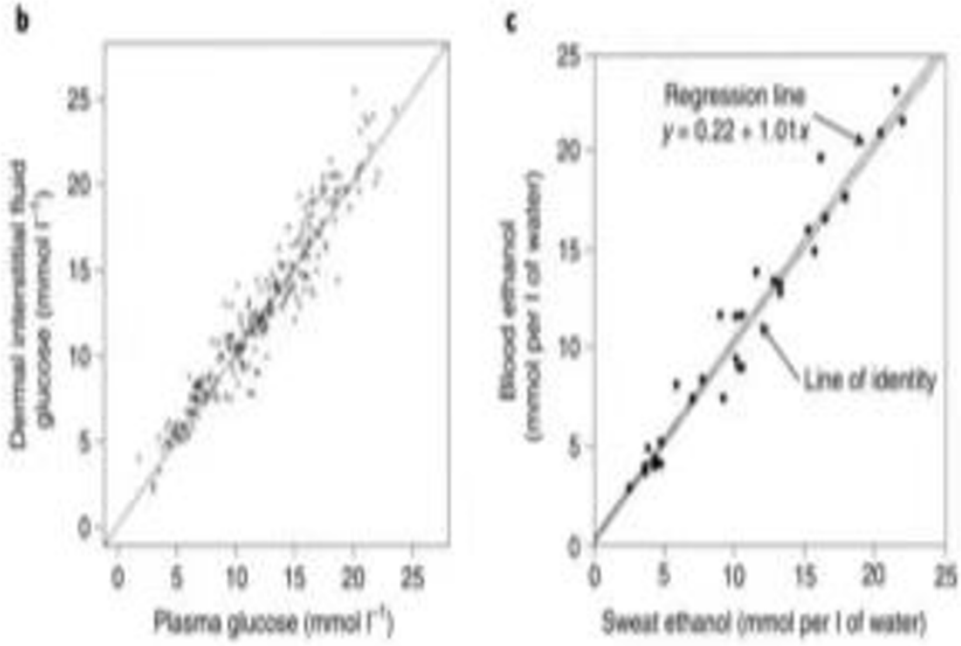

Figure 4. Glucose and ethanol in plasma and sweat

The project will be fully flexible electrochemical sweat sensor embedded in the steering wheel surface, starting the driver needs to put their hands on the steering wheel for alcohol concentration detection, and the researchers found that the content of ethanol in the plasma and sweat showed a positive correlation, so it can be a good alternative to traditional breath detection and blood test. If the amount of alcohol in your sweat exceeds the set threshold, the car will not start and will display your alcohol level. Because the device detects alcohol content in palm sweat, the high indoor alcohol concentration caused by a passenger drinking alcohol does not affect the start of the car; Secondly, the fully flexible electrochemical sweat sensor will monitor the whole process in the starting stage and the driving stage, and even if the driver makes the car start by cheating in the starting stage, the drunk driving behavior will be found when driving.

4.1.2. Non-invasive Detection of Sweat

The domestic research on fatigue detection started late, starting in the 1990s. With the frequent driving accidents caused by fatigue driving, it has attracted extensive attention from domestic scholars and researchers. At present, most of the domestic research directions are based on the direction of machine vision and pattern recognition, obtaining images through cameras, and then carrying out face detection, eye positioning and other steps.

The limitation of this method is that the accuracy of detection cannot be guaranteed when the lighting conditions are not good or the driver is wearing glasses and sunglasses. Fatigue cannot be detected by a tired driver who is trying to keep his glasses wide open; Once the driver's eyes are relatively small, it is likely to make the system mistake that the driver's eyes are closed, and this misjudgment is more likely to lead to the vehicle's DMS system alarm.

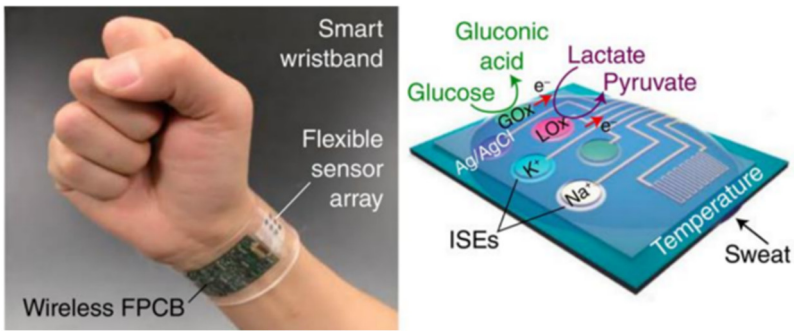

Figure 5. Integrated wrist-worn multi-parameter sweat analysis device, including flexible sensor array and flexible PCB wireless circuit (left); Sensor array based on flexible PET substrate (right)

Human sweat is rich in electrolytes (such as Na+, K+, Mg2+, Ca2+, Cl, etc.), metabolites (such as lactic acid, glucose, urea, ethanol and cortisol, etc.), trace elements (such as iron, zinc, etc.), and a small number of macromolecular components (proteins, nucleic acids, neuropeptides or cytokines, etc.).

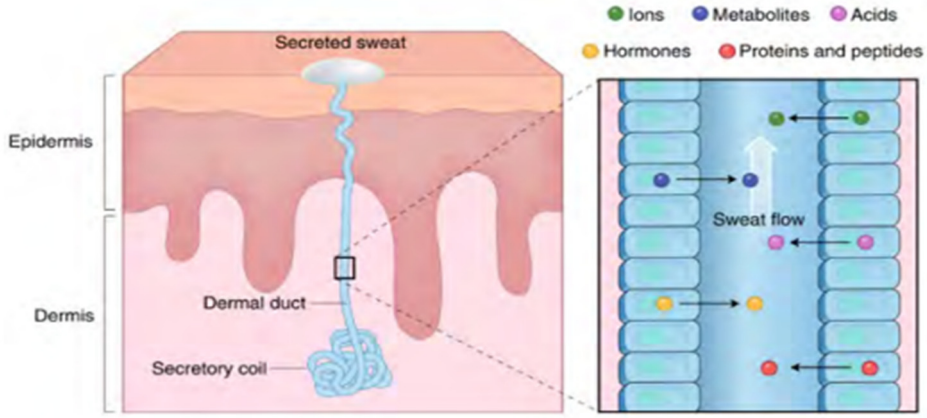

Figure 6. Schematic diagram of sweat gland structure and secretion mechanism of sweat analytes

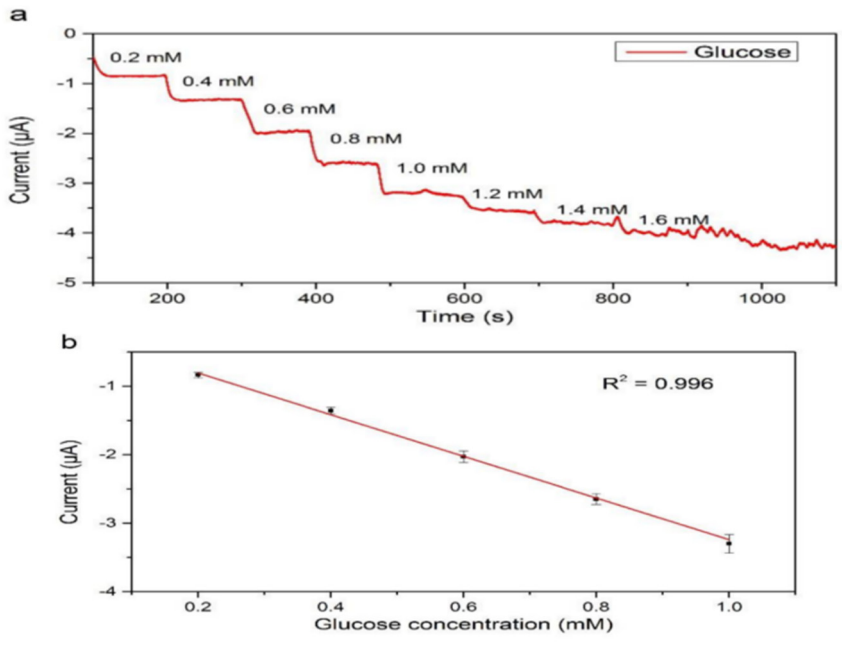

Figure 7. Chronoamperometric measurement of glucose by glucose sensor

Fatigue driving: Lactic acid is one of the most important markers of tissue oxygen binding, which plays an important role in the assessment of exercise status and medical care. It is also a sensitive substance of tissue vitality, which can provide early warning for stress ischemia, reflect the loss of oxidative metabolism and the reduction of tissue viability. Zinc, the second most abundant transition metal in the human body (2-3g), is a major biomarker for diagnosing the early onset of muscle stress and fatigue in humans, and the monitoring of these two biomolecules can be used to assist visual programs in determining fatigue driving.

Emotional driving: Cortisol is a glucocorticoid released by the adrenal cortex and plays an important role in physiological processes and functions of the human body. Not having enough cortisol in the body can lead to Addison's disease, and elevated and repeated activation of cortisol levels can lead to Cushing's syndrome, which can lead to severe fatigue, depression, anxiety, cognitive impairment, obesity, and cardiovascular disease, among other things. Scientists see cortisol as an important molecular indicator of an individual's stress levels in the recent past. The monitoring of the substance content can assist the visual scheme to determine whether the driving is emotional.

(a) The time-current curve of the glucose sensor in a standard glucose solution; (b) Calibration curve of glucose sensor (N=3), measuring range 1.0mM.Drug driving: Determine whether a driver is drugged by measuring the amount of certain drugs in his sweat.

Health alert: Sodium is the most abundant electrolyte present in sweat, and it is also a marker of electrolyte imbalance. It is important to replenish sodium levels in the body because it is essential to regulate water balance, pH and osmotic pressure.

The functions of potassium ion include maintaining normal osmotic pressure in cells, maintaining neuromuscular irritability and normal function, maintaining myocardial function, reducing blood pressure and so on. Glucose is one of the most important monosaccharides in living organisms, and it is the main

4.1.3. Paper is Used as a Flexible Substrate and Flexible Electronic Materials are Used

Paper, which is primarily made of cellulose, is used as a flexible base for building sensors because of their easy availability, low weight, low cost, fit to the human curve, portability, compatibility for biometric molecular fixation, and their porosity and ability to control flow rates through capillary core suction and evaporation, which facilitates operation without the need for external pumps. Making it ideal as a medium for transporting and managing sweat. The use of paper microfluidic channels is an extremely simple and effective method for long-term sweat collection and processing, especially for demand Settings that require rapid analysis, low cost, and simple operation.

Flexible electronics mainly refers to the emerging electronic technology whose devices, circuits, substrates and functional systems have characteristics such as bending, folding and malleable, soft as animal skin. Compared with the traditional silicon-based electronic technology based on the hard substrate, the flexible electronic system can be seamlessly connected with the traditional silicon-based electronic system, although the device structure, component materials and system functions are quite different. With the development of world informatization, production digitization, intelligent life and daily monitoring, the humanization and personalization of electronic products are crucial

The new features brought by flexible display, flexible sensing, flexible storage, flexible luminescence and flexible detection, which are more in line with the needs of complex structural interfaces of engineering application objects, will certainly bring revolutionary changes to the electronic information industry.

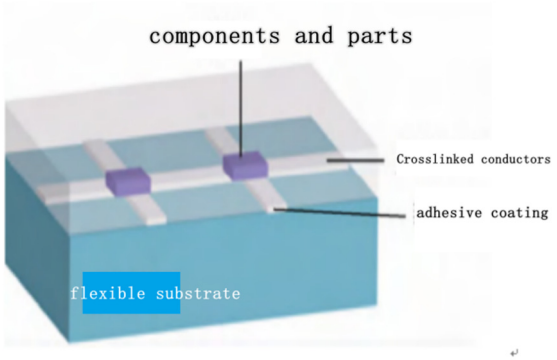

Figure 8. Basic structure of flexible electronic sensor

Compared with the traditional electronic strain sensor, the flexible electronic strain sensor overcomes the weakness of brittleness, and has the advantages of better biocompatibility, stretchability, transparency, wearability and easy continuous detection. There are many ways to realize flexible electronic devices and systems, which are mainly summarized as material flexibility and structure flexibility.

4.1.4. Electrochemical Method is Adopted

Electrochemistry is an important analytical chemistry technique, which is used to measure the change of electric potential or current generated by the analyte at the electrode interface. Electrochemical components can be assembled on flexible substrates through miniaturization and array processing technology, so electrochemical sensing is widely used in the increasingly miniaturized and convenient sweat detection. Compared with other chemical detection technologies, electrochemical detection methods have the advantages of high sensitivity, high selectivity, low response time and easy to realize wearable design. In recent years, various electrochemical sensing technologies have been used for wearable sweat analysis. These methods include potential type, current type, conductance type, etc. In order to achieve stable and accurate measurements of analytes, several characteristics of the sweat sensor must be optimized, such as selectivity, sensitivity, detection limit, stability, response time, and reproducibility.

4.1.5. Microfluidic System

The collection of traditional sweat samples is prone to problems such as evaporation, contamination and mixing of old and new sweat, which interferes with the accuracy of composition analysis results.

Microfluidic is a technology that can accurately control and manipulate fluids in the micro-nano scale space. It has the ability to miniaturize the basic functions of biological and chemical laboratories onto a chip of a few square centimeters. It can use sweat secretion pressure and capillary action to direct sweat from the epidermis to the channel for continuous sampling. This enclosed sensing can eliminate external contamination while preventing the change of sweat

composition caused by sweat evaporation. In addition, compared with traditional methods, this technology has the advantages of low demand for test samples, less demand for detection reagents used and continuous detection. With multiple sampling channels and corresponding reservoirs, multiple sweat biomarkers (lactic acid, glucose, chloride ions, pH) can be monitored simultaneously and sweat loss can be quantified. In 2018,Sekine et al. applied a fluorescent probe to the surface sweat microfluidic detection level to make accurate in-situ measurements of chloride, sodium, and zinc ions, and analyzed the resulting fluorescence through a smartphone-based imaging module.

method	classify	major principle	merit
electrochemical method	voltammetry	The current curve is obtained by scanning, because the maximum current is proportional to the concentration of the measured object, the measured object is quantitatively analyzed	The current curve is obtained by scanning, because the maximum current is proportional to the concentration of the measured object, the measured object is quantitatively analyzed
	chronoamperometry	The current generated by the REDOX reaction is proportional to the concentration of the target analyte	The current generated by the REDOX reaction is proportional to the concentration of the target analyte
	potentiometry	The potential between the sensing electrode and the reference electrode represents the target ion concentration, and the potential of the sensing electrode changes measurably with the concentration of the target analyte	The potential between the sensing electrode and the reference electrode represents the target ion concentration, and the potential of the sensing electrode changes measurably with the concentration of the target analyte
	electrochemical impedance spectroscopy	Using the applied sinusoidal voltage, the impedance of the sensing surface is obtained to reflect the binding amount of the target substance on the sensor surface and indicate the concentration	Using the applied sinusoidal voltage, the impedance of the sensing surface is obtained to reflect the binding amount of the target substance on the sensor surface and indicate the concentration
colorimetric method	/	The color change of the product produced when the chemical reagent reacts with the analyte to be measured has a high correlation with the concentration of the analyte to be measured	The color change of the product produced when the chemical reagent reacts with the analyte to be measured has a high correlation with the concentration of the analyte to be measured

Figure 9. The main analysis methods, principles and advantages and disadvantages of sweat sensor detection

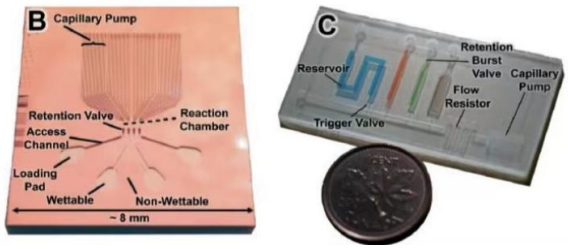

Figure 10. Microfluidic chip

4.2. Remote Photoplethysmography (rPPG)

Compared with contactless devices, video-based non-contact heart rate monitoring has obvious advantages. The method is inexpensive, does not require the user to wear a device, and uses a consumer-grade camera to capture heart rate through optical information on the surface of the human skin. This method overcomes the disadvantage of contact heart rate measurement and can monitor heart rate in real time under various environments without affecting the driver's normal driving.

4.2.1. Significance of Heart Rate Monitoring

HeartRate (HR), as an important physiological index, can directly reflect the function of the heart and sympathetic tone, and excessive heart rate is one of the main risk factors for cardiovascular disease death. As one of the important physiological indicators, heart rate can not only be used for health monitoring, but also for human-computer interaction, public safety and other fields. In the field of human-computer interaction, the machine can obtain the real-time psychological state of the human body by monitoring the heart rate, so as to make corresponding responses; In the field of public safety, it is possible to analyze the heart rate to conduct real-time lie detection on the monitored object, or to determine whether the driver has dangerous behaviors such as fatigue driving.

4.2.2. Principles of rPPG Technology

Physiological basis: Through imaging equipment, changes in light information reflected by the skin caused by changes in blood volume can be recorded, and the corresponding heart rate parameters can be obtained by further analysis of the light changes. Therefore, the tissue structure of the skin is the physiological basis of rPPG technology.

Optical basis: Beer-Lambertlaw is the basic optical principle of PPG technology, and rPPG also makes use of this principle. The Beer-Lambert law can be defined as: when a uniform beam of light of a particular wavelength passes through a homogeneous and non-scattering solution, the absorbance is proportional to the product of the thickness of the solution layer and the concentration of the absorbent substance in the solution. According to this law, the following formula can be derived:

$$I = I_0 e^{-\varepsilon(\lambda)CL}$$

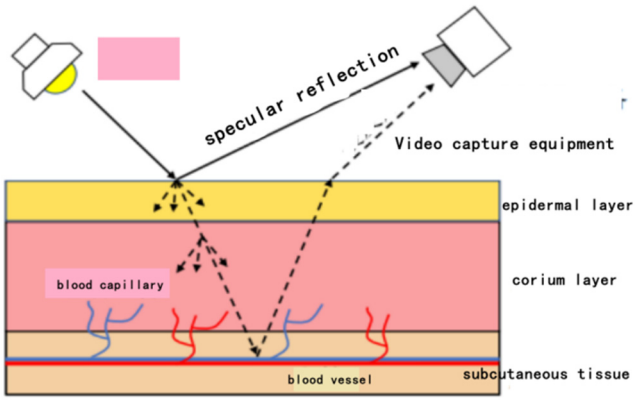

Figure 11. Skin reflex model

In rPPG heart rate detection, as long as there is a stable light source, the reflection intensity of light irradiation on the skin will change with the change of substance content in the blood,

that is, with the change of blood volume, the reflection intensity of light collected by the imaging equipment will also change. Therefore, by analyzing this light reflection intensity data, we can extract rPPG signals and calculate physiological information such as heart rate.

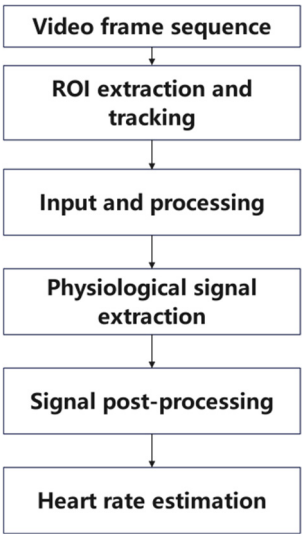

Figure 12. RPPG signal extraction process

4.2.3. Feasibility of rPPG Technology

Most non-contact heart rate detection methods can achieve better experimental results when the light is sufficient and the subject remains still. However, when the subjects exercise, the performance of the above method will be significantly reduced because the physiological signal of the face is very weak, which is easily interfered with the noise such as movement. Therefore, the interference generated by human head movement makes the heart rate detection algorithm face challenges in accuracy and robustness.

Figure 13. rPPG was consistent with heart rate measured by finger clip

However, automatic location and extraction of ROI region are realized through the combination of target detection and tracking algorithm, and then independent component analysis algorithm is used to reduce the interference caused by facial motion, so as to improve the anti-motion interference ability of non-contact heart rate detection algorithm. In addition, with the improvement of computer computing power, deep learning has been greatly developed. With the strong fitting ability of massive data and neural network, it has achieved good results in various fields.

4.3. Introduce Internet of Things Technology

As early as the end of the 20th century, Professor Ashton of MITAuto-ID proposed a new concept of Internet of Things technology, It is on the basis of traditional Internet technology, on the basis of traditional Internet clients, extended to each physical object, forming a "network between things", so as to achieve information transmission and communication between things.

Nowadays, with the continuous improvement of computer technology and information technology, Internet of Things technology has gradually been applied in various fields, and has been continuously optimized and upgraded. The main principle of this technology is as follows: firstly, the required information is collected through information collection devices such as sensors, positioning systems or video recognition, etc. Then, according to certain network protocols, the real objects applied in reality are effectively connected to the Internet, and the information of various objects in the Internet of things is collected in real time. Realize intelligent information identification, tracking, supervision and positioning functions.

Under the implementation of the Internet of Things technology, each vehicle can be regarded as a node in the crop network, and each node is collected data information, and the collected data and information are sent to the specified client through wireless transmission technology, such as traffic management departments, family members, etc. Under the detection of the technology, once the driver is detected to drink and drug driving or the health condition is critical, the automatic alarm and communication of the car can be realized, which can prevent the occurrence of traffic accidents and alleviate the traffic pressure to a large extent, and has certain promotion value and practical application significance.

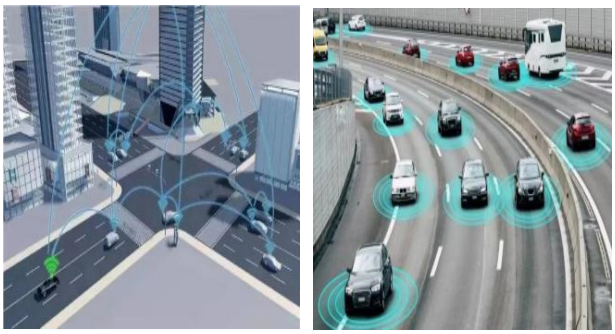

Figure 14. Smart car iot virtual map

5. Conclusion and Prospect

The present situation and future development trend of drunk driving safety detection were discussed from multiple dimensions. In this study, we first point out the severity of the drink-driving problem and analyze the shortcomings of the current driver monitoring system (DMS). To address these issues, this study proposes a conceptual solution, a driver monitoring device based on a fully flexible electrochemical sweat sensor and remote photoplethysmography (rPPG). The scheme is expected to enable more accurate non-intrusive driver condition monitoring.

Given the limitations of current DMS, the conceptual solution proposed in this study could provide a new technological path to achieve more accurate and reliable drunk driving monitoring. Through the integrated application of sweat sensor and rPPG technology, the driver's physiological state can be monitored in real time and

accurately, so as to identify drunk driving behavior in time. Also highlighted in the study is the introduction of iot technology, which will enable monitoring systems to transmit and analyze data in real time, thereby improving driving safety.

The future development of driver drunk driving safety detection has a broad vision, which may not only play a key role in improving road traffic safety and reducing drunk driving accidents, but also find applications in many other fields such as medical health monitoring and sports science, thereby bringing benefits to society at multiple levels.

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