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A study of the interaction between cognitive distraction and driving behavior

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Abstract Distracted driving behavior is a major cause of traffic accidents. Nowadays, with the popularity of navigation systems, smart phones and other in-vehicle systems, there are more and more factors that induce drivers' distracted driving behaviors. This paper summarizes the findings on the impact of distracted driving on driving safety at home and abroad by studying the literature on distracted driving behavior at home and abroad, compiling commonly used survey and research methods, and summarizing various evaluation indicators and prediction models of distracted driving. The results show that distracted driving behavior can be detected and warned, and that the practical application of the theory is still not mature enough, and there is still a broad prospect for distracted driving research.

Keywords Transportation; distracted driving; driver characteristics; distracted driving indicators; vehicle driving characteristics

1. Introduction

With the rapid development of China's economy and the increasing number of car ownership, the incidence of traffic accidents has also increased rapidly, and road traffic safety has gradually become the focus of people's attention. The World Health Organization 2021 published a study on the global status of road safety, the number of deaths due to road traffic accidents worldwide each year more than 1.35 million people, road traffic injuries have become the main cause of death of children and young people between the ages of 5 and 29. And according to China's public security traffic management department, at least 60,000 people die in traffic accidents every year, and according to the National Bureau of Statistics, 244,674 traffic accidents occurred nationwide in 2020, in which 250,723 people were injured and 61,703 people were killed; according to the findings of the 2018-2020 Chinese Youth Distraction and Traffic Accidents White Paper 2020, more than 70% of young drivers are distracted while driving, and behaviors such as making communication tools while driving are even more common. The National Highway Traffic Safety Administration (NHTSA) analyzed data on traffic crashes in all 50 states and the District of Columbia in 2016 and found that 37,461 people were killed in traffic crashes, with distracted driving accounting for 9 percent of the total number of deaths and the other 6 percent. The other 6 percent of deaths were caused by failure to yield to pedestrians, unlicensed drivers and other causes.

Numerous studies have shown that driver error is the primary factor affecting road traffic accidents. And among the many causes of driver error, distracted driving is increasingly becoming a major concern. Driver distraction is often cited as one of the main causes of traffic accidents. The essence of distracted driving is a phenomenon in which a driver's attention is diverted from the main task of driving to other activities unrelated to safe driving and affects his or her ability to operate the car. With the increasing popularity of in-vehicle information systems, drivers are using navigation systems, radios and smartphones and other electronic devices more and more frequently while driving. These devices make it easier for drivers to access information while also reducing the attention they allocate to driving, which affects the driver's visual scanning and decision-making ability, thus increasing the risk of driving.

To mitigate the effects of distracted driving, the Driver Monitoring System (DMS) was created as an Advanced Driver Assistance System (ADAS), which analyzes the driver's facial image information captured by the camera such as The system analyzes the driver's facial image information such as eye and mouth changes, and head posture to determine the driver's attention status. At present, there are two main types of driver attention monitoring systems: one is to identify the abnormal state of the driver by monitoring the changes of the driver's eye movements in real time, and directly issue an alert when the driver is detected to be in an abnormal state of attention, such as Delphi's driver driving status monitoring system (LKP); the other is to use infrared sensors to monitor the driver's attention state. When the driver does not pay attention to the road ahead, the system will alert through flashing lights and sound, and if the driver does not take action after that, the system will control the vehicle's braking system, such as Toyota's (Japan) overall vehicle safety architecture. Most of these systems monitor the driver's attention by determining whether the driver is driving with his or her eyes off the road ahead or how his or her mouth is changing.

According to MRT (Multiple Resource Theory) theory, the US Highway Traffic Safety Administration classifies distractions into four categories: visual distractions, auditory distractions, motor distractions and cognitive distractions. Visual distractions refer to the driver's eyes straying from the road ahead to focus on other visual targets at one end of the time, which can be described as "eyes off the road"; auditory distractions refer to the driver's auditory attention to things unrelated to driving, which can be described as "ears This can be described as "hands off the road"; motor distraction is when the driver's hands leave the steering wheel to do something else unrelated to driving, which can be described as "hands off the road"; cognitive distraction is when the driver focuses his or her attention on thinking about something else unrelated to driving, which can be described as Cognitive distraction is when the driver focuses on other things that are not related to driving, and can be described as "thoughts off the road". More common in actual driving is the combination of several types of distractions, and comprehensive distractions, such as driving with voice messaging includes the above four types of distractions. Different types of distractions affect drivers in different ways.

Distracted driving while performing multiple tasks at the same time will cause changes in driver attention allocation, thus predisposing to traffic accidents, and therefore has received widespread attention, and many experts and scholars have conducted a lot of research work, which can be summarized into three categories: (1) theoretical models of driver distraction. (1) theoretical models of driver distraction, which explore the causes of driver distraction; (2) driver distraction performance. The analysis of changes in driver physiology, eye movements, and driving performance when cognitive load increases during driving; (3) driver distraction detection. Through experiments, pattern recognition methods were used to identify distracted driving and focused driving. Lee [1] et al. defined driver distraction as a risky behavior in which the driver turns his or her attention to activities unrelated to the driving task, causing a decrease in the driver's vision, awareness, decision-making, and operational ability. Visual distraction and cognitive distraction can be expressed as the driver's vision leaving the road and awareness leaving the road, respectively, both of which occur to impair the driver's driving ability.Wickens [2] explained driver distraction in the multi-resource theory as it is caused by the presence of a driving subtask that occupies part of the attentional resources, making it necessary for the driver to allocate part of the attentional resources to processing while driving. subtasks.

2. Factors influencing driving distractions

In the "human-vehicle-road-environment" road traffic system, there are various factors that cause driver distraction, which can be broadly classified into three categories: driver, vehicle characteristics and traffic environment.

2.1 Driver's factors

Research on driver characteristics is further divided into two categories: one type of research focuses on one or several of the driver characteristics, for example, Romer [3] studied safe driving of adolescents based on attention allocation while driving. Cai Na [4] studied road safety analysis of female drivers. Another type of research focuses on comparing different characteristics of the same characteristic of a driver by selecting it in order to determine the effect of that characteristic on distracted driving. For example, Longfei Wang [5] selected drivers with different age conditions as subjects in his study of driver reaction time in distracted driving, and Jiménez and Sanchez et al [6] studied the control styles of steering wheel, gas pedal and brake pedal for different styles of drivers with distracted attention.

2.2 Factors of vehicles

Vehicles are generally considered to influence the driver's attention allocation during driving through different vehicle characteristics. Among the studies on this aspect, there are fewer studies that specifically focus on vehicle performance, and more often consider the effects of different types of vehicles (e.g., commercial vehicles, passenger cars, vans, minivans, etc.) on distracted driving. For example, Hanowski [7] studied driver distraction based on long-haul trucks. Hickman and Hanowski [8] analyzed the effects of commercial trucks (three-axle tankers) and buses on driver distraction using naturalistic driving data. Meirong Hu et al [9] analyzed the different effects of passenger cars and lorries on road safety issues by using the driving vision of different types of vehicles.

The demand for driver attention varies in different road traffic environments during driving, so it is necessary to define road traffic conditions when studying distracted driving, e.g., Sun Yue et al [10] carried out a study on the effect of driver distraction on their operating behavior with the traffic conditions of highways, and Horberry [11] et al. compare d simple road environments with complex road environments to examine the effect of driving Kolko [12] investigated the effect of cell phone use on road safety under rain and snow conditions.

In summary, a comprehensive consideration of all factors in the study of distracted driving would greatly increase the difficulty of the study, and the actual role of each factor is difficult to define accurately without controlling for variables, so most studies are macroscopic studies from a statistical point of view, selecting one or several factors that have a greater impact as control variables to study their impact on road safety.

2.3 Evaluation indicators of driving distractions

Evaluation metrics used to identify driver distraction generally fall into five categories, namely, subjective driver ratings, physiological metrics, severe winter metrics, driving performance metrics, and hybrid metrics that incorporate many different types of metrics.

2.3.1 Driver Subjective Rating

A driver's subjective rating is a score based on the driver's performance before and after driving based on a test form. The RSME (Rating Scale Mental Effort) scale is a one-dimensional rating scale for measuring subjective mental load, which consists of a line of 150 mm in length, marked with nine anchor points, and each anchor point is accompanied by a label describing the degree of subjective effort [13]. [The RSME scale is a simple and effective self-assessment scale of mental load [14], but since it can only describe one aspect of the psychological condition in general and cannot assess the driver's psychological state in full detail, more researchers tend to use multidimensional scales to ensure the comprehensiveness and validity of the results. NASA TLX (National Aeronautics and Space Administration - Task Load Index) and Space Administration - Task Load Index) scale is a multidimensional subjective rating scale commonly used in driving-related studies [15].

2.3.2 Physiological indicators

Physiological signals contain a large amount of human physiological information that can effectively reflect the changing physiological state of the driver and are a reliable indicator for detecting driver distraction. For example, Zhenhai Gao [16] identified two states of driver cognitive load under multitasking based on physiological signals such as ECG, dermatography and respiration, and Deshmukh [17] demonstrated in his study that electrocardiography (ECG) can consistently characterize driver physiological changes to identify driver distraction with minimal intrusiveness and low cost.

The use of physiological signals to monitor the driver's attentional state allows a high temporal resolution to continuously record the changes in the driver's physiological signals and avoids the influence of the driver's subjective will on the recorded results, resulting in a high degree of objectivity in the evaluation. However, due to the limitation of measurement instruments and cost, it is difficult to be widely used in the market, and the physiological characteristics are more often used as a validation tool for cognitive distraction detection and identification.

2.3.3 Eye movement indicators

Oculomotor signals are bioelectrical signals generated by changes in the peripheral electrical potential due to eye movements, and are widely used in linguistics, cognitive psychology, and advertising design research because of their high amplitude and easy to examine and process waveforms [18]. Commonly used eye-movement information is usually divided into the following five categories: gaze information, sweep information, blink information, pupil information, and other eye-movement information. (1) Gaze is a situation in which the eye is directed at an object and remains stationary for a period of time [19]. Commonly used gaze indicators are gaze duration, gaze frequency, gaze number, and gaze position. (2) Sweeping gaze usually refers to the movement of the eyes rapidly shifting from one point to another [20]. Sweep duration, sweep amplitude, sweep frequency, eye-hop latency, and total sweep length are often selected as mental load measures in studies. (3) Blinking is a rapid eye closure movement. This category can be subdivided into: blink frequency, blink duration, and blink interval. (4) The pupil indicator used as a measure of mental load is mainly the pupil diameter. (5) Other eye movement indicators that are more commonly used are PERCLOS (percentage of eyelid closure over the pupil) and VOR (vestibulo-ocular reflex). Among them, PERCLOS refers to the percentage of eye closure time in the total time, which is calculated as PERCLOS = (number of frames of eye closure/total number of frames in the detection time period) × 100%, and this index is commonly used for monitoring and identifying driver fatigue while driving, while VOR, vestibulo-ocular reflex eye movement, is an eye movement produced unconsciously by the driver, and can effectively measure psychological load [21].

Identifying drivers' cognitive state through eye movement signals is actually a search for the relationship between drivers' eye movements and their psychological state.Victor [22] et al. found that drivers performing a cognitive second task while driving reduced the frequency of their search for environmental information, causing their eyes to focus on a specific area (usually the center of the road).Fletcher and Zelinsky [23] showed that eye gaze direction, blink information, eye closure information, and head position can enable the detection of driver cognitive distraction. Yang Zhou [24] et al. based on simulator experiments found that as the cognitive load increased, the driver's gaze duration decreased and blink time increased.

2.3.4 Driving Performance Indicators

The broad driver operation information, namely Driving Performance, includes indicators such as driver maneuvering reaction time, operating error, etc. Specifically, the driving behavior can be divided into two categories: driver's lateral control of the vehicle and longitudinal control, in which the driving performance indicators characterizing the lateral control of the vehicle are: vehicle lateral position, vehicle transverse angular speed, vehicle lateral acceleration and Longitudinal control indicators mainly refer to vehicle speed, vehicle acceleration, following distance, gas pedal and brake pedal openness and other information. Changes in the driver's mental state can affect driving ability. Many studies have shown that drivers maneuver the vehicle differently when they are focused on driving and when they are cognitively distracted. For example, Liu's study found that drivers drove faster when they were cognitively distracted than when they were focused on driving [25]. Another study showed that drivers were more inclined to increase their following distance from the vehicle in front when performing a cognitively demanding second driving task [26].

2.3.5 Mixed indicators

Hybrid metrics are the fusion of signals from multiple sources, and in studies related to cognitive distraction detection, many studies have shown that hybrid metrics are reliable indicators for assessing drivers' cognitive load. For example, in the literature [27], real-time detection of driver cognitive distraction was achieved using a hybrid indicator combining driving performance information and eye-movement information. In the literature [28], Miyaji et al. used machine learning techniques to detect two states of driver cognitive load from driver gaze information, head turn, pupil diameter, and RRI mean (R-R Interval) obtained from electrocardiogram. And Liao Yuan investigated the monitoring method of driver distraction based on the hybrid index of driving performance information fused with eye movement information [29].

In conclusion, among the above five evaluation metrics, subjective scores cannot be tested continuously, and physiological signals are objectively accurate but their application is limited by signal acquisition equipment. Therefore, eye-movement metrics, driving performance metrics and their fused hybrid metrics have relatively good prospects for engineering applications.

3. Effects of distracted driving on driving behavior

Visual distractions and cognitive distractions have a multifaceted impact on drivers. Distracted driving can cause drivers to drive without proper thinking, which in turn leads to driving emergencies without the ability to think in a timely manner, eventually leading to traffic accidents, and drivers are punished accordingly.

Distracted drivers can cause the vehicle to slow down, blocking traffic and affecting the passing rate of other vehicles. The following is an analysis of the impact of driving distractions on the driver's visual behavior and operational behavior in 2 areas.

3.1 Effect on vision

Both visual and cognitive distractions can have some negative effects on drivers' visual behavior, but the effects of each are very different. Visual distraction tends to cause drivers to look away from the center of the road and reduce the time spent looking at the central area of the road, whereas cognitive distraction causes drivers to look at the central area of the road for longer periods of time, reducing sweeping behavior and the probability of shifting their vision between areas.

Ma Yong et al [30] used non-contact oculomotor to study the gaze behavior of drivers during visual distraction. The test divided the gaze area into four regions: the frontal region, the left rearview mirror region, the right rearview mirror region, and the interior region, and characterized the duration and frequency of gaze in each region when the distracted driver's eyes left the frontal region. It was found that the driver looked at the interior area more than 60% of the time when the driver's eyes were away from the front area, and the number of observations for the left rearview mirror was higher than that for the right rearview mirror, and about 90% of the gaze duration was less than 1.0s, and more than 50% of the gaze duration was between 0.4 and 0.8s.

Massel et al [31] simulated the cognitive distraction level of drivers using mathematical calculation problems of different difficulty levels and found that as the difficulty of the calculation problems increased, the amount of time drivers spent looking at the center of the road increased and the amount of time they spent looking at both lanes and the equipment inside the car decreased accordingly, and they even gave up looking because the cognitive distraction was too difficult. Harbluk et al. [32] found that the number of sweeping glances decreased with increasing cognitive distraction when they studied different levels of cognitive distraction caused by telephone tasks. Liang et al [33] confirmed that the blink frequency of drivers increased with increasing cognitive distraction.

Tivesten et al [34] studied drivers' visual behavior when reading and writing text messages in different traffic environments such as turning, meeting, and following. Compared to normal driving, the proportion of drivers who took their eyes off the road for long periods of time decreased in complex traffic environments. This suggests that complex traffic environments inhibit visual distraction, especially in turning and following situations.

3.2 Impact on operational behavior

The effects of visual distraction on driver operating behavior are manifested by an increase in the number of vehicle lane crossings, a decrease in steering smoothness, and a longer reaction time to the brakes of the vehicle in front. Cognitive distractions, on the other hand, focused on the driver's reduced perception of danger and decreased steering smoothness.

Wang Chang et al [35] conducted a real-world driving test with several drivers under visual distraction. The mean angular speed of steering wheel rotation decreased from 0.853°/s to 0.325°/s under normal conditions, and there was a significant difference between the two when the driver's line of sight left the road area in front of him/her. In addition, drivers were more inclined to release the accelerator pedal and slow down the vehicle speed to increase their overall control of the vehicle when they were visually distracted.

McDonald et al [36] used steering wheel reversal rate (SRR) to analyze the effect of visual distraction on driver steering. It was found that visual distraction led to an increase in steering error. Rakaus-kas et al. [37] verified that cognitive distraction increased steering entropy and reduced vehicle steering smoothness.

Fitch et al [38] investigated the effect of cognitive distraction on vehicle speed caused by handheld and hands-free phones. The results showed that there was no significant reduction in speed when the driver used a speakerphone and a significant reduction in speed when the driver used a handheld phone. It was hypothesized that only when cognitive distraction reached a certain level would drivers be forced to reduce their speed in order to maintain an acceptable level of hazard perception.

Both visual distraction and cognitive distraction lengthen the driver's time to recognize the target object and reduce the recognition accuracy. Olsson et al [39] used peripheral detection task (PDT) to study the driver's recognition accuracy and recognition time as parameters, and the driver's recognition of the vehicle in front of him/her while driving and adjusting the in-vehicle device. The study found that the driver's recognition rate and recognition time were used as parameters. Greenberg et al. [40] showed that visual subtasks (e.g., sending text messages) can lead to impaired ability to search for critical traffic signals, which is a potential hazard to traffic safety. Horrey et al. [41] showed that the cognitive distractions generated by phone calls can also reduce drivers' search ability by comparing their reaction times to stimulus signals during normal driving.

4. Distracted driving behavior survey methods

4.1 Distraction survey methods

Distracted driving behavior is defined as "the diversion of a driver's attention from activities that are critical to safe driving to activities that compete with the driving task". Research on distracted driving behavior begins with an understanding of drivers' frequent distracted driving behaviors and the dangers of these behaviors. Commonly used methods for investigating distracted driving behaviors include: hospital conversation surveys, self-assessment surveys, roadside observations, and naturalistic driving observations.

Table 1: Distraction survey methods and their advantages and disadvantages

Survey Methodology	Advantages	Disadvantages
HI	Targeted to analyze the relationship between distractions and traffic accidents	Invasion of privacy, the need for cooperation with the relevant departments, the existence of the driver deliberately concealed facts
SRS	Simple, easy to operate, low cost	The existence of subjective bias and concealment of the driver's true thoughts
ROS	Can directly observe actual driver behavior at relatively low cost	Covert distracted driving behavior cannot be observed and is only applicable when the vehicle is moving at low speed or stopped, and distracted driving behavior of drivers in fast moving vehicles cannot be effectively observed
NDS	It is the best way to observe distracted driving behavior as it can monitor the driver throughout the whole process and capture the more hidden distracted driving behavior, which can truly reflect the distracted driving behavior	Invasion of privacy, monitoring systems installed in vehicles may have the highest cost of influencing the driver's driving behavior.

Note: HI-Hospital conversation survey method; SRS-Self-assessment survey method; ROS-Roadside observation method; NDS-Natural driving observation method

4.2 Distraction monitoring methods

Five main types of indicators are applied for driver attention monitoring, namely, subjective evaluation, eye-movement information, driving performance, physiological signals, and a hybrid indicator combining several of the four previous ones. Subjective evaluation is a good quantification tool for fatigue monitoring that develops over a long period of time, but subjective evaluation is prone to subject backlash, which affects measurement validity and reliability, and cannot be used as a quantification tool for low attention caused by short-time distractions. Physiological indicators such as EEG and heart rate are difficult to apply in practice because of the large measurement instruments, and many studies have used physiological indicators as a validation tool for distraction monitoring. Overall, eye-movement information and driving performance as well as hybrid metrics incorporating multiple metrics have good prospects for application.

Machine vision-based monitoring tools are mainly applied to visual distraction monitoring, where the cumulative time of sight shift from PVAL is the main quantitative index, and visual distraction and non-visual distraction driving states are classified by time-varying thresholds or time-invariant thresholds [43]. Visual distraction recognition needs to consider the shift of vision brought by the driver's normal environmental information search, so incorporating road traffic information can improve the recognition accuracy of visual distraction.

Table 2: Study based on operational indicators and common models

Indicators	Models
Steering wheel position, accelerator pedal position, lane line, forward bend	Random Forests
Vehicle speed, vehicle position, acceleration, throttle opening	Radial neural networks, support vector machines
Following distance, steering wheel cornering	Hidden Markov model, Gaussian mixture model.

Among them, monitoring means based on driving behavior and vehicle status are more widely used, and Table 2 above summarizes the key behavioral indicators and modeling means used in some studies. For modeling monitoring of distraction on driving behavior indicators, Torkkola et al [44] (2004) also combined environmental information and introduced indicators first as model inputs; Ersal et al [45] (2010) Individual modeling uses radial basis neural networks to build a constant driving model, and then support vector machines are used to do distraction detection, and the effect of time window size on the accuracy of distraction monitoring for each driver is discussed.

With the development of Intelligent Transportation systems (ITS), more and more information can be obtained and used by vehicles. As a human-vehicle-road-ADAS system, the information exchange between various elements is very frequent and complex. For distraction monitoring, the integration of driver eye movement information, vehicle status information and current road scene information can help to comprehensively understand and identify the driver's distracted driving status, which is also the development trend of distraction monitoring research. The complexity of human attentional states is high and the relevant factors

References

[1]. Regan M A, Lee J D, Young K. Driver distraction: Theory, effects, and mitigation [M]. CRC press, 2008.

[2]. Wickens C D. The structure of attentional resources [J]. Attention and Performance VIII,1980,8(4):33-36.

[3]. Romer D, Lee Y C, McDonald C C, et al. Adolescence, attention allocation, and driving safety [J]. Journal of Adolescent Health, 2014, 54(5): S6-S15.

[4]. Cai Na. Analysis of factors influencing road traffic accidents of female drivers [D]. Beijing University of Technology, 2010.

[5]. Wang Fei-Long,Lian Jin-Yi, Yu Guo-Liang. Analysis of the effects of age and distraction on reaction time and safe vehicle distance [J]. Journal of Taiyuan University of Science and Technology, 2013, 34(04): 296-301.

[6]. Jiménez F, Sánchez J J, Gomez O. Characterization of Driving Style and the Influence of Distraction Based on Non-intrusive Driving Parameters [J]. Journal of Mechanics Engineering and Automation, 2011, 1(6): 413-419.

[7]. Hanowski R J, Perez M A, Dingus T A. Driver distraction in long-haul truck drivers [J]. Transportation Research Part F: Traffic Psychology and Behaviour, 2005, 8(6): 441-458.

[8]. Hickman J S, Hanowski R J. An assessment of commercial motor vehicle driver distraction using naturalistic driving data [J]. Traffic injury prevention, 2012, 13(6): 612-619.

[9]. Hu Meirong. Analysis of driving vision of different types of vehicles and prevention of rear-end collisions [J]. Zhongnan Auto Transport,1996(03):37-38.

[10]. Sun Yue. The influence of drivers' mind wandering on their driving behavior in highway driving situations [D]. Zhejiang University of Technology, 2017.

[11]. Horberry T, Anderson J, Regan M A, et al. Driver distraction: The effects of concurrent in-vehicle tasks, road environment complexity and age on driving performance [J]. Accident Analysis & Prevention, 2006, 38(1): 185-191.
[12]. Kolko J D. The effects of mobile phones and hands-free laws on traffic fatalities[J]. The BE Journal of Economic Analysis & Policy, 2009, 9(1).
[13]. Widyanti A, Johnson A, de Waard D. Adaptation of the rating scale mental effort (RSME) for use in Indonesia [J]. International Journal of Industrial Ergonomics, 2013, 43(1): 70-76.
[14]. Zijlstra F R H. Efficiency in work behaviour: A design approach for modern tools [J]. 1995.
[15]. Zhou Yuting. Research on driver distraction based on driver-in-the-loop testbed [D]. Hunan University,2017.
[16]. Gao Z H, Duan L F, Zhao H, Yu H L. Assessment of driver cognitive load under multitasking based on physiological signals [J]. Automotive Engineering, 2015, 37(01): 33-37.
[17]. Deshmukh S V, Dehzangi O. ECG-based driver distraction identification using wavelet packet transform and discriminative kernel-based features[C]//2017 IEEE International Conference on Smart Computing (SMARTCOMP). IEEE, 2017: 1-7.
[18]. Peng Yi. Research on the extraction and classification recognition of eye movement signals [D]. Shanghai Normal University, 2016.
[19]. Liang Y, Lee J D. A hybrid Bayesian Network approach to detect driver cognitive distraction[J]. Transportation research part C: emerging technologies, 2014, 38: 146-155.
[20]. Liang Y, Reyes M L, Lee J D. Real-time detection of driver cognitive distraction using support vector machines [J]. IEEE transactions on intelligent transportation systems, 2007, 8(2): 340-350.
[21]. Jin Huibin, Chen Jian, Liu Wenhui, Song Xiangbo, Hong Yuan. Advances in the application of eye movement index in real-time measurement of psychological load [J]. Science Technology and Engineering, 2015,15(30): 79-85.
[22]. Victor T. Keeping eye and mind on the road [D]. Acta Universitatis Upsaliensis, 2005.
[23]. Fletcher L, Zelinsky A. Driver state monitoring to mitigate distraction[C]//International Conference on the Distractions in Driving, 2005, Sydney, New South Wales, Australia. 2007.
[24]. Zhou Y, Fu R, Yuan W, Wang D, Zhang RB. Research on random forest model for driver cognitive distraction recognition [J]. Chinese Journal of Safety Science, 2018, 28(01): 20-25. DOI:10.16265/j.cnki.issn1003-3033.2018.01.004.
[25]. Liu Y C. Comparative study of the effects of auditory, visual and multimodality displays on drivers' performance in advanced traveller information systems [J]. Ergonomics, 2001, 44(4): 425-442.
[26]. Horrey W J, Simons D J. Examining cognitive interference and adaptive safety behaviours in tactical vehicle control [J]. Ergonomics, 2007, 50(8): 1340-1350.
[27]. Liang Y, Reyes M L, Lee J D. Real-time detection of driver cognitive distraction using support vector machines [J]. IEEE transactions on intelligent transportation systems, 2007, 8(2): 340-350.
[28]. Miyaji M, Kawanaka H, Oguri K. Driver's cognitive distraction detection using physiological features by the adaboost[C]//2009 12th International IEEE conference on intelligent transportation systems. IEEE, 2009: 1-6.
[29]. Liao Yuan. Research on driver distraction monitoring based on multi-source information fusion [D]. Tsinghua University,2015.
[30]. Ma Y, Fu R, Wang C, Guo Y, Yuan W, Song D-M. Characterization of driver gaze behavior during visual distraction[J]. Chinese Journal of Safety Science,2013,23(05):10-14.
[31]. Massel L, Harbluk J. The impact of performing cognitive tasks on drivers' braking behavior[C]//Proceedings of the Canadian Multidisciplinary Road Safety Conference XII. 2001: 1-8.
[32]. Harbluk J L, Noy Y I, Eizenman M. The impact of cognitive distraction on driver visual behaviour and vehicle control[R]. 2002.
[33]. Liang Y, Reyes M L, Lee J D. Real-time detection of driver cognitive distraction using support vector machines[J]. IEEE transactions on intelligent transportation systems, 2007, 8(2): 340-350.
[34]. Tivesten E, Dozza M. Driving context and visual-manual phone tasks influence glance behavior in naturalistic driving[J]. Transportation Research Part F: Traffic Psychology and Behaviour, 2014, 26: 258-272.
[35]. Wang Chang, Guo Yingshi, Fu Rui, Yuan Wei, Song Dianming. Driver's operating behavior when the line of sight leaves the front area [J]. Journal of Chongqing Jiaotong University (Natural Science Edition),2014,33(03):124-128.
[36]. Macdonald W A, Hoffmann E R. Review of relationships between steering wheel reversal rate and driving task demand[J]. Human Factors, 1980, 22(6): 733-739.
[37]. Rakauskas M E, Gugerty L J, Ward N J. Effects of naturalistic cell phone conversations on driving

performance[J]. Journal of safety research, 2004, 35(4): 453-464.
[38]. Fitch G M, Grove K, Hanowski R J, et al. Compensatory behavior of drivers when conversing on a cell phone: Investigation with naturalistic driving data[J]. Transportation research record, 2014, 2434(1): 1-8.
[39]. Olsson S, Burns P C. Measuring driver visual distraction with a peripheral detection task[J]. Obtained from August, 2000.
[40]. Greenberg J, Tijerina L, Curry RArtz B, et al. Evaluation of Driver Distraction Using an Event Detection Paradigm, Ford Motor Company, Ford Research Laboratory[C]//Transportation Research Board Annual Meeting. 2003.
[41]. Horrey W J, Wickens C D, Consalus K P. Modeling drivers' visual attention allocation while interacting with in-vehicle technologies[J]. Journal of Experimental Psychology: Applied, 2006, 12(2): 67.
[42]. Harbluk J L, Noy Y I, Trbovich P L, et al. An on-road assessment of cognitive distraction: Impacts on drivers' visual behavior and braking performance[J]. Accident Analysis & Prevention, 2007, 39(2): 372-379.
[43]. Pohl J, Birk W, Westervall L. A driver-distraction-based lane-keeping assistance system[J]. Proceedings of the Institution of Mechanical Engineers, Part I: Journal of Systems and Control Engineering, 2007, 221(4): 541-552.
[44]. Torkkola K, Massey N, Wood C. Driver inattention detection through intelligent analysis of readily available sensors[C]//Proceedings. The 7th International IEEE Conference on Intelligent Transportation Systems (IEEE Cat. No. 04TH8749). IEEE, 2004: 326-331.
[45]. Ersal T, Fuller H J A, Tsimhoni O, et al. Model-based analysis and classification of driver distraction under secondary tasks[J]. IEEE transactions on intelligent transportation systems, 2010, 11(3): 692-701.