Automotive HUD Interaction Design Based on Lane Changing Scenario

Chen-xi Jin, Fang You(✉), and Jian-min Wang

School of Arts and Media, Tongji University, Shanghai, China
youfang@tongji.edu.cn

Abstract. With the development of society, cars have become indispensable means of our daily transportation. Nowadays,researchers in industrial and academic areas are paying more attention to vehicle safety. This paper focuses on automotive head-up display technology in lane changing scenario. We use research, observation and interviews to analyze the relationship between environment, mentality and behaviors in lane changing scenario. We find that once the unfriendly environment stimulates the drivers, they will make the stress response. If the person does not effectively respond to the environmental stimulation, then he may regard the stimulation as a threat, resulting in anger, fear, anxiety and other emotional responses. These negative emotions will have constraints on people's behavior such as insufficient coping ability. Based on this, we put forward the key points in HUD interaction design. One is the efficient information organization and the other one is good interface design.

Keywords: Head-up display · Interaction design · HMI · Lane changing scenario

1 Introduction

With the continuously development of the society, cars have become indispensable means of our daily transportation. The increasing high rates of traffic accidents have aroused people's concerns. Thus, vehicle safety will be one of the most important directions of future vehicle development. With the wide use of computer and network technology in the field of vehicle transport and the developing car technology, the internal space, HMI (human-machine interaction) design, function operation and interactive process of the vehicle are having revolutionary changes. Nowadays,researchers in industrial and academic areas are paying more attention to artificial intelligence studies about technology improving the interaction between humans and automobiles via smart cars.

The main purpose of vehicle safety and driving-assistance technology is to increase driving safety. This technology uses sensors installed in cars and on roads to collect information about cars, roads, and environmental conditions. Therefore, the system can provide the driver some advice and warning. It can also control the car a little bit better in certain conditions. Now the technology mainly includes: lane departure warning systems, obstacle detection, driver state detection, vehicle control, communication, and so on.

M. Kurosu (Ed.): HCI 2016, Part III, LNCS 9733, pp. 277–284, 2016.
DOI: 10.1007/978-3-319-39513-5_26

This paper will mainly focus on the application of HUD (Heads-Up Display) vehicle safety driving assistance in lane changing scenes. The advantage of HUD is that the driver can read the information he needs without drooping or turning his head. When the driver looks forward through the HUD, he can combine the exterior image with the HUD image easily. This decreases the frequency of head drooping and turning and increases driving safety.

Research shows that vehicle safety and driving-assistance technology can not only reduce the deaths in traffic accidents but also decrease the anthropogenic accidents caused by drivers, which will make the traffic flow more freely. Moreover,this technology can reduce emissions. Thus, vehicle safety and driving-assistance technology will be an important research field of vehicle safety in the future.

2 Background

Head-up display technology can be traced back to the sixties of last century. At that time, it was used on optical aiming and radar aiming. Through development head-up display was widely used in aircraft at the end of the 1960 s. Since 1970 s, it has been used in conveyor, civil aircraft, helicopters and the space shuttle [1] Using this display system, the driver can see the important information on the wind window without bowing, which can help the driver observe emergency situation and take action timely in the status of rising.

Head-up display technology was later ported to vehicles. This technology was firstly used in cars in 1988. GM launched the first head-up display of car, which displays speed and other useful data onto the standard production windshield. Then the Japanese NISSAN and TOYOTA also launched a vehicle head up display system. In 1998, GM launched a night vision system prototype. The head-up display system used in this car can display infrared image on the front windshield view [2]. In 2000, Cadillac had incorporated full-blown thermal imaging into their HUD system. In 2005, GM introduced the world's first four color display system, which is the change of vehicle head up display from monochromatic display to the composite color display. In 2012, Pioneer Corporation introduced a navigation system that projects a HUD in place of the driver's visor that presents animations of conditions ahead, a form of augmented reality (AR). Subsequently, many car manufacturers such as BMW and Volkswagen designed their own head system. BMW has developed vision cameras that can even read temporary or permanent road signs as well as overhead signs. They can project the temporary speed limit or other hazard information onto the HUD.

Internally, the use of HUD system in aerospace has a more in-depth study, but the research for vehicular HUD system has just begun. Dongfeng Nissan Passenger Vehicle Co was the first company to equip the head up display system in China. The head-up display system equipped on Nissan Bluebird was also called the head velocity meter. In 2011, domestic Dongfeng Peugeot 508 brought the head-up display into the ordinary family. It can help the driver to grasp condition and navigation information without the eye away from roads which is more in line with the driver's visual habits and fully improves the driving safety.

3 Research on Lane Changing Scenario

3.1 Preliminary Investigation

According to the literatures, the number of deaths in road traffic accidents is very high each year in China. It ranked seventh after cerebrovascular, respiratory system and other diseases in the total number of deaths. According to the Ministry of Public Security Traffic Management Bureau news, Chinese motor vehicle amounted to 264 million in 2014 and the number of traffic accident death was 58,080. Although the number is decreasing every year, it still cannot be underestimated.

Based on these, we investigated the cause of traffic accidents. According to the annually road traffic accident description which is released by Shanghai Municipal Public Security Bureau Traffic Police Corps, we can see that in a motor vehicle accident, most drivers have 6 to10 years of driving experience, followed by less than 5 years. Besides, motor vehicle drivers' violations in traffic accident mainly dominated by not giving way by rules and the violating traffic signals [3].

Not giving way by rules mainly includes: causing accidents with normal lane vehicle when changing lanes, causing accidents with the opposite lane or normal lane vehicle when overtaking, causing accidents with the traffic going straight when turning a corner through a no-traffic light cross and so on.

In addition, we also had a questionnaire survey and depth interviews for some novice drivers. We found the problems and difficulties encountered in the actual driving are as follows: cannot predict the traffic lights in advance at the traffic light intersection, difficult to change line, motor and non-motor vehicle suddenly appeared, worse sight when meeting haze weather, difficult to reverse.

According to the above analysis, we put forward five key scenes: reversing, changing lane, crossroad, roadside trail and crowded roads. In this paper we focus on HUD design for change lane scenario.

3.2 Study on Environment, Behavior and Psychology

The problem of road traffic safety has always been a focus of concern. Road traffic system consists of the human, vehicle and road. In the past, people focused mainly on the research of vehicle and road characteristics. Until the 1950 s, people began to converse their attention on the characteristics of traffic safety effects. During 1960 s, the United States, Japan and other countries launched the extensive research on various characteristics of the drivers, including their psychological activities while driving [4]. In recent years, with the breakthrough in human physiological and psychological data collection technology, the application of psychology in the field of transportation has been more widely.

In the three elements, driver is the core of the system. In the process of driving, the driver has to complete three driving action, namely, the perception, the judgment and the driving operation. First, drivers will obtain the information through the visual, auditory and tactile perception. Then they will think and judge the traffic situation. Last, they will drive the car by their hands and feet. In this process, the environment contains the

vehicle, road and weather conditions, and some other emergencies. The driver's psychology and behavior will be subject to the quality of the environment. Once they have some psychological fluctuations by negative emotions, driving behavior is prone to slow or wrong, which will cause the dangerous consequences. To conclude, the coordination of environment, people and vehicles is the key to achieving safety requirements of road traffic system.

In environmental psychology, environment can affect people's mood and performance, while emotion is a complex concept of psychological changes and subjective experience [5]. Once the unfriendly environment stimulates the drivers, they will make stress response. The so-called stress is the unpleasant action caused by the stress response. The response to stress is the imbalance, that is, the subject copes with the environmental challenges [6]. When the subject is faced with challenges while his coping ability is insufficient, he will make the response to stress. In the beginning of stress moment, due to the survival instinct, the person will mobilize all the physical response to cope with the immediate threat and take the appropriate measures and actions. At this stage, if the person doesn't effectively respond to the environmental stimulation, then the subject may regard the stimulation as a threat, resulting in anger, fear, anxiety and other emotional responses. These negative emotions will have constraints on people's behavior.

For example, in the lane changing scene, due to change the condition of congestion and short distance, if the driver is unable to complete the change, he can easily produce the anxiety emotions. Once the anxiety emotion lasts for a long time, people's feeling and perception ability will drop, muscle strength will decrease, and the control of the car is prone to error. Take another example. When the new drivers change their lanes, big trucks will cause psychological oppression, thus generating the tension. In addition, overload behavior can also cause stimulus constraints. In the road or expressway ramp before changing lanes, the drivers have to observe not only the front and rear of the vehicle but also the signs and instructions and control the speed of the vehicle, so they may cause the slow reaction force. There is one psychological phenomenon named as "psychological confrontation", that is, when some factors interfere with or hinder the people's actions, they will lose their control. Namely, people feel their own action restricted, causing an unpleasant emotion. At this time, people may make the first reaction to re-establish the control of the scene and restore freedom. In the lane changing scene, other vehicle lanes' changing behavior will obstruct the normal driving of drivers of the lane. This interference makes the psychological confrontation to drivers, instinctively do not want to let other vehicles change lanes in, so they may not slow down avoidance behavior, which will cause vehicle collision. The weather may be different in different degrees of stress reaction. The haze rainy weather and low visibility will be easy to make the drivers in the psychological uncomfortable, depressed, depression and other negative emotional reaction of discontent.

Above is about unfriendly environment that will produce psychological impact on people and behavior constraints, but a good environment for safe driving also has hidden dangers. When the traffic environment is very good, there is very little external environmental stimulation. At this time people's physiology and mentality are in flabby

condition. Once the stimulation occurs, due to the paralytic psychological for a long time, the low sensory ability and the slow reaction rate may cause accidents.

3.3 Observation

To have a better understanding of drivers' behavior in the process of changing lanes, we took several observations of the drivers and used the v-box to record videos of driving process in different weather and road conditions to do the research.

During driving, the behavior of changing lanes including three process: perceiving information, judging information and performing operation. Perceiving information means drivers use their visual and auditory to get driving information, such as the current car speed, the vehicle distance with a nearby car and the speed of the following car, etc. Judging information is using the current data to make a decision of whether to change a lane. Performing operation is the action of changing lanes. By our observations, we found that new drivers are relatively nervous and not skilled, specially in a changing-lane situation for they are not familiar with the driving speed and the safe vehicle distance between two cars. We also found that experienced drivers conducted more lane change behavior and they may change a lane in some complicated situations. Drivers' perception of car speed on highway is weaker than on the ordinary city road because of the excessive speed on the highway. Moreover, driving blind is another problem worthy to pay attention to during the process of changing lanes. Drivers usually need to turn around to see the blind area, which may cause accidents. According to the observation of driving in different weather condition and brightness, we found that the low visibility at night, in rainy and foggy days increase the difficulty of changing lanes.

4 Automotive HUD Interaction Design

When driving a car, 80 per cent of traffic information is achieved by vision. Usually a driver needs 4 to 7 s to look down to the dash board and then look forward again. During this process, the time the driver spends on dash board is 3 to 5 s. This gap of time can be called blind-vision time which causes driving distraction and is very dangerous. According to statistics, about 30 % per cent of traffic accidents are related with this gap of blind-vision time. If there is a car running on the express way at 100 km/h, it will run 100 m forward during the visual and action distraction time which causes by looking down, reading and looking up. Therefore, Head-up display is very helpful to reduce the visual distraction.

4.1 HUD Information Organization

Information filtration. The information displayed on HUD interface has become richer owning to the technology development. However, overmuch information may aggravate the difficulty of recognition and response which makes the information filtration more and more important.

Information mainly includes status information and function information [7]. Status information describes the car status and transportation circumstance such as speed, indicator light, temperature, oil consumption, traffic condition, location and so on. Function information is based on the analysis of status information which can instruct drivers to complete the driving mission. The purpose of filtering is to select useful information to the driver.

In lane changing scenario, the purpose of safety and driving-assistance system is to help drivers avoid unsafe factors and complete lane changing safely. According to the previous observation and interview, the distance between cars, the current speed, the target speed, the lane changing path and blind area information are considered important.

Information organization. Information organization is to organize and definite the interface layout, the workflow and the interaction behaviors from interaction framework. It efficiently organizes the information which enables the driver find the needed information quickly and accurately [8]. Only by excellent information organization can the driver keeps the balance between interaction and safety.

In lane changing scenario, information can be divided into several modules and then be displayed on the interface in a tile way. According to the filtered information, we divide them into speed module, danger remaindering module and blind-area module. Besides, we also divide these modules into constant showed module and random showed module. Speed module is constant showed module. Danger remaindering module and blind-area module are only showed when dangers and blind areas appear.

4.2 HUD Interface Design

Overall, HUD interface should observe the general design rules such as clearness, readability, unification, beauty-appreciation and so on. Here we discuss visual symbols, visual color and visual motion in design.

Visual symbols. Visual symbols include character symbols and graphic symbols. Character symbols include numbers and text. Numbers are used to reminder information as speed and distance while text is used to reminder information as destination and street names. Since text needs more time for drivers to read. It is not much recommended in HUD design. The merit of graphic symbols is its readability and strong instruction. For example, in the BMW HUD interface design (as Fig. 1), they use a fork road symbol to convey the dangerous information. Besides, the white arrow shows the direction that the car should keep to the right. In addition, we should also pay attention to the size of the symbols. In the BMW HUD interface design (as Fig. 1), they make “62” much bigger than “km/h” because the “62” is the primary information. Finally, we should keep the visual unity of every symbol like typeface.

In lane changing scenario, we use acceleration as an example. As Fig. 2 showed, we can see four examples. We made a questionnaire to see which one works better. The result showed that arrow symbols are more readable and intelligible than character symbols.

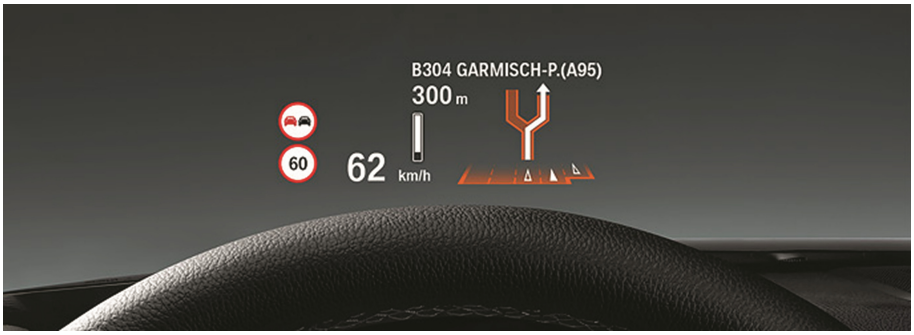

Fig. 1. BMW HUD interface design

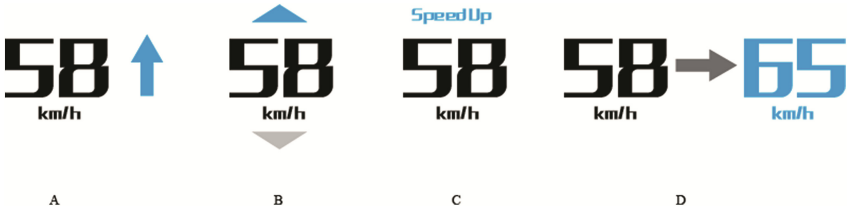

Fig. 2. Acceleration examples

Visual color. According to psychology, color can not only affect physiological reaction but also emotional reaction. In the 1980 s, a scientist proved this opinion. The blindfolded testers were asked to enter three colored rooms. When they came into the red room, their pule pressure got a 12 per cent increase. When they came into the blue room, their pule pressure got a 10 % decrease. When they came into the yellow room, everything keeps regular. Therefore, we should carefully choose the color when we design [9].

In lane changing scenario, we choose red and yellow to remind danger, blue and green to remind speed and instruction. Because in daily transportation, red means stop, yellow means caution and green means go, these colors accord with people's general cognition. As the design in BMW HUD (as Fig. 1), they use red to remind the dangers.

Besides, the saturation of color should be reduced a little in order to merge with the reality. And the color lightness can automatically change with the environment.

Visual Motion. Visual motion in HUD interface design is very important. For example, we can use glint to remind the dangers in lane changing scenario because glint is a more obvious way to catch the driver's attention than color change. However, the frequency of glint can lead to different results. High frequency may make driver nervous which will affect driver's behavior. Therefore, low frequency of glint is better. When we design the visual motion, we should consider the psychology knowledge and make it simple and readable.

5 Conclusion and Future Work

This paper analyzes the relationship between environment, mentality and behaviors in lane changing scenario and finds that unfriendly environment stimulation may lead to drivers' unstable emotion. Then drivers' response time will be increased and driving error rate will be increased too. According to the analysis, we put forward the information organization and design rules in HUD interface design. The important information elements in lane changing scenario is the distance between cars, the current speed, the target speed, the lane changing path and blind area information. The next stage we will do further research on other driving scenarios.

Acknowledgements. This work was supported by the Fundamental Research Funds for the Central Universities (0600219052,0600219053) and supported by the UXlab (user experience lab) of Tongji University.

References

1. Yang, N., Dong, H.T., Yang, S.: Study on installation of head -up display on aircraft. Electron. Opt. Control (04), 117–118 (2007)
2. Xing, W., Qi, Q.: Technologies of head-up display for automobiles. Electron. Opt. Control (01), 55–56 (2014)
3. Shanghai Municipal Public Security Bureau Traffic Police Corps: 2014 Shanghai traffic accidents description. Traffic Transport (03), 75–77 (2015)
4. Tao Pengfei. Modeling of driving behavior based on the psychology field theory, pp. 2–3. Jiling University (2014)
5. Hu, Z.F., Lin, Y.L.: Environment Psychology, pp. 117–119. China Architecture & Building Press, Beijing (2012)
6. Hu, Z.F., Lin, Y.L.: Environment Psychology, pp. 127–129. China Architecture & Building Press, Beijing (2012)
7. Schmidt, A., Spiessl, W., Kern, D.: Driving Automotive User Interface Research. IEEE Pervasive Comput. (1), 85–88 (2010)
8. Zeng, Q.S., Tan, H.: Research on head-up display navigation system. In: Proceedings of the User Friendly 2014 UXPA (2014)
9. Min, A., Yuhong, L., Xiaohong, Q., et al.: The impact of color on human physiology and psychology. China J. Health Psychol., 317–319 (2015)