Acceptance of Integrated Active Safety Systems in China

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Abstract. Yearly almost 60,000 people are killed in traffic accidents in China due to the rapid growth of the number of vehicles and bad driving habits. There is a need to increase safety and cars are being equipped with new active safety technology known as Advanced Driver Assistant Systems (ADAS), which can help driver by warning before accidents occur. A simulator study with 16 participants was carried out at a driving simulator, which equipped with an integrated visual interface prototype developed by Chalmers University of Technology in Sweden. The interface presents information visually to the driver before any critical situation with help from three Advanced Driver Assistance Systems, Forward Collision Warning (FCW), Curve Speed Warning (CSW) and Lane Departure Warning (LDW). Questionnaires and open-ended interviews were held to subjectively measure the participants' attitude toward the sound warnings and visual interface. Questionnaire results showed that most participants thought the sound warning could facilitate their driving while most users' attitude towards the visual display warning were comparatively neutral. In order to better understand how ADAS technology can be designed to suite Chinese drivers, their behaviors and preferences. There is more work need to do.

Keywords: Advanced driver assistant system · Infotainment equipment · Active safety system · User acceptance

1 Introduction

In recent years, there are almost 60,000 persons killed by traffic accidents every year in China. This number is the largest of the world. According to the statistical date in China in 2004, the traffic accident caused by driver behavior counted 89.8 % of all. To alarm drivers before the accidents take place by identifying the dangerous driving actions should be good. Thus, it is of great help to equip vehicles with Advanced Driver Assistant System (ADAS), which can alarm drivers when danger is coming.

But the visual burden for drivers is becoming heavier due to more and more adoptions of controlling components, alerting system and infotainment equipment, while other channels (e.g., auditory and haptic channels) of drivers are still not made full use of. Hence, some researchers considered to convey information through other

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channels, e.g., to adopt speech, earcon, audio and three-dimension sounds [1], to prompt drivers from crossing the line with steer vibration, or to emit the smell of coffee for a sleepy driver, etc. Today there are more than 30 ADAS being developed [2].

The design prototype consisted of sound warnings and visual information presentation. The visual information would give drivers advisory warnings that are showed continuously to the drivers throughout the scenario. The sound warnings would only ware if the encountered a critical situation [3]. The warnings that were issued (Fig. 1) were forward collision warning (FCW) when distance reaches a critical distance, curve speed warning (CSW) if the driver enters the curve with a too high speed and lane departure warning (LDW) if the driver unintentionally passes the line and does not use the turn-lights.

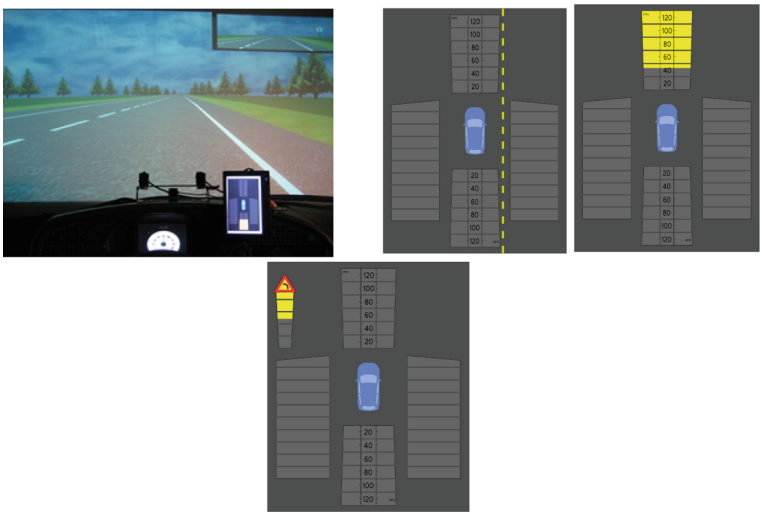

Fig. 1. Simulator setup and integrated ADAS interface

2 Method

The simulator setup consisted of a dashboard, steering wheel, adjustable seat, a projector projecting from behind, speedometer and the STISIM simulation software (Fig. 1). The whole system was mounted in the user experience lab of Sino-European Usability Center in Dalian Maritime University.

16 (8 males and 8 female) Chinese drivers were recruited. Driving years and yearly driving distances of the 16 drivers we finally chose are shown in Table 1.

The purpose of the simulator study was to evaluate the effectiveness and driver acceptance of the integrated ADAS interface and compare with only critical sound warnings. The driver drove 4 scenarios (1) baseline scenario (no ADAS information presented), (2) sound warning scenario, (3) visual display and sound warning scenario,

Table 1. Distribution of ages, driving years and yearly driving distance

Driving years	1~2	3~6	7~8	9~14
Number of drivers	4	3	6	3

Distance (km)	<5k	5k~15k	15k~50k
Number of drivers	5	6	5

and (4) baseline scenario. Questionnaires were answered after scenario (2), (3) and (4). Scenarios (2) and (3) were randomized to avoid learning effects.

Before the driving scenarios, each driver was asked to fill in a demographic questionnaire.

The first scenario was the baseline scenario which drivers drove for 15 min without warnings. The second scenario was either the sound warnings or display and sound warnings condition which were 30 min long. After each warning condition the drivers were asked to fill in a questionnaire to measure their subjective thoughts of the warning types. The third scenario was the left display warnings or sound warnings. The final scenario was another 15 min baseline scenario. The driver were asked to fill in a concluding questionnaire after this scenario.

A Likert scale with 7 levels was used in the questionnaires to measure subjective satisfaction. The concluding questionnaire was designed as a semi-open questionnaire, in which drivers could give explanations and comments to their choices.

Beside the above subjective date was collected, we also recorded some objective data from driver simulator, which is collisions, off road crashes, etc.

3 Results

The following is the analysis to questionnaires and recoded data.

3.1 Demographics Results

We found that 5 of them (31 %) thought their driving skills were above average, 9 (56 %) thought theirs were about average level, and 2 (13 %) thought theirs were below average. We also found that 12 of them had driven over speed limit, 4 had driven after drinking and 9 had the experience of fatigue driving.

3.2 Sound Warning Questionnaire Results

After analyzing the sound warning questionnaires, we found most of the drivers thought sound warnings were helpful for them. For example, the average score for the question “I believe that the sound warnings generally improved my driving…” was

5.06. For those thinking their driving skills were about average level or above average, altogether 11 drivers out of 16, the average score for this question was 5.4. We had correlation analysis to the acceptance levels of drivers to the sound warning system and the driving skills of them. The results showed that the Pearson correlation coefficient was −0.359 and P = 0.172. That revealed that driving skill and the acceptance level to the sound warning system were negatively correlative. Drivers with lower driving skill had higher acceptance level.

Table 2. Average scores for typical questions in sound warning questionnaire

Questions	Average score
Generally I found the sound warnings irritating (1-not at all, 4-neutral, very much)	3.38
The sound warnings generally improved my driving (1-not at all, 4-neutral, 7-very much)	5.06
I could imagine having these types of sound warning systems in my own car… (1-never, 4-neutral, 7-very much)	4.63

3.3 Visual Warning Questionnaire Results

After analyzing the data of visual warning questionnaires, we found most drivers held neutral opinions towards visual warning information, e.g. the average score to the question "I believe that the display information generally improved my driving…" was 4.44. Some drivers, especially those with lower driving skill, thought the warning display distracted their attention when driving. They said, "I didn't have time to see the display", "My car will deviate if I see the screen", etc. That revealed that processing the extra visual warning information might overload the driver's cognitive system. The drivers with low driving skill are afraid of moving their sights from the road, or they will miss important information of traffic situation.

Table 3. Average scores for typical questions in display warning questionnaire

Questions	Average score
Generally I found the display information irritating (1-not at all, 4-neutral, 7-very much)	4.00
The display information generally improved my driving (1-not at all, 4-neutral, 7-very much)	4.44
I could imagine having this type of display in my own car (1-never, 4-neutral, 7-very much)	4.94

3.4 Concluding Questionnaire Results

After analyzing the data of the conclusion questionnaires, we found that most of the drivers held positive opinions towards the sound warning system. They thought it could help them be aware of the potential danger when driving, especially on highway or when their attention was easy to be distracted. They were willing to have this kind of system. In Table 4, we can see that drivers held opinions to sound warning system after a baseline scenario. The average score increases from 5.06 (Table 2) to 5.25. The average score of acceptance to the visual warning system decreases from 4.44 (Table 3) to 3.63. The data of the conclusion questionnaire are more accurate on reflecting drivers' real feelings or opinions to ADAS after a second baseline scenario.

Table 4. Average scores for typical questions in conclusion questionnaire

Questions	Average score
I find the sound warnings irritating in real traffic (1-not at all, 4-neutral, 7-very much)	3.44
Generally I think the sound warnings irritating in real traffic (1-not at all, 4-neutral, 7-very much)	3.06
The sound warnings will warn too often in real traffic (1-not at all, 4-neutral, 7-very much)	4.06
The sound warnings can generally improve my real driving (1-not at all, 4-neutral, 7-very much)	5.25
The display information can generally improve my real driving (1-not at all, 4-neutral, 7-very much)	3.63

- About occasion and frequency of warnings

"I prefer to turn the system on when needed, e.g. driving at night, at high speed or with little traffic around." This reveals that ADAS is suitable for those types of driving situations and of little help to driving in busy city traffic.

"There is no need to alarm for crossing the line, or only alarm for too many times of crossing. Otherwise it is too often." We can lower the warning frequency. ……

4 Conclusions

The study showed that the use of integrated ADAS, either with the display or with sound warnings showed significant difference in collisions to the baseline driving.

The subjective results showed that the sound warnings were more accepted than the visual display warnings, and most users' attitude towards the visual display warning were comparatively neutral. Drivers acceptance should be considered when designing integrated ADAS for Chinese.

5 Discussion

Why is the less experience drivers think the sound is more acceptable? The reason may be they are more likely to take the three dangerous driving actions mentioned above in driving. And they are more likely to be nervous and panic when they encounter those kinds of danger. So they are easy to accept the sound warning system.

By analyzing the data from the questionnaires of 16 test sessions, we found that the drivers held positive opinions to the sound warning part of our ADAS. They thought it would improve their driving in real life. Scores for two related questions were 5.13 and 5.25. The drivers held neutral opinions to the visual warning part of our ADAS. Scores for two related questions were 4.44 and 3.63.

Bly revealed that reactions to auditory stimuli are faster than reactions to visual stimuli in certain cases [4]. So using sound warnings in ADAS is more helpful than visual warnings for drivers' quick reaction. Thus we think more sound stimuli should be taken in the design of ADAS.

Some drivers preferred speech as warnings in the test. They thought that would help them understand the meaning of the sounds. That is due to no special training for drivers on the sounds. Brewster mentioned that non-speech sounds are good for giving rapid feedback on actions [5]. Barker and Manji claimed that an important limitation of text is its lack of expressive capability [6]: It may take many words to describe something fairly simple. But in China, maybe the conciseness of Chinese pronunciation can find a new way for speech as warning sounds.

We will conduct further studies on sound types and warning occasions and frequency. We will start a new round of redesign and user research for our ADAS according to the results of this study. Due to the difference between the simulator and a real vehicle, like sense of position and speed, we should test our ADAS in a more real driving environment after passing laboratory tests, this should be very expensive.

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