ORIGINAL ARTICLE

KANSEI ENGINEERING APPROACH TOWARDS AUTOMOTIVE HEADS UP DISPLAY (HUD) INTERFACE DESIGN

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ABSTRACT

Driver distraction is becoming a growing concern in Malaysia since in vehicle electronic devices are becoming more common in cars. Among the technologies being installed in cars is Heads Up Display (HUD). HUDs are meant to help drivers to focus their attention towards the forward roadway while driving by providing a simplistic display of speed and car navigation while driving. In this study, a Kansei Engineering approach is used to translate the usability requirements for HUD interfaces. A new HUD interface design was developed based on important features such as digital speed indicator, speed limit sign, as well as the indicator for the next turning.

Keywords: Kansei Engineering, automotive, HUD

INTRODUCTION

Heads-Up Display (HUD) was invented primarily for pilots to fly an aircraft more effectively. The Blackburn Buccaneer was the first aircraft to utilize the first operational HUD in the 1960s (Liu, 2003). The HUD technology then trickled down into the automotive industry where General Motors (GM) introduced HUD in their Oldsmobile and Pontiac models. During the last few years, HUD technology is becoming increasingly common in cars to attract potentially tech-savvy buyers. For example, BMW, Cadillac, Toyota, Buick LaCrosse, Lexus, Kia, Hyundai, Mercedes and Peugeot are equipped with HUDs. Driving information such as speedometer, fuel level, engine speed, warning lights, gear position and navigation are presented on HUD. The image of HUD is presented either on the windshield or any transparent display, depends on the automotive manufacturer.

In some HUDs design, the presented information was fixed by the automobile manufacturer, where there are some HUDs are able to choose or select the driving information by the preference of driver. The driving information presented by HUD includes speedometer, rpm meter, navigation directions, warning signals, fuel level, speedometer and estimated destination time. The speedometer works like a conventional speedometer as it shows the current speed of the automobile, so that the drivers can easily keep track of their speed while driving. With the navigation directions feature of HUD, the drivers no longer need to glance over to the GPS screen while driving. The built-in navigation system of the automobile or by connecting to the smartphone, the HUD present the navigation directions right in front of the driver, which improve the ease of use, efficiency and driving safety.

Some HUDs come with new features called “Pedestrian in the road”, lane departure warning and adaptive cruise control. “Pedestrian in the road” is to detect pedestrian and reduces the driver reaction time, further ensure the driving safety on road. For lane departure warning, it helps to keep the vehicle in the lane by warning the driver if departure happens. Lastly will be the adaptive cruise control, which able to detect the speed of the vehicle or object ahead and adjust the vehicle speed accordingly.

HUD (heads-up display) directly displays the driving information onto the windshield, and this would greatly reduce the frequency and duration of the driver’s vision shifted away from the forward roadway (Kiefer, 1991; Kaptein, 1994). Driver able to acquire necessary information while remains focus on the road condition. Hence, the driving performance is improved and safety is ensured.

As the technology advanced day by day, the head-up display (HUD) have been implemented in automobile, to reduce the visual distraction when driving. Several studies on head-down display (HDD) and head-up display were conducted to increase the safety of driving. The conventional HDD require driver to look away from the windshield to acquire driving information which reduce the driving safety (Zwahlan, Adams and Debald, 1988). However, through HUD, the driving information that is presented either on a transparent display in front of windshield or directly on the windshield reduced the visual distraction (Ablassmeier et al., 2007). It is a documented fact that driving safety is the main priority for Malaysian drivers when it comes to automotive car interiors. (Mohamed, Rahman, B. M. T., Mat Said, & Abdul Jalil, 2015; Mohamed, Shamsul, Rahman, & Abdul Jalil, 2015). Therefore, the driver is more aware to the road environment (Sojourner and Antin, 1990; Horrey and Wickens, 2004; Liu and Wen, 2004). Generally, HUD improve the driving performance and reduce the collisions occurred (Burnett, 2003; Liu and Wen, 2004; Charissis et al, 2008).

However, with HUD, distraction still occurs, where the driver subconsciously focused on the driving information presented on HUD (Gish and Staplin, 1995; Prinzel and Risser, 2004; Tufano, 1997). It is caused by switching of vision between two sources, HUD and the road environment, especially in high traffic areas. Therefore, HUD should provide a simple and easily recognition design to reduce the attention and focus of driver on HUD. If a driver need to think and analyze the meaning of symbols or icons, it will cause distraction to the driver and eventually loss concentration on the road event. Therefore, this research was done to design and develop a head-up display interface to resolve the problem as well as to identify the consumer's needs and requirement. All the methods used were based on consumer viewpoint to ensure consumer satisfaction and acceptance of HUD technology.

METHODS

Overview

The study was conducted in three stages. Stage 1 involves a background study on the understanding of the issues related to the usage and acceptance of HUD interfaces among Malaysian drivers, utilizing the Car Technology Acceptance Model (CTAM). Stage 2 involves the analysis of the background study and on the identification of relevant design factors for the HUD interface design. Stage 3 describes the transformation of the design factors into a tangible HUD design via Kansei Engineering.

Stage 1:Background of study

CTAM questionnaire was used to determine the level of technology acceptance among Malaysian drivers who has never experienced the Heads Up Display (HUD) technology in their cars. CTAM was developed by Osswald, Wurhofer, & Tröster (2012) in order to assess the acceptance levels for a new automotive technology. Since HUD is relatively a new technology among Malaysian drivers, the level of technology acceptance needs to be determined so that the later introduction of HUD in cars would be justified among Malaysian car manufacturers.

Since the HUD is an unknown to most of the people, a video was attached into the questionnaire to explain and demonstrate the functions of HUD to them. The questionnaire is categorized into 9 groups and consist of 39 items. The survey was conducted by using the Google Forms, which the participants require to answer all the questions and submit the form through the Internet. As many as 30 participants participated in the CTAM online questionnaire.

Stage 2: Identification of relevant design factors for HUD

Stage 2 was accomplished using Kansei Engineering (KE). In KE implementation steps, participants had to evaluate a number of design samples using several Kansei concepts. Six HUD design samples, and 10 Kansei concepts were used. The design samples and the Kansei concepts are shown in Figure 1 and 2 respectively.

Figure 1: HUD design samples

Distinguishable
Recognizable
Readability
Usefulness
Guessability
Legibility
Understandability
Modern
Simple
Interpretability

Figure 2: Kansei concept words

Stage 3: Design of new HUD

After the KE evaluation was done, the results from the KE process was analyzed and a list of design specifications for a new HUD design was developed. The new design specifications was then used to design a new HUD interface.

RESULTS

The CTAM questionnaire analysis is shown in the table below:

Table 1: CTAM results

Questions	Average score (1 to 7 scale)
Perceived Expectancy (PE)	
The system would be useful while driving.	5.6
Using the system enables me to accomplish my goals more quickly.	4.8
Using the system increases my driving performance.	5.2
If I would use the system I will reach my destination safely	4.8
Effort Expectancy (EE)	
My interaction with the system would be clear and understandable	5.4
It would be easy for me to become skillful at using the system.	4.9
I find the system easy to use.	5.2
Learning how to operate the system is easy for me	5.1
Attitude towards Using Technology (ATTITUDE)	
Using the system is a good idea.	5.8
The system makes driving more interesting.	6.2
Interacting with the system would be fun.	5.4
I would like interacting with the system.	5.4
Social Influence (SI)	
I would be proud to show the system to people who are close to me.	5.3
People whose opinions are important to me would like the system too	5.0
My passenger(s) would be helpful when using the system.	5.1
In general, people who I like would encourage me to use the system	5.0
Facilitating Conditions (FC)	
While using the system I can maintain a safely driving behavior.	4.8
I have the knowledge necessary to use the system.	4.8
The system is compatible with other systems I use.	4.8
There would be somebody I can ask for assistance with system difficulties.	4.8
Self-Efficacy (SE)	
I could complete a task or activity using the system if there was no one around to tell me what to do.	5.1
I could complete a task or activity using the system if I could call someone for help if I got stuck.	4.8
I could complete a task or activity using the system if I had a lot of time.	5.1
I could complete a task or activity using the system if I had just the built-in help facility for assistance.	5.3
Behavioral Intention to use the System (BI)	
Assuming I had access to the system, I intend to use it.	5.3
Given that I had access to the system, I predict that I would use.	5.1
If the system is available I plan to use the system in the next months.	5.2

Results from the CTAM survey showed that the construct for “attitude towards technology” scored the highest average of 5.7, and the lowest score belongs to the construct of “facilitating conditions”.

A simple linear regression tool was also used to predict behavioural intention to use HUD, based on the perceived expectancy, effort expectancy, attitude towards technology, social influence, facilitating conditions, and self efficacy.
The regression analysis [(F(6,10)=2.095, p>0.144] with an R2 = 0.557. The predicted behavioural intention to use HUD is equal to 1.275 + 0.001PE + 0.069EE + 0.435ATTITUDE + 0.012SI + 0.144FC + 0.107SE. Only ATTITUDE is

a significant predictor of the behavioural intention to use HUD.

The attitude towards a new technology plays an important influence towards the acceptance and usage of a new technology. Designers often try their best in order to make a good impression for their potential users, so their products will benefit their users. However, the designer can only do so much in for their product design, the users will have to have a positive mindset towards the product that they are going to use, otherwise the product will not be utilized by the users, or the user may end up with poor user experience with the product.

It needs to be noted that the participants' age in the HUD study ranged between 18-30 years old. Persons between 18-30 years old are considered as "young adults" and will readily embrace any new novelty in their life. In contrast, the older adults (adults between 30-60 years old) may not embrace any new novelty so easily as their past life experience has been formed in their mind, so any new novelty will always be approached with a certain level of doubt or cynicism.

Participants in the study exhibited a certain level of caution in regards to their technology usage, which can be seen in their low average scores for "facilitating conditions" construct (4.8 out of 7). The overall average score for the CTAM survey is 5.16. This indicated the need for greater facilitating conditions during the usage of HUD. Currently, since the technology is new, there are not many provisions available to help users in using the HUD system in cars. Safety while driving is also a major concern for the users as they interact with the HUD technology. The interface design of the HUD in cars should minimize driver distraction and enhance driving safety. Driving safety is the utmost concern for drivers in Malaysia as indicated by (Mohamed et al., 2015) and the design of automotive interfaces should place safety as the main concern.

Kansei Engineering evaluation was analyzed using Partial Least Squares (PLS). The PLS analysis results are shown Table 1, where the design elements with the highest positive coefficients are shown.

Kansei Engineering Results Analysis

Table 1: Kansei Engineering results

Design element	Coefficient value
Speed limit sign round shape	0.89638
Medium font size	0.89638
Orange GPS font	0.13509
Green Speedometer	0.18827
White Direction Arrow	1.2991
Direction arrow with realistic background	0.74522
Transparent background	0.22856

The results show that transparent background was preferred by the participants. This feature is preferred together with the design of arrow with realistic background. Photographic and simplified drawing can be impractical in the context of driving (Horton, 1994), however, the level of realism of existing HUD interface have less variety, therefore it is only categorize in either with realistic background or without. This limitation may not encourage positive impression for drivers with an acute sense of aesthetics for interface design.

In term of the color of direction arrow, the white arrow was most preferred among other colors. This outcome was supported by the finding of Camgoz et al. (2002), where background color with maximum brightness and high saturation levels are more preferred than any other colors. White color arrows can provide excellent contrast against a realistic looking map background. This is indicated in Table 1 where the white direction arrow scored the highest coefficient value.

Figure 3: Interface 1 design sample

Among the interfaces, the white directional arrow in Interface 1 has the best contrast against the background and therefore it is more preferred than others.

In term of color of speedometer and GPS font, green and orange were preferred than other colors. This outcome might due to the good contrast between these colors and the color of road.

In term of overall font size, medium size was the most preferred among the font sizes. Font sizes must be at the perfect size for any interface design for the purposes of quick readability for all types of user. It must not be too big or too small for the interface. However, the preferences of font size according to age group are different.

Based on the findings of Darroch et al. (2005), younger users would prefer medium font size and older users prefer a slightly larger font size. Since the participants were all from young adults, people, therefore the result corresponds with the findings. Besides, the reading speed for medium font size is usually faster and the accuracy is higher than small font size.

In term of the shape of speed limit sign, round shape was the most preferred than other shapes.

As earlier stated, general icons should be used to reduce the burden of users and design complexity. Malaysian road users are accustomed to the round shape of the speed limit sign hence the highest preference for round shape signs.

Development of new HUD interface design

Results from the Kansei Engineering analysis were used to develop an improved version of the HUD interface. Referring to the Kansei Engineering analysis results, the sign of speed limit should be designed as round shape. Therefore, it is designed in that way and with the reference of existing speed limit sign on the roadside. Hence, it comes with a red round shape with white background. The font color of the sign is temporary set to black as the background is still empty. On the other side, the speedometer is designed is two different way, one is analog and another is digital form. For fuel meter, it is designed in a bar form, which able to clearly indicate the fuel level, continuously and not discrete. Next, the lane departure warning is designed in a perspective view which allows it to look more 3D and realistic. An additional green word "On Track" is used to inform the users that their cars are currently on track and it will turned red if it is not on track. Lastly is the GPS, it is also designed in perspective view to give a 3D and realistic feel to the users. As any other common GPS interface design for automotive HUDs, the distance meter appeared on the top and road name on the bottom.

Once the icons were designed completely, an actual road photo was inserted into the design as a realistic display background for the interface. A careful matching of colors and background was also done by the designer in order to maintain the best color selection. As it can be seen, the analog speedometer was removed as it is not match with the display background. The lane departure warning was moved to the top of digital speedometer as it is look much better than beside the GPS. On the other hand, the color of the fuel meter changed to radiant color of green and red, as the greed indicates full and the red indicates empty. Post-effect like glowing was used in those icons to allow them to look closer to an actual HUD that display on the windscreen.

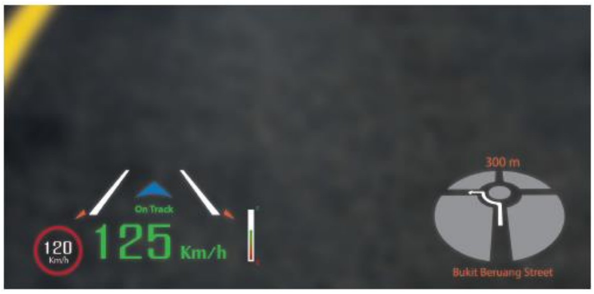

Figure 4: New HUD interface design

CONCLUSION

This study has investigated the behaviours of consumers react towards head-up display (HUD) technology and explored the possibility of design and develop HUD interface through Kansei Engineering study. From the obtained results, most users indicate high technology acceptance of the HUD interface, however, safety while driving is their primary concern while using the HUD interface.

In term of consumer requirements, the Kansei Engineering study had identified the relation between

the perception of the consumer and the design aspects of the interface. Based on the findings, the user perception had been translated into coefficients of design elements through PLS regression, which the value of coefficient indicate the scale of the impact of the design elements toward the interface design. Several design elements have overall positive impact to the HUD interface, which is transparent background, direction arrow with realistic road background, white color of the direction arrow, green color of the speedometer, orange color of the GPS font, overall medium font size and round shape of speed limit sign. Through this study, the new HUD interface was able to meets the consumer needs and expectations. It makes users to feels that the interface was specially designed for them. Hence, it greatly increases the consumer acceptance as well as the performance of the interface itself. Not only that, the interface was much easier for driver to recognize hence reducing the eye glance time on the system.

COMPETING INTERESTS

There is no conflict of interest.

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