How to cite this paper:

Fatin Shamimi Mohd Zuki & Suziah Sulaiman. (2017). Exploring usability of various touch gesture in touch screen IVIS using paper prototype in Zulikha, J. & N. H. Zakaria (Eds.), Proceedings of the 6th International Conference on Computing & Informatics (pp 683-690). Sintok: School of Computing.

EXPLORING USABILITY OF VARIOUS TOUCH GESTURE IN TOUCH SCREEN IVIS USING PAPER PROTOTYPE

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ABSTRACT. Most modern vehicles are equipped with touch screen IVIS due to the growth of technology. The application of touch screen in IVIS is found to increase user satisfaction and initial acceptance due to the ability of users to make direct manipulation onto the screen. Currently, tapping touch gesture is the main control used to navigate around a touch screen IVIS, however, a combination of touch gestures have the potential to be applied in IVIS to replace hard-knobs and buttons, and touch screen that applies tapping touch gesture. The objective of this study is to explore the usability of various touch gesture application in IVIS using paper prototype method. The taxonomy of gestural interaction was developed through literature review of existing researches and applications. A paper prototype was constructed and tested with test participants based on the sketched user interface and gestural interface developed. The result of the usability test showed that the system applying various touch gesture is easy to use, will be easy to learn for most people, is not cumbersome, and not much learning is needed to be able to use this system. The visual attention the road was also found to be less distracted while using this system as reported by the participants.

Keywords: IVIS, touch screen, various touch gesture, visual attention

INTRODUCTION

Technology is ever-changing, keypads are replaced by touchscreens, and touchscreens evolved from solely tapping touch gestures to various touch gestures. As technology grows, users are also getting more used of the latest technology and want features that are available in some gadgets such as the smartphone to be applied to other types of devices too. Smartphone enables users to use various touch gestures in navigating around the device while most of the In Vehicle Information System (IVIS) with touchscreen features tapping touch gestures only. The growing complexity of IVIS due to its more advanced functionalities makes the idea of applying various touch gestures appealing. Introduction of the various touch gestures in IVIS have garnered the interest of many automobile manufacturers (Kim & Song, 2014). Researchers (Bach, Jæger, Skov, & Thomassen, 2008; Bjørneseth, Dunlop, & Hornecker, 2012; Ecker, Broy, Hertzschuch, & Butz, 2010; Harvey, 2010; Harvey, Stanton, Pickering, McDonald, & Zheng, 2011) have also studied the comparison between rotary controllers and hard buttons, tapping touch gestures, and various touch gestures on a few application in the IVIS. The studies showed favorable result in applying some various touch gestures in some of the chosen applications.

Besides driving related services such as the mileage meters, the IVIS is able to provide drivers with non-driving related services such as radio and communication (Peng, Boyle, & Lee, 2014). Infotainment system in vehicles is a system that delivers entertainment and information content (Vangie Beal, n.d.), radio and music player are an example of infotainment available in vehicles. The radio function nowadays are integrated with music players that can play songs from various sources such as the compact disc (CD), USB thumb drive, and by Bluetooth connection. Music player keeps driver and passengers entertained during driving.

The aim of this study is to explore the usability of various touch gestures on radio application in IVIS using paper prototype before developing a high fidelity prototype application. Several touch gestures are to be implemented based on the features in a radio application to be tested. The touch gestures include tapping, sliding, and swiping with one finger and two fingers which are gestures that are commonly used in smartphones. A paper prototype of the radio application is to be constructed and tested in small experimental setting. Participants for the test are required to perform some tasks involving these various touch gestures. Observations of the participants' interaction with the paper prototype and the System Usability Scale (SUS) survey determine whether the music player infotainment in IVIS using touch gesture is usable.

This paper presents the usability of various touch gesture music player infotainment in IVIS based on paper prototype usability testing. Part II describes IVIS and visual attention, the advantages and disadvantages of the application of touch screen in IVIS, and the comparison between the tapping touch gesture and various touch gesture. Part III is on the methodology of the paper prototype construction and the usability study. Part IV discusses the result of the usability test based on observation and System Usability Scale (SUS).

OPERATION OF IVIS AND VISUAL ATTENTION

While users are able to enjoy the extended functions in IVIS, such wide array of functionalities available could inevitably cause accidents due to negligence while driving. Based on the behavioral model of driver that was used by Hankey, Dingus, C., Hanowski, & Wierwille (2000) which is the resource model, drivers are viewed as a group of information processing resources. According to Hankey et al. (2000), there are three primary tasks of a driver which are classified into conceptual, general, and specific tasks. Conceptually, a driver's primary task is driving while also attending to in-vehicle tasks from time to time. Generally, driving requires attention to the things happening outside of the vehicle. Specifically, driving consists of positional controls, and hazard detection as well as other subtasks such as navigating and selecting speed. Secondary tasks are tasks performed in the vehicle besides driving. Secondary tasks, as well as IVIS tasks also require the use of driver resource. While attending to IVIS, diversion of resource into the vehicle occurred, or in another word, driver has to divert attention from outside of the vehicle into the vehicle, causing interference between the primary driving tasks and the IVIS operating tasks (Kim & Song, 2014).

TOUCH SCREEN IN IVIS

The application of touch screen in IVIS has its own advantages and disadvantages. Existing studies had identified that the use of touch screen enriched users' experience, however, in some aspects, it might worsen users' experience.

Touch screen interaction in IVIS involves direct relationship between what the eyes see and what the hands do (Dul & Weerdmeester, 2001; Harvey, Stanton, Pickering, McDonald, & Zheng, 2011), besides, the touch screens are applied in IVIS because they allow direct manipulation of the devices as compared to hard buttons or touch pads (Kim & Song, 2014).

Direct relationship between the sight and action has been shown to increase user satisfaction and initial acceptance (Harvey et al., 2011; Rogers, Fisk, McLaughlin, & Pak, 2005).

The operation of devices with finger gestures is more intuitive hence easier for inexperienced users to learn (Harvey et al., 2011; Rydström, Broström, & Bengtsson, 2012; Taveira & Choi, 2009). Furthermore, it also enables interaction between users and interfaces to be more efficient (Kim & Song, 2014) compared to interaction approaches based on tangible controllers (Ecker et al., 2010).

Despite the advantages of interacting with touch screens in IVIS, it also has its own limitations. Most of it are ergonomic drawbacks. While the interaction is more efficient in touch screens, users have to examine the display in order to detect visual objects they want to select (Ecker et al., 2010). Although touch screens increased intuitiveness by using finger gesture, the study by Ecker et al. (2010) also noted that the finger must be coordinated to the visual display object without any tactile lead. Another related ergonomic disadvantage of touch screens is the missing haptic feedback and kinesthetic cues in reaction of user input (Ecker et al., 2010), in which according to Burnett & Porter (2001) and Burnett & Irune (2009) are highly important in cars safety.

TAPPING TOUCH GESTURE VS. VARIOUS TOUCH GESTURE IN IVIS

A study on the use of touch screen gestures for a safety critical maritime domain where skills and precise control is needed to position the vessel showed that tapping gesture and menu interaction was found quicker and less erroneous compared to various touch gestures (Bjørneseth et al., 2012). However, according to Kim & Song (2014), interaction with touch screen grew beyond tapping touch buttons. Using touch gestures opens new possibilities, especially for mobile interaction with reduced visual attention. Although Bach et al. (2008) revealed that controlling IVIS using tapping touch gesture was more rapid and efficient than using hard buttons or various touch gestures, Ecker et al. (2010) claimed that the combination of various touch gestures such as tapping, swiping, and pinching in a system required less visual attention from users. One of the observation made in a study by Kim & Song (2014) found that the flicking gesture in IVIS is slower and might use more resources than tapping button. On the contrary, participants in the test prefer flicking gesture more than tapping button as flicking gesture allows rapid movement for them to locate the target faster. According to the study, flicking gesture is possible to be applied in the operation of IVIS given that the flicking speed is optimized to fit real driving situations as the flicking speed in smartphones and tablets are found to be too fast. With some optimization on speed, various touch gesture might be a good implementation in infotainment in commercial vehicle IVIS as it is not as critical as the maritime domain while still promoting safety due to requiring less visual attention.

METHODOLOGY

Paper prototyping is a low-fidelity or Lo-fi technique of testing with users using sketches and papers. It is a powerful tool for designers to test designs with users early in the design process (Chen & Zhang, 2015; Rettig, 1994). There are two main phases in conducting this study. The first phase is the preliminary studies that includes activities such as defining the taxonomy of gestural interaction for the infotainment system and developing paper prototype. The second phase of the study is the usability study for the information system.

Firstly, the general overview on the user interface of the infotainment system is studied. The layout chosen is based on the existing interface in available study, radio IVIS, and music players in smartphones. The findings of the study by (Kujala & Salvucci, 2015) shows that a list view of six songs in one page of a playlist is the least distracting in terms of the safety-

critical long in-car glances in any situations. Hence, the paper prototype will follow the guideline suggested by the study. After all the sketches are completed. The touch gestures are assigned to each functions. These touch gestures are also based on the current study, and music player in smartphones. Unsuitable touch gestures such as flicking to scroll, and panning to zoom are avoided based on the suggestion in study (Kim & Song, 2014), furthermore, these gestures are not important for this type of music player application.

Table 1. Tasks and Gestures.

Task	Gesture
Choose from main menu	Tap icon
Navigate to the next station in radio	Slide one finger to the right
Navigate to the previous station in radio	Slide one finger to the left
Navigate to the next song in the "now playing" page	Slide one finger to the right
Navigate to the previous song in the "now playing" page	Slide one finger to the right
Go to next or previous page of the playlist	Tap "up" and "down" button
Increase volume in radio or "now playing" page	Slide one finger up
Decrease volume in radio or "now playing" page	Slide one finger down
Pause song in radio or "now playing" page	Tap the screen once
Go to the previous page	Slide two fingers to the right

Gestures for each tasks are tabulated in Table I. The tapping gesture is unavoidable as it is the standard gesture in making selection in touch screen. Sliding one finger to the right and left to navigate between the next and previous song and radio station in the music player was adopted from most of the touch gesture applied in music players in smartphones. This touch gesture was adopted as it is intuitive and many users would be familiar with it. To increase and decrease the sound volume, driver has to slide one finger up and down on the touch screen. This type of touch gesture was applied in a smartphone video player application, named VLC. User will be able to touch anywhere on the screen and manipulate the loudness of the volume by sliding their finger up or down. Lastly, to go back to the previous page, two fingers are to be slide to the right. This was inspired by the Apple touchpad, where users only need to slide their fingers to go to previous sites in the internet browser. All the gestures to be used in the system are not something new as they were adopted from other applications. This will create a sense of familiarity for the users.

The paper prototype in Figure 1 is then constructed using papers and handwriting. The size of the paper prototype is set to the standard 7" touch screen for IVIS, with the dimension of 15cm X 9cm.

According to (Nielsen, 2012), five test participants is sufficient in a qualitative usability study because it detects almost as many usability problems as a test conducted with many more test participants. Five participants aged from 20 to 26 years old participated part in this usability testing. These participants are familiar with the touch screen applications and various touch gestures. Each participant is briefed about the test and instructions on the touch gestures are given. Participant is allowed to ask questions if there are any unclear instructions or doubts. When the participant is clear about the tasks that they need to perform and the touch gesture that they are given, they are introduced to the car simulator game, VerkeersTalent Online. The car simulator game is an online game that emphasizes on responsible driving which simulates the real driving rules. However, the game is keyboard-controlled which takes away the realness of driving a car. The paper prototype is propped on a photo

frame to mimic the position of an IVIS display rather than laying it on the table as shown in Figure 2.

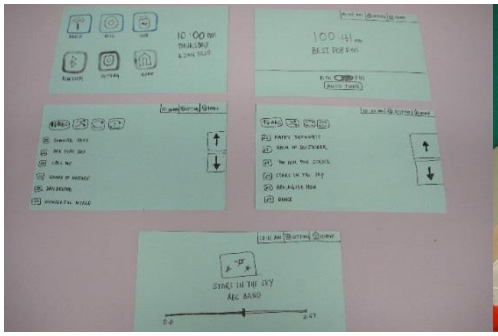

Figure 1. Paper Prototype.

Figure 2. Usability Testing Set-up.

The participant is required to perform tasks on the infotainment system while driving in the car simulator game such as changing the radio channel, skipping to the next song, increasing and decreasing sound volume, and browsing the playlist to find songs. Participant is expected to run the tasks on their own, however if the participant is unsure of what to do during the test, instructions for the tasks are given as a guide to ensure that all tasks are accomplished. Other than that, commands for the tasks are also given randomly to all participants while they are driving to observe the reaction of the participants on operating the system.

RESULTS AND DISCUSSION

Observation during usability testing

Observation on the participants was made during the usability test using the paper prototype. Firstly, participants are quick to understand to operate the infotainment IVIS. Based on first impression during the observation, the application of various touch gesture in the system is easy to learn. Secondly, while driving on the car simulator game, participants spent less time looking at the IVIS when performing tasks. Participants were seen to be focusing on the display less during the random tasks such as to navigate around the next song or to the previous song in the "now playing" page. This might be because there is no need to locate buttons when using swiping touch gesture as opposed to tapping a button on the screen to change songs. However, participant spent the most time on the playlist page to find songs. Thirdly, the application of various touch gesture in infotainment in IVIS is perceived to be intuitive as the participants were able to complete task without much thinking when tasks were randomly instructed. The participants were able to almost immediately carry out the task successfully and on top of that, with less visual distraction from their driving. Nevertheless, since this is a test with paper prototype, participants did feel awkward interacting with IVIS. Controlling the car with arrow buttons instead of the steering wheel also made the operation less natural.

Feedbacks were also gathered from the participants verbally after the test. One participant revealed that this type of touch gesture interaction is better than tap gesture interaction as there is no need to find the buttons to tap. Another participant also commented that with the tap gesture, driver need to pay more attention to the screen to find buttons. Meanwhile with various touch gesture, driver does not need to search for the button to adjust the volume. This action is similar to adjusting volume knob in older IVIS which was also known to be more intuitive and quick (Rydström et al., 2012).

System Usability Scale

After the usability test, participants were required to answer the System Usability Scale (SUS) survey. The survey consists of ten standard SUS questions and scale rating with 1 being strongly disagree and 5 being strongly agree.

All participants agree that they would like to use this system frequently although one strongly agree that the system is unnecessarily complex. The other four participants are neutral about the complexity of the system. Every participant agree that the system was easy to use despite one participant finding it unnecessarily complex. There were divided opinions on question four as two of the participants do not think that they will need technical support to operate this system while one participant is neutral, one participant need technical support, and the other really need technical support. However, this concern is not an issue as a tutorial could guide the users before using the system. One participant felt that the various functions in this system were not well integrated while two are neutral and the remaining two found that it was well integrated. One of the reasons could be because the participants felt disconnected to the IVIS as it is a paper prototype and they cannot experience smooth transitions and functional features during the testing.

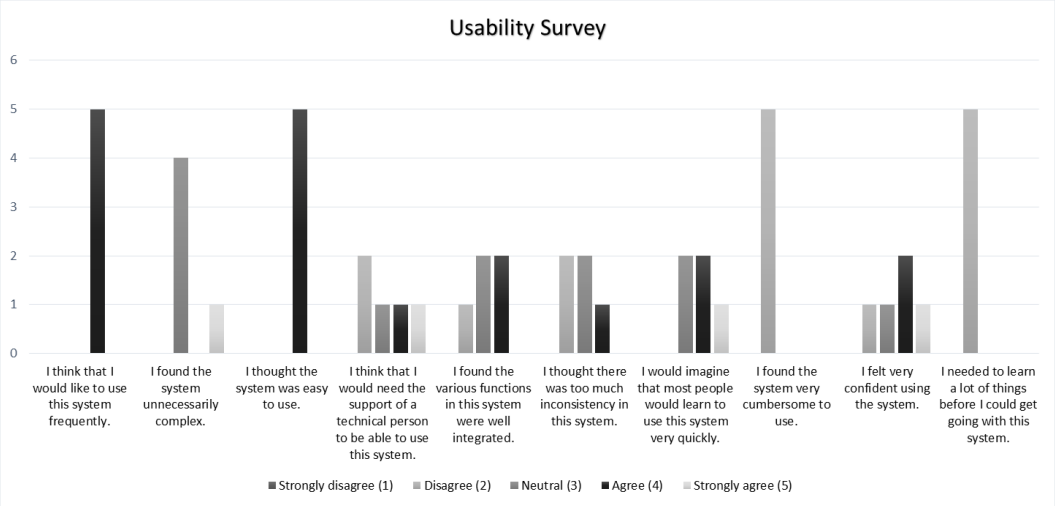

Figure 3. Result of System Usability Scale Survey.

As shown in Figure 3, only one participant agree that there was too much inconsistencies in this system while the others disagree or remained neutral. Based on the observation, we also agree that there are some inconsistencies with the system found during the test. Majority of the participants agree and strongly agree that most people would learn to use this system very quickly. This corresponds well with the participants thinking that the system was easy to use but also need some tutorials before operation. All participants disagree that the system was cumbersome to use, this reflected their answer in question two that this system was easy to use. Not all participants felt very confident using the system as one participant disagree, an explanation for this might because the participant is still unfamiliar with the various touch screen in IVIS. Lastly, everyone disagree that they need to learn a lot of things before they could use the system. The reason for this is because this system was designed to be uncomplicated and the various touch gestures applied are similar to the touch gestures that participants are familiar with in their smartphone applications.

CONCLUSION

The growth of IVIS and touch screen gestures piqued the interests of several researchers and manufacturers in integrating both of the systems together. While various touch gesture were found to be not as quick as traditional hardware controllers or tapping touch gesture, it requires less visual attention to operate. Other than that, various touch gesture is found to be more intuitive for users and in turn gives better user satisfaction. A paper prototype of a music player infotainment system in IVIS was constructed based the suggestions on current studies and available smartphone applications. Next, a usability test was conducted to find out the usability of the system. The result of the observation showed that the participants were able to learn the gestures quickly to navigate around the system. Participants also commented that the system applying the various touch gesture is better than system applying only tapping touch gesture as it reduces the time the eyes are away from the road. The System Usability Scale (SUS) also revealed that system is easy to use, will be quick to learn, not cumbersome, and is not complicated to learn. In conclusion, application of touch gestures in infotainment in IVIS might solve the disadvantage of drivers having to pay extra attention to the display to locate which buttons to select. With the touch gestures, a driver can point at any area of the touch screen monitor to make changes.

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