Indonesian Journal of Electrical Engineering and Computer Science
Vol. 4, No. 3, December 2016, pp. 649 ~ 654
DOI: 10.11591/ijeecs.v4.i3.pp649-654

Designing Multi-Dimensional User Interaction for a Virtual Museum System

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Abstract

The focus of this study is to improve the display platform for the State of Terengganu Virtual Museum System (muziummaya.terengganu.gov.my). The existing virtual museum can be displayed via desktop computing system where information is displayed on-line using features for searching, browsing, and manipulating artifacts and galleries. However, presentation of information on mobile device screens cannot be viewed effectively and is difficult to navigate due to the user's cognitive load. Therefore, this study will establish effective interaction design, taking into account the multi-dimensional context for the design of a user interface via a mobile device in the hopes that users who are students, curators, researchers, and the public can access the virtual museum system via desktop as well as from their mobile devices. This study was conducted in three stages i.e. user requirements analysis, interface design, and usability evaluation. The result of this research is the design of a multi-dimensional user interaction context that meets the display requirements and navigation information for mobile devices.

Keywords: *user interaction, information presentation, designing mobile interface, virtual museum*

1. Introduction

The presentation of information should be displayed via a multi-dimensional user interaction context, which is not only limited to the computer screen but should also include small screen displays such as the ones on mobile devices. However, the challenges in designing a user interface include cognitive load and information presentation. Cognitive load issues occur when the user is forced to simultaneously divide his or her attention between certain tasks on a small display. Besides that, an excess of information presentation at any one time could result in information overload. Interface design for mobile devices should assist users to access relevant information without having to rely on their memory and strong visual attention on said interface.

Zhang et al [1] stated that the main issue that interface designers face is how to present a lot of information on a small screen for effective and simple navigation, so as not to tax user memory load. The work of [2] showed users experienced a change in emotions when they visited the virtual museum as a result of information overload on the small screen of mobile devices. Users need a mobile application that can access and display the gallery panorama including the artifact hotspots in the gallery. Wook T [3] also suggests that the gallery display technique (floorplan and panorama) be used in the existing virtual museum, as it can optimise the screen space of mobile devices, which have smaller screens than computers, and thus, access and display artifact information in 3D.

Each user has different personalities and attitudes when surfing for information on the Internet. This proves that user behaviour is important factors, which, besides information content display (gallery, artifact, and information), also involves interaction. The user interaction context via mobile devices calls for meticulous design and entails different requirements than desktop computing displays [4]. The design of information on mobile device displays must be more attractive to engage users to search for information and to increase the fun factor. Since information searching in the virtual museum environment allows for 360° exploration and 3D image display, emotions that can induce ‘sensitive memories’ would also be indirectly

Received September 11 2016; Revised November 10, 2016; Accepted November 30, 2016

involved [5]. If sensitive memory is integrated with user usability context, a richer experience could be attained compared to visitation via computer desktop displays. Therefore, this study will create a multi-dimensional user interface context based on user requirements, which can easily and effectively increase the usage of the virtual museum system among its visitors.

2. Related Studies

Design based on the multi-dimensional user interaction context is important to estimate the design challenges involving the use of mobile devices [6]. There are a few elements that can affect user interaction when using mobile devices including movement, various physical parameters, sound and light, limited screen size, and other external factors. Chen and Kotz [7] define these factors as an 'environment' that can markedly change the way users interact with mobile devices. All these parameters can be grouped into the concept of multi-dimensional context. According to [8] context can be defined as usable information that can explain the condition of an entity. The entity should be regarded as the subject that relates to the interaction between the user and the application such as a person, place, or object, including the user and application itself. In general terms, context refers to location, identity and culture, group, and physical and computing objects.

Adipat et al [9] suggested three techniques to present information so as to avoid information overload on mobile device screens. These include information visualisation (IV), an adaptive interface, and multimodal displays. The information visualisation technique presents graphics supported by the computer system that display data in a meaningful and intelligent way via four categories: 'Presentation Optimisation', 'Semantic Changes', the 'Zoom Method', and the 'Focus and Context Approach'. This technique can be used separately or in tandem with other techniques to provide an effective information presentation on mobile device. Besides that [9] also states that the taxonomy of context visualisation involves context dimensions i.e. 1D content contains text documents only, 2D is made up of images, maps, and schedules, whereas 3D includes the virtual reality of an actual object.

An adaptive interface is the dynamic re-configuration of presentation according to user actions. The use of an adaptive interface in a mobile environment could benefit the user in two ways i.e. in the provision of additional information that is known to be of interest to the user, and the style adjustment and format presentation according to user preferences and characteristics [10]. The characteristic of an adaptive interface is controllability, predictability and transparency, and non-distruptive. Controllability refers to the extent to which the user could control the execution of an action. Predictability is the extent to which the user could predict an outcome after executing an action. Transparency means the extent to which the user understands the system behaviour or has a clear picture of how the system functions. Lastly, non-distruptive refers to the extent to which the user can focus on a task without having to pay attention to the interface [10].

Based on their study, [11] suggest that mobile cloud computing be used to present multimedia content based on the existing limitations of mobile devices, such as space storage, computing power, and broadband strength, in support of an adaptive interface. Cloud computing can be visualised as a new paradigm for mobile applications whereby the processing and storage of data could be transferred from the mobile device to a powerful computing platform centred on a 'cloud'. This centred application could be accessed via wireless connectivity from the web browser on mobile devices. In this way, mobile devices would not require power-heavy configurations (e.g. CPU speed and memory capacity) because all complex computing modules can be processed on the 'cloud' [12].

On the other hand, the multimodal interface offers an interface that behaves naturally (Natural User Interface, NUI) via gesture interaction. These gestures involve natural user behaviour via the hand, shoulders, face or body gestures, to communicate information to the computer [13]. The gesture interface includes manipulative and communicative gestures where each can be used to interact with an object (direct gesture with the screen such as 'tap') and for communication purposes i.e. using speech. Both these gestures can be executed using direct manipulation, making the interaction with the multimodal NUI more realistic such as the emulation of actual human communication in the real world.

The research findings on the design of multi-dimensional user interaction context when designing a user interface for mobile devices have shown that a design that fulfills user requirements could be realised from a transparent interface that is able to integrate desktop computing and naturally adapt it to the interaction design on mobile devices. Therefore, this study has conducted a Virtul Museum System (VMS) interface design process via application of the IV technique based on the visualisation taxonomy involving 1D, 2D, and 3D content dimensions. This technique will help the study to visualise a set of data from an image that is generated. Besides that, the application of the IV technique could contribute to an in-depth understanding for the user when using a system that is equipped with simple controllability and effective information presentation.

3. Method

The research methodology involves three stages i.e. requirement analysis, interface design, and usability testing.

3.1. Requirement Analysis

The requirement analysis was conducted via the interview technique with seven respondents consisting of public users. The aim of this analysis is to determine actual user requirements. The respondents were briefed on the desktop VMS and the following questions were asked:

1) What kind of functions would they require if they had to use a virtual museum tour mobile application?
2) Would they need a directory to direct them in the museum?
3) What kind of interactions is easiest for the user to determine artifact information?
4) What kind of interactions is easiest for navigation in the museum? Arrow or swipe screen?
5) How do they prefer to choose the galleries? Floor map or tree map?

3.2. Interface Design

This study generated the VMS interface prototype design based on the user requirement analysis. Two activities were conducted i.e. the storyboard sketch followed by high-fidelity prototype development. The storyboard sketch was created to visualise the user requirements i.e. 360° exploration with map directory and tree map guidance, swipe feature, and application of the minimalism principal. Next, the prototype design was developed to achieve the user requirement objective consisting of information (gallery and artifact) and navigation function, swipe, links, access, and manipulation. At this stage, the protoype is nearly identical to the final product but is still incomplete.

3.3. Interface Design

Usability testing was conducted using the Cognitive Walkthrough evaluation technique, involving five respondents that are experts or are literate in determining the learnability aspects of the system. This technique extracts the perception of user experiential successes and failures when using the VMS prototype via task completion provided during testing. Subsequently, this perception is used to enhance the usability of the interface design. Four questions were addressed to the respondents:

Q1. Is the effect of current action the same as the user's goal?

Q2. Is the action visible? This relates to the visibility and understandability of actions on the interface.

Q3. Will the user recognise the action as the correct one? Users often use the "label-following" strategy, which leads them to select an action if the label for that action matches the task description.

Q4. Will the user understand the feedback? This is to check the system feedback after the user executes the action.

4. Result and Discussion

4.1. Requirement Analysis Results

The analysis results show 100% respondent agreement that it is good if the museum could be browsed in a 360° environment but the directory is still needed as a guide to the museum. 57% of the respondents chose the floor map directory whilst the rest preferred the tree map for choosing the galleries they wanted to visit. The interaction element gained 100% respondent agreement i.e. they liked the swipe feature on the screen compared to touching the arrow icons for navigation. Besides that, the respondents liked the minimalist interface more, as it was easy to use and to remember during interaction.

4.2. Interface Design Results

The findings for interface design include a visual storyboard sketch and a prototype. The storyboard that was created is a conceptual sketch of the user requirement and layout design display without any functionality. Figure 1 illustrates the storyboard that visualises the directory map and tree map guidance used for the interface.

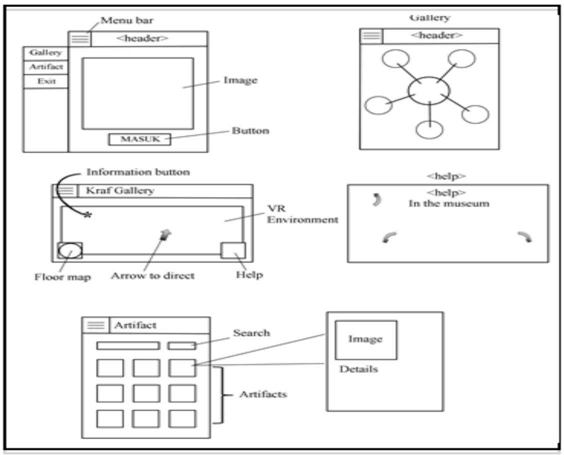

Figure 1. Storyboard

4.3 Usability Testing Results

Figure 3 shows the usability testing results using the Cognitive Walkthrough technique based on the four questions presented in Section 3(C). 100% of the respondents agree that the navigation function worked well and was easy to use. However, for Question 4, only 85% agreed that the button to access more detailed information about the artifacts was easy to use.

After the evaluation, all user feedbacks were taken into account. Overall, most of the users agreed that all the functionalities of the system worked well and the icons were easily recognisable except for the star button used to represent the information button. The users left some comments about this icon, i.e. it was too small and not visible at first glance. Other than that, the users could not recognise the star icon as representing artifact information. Besides that, the users also suggested ideas on adding a zoom function so that they would be able to see the artifact more closely and clearly.

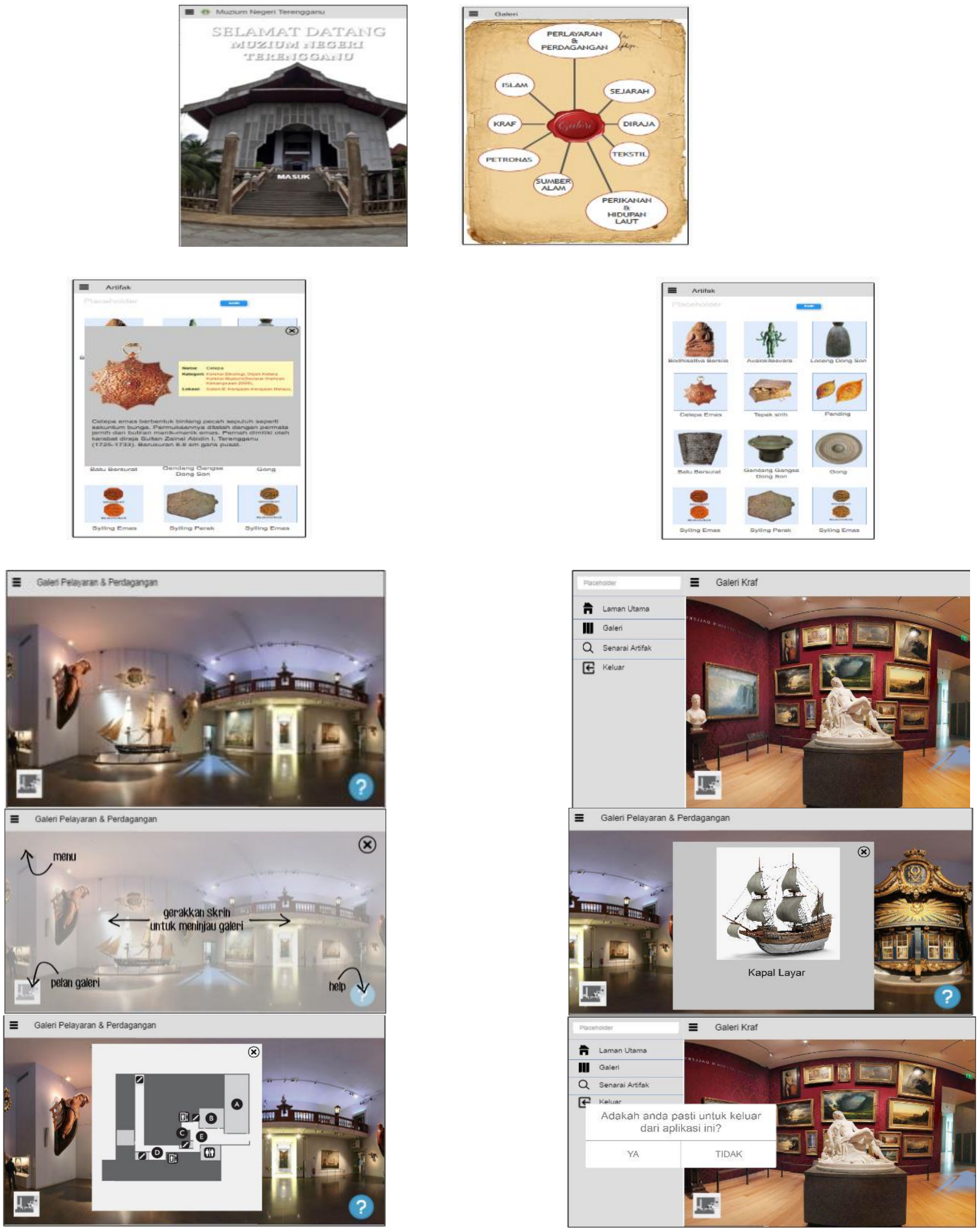

Figure 2. Prototype

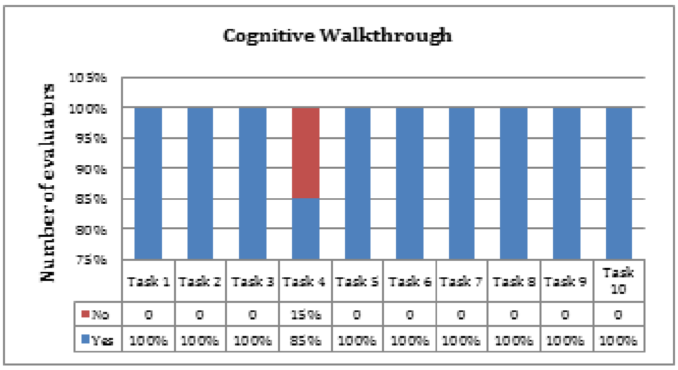

Figure 3. Cognitive Walkthrough Chart

In order to make the application more accessible, some improvements were implemented based on the feedback obtained. The improvements are:
1) The star icons were changed into the standard icon for information, which is the “i” icon, to make the icon more visible and easier for users to understand.
2) The zoom function was added for the user to be able to see the artifacts up close.

5. Conclusion

This study concludes that the VMS interface design in a mobile device environment, which applies the IV technique, could optimise the small screen space of mobile devices for accessing and displaying artifact information in 3D. The study’s findings on multi-dimensional interface design context based on user requirements could effectively and easily enhance the usability of the virtual museum system among its visitors.

Acknowledgements

This work was supported by Universiti Kebangsaan Malaysia, Faculty of Information Science and Technology, Center for Software Technology and Management, Multimedia Software and Usability Research Group and FRGS/2/2014/ICT05/UKM/02/1 research grant.

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