

CUSTOMIZING INTERFACE DESIGN FOR USERS WITH IMPAIRMENT USING A PAPER PROTOTYPING

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ABSTRACT

Impaired users are often digitally excluded due to their physical and/or cognitive limitations in accessing information and technology. This paper presents a usability study on the user interface design of a mobile phone application for users with impairment. In this study, a paper prototyping is used to examine the interface design, particularly on the size of an image, and the selection of fonts and background colors. An expert review was conducted to validate the design interface. Three experts on the physical impairment field took part in the study. The study findings confirmed earlier claim that bigger image sizes with a suitable font and background colors give a significant impact on user interaction.

Keywords: usability, user interface, mobile application, physically impaired

INTRODUCTION

The advancement of technology breaks the communication barrier and social interaction for people with disabilities. Digital technologies enable people with disabilities to receive and access information in the format that they can perceive and prefer the most. Accessing the information can be done through embedded features within the assistive technologies such as voice recognition, touch and gesture input, magnification of screen and the ability to change color and contrast settings. For example, a mobility impairment user can use voice recognition to operate and navigate the assistive technologies. Unfortunately, technology could also widen the disparities between people with and without impairments if they are not designed to be accessible and inclusive. The gap of socioeconomic inclusion among impairment users is due to the adaptation, operationalization, and the implementation of technology for inclusive development within the ecosystem [1]. The technology used is significantly impacted by stakeholders' knowledge and awareness

of the technology solution, laws and policies, and the capacities of various stakeholders to support accessible technology services [1]. Therefore, the main factor for socioeconomic inclusion is the adequate design of the user interface.

One of the fundamental challenges of these new products is to ensure their usability since the support for accessibility affects how traditional aspects of usability are designed. Traditional applications have already default patterns of requirements for usability [2]. Hence, the inclusive design enables the designer to understand the current approaches beyond capabilities-based research and also beyond the traditional confines of the design process.

This paper presents a usability study on user interface design for physically impaired users by using paper prototyping. This paper aims to generate cost-effective design quickly and efficiently gain expert review and feedback early in designing the user interface for physically impaired users.

This paper is organized as follows. Section II discusses on inclusive design, usability for physical impairment, and the importance of low fidelity prototype in system design. Section III details our research methods on paper prototyping. Study findings and a summary of our work will be presented in Sections IV and V, respectively.

RELATED WORKS

Inclusive Design

The inclusive design bears similarities to universal design. The design of products or services that are accessible to many people in various situations without the need for unique adaptation or specialized design [3]. Principally, it should be acknowledged that inclusive design is not a fixed set of design criteria, but a constantly evolving philosophy [3]. Accessible design requires knowledge and experience from the designer, but most Human-Computer Interaction (HCI) designers have less experience in designing for people with impairments. Even if they are aware of accessibility issues, and they are willing to 'design for all', they can suffer great difficulties due to their lack of experience related to this field [4].

Many sets of inclusive design guidelines are nowadays accessible through the Internet. Besides, design guidelines are an excellent way to incorporate design criteria coming from successful experiences obtained by other designers. The inclusive design also aims to change the minds and attitudes of product and service designers through better information and presentation of the business case for broader product consumption [5]. Guidelines may present some problems. When guidelines are too numerous, they may be difficult to handle, but they prove to be a suitable method to transmit satisfactory design experience within large design groups. Nevertheless, these guidelines must have been validated and verified with real users.

Usability for Physical Impairment

It is important to clarify that universal design does not solve all accessibility problems. Due to the great

diversity of users' characteristics, it is almost impossible to consider all users in the design phase, but it is possible to avoid unnecessary barriers to accessibility that are frequently added on later [4]. When the design is rigid, the users often have to adapt to the computer's features. Therefore, usability allows the design of user interaction that adapts to the user's features.

This paper adopted the usability requirements for impaired users in the mobile application based on Siebra's [6] research work. Siebra et al. have conducted a literature review analysis to identify requirements for a mobile application that aimed at supporting impairments. In this paper, we will focus on the usability requirements instead. Even though Siebra et al. emphasize physically impaired users, such impairment may affect users' cognitive ability when performing tasks. Among the group of users within this category are the elderly and those who have endured a stroke attack and still recovering from it.

Based on Table 1, this study will focus on the usability requirement on customization of design interfaces such as color contrast, font and image size. The customization of the design interface is important to configure a suitable layout features that can provide accessibility without loss of information [6]. The customization of the design interface in the mobile application by using paper prototyping will further elaborate in Section III.

The Importance of Low Fidelity

Prototyping serves an important role in detecting and addressing usability issues in a user interface. Low fidelity prototyping is a fast and cost-effective approach that fits well with short iterations typically found in agile software development process [7, 8]. Usability testing of prototypes detects usability issues that can be fixed which leads to both improved and more intuitive interfaces for users.

Paper prototyping is also a widely used method to develop software that meets users' expectations and needs [9]. Generally, low fidelity prototypes are used to examine usability errors rather than efficiency measures [10]. As stated by Nielsen [11], usability

testing on prototype fidelity is the most fundamental and important method to identify problems in user-product interaction.

Paper prototyping also helps the designer in the early stages of design to gain the expert review and user feedback without the need to implement a fully operational high-fidelity prototype. However, the disadvantages of paper prototyping lead to limited interactive and dynamic experience as compared to the actual user experience of high-fidelity prototypes. Paper prototyping requires a facilitator to demonstrate the system and provide feedback during the command simulation sequence.

METHODOLOGY

A user interface design of mobile application for a physically impaired user was sketched based on usability requirements in Table 1. This paper prototype follows the actual size of the mobile application with 600 x 1024px and 170ppi. This study will emphasis layout features on the customization of the design interface:

Size of the image

The size of an image in the mobile application is important for physically impaired users to ease them accessing the information. Figure 1 shows three sets of different image sizes in this research study.

Table 1 Usability Requirements for Physically Impaired Users in Mobile Application

Author	Usability Requirements for Physically Impaired Users
Siebra et al., 2017 [6]	a. Customization design interface b. Signalize changes in the interface via sound, images, vibration c. Guide and provide feedback to users d. Provide touch interactions e. Provide form interactions f. Provide linear and intuitive navigation g. Provide configuration of feedback speed h. Provide assistance to find content and guide users through the system i. Avoid limits of time control to users' reading or interaction j. Provide coverage of uses errors and suggestions about their corrections

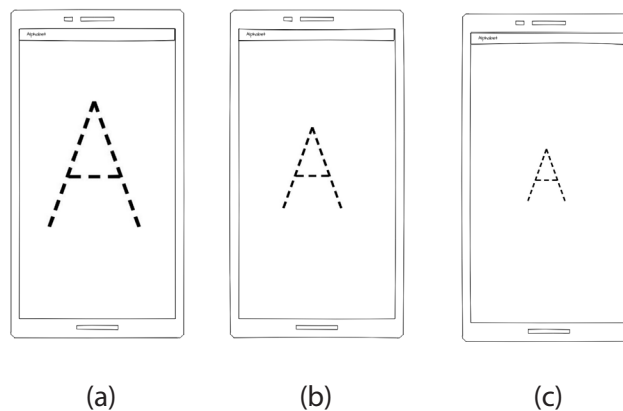


Figure 1 Three sets of different image size

The different sizes of images based on Figure 1 tabulated in Table 2 below. The image size from Table 2 calculated by using this formula:

$$\text{Inches} = \text{pixel dimensions (dp)} / \text{resolution (ppi)} \quad (1)$$

The resolution of the image kept constant, while the pixel dimension will vary. In this paper, the initial pixel dimension set with 450 x 450dp. Then, the pixel dimension will reduce 2/3 of the first-pixel to be 300 x 300dp. The pixel dimension also enlarged by 4/3 of

TABLE 2 Image size

Type	Resolution (ppi)	Pixel dimensions (dp)	Inches (in)	Centimeter (cm)
(a)	170	600 x 600	3.52	8.94
(b)	170	450 x 450	2.64	6.70
(c)	170	300 x 300	1.76	4.47

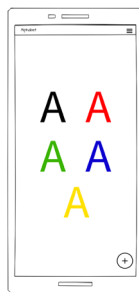


Figure 2 White Background

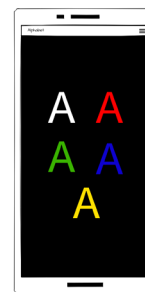


Figure 3 Black Background

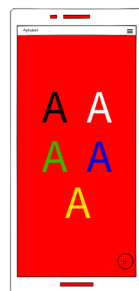


Figure 4 Red Background

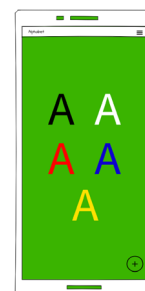


Figure 5 Green Background

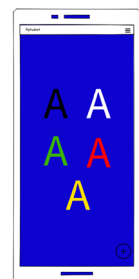


Figure 6 Blue Background

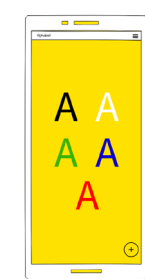


Figure 7 Yellow Background

the initial pixel to be 600 x 600dp. The layout design of the image size from Figure 1 drawn by using inches.

Background Color and Font Color

It has been claimed that inappropriate background and font color may cause discomfort feeling in accessing the mobile application. Hence, a study on a suitable combination of color contrast is required in designing a user interface.

This study on the selection of background and font color consists of 6 color combination, which is white, black, red, blue, green and yellow. There are also 6 sets of different background color to be matched with five different font color of A's in the design layout.

Procedure

An expert review was conducted to validate the usability requirements of the customization user interface based on the size of the image, background color and font color. A cognitive walkthrough method used for this expert review. The test participants were one physiotherapist from Hospital Changkat Melintang, and two practitioners at the National Stroke Association of Malaysia (NASAM) Ipoh. The choice of evaluators enables us to justify our usability requirements from the perspective of people who are knowledgeable in users with physical impairment as well as deteriorated cognitive abilities.

Each test participant was brief about the study. They were invited to walk through the prototype and select the preferred image size and the color combination between font colors with the background color. The participant was allowed to ask questions if there are any unclear instructions or doubt. Feedbacks were also gathered from the participants verbally after the study to justify their choice.

RESULT & DISCUSSION

Findings Based on Cognitive Walkthrough Activities

The study findings of the three experts' feedback on their choices of suitable image size and color combination are summarized in Table 3.

From Table 3, all participants agreed to select set (a) for the image size due to the bigger size of the image as compared to set (b) and set (c). The participants also stated that set (b) with the image size of 2.64 inches is still acceptable. However, all participants agreed to prefer set (a) with 3.52 inches for the image size that is the most suitable for physically impaired users.

For a suitable color combination, Participant 1 chose a white background with the black font as his/ her preferred choice. Meanwhile, Participants 2 and 3 chose black. The pattern of choices as obtained from this study, indicates that all participants prefer contrasting background and font color. They agreed to adopt a dark color as a background color layout.

The least preferred color combination comes from the combination of either red, blue, or green as the background and font color. One of the participants said that the combination of a red background with a blue font gives an unpleasant sight to their eyes during the interaction. The font color also seems not able to blend well with the background color.

Implications of the Study

It was found that customization interface design has a significant influence on the image size, followed by font and background colors. The observation was carried out to access the usability of the system by using a paper prototype with expert users in an impairments domain group. An increase in image size attracts more visual attention during the interaction. Nevertheless, for the color combination of fonts and background colors, more in-depth studies are required to consider the most preferred color in designing the user interface. Overall, the presented results show that the dark color is suitable to be chosen as the background color. These findings may come as no surprise, but the confirmation from the three experts provides value to the work. These could be useful to inform designers when developing interfaces with impaired users in mind.

Table 3 Usability Testing

Participants	Set image size	Most suitable color combination	Least suitable color combination
1	Set (a)	Background: White Font: Black	Background: Red Font: Blue
2	Set (a)	Background: Black Font: White	Background: Blue Font: Green
3	Set (a)	Background: Black Font: Yellow	Background: Green Font: Red

CONCLUSION

This study involves determining the usability requirement specifically in customization of interface design for users with impairment. A paper prototype of a mobile phone application interface was developed and used for this purpose. The study was performed by investigating a variety of different image sizes as well as the background and font colors of the interface. Experts evaluators, who are practitioners knowledgeable in people with an impairment, validated the work. The study findings obtained have laid an important platform from which to enhance the usability of a system. Future work would attempt to test the design in the high-fidelity prototype. The limitation of the intuitive design of this study using the paper prototype can be improved in the future.

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