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EVALUATION MODEL FOR LOW VISION USERS IN MOBILE APPLICATION

移動應用中低視力用戶的評估模型

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Abstract

This paper aims to discuss the usability evaluation model for mobile applications used by low vision users. Low vision users have difficulties using mobile applications due to limited view, bright sunshine, small text, and other reasons. This type of user uses mobile applications designed for users with normal vision, and they have many difficulties in reading, accessing, and understanding. Therefore, this paper provides a mobile application usability evaluation model for this type of user, and the proposed model includes usability measures that fulfill their usability requirements. This study employed a systematic review of previous research on good practices and requirements for low vision users to use mobile applications. Also, the new model was evaluated by the domain experts through a focus group session. This model aims to support the development of a mobile application that low vision users can use, which has not been supported in previous studies since it guides mobile application developers to develop mobile applications that fulfill low vision users' usability requirements. It also helps to identify usability problems in the current mobile applications for this type of user. This study will benefit low vision people in using mobile applications effectively, easily, and comfortably.

Keywords: Low Vision, Usability, Criteria, Dimensions

摘要 本文旨在討論低視力用戶使用的移動應用程序的可用性評估模型。由於視野有限、陽光明媚、文字小等原因，低視力用戶使用移動應用程序存在困難。這類用戶使用專為視力正常用戶設計的移動應用程序，他們在閱讀、訪問和理解方面存在很多困難。因此，本文為此類用戶提供了一個移動應用程序可用性評估模型，所提出的模型包括滿足其可用性要求的可用性度量。本研究系統回顧了先前關於低視力用戶使用移動應用程序的良好做法和要求的研究。此外，領域專家通過焦點小組會議對新模型進行了評估。該模型旨在支持開發低視力用戶可以使用的移動應用程序，這在以前的研究中沒有得到支持，因為它指導移動應用程序開發人員開發滿足低視力用戶可用性

要求的移動應用程序。它還有助於為此類用戶識別當前移動應用程序中的可用性問題。這項研究將使低視力人群有效、輕鬆、舒適地使用移動應用程序。

关键词: 低視力、可用性、標準、尺寸

I. INTRODUCTION

Globally, users of mobile phones, mobile applications, and the internet are increasing every day. In 2020, the number of mobile phone users reached 3.6 billion [1]. At the same time, 218 billion mobile applications were downloaded in the same year [2]. Similarly, in January 2021, the active Internet users worldwide were estimated at 4.66 billion [3]. These figures show that mobile technology plays an important role in everyone's life, including people with disabilities [4].

The daily lives of the visually impaired require the use of mobile applications to assist them, especially with the spread of coronavirus disease (COVID-19). Nevertheless, approximately 2.2 billion visually impaired people worldwide [5], including those with low vision, have problems using mobile applications. For example, accessing and using mobile interface components such as buttons and interface navigation is difficult for visually impaired users [6]. Low vision is one of the visual impairments that leads to visual problems that cannot be fully corrected by medical treatments, glasses, or contact lenses [7].

Therefore, there are usability issues for low vision users due to mobile applications for normal vision users. Their usability is not evaluated for this type of user. Since there are no models to evaluate the usability of mobile applications for low vision users, most of the previous studies focus on the accessibility of mobile applications for low vision users more than other usability factors that are important for them, such as read understandability. For example, WCAG 2.1 supports developers in designing accessible mobile applications for people with disabilities, including low vision users [8]. It also uses modified generic models such as Nielsen's model that focus on normally sighted users [9].

Used general models cannot define the measurements for evaluating a mobile application interface [10-13]. Besides that, they are not suitable for a special need user [14], as they are not meet the usability requirements of this type of user. Consequently, it is necessary to provide an evaluation model, to evaluate the usability of a mobile application for low vision users. This objective was achieved through three sub-objectives as follows:

1) To identify the mobile application usability requirements for low vision users.

2) To identify current usability dimensions, criteria, and metrics of a mobile application for low vision.

3) To develop a mobile application usability evaluation model for low vision users.

II. RELATED WORKS

Usability evaluation is a combination of methodologies used to measure and evaluate the usability attributes of a system. This procedure is to detect usability problems in the design of the system [15, 16]. During the last twentieth years, HCI researchers and usability experts have intensely addressed usability evaluation through proposing and providing a considerable number of usability evaluation methods and models, which have been used to measure usability as a quality construct [17]. There is an increment of software assortment, thus designing successful software that achieves its purposes with ease of use is important, but this task is not easy. Therefore, several different standards, models, and guidelines exist to evaluate software usability (e.g., ISO 9241, Nielsen model, GQM approach, QUIM model). Some of these models, guidelines, and standards are used to develop usability evaluation models for mobile applications in general and users with specific needs. However, these models are difficult to use directly for mobile applications for specific needs users due they require modifying.

Besides that, mobile applications are used in medicine, education, and other areas; thus, users require different functional and non-functional requirements during usage. Therefore, usability evaluation models and guidelines are important to evaluate various mobile applications for various users [18]. Therefore, developed many usability evaluation models for mobile applications such, mGQM and PACMAD. Since these models do not meet the usability requirements of users with specific needs, the MAEHI model for mobile applications for deaf and hard of hearing users was developed [19], as well as version two of the Heuristic Evaluation for Deaf Web User Experience (HE4DWUX)

was provided, and also CLUE as a checklist for usability evaluation of multimodal games for blind children was provided, (WCAG 2.1) to support the design of accessible mobile applications for disabled users. Since these usability evaluation methods do not meet all usability requirements of visually impaired users, accessibility guidelines were provided by [20] to provide an accessible mobile application for visually impaired users. Also, a CLUE checklist was provided to evaluate the usability of multimodal games for blind children by [21]. However, these usability methods support the accessibility dimension, else used for one type of mobile application, while low vision people use many types of mobile applications and should evaluate other usability dimensions, such as readability, thus providing a usability evaluation model of mobile applications for low vision users, that is necessary to meet their usability requirements.

III. Research Methodology

The inductive approach was used in this qualitative research to generate a new model [22], using various data collection methods, including interviews and text analyses [23], beginning from the specific to the general [24]. This study started with identifying the usability requirements of low vision users and the theoretical study towards developing a mobile application usability evaluation model for low vision users due to the importance of evaluating the findings in qualitative studies [25]. The developed model was evaluated by conducting a focus group session with the domain experts.

Low vision users' requirements and usage problems were investigated by analyzing the content of eighteen (18) of the related literature and interviewing ten (10) low vision users in Kedah State, Malaysia. After summarizing and comparing the results, five (5) main usability issues were identified: difficulty in reading a text, difficulty understanding the application, difficulty in using an application fully, difficulty in completing a task, and discomfort in using a mobile application. Three (3) main usage requirements were also identified: readable text, understandable and simple structure, and accessible application.

In addition, forty-eight (48) related papers evaluating usability in general and for mobile applications in particular, also those related to the use of mobile for the visually impaired, were reviewed via Systematic Literature Review (SLR), as provided by Kitchenham [26]. Depending on a few search keywords and similar terms related, the search domain was expanded to include the complete structure: ("Usability evaluation" OR "Usability measures") OR /AND ("Usability dimensions" OR "Usability factors" OR "Usability attribute" OR "sub-factors" OR "Usability sub-attributes" OR "Usability metrics") AND /OR ("Ipad" OR "Mobile Phone" OR "Smartphone" OR "Tablet") AND /OR ("Visually impaired" OR "Visual impairment" OR "low vision" OR "Blind" OR "Disable" OR "Disability"). The result of conducting the SLR was the identification of twenty (20) usability dimensions and twenty-five (25) criteria. The dimensions were selected depending on the frequency of these dimensions in the literature, mentioned or used at least four times, and most discussed concerning HCI and usability.

Finally, domain practitioner evaluation was conducted for the developed model through the focus group method. It is one of the most convenient and reliable ways to collect data and valuable comments from six practitioners and domain experts [27].

IV. Results and Discussion

The measures from SLR were simplified into six (6) dimensions and fifteen (15) criteria. Since twenty dimensions are considered too many to ensure the usability evaluation's practicality, this number of usability dimensions complicates the evaluation. Therefore, the strategy ISO was chosen, which represents the greatest possible simplification [28].

It also considers contextual factors that include the user, the environment, the technology, and the activity/task. Therefore, the usability requirements and problems of low vision users were considered to select usability measures for low vision users, as shown in Figure 1 below.

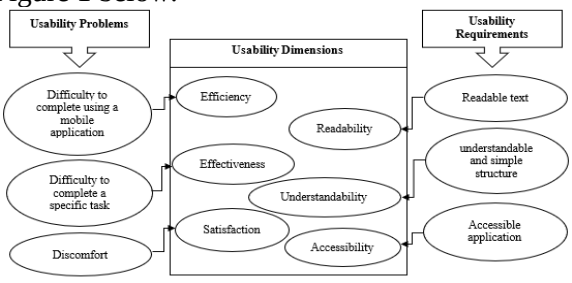

Figure 1. Mapping usability requirements and problems to usability dimensions derived from SLR

As mentioned earlier, the dimensions selected considering the proposed model are chosen for the specific group of users with disabilities, resulting in a careful selection of dimensions to ensure that applicable measurements are made for mobile applications for users with low vision.

Therefore, the proposed model pays attention to readability for the low vision, understandability, and accessibility, and these three usability dimensions were selected. In addition, the dimensions of efficiency, effectiveness, and satisfaction were selected because efficiency is mentioned in twenty-nine (29) studies, and effectiveness and satisfaction are mentioned in twenty-seven (27) studies. Moreover, these three dimensions represent the intended outcomes of the interaction while do not represent all sides of the usability evaluation [29]. Therefore, low vision readability, understandability, and accessibility were proposed to meet the usability requirements of low vision users and avoid their problems when using mobile applications. The proposed dimensions are presented in Figure 2 below.

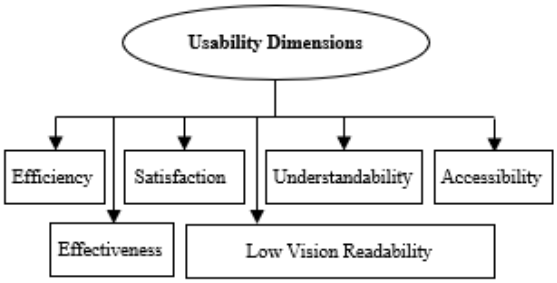

Figure 2. The proposed dimensions

In addition, fifteen criteria related to the previous dimensions were selected from the SLR result to achieve the main objective of this model. Also, QUIM method [30] was used to link the usability dimensions and criteria depending on their relationships.

Table 1.
Categorization of the criteria into the selected dimensions

	Dimension					
Criteria	**Efficiency**	**Effectiveness**	**Satisfaction**	**Low Vision Readability**	**Understandability**	**Accessibility**
Minimal action			✓			
Operability						✓
User guidance			✓			
Consistency					✓	
Compatibility	✓					
Accuracy		✓				
Completeness		✓				
Perceivable						✓
Fault tolerance		✓				
Time behavior	✓					
Simplicity					✓	
Familiarity					✓	
Readability of text				✓		
Supporting text skimming				✓		
Display			✓			

Hence, matched time behavior and compatibility criteria with efficiency dimension, accuracy, completeness, and fault tolerance criteria were proposed to measure effectiveness [19, 29-33], using three criteria related to the satisfaction dimension to measure low vision user satisfaction: user guidance, display, and minimal action [29-31, 33].

Text readability and supporting text skimming to measure the readability of a mobile application were adopted [34]. In order to measure the understandability of mobile applications for low vision, three criteria are simplicity, consistency, and familiarity [35]. They finally matched operability and perceivable criteria with accessibility dimensions [8, 19, 30, 31] to measure the accessibility of a mobile application for low vision users. Table 1 shows each usability dimension with its related usability criteria.

This model was evaluated, and the focus group session results show that the experts accepted the developed model. They expressed their enthusiasm for using it in the real world upon discovering that it is understandable, readable, and well-organized. The model can significantly and effectively assist in evaluating the usability of mobile applications for low vision users. The experts' level of agreement for using the developed model is higher than 83%, confirming the acceptance of the model and its applicability in the real environment. Figure 3 shows the total percentage of agreement for each validation measure discussed during the focus group session.

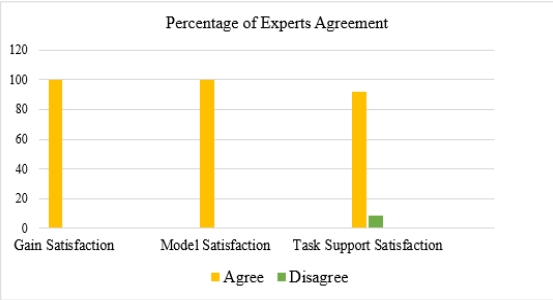

Figure 3. Total percentage of agreement among expert

V. CONCLUSION

This study maps usability requirements of mobile application low vision users with existing usability measures to develop a new usability evaluation model for low vision users on mobile applications. This model facilitates using mobile applications for this type of user as it assists in identifying the usability issues of the mobile applications for low vision people. It also guides mobile application developers to design applications that they can use. In addition, this study contributes to the body of knowledge in HCI as there are currently very few studies focusing on the topics of the mobile application for the visually impaired and usability models for users with disabilities. The findings of this study fill the said gaps, facilitate studies on the usability evaluation of mobile applications for low vision users, and be used as a reference to derive related research dimensions.

This model needs to be updated to suit the development of mobile applications. Additionally, the measures of this model only focused on the usage of mobile applications for low vision users in general, such as shopping and social media applications. It does not cater to mobile applications that require more specific measures, such as m-banking. Therefore, future research could address these gaps.

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