Gesture Design for Visually Impaired People on Mobile Platforms: A Systematic Literature Review

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Abstract*: Visually impaired people are part of everyday smartphone users. Most smartphone app developers follow the same design principles in designing mobile app's user interface. But in the case of designing for users with visually impaired, the user interface design is not always easy. Gesture engineering is required to improve the existing gestures in order to allow visually impaired people to utilize their smartphones better and easier. The amount of existing gestures design studies for visually impaired people is few and need to be further increased in order to ease visually impaired people to use smartphones. More solutions such as new gestures or forms of input modalities for smartphone applications needed to be provided to enhance the use of smartphone by visually impaired people. The objective of this paper is to comprehend better and closely review the current state of analysis concerning gesture design for visually impaired people on mobile platforms. A systematic literature review has been conducted as an approach to gather, examine and analyze knowledge from previous articles targeted on this analysis field which addresses a range of topics published online between 2010 and 2018. We used a Systematic Literature Review (SLR) method to collect and review studies by following a predefined review procedure that imposes a set of research questions used to generate keywords to be searched on digital databases. The resulting articles are filtered and chosen based on the inclusion and exclusion criteria of study. 22 studies had been identified presenting analysis concerning gesture design for visually impaired people reviewed through systematic review process that draw knowledge to answer an outlined set of research queries. Topics such as gesture design for visually impaired people, problems faced by them while using smartphone and eyes-free design solutions had been analyzed. From the analysis, the studies targeted on gesture design for visually impaired people are mostly highlighted and this successively caved a path for more analysis and future research. The review process concluded that despite of having numerous studies that provide solutions for gesture design for visually impaired people, it is still insufficient to solve the gesture design problems faced by them. This study shows the research gap that includes existing issues in current gesture design which promises a new area of research that can provide better solutions to provide a favorable experience of visually impaired people while using smartphones.

***Index Terms*: Systematic Literature Review, User Gestures, Mobile Interactions, Visually Impaired People, Universal Design.**

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I. INTRODUCTION

Smartphone has become an important necessity in everyday lives. Smartphone has a variety of functions that includes calling, messaging and the ability to connect to people via social networks. Smartphone provides a variety of functionalities and friendly interfaces that are usable by the majority of the people which has contributed to a huge number of smartphone users. Smartphone users were estimated to exceed five billion in 2017 [19]. Out of 245 million people with visual impairment in the world, 217 million of them have a visual impairment and 39 million of them are blind [4]. Gesture design for visually impaired people is important as it provides the base guidelines for visually impaired to use the smartphone. Gestures should be learnable and easy to perform as blind users are only able to get an appropriate response from mobile phones after performing the correct gestures. Incorrect gestures performed may lead to undesired output and blind. users may not know how to revert back to their previous actions. Gesture design in smartphones is available in IOS and Android, known as accessibility functions which provide voice and vibration feedback whenever an element on the screen is invoked. Besides, a user is allowed to perform actions such as flicking through the screens, making and receiving calls as well as sending messages via message application and social media apps such as Telegram or Whatsapp. Mobile vision is now implemented as assistive technologies to aid people with visual impairment to move around the virtual environment in the smartphone [10]. The importance to design user interactions that are proven accessible for visually impaired smartphone users is prevalent because tasks such as reading and replying to a message and flicking through the home screen can be difficult for people who do not possess sight or have low vision. Functionality and usability of a design are some of the main focuses of Human-Computer Interactions [20] which is now more commonly known as UX/UI Design. Only when a user is able to utilize the functions provided by a smartphone, the function becomes evident [17]. The term "Universal Design" which is defined as designing a product for use of all, covering a variety of user targets regardless of their age, status and physical abilities, as coined by Architect Ronald L. Mace, Universal Design can be adopted while designing accessibility or usability features in a smartphone [4]. This paper adopts a systematic literature review (SLR) to study the issues and

the solutions related to the Gesture Design for Visually Impaired People on mobile platforms. The primary objective of this paper is to gather more facts that are related to the gesture design for visually impaired people focused on mobile smartphones. The following Section II discusses the related works on gesture designs on mobile platforms for visually impaired whereas Section III discusses on the review process respectively. Section IV reports the result of the review process and discussion. Finally, Section V concludes the study and discusses possible future research on this domain.

II. RELATED WORKS

Previous works on designing user interactions for visually impaired people for mobile platforms has allowed the evolution of gesture engineering throughout the years. Kane et. al. proposed an application named as Slide Rule that uses gestures as its input and gives audio feedback to blind users to allow them to use smartphones easily [8]. Slide Rule incorporates multi-touch interactions on mobile phone touchscreens. An experiment was held with ten blind participants and the outcome of the experiment showed that the Slide Rule was relatively faster to use and easier to be used than Symbian phones with buttons. Seven out of ten participants agreed to this. However, due to the lack of familiarity with the new interface interaction, users made more errors while using the Slide Rule. Morris et. al. used the participatory design methodology to elicit usable and good gestures from users with their consensus [11]. The participants defined good gestures as gestures that meet usability criteria such as easy to memorize, reliable, easy to perform and easy to discover. Another study of spatial gestures using smartphone motion sensors was conducted that adopted gesture elicitation techniques from its participants [13]. Gesture design for visually impaired people is related to input modalities of the mobile interface. The way user inputs their desired action influences the type of suitable gestures that can be engineered to facilitate the specific type of inputs. There are 7 categories of input modalities as shown in Table 1.

Table. 1 Categories of Input Modalities for Visually Impaired users [6]

Category	Explanation
Surface Gesture	User inputs on a two-dimensioned touchscreen devices.
Motion Gesture	Users manipulate the position of the device or move their body parts that are detected by the device.
Body Movement Input	User body movements behave as the input to the application.
Braille Input	User enters input using braille tactile buttons.
Speech Input	User says out a command to the system
Environment-content Input	Input from the environment and surrounding of the user.
Keyboard/Mouse	User inputs by touching the alphabets on the keyboard or using a mouse to choose their desired icon.

Yosra et. al. carried out an experiment to study the toughness of multi-touch gesture articulation [12]. The results showed that difficulty was perceived mostly by the number of fingers used and the number of strokes performed. They carried out the experiment with a set of guidelines and recommendations. Sandness et. al. conducted a study on the use of a finger and a stroke touch-based gestures on devices that require self-service [15]. Interface that was proposed through this study consists of a menu with options on borders of the screen. The prototype was validated and was proven friendly for both sighted people and visually impaired people.

III. REVIEW PROCESS

This review paper adopts the Systematic Literature Review which is defined as the collection, determining and analyzing research materials that could provide answers to proposed research questions. There are four procedures for this review process which are detailed out in sub-sections. Figure 1 shows the stages of review protocol.

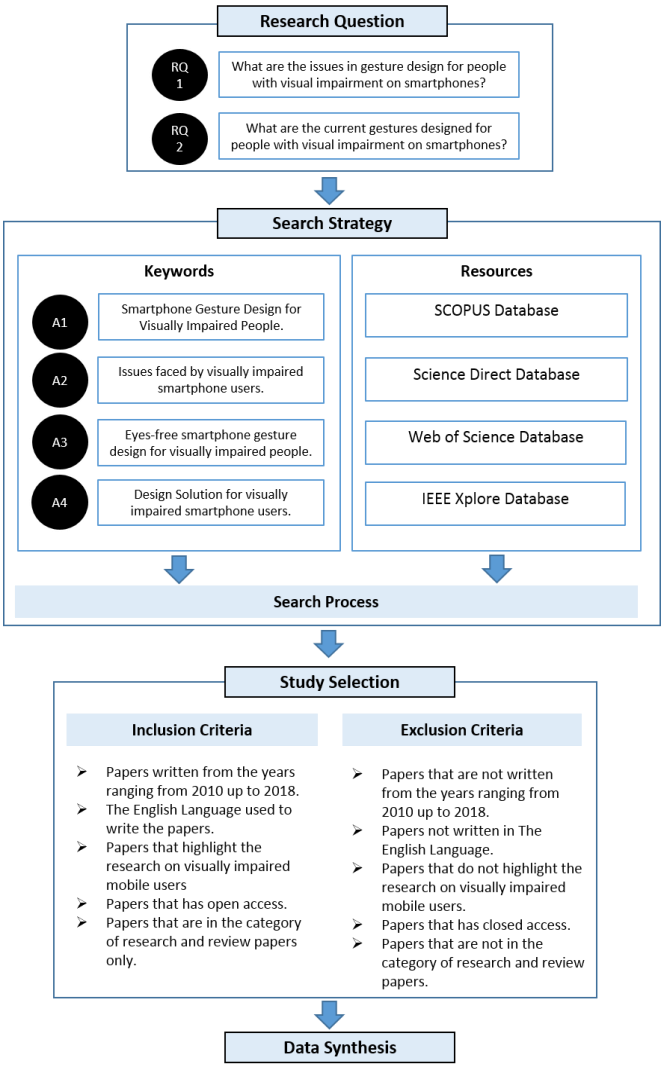

Fig. 1 Stages of review protocol

A. Research Questions

Research questions drive the search process of the systematic literature review. Research questions will be answered based on the materials searched through the search process. This research concerns two questions:

- RQ1: What are the issues in gesture design for people with visual impairment on smartphones?
- RQ2: What are the current gestures designed for people with visual impairment on smartphones?

B. Search Strategy

The aim of this research is to collect existing works on gesture design for people with visual impairment on smartphones. The search strategy is to use keywords of the domain to find for research papers, articles and journals. We target four electronic databases which are Scopus, Science Direct, Web of Science and IEEE Xplore. Targeted research materials focus on papers that present issues of gesture design for visually impaired mobile users and current gesture designs that has existed to this day.

We use keyword codes to find for relevant research materials as shown in table 2.

Table. 2 Keyword codes and its respective meanings

Keyword Code	Meaning of the keyword
A1	Smartphone Gesture Design for Visually Impaired People.
A2	Issues faced by visually impaired smartphone users.
A3	Eyes-free smartphone gesture design for visually impaired people.
A4	Design Solution for visually impaired smartphone users.

C. Study Selection

The study selection covers on the inclusion and exclusion criteria which defines categories of research materials that would be included in our search process and criteria that would be excluded, further refining the search process. Areas of study include software engineering, human-computer interactions, usability design and universal design.

D. Data Synthesis

Data synthesis aids in gathering evidence from the selected papers. The data obtained from this study are the issues faced by visually impaired smartphone users and solutions/prototypes suggested by author of the studies to overcome the issues. These evidences are vital for future works that will address the issues encountered by visually impaired smartphone user, contributing to a better design of accessible gestures.

IV. RESULTS AND DISCUSSION

The systematic literature review results are retrieved from the targeted online digital libraries. A total number of researches on gesture design for visually impaired users on mobile platforms is 55. However, only 22 research and review paper are compliant with our research question. The rest of the 33 articles did not answer or partially answer our research questions. Figure 2 shows the selection process carried out to select the relevant articles.

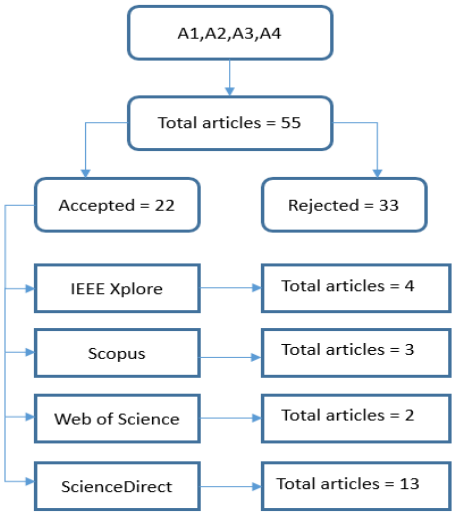

Fig. 2 The selection process

The selected articles have been categorized into publication years. Figure 3 illustrates the trends of articles on gesture design for people with visual impairment on smartphones from the year 2010 up to 2018. The chart shows that the most number of articles related to the domain has been published in the year 2015.

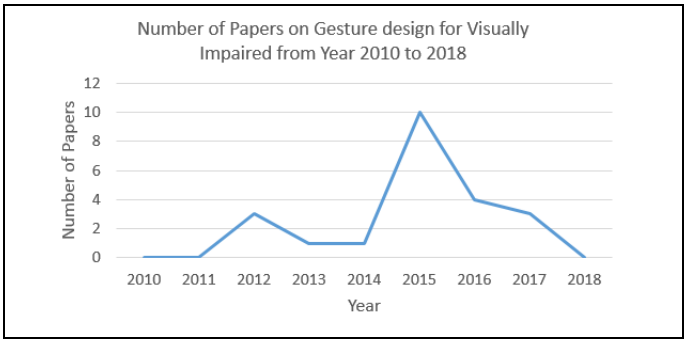

Fig. 3 Number of Papers on Gesture Design for Visually Impaired from the year 2010 to 2018

RQ1: What are the issues in gesture design for people with visual impairment on smartphones?

6 papers are selected as they elaborate and answer the research question on the issues that arise for gesture design for visually impaired people on mobile platforms. Table 3 summarizes the study conducted on gesture design and the issues that are discussed in the article. Firstly, Khan et al. investigated the issues in gesture design for visually impaired smartphone users which are the fatigue less experienced by a user while they were performing gestures [9]. Users prefer repetition gestures as they perform it in their daily lives. Menu items should be rehearsed in order for users to know the exact location of items on the touchscreen. Smaradottir et al discussed the issues in current accessibility gesture design for mobile smartphones [18]. Participants from his experiment said that gestures were easy to perform however they need prior training in order to perform correct gestures and some correct gestures did not receive adequate responses from the system. Chen et al. (2015) incorporated gesture design along with vibration and voice message as an output message when BlindNavi navigates along the road together with the importance of implementation of gesture shortcuts to assist users to locate where they are currently located [5].

Rivera et al. discussed the sensory modalities visually impaired use to perceive the environment which is hearing and tactile gesture design is needed to perceive feedback in a noisy environment [14]. Besides, Alnfiai and Sampalli concluded that blind people face adversity when it comes to entering inputs due to the difficulty in locating an object position on a touchscreen [1]. They also added that the need for multiple finger gestures is unnecessary. Lastly, Serra et al. concluded that many accessibility issues related to gesture design on mobile platforms are due to the failure to obey the Web Content Accessibility Guide such as lack of accessible labels and descriptions along with lack of meaningful sequence of objects that cause visually impaired people difficulty to locate items on screen [16].

Table. 3 Study Conducted on Gesture Design and Issues Tackled

Study/Proposed Work	Issues tackled	Author(s)/ Year of Publication	Method used for data extraction
Marking Menu Selection using 3D Motions.	Limited features and gesture design for user interface and the need for a faster feedback for visually impaired and lack of accessibility to utility applications.	Nem Khan Dim, Kibum Kim, Xiangshi Ren (2017)	Dual-axis tilt calculation method that support com-plete 360 °tilt sensing.
Performance of touchscreen gestures by Visually Impaired People.	Gesture performed need more user training for memorability and speech feedback respective to gesture design is inconsistent and 4-finger tap gestures are difficult to perform.	Smaradottir, B. F., S. G. Martinez, J. A. Haland, (2017)	Mixed methods research approach with quantitative (Time taken for individual user training) and qualitative (Usability test and posttest interview) measures.
BlindNavi, a Navigation Application for people with visual impairment on Mobile Platforms.	Touch-based gestures for user interface along with visual feedback provides a faster and safe response.	Chen, H., Lin, Y., Chen, C., Wang, I (2015)	Interface usability studies and on-road navigation tests.

Haptic interface for indoor navigation based on appearance.	Tackles visual feedback issues by highlighting the tactile feedback.	Rivera R, J., Arulkumaran K., Rishi, H., Alexiou, I., Bharath, A. A. (2016)	Vision-based localisation by using the location derived from SLAM-based algorithm and indoor surveying equipment.
Text-entry method for braille users using SingleTapBraille.	Gesture design for visually impaired must follow the blind user conventions of typing the braille characters (left to right)	Alnfiai, M., Sampalli, S. (2016)	Experiment conducted to test blind users with braille knowledge to type the entire alphabets and numbers 0 to 10 on SingleTapBraille.
Accessibility evaluation on e-government Application.	Violation of WCAG 2.0 on gesture and interface design	Serra, L. C., Carvalho, L. P., Ferreira, L. P., Vaz, J. B., Freire, A. P (2015)	Accessibility Audit Procedure using review of guidelines that analyzes 61 success critria of WCAG 2.0

RQ2: What are the current gestures designed for people with visual impairment on smartphones?

Three papers have been chosen out of twenty-two papers that provide the best solutions for gesture design for people with visual impairment on smartphones. Table 4 summarizes the solutions in gesture design for visually impaired people on mobile platforms.

Table. 4 Proposed Works on Gesture Design for Visually Impaired Smartphone users

Solution/ Proposed Works	Author(s)/Year of Publication
BrailleEnter, A Braille Text Entry Technique on Smartphone for Visually Impaired People	Alnfiai and Sampalli (2017)
BrailleEasy: Braille Keyboard for Mobile Phones using One hand	Barbara et al. (2015)
Voice4Blind: Assisting Blind users in Text Messaging via Talking Braille Input	Hamzah et al. (2016)

Alnfiai and Sampalli proposed BraileEnter, a text entry input method using Braille characters using one finger gesture that allows users to interact with the screen by typing letters (small and capital), typing symbols, punctuations, numbers and system functions [2]. Based on their study, they concluded that one finger gesture is the most accessible for visually impaired users. Besides, Barbara et al proposed BrailleEasy, a one-handed keyboard that allows a user to enter braille input along with BrailleTutor, a braille tutorial application that teaches user on how to use this application [3]. Every gesture invoked is accompanied by audio feedback and the fingers are not necessarily fixed position at one place, providing flexibility for visually impaired people. Lastly, Hamzah et al. proposed Voice4Blind, an SMS application that uses speech gesture input and utilizes text to speech technology to allow people with visual impairment to send and receive text messages [7].

V. CONCLUSION AND FUTURE WORKS

This paper discusses the Systematic Literature Review on Issues in Gesture Design for Visually Impaired People and proposed works. Two research questions have been created during the search process of the SLR and were answered in the Results and Discussion section. Despite having numerous issues regarding gesture design for people with visual impairment, limited research was conducted to propose a solution to the issues. Understanding the way a blind user uses a mobile device is necessary to design accessible gestures that can be utilized by visually impaired people in their daily lives. Proposed solutions should lead to more future works on gesture design to address the gaps in the current.

Currently, both IOS and Android have their own accessibility features that can be utilized by visually impaired smartphone users to perform tasks such as make calls and sending text messages. The current screen readers in both IOS and Android can be enhanced to include multimodal gestures that are natural to users. Gestures should be designed to include personification factors such as using speech recognition, touch and motion sensing gestures instead of touch gestures only (unimodal). This is to minimize the visually impaired smartphone user from performing too much taps to perform the desired task. A prototype of an application that combines all these three gestures mentioned should be developed and compared with the existing screen reader applications to compare the efficiency, effectiveness and satisfaction of use of the new proposed design. This prototype should address the issues of gesture design for visual impaired people that was discovered from the systematic literature review conducted in this paper so that a better design on accessibility features of smartphones can be developed in the future.

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