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Design and Implementation of a Mobile Voice Assistant System for the Visually Impaired

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Abstract

Voice assistant systems are now becoming the newest technology in human computer interaction. However, the use of voice assistant systems has not been fully explored to help visually impaired individuals get the best out of their mobile devices as there have been challenges revolving around privacy and ease of use. The system was implemented using Kotlin for Android apps to work offline facilitating more reach for users with little or no internet connection. The result of the implementation shows that blind users can make use of their mobile devices without dependence on third party, internet connection or privacy-related issues that they had prior to the system implementation. The system is hereby recommended to blind users to help them make the best out of social interaction using their mobile devices.

1. Introduction

With so many advancements in technology and the mobility of technology devices nowadays, people can easily get solutions to most of their problems while walking along the street or sitting at a park, the possibilities are endless. Some of these advancements has led to development of Voice Assistant Systems that work on-the-go. These systems have made computing easier for computer user as they facilitate the easy input and output of information through voice and sound recognition. The use of voice assistants cuts across so many aspects of human-computer interaction as they are used in homes, educational environments and for other beneficial purposes.

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All daily activities of a human are carried out using the eyes. Visual disability essentially affects the existence of individuals who experience it just as it affects that of their family and friends and the society at large. This loss of one's eyesight tends to feel terrifying and overpowering, leaving those affected to ponder over their capacity to keep up with their autonomy and carry out their tasks without involvement of unavailable third parties. This can affect one's independence, mobility and access to quality life.

Humans' vision loss affects their ability to work independently and take adequate care of themselves because it affects countless other daily activities like placing phone calls, sending text messages, reading and socializing [4]. This explains why people with disabilities are under-represented in society. Visual impairment imposes challenges on older adults and this may cause them to depend on caregivers for a longer time.

Mobile devices are computing devices that are mobile as they can be lifted and taken from one location to another, these devices have gained popularity among visually impaired individuals because they are portable, cheaper and easy to use. Numerous studies have focused on the development of systems for individuals with visual impairment focusing on mobile devices, examples are Google Assistant and Apple's Siri. However, some of these existing systems pose threats of difficulty in use and high phone memory consumption.

In this paper, we focus on the development of mobile voice assistant systems that leverage the capabilities of screen readers for visually impaired users. The need for autonomous living via mobile devices is perceived in the instance of visually impaired individuals who face an assortment of issues, including social detachment due to low or no means of assistance from the outside world.

This poses a need for a system that facilitates access to a mobile assistant that helps them carry out common tasks like placing calls, taking pictures, sending text messages and other various computations on their mobile device. This kind of system is essential to help these individuals function effectively in this era of technological advancements.

Despite technological advances, individuals with visual impairments encounter issues using basic functionalities on computing devices [11]. With the advent of touch interfaces which rely on visual cues, the problem is taken to a greater extent posing more threat to the use of mobile devices (Sanchez & de Togores, 2012).

According to [**?**], visually impaired individuals need helpful tools for operating digital devices. [1] opined that voice assistants are serious tools for the visually impaired, as they make possible day-to-day tasks which others may take for granted. An analysis of reviews of verified purchases of Amazon Echo devices carried out by [10] found out that almost 38% of reviews mentioned individuals with visual impairments, suggesting that voice assistants can be of great use to the visually impaired.

As a result, there is a need for the development of a mobile voice assistant system that keeps in mind the visual impairment of the targeted user geographic to improve accessibility to basic functionalities provided by mobile devices.

1.1. **Review of Related Literature.** For years, scientists and engineers in field like Computer science, linguistics, cognitive science, and information engineering have thought and worked on ways to design systems that could process and analyze speech, the ability to be able to interact with machines has been their long-lasting goal [13]. It was until the invention of Artificial Intelligence and Machine Learning that voice assistants began widely spread. Now, computers can gain insights from user voice and perform computations based on the instructions provided in the voice.

Voice assistants such as Google Assistant, Siri, Alexa are programs developed to help users perform tasks efficiently through efficient use of voice. They are sometimes called virtual

assistants, digital assistants, or intelligent personal assistants, they represent a paradigm shift of human-computer interaction [13].

Looking back at the history of voice assistants, humans have dreamed of ways to interact with computers directly. Voice assistant technologies are the applications that expose users to a higher level of human-computer interaction compared to interaction via keyboard, mouse, or touch screen.

Voice technology lets users engage with the digital world through speech and conversational user interfaces. This is because voice is how we interact with other humans, it therefore makes it easier to interact with technology through voice [13]. The chances of voice becoming the new operating system has the potential to change and improve the way we live. This has effects on varieties of industries like computer science and engineering, marketing and advertising, and interpersonal communication and psychology.

Voice assistants have the potential of revolutionizing translation [7]. Google recently debuted a set of earbuds that pair with voice assistants to perform real-time language translation [7]. This facilitates easier communication and breaks the barriers to effective interaction. However, the technology is error-prone, particularly for complex medical terms, the near-instant results make it useful for simpler conversations [9].

Voice assistants can greatly impact the process of buying and selling [5]. Companies and institutions can leverage on voice assistants to transform the way customer search and choose what they buy from them.

According to [8], by 2021, there will be almost as many AI assistants as people. He opined that users can query assistants and receive answers as they would with search engine, but also interact and play games, control other connected IoT devices and carry out other daily and business activities.

Searching information through voice is easier than typing and using voice, users can easily complete tasks with greater ease and efficiency [5]. This elaborates on the ease of use of voice assistants for completing daily tasks for blind and non-blind individuals.

With voice assistants, the use of digital reminders is taken to a greater extent. By using digital reminders, customers can easily save lots of paper work, losing track of time and lose of important document is minimal [5].

Researchers have done some work in the past in relation to voice assistants. There are systems that have been built to help the visually impaired make the best out of their mobile devices to enhance their interaction in the society [2].

[3] proposed a system to help the visually impaired with sending and reading emails, reading weather forecast, daily news, and maintaining an online blog. The system receives voice instructions from the user, processes the instructions, and uses different modules to process the instructions while providing output to the user in form of speech. However, the system had some constraints such as dependence on internet connection to recognize speech and process them, this limits accessibility for users with low to no source of internet connectivity. Also, tasks that users perform on their mobile devices exceeds what the system proposes limiting users access to more functionality.

[12] developed a mobile application which was made to read the documents for the visually impaired user by speech. The system was developed to get rid of the barrier users had when using Braille format to read documents. A comparison was made between the use of the system and Braille to read documents and the system performed brilliantly well helping users to close this barrier. However, while the system helps blind users to bridge the gap of the use of Braille format to read text, the system only takes into consideration one of the very many tasks that users perform on daily basis. The app only focused on helping users to read documents.

[2] developed an object recognition system called VisualPal for the visually impaired. VisualPal is an object recognition system for visually impaired individuals. The system helps in the detection of maximum light, detects colors, and recognizes objects [2]. The system uses a phone camera to capture images of objects with minimum resolution possible, the captured image is recognized by the system and reported to the visually impaired individual by speech [2]. The system is also used to detect colors and direction of maximum brightness and it is reported to the user through speech. The system developed by [2] solves some of the problems that blind users face on daily basis such as object recognition, color detection, however, the system does not tackle other common issues that blind users face that are important to their daily interactions.

2. Methodology

Voice assistants have now evolved in their wide adoption by individuals. As they are at the forefront of making human-computer interaction better, they carry out tasks that bridges the computer usage barrier for the visually impaired and non-visually impaired alike.
Voice assistant have been developed before now to help individuals to generally complete tasks easily. However, it is apparent that these systems contain flaws and do not really target the visually impaired.
The design and implementation of a mobile voice assistance system for the visually impaired; a system that provides visually impaired individuals with an accessible voice assistant to interact with their mobile devices.
The system runs on the most widely used operating system, Android, making it accessible to billions of users without the need for an internet connection.
The proposed system poses to solve the limitations of the existing system introducing the following:

(1) No dependence on internet connection.
(2) Improved accessibility for the visually impaired.
(3) Limited ambiguity.
(4) Improved privacy for users.
(5) Open-source, giving room for modification and expansion.

With the implementation of this system, challenges faced by previous voice assistant systems for the visually impaired will be totally eliminated.
Challenges like user privacy which is one of the biggest challenges associated with voice assistant systems is totally eliminated as the system works offline without synchronizing any of the user's data to an external server. All data related to user interaction is available to the user without intruding the user's privacy. The analysis of the proposed system is given as follows:

(1) The system is built with accessibility in mind to target mainly visually impaired individuals using their Android smartphone.
(2) As the system is built to accommodate every user geographic and different age range, the system does not implement any form of authentication. This makes the system "plug and play".
(3) The system uses two forms of getting commands from a blind user:
    (a) (i) Voice commands.
        (ii) Touch inputs using screen readers.

(1) From the inputs the user has specified, the system performs the specified operation and gives output to the user in form of speech.

Figure 1: Activity Diagram for proposed system

3. Implementation and Result Analysis

The purpose of the system implementation is to make a mobile voice assistant system readily available for the visually impaired. This system will serve as a helping hand to these individuals by helping them complete their most needed tasks on their mobile phones. The implementation result of the system is shown below:

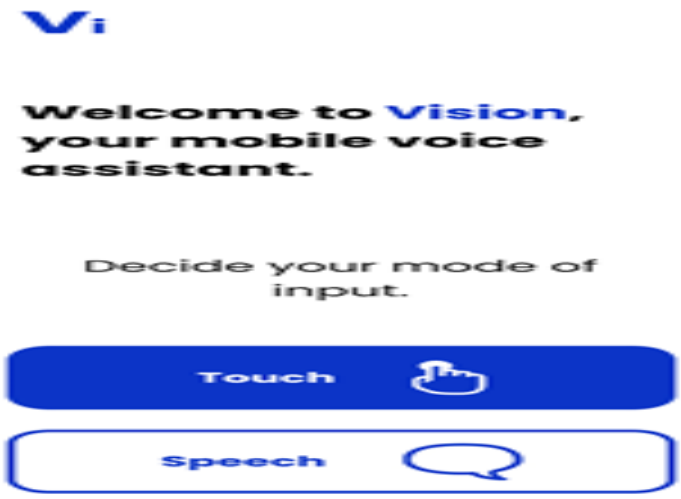

Figure 2: User greeting and input type specification screen

Figure 2 welcomes the user to the app and allows users to decide their input type between Touch and Voice inputs.

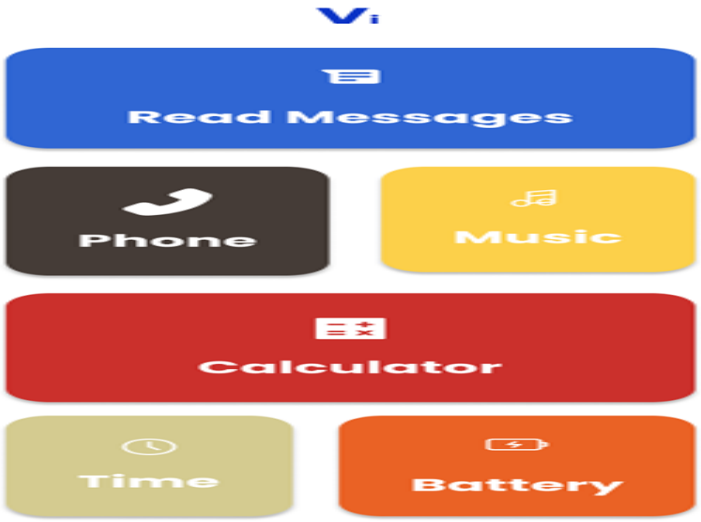

Figure 3: Main menu screen

Figure 3 shows up after the user has successfully specified their input type and it lists the different operations that the user can perform within the app.

Figure 4: Make phone call screen

Figure 4 allows users make phone calls using whichever input type they specified on the User greeting and input type specification screen.

Figure 5: Play music screen

Figure 5 displays to allow the user to make play music available on their phone storage using whichever input type they specified on the User greeting and input type specification screen.

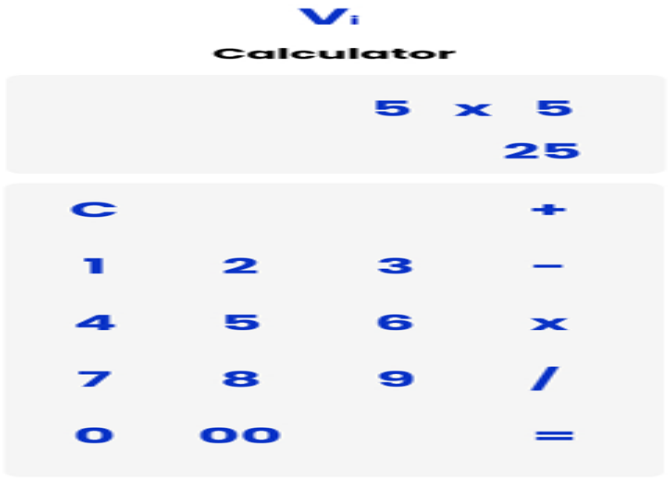

Figure 6: Use calculator screen

Figure 6 allows users to use the calculator to perform calculations with the input type they specified on the User greeting and input type specification screen.

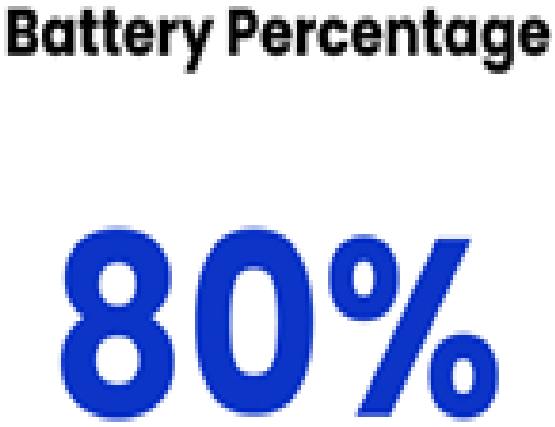

Figure 7: Read out phone battery percentage screen

Figure 7 reads out phone battery information.

Figure 8: Read out time screen

Figure 8 reads out current time.

Conclusions: Figure 6 allows users to use the calculator to perform calculations with the input type they specified on the User greeting and input type specification screen.
This research examined related literature on voice assistant systems, existing concerns and limitations with existing voice assistant systems, and the need for a mobile-friendly voice assistant system. As a result of the insights gained, a comprehensive mobile voice assistant system was designed to tackle the issues that previous voice assistants had. Issues such as privacy, accessibility, and portability, were fixed. The system is adaptable and efficient when it comes to assisting visually impaired users with their daily tasks.
The ability to perform daily tasks for disabled people requires a lot of efforts on their side, as they need help from third parties, this is an infringement on their privacy and limits how much experience they can gain from mobile usage. The system provides major advantages such as accessibility, mobile friendly interaction with mobile device, reliability and operation accuracy.
We suggest further research on the following topics relating to mobile voice Assistant System for visually impaired individuals:

(1) Addition of more operations to enable more accessibility for users.
(2) Use of machine learning to predict most used operations of users to improve efficiency.

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References

[1] Abdolrahmani A., Kuber R. & Branham S. M. (2018). "Siri Talks at You" An Empirical Investigation of Voice-Activated Personal Assistant (VAPA) Usage by Individuals Who Are Blind. *In Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility.* –(-), 249-258.

[2] Bagwan S. M. R. & Sankpal L. J. (2015). VisualPal: A mobile app for object recognition for the visually impaired. In *2015 International Conference on Computer, Communication and Control (IC4)* (pp. 1-6). IEEE.

[3] Bose P., Malpthak A., Bansal U. & Harsola A. (2017). Digital assistant for the blind. In *2017 2nd International Conference for Convergence in Technology (I2CT)* (pp. 1250-1253). IEEE.

[4] Brown J. C., Goldstein J. E., Chan T. L., Massof R. & Ramulu P. (2014). Low Vision Research Network Study Group: Characterizing functional complaints in patients seeking outpatient low-vision services in the United States. *Ophthalmology*, *121*(**??**), 1655-1662.

[5] Darda P. & Chitnis R. M. (2019). A Review on the Adoption of Voice Assistant in Banking and Insurance Sector. In *International Journal for Research in Engineering Application & Management (IJREAM), 5*(**??**), (pp. 81-85).

[6] Felix S. M., Kumar S. & Veeramuthu A. (2018). A smart personal AI assistant for visually impaired people. In *2018 2nd International Conference on Trends in Electronics and Informatics (ICOEI)* (pp. 1245-1250). IEEE.

[7] Hoy M. B. (2018). Alexa, Siri, Cortana, and more: an introduction to voice assistants. *Medical reference services quarterly.* **37** (1), 81-88.

[8] Jones V. K. (2019). *Experiencing Voice-Activated Artificial Intelligence Assistants in the Home: A Phenomenological Approach.* Doctoral dissertation, The University of Nebraska-Lincoln.

[9] Patil S. & Davies P. (2014). Use of Google Translate in medical communication: evaluation of accuracy. *Bmj.* 3-49.

[10] Pradhan A., Mehta K. & Findlater L. (2018). " Accessibility Came by Accident" Use of Voice-Controlled Intelligent Personal Assistants by People with Disabilities. In *Proceedings of the 2018 CHI Conference on human factors in computing systems.* 1-13.

[11] Rodriguez-Sanchez M. C., Moreno-Alvarez M. A., Martín E., Borromeo S. & Hernandez-Tamames J. A. (2014). Accessible smartphones for blind users: A case study for a wayfinding system. *Expert Systems with Applications.* **41** (16), 7210-7222.

[12] Sabab S. A., & Ashmafee M. H. (2016). Blind reader: An intelligent assistant for blind. In *2016 19th International Conference on Computer and Information Technology (ICCIT)* . 229-234. IEEE.

[13] Shih W. (2020). Voice revolution. *Library Technology Reports.* **56** (4), 5-13.