An Arduino-Based Assistant for People with Visual Impairment

Brian A. Alabado[1], Christian Jason V. Cornel[1], Anna Maureen R. Pare[1], Philip Daniel Solidum[1] and Juan Miguel S. Valdez[1]

Abstract

This study focuses on developing a prototype device for visually impaired people. It is initiated because of the numerous blind people in the Philippines who cannot afford expensive equipment for their everyday navigation. In this situation, the study about providing a solution to vision-related issues is necessary to help them become active in their lives. This is especially to those who completely lost their vision because of the error in eye refraction and other kinds of eye disease. The components used during the development are extensively cheap and affordable for people who cannot invest in equipment from other competitors. The study uses Descriptive Research for the research design. The prototyping methodology is adequate for the optimization of the device. Ingathering of the participants, the study used the purposive sampling technique. The participants and I.T. experts will use ISO 25000 to evaluate the device's quality. Alongside the participants' observation, the statements and comments of the visually impaired participants are used to provide a verdict after this study. The visually impaired participants gain more confidence when navigating in an unfamiliar area. The sound that is being emitted is helpful to intuit the distance of a wall or object from them. The adjustment knobs and buttons on the device are beneficial for their preferences. The researchers concluded that the prototype device can accommodate the basic needs in the navigation of a visually impaired.

Keywords: *visually impaired, arduino, ultrasonic sensor*

Introduction

Implementing technology in the medical field is one of the commitments of innovation that medical students can use for further information and studies. According to Sherman (2014), medical technology is responsible for the quality of life and increases an individual's life expectancy. In Europe, between 1980 and 2011, the life expectancy of an individual increased by more than six years. They stated that the application of technology in the medical field is giving massive improvement to an individual's overall health. It also lowers the rate of fatality when it comes to the well-being of a person.

The technology also evolves in the eye medical field, from examining eye problems to executing the proper method for medical operations. According to World Health Organization (2019), the leading reason for vision impairment is uncorrected refractive errors and cataracts. It is also stated that 2.2 billion people worldwide have a vision impairment or, in severe cases, blindness. It is clear that eye diseases are a global problem and will further increase due to uncontrolled population growth. It also has an impact on an individual's life. As Morse (2019) stated, the effects of vision loss on an individual can

[1]*Bachelor of Science in Computer Science*

lead to depression. People who lost their vision have two to three more chances to be depressed than the general population.

In the Philippines, during 2017, it is estimated that the total number of individuals who are bilaterally blind is 332,150, around 109,609 or 33% are due to cataract, the next 83,037 or 25% are caused by errors of refraction (EOR). The 46,501 or 14% are under the condition of glaucoma. The remaining are due to other eye conditions (DOH, 2017). The number of eye disease cases is enormous and needs to be resolved for safety and relief. Unfortunately, some cases cannot be restored from their original vision that leads to permanent vision loss. One of the leading causes is chronic retinal detachment. It means the retina at the back of the eye pulls away from its normal position. It leads the retina to detach from the eye (Lowth, 2016).

In this study, the researchers propose the Arduino-Based Assistant for People with Visual Impairment to provide a prototype device for people under the condition of blindness and visual impairment. The device aims to provide confidence and safety. Their incapability to navigate freely limits their ability to perform everyday activities. The quality and social life are affected by the inability to interact effectively due to a lack of confidence. The said research is used to develop a prototype device. It will serve as a guide and assistant for them to walk independently in small areas, allowing them to be active and make them more confident.

Method

The conceptual framework is shown in Figure 1.

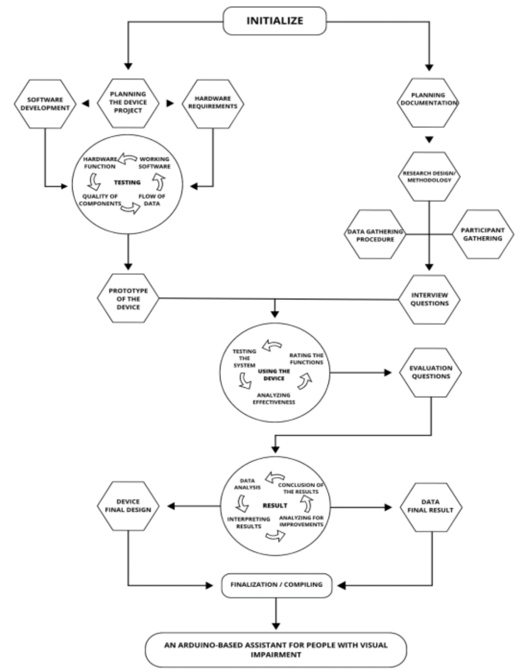

Figure 1. Conceptual Framework

An illustration for the development of the study. The study discovered the necessary variables to achieve the desired final result. The paths in the presented conceptual framework are separated into two parts. The left path, where the hardware components and software tools reside, are used during the development to focus on the progress of the prototype device. In contrast, the right path is the collection of necessary data that has been used as a factor to determine the overall quality of the prototype device's final result. The junction of the two paths is the part where the Users partake in the development. In this phase, the Users can share their review of the prototype device. The next phase is the result of the study. This is where the study elaborates the cause and effect of the prototype device to its target Users. The study's primary objective is to develop a prototype device that will assist a visually impaired in their navigation. In terms of the eye medical field, the proposed prototype device is an innovative tool for providing a solution to vision-related issues.

Prototyping methodology is commonly used in big and flexible projects that are prone to urgent application and implementation of new ideas during the process quickly, which supports the concept concurrently without a hindrance. The Prototyping Methodology consists of 6 phases: (1) Requirement Gathering and Analysis, (2) Quick Design, (3) Build Prototype, (4) User Evaluation, (5) Refining Prototype, and (6) Engineer Product. The prototype model is presented in Figure 2.

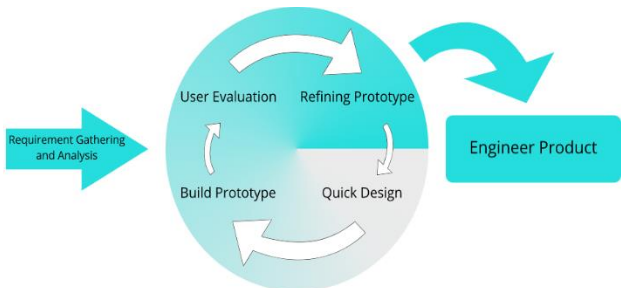

Figure 2. Prototype Model

The wristband and eyeglass are presenting the different modes of the system. In the flowchart, the sonar needs to satisfy a condition. After the condition, the system will proceed to the other components to execute their functions. If the User wants to terminate the system's process, the User can turn off the system by changing the status of a switch to off. The flowcharts for the eyeglass and wristband is presented in Figure 3 and 4 respectively.

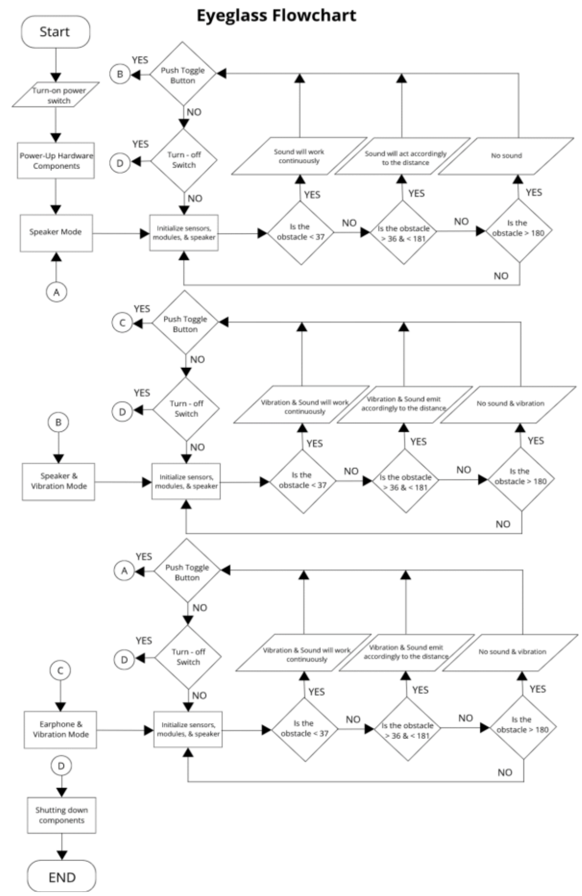

Figure 3. Eyeglass Flowchart

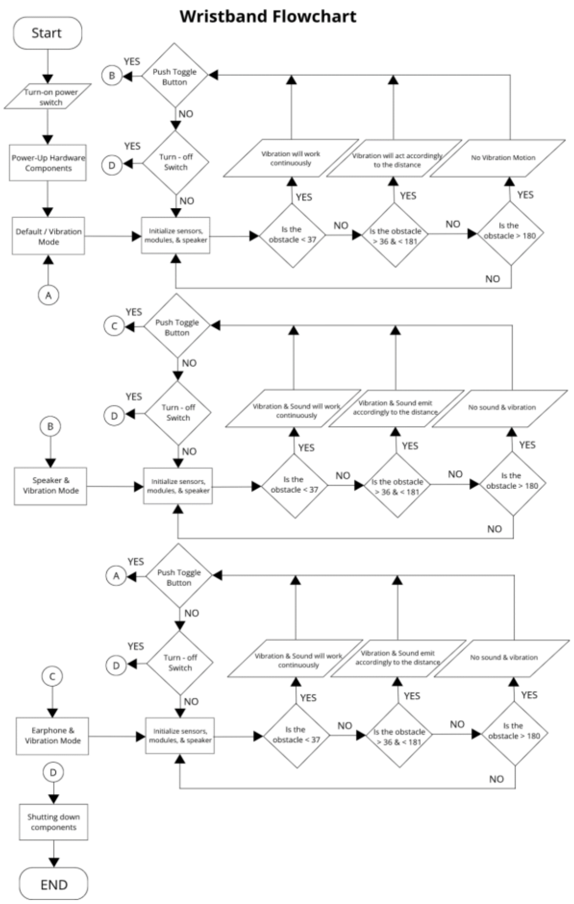

Figure 4. Wristband Flowchart

The prototype device consists of different scenarios: Loud Place, Quiet Place, and personal preference. The prototype device can adjust to the given scenario by switching to other modes that the User finds adequate. There are three (3) modes that are available for the User to choose. In the eyeglass, the first mode is Speaker only Mode, the second is the Speaker and Vibration Mode, third is the Earphone Mode. While in the wristband, the first mode is the Vibration/Default Mode, the second is the Speaker and Vibration Mode, and the third is the Earphone Mode.

Figure 5. Maximum Reach of the Sensor for Front (Left) and Rear (Right) in the Eyeglass

The eyeglass fits on the head and ears. The eyeglass prototype is worn on the head like how the user would normally wear an eyeglass. The prototype can detect an obstacle 6 feet away from the user. When the prototype is near the obstacle, it will emit a sound that changes tempo as the wall or object comes nearer. The volume of the sound can be adjusted accordingly to the user's preference.

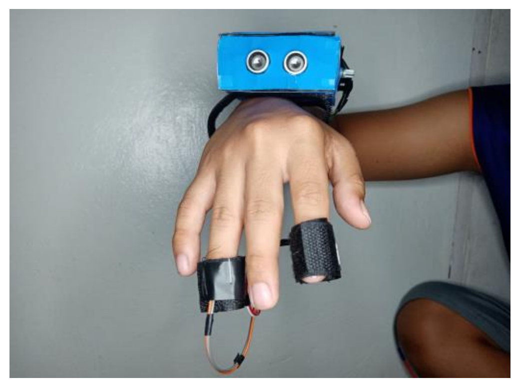

Figure 6. Wristband

The wristband is worn over the hand that the user prefers. It has a strap that secures the device on the wrist. The Vibration Motor Module generates vibration motion through Eccentric Rotating Mass (ERM) motors placed onto the fingertips. The wristband prototype emits a sound similar to the eyeglasses. It creates a vibration motion to which the user could feel on the fingertips. The volume is adjustable to the user's preference. The tempo of the sound increases as the object draws near within 6 feet from the user.

Results

This part of the study presents the complete result of the evaluation conducted by the users and IT experts. The evaluation criteria were based on the characteristics or metrics of ISO-25000 or the Software Quality Assurance. The respondents for the evaluation consisted of nine (9) visually-impaired respondents and three (3) IT experts.

Table 1 represents the results from the IT Experts and Table 2 represents the ratings from the respondents.

Table 1. Assessment of IT Experts

Criteria	Mean	Descriptive Reading
Functional Suitability	4.00	Very Good
Performance Efficiency	4.00	Very Good
Compatibility	4.00	Very Good
Usability	4.05	Very Good
Reliability	4.00	Very Good
Security	3.33	Good
Maintainability	4.00	Very Good
Portability	4.00	Very Good
Overall Mean	**4.00**	**Very Good**

Table 2. Assessment of Respondents

Criteria	Mean	Descriptive Reading
Functional Suitability	4.62	Excellent
Performance Efficiency	4.59	Excellent
Usability	4.74	Excellent
Overall Mean	**4.65**	**Excellent**

Discussion

Based on the evaluation result of the nine (9) visually-impaired participants and three (3) I.T. Experts. The study finally arrived at the interpretation of the factors to its user. In the perspective of the I.T experts, the overall result of the factors is not far from each other, except for security that received the lowest rating. While in the opinion of the visually-impaired participants, the overall rate remarkably reaches a high grade. The comparison between the marginal difference of I.T Expert's and User's overall rate concludes that the device is in favor of Users rather than the I.T. Experts. Despite the difference, the comments and suggestions for enhancing the prototype device are a massive overall improvement of the prototype device for assisting the visually impaired. It is excellent to reconsider the suggestions to improve the overall rating.

Conclusion

Based on the findings of the study, the following conclusion is stated to emphasize the problems that are being solved by the study. The implemented functions of the prototype device assist a visually impaired to navigate safely in small areas. It enables them to identify if there is a wall or something large object blocks in front of them, making them more confident for navigating without using any kind of heavy cane or equipment to assist them while they are walking. The vibration motion and sound emitted by the device simultaneously react to the ultrasonic sensor, which helps them accurately identify the distance of nearby walls or objects. Lastly, the components that have been used for developing the prototype device are inexpensive. The overall expenses are low, which makes it affordable. It can be affordable for visually impaired people who cannot acquire advanced and expensive equipment usually available in foreign countries.

References

Admin, J.-G. (2018, October 25). Descriptive Research. Retrieved from J-Gate: jgateplus.com/home/2018/10/25/descriptive-research/

Ainsworth, Q. (2020, June 1). Data Collection Methods. Retrieved from JotForm: https://www.jotform.com/data-collection-methods/

Bhasin, H. (2019, March 27). Types of interviews in Qualitative Research. Retrieved from Marketing91: https://www.marketing91.com/types-of-interviews-in-qualitative-research/

Brogan, J. (2016, February 2). What's the Deal With Algorithms? Retrieved from Future Tense: https://slate.com/technology/2016/02/whats-the-deal-with-algorithms.html

Busbee, K. L. (2018). Flowchart. Retrieved from Rebus Community: https://press.rebus.community/programmingfundamentals/chapter/flowcharts/

Chappelow, J. (2021, February 18). Statistics. Retrieved from Investopedia: https://www.investopedia.com/terms/s/statistics.asp

Crossman, A. (2020, March 19). Understanding Purposive Sampling. Retrieved from ThoughtCo: https://www.thoughtco.com/purposive-sampling-3026727/

Deckelmann, D. (2020, February 13). What is a Likert Scale, and How do I Use it? Retrieved from Livesurvey: https://livecusurvey.com/likert-scale-definition/

Derricott, B. (2014, July 16). The Biggest User Interface Design Mistakes. Retrieved from Pannam Imaging: https://www.pannam.com/blog/the-biggest-user-interface-design-mistakes/#Derricott

Dickson D., E. K. (2018). Theoretical and Conceptual Framework: Mandatory Ingredients Theoretical and Conceptual Framework. 438.

DOH. (2017, August 6). Public Told: Protect your eyes from Blindness: DOH press release/ 06 August 2017. Retrieved from Department of Health: https://doh.gov.ph/node/10735

Frankel, J. (2019, February 27). Calculating Frequency Distribution in PostgreSQL. Retrieved from Development SImplified: http://joshfrankel.me/blog/calculating-frequency-distribution-in-postgresql/

Grusin, M. (2010, Nov 17). How to read a Data Sheet. Retrieved from SparkFun: https://www.sparkfun.com/tutorials/223

Jansen D., K. W. (2020, December 21). Quantitative Data Analysis 101: The lingo, methods, and techniques, explained simply. Retrieved from GradCoach: www.gradcoach.com/quantitative-data-analysis-methods/

Lowth, D. M. (2016, October 3). Retinal Detachment. Retrieved from Patient: https://patient.info/doctor/retinal-detachment-pro

Lynch, W. (2019, July 16). Use Case Modelling. Retrieved from Warren Lynch: https://warren2lynch.medium.com/use-case-modeling-e314b9eee0ba

Martin C., H. L. (2017). Technology and innovation for the future of production: Accelerating value creation. World Economic Forum, 9.

Morse, A. R. (2019, May 30). JAMA Ophthalmology. Retrieved from Jama Network: https://jamanetwork.com/journals/jamaophthalmology/article-abstract/2734213

Peterson, Z. (2019, August 26). What is a Circuit Schematic. Retrieved from NWES: https://www.nwengineeringllc.com/article/what-is-a-circuit-schematic.php

Regoniel, P. (2017, February 12). Research Design: A simplified definition for beginning researchers. Retrieved from simplyeducate.me: www.simplyeducate.me/2017/02/12/research-design/

Sabale, R. G. (2012). Comparative Study of Prototype Model For Software Engineering With System Development Life Cycle. *Journal of Engineering*, 22.

Sharma, A. (2020, May 12). Decision Tree vs. Random Forest - Which Algorithm should you use? Retrieved from Analytics Vidhya: www.analyticsvidhya.com/blog/2020/05/decision-tree-vs-random-forest-algorithm/

Sherman, S. W. (2014). Medical Technology. *Journal of the Medical Association of Georgia*, 4.

Upasana. (2020, November 25). Decision Tree: How to create a perfect decision tree? Retrieved from edureka: www.edureka.com/blog/decision-trees/

WHO. (2019, October 8). Blindness and vision impairement. Retrieved from World Health Organization: https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment