Heuristic evaluation of User-Centered Design Obstacle Detection and Avoidance

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Abstract

Navigation is a part of our daily lives and it is a tedious task for the visually impaired as they are unable to use their vision to identify obstacles and the layout of their environment. Accurate guidance and detection of obstacles through audio is required to allow these individuals to carry on their lives much more safely. Identifying the problems that the users face is of great significance to produce a product that can achieve our goal. This paper briefly describes the methods that are used to develop a simplified heuristic evaluation (HE) suitable for the evaluation of our Obstacle Detection and Avoidance(ODA) system, creation of an HE instruments used in the evaluation, and the results of the evaluation of the prototype that has been mentioned previously. The paper also shows how we categorize problems identified through the HE and the solutions that have been created to resolve these problems. A total of three usability experts reviewed our prototype and provided feedback so that further improvements were made. The heuristic evaluation that had been implemented for this paper was direct and inexpensive.

Keywords: Obstacle avoidance, Visually Impaired, Heuristic evaluation, White cane, Real-time analysis

1.0 Introduction

The approximated population in the year 2020 is an astonishing amount of 7.79 billion people and out of the 7.79 billion people, there is an estimated amount of 49.1 million that are blind which has increased by 14.7 million people since the year 1990 [1]. Vision is considered an one of the most important senses of the human body because it plays an important role in our daily lives as we require vision to determine our own position and direction and also the relative location of obstacles and dangers in the surrounding and thus, a loss of vision brings about severe effects to our ability of completing these tasks [2,14].There are two processes in navigation, one is collecting information through visuals about the surroundings and the second is to be able to update where an individual is continuously throughout the navigation[9]. The inability to avoid obstacles would make them feel useless or even put them in harm's way[8].

The blind individuals in our community will have to face challenges when trying to navigate themselves in their daily lives such as navigating around in a building where they cannot obtain information on where to go and this discourages them from going out by themselves [3]. Various attempts have been made to help these individuals overcome their difficulties in navigating themselves such as navigation tools that are able to help them and also programs such as the orientation and mobility (O&M) program which allows the individuals to learn how to use the white cane and also sensory compensation to enhance their lifestyle[2,3,13]. Visually impaired individuals use O&M skills in order to help in the process of travelling unfamiliar environments and also for safer navigation[10]. Retinal implant technology has also been used in order to induce visual perception through the usage of electrical stimulation of the retina with implantable micro-electrode arrays[15].

Over the century, there have been various prototypes of electronic travel aids (ETA) which were worked on by the researchers caused by the rapid development of radar and sonar systems that apply the same concept during the Second World War [2]. One of the various ETA developed is a Global Positioning System(GPS) based device that acts as a localization aid for the users[12]. In Malaysia, the St Nicholas Home has come up with a mobile application that is known as 'ViNV' and it is a Bluetooth beacon-based navigation system that provides audio cues and visual guidance to the users as they enter a building that is equipped with a beacon and this initiative is supported

by the Penang Island City Council as they are sensitive towards the different needs that are present within our society [4]. The mayor of the Penang Island City Council has said that all local government and Malaysian Authorities of Local Authorities are committed to provide equal rights and opportunities in all aspects of life for the people with disabilities and also prioritise the provision of better and more user-friendly facilities that are in line with the government's goal of providing a better place of living for those with special needs [4].

Therefore, it can be seen that our government is supportive of these types of initiatives and it is aligned with their goal of providing a better living space, equal rights and opportunities for the whole community. In the following section, the prototype is described briefly and followed by reviews given by the experts. Further revision is then made to the prototype to achieve our goal to provide accurate guidance and obstacle detection in real time for the safety of the users.

2.0 Method

2.1 Empathy Map

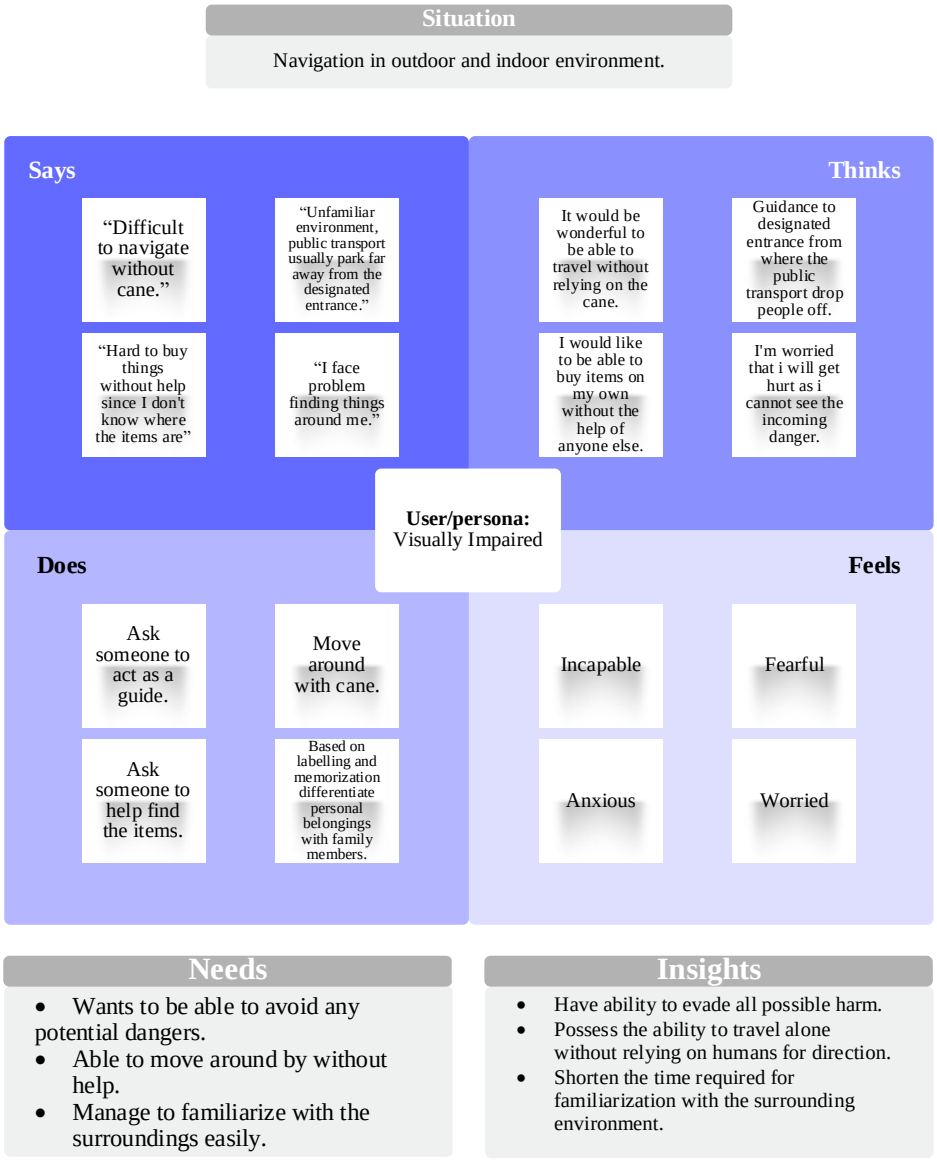

Figure 2.1 Empathy Map

Through the empathy map above, we are able to see what the users say, think ,do and also what they feel. The empathy map was created by collecting data from the users through an online survey. It clearly shows what the user wants and the methods that we can use to fulfill their needs. The users desire the ability to avoid any potential dangers, to move around individually without help and also familiarize themselves with the surroundings easily. Hence, insights were obtained from their desires and turned into functions that should be included in the prototype.

2.2 Heuristic Evaluation

Heuristic evaluation is a system in which experts use thumbs rules to test the usability of user interfaces in separate walkthroughs and report problems. It is a fast yet practical way to handle problems and make decisions. Through Nielsen-Molich heuristics, it states that a system should contain a checklist of criteria to identify the flaws of the design that the team might have overlooked [5].

We decided to use Nielsen's heuristic evaluations as it has been applied in the evaluation of other designs besides websites[7]. We decided to use it for our project as it is a powerful tool to measure a design's usability. There are many benefits that can be ripped off through heuristic evaluation. By using this method, the evaluation is specifically evaluated on each issue, it helps us to identify whether we have overlooked something that might be important. Besides, heuristic evaluations can help us to detect faults with individual components early on and evaluate whether it affects the overall user experience. Furthermore, as we are getting evaluation from experts, we will have better and practical feedback to lead the way to the desired solutions.

The heuristic evaluation will be carried out by providing our experts with the screenshots of our prototype in action. They will be given a scenario based on the screenshots and are then asked to rate it according to the scale that we have provided.

Below is the checklist of the heuristic evaluation.

Table 2.1 Heuristic Definition

Heuristic	Definitions
Visibility	The user should be able to view their own status.
Feedback	The user should receive an appropriate message for their actions.
Control	The user should be able to control when to use their product.
Language	The language used should be understandable for the user.
Prevent errors	The system should be able to avoid situations that cause errors.
Memory	The user should be able to use the system without memorizing anything.
Flexibility and efficiency	The system should be able to adapt to any situation and complete the task efficiently.
Minimalist	There should not be any excess data that is not related to the current task of the system.
Error messages	The user should receive messages when an error occurs.
Documentation	The system should have instructions that are easy to access.

The heuristics above were decided based on what Nielsen-Molich heuristics stated a system should have[5]. They were then modified by classifying them and providing them with their own respective definitions that are suited for our evaluation. Ratings will be given by our experts which determine the severity of the problem in our prototype according to the scale provided below.

Table 2.2 Severity Rating

Severity Rating	Definition
0	I don't agree that this is a usability problem at all
1	Cosmetic problem only: need not be fixed unless extra time is available on project
2	Minor usability problem: fixing this should be given low priority
3	Major usability problem: important to fix, so should be given high priority
4	Usability catastrophe: imperative to fix this before product can be released

Nielsen [6].

Before we move on to evaluating the prototype, our group has to first review the heuristics and decide which heuristics are actually suited for it. The heuristics that were chosen by our group are what we considered as the most important aspects that our prototype should fulfill. After the relevant heuristics have been selected, scenarios were created for us to observe whether the product has any problems in terms of usability. The scenarios are a collection of slideshows that have narration which will show how the ODA system will be implemented and used in the lives of our users and the experts will provide comments on problems they find throughout the scenarios based on the relevant heuristics that have been identified. We have chosen three experts to help us in our heuristic evaluation in order to find any major usability issues that might exist without us noticing.

The experts are provided with instructions in the form of a note and once they have understood the instructions, the evaluation sheet was given to them to state any usability issues that they might have found throughout the scenario, comments on the problem found and also rate the severity of the problem according to the scale provided above.

3.0 Results and Discussion

3.1 Relevant heuristics

Table 3.1 Reviewer Choice

Heuristic	1	2	3
Visibility			
Feedback	x	x	x
Control			
Language	x	x	x
Prevent errors	x	x	
Memory	x	x	
Flexibility and efficiency	x	x	x
Minimalist	x	x	x
Error messages	x	x	x
Documentation			x

As shown in the table above, the heuristic evaluations that we choose are feedback, language, flexibility and efficiency, minimalist and Error messages. These are the evaluation criteria that we think matter most for our design. The evaluators were then asked to evaluate the scenarios based on this list of heuristics chosen.

After the session with experts, we acquire tons of advice and feedback from them. It definitely helps us improve our design and helps us to identify our major problem that should be taken care of. As we are dealing with vision impairment individuals, the feedback and language is the most important tool in order for the cane to communicate with the user. Moreover, since the cane is used to detect obstacles that might be harmful to the user, they must be equipped with a flexible and efficient system that is prepared for adapting to different situations. We should minimize the complexity of our system too. As the user will be using the cane for his daily

activities, it is better to keep the system simple to prevent acquiring an excessive amount of data for the user when using it. Lastly, Error messages are our priority too. Error messages such as battery low should be implemented to warn users. Since they have trouble with their vision, error messages become more important as they are unable to identify whether the cane is functioning or malfunction.

Table below shows the experts' concern and advice for our system :

Table 3.2 Heuristic Evaluation of Experts

No.	**Problem**	**Heuristic category**	**Severity rating**
1	Limitation of language	Language	3
2	Limitation of detecting moving objects like balls	Flexibility and Efficiency	3
3	Inability to provide error message when error occur	Error messages	4
4	No notification for battery low or no battery	Error message	3
5	Should get feedback to blind people like what he should do after he meet obstacle	Feedback	3
6	User might accidentally turn off stick	Feedback	1
7	Change the audio feedback of "Unable to detect obstacles"	Language	3

After the evaluation from the experts, there are 7 problems that must be taken care of. Almost all of the problems have a high severity rating which are 3 and only 1 problem is considered low. The figure below shows our prototype.

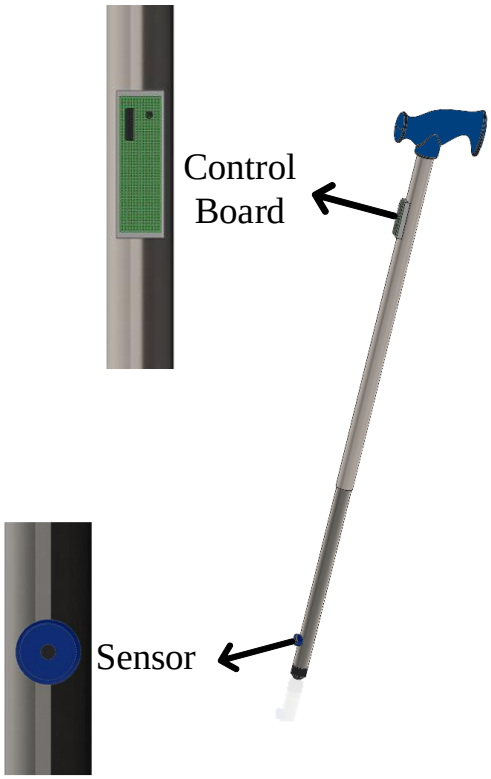

Figure 3.1 ODA White Cane

The ODA White Cane has built in sensor with control board. The control board has an on/off button on it which can open and close the ODA system. The sensor is help visually impaired to detect the in front obstacle. It is an infrared-enabled depth sensor which able to detect the surroundings and obtain message from the surroundings regarding obstacles that are present [11].

For problem 1, experts are concerned about the limitation of language provided by the cane. Despite the user having their own preferred language, the cane seems like it lacks a setting that is able to change the language freely. This limitation is a big concern for visual impairment users. For our system, we initially design an inbuilt language and the user will not need to set it for himself. However, that approach is not suitable as it is not user friendly. The experts comment that the visual impairment individuals might lend their cane to their friend who might also suffer from visual impairment, a foreign language certainly makes the work hard for them.

Continuing with problem 2, limitation of detecting moving objects such as balls. According to experts, a moving object is more dreadful than a stationary object. However, the system that we

currently use did not prioritize the object that cane should be detecting. This will cause unwanted injury and the system will not be able to function according to its goal which is to provide safety to the individual. Hence, it is a problem that should be prioritized to enhance the system so that users will be more reassured to use it.

For problem 3, the cane is unable to provide a constructive error message when error occurs. When an error occurs and makes the cane unable to function properly, an error message using audio voices will be sent to the Bluetooth earphones to notify the user. However, the error messages are not constructive enough. Visual impairment individuals will still have a hard time to fix the error and thus the cane's system will render useless. One of the aims of the cane is to provide safety for users when there is no one that is able to help them. If an error suddenly occurs, the user will not be able to fix it by themselves. Hence, it is certainly a problem that should be avoided.

Moving forward, problem 4 is the notification of battery status. When we did our prototype, we did not account for the battery status and that is a major mistake. We certainly do not want the battery to die out without notifying our user.

Another problem stated by the experts is the cane did not instruct the user how to handle the situation when an obstacle occurs. If the system has a slow response toward fast objects, the user will certainly be in danger. Hence, it is better to instruct the user how they should react rather than notifying. It will greatly improve the performance of the cane system.

Moving on, experts point out that the user will not realize that they have accidentally turned off the cane detection system. It might not be important at first glance since the severity rating is only 1. However, we realize that a user that relies much on the detection system might not be able to react when a danger is approaching him if an external factor accidentally turns off the cane. Hence, the problem is certainly a major concern and should be improved as soon as possible.

Lastly, Experts suggest we change the audio feedback of our cane. For example, "Unable to detect obstacles". For this command, it is to notify the user that there are no obstacles. However, the user might misinterpret it as faulty or the system has malfunctioned. Thus, it is better to change the audio feedback for better user experience.

3.2 Solution

No	Problem	Solution
1	Limitation of language	Implement additional button for toggling main languages
2	Limitation of detecting moving objects like balls	Cane should prioritise moving objects first
3	Inability to provide error message when error occur	An error message should appear to notify user and provide them the nearest repair center
4	No notification for battery low or no battery	Implement audio feedback to notify users about battery status
5	Should get feedback to blind people like what he should do after he meet obstacle	provide instant instruction instead of giving the information about the obstacle when a fast moving object approaching
6	User might accidentally turn off stick	An audio feedback will tell the user to press the power button again to turn off
7	Change the audio feedback of “Unable to detect obstacles”	Change to “No obstacle detected”

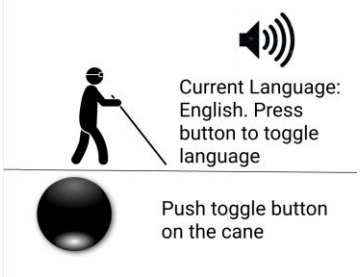

Figure 3.2 Solution of the First Problem

A button is installed to toggle language

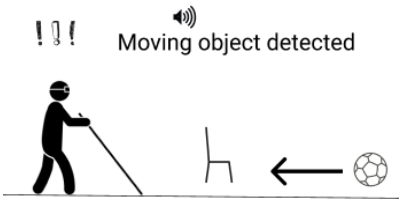

Figure 3.3 Solution of second problem

The cane will notify the user about the moving balls first instead of stationery chair

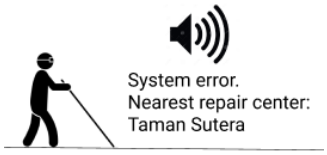

Figure 3.4 Solution of the Third Problem

The system will notify the user for the nearest repair center when system malfunction

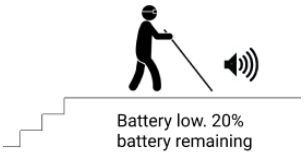

Figure 3.5 Solution of the Fourth Problem

Notify the user when the battery low

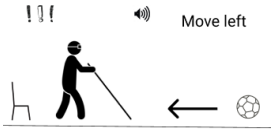

Figure 3.6 Solution of the Fifth Problem

When a fast moving object approaching, the cane call user to move left instead of telling there is an object

Figure 3.7 Solution of the Sixth Problem

Prompt the user to press the power button again

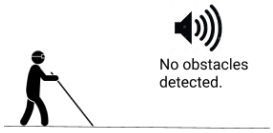

Figure 3.8 Solution of the Seventh Problem

*Change audio feedback to "**No obstacle detected**"*

4.0 Conclusion

Heuristic evaluation is a well-known usability testing approach that needs experts to assess the user experience (UX) design and product's usability. Basically, our product lets visually impaired have a chance to improve their life by using technology. The visually impaired are neglected due to public lack of awareness to them in our lives. By exploring the intersection of design, technology, and accessibility, Obstacle Detection and Avoidance has been designed to solve the problem of visually impaired. Since the visually impaired have not a good eyesight, this product - Obstacle Detection and Avoidance (ODA) is mainly focused on user experience (UX) design. ODA is able to detect the obstacle in front of the visually impaired and it will give some audio feedback in certain conditions. Through this evaluation method, experts have pointed out some room for improvement of ODA. The findings of this paper explore the challenges and problems experienced by the people of visually impaired when during indoor navigation. This paper has also provided the solution for the problem which experts have evaluated.

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