VISUAL ASSISTANT HAT

THE PROMOTION OF INDEPENDENCE AMONG VISUALLY IMPAIRED COMMUNITIES: EXAMINING CAUSES OF LIMITED ELECTRONIC AID ACCEPTANCE

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Challenges of Visual Impairment

Visually impaired people face several issues with everyday tasks that non-visually impaired people do not face. These tasks range from simply walking around their homes, to operating a vehicle. According to the World Health Organization, 43 million people globally face blindness, while an additional 295 million people experience some sort of visual impairment (Bourne, 2021, n.p.). The issue of visual impairment is incredibly widespread and is on the rise, in fact, it is anticipated for the population of affected people in the United States to double by 2050 (Bourne, 2021, n.p.). Visually impaired people struggle with daily life tasks, some as simple as path finding, which, in turn, results in "negative changes" in their lives, both in regards to socializing and economic status (Bassey, 2020, n.p.). Studies show that people who are visually impaired tend to report a "decrease[d] sense of independence", which leads to "low self-esteem" (Bassey, 2020, n.p.). Other studies, as done by Wahl (1998, n.p.), show that such implications also result in higher reports of depression and decreased participation in leisure activities. Ultimately, this leads to faster medical and social decline as well as reduced income among the visually impaired population, as opposed to those who do not face issues with vision (Jacobs, 2005, n.p.). In response to the problems visually-impaired people have with path finding, my capstone team will develop an obstruction detecting hat to provide these users real-time feedback regarding their surroundings in order to promote greater independence in completing daily tasks. From a sociotechnical perspective, existing literature must be used to assess the relative merits and shortcomings of existing visually assistive devices, primarily in the wearable technology domain, in order to better understand what determines the ultimate acceptance and use of these devices.

The Development of an Obstruction-Detecting Hat for the Visually Impaired

Devices that gather information about a user's environment via sensors and then relay this information to the user are considered "electronic travel aid[s], ETAs" (Elmannai, 2017, n.p.). The creation of sensor-based obstacle detecting technology for the visually impaired, especially in the wearable technology domain, is not a novel idea, however there are several issues with existing models. Many existing systems are too complex for users to use easily or lack everyday functional utility as they are "bulky" and "difficult to hold" (Dakopoulos, 2010, p. 30). In relation to the feel of the device, the perceived aesthetics of the device also play an important role in influencing whether or not it will be used (Piculo dos Santos, 2019, n.p.). Additionally, many existing devices only consider obstruction detection from a user's front side, failing to give the user a full understanding of their surroundings by considering their left, right, and back sides (Elmannai, 2017, n.p.).

From a more technical perspective, many existing devices use ultrasonic sensors, which emit ultrasonic sound waves to compute the relative distance of objects, to detect obstructions ("What is an Ultrasonic Sensor"). One notable device is the Smart Cane, which functions like typical blind canes, but uses ultrasonic sensors to detect obstacles and speakers to relay notifications to the user. For user's who may be auditorily impaired, the device makes use of special gloves that provide different types of tactile feedback on each finger, each signifying a different message (Wahab, 2011, n.p.). Another commercial device is the iGlasses Ultrasonic Mobility Aid, which uses ultrasonic sensors and gentle vibrations to indicate obstructions ("IGlasses").

These devices, however, have many issues. In terms of the Smart Cane, the device lacks everyday utility as it requires the user to hold it in the correct orientation at all times. The audio feedback provided by the device is also given too far from the user's ear, as it comes from the cane itself, leading to the risk of the user potentially not hearing the warnings. Further, the use of different vibrations on each finger to specify different messages is overly complex and may lead to confusion. Regarding the iGlasses, this device is unable to detect drop-offs or inclines in paths. Ultimately, both the Smart Cane and the iGlasses fail to give the user feedback on obstacles that may be on either of their sides or coming up from behind as well.

Thus, despite the fact that the goal of such visually assistive devices is to make people's lives easier, many people choose not to invest in them due to these described weaknesses and associated affordability concerns (Kan, 2021, n.p.). Since these devices are dedicated to improving the lives of visually impaired people by helping to mitigate the challenges they face every day, it is important to address the weaknesses of these devices to promote their increased usage and acceptance.

My capstone group will build upon the existing work done on creating wearable assistive visual devices in order to create a visually assistive hat that should mitigate issues with existing designs, specifically by giving users a fuller understanding of their surroundings. The hat should intuitively provide tactile and auditory feedback to blind and visually impaired individuals based on obstruction detection conducted via two main sensor types – LiDAR and ultrasonic. LiDAR, which stands for "light detection and ranging," is an incredibly powerful remote sensor type that uses light pulses in the form of lasers in order to measure variable distances ("US Department"). Due to the power of the LiDAR sensors, three LiDAR sensors will be embedded on that hat in the locations where obstruction detection is the most important – the front, the brim facing the ground for incline detection, and on the back. Two ultrasonic sensors, which are less powerful, but more affordable, than LiDAR sensors, will be placed on the left and right sides of the hat. All sensors will be connected to a central microcontroller board which should handle all of the input processing and the feedback generation. Using the information provided to the microcontroller via the sensors, vibrating motors, which will be embedded inside the hat, should be programmed to vibrate whenever an obstruction is detected, with their vibration frequency increasing as the object gets closer. Additionally, small speakers will be mounted to the sides of the cap, near the user's ears to provide auditory feedback. The physical layout for the device can be seen in Figures 1 and 2 (Created by Author and Capstone Team). Ultimately the device should be lightweight and provide the user with a fuller awareness of their surroundings.

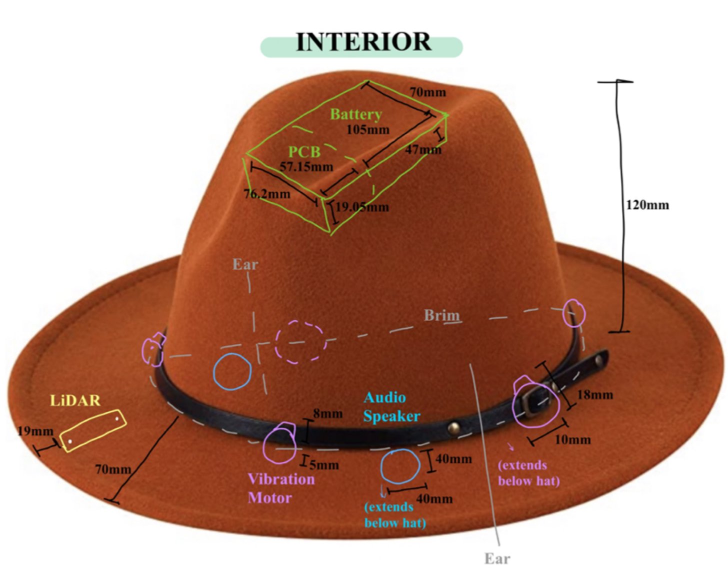

Figure 1. *Interior Overview of Visually Assistive Hat* - The layout of the technical components on the inside of the hat. These components will not be visible from the outside when the hat is in use (Created by Author and Capstone Team).

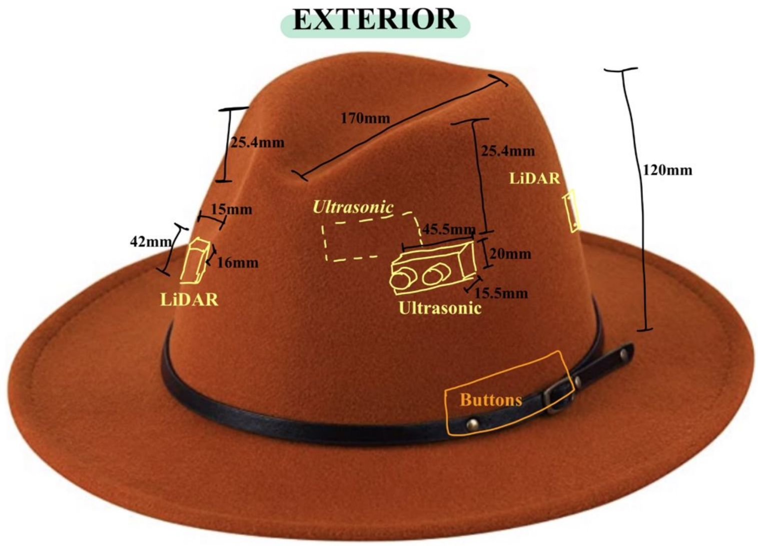

Figure 2. *Exterior Overview of Visually Assistive Hat* - The technical components that will be visible from the outside of the hat, including the sensors and buttons for the user to control the hat (Created by Author and Capstone Team).

Understanding the Merits and Shortcomings of Existing Visually Assistive Wearable Devices and their Relation to Public Acceptance

Although the main goal of ETA's is to help visually impaired people become more independent and promote their social and emotional wellbeing, many people choose not to invest in them. As described by Gao (2015, n.p.), many wearable devices, primarily in the healthcare sector, are dedicated to making peoples' lives easier by mitigating the issues they face due to medically related disabilities. Thus, ETAs can be considered under the medical devices branch within the healthcare sector. Despite having such invaluable purposes, the fact that there is no widely accepted ETA raises the question as to what specific factors impact public acceptance and actual adoption of these devices. It is important to ultimately overcome these issues regarding the acceptance of these devices, so people who serve to benefit from their use actually will.

One possible reason no device has gained widespread acceptance could be that they are too unwieldy and attention-drawing. As stated previously, these devices face much scrutiny over their perceived aesthetics when it comes to determining their actual use in a person's life (Piculo dos Santos, 2019, n.p.). Additionally, existing ETA prototypes are very costly and come with concerns regarding robustness and reliability from a technical standpoint, for example in areas such as battery life (Jafri, 2014, n.p.). Many existing visually assistive devices also undermine the usefulness of "spatial audio technology", which involves relaying messages via accurate auditory cues and has been cited to be immensely useful for feedback generation for the visually impaired (Spagnol, 2018, p. 4).

As a result of these issues, no visually assistive device has been able to gain widespread public acceptance as yet (Spagnol, 2018). As such, the overall public acceptance of visually assistive devices has been hindered and their resulting benefits are being wasted and going unnoticed, while visually impaired people continue to struggle with issues regarding path finding and their own perceived sense of self-reliance (Binyamin, 2020, n.p.). Research done by Fensli (2008, n.p.), and others, has been focused on redesigning frameworks regarding the development of sensor-based wearable technology in a way that promotes user acceptance. Additionally, numerous studies show that the acceptance of medical wearable devices are impacted primarily by concepts such as "effort expectancy," which relates to the ease of use of the device and "performance expectancy," which is the degree to which the device will improve a user's performance in specific tasks (Binyamin, 2020, p. 4-5). Furthermore, other researchers, such as Park (2020), claim that overall user satisfaction and the cost of the device also seems to play an important role.

By studying and more clearly following such framework designs and studies, it will better be ensured that visually assistive wearable devices are designed specifically with the visually impaired population's needs in mind. The methodology I will generally follow for this research can be seen in the flowchart displayed in Figure 3 (Created by Author). Additionally, by studying existing technologies under the framework of Actor Network Theory, I will be able to better understand the intricate relationships visually assistive wearable devices have with both human and nonhuman actors. Ultimately, by building upon related research and existing design frameworks, I can effectively assess the merits and shortcomings of related visually assistive wearable devices and understand what factors impact their overall user acceptance to better increase the chances of my own device gaining public acceptance, while effectively meeting the users' needs.

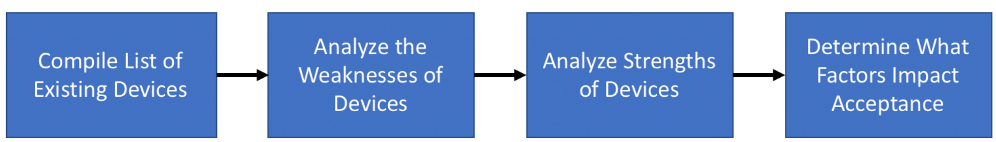

Figure 3. *STS Research Methodology* - The flowchart depicts the general research methodology that will be employed in the conduction of the related STS research (Created by Author).

Conclusion

Through the technical work in my project, I intend to create an obstruction detecting hat for visually impaired users that will provide real-time feedback regarding their surroundings. My STS research is an analysis of the shortcomings and merits of existing wearable technology aimed at helping the visually impaired in order to determine what factors most contribute to the public's acceptance of these devices. If the technical deliverable is successful, visually impaired people can experience an increased sensation of independence as they will have access to an intuitive device that will give them a more thorough understanding of their surroundings. Such impacts can serve to improve their overall emotional and social wellbeing as well. If the STS deliverable is successful, the acceptance of wearable devices that aim to help people in need can increase as these devices can be designed in a manner that more specifically considers user acceptance.

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