Seeing for The Blind: The OptiGlass

A Novel Device That Uses Echolocation and Machine Learning To Give The Blind Access To Greater Mobility

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EXECUTIVE SUMMARY:

This patent-pending invention uses technology to give the blind a greater understanding of their surroundings so they can have increased mobility. Our device uses an echolocation system to locate objects in the vicinity of the user and alert them by outputting sound and vibration. The device also has an object identification system that uses a deep learning neural network to identify the name of an object or text and repeat the name back to the user. With both systems, the user is able to understand what objects are around them and where they are in relation to them, which allows them to have a greater sense of orientation. The device must also remain cost-effective, portable and accessible. With the completion of the project, the goal is to help the visually impaired navigate in a real environment.

1. THE PROBLEM:

285 million people are legally blind worldwide. Legally blind means that one's vision is weaker than 20/200 with eyeglasses or contacts on. They also may lack depth perception, peripheral vision, or even have splotches in their vision. 39 million of this group are fully blind, meaning that their retinas are degraded to the point at which they are unable to perceive light and create an image in their mind (Hellem, 2017). Regardless of the condition one may have, they experience significant difficulty with navigating their surroundings.

There are already some solutions in place to help assist the blind, including human guides, dog guides, canes, orientation and mobility therapy, and even placement into a care facility. However, there are several flaws with these solutions, including a lack of distance perception, fatigue for the user, limited range, high prices, a lack of independence, inaccessibility, a lack of portability and the fact that these solutions do not specifically tell the user what the objects in front of them are. There also exist some high-tech solutions, including smartphone apps that identify objects through the camera, and devices that use infrared or sonar to alert the user of any obstacles. However, these devices do not give the blind a full comprehensive understanding of their surroundings, nor are they compact or convenient (Rosenthal & Kelley, 2001). Thus, a new device must be created that can tell the user what objects are around them and where they are in relation to them, while being compact, wearable and easy to use for the visually impaired user.

With one of their senses dysfunctional, the other four senses – specifically touch and hearing - are available to be used as a means of conveying information to the blind. Because a blind person has more heightened senses, he/she will be more sensitive to touch and hearing (Miller, 2017). Thus, incremental changes in perceived touch and hearing can be used to convey information. This device takes advantage of this fact and alters auditory and tactile outputs to convey distance to objects.

2. CUSTOMER PROFILE:

As of right now, there are 285 million people who are blind (including those who are legally blind and have blurry vision), and 39 million people who are fully blind, meaning that they cannot see at all. This product is aimed at both legally and fully blind users and is especially directed towards people who have become blind after birth. Those who have become blind after birth understand normal sight-based reactions, and therefore the *OptiGlass* will be a natural extension to them more than it would it be to a person who has never experienced sight. The *OptiGlass* provides the customers with a better sense of navigation, thereby greatly easing their lives.

3. THE SOLUTION

a. Solution Overview

This device must be able to give the user information on their surroundings so that they are able to navigate with ease. In order to create a fully comprehensive understanding of the objects in a user's surroundings, the device must be able to find where the objects are in relation to the user, and what those objects are. The device is able to do using two systems: the echolocation and object identification systems.

In the echolocation system, the device uses a sonar placed on a pair of glasses and shoes, that works to determine the distance between the user and any obstacle in front of them. This distance measurement is then processed by an Arduino microcontroller, which interprets the data and returns a corresponding output either in the form of sound or vibration. As the user walks toward an obstacle, the pitch and frequency of the sound and the intensity of the vibration is increased to alert the user that they are nearing an object. This system allows the user to understand where objects are in relation to them. However, the user does not know what specifically these objects are. This is the role of the object identification system.

The object identification system uses a camera to take a photo of the user's surroundings on their request. The image is then sent to a raspberry pi, which analyzes the photo in a deep learning neural network. The algorithm identifies the object or text, and the name or text is read back to the user through an earphone. The combination of both systems allows the user to fully understand their surroundings, by knowing where and what objects are around them.

b. Methods

When building the echolocation system, there was a specific design process followed, the first of which includes deciding the position for where the sonar should be placed. The first option is on the white cane. While this is a useful solution, it would be hard for the user to perceive the distances to the objects as the field of vision is constantly moving. Additionally, this does not solve the problem of fully eliminating the cane, as the user is still dependent on it. The second option is a handheld device. It does seem intuitive to have the device be a small box that can fit in the hand, or even on the back of a smartphone, however the person will only have one hand free, and having something that is not on your body makes it easy to lose. And because they are blind, if they put the device down and try to pick it up later, locating the device is not easy for them, even if it is inches away from their fingers. Another option is on the waist. It seems simple enough to keep the sonar on the waist as it is the optimal height for having a single viewing angle. However, it is not intuitive for the blind to “see” from their hips. The final option is at eye level. This is the best location for the sonar to be placed, as when placed on glasses, it is in a good angle for viewing. Wearing the product on glasses is also comfortable for the user, and is not giving them any additional load, as many of the blind wear glasses anyways. Also, this method is very intuitive, especially for those who became blind after birth. They are already used to seeing from eye level, so having the source of artificial sight at eye level would make it easier for them. While this viewing angle only reports on objects at eye-level, this can be corrected by building the same system on the shoes for ground-level.

Another choice is choosing a method of portraying distance. For the case of eye-level measurement, sound is selected. This is due to a human’s strong auditory sense, which is especially heightened in the visually impaired. A series of “beeps” in an interval are given off, where the pitch of the beep is modulated based on the distance measurement. Beeps are used rather than having one continuous sound, because it will be easier for the user to distinguish pitch. Additionally, having beeps allows for another way to convey distance, as the time between each beep (or the frequency of the beep) can be altered. The sound output is given off through an earphone. The user will have one earphone in one ear and keep one ear free to listen to the surrounding environment. For the case of ground-level measurement, tactile senses are used, and are given off in pulses for the same reason as why sound and ‘beeps’ are used in the eye-level model.

For the ground-level measurements, the sonars are placed on both pairs of shoes, rather than just one, and the reported distance from the user to the obstacle is the average of the two measurements (the center of your body is normally halfway between your two feet). When the user takes a step with one of their feet, an onboard accelerometer detects this movement and cancels out the measurements from the moving foot and reverts to the measurement of the stationary foot. If both feet are moving, the last known measurement is used. This allows the measurements to be more accurate. When finding the optimal angle to place the sonar on the shoes, calculations are made such that the field of view will not measure the ground. Because the field of view is a cone, one side is defined to have a straight line. That straight line is the bottom of the field of view and is positioned to be exactly 1 centimeter above the ground. Using trigonometry, the optimal placement of the sonar is found to be 3.5 degrees. The sonars and accelerometers fit on a rig, which is attached to the shoe by Velcro, so it can fit any user’s shoe size.

c. Tests

Informal tests with users indicate that when wearing the device, blind users are able to use the feedback from the sonar to locate objects in front of them. In tests, users are able to navigate through a hallway or room and identify the walls and people in the vicinity using the echolocation system. They have also used the object identification feature and have found it useful to understand what objects are in their vicinity.

4. REVENUE MODEL

a. Primary Revenue Streams

Most of our revenue will come from selling the product directly to customers. This will be done through third party online retailers such as Amazon. The customer will purchase the product through the retailer, giving Seeing for the Blind 85% of the retail price in revenue. The customer will pay for their own shipping, which will cover the cost to ship the product from the factory to their residence, so shipping costs will not be incurred by the company.

b. Unit Variable Cost

In order to create one pair of glasses, nine total items are required. In the prototype, the following items were used. First is the Arduino MKR1000, which is a microcontroller, and costs $18. Second, the product needs three sonars, which will be used to measure distance, and cost $2.97 total. Thirdly, there needs to be a headphone jack, which will provide auditory output and costs $0.30. After that, jumper cables are needed to connect the sensors, costing $2.99. It also needs two accelerometers, which cost $8.54. Two belt pouches are also necessary for storage, costing a sum of $8.56. Penultimately, the Arduino MEGA is as a secondary microcontroller, and costs $12.99. The *OptiGlass* also needs a Vibration motor and camera, which cost $2 and $7 respectively. Finally, the *OptiGlass* requires a Raspberry Pi computer module, which costs $5. Our product, in the prototype phase, totals to $60.35, however, once our company expands, we plan to create a production version, resulting in a lower overall price for each individual pair of glasses. According to our calculations, the cost will go down by 83.4%. The expected cost will be around $10 dollars for the production model.

c. Product Selling Price and Unit Profit Margin

One unit of the *OptiGlass* will sell for $195, a price we have decided due to both the assets that our product provides and comparison to competition. Many other sources of competition sell products that assist the blind for around $150. This includes the *iGlass (retail price $166),* which only uses tactile feedback and infrared to alert the user of possible obstructions. Another solution is *VoiLa (retail price $145),* which is a label reader that can readback the names of certain objects, but requires the user to personally place labels on the objects. *Optiglass* is a product that exceeds other competitive products by telling the user both what objects are, and where they are in relation to them, rather than one or the other. Because this product is more premium than its competitors, we can charge more than $150, but we still want this to be an affordable solution. Therefore, a price of $195 is ideal. With a production version of this product that sells for $195 dollars, our unit profit margin will be $155.75.

d. Development Cost

It will cost an estimated $50,000 to hire a team of engineers to develop a compact production model. This includes the design process of the model, and the contracting cost of a company to develop the physical production ready model.

e. Operating Cost

For the production of the model, it is expected to be $10 per unit. When selling the product, it will be sold through an online retailer such as *Amazon.com*, which typically charges 15% of the price of the product. This means that the operating cost is defined by the equation:

$$\begin{aligned} &Operating\ Cost \\ &\qquad = (unit\ production\ cost \times number\ of\ units) \\ &\qquad + (15\%\ of\ selling\ price \times number\ of\ units) \end{aligned}$$

$$Operating\ Cost = 10x + 29.25x \quad \textit{where x is the number of units}$$

f. Breakeven

Our profit is defined as the revenue minus sum of the operating cost and development cost. In other words, profit is defined as:

$$Profit = 195x - (50{,}000 + 10x + 29.25x)$$

According to our equation, we must sell 322 units in order to break even.

5. TEAM

Arunima Saxena is a product manager and marketer for the company, and she is also the team leader. She has participated in entrepreneurship competitions, in which she has won first place awards. Her interests include interacting with others and making connections. Sidharth Anantha is also a product manager, however he deals more with the engineering. He is the only other team member, and has taken the product to several invention competitions, where it has won first place multiple times. He likes to spend his time inventing things.

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