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BAT (Blind Assistive Technology) - Project Proposal

Problem:
Lack of effective, affordable, and convenient technology to aid those with visual impairments.

Background:
Phineas' grandfather is losing his sight quite rapidly. His family has been struggling to find technologies that could help him do things even as simple as move around without assistance. Although there are devices out there more complex than a simple cane, they are costly, difficult to operate, and can be intrusive. We feel like there should be something that can be done to help him and countless others like him, and feel that this project would be a good way to do that.

Significance:
More than 3.4 million Americans alone are either legally blind or are visually impaired. The technologies available to the visually impaired are either very primitive, such as canes, or too complicated to be practical. Finding an inexpensive middle ground would enable us to help countless people across the world and greatly improve the quality of life of people with visual impairments. Additionally, this could help contribute to a market for blind assistive technology that hasn't really previously existed.

Current Research/Development:

Currently, Light Detection and Ranging (LiDAR) systems are employed by self driving cars for obstacle detection. At its core, LiDAR is a laser scanner that measures distance using the time elapsed for a beam to hit a surface, reflect, and return to the sensor. However, in order to generate a point cloud of distances, the sensor must be mounted on a motor and use an IMU to get orientation data (Agarwal).

Solid-State LiDAR systems are an emerging technology. One method makes use of a powerful light source to flash across the entire scanned environment. To prevent damage to human vision, these light sources must be outside of the visible-light range (Mokey). Conventional silicon imagers are unable to detect these non-visible wavelengths, so more exotic semiconductors must be used, significantly raising prices.

Another method of creating a solid-state LiDAR system is to follow the route of radar and its phased arrays. Using an array of light emitters and controlling their phase, it is possible to sweep a beam across a surface (Liu et al.). This option is the most tempting LiDAR system to use in our project, but the costs (in the hundreds) and size still leave much to be desired.

Thus, we look to the less complex version of LiDAR— Time of Flight (ToF). It's essentially a one-dimensional LiDAR sensor that doesn't use motors and an IMU to rotate.

Usually, ToF sensors are used when the accuracy or field of vision of a LiDAR system are unnecessary. Since they are cheaper and less capable, ToF sensors are used for distancing in less hazardous, demanding applications like topography and robot navigation (Corrigan).

Given these applications, we feel that ToF will be a viable substitute for LiDAR and that we will be able to carry out our project using ToF based systems. In addition, ST electronics has made compact, short range ToF sensors that we could utilize in our project. Sensors such as this have been combined with haptic feedback to accomplish similar goals (Katzschmann et al.), but we feel like we will be able to modify these techniques in order to make this device implementable in a greater variety of situations.

Application Potential:

The product that we have in mind would be for use in the home in order to better navigate around obstacles that would be a problem for people with visual impairments. These obstacles would include both stationary objects (ex. furniture) and mobile objects (ex. other people). It could be extended to work in outdoor spaces and account for moving objects such as automobiles.

Objectives:

Develop an assistive technology for the visually impaired capable of doing the following:

1. Detecting objects within 3 meters of an individual (radially outward, at least 180 degrees of horizontal range) and alerting the user of both the presence and general location of the objects using haptic feedback systems
2. Being able to detect changes in elevation (ex. stairs) in order to prevent falls
3. Being wearable in a way that is not burdensome to the user
4. Being affordable (target price of $200 or less)

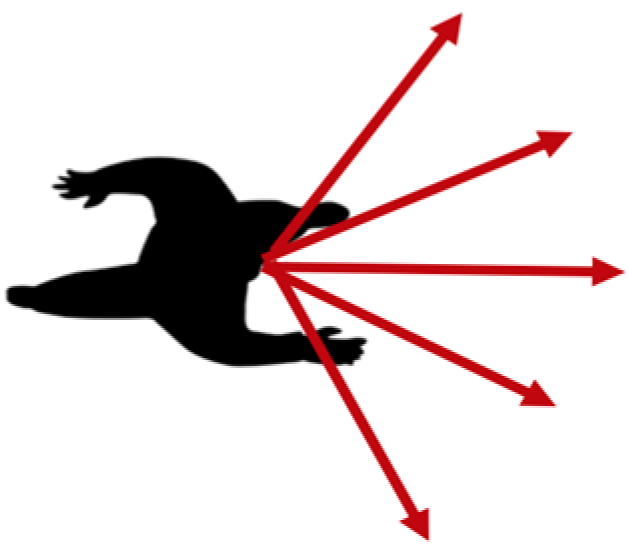
Approach:

Both methods of solid-state LiDAR are too complicated to be replicated given our time constraints. We plan to create our own mechanical LiDAR system using an array of motors, IMUs, and ToF sensors. The motors would spin the ToF sensors to give them the capability to scan in a 2D plane, and the IMUs would provide orientation data of the sensors to help generate the distance point clouds. With this information, we would be able to code methods similar to the ones implemented by LiDAR based systems. We must account for the fact that the sensor will only scan in one plane. In order to do so, we will either place the sensor in a position on the body that will account for the most obstacles, or place multiple sensors at different points on the body. We will most likely do the latter, with at least one sensor oriented downwards to detect changes in elevation and one sensor oriented straight ahead to detect any major obstacles in the path of the user.

To do this, we will be 3D printing an encasement for the sensors and motors. This would be mounted somewhere near the user's abdomen while the battery could be strapped to a belt or stored in some sort of built in pocket. All of this might be easier to incorporate into a vest, because it would allow us to attach all of our components in one place. We will work with sewing techniques to embed the electrical components into the vest, and then implement a PCB board to minimize wire clutter. The battery will also be stored somewhere in the vest. As we work towards a final product, we will work to make the product more aesthetically pleasing through better electrical component integration into the vest.

Preliminary Parts List:

1. PLA for printers
2. X number of VL53L1X ToF sensors (We currently have 4 in the purchase sheet, but we shouldn't need any more than 10)
3. X number of IMUs (1 per ToF) - BN005 IMUs
4. X number of micro-servos (1 per ToF) - 9G Micro Servo for Arduino
5. Arduino Micro
6. PCB board



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Project Management:
October 24th - Project Proposal
December 19th - Finish Coding & Testing Methods
February 1st - Start Testing with Construction & Assembly Techniques
March 14th - First Prototype
April 12th - Final Model Completed
May 9th - Project Paper Completed
May 17th - Project Presentation Completed
May 31st - Project Poster Completed

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