# ProxiPole

An Electronic Walking Stick for the Visually Impaired

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# Introduction

## Objective

One of the main objectives of creating an enhanced walking stick capable of sensing surrounding objects is to create an electronic system that is portable, reliable, and durable enough to be mounted on the lightweight walking sticks currently in use. Many of the attempts at enhanced walking sticks have only included single-dimensional information, like the object range, and typically only include one proximity sensor.[1] These solutions really only give the user rudimentary range and direction information. The inclusion of an array of sensors can give the user an even better understanding of exactly where, and how far, the detected obstacle is. This can provide a significant improvement over current solutions.

The goal of ProxiPole is to allow its users to have an enhanced understanding of their surroundings by using electronic sensors. ProxiPole will make use of a small array of laser proximity sensors, haptic motors, and audio devices to detect incoming obstacles and alert the user to their approximate range and direction. This information will allow the user to have a heightened awareness of their environment, and by extension afford them the opportunity to make better informed decisions.

## Background

Currently, there are approximately 940 million people in the world who suffer from some form of vision loss, with 39 million of those people being completely blind.[2] Although many blind people are able to adapt very well to a life without sight, there are still many issues they have to deal with that normally-visioned people do not even think twice about. Auxiliary issues associated with blindness include non-24-hour sleep-wake disorder,[3] depression,[4] anxiety,[5] and many more. One of the main obstacles that blind people face is navigating their surroundings, especially in unfamiliar environments. A lack of situational awareness can pose serious threats to the safety of blind people, and many tools have been created to aid them in increasing that awareness. One of the main tools that the visually impaired use is a walking stick. They sweep the stick out in front of them to physically probe for objects, allowing them to avoid obstacles and to navigate other changes in their environment. Because of the issues that blind people face, it’s a moral imperative to help them as much as possible to make their lives easier.

# High-Level Requirements

1. At the crux of this device's functionality is its ability to provide directional haptic feedback. The electronic walking stick should be equipped to detect and alert the user of any obstacle that lies within a sector range of 120 degrees ahead of it and a straight distance of roughly 2 meters. The belt worn by the user will have equally spaced vibratory motors fitted inside. The choice of motor that would vibrate would depend on the direction the detected obstacle is in. We plan to include the ability to handle multiple obstacles at once as well.
2. The user will be alerted of the horizontal distance from the obstacle via the vibration motors' intensities. The intensity would increase in magnitude  when the user starts closing in to the obstacle. Additionally, the installed speaker would also sound an audible beep when the obstacle is extremely close to the user.
3. For completely novel and uncharted terrains, where the user has no mental comprehension of the surroundings, an SOS Panic button will be installed in the stick. When pressed, this will output a catchy noise and a voice message, asking for assistance, from the speaker to alert surrounding by-standers for aid.

# Design

## Block Diagram

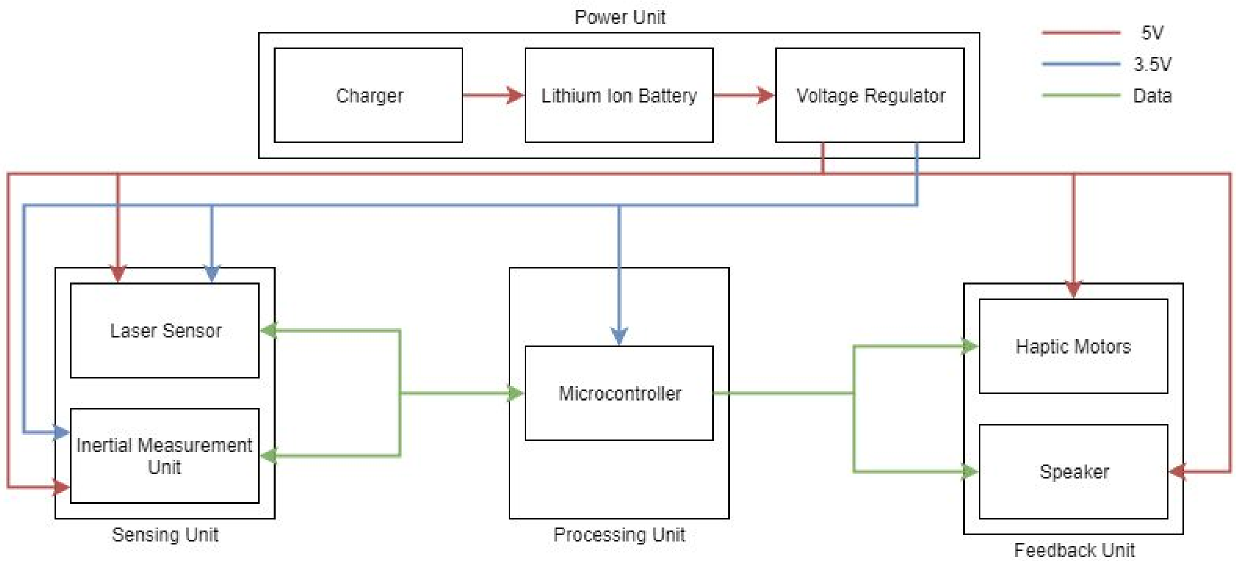


***Figure 1: Block Diagram of ProxiPole***

This design provides our system with the 4 main components that are needed: a power system to power the components, a sensing system that will provide spatial and locality information, a microcontroller to process the input, and the feedback system that will report to the user information about their surroundings.

## Physical Design

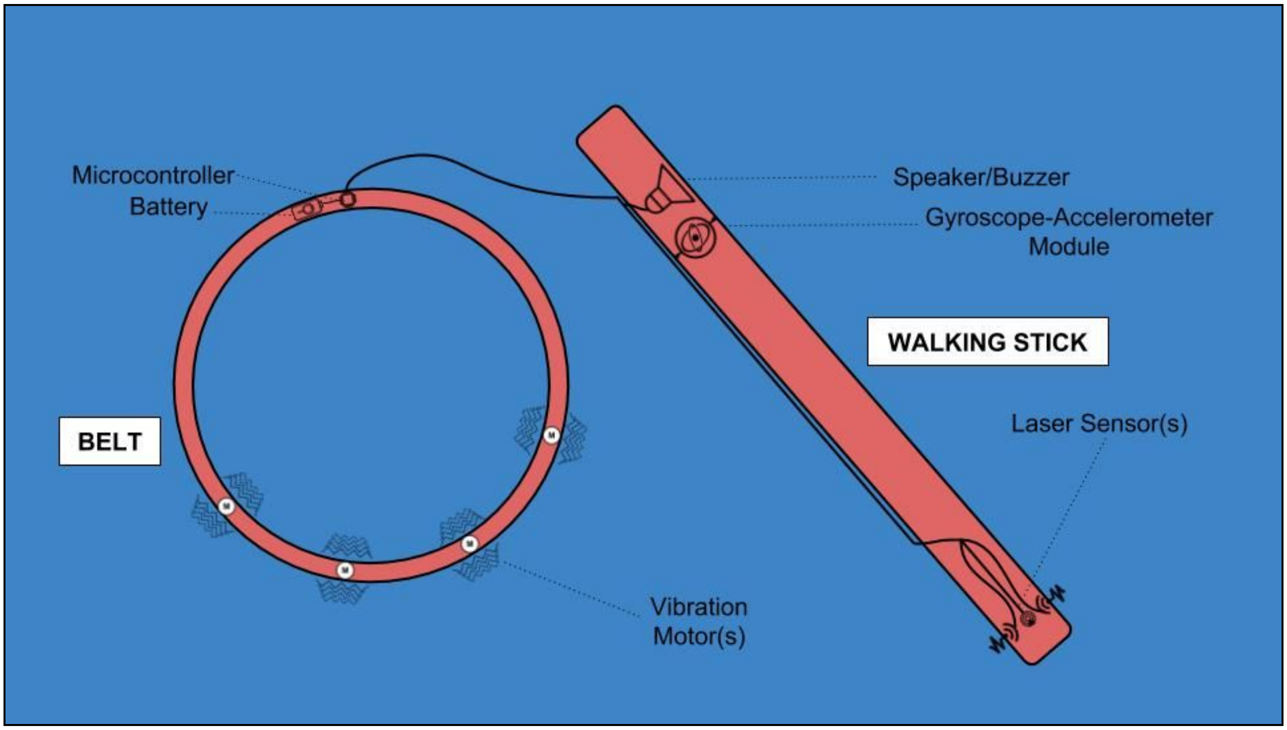


***Figure 2: Physical Design of ProxiPole***

We aim to to have 2 physical modules comprising our final device. These would be a belt unit, that will be worn around the user's waist, and the actual electronic walking stick, which will be handheld. Practically speaking, we plan to minimise the number of components on the stick in order to reduce the weight of that module. Instead, the main circuit component and power source will be fitted onto the belt itself, as depicted in Figure 2. Lastly, our walking stick will also have a grip that would make it easier to hold on to.

# Functional Overview

The block diagram is separated out into 4 main components, the power system, the sensing system, the microcontroller, and the feedback system.

## Power System

The power system will provide the power necessary to drive both the digital circuitry (including the sensors and the microcontroller) and the haptic motors. The power will be supplied with a bank of rechargeable Lithium Ion batteries that are recharged through a proprietary lithium ion charger. We do not intend to implement our own charging system because of the dangers associated with accidentally overcharging Li-ion batteries. The power system will also need to be regulated through a power regulator. The regulator will ensure that each of the components in the entire system are receiving the voltage necessary for safe operation, as well as providing electrical shorting safety mechanisms (implemented with simple fuses).

### Requirements

The power system should be able to maintain two voltage sources at 3.3V and 5.0V with a tolerance of ±5%. It should keep our battery above its minimum voltage requirement to avoid overdischarge.

## Sensing System

The sensing system will provide our product with sensing capabilities of the outside world. There will be two main types of information provided: object locality/object distance through the use of infrared laser sensors, and system orientation through the use of electric gyroscopes and accelerometers, in a circuit called Inertial Measurement Unit (IMU). The IMU will be used primarily to determine the true direction of detected objects relative to the user as the user sweeps the stick back and forth. The reason why this is needed is because we require the system to activate the haptic motor that points to the actual location of the detected object, irrespective of the orientation of the walking stick at any point in time.

The IMU will be a 3-axis system that uses a combination of accelerometers and gyroscopes to determine spatial orientation and location. The board will feature an on-board digital processor that uses the MotionFusion algorithm. The spatial location will be sent to the microcontroller via I2C.

### Requirements

The range-finding sensors should be able to detect an object within a cone around the array of at least 120 degrees and reliably detect obstacles as far away as 1 meter. The combined sensing system should be able to detect an object and deterministically identify an angle of detection relative to the holder of ProxiPole.

## Microcontroller

The microcontroller will be the “brains” of the operation. This chip will receive incoming input data from the IMU and the proximity sensors, and implement a basic algorithm to determine the position of the detected object relative to the user and activate the corresponding haptic motor. If the chip detects an object is within a predetermined threshold, it will sound an audible alarm. The program that is executed on the microcontroller will be written in C and compiled to the native architecture of the chip. Additionally, some minor circuitry will be needed to implement a clock for the microcontroller.

### Requirements

The microcontroller must be capable of addressing 4 separate laser sensors through its GPIO pins either directly or via the usage of a multiplexer. It must also be capable of communicating with devices through I2C. The clock that’s fed into the microcontroller must be fast enough to allow it to poll all 5 sensors (4 proximity and 1 IMU) and activate the 5 feedback units (4 haptic motors and 1 audible alarm) at least 4 times a second.

## Feedback System

The feedback system will be what provides the user with information on object range and locality. It will be a fairly simple system that comprises of 4 haptic feedback motors, and one audible speaker mounted on a wearable belt. These devices will be connected to and controlled by the microcontroller.

### Requirements

The feedback system should be able to activate our motors given a microcontroller input. The speaker should emit a characteristic tone that will indicate an imminent collision given microcontroller input.

## Risk Analysis

The blocks that pose the greatest risk to the successful completion of this project are the sensing unit and the microcontroller. The most challenging part will be integrating these two systems together in an efficient way. We envision that both the IMU and the microcontroller will be mounted on the same PCB, so not only will we need to ensure they can interface with each other, but we will also need to ensure that the PCB is designed correctly for our requirements. Furthermore, Parts of our design are physically separated by some distance. Our feedback system will be completely separated from the rest of the system since it will be located on the belt. We envision wires will connect these two systems together, however, great care should be taken to make them as unobtrusive as possible.

# Safety and Ethics

### General Ethics

This project was motivated by the lacking technology to aid the visually impaired. Part of our ethical requirements is to hold the health and safety of other people with high regard. By tackling this project, we will be improving the safety and overall quality of life for the blind. In addition, the group understands that in order for us to succeed in the design process we must support each other. Generally speaking, we should be following the IEEE code of ethics which hilights our responsibilities when making our product[6].

### Laser Safety

The range finding sensors we propose to use are a class 1 laser of the infrared spectrum. Our design will use several of these sensors which could be pointed by the user in any general direction. According to IEC 60825-1:2007, Such class 1 lasers are completely safe under normal operating conditions and even if viewed by the naked eye under normal telescopes and microscopes[7]. With such a classification we can be assured that the lasers will be harmless in our application.

### Lithium-Ion Batteries

Lithium batteries can be very dangerous if care is not taken to insure proper functionality. In general these batteries can overheat and become damaged very easily from a short circuit. Our design will take this into consideration and strive to eliminate this possibility. Furthermore, lithium batteries can be damaged from over discharge and overcharge. We plan on implementing over discharge protection into our power subsystem and purchase a 3rd party charger to keep the battery within acceptable voltages.

# References


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