Designing an Assistive Device for the Visually Impaired For Ground-Level Object and Surface Condition Detection

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Engineering Need:

Individuals with visual impairments have difficulty navigating while alone due to unknown obstacles and uncertainty in ground conditions.

Engineering Objective:

The goal of this project was to design technologies that can be used in a device to inform the user of obstacles and hazardous ground conditions.

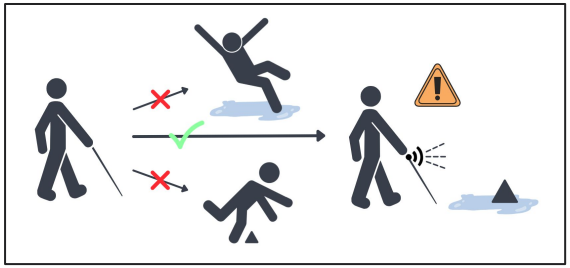
Background

ETA - Electronics travel aid

Most **current assistive devices** for hazard detection **only include obstacle detection**. Many current devices are **expensive**, **uncomfortable**, and/or **ineffective**. (Bing et al., 2020, pp. 85–105)

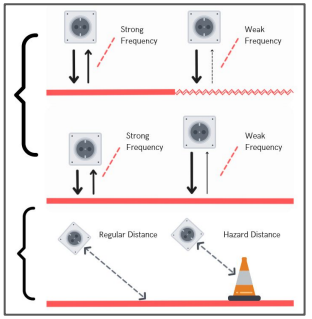
There are **no commercially available devices able to detect a variety of ground conditions**. Most methods use machine learning to analyze camera images or are based solely around the detection of road surface conditions. Furthermore, **few of these technologies are non-contact and/or portable**. (Gui et al., 2019)

Graphical Abstract

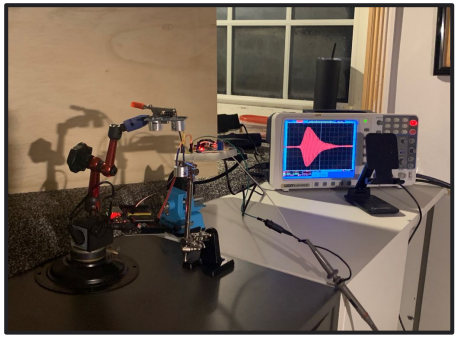


Ground Condition Detection

Obstacle Detection



GCD Prototype



Methods

Ultrasonic Sensors were used for both the **ground condition detection** and the **obstacle detection**

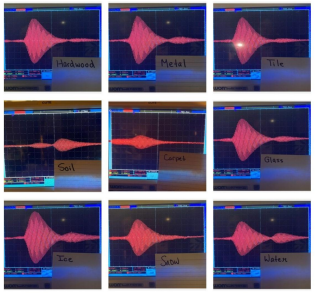
Obstacle Detection:

- Distance readings from ultrasonic sensor were obtained. Small distances would indicate a hazard.

Ground Condition Detection:

- Two ultrasonic sensors were used. One was the **transmitter**, the other was the **receiver**.
- The **transmitter** output pings at a constant 30 Hz.
- The original method obtained the **voltage** of the signal from the **receiver**.. However, the arduino did not sample fast enough to create the full curve.
- Current method has the **receiver** connected to an **oscilloscope**. This allows for visual data.

Oscilloscope Output



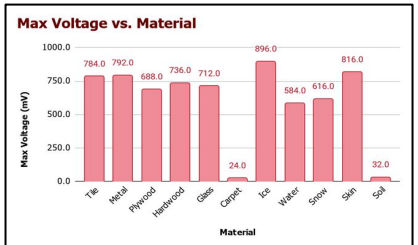


Figure 3: ***Max Voltage vs Material.*** This figure shows the max voltage read by the oscilloscope for each of the materials listed.

Results and Extensions

The obstacle detection method worked as planned and the distance changed when there was an obstacle in front of the sensor. With further work, haptic or audio feedback could be applied to this technology so that it can be used in an assistive device.

As can be seen from the chart of oscilloscope outputs, there is noticeable difference between each of the surfaces. While the current data is visual, with a circuit board capable of faster sampling than the Arduino Uno this data could theoretically be obtained numerically. Numerical data would allow for material detection methods, such as machine modeling, to be pursued.

More testing still has to be done for variables such as distance and material thickness for the GCD. However, both of the technologies researched would be able to contribute to an effective device for individuals with visual impairments.

References

Bing, A., Chai, C., Lau, B. T., Pan, Z., Chai, A. W., Deverell, L., Al Mahmu, A., McCarthy, C., & Meyer, D. (2020). Improved Mobility of the Visually Impaired. In *EAI/Springer Innovations in Communication and Computing* (pp. 85–105). Springer International Publishing. https://doi.org/10.1007/978-3-030-16450-8

Gui, K., Ye, L., Ge, J., Cheikh, F. A., & Huang, L. (2019). Road surface condition detection utilizing resonance frequency and optical technologies. *Sensors and Actuators A: Physical*, *297*, 111540. https://doi.org/10.1016/j.sna.2019.111540