Use of Computer Vision to Develop a Device to Assist Visually Impaired People with Social Distance

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Abstract

The project developed a device to assist blind and visually impaired users in complying with social distance rules. The main challenge was how to identify people from other objects and notify the user accordingly. Equally ambiguous was how to best notify the user that a person was violating the social distance rules. The hardware used is a Raspberry Pi running an image classification algorithm and hooked to a depth camera. The use of prediction labels and accuracy combined with the distance calculated by the depth camera made it possible to detect when a person was getting closer than 2 meters (6 ft) to the user. The device was tested both in daylight and at night, and with different lighting conditions. Testing showed that the camera is capable of identifying people coming from a 30 degrees angle from either side at around 1.9 meters of distance, giving a good range of object detection.

Introduction

With the rise of COVID-19 many governments have developed mandatory use of face covers and the practice of social distance. As confusing and inconvenient these measures may seem to a regular member of the society, the implications are much bigger for those of us who have visual impairments. Visual impairments reduce the capacity of one to determine the distance to another person, or in the case of blindness make it totally impossible. Visually impaired people are able to have a life very close to normal in a non-pandemic society, but with the current tools used to aid visual impaired people with navigation, social distance is almost impossible to be practiced.

The issue of independent navigation for blind and low vision people is one that we as a society have been trying to address for years. Blind and low vision people mainly use two different ways of walking around, which are a white cane or a guide dog. The use of the white cane makes independent navigation efficient and safe. Using a guide dog brings more independence and safety but it is not always possible. With the technological developments more advanced devices have been developed. However, a common issue it is that they provide distance to obstacles. The distance is precise enough to avoid obstacles, but not enough to maintain social distance. The devices are designed to avoid obstacles, hence providing a precise distance until collision is not necessary. Accessibility goes in both ways, as people with disabilities wish to become regular members of the society, being subject to the same rules comes with that. This is the reason for the development of this project. In the project we aimed at finding a fine equilibrium between giving enough information but not too much to overwhelm the user. The main decision was to use beeps to communicate distance.

Related Work

The systems that have been developed fall in two main categories: infrastructure based (ISB), which require installations in the environment in addition to the navigational device itself, and infrastructure less (ISL) which require only the navigational device. Multiple ISB require RFID detectors in the cane and on the ground (D'Atri et al. 2007), or a wearable cap to locate IR and ultrasound systems in the room (Islam et al. 2018). In ISL systems IR and sonars are also used (Ando 2008) but in a way that is independent of the installation. For all systems there is a common question, how does a blind person perceive a new environment? In (Lahav and Mioduser 2004) investigators developed a virtual 3D environment where blind people navigate using a force stick. Computer vision can be used to process multiple images to obtain information about which objects are present and where. One of the common issues with computer vision is the difficulty that blind people have to position the camera correctly to detect the image (Jayant 2010). This is definitely one of the issues we have tackled in our work.

The Blind Distance Device

Since a good calculation of depth is essential, we decided to use an Intel Real Sense D435 camera. The camera was hooked to a Raspberry Pi 4 with 4GB of memory. To make the system mobile, power is provided by a hat with two 18650 batteries, which provide at least one hour of use. The sound is produced by a 5v active buzzer using a 10k potentiometer to regulate the volume. The Raspberry is hooked to a standard cooler.

The standard approach to calculate distances is to use disparity maps. Instead we decided to use a set of preprogrammed apps from AlwaysAI, specifically the realSense-objectDetector. The camera has depth recognition, which

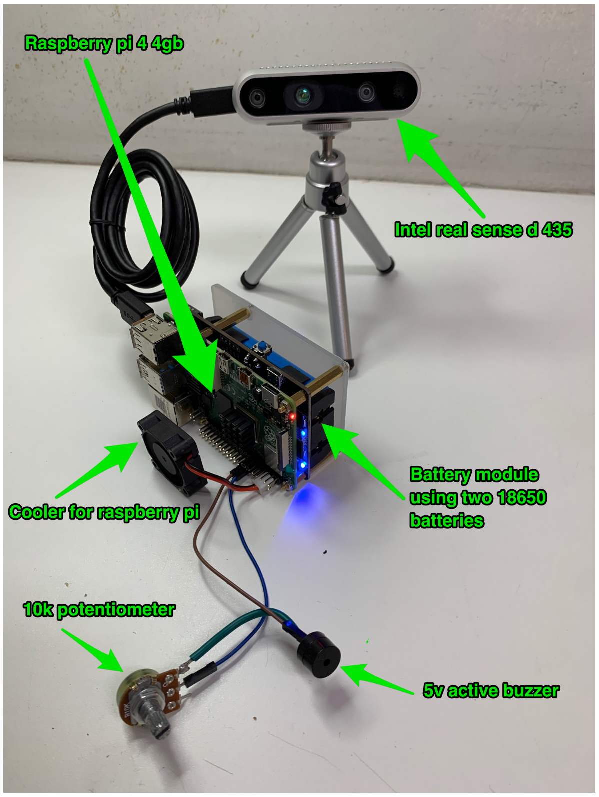

Figure 1: The Blind Distance device

makes it possible to get the precise distance between the camera and an object. The next step was to run the image in a pre-trained classification model, in our case the "alwaysai/mobilenet_ssd," which returns the prediction label and the confidence in the result.

The code was modified so instead of sending the live video to the browser, it sends the distance and the prediction label to the terminal. To alert the user we used a 5v active buzzer. The decision to use the buzzer was made considering the directness of the information provided by the buzzer together with its low cost and implementation simplicity.

Experimental Results

We tested the device in different scenarios. It is remarkable that the internal lights and the infrared projector of the camera made it possible to get a good precision even in complete darkness. Limitations of the current system, including portability and practical use, will be addressed in the future.

We positioned the device on a glass table and pointed it straight into an empty area. Whenever people got into a range of less than 2 meters from the device the buzzer started beeping, alerting the user of the proximity of another person. We studied the precision of the device by asking people to slowly walk from 3.15 meters to the distance at which the beep would activate. Different people walked in different directions from the camera until they reached the buzzer activation distance. When programmed for 2 meters, the buzzer activates when the person is anywhere between 1.9 and 1.95 meters from the camera facing forward. Whenever the person was coming from the left or from the right at different angles the results were very similar. The closer the buzzer was activated was 1.26 meters, coming at 30 degrees angle and in total darkness. This was recorded around midnight outside with lights off. We found that the device detects people at a maximum of 30 degrees angle to the left or to the right. During the day in perfect conditions the detection happened around 1.8 meters on a 30 degrees angle, which is the worst-case scenario. This test was done with different people in different light conditions with very similar results. Other conditions included testing on a dog positioned at the same distance, where the beep did not activate as it did in the presence of people. Asking the subject to sit down activated the beep at the same distances. Other trials were done with people standing behind lower objects, such as a chair or bench; the beeper activated around the same distance. For training purposes, we set the maximum distance that the camera would register a person around 3.15 meters.

Conclusions and Future Work

Developing the Blind Distance device was both a personal and academic achievement. These times are challenging, especially for those with disabilities. Blind people are struggling more than ever to reduce the gap between living as a blind person and as a non-blind person.

Because of the limitations of quarantine and lockdowns it was not possible to test the device in real world situations, like walking on a street or in a crowded area. This is a future area of testing that might provide other interesting results and insights. Testing with different people to understand how they respond to the beep would also be useful. Does everybody perceive the beeps in the same way or is it more distracting for some people and less for others? Those tests are not difficult to do, once the restrictions of quarantine are lifted, and they may bring novel conclusions for future updates to the device.

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