

A Smart Cane to Help the Blind People Walk Confidently

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Abstract. With the rise of the population of blind people in the world, it's necessary to design a more useful cane for them to get the way. Cane is a tool that can serve as the third leg of the old people and the handicapped. With the help of our system, it also can used to sense the enviroment for the blind people, serving as the third eye. The cane that we design can detect the obstacle barriers and holes, and the other function is to remind blind people of walking in the blind sidewalk. We produce the cane with different alert sounds on the basis of the distance between the obstacles and the depth of the holes. The distance of the obstacles that we consider is from 200 cm to 2 cm. And the depth of the hole is from 50 cm to 10 cm. Depending on the distance to the obstacles and the depth of the holes, the buzzers emits a warning sound of different frequencies, thus we could remind the people of noticing the obstacles and holes. What's more, it can direct the blind people to walk down the blind sidewalk with the speech prompt module.

1. Introduction

We have a lot of blind sidewalk on the street, but there are no blind people walking on it. Ask some blind people to know they are afraid to walk on it because there are many obstacles, even some pits and holes. Love is full of my mind. In order to make them more confident to walk on the blind sidewalk, so this paper designed this smart cane.

Giva Andriana Mutiara, et al conducts some studies of the smart cane to make blind people walk with confidence. They made a smart cane equipped with ultrasonic sensor which can warn the people with visual impairment about the existence of obstacles or holes in front of them through a buzzer beep (Mutiara, Hapsari, & Rijalul, 2016) while M.F. Saaïd made an experiment about what is the most practical configuration, which includes position and angle, of the ultrasonic ranging module to detect obstacles. The result shows that the upper positioned sensor with the angle of 90° has the best test results. (Saaïd, Mohammad, & Ali, 2016).

Rajesh Kannan Megalingam, et al, designs a smart cane equipped with bluetooth enabled barrier detection module. The distance between the barrier and the person will be sent to an Android device via Bluetooth. Then, the person is informed about the distance by a hint voice through a Bluetooth headset (Megalingam, Nambissan, Thambi, Gopinath, & Nandakumar, 2014).

Some study put forward by Tushar Sharma, et al uses an infrared sensor and a water sensor additionally to make their smart cane detect obstacles more accurately and dodges puddles (Sharma, Nalwa, Choudhury, Satapathy, & Kumar, 2017).

Some research on blind sidewalk detection conducted by Xu Jie, et al, suggests that the methods of a serous of image processing like image segmentation, image edge detection and blind sidewalk edge detection to divide the blind sidewalk from the pavement is useful and effective to get the information



of the blind sidewalk orientation (Jie, Xiaochi, & Zhigang, 2010). In fact, the image process is a general and good way to detect the blind sidewalk (Jing & Ren, 2014).

In this paper, there is an idea to create a blind tool that can be used to help their daily activities based on previous research. On one hand, this paper will also use the ultrasonic ranging module to detect obstacles and holes. On another hand, this paper will use the OpenCV library to get the blind sidewalk information. The OpenCV is a cross-platform computer vision library based on BSD license (open source), which can run on Linux, Windows, and Mac OS operating systems. It is lightweight and efficient. It is made up of a series of C functions and a few C++ classes. At the same time, it provides the interface of Python, Ruby, MATLAB and other languages, and implements many general algorithms of image processing and computer vision. So we implement our blind sidewalk detection module using the OpenCV library to process sidewalk images from the camera.

2. Theory

2.1 Intel® Galileo Gen2 – Arduino

Intel Galileo Gen2 is not only compatible with the Arduino software development environment but also has several PC industry standard I/O ports and features to expand capabilities beyond the Arduino shield ecosystem.

Intel Galileo Gen2 can run with a Linux system. The Linux system is very flexible and can be tailored to fit specific purposes. For Intel Galileo Gen2, there is an IoT Devkit Image. This image can support the OpenCV for python, which makes image procession is easy and convenient.

2.2 Ultrasonic Ranging Module: HC-SR04

To detect obstacles and holes, we choose the Ultrasonic Ranging Module: HC-SR04. This module is measured in a range of 2 centimeters to 400 centimeters, and the measuring accuracy is 3 mm, which has the same ranging accuracy and longer ranging distance than PING Ultrasonic sensor. The module has a total of four pins, Ground, VCC, Trig and Echo. Ground and VCC pins need to be connected to the ground and 5 V power pins of the Arduino development board respectively and the Trig and Echo pins to any Digital I/O pin on the Arduino development board. We need two separate HC-SR04 modules, wherein one is for the obstacles and another one is for the holes.

Holding the Trig pin on a digital “1” state for 10 μ s. the module will send out an 8 cycle sonic burst which will travel at the speed sound and it will be received in the Echo pin. Then the Echo pin will stay high in a period of time. The time is actually the time the sound wave traveled. The following picture shows this process.

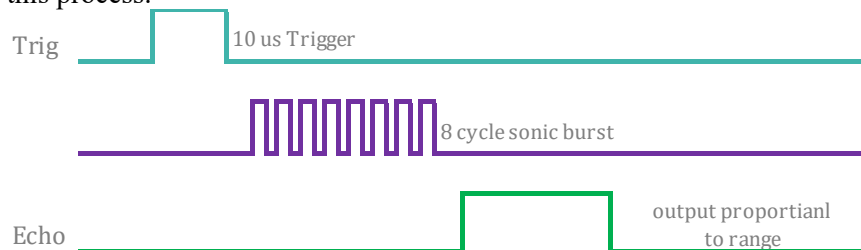


Figure 1. The process of ultrasound module works

2.3 Logitech Webcam C200

Our blind sidewalk detection module needs a camera to catch the road information on time. Because the Linux kernel supports the USB camera originally, we chose a USB camera as our “eyes”.

Getting the images, the Linux system with the OpenCV for Python library will process the image with color segmentation algorithm and tell the blind whether they are in blind sidewalk according to the procession result.

On one hand, we can see that the Logitech Webcam C200 is officially supported by the Linux kernel from the website: <http://www.ideasonboard.org/uvic/>, on another hand, this webcamera is

cheaper and can satisfy our need. That is why we choose the Logitech Webcam C200 as our blind sidewalk detection module camera.

2.4 VS1003B MP3 Decode module

VS1003B MP3 decode module consists of the following sections: VS1003B, SPI interface, Headphone and audio output interface, power indicator and so on.

This module receives its input bitstream through a serial input bus. And the input bitstream comes from the hint voices stored in the SD card. This prompt voices will be decoded and passed to an 18-bit oversampling, multi-bit, sigma-delta DAC. Then, the DAC will output the analog signals to the power amplifier modules, headphone and audio output interface. Last, the blind will hear the prompt voices to sense the environment.

3. System Implementation

3.1 hardware design

Our system consists of the Intel® Galileo Gen2 board, some function modules, and a power supply system. Function modules include obstacles and holes detection module (O/HDM), sidewalk detection module (SWDM), a speech prompt module (SPM) and alarm module (AM). The system requirements can be seen at the following table.

Table 1. the system requirements

Hardware	number	Description
Ultrasonic Ranging Module	2	One is for detecting obstacles and another one is for detecting holes
Usb web camera	1	Catch the sidewalk information
VS1003B MP3 Decode module	1	Decode the prompt sound stored in the system and convert them into analog signals
Speaker	1	Output the sound in the prompt module
Buzzer	1	Sounding beep buzzer of the alarm module
Power bank	1	Supply power to the system
Intel Galileo Gen2 Board	1	Controlling central and image processing central

We design our prototype system and connect all of the modules as shown in table 1. The system of the hardware block diagram can be seen in figure.2.

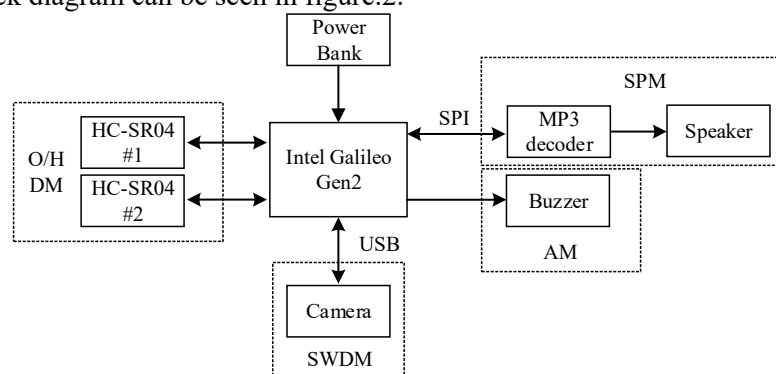


Figure 2. The system hardware block diagram

3.2 Software Design

Our Intel Galileo is running Linux system, so the overall software architecture is basically the same with the PC. Our software contains Arduino sketch and Python script, which are an application for Linux system. They have their own functions, but they are interconnected. First, the Arduino sketch, do the obstacle detection job and the holes detection job, and also carries on the corresponding reminding function. Second, it will call the Python script through the *system* function which is used to

issue a command to your operating system's command processor ("Galileo Unread Email Counter - learn.sparkfun.com," n.d.). Then, it will read the sidewalk information returned by the Python script, which can be done with the included Arduino SD library. Last, the Arduino sketch carries on the corresponding alarm and the prompt work. These steps will be repeated all the way until the system is powered off. The Python script, with the help of the OpenCV library, completes the identification and detection of the blind and saves the results in a text file, which is then read and processed by the Arduino sketch with the included Arduino SD library. Figure 3 shows the flowchart of the Arduino sketch and the relationship with the Python script. Table 1 defines the meaning of the text results saved by the Python script.

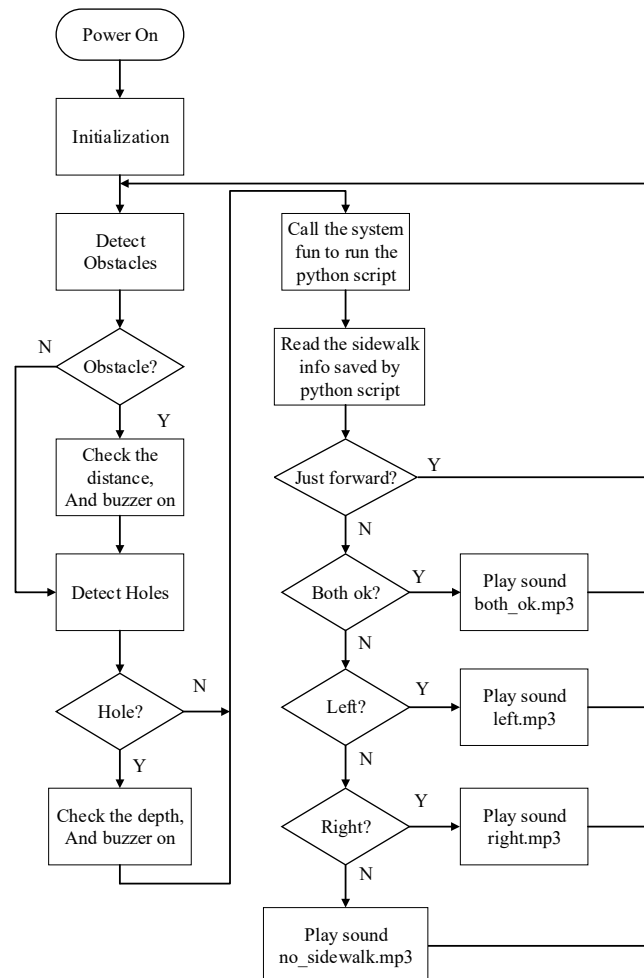


Figure 3. The flowchart of the Arduino sketch and the relationship with the Python script

Table 2. The meaning of the text results

Character	Meanings
F	Just go forward!
B	Both directions are ok!
R	Turn right!
L	Turn left!
N	These are no sidewalk ahead!

4. Testing System:

After completing the system design, we tested the important modules. The obstacle detection module, the hole detection module are mainly tested. For the obstacle module and the hole detection module, we tested the detection range.

4.1 Testing the obstacle detection module

After the experiment, we can know that when the distance between the blind people and the obstacle between 450 cm and 2 cm range, the smart cane designed in this paper will be issued a corresponding frequency of different warning tones. The result of the testing can be seen in table 3.

Table 3. Obstacle detection testing result

Distance(cm)	Output	Sound Frequency (Hz)
2-50	Sound type 1	1000
51-100	Sound type 2	250
101-150	Sound type 3	500
150-200	Sound type 4	1
>200	No Sound	No Sound

4.2 Testing the hole detection module

After the experiment, we can know that when the blind people in front of 10 centimeters to 50 centimeters of pits and holes, this article designed by the smart cane will be issued a warning tone. The result of this testing can be seen in table 4.

Table 4. Hole detection module testing result

Depth (cm)	Output
3-9	No sound
10-50	Beep sound
>50	No sound

5. Conclusion and Future Work

The experiment shows that the smart cane we designed is capable of measuring the distance between the obstacles and detecting the holes. What's more, it can direct the blind people to walk down the blind sidewalk, which makes them feel safer and easier to walk down the blind walk.

In the future, we will improve our system in some aspect. For example, we will choose a more powerful processor to make the system get the blind sidewalk information more quickly. To achieve that, we can use the Intel® Edison or more power Arduino board. Again, for example, we will make our system be capable of detecting the sidewalk which is not marked by yellow with improving algorithm of blind sidewalk detecting algorithm.

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