Project Proposal: SmartCane - A Sound based Naviagtion Assistant for the visually challenged

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1 INTRODUCTION

The white cane has been very handy and a popular device amongst the visually challenged community. The simple traditional white cane has been in use for over a century. With the advancements in the technology especially the mobile devices, the white canes are becoming smarter. In the recent days, couple of smart add on devices for the cane are available in the market. These devices are popular among the blind community, since these devices give them greater independence and autonomy.

1.1 Motivation

American Foundation for the Blind (AFB) released a special report on Aging and Vision Loss [1]. As per the report, 5.5% of the Americans aged between 18 and 44 have had vision loss. This may be due to various reasons such as accidents, treatments, genetic disorders etc. These people who turn blind during their life time have difficulties in developing extra sensitive sense organs which supplant the vision loss, as compared to a person who was born blind. Hence, these people have difficulties in perceiving the sound produced by the tap of the white cane and using them for independent navigation. This clearly briefs the need for a sound based assistive device which helps the visually challenged navigate and also find obstacles on their way.

2 LITERATURE REVIEW

With the advancements in the technology in the past decade especially in mobile computing, this has paved way for a dozens of smart add on devices which has enabled the visually challenged be more independent and navigate around with ease. Ultra-sonic senor has been used extensively in couple of add-on devices for the white cane. Devices such as Smart Cane [2] and Bawa [3] uses the Ultra-sonic sensor to detect the obstacles on the way and alert the user well in advance. Smart Cane focuses on identifying the overhead obstacles, which may not be found by the movement of the white cane. Bawa identifies obstacles and gives haptic feedback to devices connected to it, such as smart phone and wearables .

Sherpa from Handisco [4] is another smart device which acts as a personal assistant. It helps in directions for navigation using GPS and also by identifying sign boards. The device can be operated completely by using voice commands. Also, there has been attempts on using textured floor mats for indoor navigation. The texture on the mat guides the visually impaired identify the directions. The textures on the map are found using the white cane.

Using a camera in the cane also has been quite prevalent. Camera has been used to detect the objects and persons in front of it and give feedback to the user [6]. Recently, there has been attempts on using 3D camera to assist the visually challenged navigate [9].

The functionality of all these device are subject to the environment and their connectivity to the Internet. The ideal conditions required for these devices to function may not be feasible all the time. Cost is also a limiting factor for few of these devices.

2.1 Background Information

It is well known that different objects produce different sounds, when it is hit with some object. This has been the basic idea behind the white cane and the visually impaired have been using this idea for decades to navigate and perceive their environment. As discussed in the previous section, the persons who turn blind after birth may not be comfortable in observing the sounds keenly, that they can be used for navigation.

Usually, the type of flooring in different environments are different. For instance, in a shopping mall there is usually ceramic flooring in the aisle and near the escalator there is steel flooring with patterns on them. The sound produced by the tap of the cane on the floor changes, when the person nears the escalator. These differences in the sound can be used to perceive the environment and alerts the user on how to react. Also, the taps on the side walls can be used to detect the doors on the way and the person can keep a track of the number of doors he came across to navigate. The objects and obstacles on the way like dustbins etc. can also be detected using the sound difference and this helps the user to understand the environment better.

3 OBJECTIVES

Our goal is to develop an user friendly and cost effective smart assistive device which aids the visually impaired navigate with greater autonomy. The device tracks the patterns in the sound produced by the taps of the cane and alerts the user when there is an anomaly in the sound produced. The device also identifies some of the common objects found every where using the sound produced by the tap and alerts the user. The device is mainly targeted for the persons who lost their vision during their life time and have difficulties in perceiving the environment using sound.

4 PRELIMINARIES OF SIGNAL PROCESSING

4.1 Fast Fourier Transform, FFT

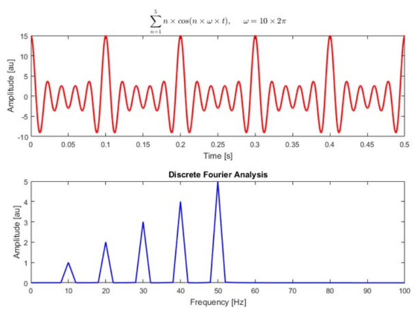

Figure 1: Fast Fourier Transform

A Fast Fourier Transform (FFT) algorithm is used to convert a signal from time domain to the frequency domain in order to get the frequency information from the sound, as shown in Figure 1. Also, Fast Fourier transform is broadly used for many applications in engineering, science, and mathematics [5].

4.2 Short-time Fourier Transform, STFT

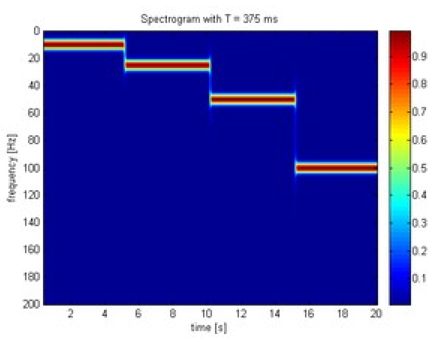

Figure 2: Short-time Fourier Transform

The Short-Time Fourier Transform (STFT) is similar to the Fast Fourier Transform. It is used to determine the frequency and phase content of local sections of a signal according to changing time. The STFT divides a longer time signal into shorter segments of equal length and then computes the Fast Fourier transform for each segment [8]. Thus, STFT can capture the peaks and harmonic frequencies better.

5 INTRODUCTIONS OF THE SYSTEM

Our proposed system identifies the obstacles and its types using the sound produced by the tap using the white cane on an unknown object. The device attached to the cane records the sound and send it to a smart phone using Bluetooth. The sound is processed in the smart phone and the type of obstacle is found using the sound processing techniques. Figure 4 gives an overview of our proposed system and Figure 5 shows the data flow between the modules.

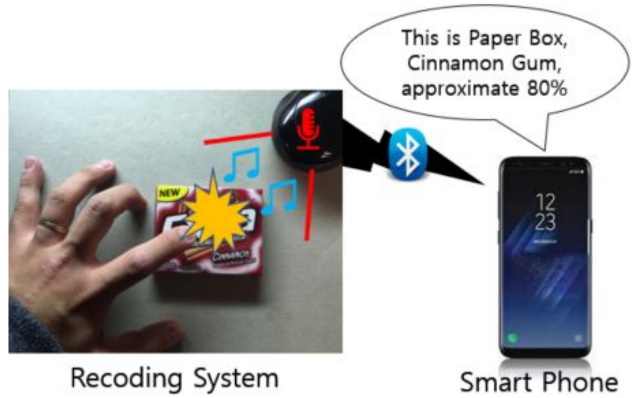

Figure 4: Illustration of the proposed idea

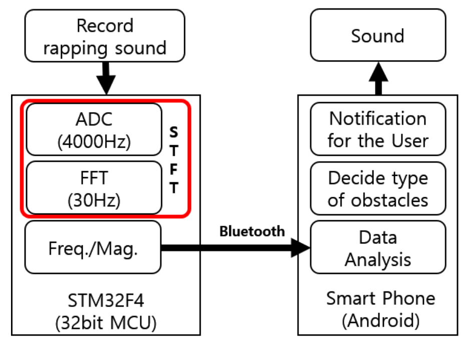

Figure 5: The Data flow in the proposed system - Block diagram

5.1 Sound Recoding System

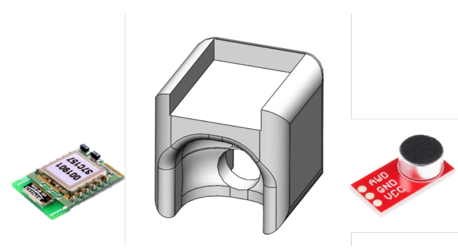

Figure 6: Components of sound recording system. Bluetooth module, 3D printed case and microphone (from left to right).

The sound recording system, which will be attached to the cane consists of a microprocessor, a microphone, a Bluetooth module and a 3D printed case to assemble and attach the devices to the cane. The various parts of the sound recording system is shown in Figure 6.

The STM32F4 is used as the microprocessor. The device records the sound produced on tapping the white cane using the microprocessor. Then the sound is processed using an analog to digital

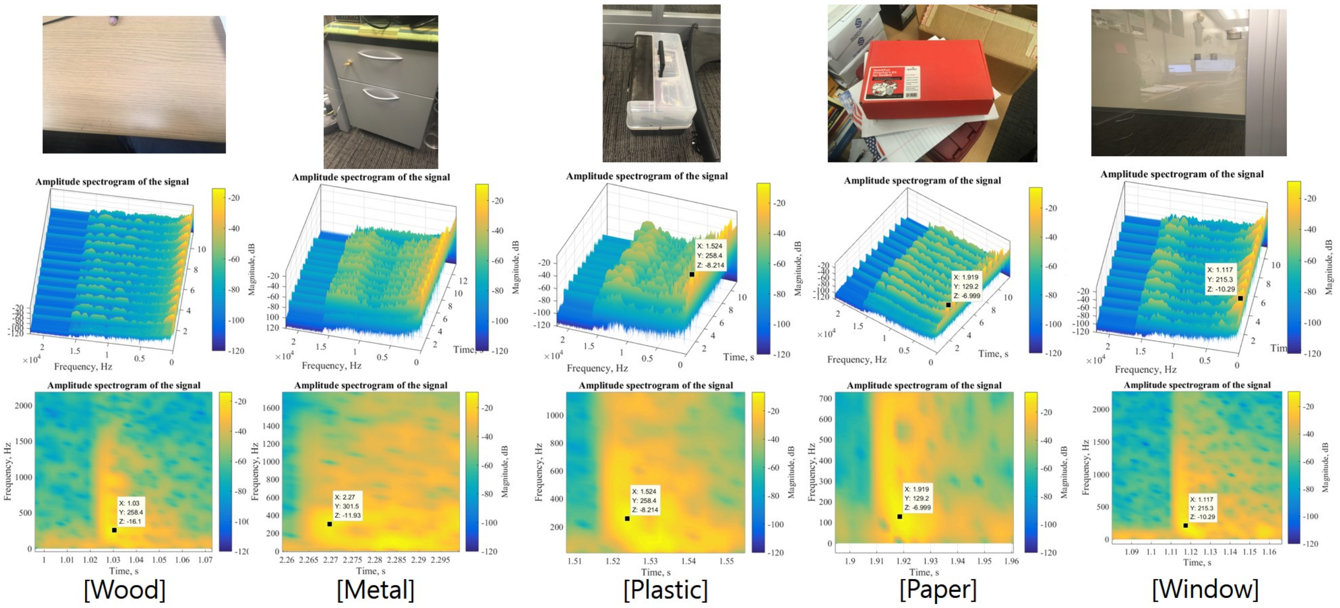

Figure 3: The spectrogram plots of the sounds recored in during the study. (The first row shows the objects and row 2 and 3 shows the spectrogram plots.)

converter and stored in the system memory. This process is termed as Direct Memory Access (DMA). Later the sound is converted from time domain to frequency domain using Short Time Fourier Transform. The STFT gives the peaks and harmonic frequencies. These data are transmitted to the smart phone using Bluetooth for processing. This data flow process is shown in the left block in the Figure 5.

5.2 Data Analysis System

The smart phone acts as the sound data analysis system. The smart phone receives the sound data from the module attached to the white cane using Bluetooth. The smart phone receives the data in the form of frequencies. Then these data are continuously monitored for an anomaly, i.e a suddenly change in the frequency. When this occurs the user is alerted using some haptic feedback like vibration. The frequency corresponding to the anomaly is also compared to a local repository with peaks and frequencies of commonly found objects and if a match is found the user is informed about that object too. Peak and harmonic frequencies are used to find the differences in sound because peak frequencies decide the sound scale and harmonic frequencies and duration determine the timbre of sound[7]. This data flow process is shown in the right block in the Figure 5.

6 PRELIMINARY STUDY

6.1 Survey on obstacle types

We performed a survey to document the commonly found objects and obstacles in the university building as well as the roads in the campus. Some of the commonly found objects in these locations are shown in the Figure 7.We found that glass, metal, wood, paper boxes and plastics are mostly common found in most of the buildings in the campus. For instance, in Wang Hall and Knoy Hall of Technology, we found wooden desks, wooden doors, metal chests and plastic trash cans in the hallways, which are dangerous to blind people to navigate.

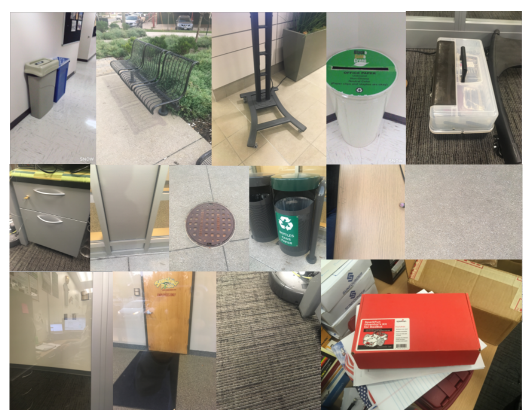

Figure 7: Common objects found during survey.

6.2 Experiment condition

We recorded the sounds by tapping various objects like wood, metal, plastic, paper, and window materials using smart phone to identify the difference in the frequency of the sound produced. The sounds were recorded by keeping the smart phone close to the objects as shown in Figure refThe experiment condition. The sounds were recored for about 10 seconds and were sampled into frequencies using Matlab.

Figure 8: The experimental setup.

6.3 Experiment result

In the experiment the peak frequencies of some the common objects like wood, metal, plastic, paper and glass window were found. The frequencies recorded were 258Hz, 301.5Hz, 258Hz, 129.2Hz and 215.3Hz. It can be almost all the objects have distinct peak frequencies except wood and plastic, which have the same peak frequency. Though their peak frequencies are the same, it can be seen that the harmonic frequency and duration are significantly different in the STFT results. This clearly shows that sound can be used as a primary factor to distinguish objects. Figure 3 shows the spectrogram plots of the sound produced by tapping various objects. (The first row shows the objects and row 2 and 3 shows the spectrogram plots.)

7 CONCLUSIONS AND FUTURE WORK

Hence, we have proposed an obstacle detection and recognition system using sound to assist the visually challenged in their day to day tasks. The system records the sound and samples the sound and then sends the frequency information to a smart phone. In the smart phone, the data are processed and the type of obstacle is found.

From the preliminary study, we found that it is possible to detect the type of obstacle just by using sound alone. The device does not use complicated hardware and hence reducing the cost.

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