Programmable Sound Detection

Joseph S. Stanislow  
National Technical Institute for the Deaf/Rochester  
Institute of Technology  
Information and Computing Studies (ICS)  
Rochester, NY, USA  
jssnbs@rit.edu

Gary W. Behm  
National Technical Institute for the Deaf/Rochester  
Institute of Technology  
Center on Access Technology (CAT)  
Rochester, NY, USA  
gwbnts@rit.edu

Abstract—The development of the project is to design, develop and build a notification device that will allow deaf/hard-of-hearing (DHH) people to be notified when a device such as toaster, microwave oven, smoke alarm, door bell or instruments produce sounds. The name of the project is “Programmable Sound Detection (PSD)”. The function is to record a specified sound of the device, store it in Programmable Sound Detection Device (PSD) and notify a person when the sound is activated. PSD stores several different audible sounds of different devices. Based on which specified audible sound from the device, the PSD can notify a person which device by flashing light, vibration, or message.

Keywords—notification; audible; Deaf and Hard of Hearing; sound detection; accessibility

I. INTRODUCTION

Today DHH scientists/technologists and healthcare workers may not able to hear the beep sound when the audible lab instrument finishes running as shown in Figure 1. DHH electrical engineers also may not able to hear the beep sound when the circuit is shorted through Digital Multimeter (DMM) as shown in Figure 1. There are many audible lab/medical instruments and equipments which do not meet the accessibility needs of DHH scientists/technologists. Many DHH people may not able to hear the audible sound when the household appliances such as stove, microwave oven, or washer/dryer is completed.

![Fig. 1. Lab Instrument (BIO RAD) and Digital Multimeter (DMM)](image)

II. NOISES IN THE ENVIRONMENT

In today’s environment, there are so many different audible alarms and devices and it is challenging for DHH to deal in responding to these devices without being able to hear the sounds.

As an example, at home there are several audible alarms /notifications that are installed in the house such as smoke detector, carbon monoxide detector and security alarms. The purpose is to alert people to danger and signals an emergency procedure should be followed. The audible sounds from the doorbell and telephone rings are another example of notification. Also, the appliances such as dishwasher, washer and dryer generate audible sounds to notify the person that the process is completed.

As you can see, the DHH people have to deal with it every day by “polling” different audible devices at home through visual inspection. It is unfortunate that these audible devices do not built-in or add-on visual signals.

It is the same situation when DHH people have to deal with different audible alarms and devices at workforce.

III. FOCUS

The purpose of the project is to assist DHH scientists/technologists and healthcare workers with lab instruments. The focus is on the development of filtering and detecting the sounds, communicating and notifying the scientists/technologists. There are many lab instruments which do not meet the accessibility needs of deaf & hard-of-hearing scientists/technologists. The short term solution is designing and developing a notification device as add-on to use for detecting the sound. The long term solution is to integrate the notification device into the lab instrument as part of the universal design.

IV. CHALLENGE

The challenge is to filter and detecting the sounds, identify which device that sound was created and notifying the DHH people. There are many lab instruments, equipments, devices, and detectors which do not meet the accessibility needs of DHH people. In an ideal situation the notification devices should be built-in or add-on for all above in the long term.
V. FILTERATIONS

The Goetzel Algorithm is a Digital Signal Processing (DSP) technique that provides a means for efficient evaluation of specified frequencies from devices' sounds.

\[
(f * g)[n] \triangleq \sum_{m=-\infty}^{\infty} f^*[m] \cdot g[n+m].
\]

\[
\begin{align*}
\alpha_k[n] &= z[n] + 2 \cos \left( \frac{2\pi k}{N} \right) \cdot \alpha_k[n-1] - \alpha_k[n-2] \quad (1) \\
\gamma_k[n] &= \alpha_k[n] - W_k^N \cdot \alpha_k[n-1] \quad (2)
\end{align*}
\]

Fig. 2. Filterations

VI. DATA COLLECTION OF HOUSEHOLD TIMER'S SOUND

Praat SoundRecorder Software [1] is a scientific tool for those studying linguistics that can analyze spectrograms. The zip file from Praat: Doing Phonetics by Computer website was downloaded to Windows PC for this project. It can record and read sounds recorded with the program or audio files recorded in another way. Once loaded, Praat generates a graph of the sound waves. In this case, it created household timer’s sound which is recorded and appeared in the Object window at a sampling frequency of 44100 Hz as shown in Figure 3.

Fig. 3. The data collection of household timer’s sound in Figure 4.

VII. HIGH-LEVEL DESIGN OVERVIEW

As shown in Figure 4., e.g. Timer signals the sound beep to the Device 2 which has microphone to receive the sound beep then the Device 2 signals the message to the PSD Server through Bluetooth then the PSD Server signals the message to the PSD Software that supports Android, iOS, and Windows devices to notify a person by flashing light, vibration, or message.

VIII. PSD DESIGN OVERVIEW

As shown in Figure 5., the PSD device may communicate through Bluetooth or Internet (TCP/IP) via the PSD Server. Bluetooth has a serial port profile, one host to multiple end-devices, and up to seven simultaneous connections. The Internet has Transmission Control Protocol/Internet Protocol (TCP/IP) that offers protection against data loss or distorted and User Datagram Protocol (UDP) which offers “Broadcast” and “multicast”. The PSD software supports Android, iOS, and Windows devices.

Fig. 4. High-level Design Overview

Fig. 5. PSD Design Overview
IX. SYSTEM: PSD DEVICE

As shown in Fig. 6., the microphone is an input device to receive sound on a specific timer frequency. The microcontroller is an in-output device and has one input and two outputs. When the microcontroller receives a specific frequency from the microphone as input, it processes to trigger the bright LED flashing and send a signal to WT12 Bluetooth Module as output. The WT12 Bluetooth sends signal to the PSD Server as shown in Fig. 8.

![Fig. 6. PSD Device Logic](image)

The hardware for the PSD device as shown in Figure 7. consisted of a microphone, a mbed microcontroller, a bright LED, and a WT12 Bluetooth module.

![Fig. 7. PSD Device Hardware](image)

X. SYSTEM: PSD SERVER

As shown in Fig. 8., the WT12 Bluetooth Module is an input-output device and has one input and one output. When the WT12 Bluetooth Module receives a signal from the PSD Device’s WT12 Bluetooth Module. It sends another signal to the microcontroller as output. When the microcontroller receives a signal as input, it processes to send a signal to Ethernet – R45 Jack as output. The Ethernet – R45 sends signal to the PSD Software that supports Android, iOS, and Windows devices as shown in Fig. 10.

![Fig. 8. PSD Server Logic](image)

The hardware for the PSD server as shown in Figure 9. consisted of a mbed microcontroller, a WT12 Bluetooth module, and Ethernet jack.

![Fig. 9. PSD Server Hardware](image)
XI. SYSTEM: PSD SOFTWARE

As shown in Fig. 10., the PSD Software is an in-output device and has one input and one output. When the PSD Software receives a signal from the PSD Server’s Ethernet – R45 Jack, it sends another signal to Android, iOS, and Windows devices that notify a person by flashing light, vibration, or message.

![Fig. 10. PSD Software Logic](image)

XII. FUTURE WORK

In our future work, we will continue to improve, expand, and introduce new PSD products for home and work environments. We may add User Datagram Protocol (UDP) into the products and expand to include support for Android, iOS, and Windows devices as well as we refine software and hardware interfaces.

We also may talk with companies to add the new features in their future products to notify DDHH people through Bluetooth, Internet, or/and WiFi.

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REFERENCES