

# **A.Ds: Aid Device for Deaf Drivers**

**Junghee Lee**

Vaughn College, Flushing, NY, USA, [a.aero.engineer@gmail.com](mailto:a.aero.engineer@gmail.com)

**Faculty Mentor:**

Dr. Amir Elzawawy

Vaughn College, Flushing, NY, USA, [amir.elzawawy@vaughn.edu](mailto:amir.elzawawy@vaughn.edu)

Dr. Hossein Rahemi

Vaughn College, Flushing, NY, USA, [hossein.rahemi@vaughn.edu](mailto:hossein.rahemi@vaughn.edu)

## **ABSTRACT**

Worldwide, deaf people are allowed to drive. However, as many people wonder, deaf people cannot hear audible cues such as a police siren, an ambulance needing the right of way, or even a honking horn. Deaf people say they simply pay attention to visual cues, such as the flashing lights, but honking horns do not have visual cues. For the safety of deaf people and to reduce the discrimination of society about deaf people driving, need of a device that will alert a deaf driver and also, indicate where the sound is coming is noticed. To build a desired device, the Arduino Uno board is to be used as a microcontroller to acquire the sound signal, and since MATLAB is compatible with Arduino Uno board [1], MATLAB is used to analyze the data and write the program..

**Keywords:** Arduino Uno board, MATLAB, Audio to visual cues, Communication, Deaf drivers driving

## **1. INTRODUCTION**

In order to prove if hearing is really required for driving, many professional researchers study and collect data. However, the data is still not enough, and some people believe the lack of data regarding hearing and driving safety may be due to the fact that hearing plays only a minor part in the overall driving task. Still, very few data exist for each situation to determine and more studies are needed, but the well-designed study of deaf automobile drivers by Coppin and Peck in California [2] found that deaf men had 70% more road crashes than non-deaf men. In fact, Henderson and Burg (1974) [2] have outlined four, non-routine driving situations in which hearing could be important, and the audibility of warning sound from outside the vehicle was one of them.

Over 90 countries allow deaf people to drive. Even though there are still countries denying it, U.S. has nearly always believed deaf people have right to drive. In the past, a number of case reports of deaf drivers driving safely for years supported a theory that hearing is not a necessary requirement for driving [3], but many non-deaf people still wonder how deaf people can drive without being able to hear what is going on outside of the car. Some of them consider deaf driver as a safety threat. Even though most insurance companies consider deaf people as safer drivers than non-deaf people, hearing people say letting deaf people drive is not safe because deaf drivers cannot hear audible cues such as a police siren, an ambulance needing the right of way, or even a honking horn. Because of this kind of reason, deaf people get discriminated, and some are not even allowed to drive at all. However, this should not be the reason to stop deaf people from driving a car. As a human being, all the deaf people have right to drive [3], and non-deaf people shall not judge their abilities to drive. If a device can be ears for deaf drivers and make non-deaf drivers feel safer about deaf people driving, this device should be developed and bring equality for deaf people.

## **2. DESIGN**

One proposal to solve the problem is, creating a device that will alert a driver and also will indicate where the sound is coming from is decided. A.Ds, Aid Device for Deaf Drivers, will mainly have three parts in order to convert audible cues to visible cues and vibration alert.

### 2.1. INPUT

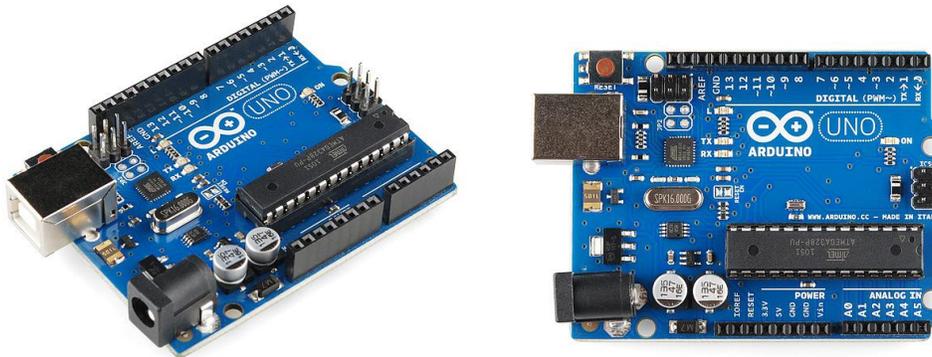
First, six small microphones will be installed to the outside of the car body to receive the audible cues. In order to indicate where the sound is coming from, each microphone shall be installed around the car about every 60°. Microphone sensor such as the one shown below in Figure 1 is to be used. This type of microphone sensor is Arduino board compatible.



**Figure 1. Arduino board compatible microphone sensor**

### 2.2. MICROCONTROLLER

Second part is a microcontroller. When the input sound signal is received, the signal is should be analyzed and filtered in order to trigger the output signal. The Arduino Uno board is used to process the signal.



**Figure 2. Arduino Uno board**

This microcontroller board has 14 digital input/output pins, 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It can be powered by a computer with a USB cable or a AC-to-DC adapter or battery to get started. Therefore, in a car, the device using this board, A.Ds, can be simply powered by the cigarette lighter receptacle with a USB cable and a USB car adapter. The Arduino board can be originally programmed with the Arduino software, but in this project, MATLAB was used instead. Arduino board will be used to connect six microphone sensors to vibration device and LED lights. Arduino board

also will be programmed to sense car-honking sound through the traffic noise and convert this input sound into output signal, which will activate the vibration device and LED light on the panel.

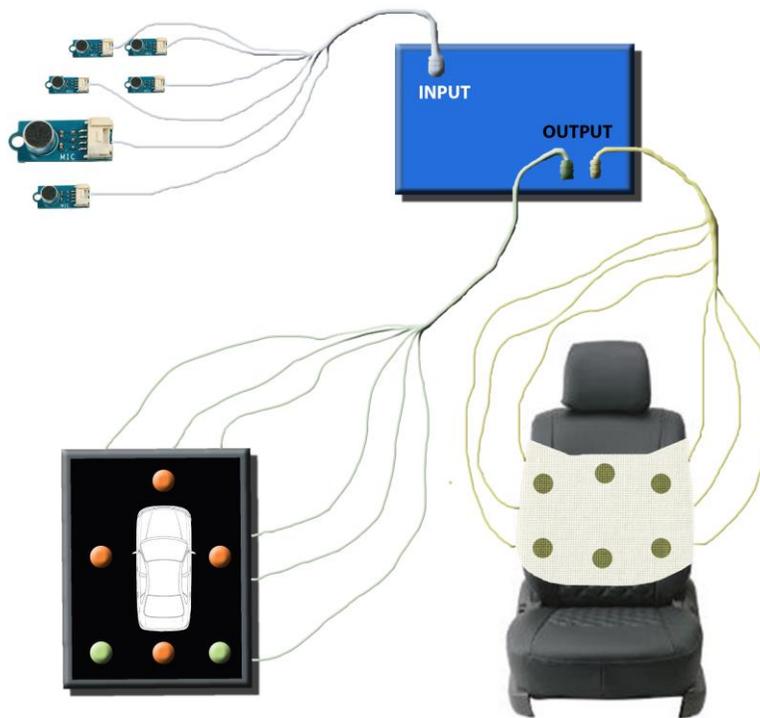
### 2.3. OUTPUT

To alert a deaf driver, output signal is important and necessary. Among many options, the vibration motor and the LED light are chosen. The vibration motor will be added to the driver's car seat to convey the instantaneous alert signal. Additionally, LED panel indicator is designed, and will have six LED lights, and each LED light represents each sensor. When the sound is received, LED light will flash to indicate where the sound is coming.



**Figure 3. Output: Vibration motor and LED light**

Following Figure 4 shows complete design of the device.



**Figure 4. Conceptual design of three parts of microphone sensors, vibrating device and LED panel indicator**

### 3. ANALYSIS AND PROGRAMMING: MATLAB SCRIPT

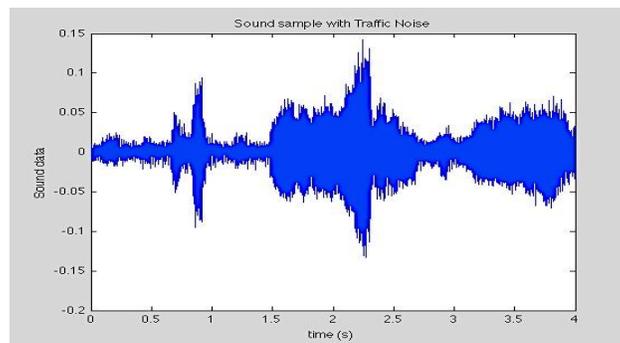
After the design was completed, the sound samples of honking sound was recorded and collected. In this project, instead of live input, recorded sample was used. Through the analysis and programming, success of verifying if the sound is a honking sound or not is desired.

By using MATLAB, testing the sample, reading a WAVE file, and plotting it was possible. First, in order to load the sample WAVE file, `wavread('')` command was used. After loading the sound, the sound was plotted as Figure 6. The size of the sample was computed, and with its sample rate, which is 44100 Hz, time increment per sample was calculated. Next, Fast Fourier Transform algorithm function [4], FFT, was used in order to create the frequency spectrum [5]. In MATLAB, discrete Fourier transform (DST) is used to implement FFT as described below.

$$y_{p+1} = \sum_{j=0}^{n-1} \omega^{jp} x_{j+1}$$

$$\omega = e^{-2\pi i / n}$$

Where  $y$  is the FFT output for  $x$  vector (sound signal in time domain) with length  $n$ ,  $j$  and  $p$  are the indices associated with the vector in a double for loop.  $\omega$  is a  $s$  complex  $n$ th root of unity [6].



**Figure 6. Plot of a second sample from 37 to 41 sec**

The FFT allows you to efficiently estimate component frequencies in data from a discrete set of values sampled at a fixed rate. Following MATLAB script is used to get the frequency spectrum of the sample.

`% Selecting a portion (37s to 41s)`

```
b1=b(44100*37:44100*41);
size(b1)
```

```
soundsc(b1,44100);
pause(3)
```

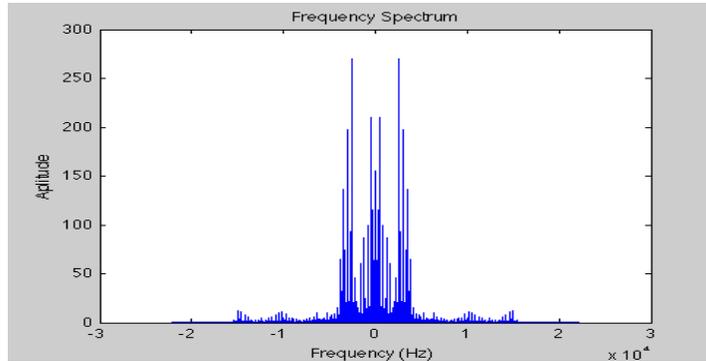
`% FFT algorithm`

```
n=176401;
fs=44100;
ts2=1/fs;
tmax2=(n-1)*ts2;
t2=0:ts2:tmax2;
f2=-fs/2:fs/(n-1):fs/2;
z2=fftshift(fft(b1));
```

`% Plotting the Frequency Spectrum`

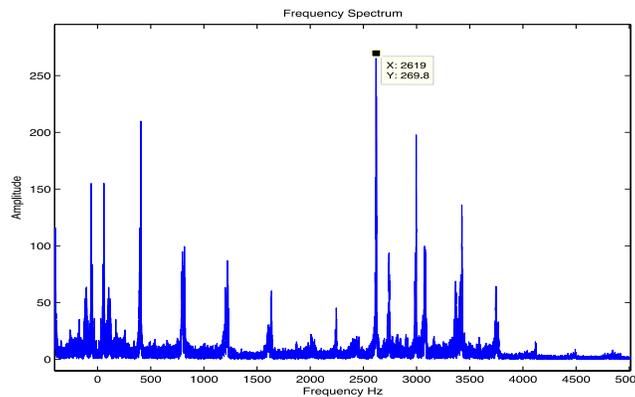
```
figure(2)
plot(f2,abs(z2))
title('Frequency Spectrum');
xlabel('Frequency Hz');
ylabel('Amplitude');
```

Plot of the frequency spectrum of a sample after FFT is shown below.



**Figure 7. Frequency spectrum of a sample**

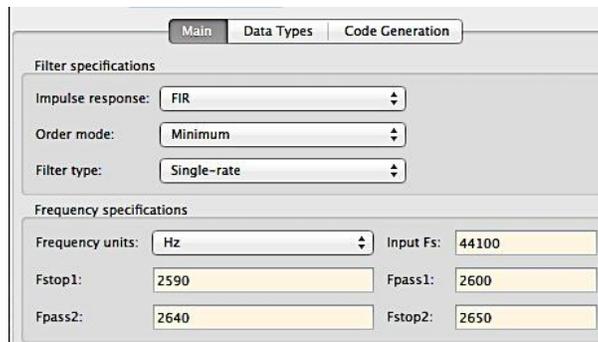
After realizing that each frequency shows difference in sound, the frequency spectrum of a sample was zoomed and studied closely.



**Figure 8. Maximum amplitude at  $f = 2619$  Hz**

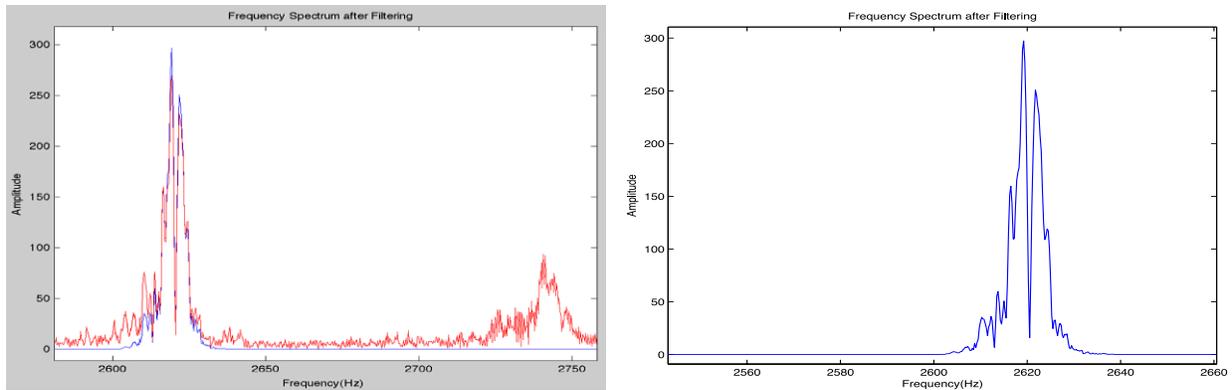
From the research, frequency of the car honk was found to be around 400 to 500 Hz [7]. However, unlike the data from the research, from close observation, maximum amplitude of the frequency spectrum came out to be 2619 Hz. Therefore, instead of the research data, following the experimental data seemed like a right choice.

After FFT, the sample sound was filtered based on this experimental data. For filtering, bandpass filter [8] was chosen.



**Figure 9. Bandpass filter specifications**

After the filter was applied, following graph was obtained.



**Figure 10. Frequency Spectrum after Bandpass Filter**

The filtered sound was checked, and it definitely had high noted beep sounds. It was clearly different from the original sound, and proved that this data can be used for the A.Ds device to filter out other noise and verify if received sound is a honking sound or not. Therefore, x data and y data were obtained from Figure 10, and found maximum amplitude as y max value and found x value for this y max. With those two values, the code that will verify whether the sound is a honking sound or any other noise was programmed. Also, the code that will connect to the Arduino Uno board and send out the output signal was written. However, in order to reduce the time to receive the outcome signal, the code connecting the Arduino Uno board to the computer was replaced at the beginning of the whole script. Following MATLAB script shows the whole process.

#### 4. MATLAB SCRIPT

```
% Connect Arduino board :D !!
a=arduino('/dev/tty.usbmodemfa131')
% specifies output pin mode for pin 10
a.pinMode(10,'output');
% Once the Arduino board is connected, second sample should not have above
% command
%%%%%%%%%%
% Reading wav file
b=wavread('/Users/Brielle/Desktop/traffichonk.wav');
% Selecting a portion (37s to 41s)
b1=b(44100*37:44100*41);
size(b1)
soundsc(b1,44100);
pause(3)
% FFT algorithm
n=176401;
fs=44100;
ts2=1/fs;
tmax2=(n-1)*ts2;
t2=0:ts2:tmax2;
f2=-fs/2:fs/(n-1):fs/2;
z2=fftshift(fft(b1));
% After bandpass toolbox is used, alert saying "The variable 'Hbp' has been
```

```

% exported to the command window.' will show up.

% Plotting the sample b1

figure(1)
plot(t2,b1)
title('Plot of a Sound Sample');
xlabel('time(s)');
ylabel('Sound data');

% Plotting the Frequency Spectrum

figure(2)
plot(f2,abs(z2))
title('Frequency Spectrum');
xlabel('Frequency Hz');
ylabel('Amplitude');

% Checking the sound

b3=filter(Hbp2,b1);
z4=fftshift(fft(b3));

soundsc(b3,44100)

% Plotting the frequency spectrum after filtering

figure(3)
plot(f2,abs(z4))
title('Frequency Spectrum after Filtering');
xlabel('Frequency(Hz)');
ylabel('Amplitude');

h =(gcf; %current figure handle

axesObjs = get(h, 'Children'); %axes handles
dataObjs = get(axesObjs, 'Children'); %handles to low-level graphics objects in axes

objTypes = get(dataObjs, 'Type'); %type of low-level graphics object
xdata = get(dataObjs, 'XData'); %data from low-level graphics objects
ydata = get(dataObjs, 'YData');

% MAX Amplitude ymax and x value

[ymax,xindex]=max(abs(z2))
xvalueformax=abs(xdata(xindex))

% Verifying Honking sound 1=Honk 0=Noise

for i = xvalueformax;
    if le(2630,i)
        p=0;
    elseif le(i,2615)
        p=0;
    else
        p=1;
    end
    for p=1;
        if le(ymax,30)
            p=0;
        else
            p=1;
        end
    end
end

i
p

% Output

a.digitalWrite(10,p);
pause(3);

```

a.digitalWrite(10,0);

## 5. APPLICATION

Even deaf people have right to drive. They cannot hear, but they still can see and feel. The main purpose of this device is to decrease the gap of sensing alert while driving between deaf people and non-deaf people, so the discrimination against deaf people driving can decrease.

A study has found that the number of crashes caused by blind spots [9] has risen by 50% in between 2009 and 2011. The blind spot causes accidents to all the drivers. However, sometimes before you get into a car accident, honking from the other car alerts drivers and prevent the car accidents. Reacting to that alerting sound, drivers will rapidly take an action to correct their course. However, since deaf people cannot hear the honking sound, it is not applicable for them. Therefore, instead of that alerting sound, by using this A.Ds device and giving a vibration alert, the same result is expected for deaf drivers.

## 6. CONCLUSION

The primary goal of this project was to make Aid Device for Deaf Drivers that will alert them when the car honking sound was detected near a car. Because each sound forms its own sound wave, the frequency of sound waves is also unique. Therefore, frequencies of the sounds were essential to be studied, and through the process of research and practice, it is possible to distinguish between the car honking sound and other sounds by using the difference of frequencies and the amplitudes of frequencies from sounds.

MATLAB is used for analyzing and filtering in the process. After the frequency spectrums were plotted, the useful band of frequencies was identified. Other than that band of frequencies, they were considered as noises and got eliminated by bandpass filtering. The maximum amplitude was used to find the useful band of frequencies, and the presence of this maximum amplitude in the waves triggered the output signal. The output signal was transmitted to the Arduino board and lit the LED light.

Proving the possibility of creating the Aid Device for Deaf Drivers by succeeding in getting output signal out through the Arduino board, the hope of reducing the discrimination of society toward deaf drivers increased. However, the time MATLAB took to communicate with the Arduino board delayed the output LED light signal. For spontaneous output signal, generating the Arduino code from MATLAB code could be practiced to upload and save the programming code on the Arduino board directly. To make a practical device, microphone sensors are to be added as an input and develop code for receiving the live input signal instead of reading wave sound of samples. Until this device comes true in real life and help deaf drivers, this project should be continued.

## REFERENCES

- [1] "Arduino Support from Simulink." *MathWorks*. N.p., n.d. Web. 14 Nov. 2013. <<http://www.mathworks.com/hardware-support/arduino-simulink.html>>.
- [2] *Hearing Disorders and Commercial Motor Vehicle Drivers*. Washington, D.C. 20590: Office of Motor Carriers, Oct. 1992. PDF.
- [3] World Federation of the Deaf, "WFD Statement on Deaf People's Right to Drive a Car or Other Vehicles." March 31, 2009 <<http://www.wfdeaf.org/wp-content/uploads/2011/04/WFD-Statement-on-Deaf-Peoples-right-to-drive-a-car-or-other-vehicles-updated-31-March-20091.pdf>>
- [4] Didier. "FAST FOURIER TRANSFORM (FFT) (PART 1-11)." *Arduinoos RSS*. N.p., 05 Oct. 2010. Web. 01 Dec. 2013. <<http://www.arduinoos.com/2010/10/fast-fourier-transform-fft/>>.
- [5] "Graphing a Frequency Spectrum with Matlab." *YouTube*. YouTube, 16 Nov. 2010. Web. 5 Nov. 2013. <<http://www.youtube.com/watch?v=dwzQnbeKnQg>>.
- [6] "Discrete-Time Signal Processing", by Oppenheim, A. V. and R. W. Schaffer, Prentice-Hall, 1989

- [7] "Vehicle Horn." *Wikipedia*. Wikimedia Foundation, 09 July 2013. Web. 23 Oct. 2013. <[http://en.wikipedia.org/wiki/Vehicle\\_horn](http://en.wikipedia.org/wiki/Vehicle_horn)>.
- [8] "Bandpass Filter." *MathWorks*. N.p., n.d. Web. 14 Nov. 2013. <<http://www.mathworks.com/hardware-support/arduino-simulink.html>>.
- [9] "Blind Spot Crashes Increase." *The Telegraph*. Ed. David Millward. N.p., 22 Sept. 2011. Web. 01 Oct. 2013. <<http://www.telegraph.co.uk/motoring/news/8779153/Blind-spot-crashes-increase.html>>.

***Authorization and Disclaimer***

*Authors authorize LACCEI to publish the paper in the conference proceedings. Neither LACCEI nor the editors are responsible either for the content or for the implications of what is expressed in the paper.*