LAB REPORT 1
AN ANALYSIS OF A
MATLAB SCRIPT FOR THE DOPPLER EFFECT

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ABSTRACT

This report is a detailed outline of recreating the Doppler effect in Matlab. I have acquired a MATLAB script via the Internet and will attempt to explain how the script works in detail. I will also be doing a slight modification to the script by applying it to a wave file that the script was not intended for. This will then be concluded with an overview of my results and findings.

1. INTRODUCTION

1.1. Overview

The Doppler effect can be explained as corresponding changes in frequency produced by a moving object at significant speeds. It is usually heard when an emergency vehicle passes an observer at a high speed. [3] This report is a documentation of the recreation of this phenomenon in Matlab using an existing Matlab script that I have obtained on an Internet forum. [9] However, this script will be altered for the following reasons.

1. For the script to be functional.
2. To explain the script in my own words.
3. To apply the script to a siren sound effect.

1.2. Aims

The objectives of this report are:

- To USE an existing Matlab code of the Doppler effect and explain it in detail.
- To modify the code so that it is operable.
- To modify the code so that it can be used on a siren sound that I have acquired through a sound effects library.

This lab report is part one of two reports. This report is a documentation of the work I have done to the Matlab script to make it functional. This script will apply a pitch shift over time to an existing siren effect. Lab report 2 will then include

- A correction in any errors in the script
- Turning the script into a stereo matrix
- Adding amplitude changes to the script that will be applied to the approaching and receding siren.

The overall objective of the two reports is to emulate a siren passing a stationary observer. This will result in three elements in the script.

1. Movement of the siren from left to right in the stereo field.
2. An increase in amplitude of the siren as it moves towards the observer and then a decrease in velocity as it recedes away from the observer.
3. A decrease in pitch as the siren moves away from the observer to emulate the Doppler effect.

The final submission will consist of four files; the report in PDF format, the original siren sound as well as the manipulated siren sound in .wav audio format and a Matlab script in the form of a function submitted in a .m format.

2. METHOD

After searching online for a suitable script I found one that was appropriate for this report. I then copied and pasted the script from an internet forum into a Matlab function file. I then attempted to run the function which was.
[yout f_coeff] = doppler_effect(input, v, x0, y0)

yout = output file name
f_coeff = defines the coefficient that implements changes in frequency over time
doppler_effect = Function name
Input = Input file to be processed by the function.
V = The speed of the approaching sound, in this case it will be a siren.
x0 = Horizontal distance between the observer and the siren.
y0 = Vertical distance between the observer and the siren.

The suggested example of the function call was
[y2 f] = doppler_effect(y, 70, 100, 3.5);
However, I imported the file 'siren.wav' and then applied the function to the wave file by replacing the input 'y' with the siren. The resulting function call entered into Matlab was
[y2 f] = doppler_effect(siren, 70, 100, 3.5);
siren = wavefile
70 = km per hour
100 = Horizontal distance in metres
3.5 = vertical distance in metres

After entering the function call into Matlab a series of errors occurred. The error message that appeared was "unidentified function or method". I identified the errors by the lines and columns where Matlab had indicated. The errors occurred because some of the text that explained the script were imported into adjacent lines and therefore did not have percentage signs next to them. Matlab had read these as unidentified variables. Due to these errors I had to delete certain script lines that were not command based and re-adjust the script so that comments corresponded with the script.

2.1. Variables

The following is a table of variables that are present in the Matlab script.

Variables	Explanation
N = length(input);	Defines the length of the input signal in samples
x = linspace(-x0, x0, N);	Generates the linear space vectors for the horizontal distance between the receiver and signal of the input signal
alpha = atan(y0./-x);	Defines the angle between the source and receiver
index = find(alpha < 0, 1, 'first');	Variable yet to be identified and defined.
alpha(index:N) = pi + alpha(index:N);	Variable yet to be identified and defined.
c = 343;	Defines the speed of sound in m/s.
v2 = v*1.61/3.6;	Converts the velocity of sound from miles per hour to km per hour.
vdoppler = v2.*cos(alpha);	Velocity changes between the source and receiver.
v0 = 0;	The velocity of the receiver is zero because the receiver is stationary
f_coeff = (c + vdoppler)/(c - v0);	(See figure 8.2) A coefficient that implements change in frequency were f0 is the fundamental frequency of the input signal

The second half of the script is a 'for loop' which processes and resample the waveform in sample portions.

3. RESULTS

The output signal was a siren that had been a shift in frequency over time. The problem with the output, signal was that all positive amplitude values of the siren signal had been truncated. The truncation has therefore caused distortion of the output signal. (shown in figure 8.2. on page three) Notice the amplitude values from approximately 0.14 and above have been truncated, and this has resulted in distortion.

4. DISCUSSION

The input signal of the siren fluctuations in amplitude was in excess of 0.4. However the output signals positive amplitude values reach only 0.14. This has resulted in the truncation of amplitude 0.26 from the original signal. The fundamental problem of the results is the distortion that has been created by this truncation. I believe that the following may have caused the source of the problem

1. A phase problem in the script with all positive amplitude values.
2. An error in the for loop/ resample section of the script.

If the source of the amplitude problem is found, not only can I eradicate the distortion of the output signal but I can use that element of the script to increase the amplitude values as the siren approaches and decrease those values as the siren recedes.

5. CONCLUSION

The Matlab script works with the function creating a shift in pitch over the time of the input signal. However the following problems need to be addressed before the next report.

1. Rectify the problem of the distortion of the output signal.
2. A stereo matrix needs to be included into the script to recreate the stereo field of the siren as it approaches and moves away from the listener
3. A progressive increase in amplitude as the siren approaches and a decrease in amplitude as the siren recedes from the receiver.
4. Identify and define variables where the function is not known.

Once these four problems have been solved an accurate depiction of the Doppler effect will be recreated in Matlab.

6. ADDITIONAL FILES

This report will be submitted in PDF format and be accompanied by two wave files and a Matlab function file. The names of these files are:
[siren_original.wav]
[siren_doppler.wav]
[doppler_effect.m]

7. REFERENCES

[1] T. Koupelis, *In Quest Of:* The Universe. Jones & Barlett Publishers, United Kingdom, 2011. pp 116 – 118.

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[7] G.P. Bell and M.B. Fenton, "The Use of Doppler- Shifted Echoes as a Flutter Detection and Clutter Rejection System". *Behavioral Ecology and Sociobiology.* Vol 15, No.2 Springer Carleton University, Ottawa Canada 1984 pp 109 – 114.

[8] B. Ram. "On the Doppler Effect" Physics Dep, New Mexico University, Las Cruces New Mexico *AJP* Vol 40 pp 1116 – 1118.

[9] Username: Ziko "Doppler Effect – How if Possible" http://www.mathworks.com/matlabcentral/newsreader/iew_thread/238192. Created 31Oct 2008

8. GRAPHS

Figure 8.1. ‘siren_original.wav’ Shows the original sound wave of the siren before it is processed.

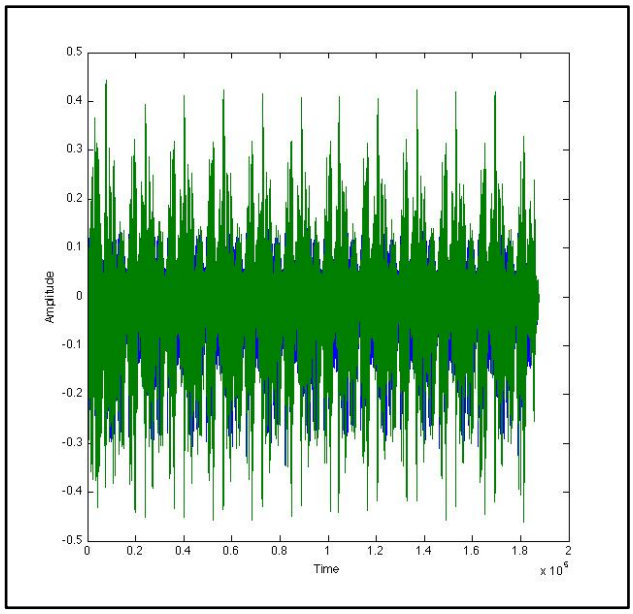

Figure 8.2. ‘siren_doppler.wav’ Shows the output signal. Positive values of 0.14 and above have been truncated.