EEE 321 LAB WORK 3

November 4, 2022

1 Introduction

In this lab experiment, we were expecting to capture an impulse response such that the impulse response is a balloon explosion. After we have recorded the impulse response, we needed to produce an output function by convolving the impulse response with a chosen input function music. To realize that I have chosen *mozart_vl2_6.mp3*, which is downloaded by the provided link, as input function.

The input response was recorded in Odeon, I have blown a balloon with needle at the stage of Odeon, and my friend recorded the sound of balloon explosion while sitting at the back stairs.

Figure 1: Me on the stage to blow the balloon

2 Procedure

After recording step, both input function and impulse response were converted into arrays using the audioread() function of MATLAB. Since the sampling rate of both function were 48000 Hertz, there were no problem in convolving those functions. In order to find their convolutions, default conv() function of the MATLAB has been used. As expected the

Figure 2: My friend who recorded the blow sound of balloon explosion

sampling rate was 48000 Hertz again. After this process, the output function has been converted to audio file using audiowrite() function of MATLAB. As last step, all the functions have been plotted to see them in details.

The corresponding equation for this convolution is shown below. Where $y[n]$ is output function,$x[n]$ is input function and $h[n]$ is impulse response function.

$$y[n] = x[n] * h[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k]$$

The equation is written in discrete form since when the audios are stored they must be quantized, which means they become discrete in order to store in digital environment.

3 Questions & Results

3.1 The Quality of Impulse

Since the recording is performed in an open area, there were some noises which can be seen in the figure-3. Even if there are some noises, it did not affect the general structure of impulse response function . Therefore, it can be said that the quality of the impulse response was good enough even if it is not perfect.

3.2 The Nature About the Impulse Response

The impulse response of this experiment was the explosion sound of a balloon in Odeon. Thefore in this experiment instantaneous increase was expected in the sound volume. Also because of the acoustic Odeon environment, this leap was expected to be followed by its echoes such that they have exponential decay in their volumes. As expected we got a jump and its echoes, which is shown in figure-3. Since there is an instantaneous jump with the explosion of balloon before the echo, the function can be assumed as an impulse.

3.3 Validity of the Linear Time Invariant System Assumption of the Acoustic Environment

It can be seen in the figure 3 that the echo in the explosion signal is squezed and repeated type of the real impulse. That is the the echoes are the shifted and smaller amplitude version of the original impulse. Therefore it can be said that the system allows a function to recreated with time shifted and sum of other functions with different amplitudes version. Thus the system is linear time invariant (LTI) system.

3.4 Distortions and Their Reasons

The first reason for distortion is that audios are analog signals; however, they must be sampled in order to store in computers. That is analog signals must be converted to discrete digital signals. In order to make the distortion small, the frequency of quantization can be choosen as high frequency. In this way discrete points will be so close to each other and it will look like a continuous signal. In the experiment frequency was 48000 Hertz for both impulse and input, which is high sampling. Therefore, the plotted signal looks like a continuous time signal. In this way dissortion was made small. In addition to those, as stated in the lab manual plenty of musics are compressed in a lossy fashion while storing. Because of those losses, distortions occur. Fortunately, none of mentioned distortions are noticed with human ear if the frequency is high and compression technique is not so lossy.

3.5 Noise During the Recording and Its Effects

The impulse response has some noises due to the open air envrionment of the Odeon. Therefore, the convolution of noisy impulse response with the input function contains noises in the system's output signal. The noises can be seen in the plot of output function, which is figure 5. Also if the output is listened carefully some noises can be noticed, but in overall they are hard to notice noises.

3.6 Effect of Acoustical Structure of the Listening Environment to the Listening Quality Experienced by the Audience

In this lab experiment we have used an aneochoic music to convolve with a impulse response, such that the impulse response was recorded in a acoustic environment. Therefore, the output function of this convolution converts the input function to a acoustic structural function. That is it is felt like the music is listened in Odeon. This is because the listener can experience acoustical structural music without going to Odeon. Therefore, I think the music of output function is more pleasant than the original music.

3.7 Graphs

The graphs of all the functions, which are impulse response, input function and output function respectively, given below.

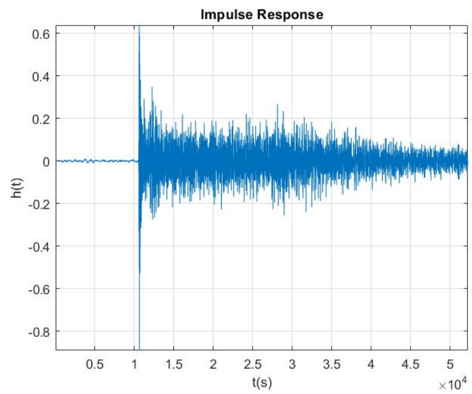

Figure 3: The graph of the balloon explosion which is impulse response

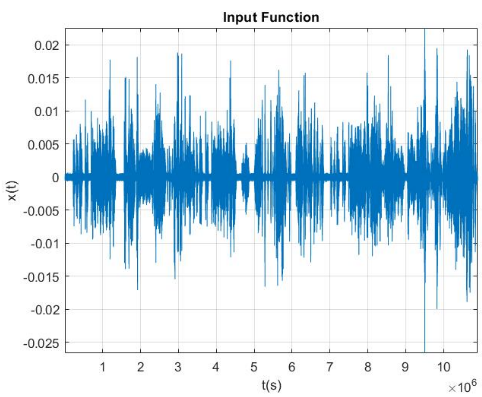

Figure 4: The graph of the input function, $mozart\_vl2\_6.mp3$ music

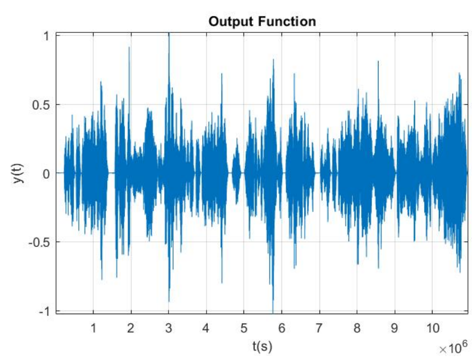

Figure 5: The graph of the output function which is convolution result

4 Appendix-Matlab Code

```
[ht,F2] = audioread("impulse response.m4a");
[xt,F1] = audioread("mozart_vl2_6.mp3");
yt = conv(xt,ht);
audiowrite('Output.wav', yt, F1);

figure
plot(xt);
xlabel('t(s)');
ylabel('x(t)');
title('Input Function');
axis tight;
grid on;

figure
plot(ht);
xlabel('t(s)');
ylabel('h(t)');
title('Impulse Response');
axis tight;
grid on;

figure
plot(yt);
xlabel('t(s)');
ylabel('y(t)');
title('Output Function');
axis tight;
grid on;
```