COMPENG 4TL4 – Lab 2 Report

Resampling, Reconstruction and Convolution

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Section: L03
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Introduction to Convolution

1 a) Create a discrete-time sequence:

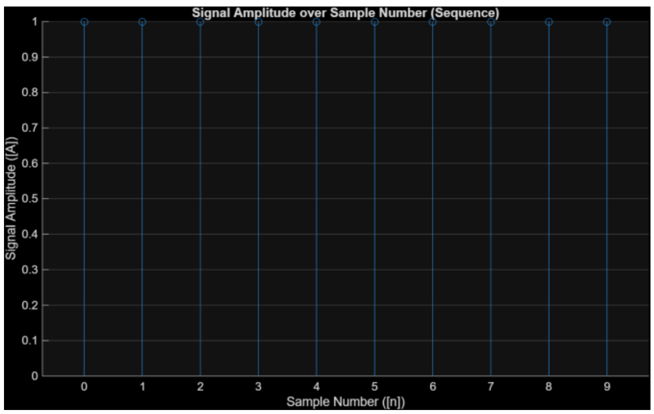

Figure 1: Discrete time sequence for x[n]=u[n]-u[n-10] with no zero elements

1 b) Convolution of Signal:

The signal was convoluted with itself first, then the original signal was convoluted with the first convolution. This repeated two more times, with the plots of each signal shown in 1 c).

1 c) Plotting of Convolutions

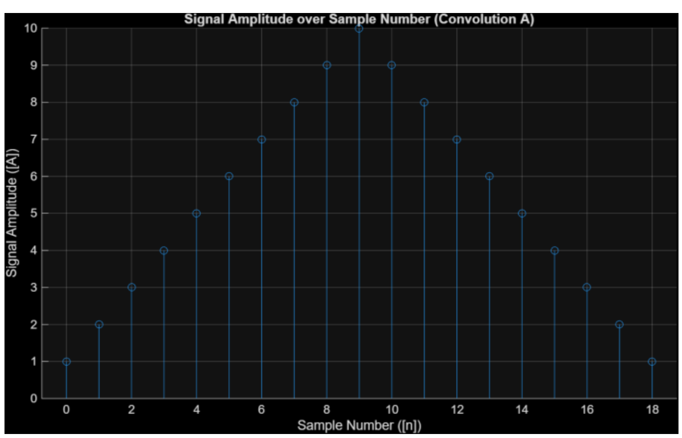

Figure 2: Convolution of x[n] with itself produces convolution signal A

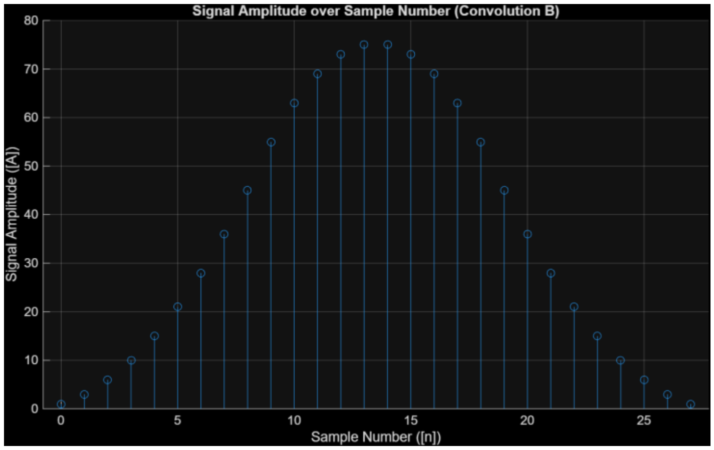

Figure 3: Convolution of convolution signal A with x[n] produces convolution signal B

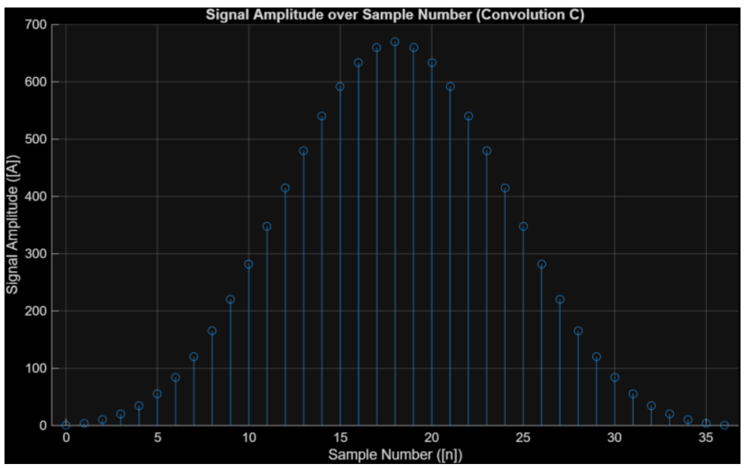

Figure 4: Convolution of convolution signal B with x[n] produces convolution signal C

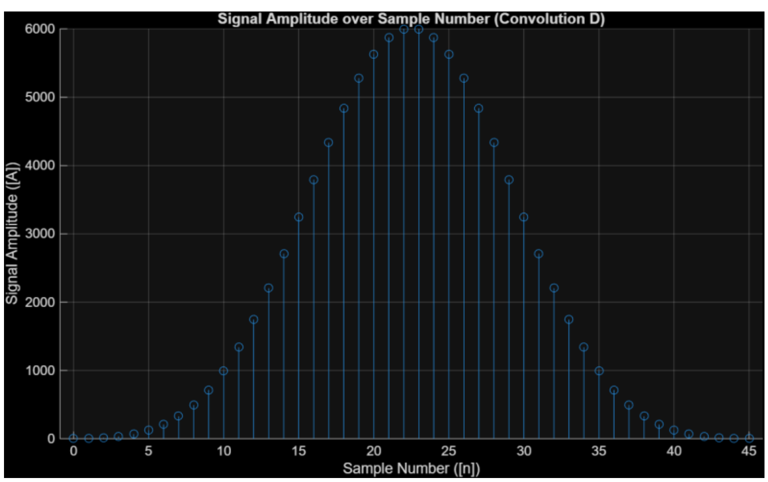

Figure 5: Convolution of convolution signal C with x[n] produces convolution signal D

Convolution of Signals and System Impulse Responses

2 a) The signal was loaded into MATLAB using audioread(), it has a sampling rate 44100 Hz.

2 b) The audio sounded like a loud noise (something falling or being hit) followed by an echo. The plot of the impulse noise waveform shows this with a high magnitude peak at the start of the waveform followed by many smaller peaks afterwards that decrease in magnitude. The following is a plot of the impulse response:

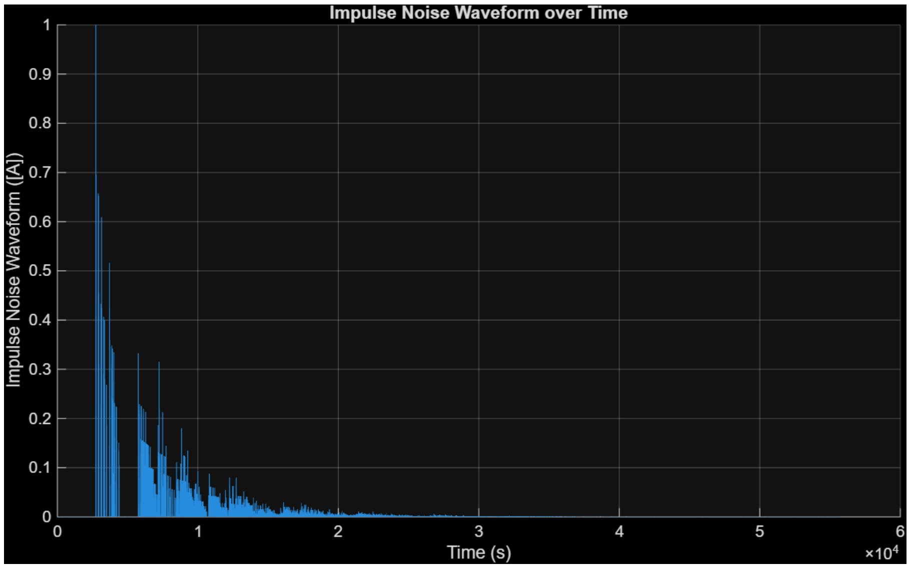

Figure 6: Plot of "roomIR" audio recording meant to represent an impulse response

2 c) The following is a plot of the supplied speech signal:

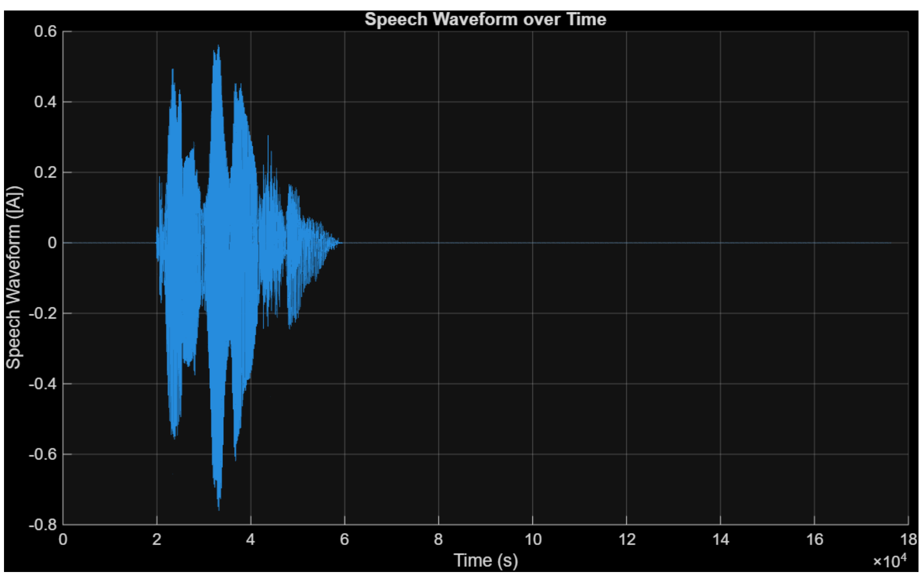

Figure 7: Plot of "convolution" audio recording where someone is saying the word "convolution"

2 d) When the convoluted signal is played, the same audio as the original convolution signal is heard except with the inclusion of a small echo. Based on impulse response theory, the convoluted signal is the

impulse response of an LTI system. If the signal was a pure impulse, they should be the same signal. However, because the original impulse response audio had an echo, this was captured during the convolution resulting in the echo we heard in the new signal. From the plot of the convoluted signal, there is a similar shape except that the magnitude has increased, particularly at the peak of the signal (because of its location in the speech waveform, magnitude, and the imperfect nature of the impulse response signal). The following is the plot of the convoluted signal:

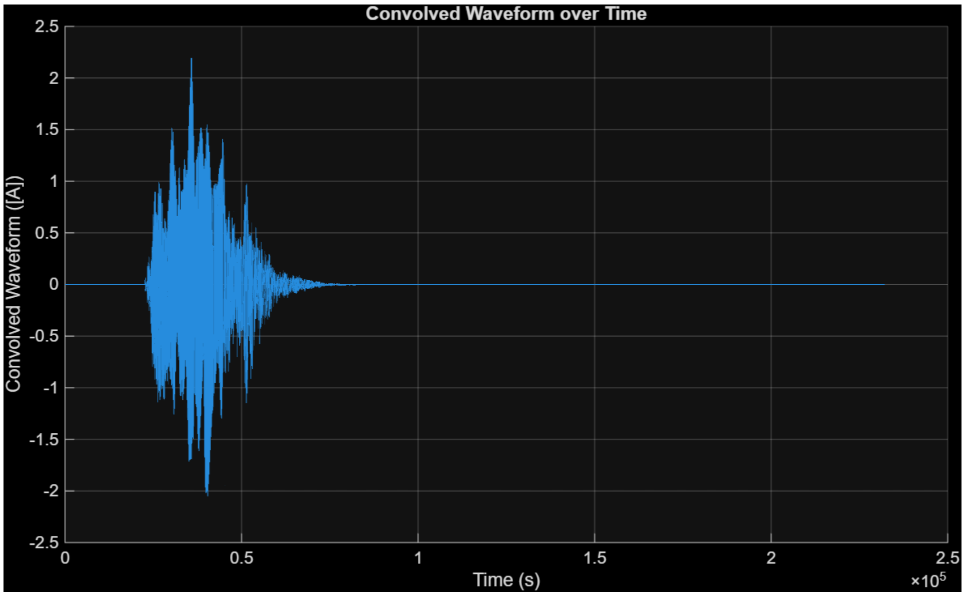

Figure 8: Plot of the impulse response audio convoluted with the speech audio

Image resampling and reconstruction

3 a) The size of KillarneyPic.png is 776x1395 and the bytes is 1082520.

```
>> Lab_2_P3
  Name                 Size                 Bytes  Class    Attributes

  killarney_pic      776x1395             1082520  uint8
```

Figure 9: Command window output showing size and bytes of KillarneyPic.png

3 b) Imported KillarneyPic.png image in MATLAB converted to a double-class variable and displayed.

Figure 10: Orignial KillarneyPic.png

3 c) i) Impulse sampling at 1/5 of the original rate.

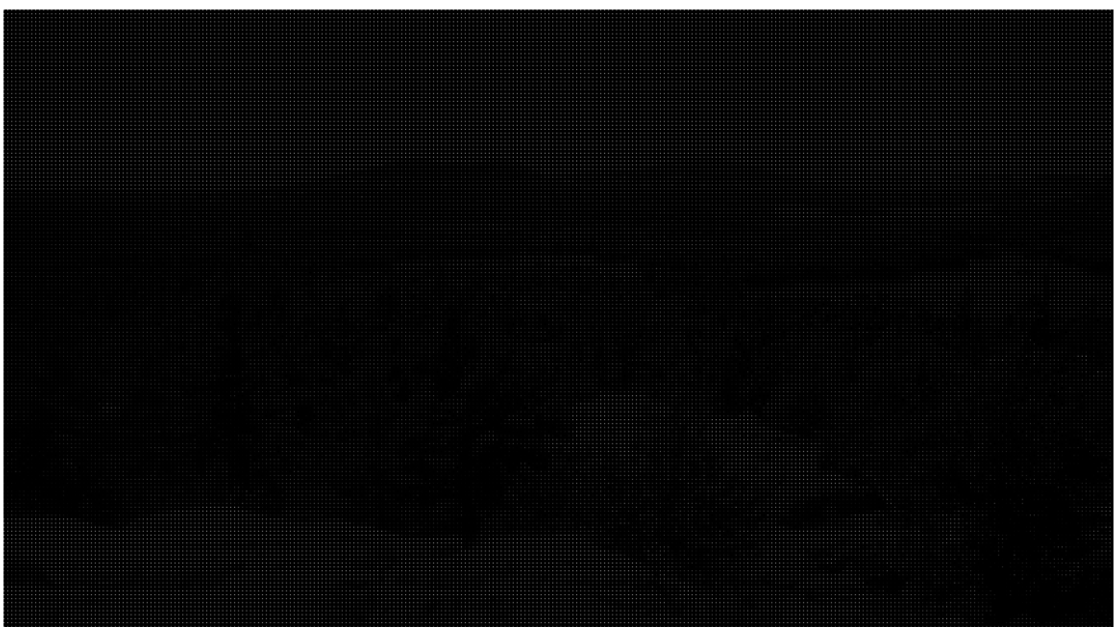

Figure 11: KillarneyPic.png impulse sampled at 1/5 of the original rate

3 c) ii) Downsampling by a factor of 5.

Figure 12: KillarneyPic.png downsampled by a factor of 5

3 c) iii) Zero-order hold reconstruction (back to the original rate) from the downsampled image created in part (ii) above.

Figure 13: Downsampled KillarneyPic.png (by factor of 5) after zero-order hold reconstruction

3 c) iv) First-order hold reconstruction (linear interpolation—back to the original rate) from the downsampled image created in part (ii) above.

Figure 14: Downsampled KillarneyPic.png (by factor of 5) after first-order hold reconstruction

3 d) The image that least resembles the original image is the impulse sampled image. Although it carries the same amount of information as the downsampled image, the introduction of 4 black pixels (not in the original image) for every 1 sampled pixel produces an almost fully black image that is mostly different from the original image. The next best image in terms of fidelity to the original image is the downsampled image since 80% of the original pixels are lost and it does not have the same size as the original image. However, many of the original details can still be spotted in the downsampled image. The next best image in terms of fidelity to the original image is the zero-order hold reconstructed image because although it looks like the downsampled image but made bigger, it is the same size as the original image. The best image in terms of fidelity to the original image is the first-order hold reconstructed image because by inferring the missing pixels with a linear slope, it is a better representation of the actual missing pixels compared to inferring with just a constant value in zero-order hold. The first-order hold reconstructed image also has the best PSNR of 25.68 dB compared to the zero-order hold reconstructed image with a PSNR of 20.99 dB and the impulse sampled image with a PSNR of 3.91 dB.

FMCW Radar Signal Processing Project with TMS320C6713 DS

4 a) The waveform of the transmitted signal in the lab document does not match the waveform shown in Figure 15. The waveform in Figure 15 appears to be 1 period on the signal depicted in the lab document and then a reflected version of that signal. This occurs as the bandwidth of the signal and the sampling rate are the same. This results in aliasing (which is why we get the observed reflected signal) as the proper sampling rate should be at least twice the original bandwidth of the signal. Figure 16 highlights the reflected signal. It is difficult to determine the number of targets in the coverage (maybe around 12 based on the peaks) as the signal has not been properly filtered/processed properly. Finally, Figure 17 depicts the transmitted signal down sampled by a factor of 2. It is apparent that there is still aliasing that has worsened along with missing information from the original signal.

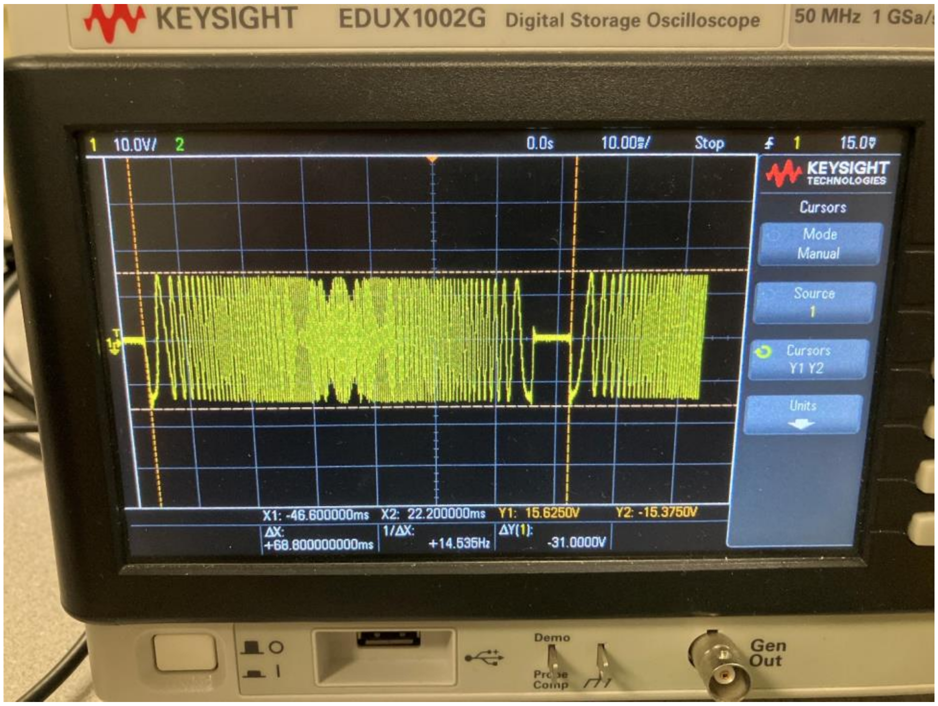

Figure 15: Waveform of transmitted signal

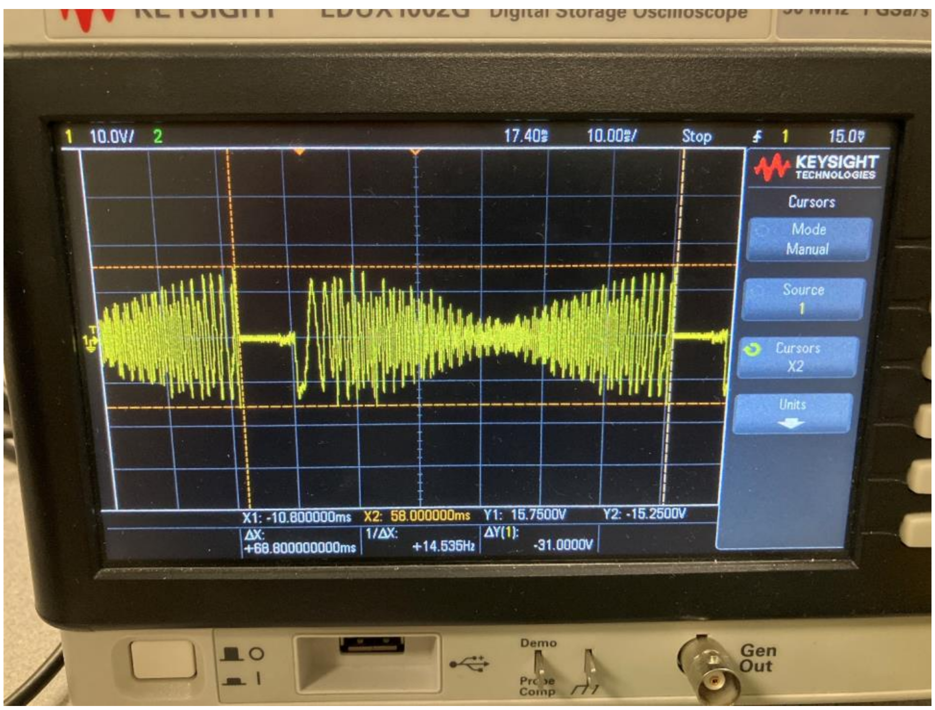

Figure 16: Waveform of received signal

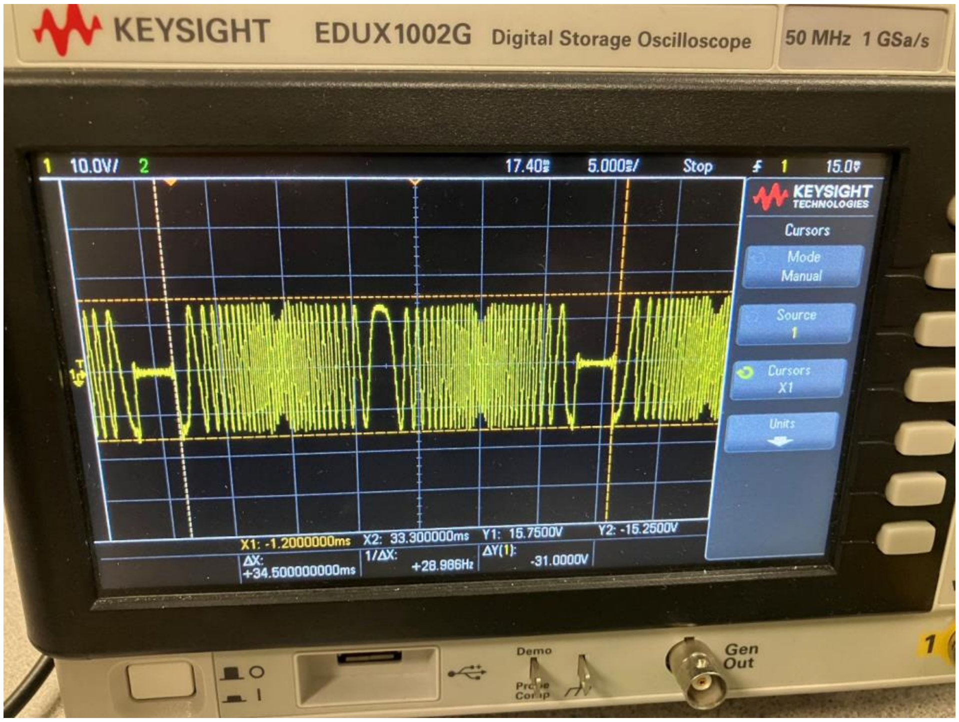

Figure 17: Transmitted Signal downsampled by 2