Zewail City of Science and Technology
Team
University of Science and Technology
Communications & Information Engineering Program
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Digital Signal Processing
FFT-Spectrum Analyzer
Project - Phase #1

Team Members

Riham Al-Sayed Abdo	201601808
Fatma Moanes	201700346
Mahmoud Ashraf	201700989

Contact Info

s-rihamabdo@zewailcity.edu.eg

s-fatma_moanes@zewailcity.edu.eg

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Option 1 | Discrete-Time Convolution Demo

Overview

Convolution is a mathematical operation performed on two functions resulting in a third. The output is an expression of how the shape of one function is modified by the other. It can be used to determine the output of a system for a given input. The sifting property of the discrete-time impulse function results in the possibility of representing the input signal to a system as a sum of scaled and shifted unit impulses. Therefore, by linearity, the output signal would be as the sum of scaled and shifted unit impulse responses. That is exactly what the operation of convolution accomplishes. We may determine an LTI's system output by knowledge of the input and the impulse response.

Discrete-Time convolution is defined by the following summation:

$$y[n] = x[n] * h[n]$$

$$y[n] = \sum_{k=0}^{N-1} x[k]\, h[n-k]$$

The summation of the product of the two functions after one of them is reversed and shifted. If the signal's length is N and the second signal's length is L, then the output's length should be N + L - 1. For the purpose of demonstration, we show only 40 samples of it; each corresponding to the summation of the product of one sample from x and the reversed shifted h.

Features

The interactive app is a demonstration of the performance of discrete-time convolution on two functions. Signal 1 and 2 are the functions to be convolved; the user may choose one of the following options: exponential, truncated sinc and rectangular. You may observe the effect of varying the functions amplitude, width or power on the output signal. Advancing the sample index's spinner shows the computational details.

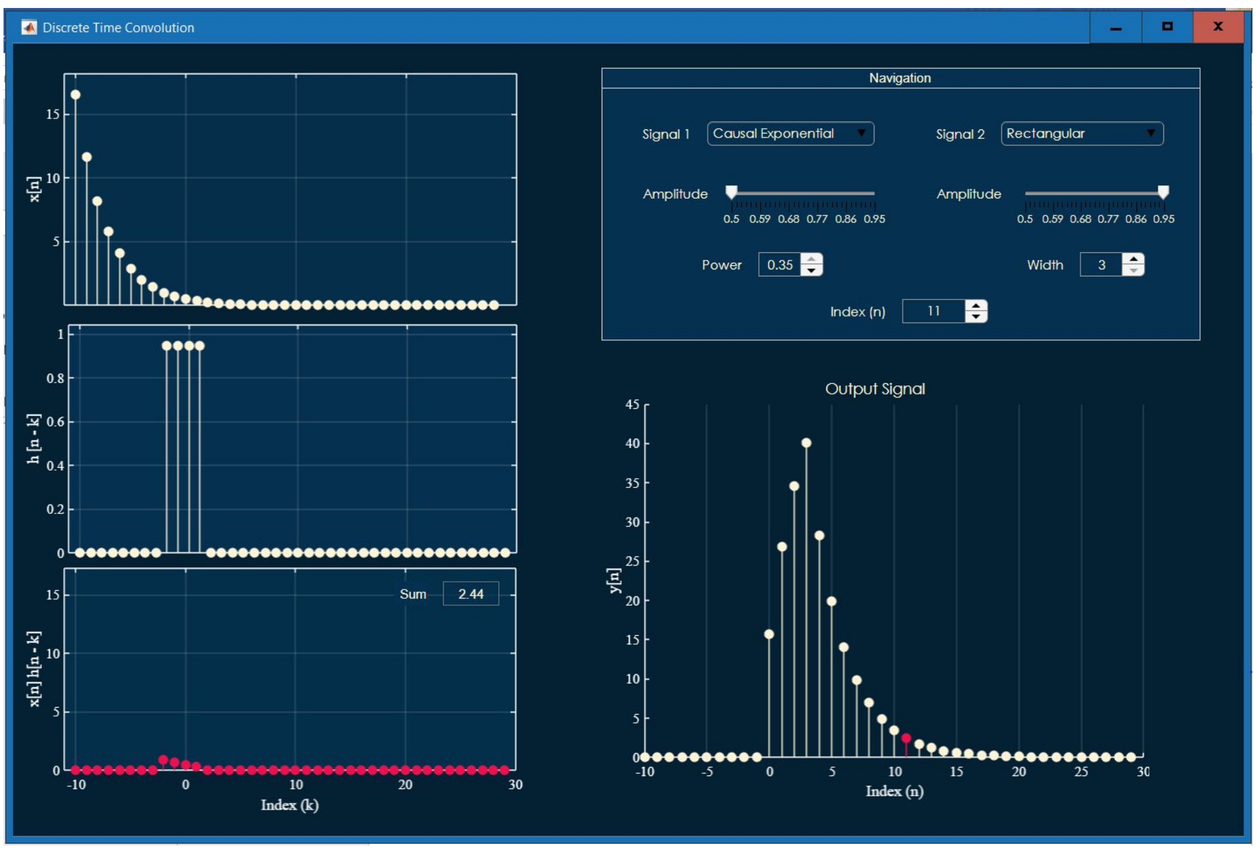


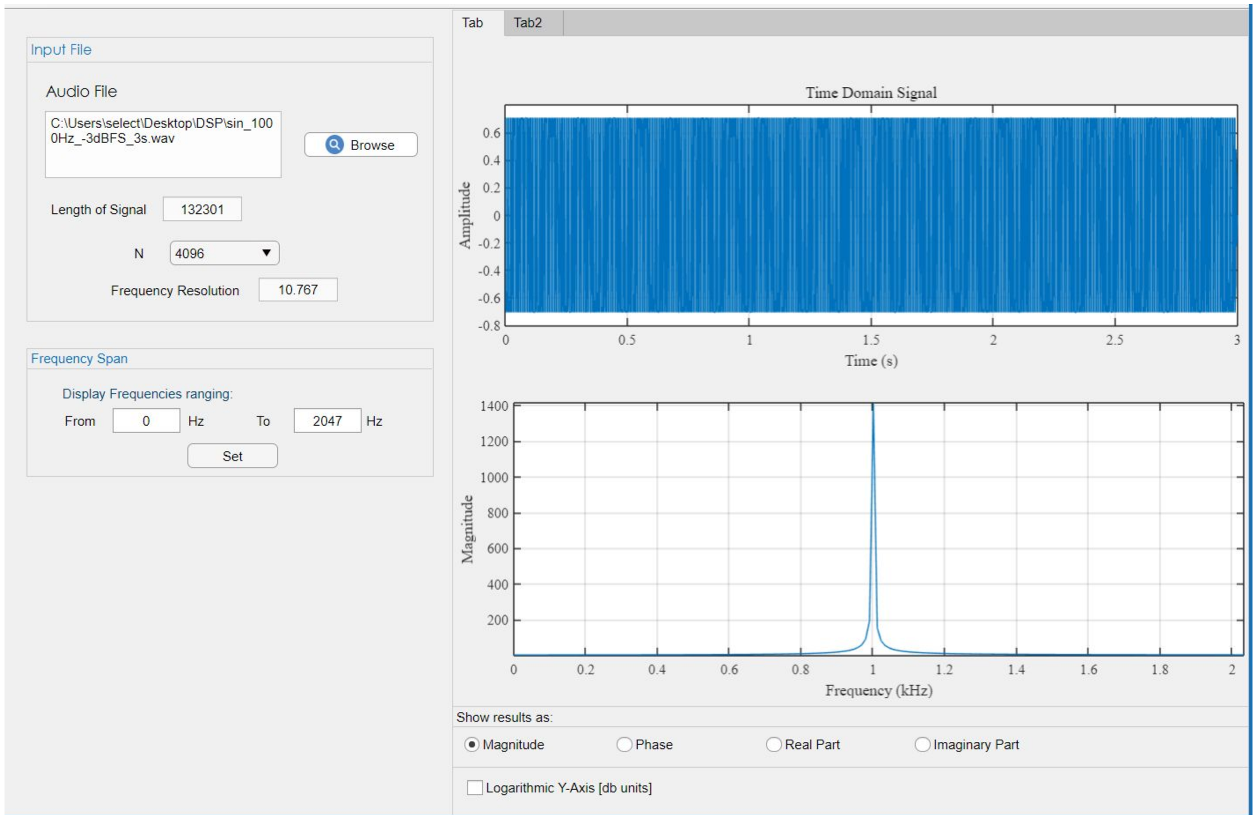
Fig.1. GUI of Discrete Convolution

Option 2 | FFT Spectrum Analyzer

Overview

The Fast Fourier Transform (FFT) is a powerful tool for analyzing and measuring signals. For instance, we are able to effectively acquire time-domain signals, measure the frequency content, and convert the results to real-world units and displays as seen on a traditional benchtop spectrum analyzer. Analysing the frequency spectrum of a signal gives us an idea about the frequency components of a signal, its power, bandwidth and other specifications of the signal that cannot be detected in the time domain.

FFTs produce the average frequency content of a signal over the entire time that the signal was acquired. For this reason, FFT is used for stationary signal analysis or in cases where you need only the average energy at each frequency line. The two-sided results from the analysis functions include the positive half of the spectrum followed by the negative half of the spectrum. We display only the positive half of the frequency spectrum because the spectrum of a real-world signal is symmetrical around DC. Therefore, the negative frequency information is redundant. We turn the double-sided magnitude spectrum to single-sided magnitude spectrum.



The phase information the FFT yields is the phase relative to the start of the time-domain signal. A sine wave shows a phase of –90° at the sine wave frequency. A cosine shows a 0° phase. Mostly, our concern is the relative phases between components.