Signals and Systems Laboratory Discrete and Continuous Convolution

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***Abstract*—This report presents the development of a computational program, made in Matlab, with the purpose of implementing the different topics given in the course on signal convolution. The convolution of signals in the seven different waves is presented, and the different ways of convolution that are performed; like the convolution of triangular signal with a rectangular.**
This starts with the identification of each signal requested, that is, the way the wave of each signal is seen, followed by the function that gives as a specific description of each signal (the function that defines the type of signal), now with this its placed the mathematical definition. All signals have a different convolution since they have a a different wave transfer and different parameters; this means that the convolution of signals is as specific as are the parameters given by the user.

***Index Terms*—Matlab; Signal convolution; continuous; discrete.**

I. Introduction

THIS report presents the development or representation of a discrete or continuous signal from the input signal to the output signal. The program was designed to generate 4 examples of signals, these are the exponential, sinusoidal, triangular and rectangular. The presented program is also able to demonstrate the input graph and the impulse response for each of the signals, taking into account the methods described in the book ”Introduction to Signals and Systems”, the parameters of the functions are represented in order to convolve the signals.
The program also graphs three types of signals, which are similar to the triangular wave that are ramps, they are three types of waves a little more specific; these three types of signals must have the ability to convolve with any previous signal, either square or triangular:

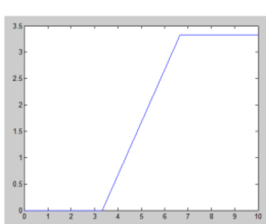

Figure 1. Ramp 1

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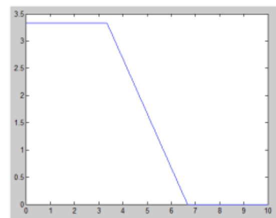

Figure 2. Ramp 2

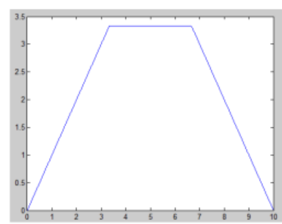

Figure 3. Ramp 3

II. Experimental framework and Results

A. Definition of variables and the user interface

The parameters to change for the creation of the signal are defined, these parameters are the amplitude, start and end point and a period, the different types of signals are shown from its scaling to its convolution. During this development, an example of each convoluted signal is shown with a different signal, either continuous or discrete.
In this part a friendly interface is created so that the user is able designate the parameters of the signal and the type of signal, then there is another interface to choose the method to be developed and allows the convolution between the two different signals.

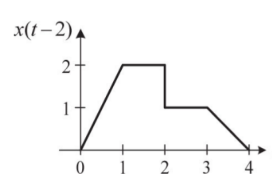

Figure 4. Representation of the user interface

B. Sine signal plotting

A sine wave is the definition of the mathematical sine function, the qualities of this wave are that the termination of

the sine wave in the graph depends on its amplitude, this is justified with this formula:
y(t) = A·sin(2·pi·f·t)
The displacement of this wave is analogous to a continuous signal since the sine function is continuous and periodic, and also the scaling of this signal is directly associated with the amplitude and frequency at which you want to expand or compress the signal.

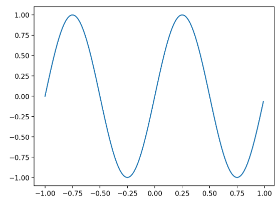

Figure 5. Representation of the sinusoidal signal

The sinusoidal signal behaves as dictated by its sine function, in the discrete example its waveform change is demonstrated by its convolution with a triangular signal.

C. Exponential signal plotting

An exponential wave is commonly defined as a graph that has an upward or downward termination depending on whether ”b” is positive or negative: y(t) = Ae^{-bt}

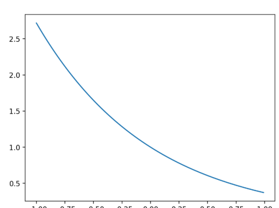

Figure 6. Representation of the exponential signal

In this example we can see the discrete signal and then the continuous signal convolved with a sinusoidal signal.

D. Triangular signal plotting

It is characterized as a periodic wave with a symmetrical slew rate in most of the functions, it has a kinship with the sinusoidal signal for its low harmonic content, the behavior of the wave is known as ramp:

$$x(t) = \sum_{i=0}^{N} (-1)^i n^{-2} (sin[nt])$$

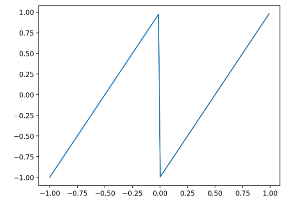

Figure 7. Representation of the triangular signal

The convolution of the triangular signal with a rectangular signal is displayed.

The signals described here can be selected from the drop-down menu in the interface described and exemplified, and the formula for each signal is shown in this interface. These signals are shown graphically and their response to the impulse in the aforementioned interface, and the user is free to choose the parameters of the functions to be convoluted, and in the case of the exponential function, the exponent can be modified to generate the output desired by the user. - In the case of the sinusoidal, triangular and rectangular functions, the starting point of each signal is irrelevant, they always show a complete cycle for the task in question and the period can be modified at the user’s will. In the case of the ramp signals, three ramp signals are shown, which were previously shown, and there were some difficulties with regard to the third ramp signal, but this is contextualised on the basis of the other two, as these are simply sections of the others, and the user can modify the proportions of these signals as desired in the graphic interface; it should be noted that for these signals the amplitude does not need to be modified, so when selecting this type of signal this parameter will not be displayed in the interface.

When visualising the discrete signals and their convolutions, when representing the sinusoidal function, it was constructed with sufficient samples based on the Nyquist theorem and at the same time the complete cycle of the signal mentioned here is shown. It is worth mentioning that all the functions can use each other to perform the convolutions desired by the user (functions of the same type, i.e. discrete with discrete and continuous with continuous). To conclude the explanation of the signals and interface, it can be mentioned that the convolution process is shown by means of a dynamic process, i.e. an animation that shows the process that the signals go through during convolution.

III. Conclusions

In conclusion, the majority of the objectives were achieved despite the obstacles in the course of the project, such as bugs in the animations, especially in the continuous signals, but the animations in general were carried out normally and efficiently. Throughout this document, the type of signals and how they behaved when convolution with each other, whether in the continuous or discrete domain, were explained and visualised, thus demonstrating the correct use of theoretical knowledge in order to put it into practice in the laboratory described here. Finally, it is worth mentioning that although the last ”ramp” signal is not shown, it explains and contextualises with the other ”ramp” signals how the result of this last one would be based on the previous similar ones, this being a way of culminating the laboratory even with the setbacks presented.

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