

Digital Signal De-Noiseing using MATLAB-Simulink Wavelet

Makhamadsulton USTAZHANOV *

Abstract

Important parts of digital signals are corrupted with unwanted noise signals. Current digital low pass filters are not enough in some circumstances, for instance when there are digital and noise signals with high frequency. The new methods of wavelet analysis are studied by using MATLAB-Simulink Wavelet Tool in order to reduce unwanted noise signal from digital signals. This field of science has different Wavelets that can be used and a comparison of the results is possible.

Keywords: Noise, Signals, Digital, Digital-Signal, MATLAB, Noise Wavelet, De-noising

Introduction

There are various methods of noise reduction in practice. Noise is an unwanted signal which is corrupting the original signal. Noise degrades the quality of the information of the original signal. There are many applications to the noise control based on signal types. Nowadays Digital Signal based applications are becoming a more popular field of Technology. Unfortunately generally used signals are till now experiencing some troubles from unwanted noise signals. Therefore there is still the need for serious studies to eliminate unwanted noise signals. As a new approach, wavelets in signal processing techniques are being used with success. Lately MATLAB has made great effort on development of signal processing tools. There is a wavelet tool within MATLAB. In the following, by using Simulink, the noise signals are saved as *.mat file. Wavelet tool loads this file and makes analysis using different algorithms. For instance it uses soft and hard threshold methods and gives the detail signals as de-noised signal.

Some Simulink Elements

In the following chapter, the important elements of Simulink are illustrated. The Simulink elements which were used in the study have been referenced in: [http://www.mathworks.com]

Methodology

1. Creating a *.mat file by using Simulink

The Figure 6 shows a simulation of digital signal with uniform random number signal. The resulting signals are plotted on scope (Fig.7) and the total signal is stored in a *.mat file.

2. Wavelet De-Noiseing

Wavelets are described in many references [4, 5, 6, 7]. Wavelet de-noising has been studied in many research activities. Combination of Simulink and Wavelet tool is a new approach, which is illustrated in this paper. The high and the low frequency coefficients are termed details and approximations, respectively. There are two main variations of the de-noising method: soft thresholding and hard thresholding. These methods imply that by using an appropriate operator on the coefficients of the Wavelet Transform the signal can be de-noised. A measurement consists of the useful signal and the noise:

$$s(t) = x(t) + n(t)$$

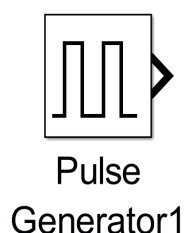


Figure 1
Pulse Generator

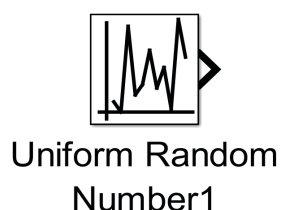


Figure 2
Uniform Random Number

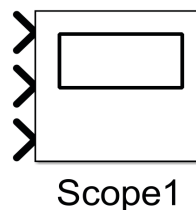


Figure 3
Scope

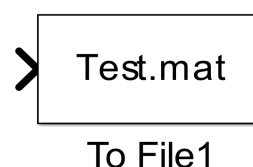


Figure 4
To File

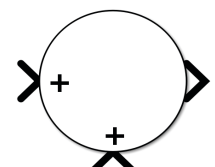
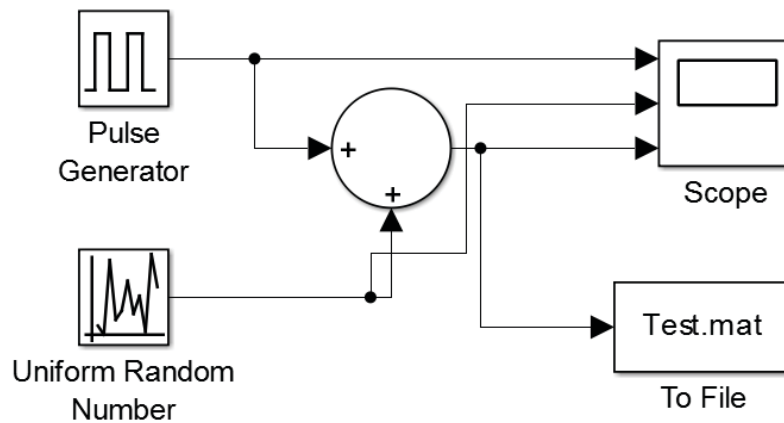
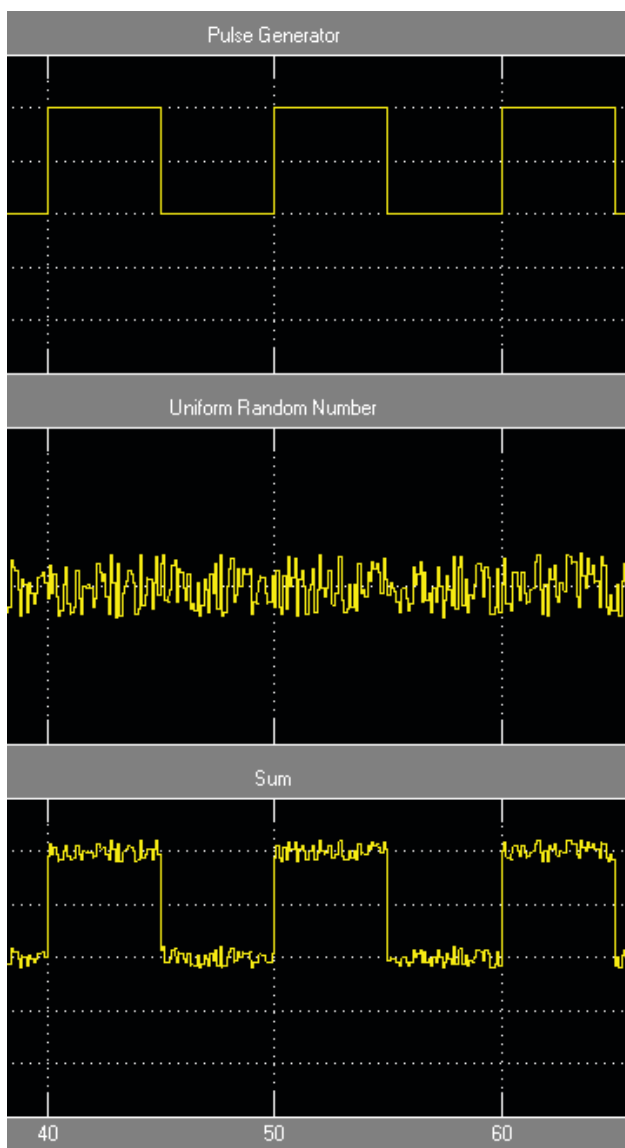


Figure 5
Sum

* Faculty of Engineering, Nigerian-Turkish Nile University, Abuja, Nigeria.
E-mail: ustajanov@gmail.com


Figure 6

A simulation of digital signal with uniform random number signal.


Figure 7

Resulting signals which are plotted on scope.

The wavelet transform gives coefficient c . The de-noising process is:

$$a = \text{den}(c, p)$$

where p is a parameter. When the method of soft

thresholding is used the operator den is:

$$\text{den}(c, p) = \text{sgn}(c) * \max(0, |c| - p)$$

At the hard threshold the operator den is only nullifying the values of the wavelet coefficient that are less than the value of p :

$$\text{den}(c, p) \text{ is equal to } c \text{ if } |c| > p, \text{ otherwise } 0.$$

Also the noise components will usually have much higher frequency. Hence, all the details coefficients will represent noise. So zeros can replace these coefficients and hence the reconstruction process will involve only approximations.

Applications and Result

The following steps were used for the application:

1. Start MATLAB
2. Input the command "wavemenu"
3. Click SWT De-noising 1-D button (see fig.8)
4. Load the data file *.mat (see fig.9)
5. Chose wavelet type (see fig.10)
6. Click decomposition button
7. Click de-noising button

The results of wavelet analysis is given in Fig.11

Discussion

As shown in the chapter above, the detailed steps of wavelet analysis are illustrated. Soft and hard thresholding for each wavelet type are possible. The example illustrates the analysis with haar wavelet 5.th level and for soft thresholding.

Conclusion

Digital signals are usually corrupted with unwanted noise signals. Current Digital low pass filters are not enough in some circumstances. The new methods of wavelet analysis have been studied by using MATLAB-Simulink Wavelet Tool for reducing unwanted noise signal from digital signals. An example, digital signal with noise is analyzed using wavelet toolbox,

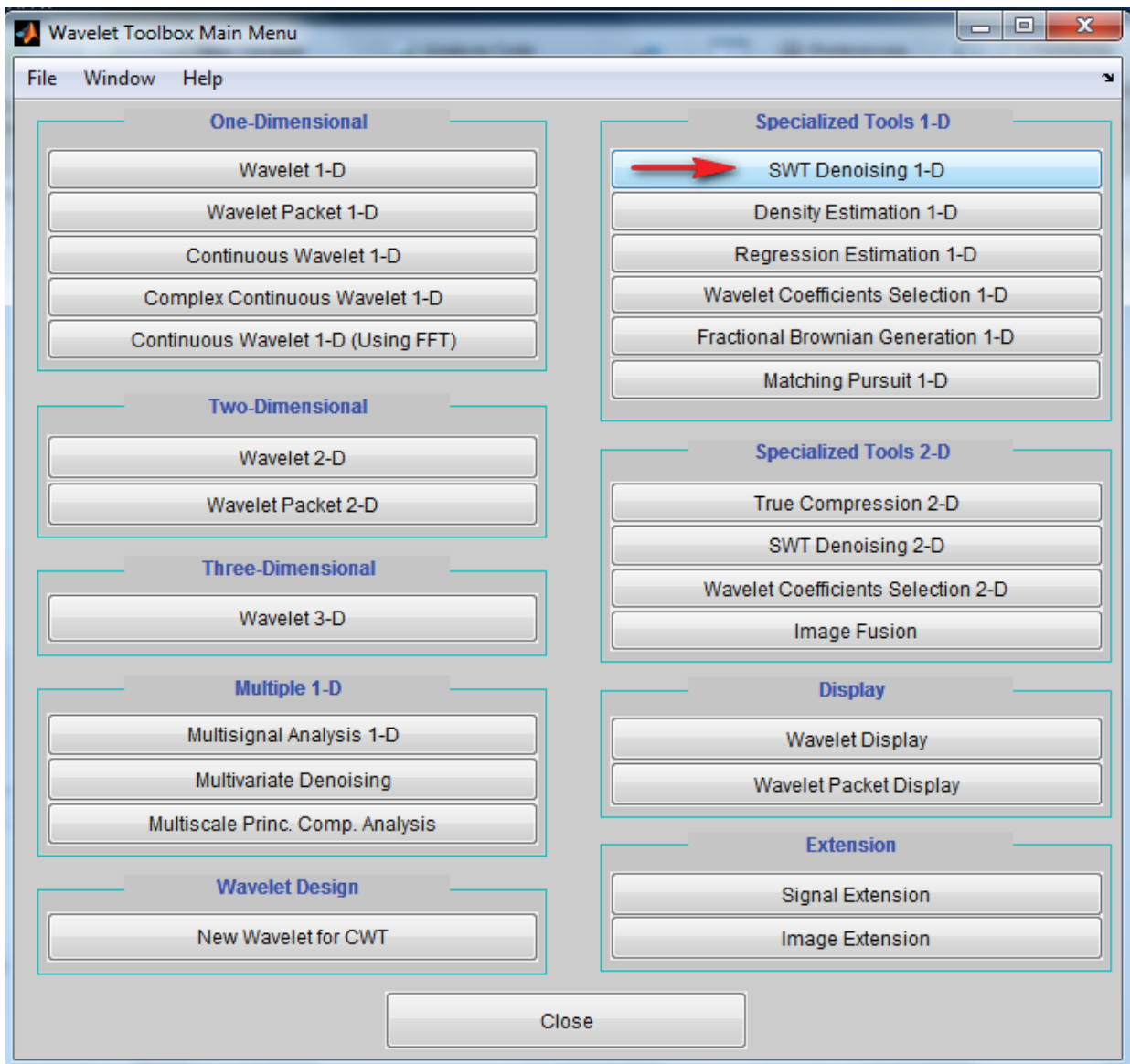


Figure 8
Selecting SWT De-noising 1-D button

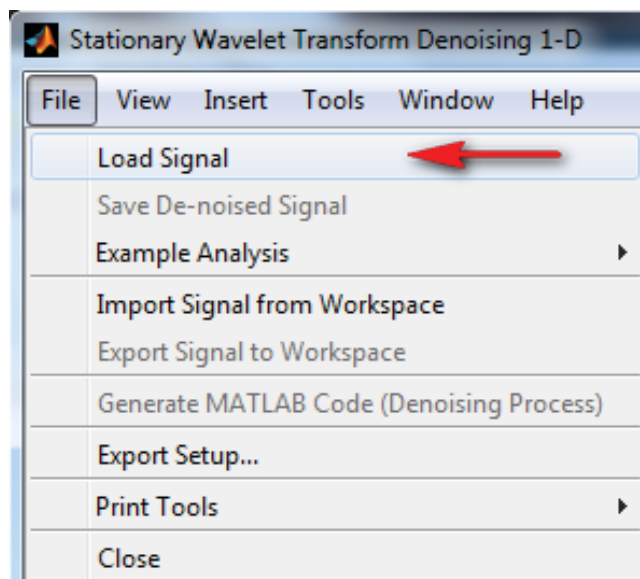


Figure 9
Loading the data file *.mat

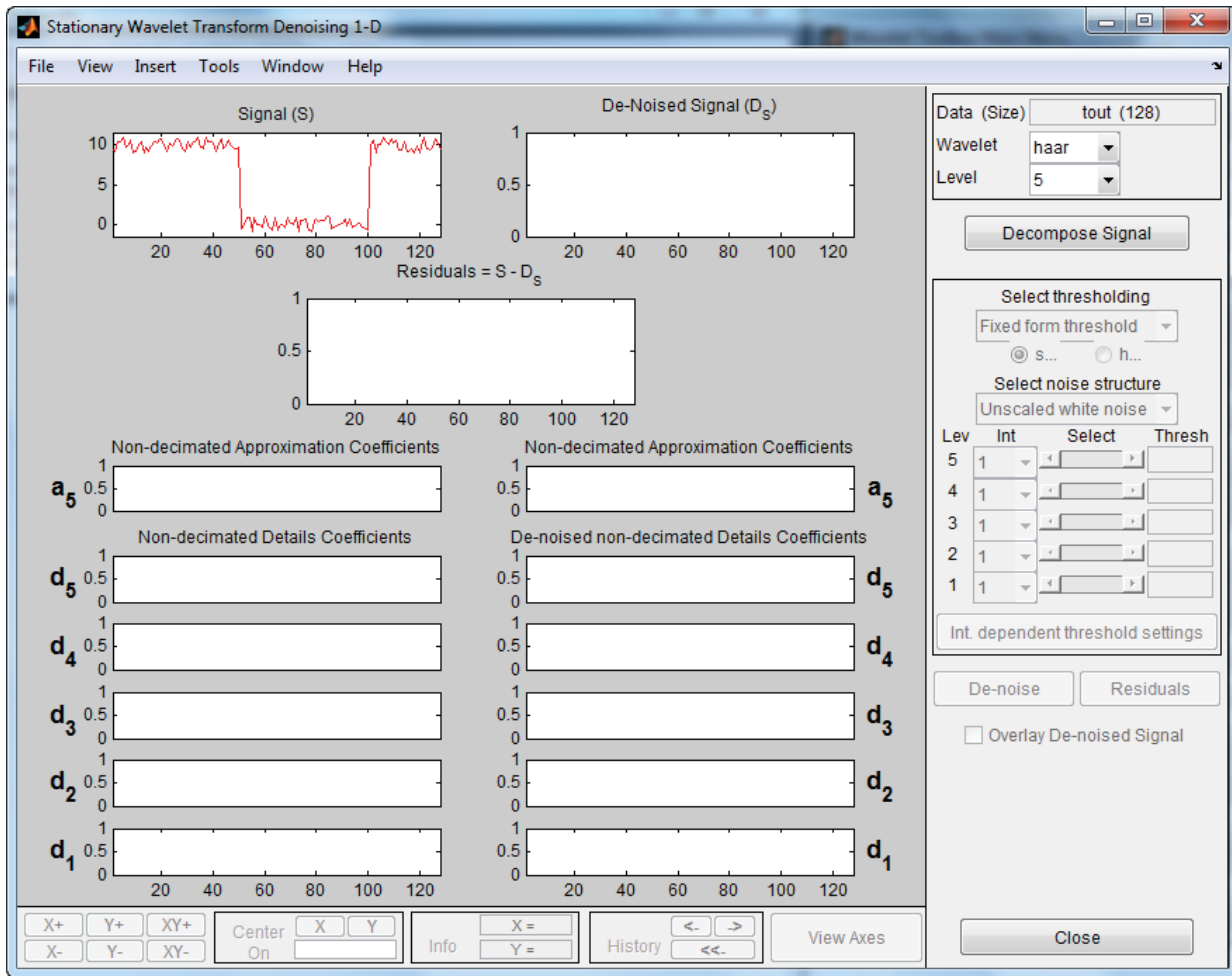


Figure 10
Choosing wavelet type

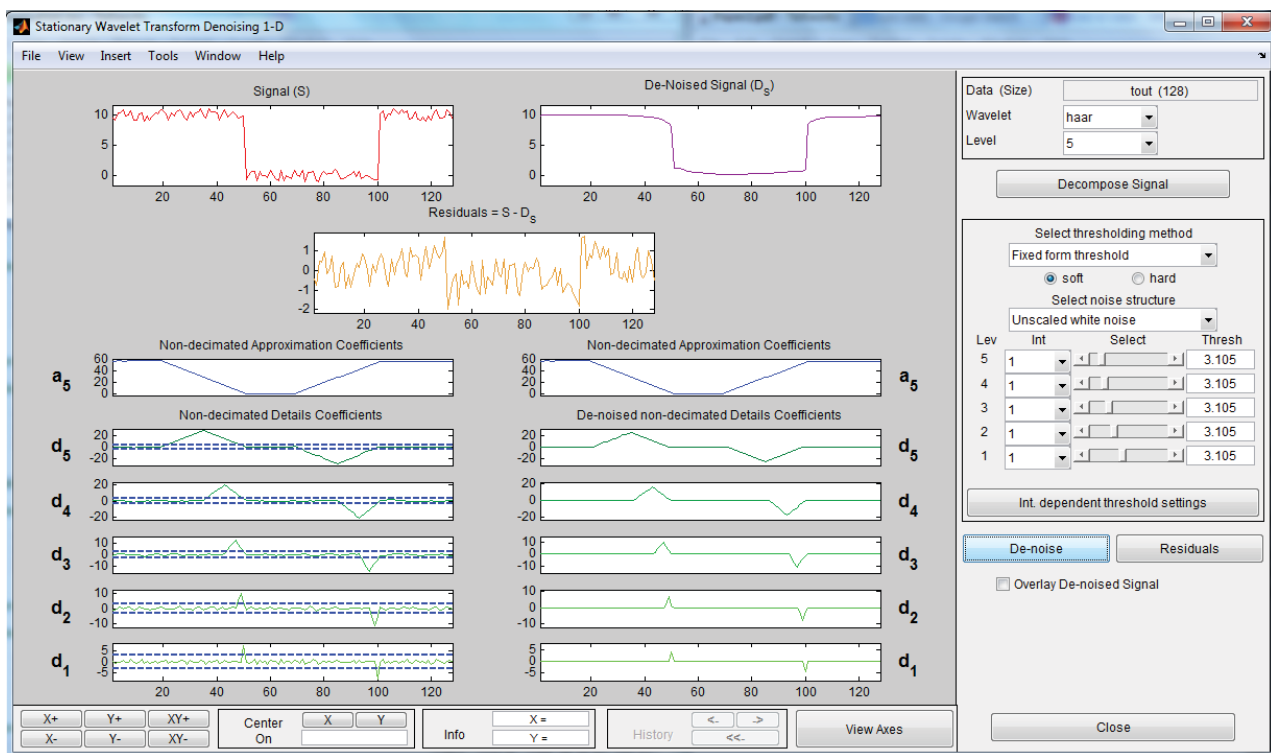


Figure 11
Results of the wavelet analysis is represented.

haar wavelet and 5th level. It is possible to apply with other wavelet algorithm.

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