APPENDIX B

Here, we see how to plot and interpret the CWT scalogram. The CWT equation is repeated here for convenience

$$C(a,b) = \int_{-\infty}^{\infty} f(t) \cdot \frac{1}{\sqrt{|a|}} \, y^*\left(\frac{t-b}{a}\right) . d(t)$$

Thus, CWT is a function of 2 quantities, the scale 'a' and shift 'b'. The CWT coefficients need to be evaluated at each point and plotted. The graphs is expected to be a 3-d graph. Instead of this, we use scalogram. The brightness of a point indicates the strength of CWT coefficients. Brighter the point, higher is the value of CWT coefficient corresponding to the particular scale and shift.

Note that the strength of the CWT coefficient at any point is indicative of the correlation between the signal and the wavelet, scaled and shifted appropriately.

A review of chapter 3 would be useful at this point.

MATLAB® computes the scalogram directly. If, in addition, we know the sampling frequency of the signal, we can get the sinusoidal frequency present in the signal at different times.

In the rest of the section, we present a step-by-step procedure to accomplish the same.

Note :

We will make use of example 2.1. In Appendix A, we plotted the signal and its FFT. We also created 2 MAT-files for the two signals. Here, we will need those 2 files.

Recollect that we used t = 0 to 0.2 seconds , and used 10,000 points. Thus the sampling frequency is

$$\frac{10000}{0.2} = 50000 \text{ Hz}$$

The sampling period is thus,0.00002 seconds.

B.1. COMPUTATIONS IN MATLAB â

At the command window of MATLAB®, type

```
wavemenu;
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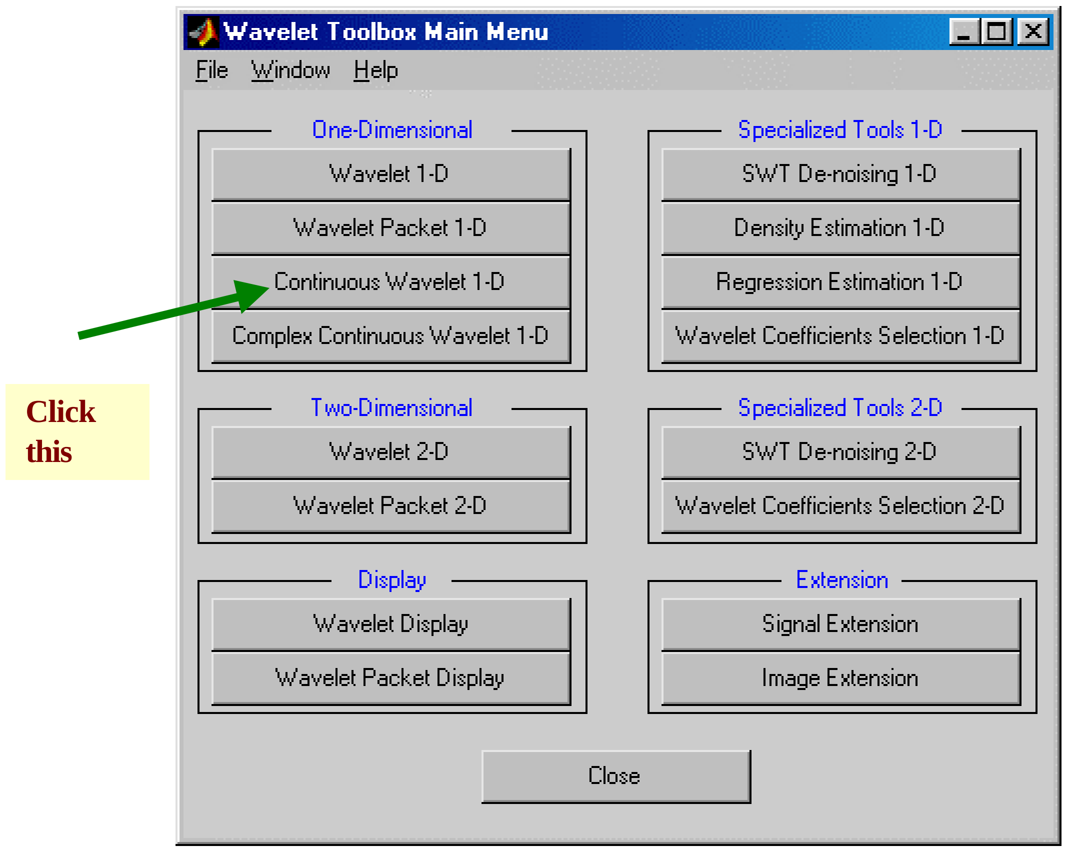
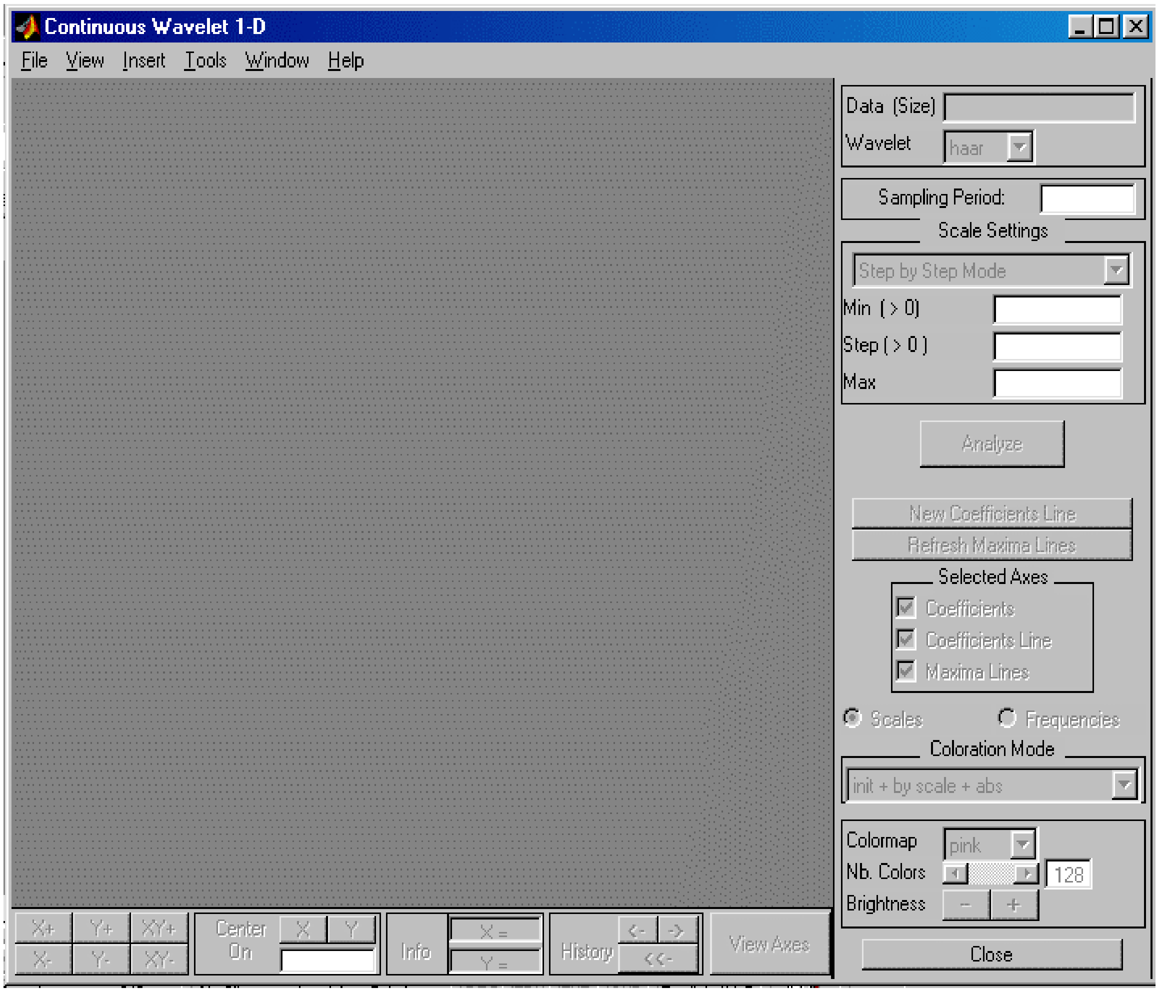
The following window opens up.



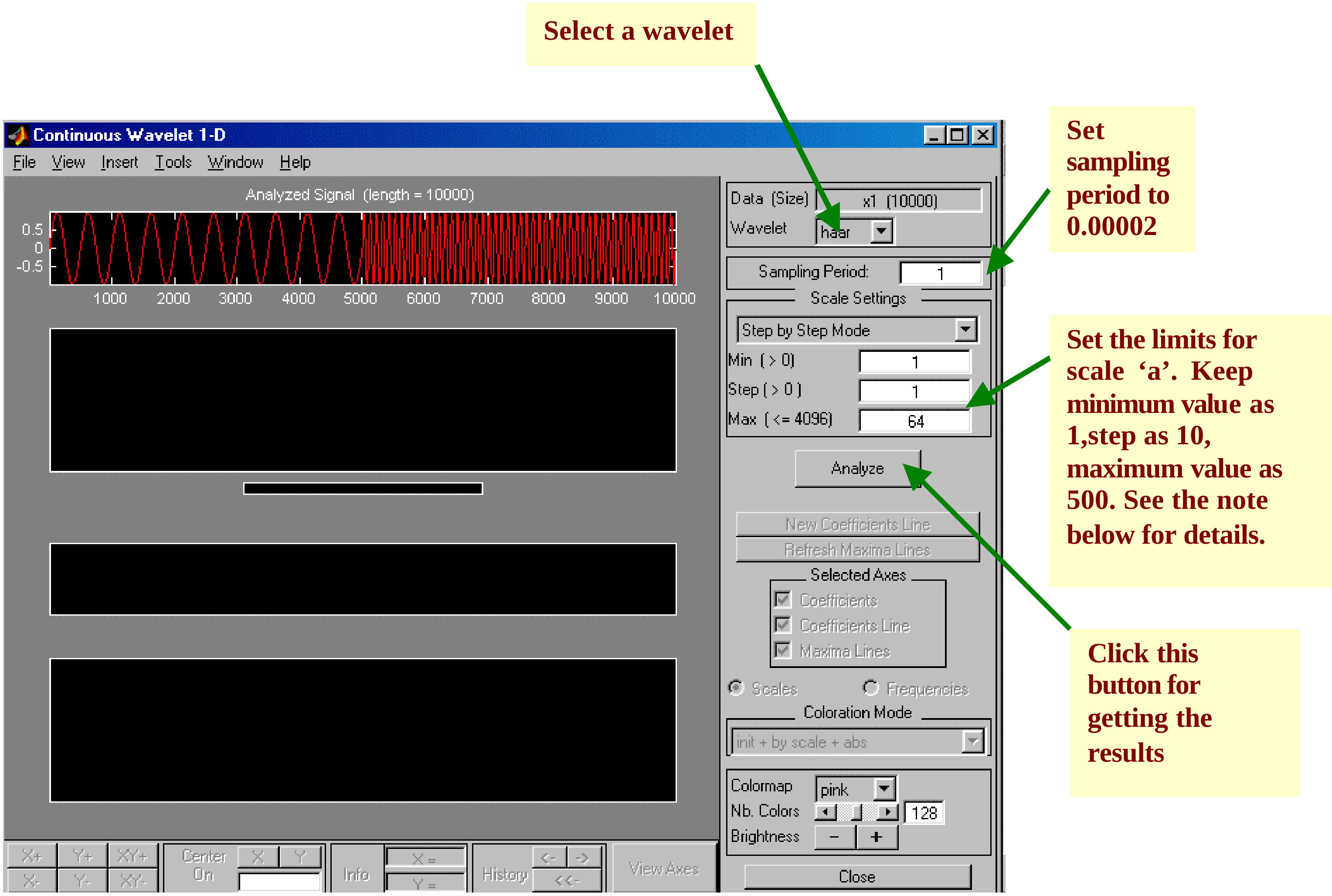
At this window, click on the 'Continuous wavelet 1-D' button.

The following window opens.



Now click the ‘File’ menu and then select the ‘Load signal’ option.
You will be asked to select a file. Open the file you want. In this case, we have used the file ‘myvar1.mat’ which was created in Appendix-A.

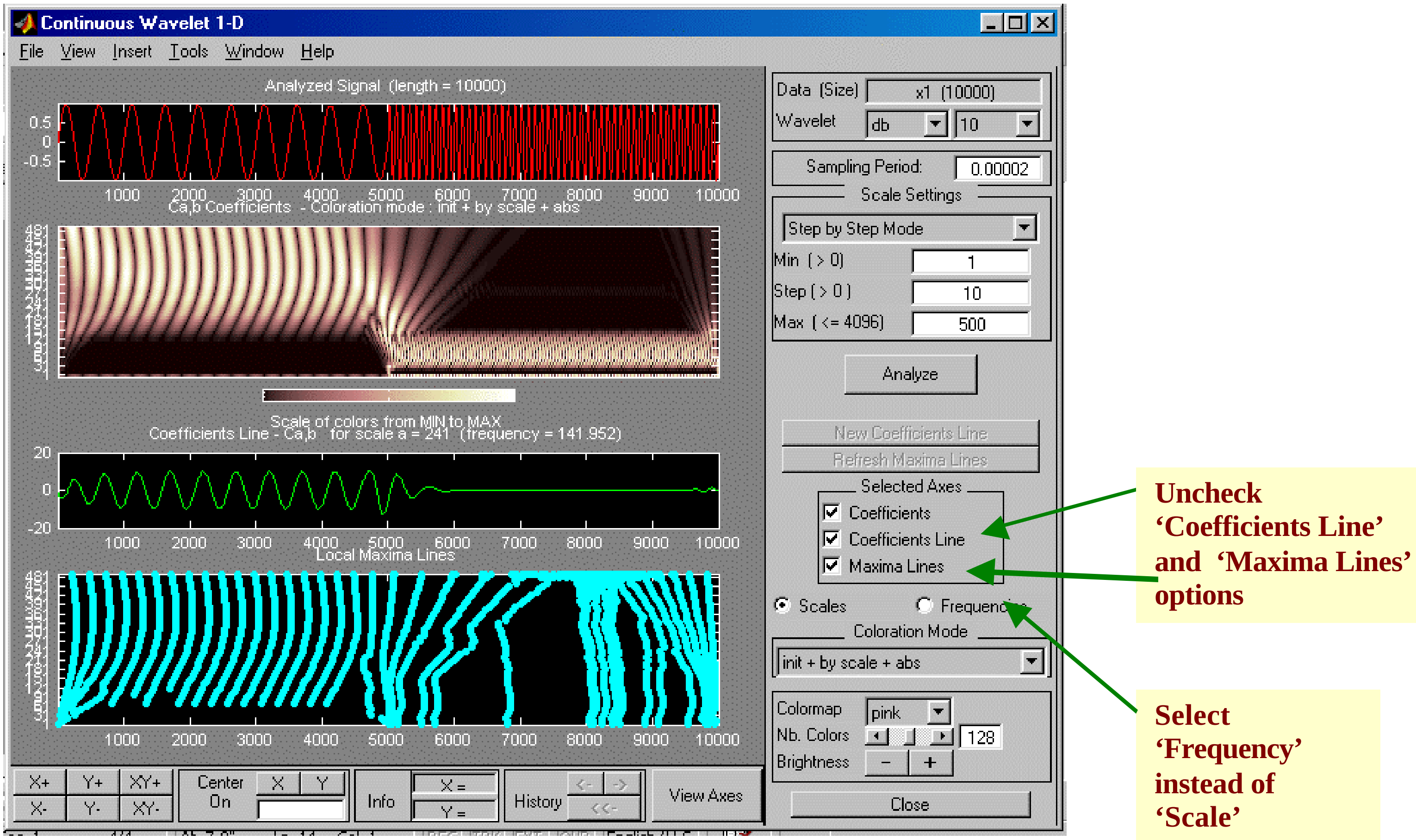
When you open the file, the signal will be loaded in the top part of window, which now looks as shown below.



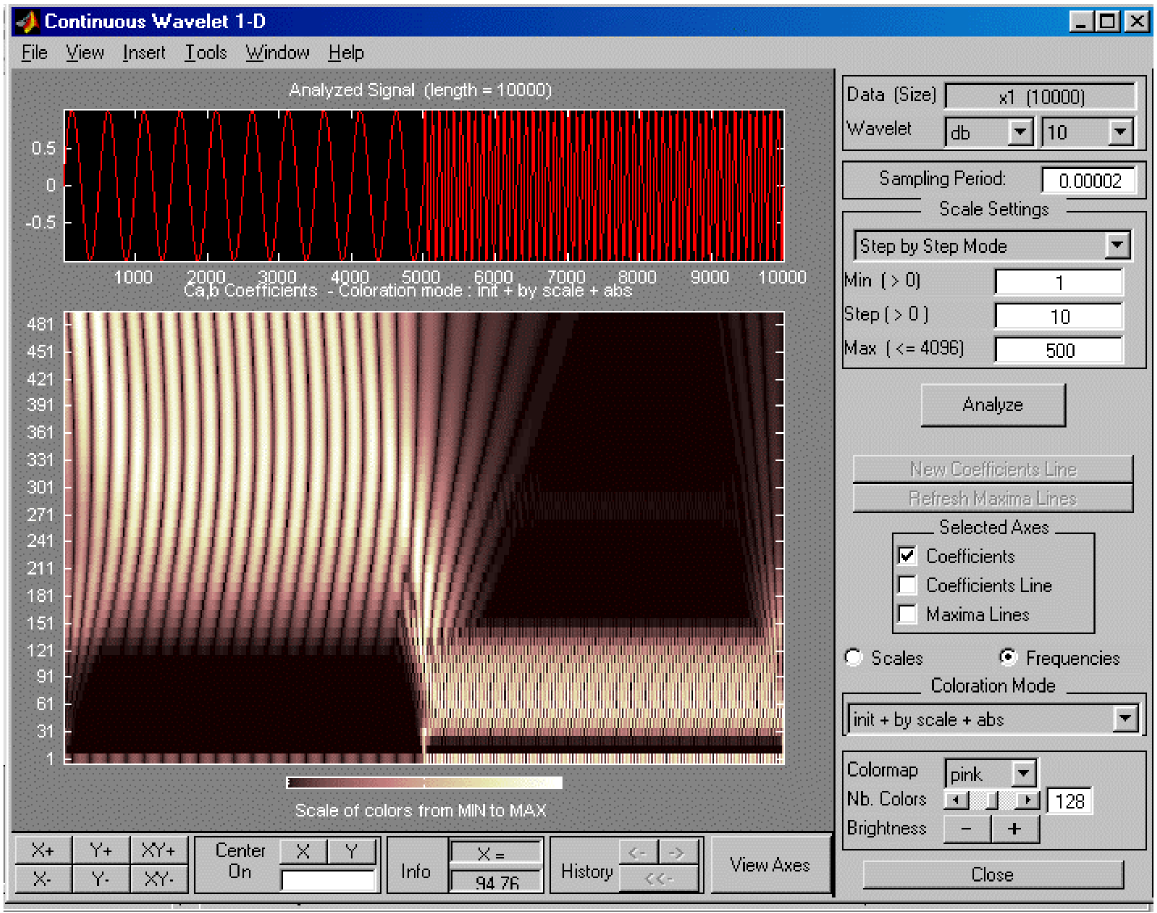
Note that here we use the limits for scale as 1 to 500 with step size 10. This enables us to get a large frequency range. Later we can reduce the range of scales, and step size for better precision.

After you click 'Analyse', you will be asked to wait for some time depending on the limits and step size you set for scale 'a', and of course, the speed of your computer.

The results are shown below.



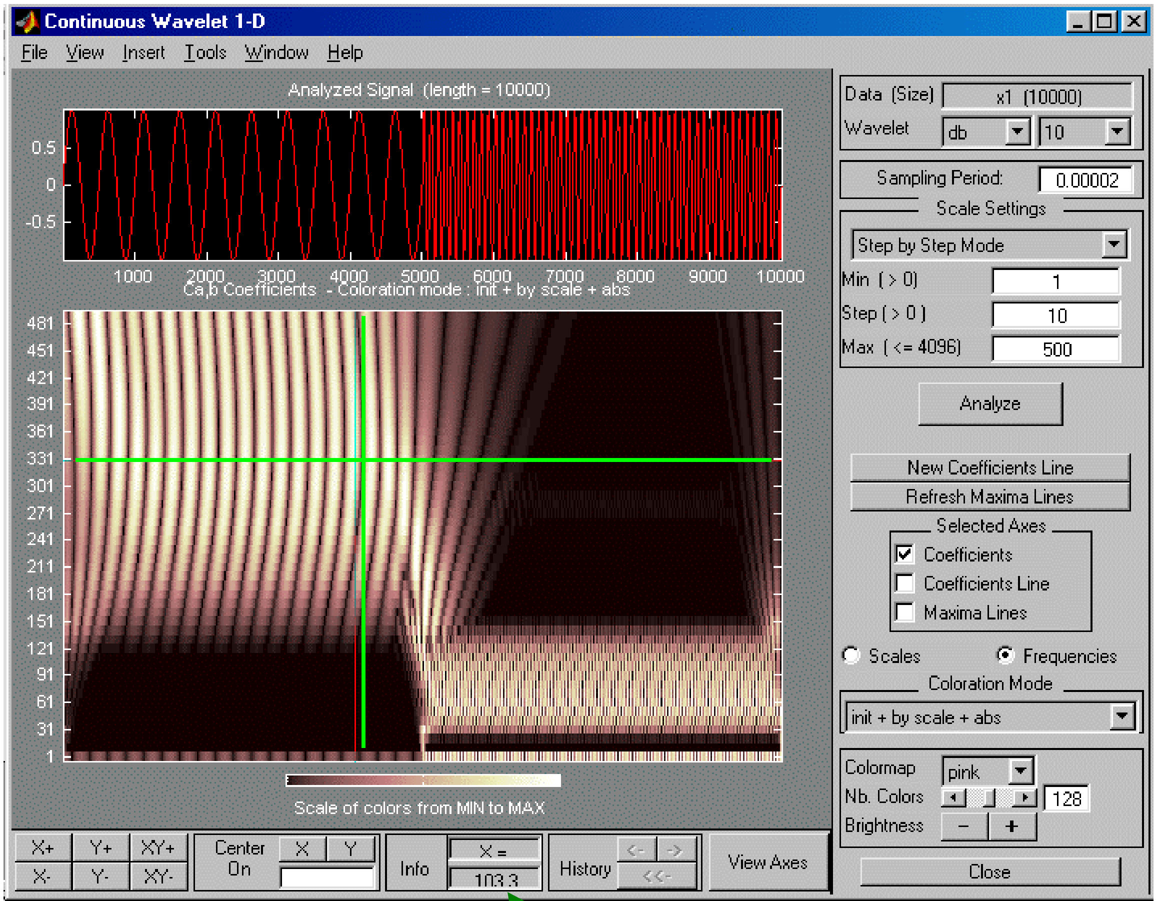
Uncheck the two options shown in the above diagram, so that you get a larger scalogram., as shown below. Also, select the ‘Frequency’ instead of ‘Scale’ so that the answer would be given directly in terms of Frequency. For a relation between frequency and scale, please review section 3.6.



The above scalogram represents the CWT of the signal. To get the frequency content of the signal at any particular instant, follow the steps given below.

Select the brightest point for the given time instant. Say for example, you are required to find the sinusoidal frequency in the signal at the instant when n =4000. Of all the points on the scalogram , select those which have the X-coordinate as 4000. These points will form a vertical line. From this vertical line , select the brightest point. Right-click this point and check the frequency as shown below.

Note that this method is based on the notion that at any given instant the CWT will have maximum value for a particular scale 'a' . At this instant, the signal closely resembles the chosen wavelet that is scaled appropriately by a value 'a'. Now , use the relations given in section 3.6 to get the analog frequency.



Read the frequency here.

In the above figure , we have chosen the point for which scale 'a' on Y-axis is close to 331, shift 'b' corresponds to n=4000.

The value shown is 103.3 Hz. Note that the original signal is of 100 Hz, as is evident from the equation given in example in section 2.2 and which is repeated in Appendix-A.
The value computed from CWT scalogram is remarkably close to original value. The difference arises from that fact that we have chosen the step size to be 10 for scale. To get better accuracies, choose lower step size. But this will increase computation time. Note that now since we know a rough value of the required scale, we can change the limits also, thereby keeping the computation time same.

As an example, take the min and max value of scale as 320 and 350 respectively and step size as 1. Note that upon doing this, your scalogram will have little information on the right and side, ie that time duration where the signal is of 500 Hz , since we are now considering only the higher scales, or lower frequencies.

PLEASE NOTIFY ANY INCONSISTENCY IN THIS APPENDIX AT THE FOLLOWING EMAIL

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