Sharif University of Technology

Medical Signal Processing LAB

Assignment 03

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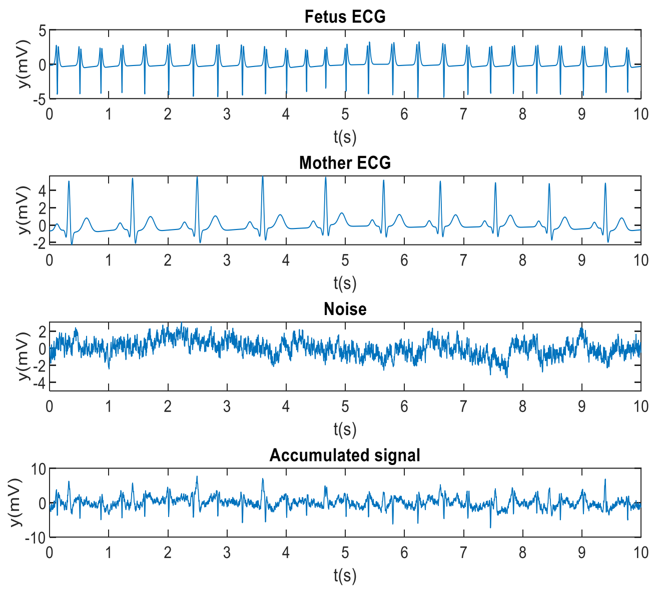
Section 1.

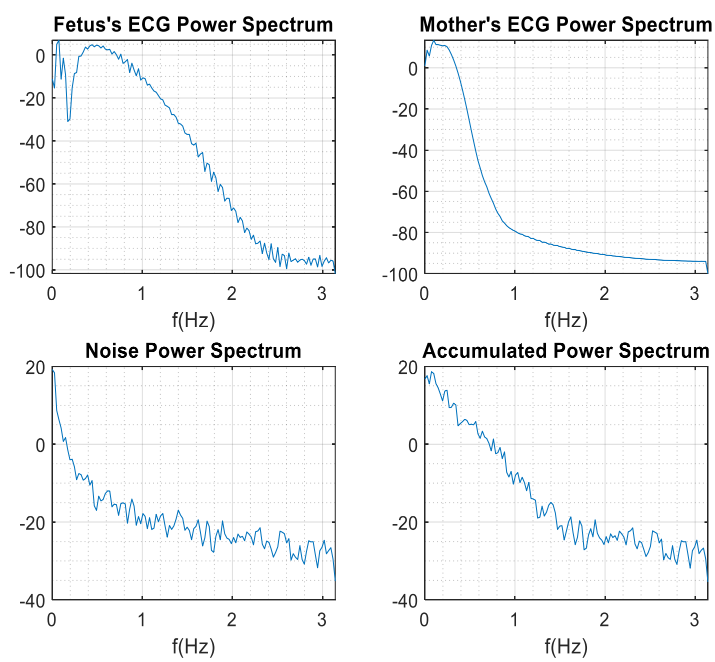
Part 1.

The result for this part is shown in the following figure.



Part 2.

Using the ‘’pwelch’’ command in MATLAB, we obtain the following figure for the frequency component of the mentioned signals. (Note that signal powers are in dB.)



As you can see, all the three signals are somehow lowpass in frequency. Although the bandpass of each is a bit different. As you can see, the fetus signal has a larger bandpass frequency than mother's and the mother signal have a larger bandpass frequency than the noise signal. Also, it's good to note that the fetus signal has a kind of notch signal structure as well and it's note purely lowpass.

Part 3.

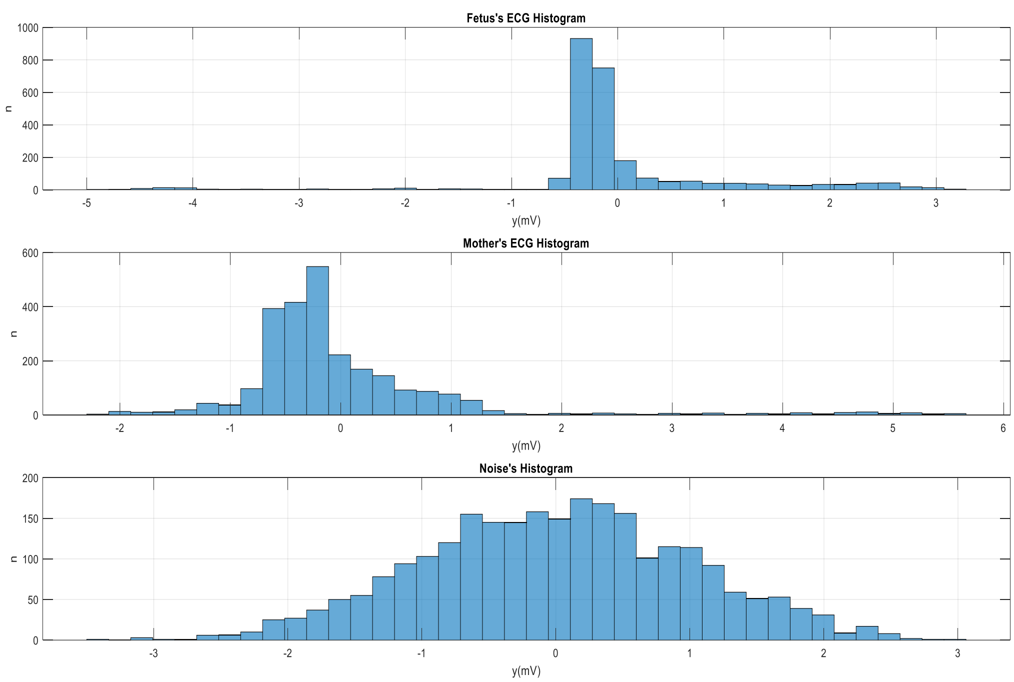
The result for evaluating the mean and variance of each signal is:

```
The mean of fetus signal is: -4.25e-10 and the variance of the fetus signal is: 1
The mean of mother signal is: -2.4662e-10 and the variance of the mother signal is: 1
The mean of noise signal is: -4.7691e-10 and the variance of the noise signal is: 1
```

As you can see, the variance of all of the signals is exactly equal. Thus, the variance of signals has no relevance with their frequency content. Also, the mean of the signals is all almost equal since they're negligible.

Part 4.

The histogram of the mentioned signals is shown in the following figure.



Also, the 'kurtosis' value of each signal is:

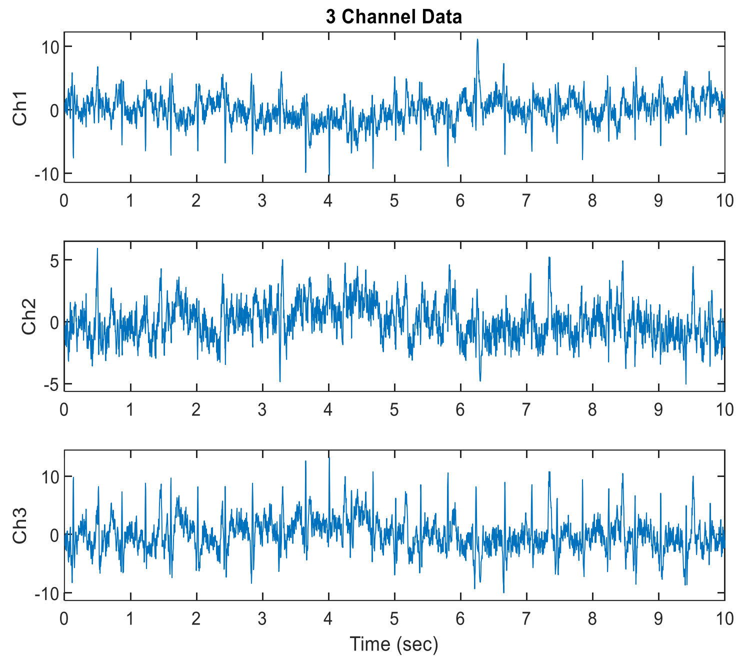
```
The kurtosis of fetus ECG is 8.9901
The kurtosis of mother ECG is 14.0421
The kurtosis of noise ECG is 2.7662
```

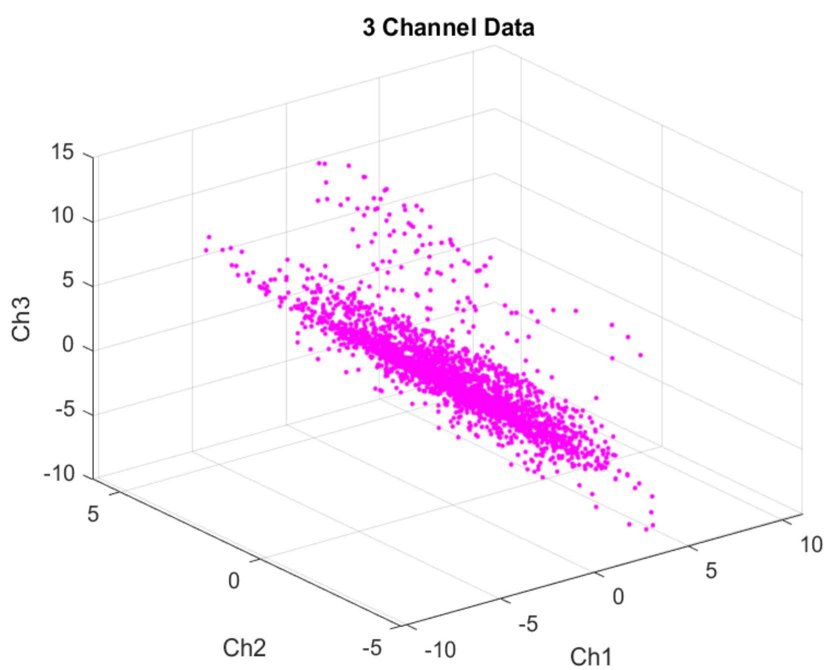
As it’s obvious from the histograms and also the kurtosis values, it’s quite easy to deduce that the lesser the kurtosis value, the more similar the signal pdf to a Gaussian pdf.

Section 2.

Part 1.

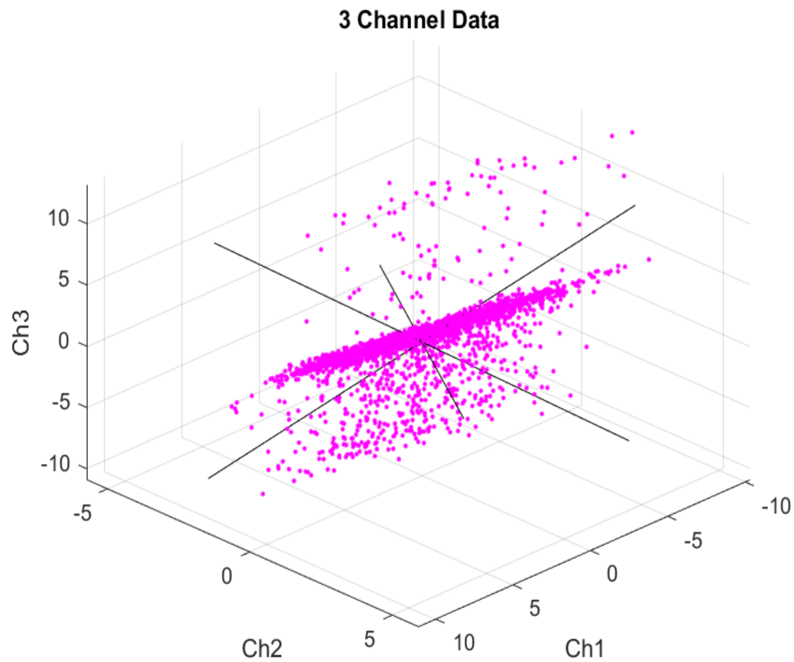
The result of plot3ch of the given data is shown in the following figures.





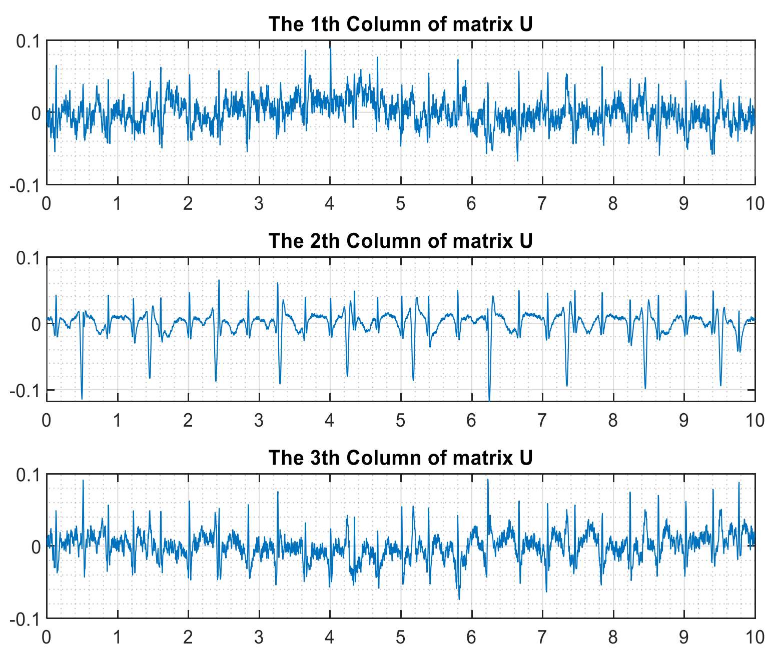
Part 2.

The result of plot3dv of the first 3 columns of V matrix is shown in the following figure on the scatter plot of the previous signal.



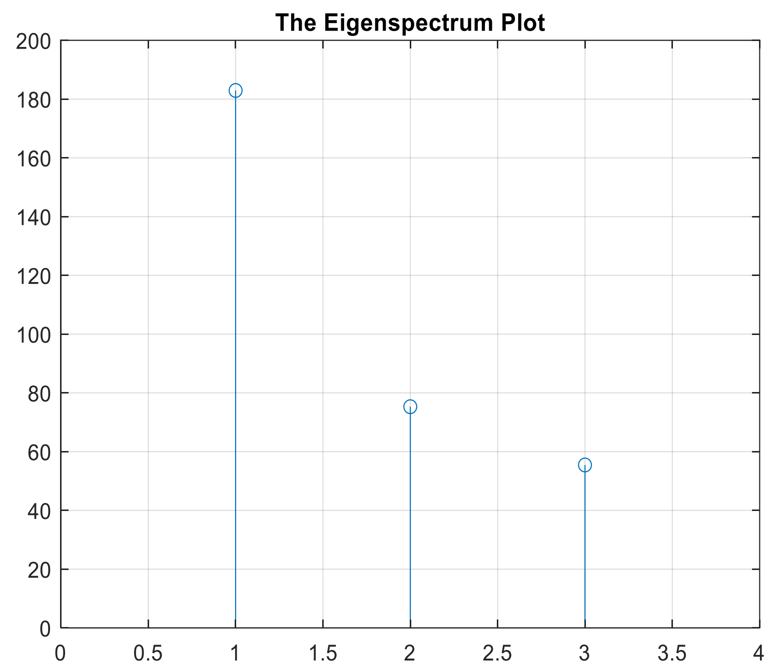
Part 3.

The plot of the first 3 columns of matrix U is shown in the following figure.



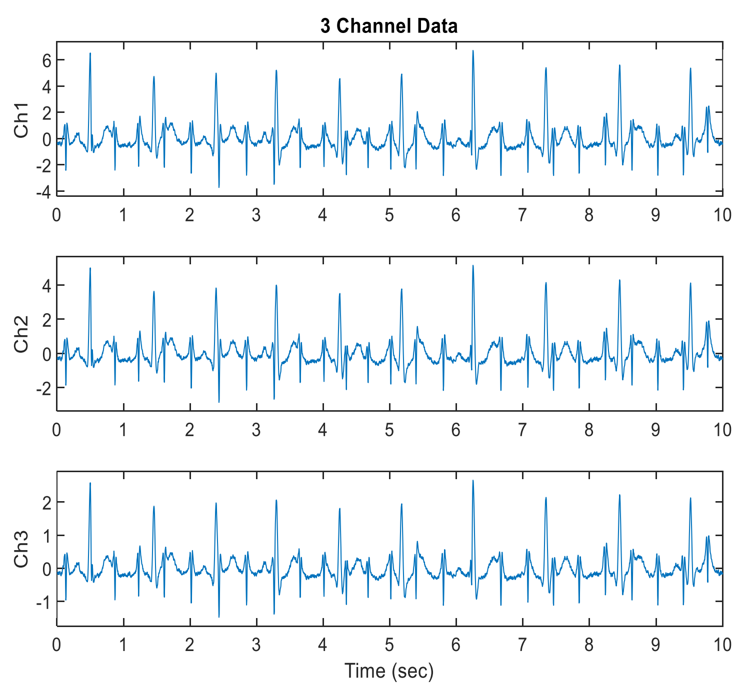
As you can see, the signal from the 2nd channel is more similar to that of the fetus ECG as we saw in the previous section and the 3rd channel data is more similar to that of the mother ECG signal.

Also, the eigen spectrum of the SVD decomposition is shown in the following figure as requested.



Part 4.

Now using the SVD reconstruction of the signals, we obtain the following figure.



As you can see, the extraction of the mother and fetus ECG signals wasn't quite successful using SVD method. Although, it's good to note that the signals are denoised almost perfectly which shows the advantage of SVD method in denoising of the signal.

Section 3.

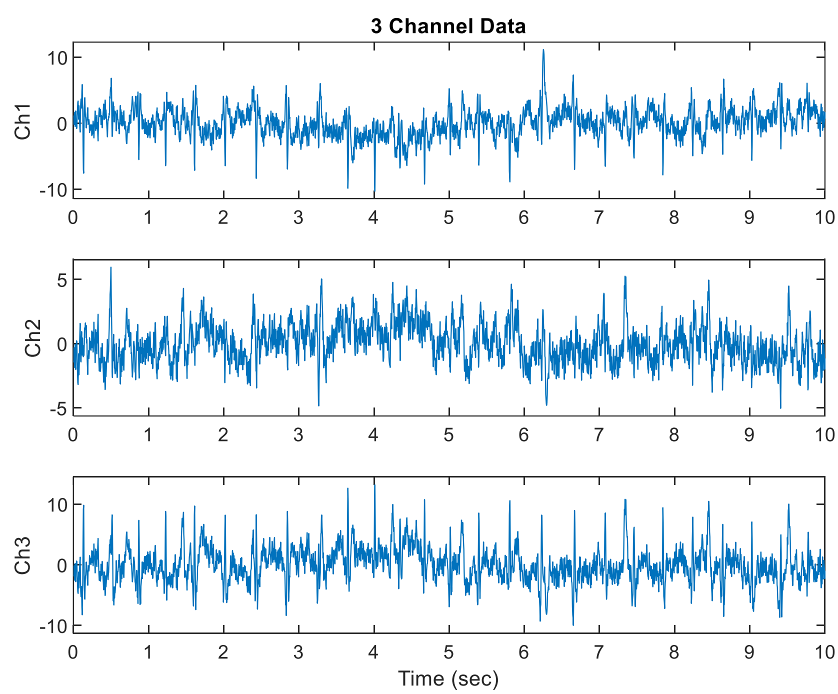
Part 1.

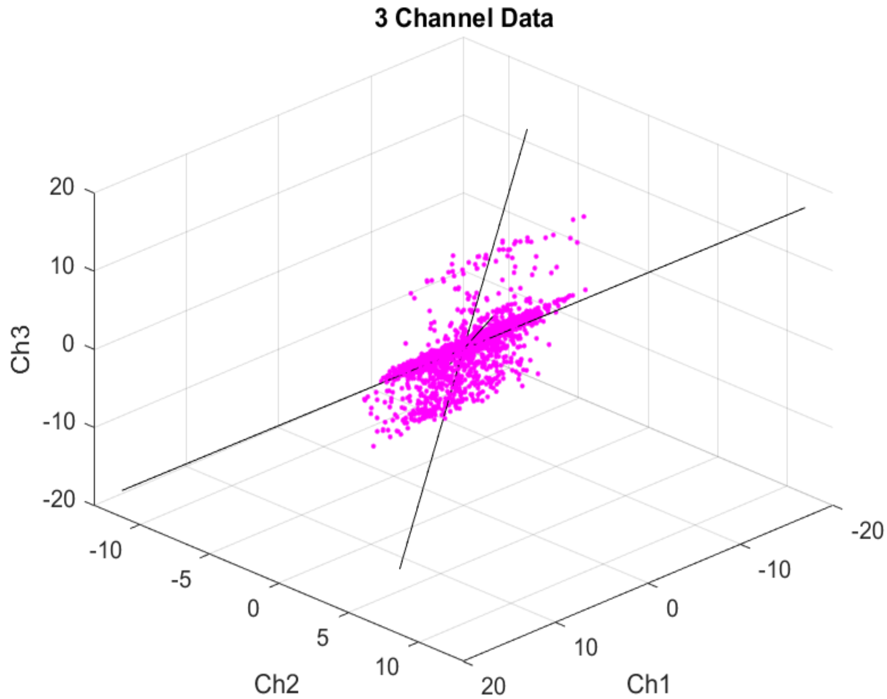
The mentioned matrices are calculated and saved using the following script.

```
%% Section 3 - Part 01
[W,Zhat] = ica(X.');
A = inv(W);
save('Zhat_mat.mat','Zhat')
save('W_mat.mat','W')
save('A_mat.mat','A');
```

Part 2.

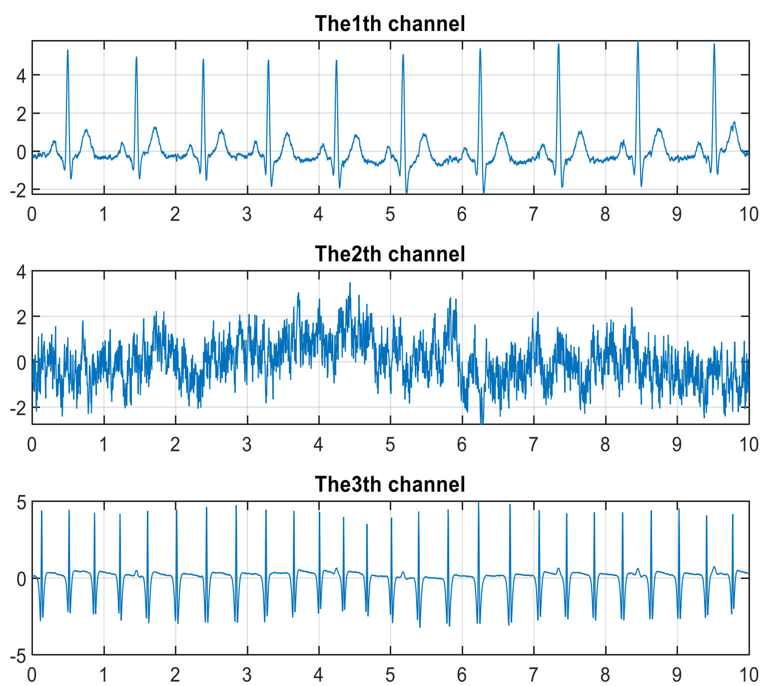
The scatter plot of the original signal and the corresponding sources from W^{-1} is shown in the following figures.





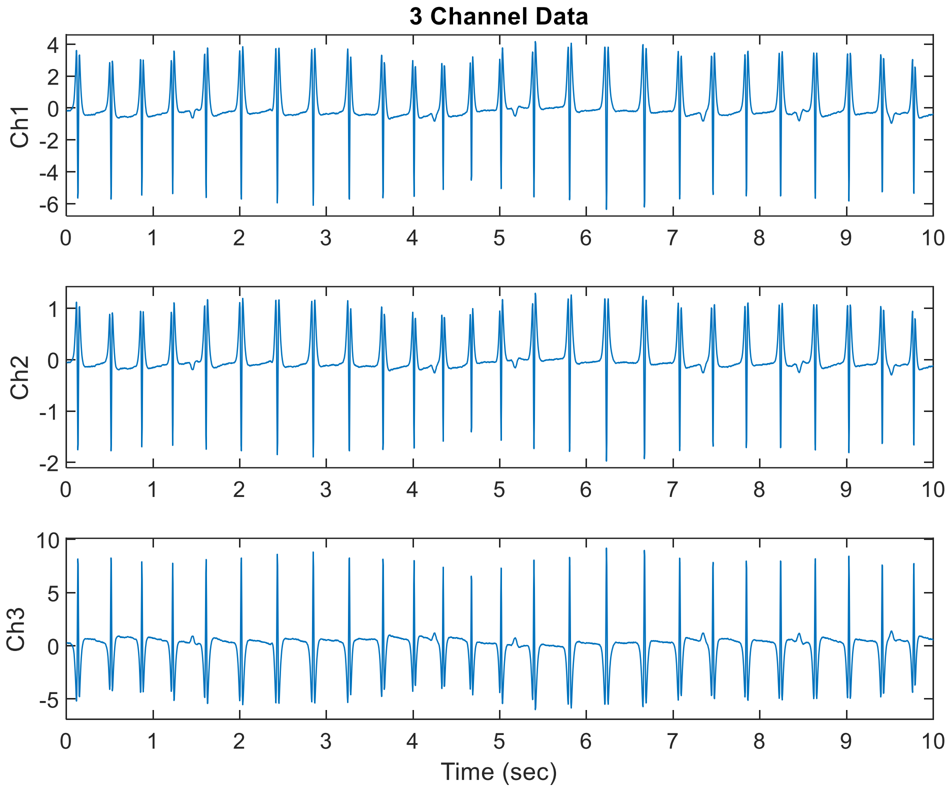
Part 3.

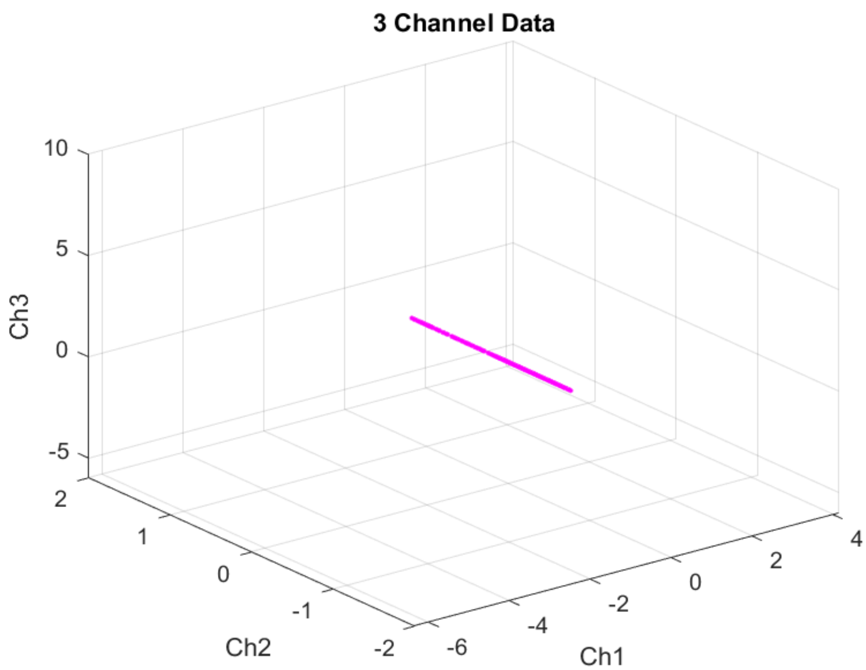
The corresponding plot of first 3 columns of Z matrix is shown in the following figure.



As you can see, the 3rd columns data looks much like the fetus ECG signal. Thus, we keep the component of this column. Thus, the result of the signal reconstruction is shown in the following figure.

Part 4.



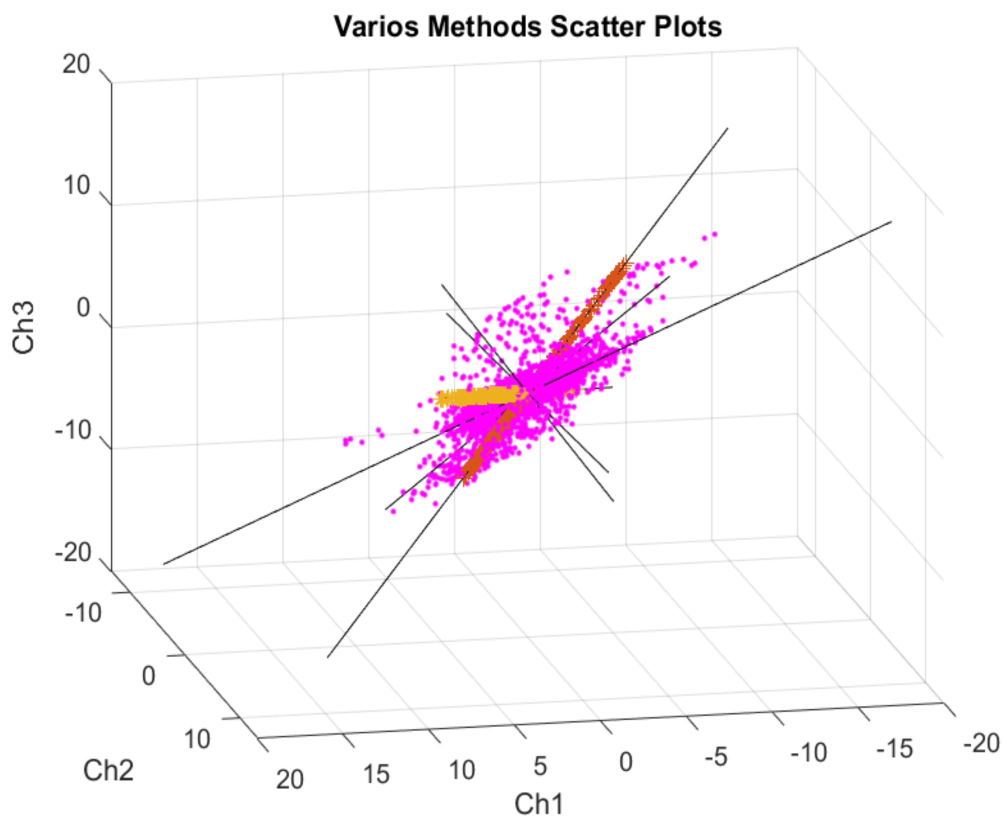


As you can see, the fetus component of the channel data is well extracted from the mother signal component as we can see the obvious different of 1st and 2nd channel difference with the 3rd channel.

Section 4.

Part 1.

The requested figure is shown in the following figure.



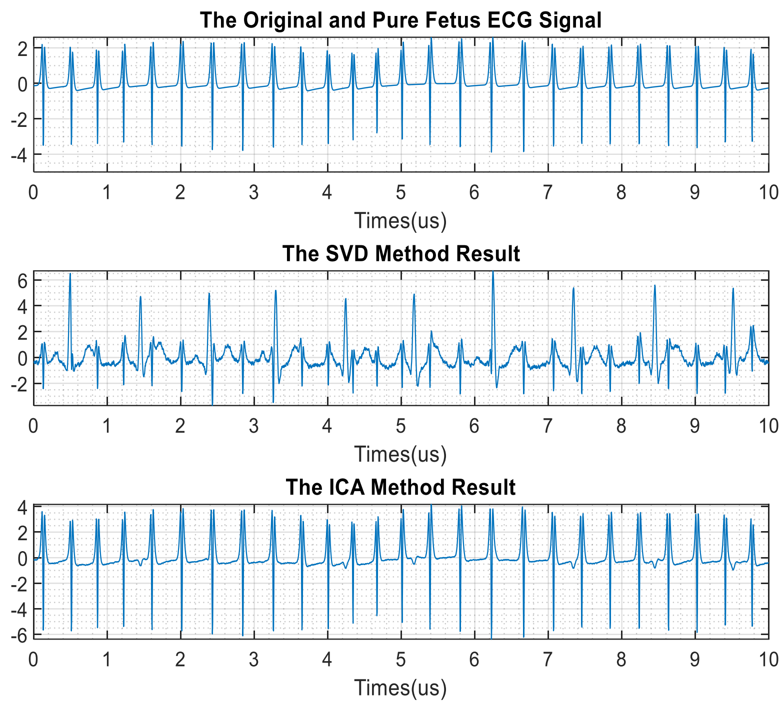
The norms and angles are shown in the following figure as well.

```
>> angles_V

angles_V =

    90     90     90

>> norm_V

norm_V =

    1.0000     1.0000     1.0000

>>
```

```
angles_A =

   62.0287   71.3380   37.6082

>> norm_A

norm_A =

    1.6350    2.9135    2.3079
```

Part 2.

The result is shown in the following figure.



As you can obviously observe, the ICA method outperforms the SVD method landside. The signal for Fetus ECG is exactly recovered as we wanted.

Part 3.

The correlation factors computed using the ‘corrcoef’ command in MATLAB are shown in the following figure.

```
The correlation factor of SVD method is: 0.49553
The correlation factor of ICA method is: 0.99784
```

As you can see, the ICA result is much alike the original result by comparing its correlation factor compared the one for SVD method which is almost half of the value of ICA method correlation factor.

Part 4.

As we have seen throughout this experiment, we saw that the ICA method is by far more successful is recovering the separated signals given the combined signal from various sources compared with SVD method. But this doesn't mean that SVD method is of no-good use at all. As we saw, this method is quite successful in denoising the signals given to it and gives us a denoised version of the given signals. The ICA method also improves signals clarity in terms of denoising as well and perform as well as the SVD method.

Part 5.

The main point of this experiment is that ICA method would be much helpful for source separation in various domain like ECG compared with SVD method.