Digital Signal Processing

Digital Signal Processing Project

Tracking Cardiac Rhythms

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Contents

1Introduction

1.1Electrocardiogram(ECG)

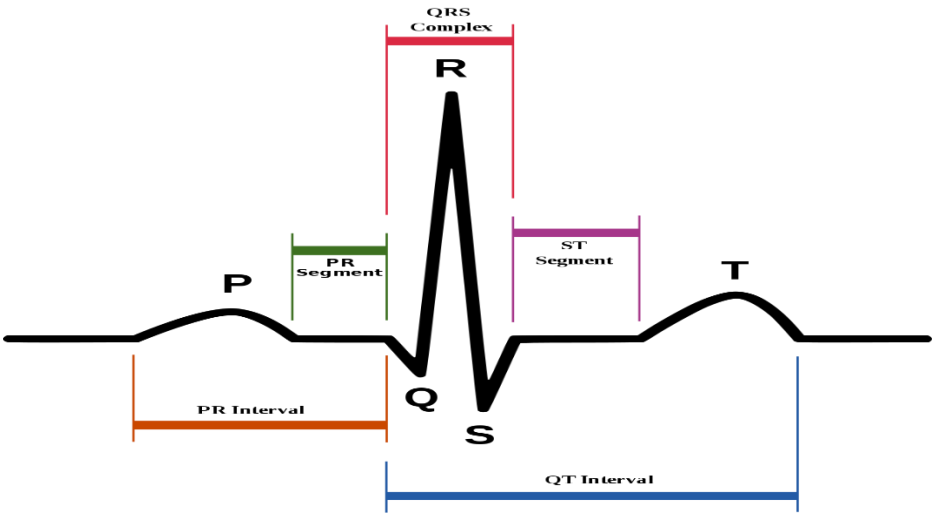
Electrocardiogram(ECG) is electrical activity of muscles of the heart. It consists of p-waves , QRS complex, T wave and U wave

p-wave-> depolarization of atria

QRS complex -> depolarization of ventricles

T-wave -> repolarization of ventricles

Repolarization of atria is not visible and QRS complex detection is the most important task in ECG analysis



2Objective of the project

2.1 Problem Statement :

- The Mother_ECG (MECG) signal is the dominant source which is larger in amplitude when compared with the fetus_ECG (FECG).

- So, for the processing the signal for fetal monitoring and diagnosing the removal of MECG is more important.

- The fetal heart beat signal is corrupted with the mother's heart beat signal and also there are other types of noise and overlapping frequencies by considering all of these the extraction of fetal heart beat from mother's womb is difficult

2.2Motivation

The motivation of this project is to find the fetal heart rate and mother's heart rate

At the time of Delivery an electrode is placed on fetal scalp by this accurate recordings was done. And Examination of the FECG from ECG-recordings measured on the mother's skin (cutaneous recordings) plays an important role at this point of time.

We can visualize the electrical activity of a fetal heart i.e
the fetal electrocardiogram (FECG) contains important indications about the health and condition of the fetus. In this respect, analysis of the fetal heart rate (FHR) has become a routine procedure for the evaluation of the well-being of the fetus.

3 Methodology

3.1 Implementation

Here Two processings has been take place

- we have to extract the fetus ECG (FECG) from the signals x1(n) and x2(n)
- estimate the cardiac rhythm of the fetus based on the obtained signal.

X1(n)= mother's heart signal filtered by travelling thoracic tissues

(filtering fetus's heartbeat)

X2(n)= sum of the cardiac signal of the mother, filtered by traveling through the abdomen tissue and a signal originating from the fetus's heart.

cM(n) = Mother's Cardiac Signal

np = propagation delay through the chest through the chest

na = Propagation delay throughabdomen

cF(n) = fetus's cardiac signal

3.2Finding ECG for Mother Abdominal and Fetus

Traveling through the tissue acts as a FIR filter with a length Kp

$$x_p(n) = g_1 c_M(n - n_p) + \cdots + g_{K_p} c_M(n - n_p - K_p + 1)$$

Mother's heart signal acts as a noise for abdomen sensor signal and this has to travel through abdomen before reaching abdomen sensor ,

this abdominal transfer acts as FIR filter with length Ka

this noise is defined as **vM(n)**

$$v_M(n) = f_1 c_M(n - n_a) + \cdots + f_{K_a} c_M(n - n_a - K_a + 1)$$

.

We can also define relation between disruptive signal from abdominal sensor and heart's sensor as

$$\begin{aligned} v_M(n) \quad = \quad & h_{-M} x_p(n + M) + \cdots + h_{-1} x_p(n + 1) \\ & + h_0 x_p(n) + \cdots + h_{L-1} x_p(n - (L - 1)) \end{aligned}$$

With respect to figure we can say that

$$\begin{aligned} x_v(n) &= h_{-M}x_p(n+M)+\cdots+h_{-1}x_p(n+1) \\ &\quad +h_0x_p(n)+\cdots+h_{L-1}x_p(n-L+1)+c_F(n) \end{aligned}$$

If np>na ,then Xp(n) is delayed w.r.t Vm(n)
So we considered the 'anticausal' part which is represented by the terms h(-M),...,h(-1)
If np<na ,then we need to make sure that h(-M),...,h(-1) are almost null.

Matrix form, $\boldsymbol{x}_v = \boldsymbol{X}_p\boldsymbol{h} + \boldsymbol{c}_F$

Using our input signals **xv , xp** we have to find **h** using leastsquare ordinary method and then using the results we find **cF(n)**which is nothing but fetus's heart signal **h = X#p xv**. **X#p** -pseudo inverse of Xp Or **h = Xp/Xv**

cF =xv – XpX#p xv.

3.3<u>Estimating Cardiac Rhythm</u>

We used periodicity property to find the fundamental frequency of Cf .If S(n) is periodic with period p,then

$$g(k) = \lim_{K\to+\infty} \frac{\sum_{n=-K}^{+K} s(n+k)s(n)}{\sqrt{\sum_{n=-K}^{+K} s^2(n)}\sqrt{\sum_{n=-K}^{+K} s^2(n+k)}}$$

g(k) is also periodic with period p.It reaches maximum at k=0 and for multiples of P

- v0 = [s(1) . . . s(L)] T vk = [s(k + 1) . . . s(L + k)] T .
  Constructed from s(n) , k is multiple of P then

$$\frac{\boldsymbol{v}_k}{\|\boldsymbol{v}_k\|} = r(k)\frac{\boldsymbol{v}_0}{\|\boldsymbol{v}_0\|} + \varepsilon$$

Let wk = vk/||vk|| , w0 = v0/||v0||
We will find r(k) using least squares

$$\hat{r}(k) = \frac{1}{\boldsymbol{w}_0^T \boldsymbol{w}_0} \boldsymbol{w}_0^T \boldsymbol{w}_k = \frac{\boldsymbol{v}_0^T \boldsymbol{v}_k}{\|\boldsymbol{v}_0\| \|\boldsymbol{v}_k\|}$$

$$= \frac{\sum_{n=1}^{L} s(n+k)s(n)}{\sqrt{\sum_{n=1}^{L} s^2(n)} \sqrt{\sum_{n=1}^{L} s^2(n+k)}}$$

We will use the periodicity property by varying k we will find the heartbeat of given data. If the maximum value of r(k) is greater than a threshold ρ chosen beforehand, the signal is considered periodic. In this case, the first maximum of r(k), greater then ρ, leads to an estimation of the period P. The value of ρ is chosen experimentally based on a large number of observations of the signals to be processed.

4 Results for one data set of ECG signals

1.In the following screen shot we are seeing the three different ECG signals one is ECG signal of the mother the second is ECG signal of the Abdominal The third is ECG signal of the Fetus

Figure 1: Output 1

2.In the following screen shot we are seeing level correlation of mother and level correlation of fetus

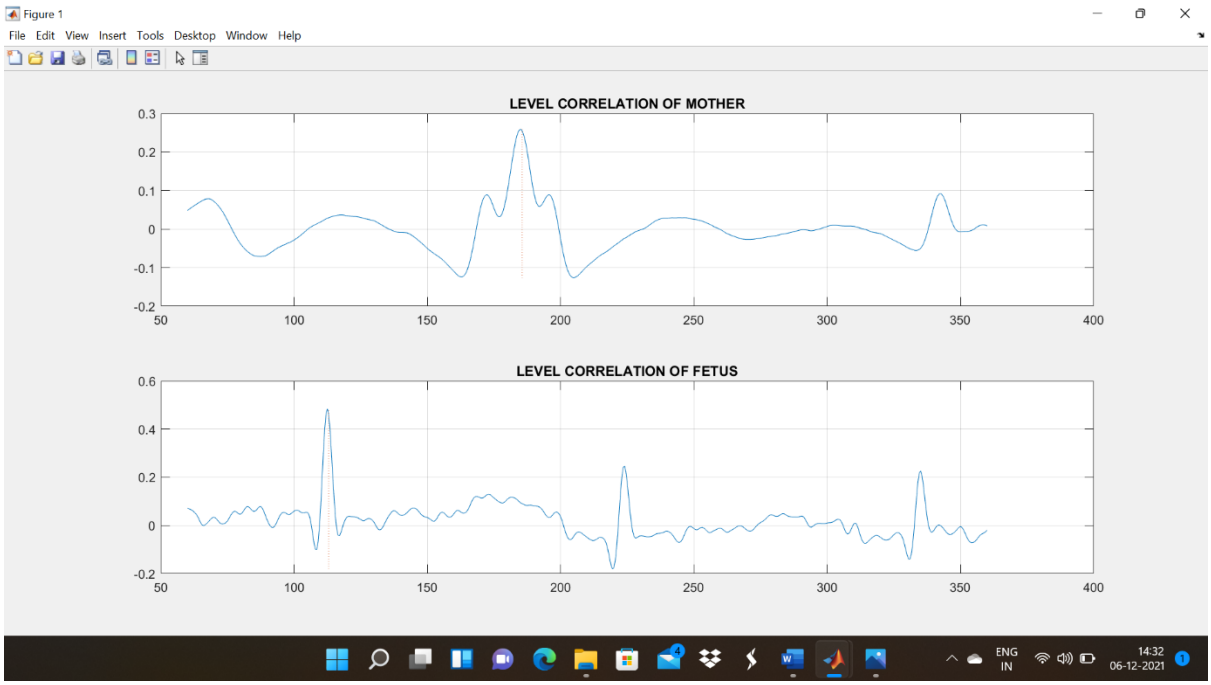


Figure 2: Output 2

3. Here we are seeing the pulses of mother and Fetus

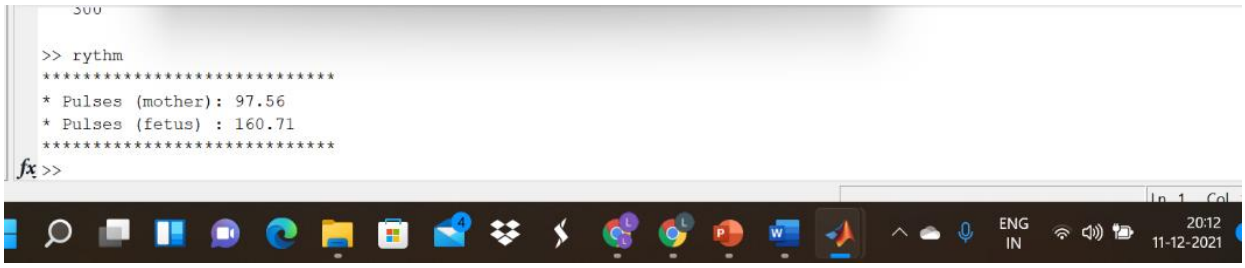


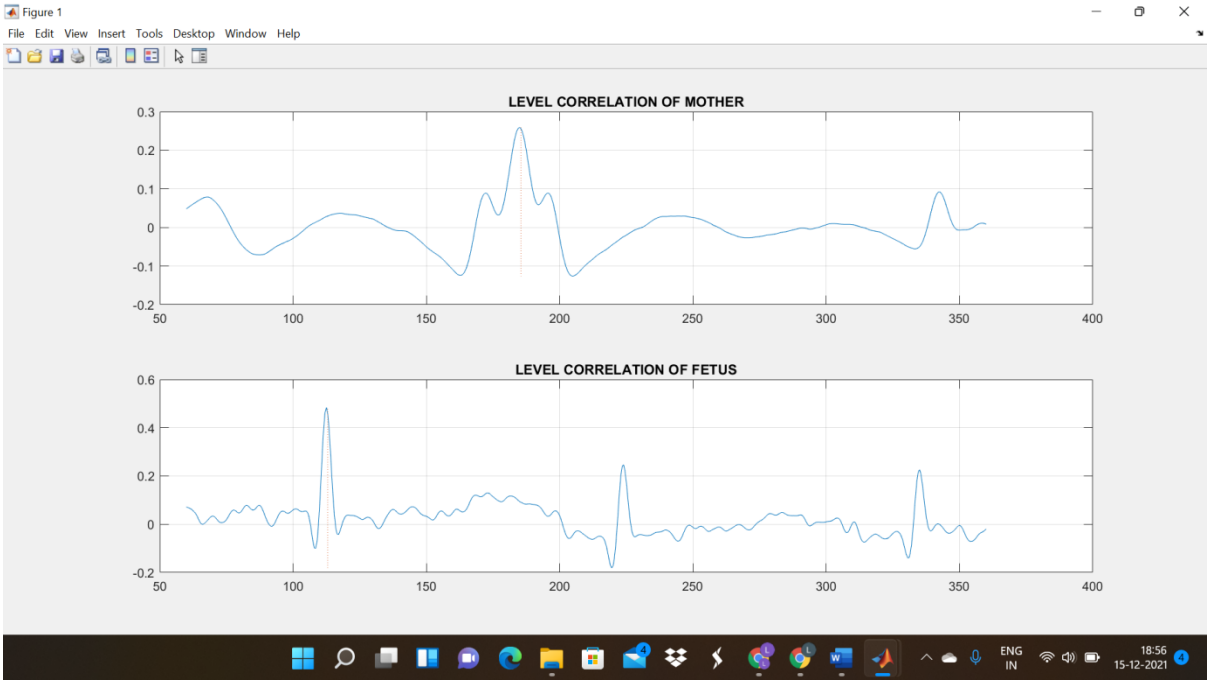
Figure 3: Output 3

5 UPDATED : Extended the analysis to one more set of ECG signals

6 6.1 Results for the two data sets of ECG signals

Figure 1: Output 1

6.2 Correlation level of mother and Fetus



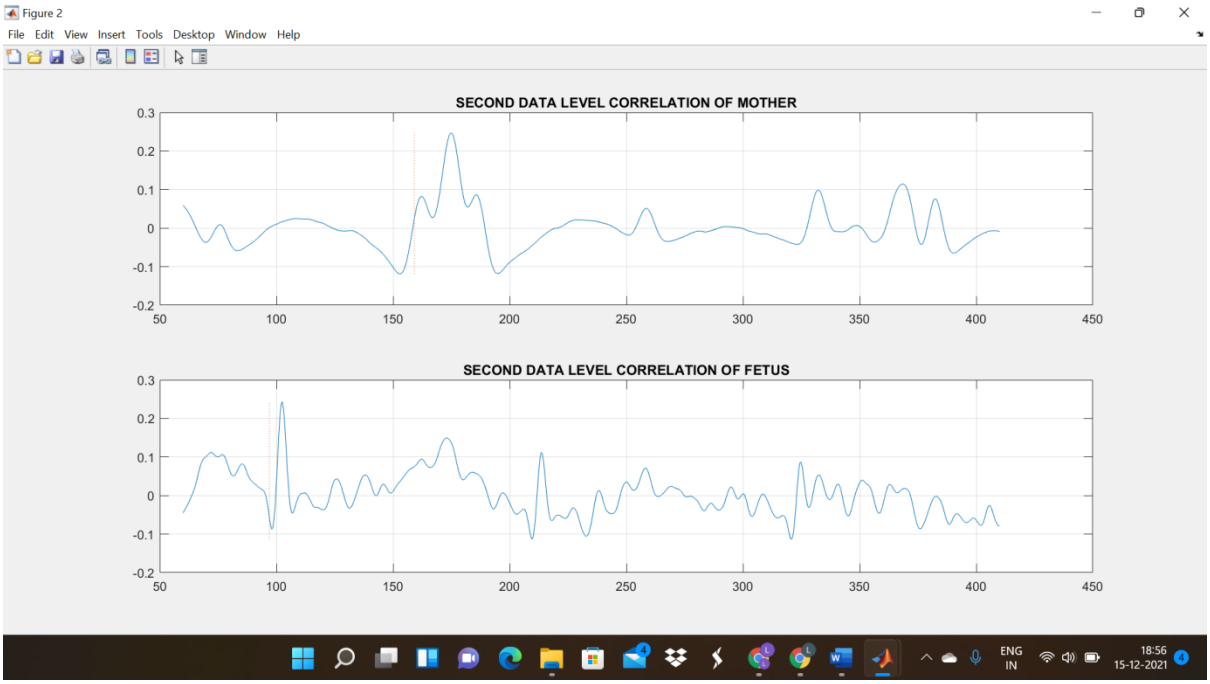


Figure 2: Output 2

6.3 The pulse count – (observation)

The cardio rate of fetus is small less than relatively double the rate of mother in both the cases.

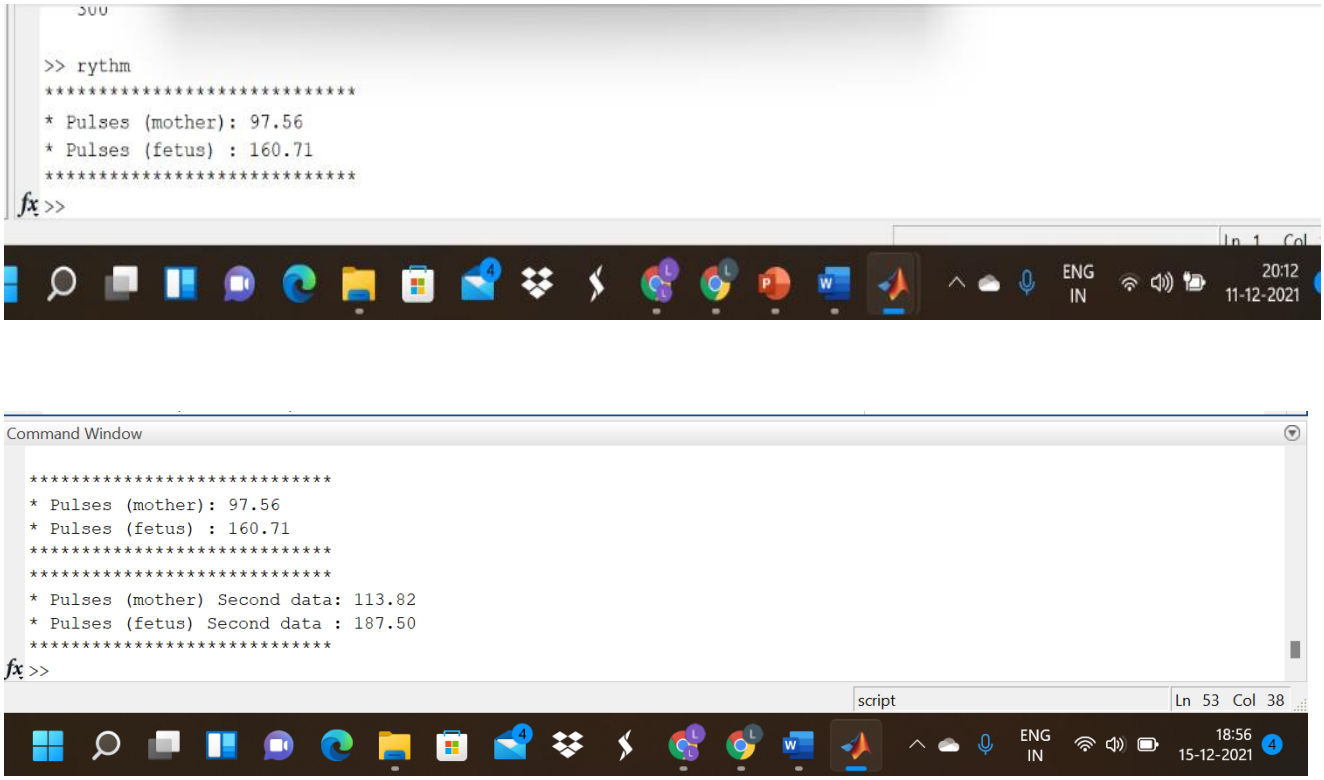


Figure 3: Output 3

7 Contributions

1.Laxmi Narayana K： Downloading the data and Extracting of fundamental heart beat signal, and Report

2.Vishal D : Loading the data downloaded & Finding and Plotting FetusHeartbeat signal (FECG) , and ppt

3.Chaitanya Dattu B: Finding levelCorrelation of mother and Fetus

8References

1.Digital Signal and Image Processing using MATLAB Volume Advances and Applications: The Deterministic Case Gérard Blanchet Maurice Charbit
Link:
https://drive.google.com/file/d/1c8Wc_nz2AmnfMWpv67PUb5uO1F7j_8L/view?usp=sharing