Chapter 9

Conclusions and Scope for Future Work

9.1 Fetal Heart Rate Detection System

I. An algorithm for real time fetal electrocardiogram (FECG) QRS complex feature extraction system based on multi-scale discrete wavelet transform (DWT) technique has been developed to extract Fetal Electrocardiogram (FECG) from a maternal abdominal ECG signal. A real-time fetal maternal ECG monitor has been developed and tested in local hospital in order to do clinical monitoring studies. The proposed method was tested using real signals, recorded at different weeks of gestation, covering most of the pregnancy period. The system performs well, since all fetal beats are detected in five minutes of recording for each subject.

II. The maternal abdominal ECG signal is a superposition of the cardiac electrical signal of the mother and the cardiac electrical signal of the fetus. Due to the indirect measurement and the differences in cardiac size, the fetal contribution is smaller by at least one order of magnitude. Furthermore, there are many additional noise sources, such as maternal muscle activity, fetal movement, uterine contractions, and external electrical interference, etc. We have designed and developed a new method to assess fetal heart rate variation during gestation period with automated analysis of FHR variability using Doppler ultrasound method for obese and non-obese mother. The Doppler Ultrasound method overcomes these obstacles successfully and provides reliable and accurate results comparable to direct electrocardiography. This enabled us to explore the fetal autonomic development and maturation. This system is observed and followed to be more accurate compared to direct electrocardiography method as it avoids the invalid cardiac cycle measurements. Based on these findings, it can be concluded that the developed Doppler ultrasound method provides a valuable tool for obtaining power spectral information on the fetal heart rate in stages earlier to labor.
9.2 Diagnostics Indices Measurement for Early Detection of Autonomic Nervous System Activity

I. Analyses based on the time and frequency domains of heart rate variability using Doppler ultrasound method enable an evaluation of fetal ANS diagnostic indices. It is observed that the parasympathetic nervous activity increased with gestational age in the normal pregnancy group. It is also observed that the parasympathetic nervous activity declined with increase in body mass index in the normal pregnancy group.

II. The results obtained from regression clearly indicates that orthostatic index which is ratio of LF/HF ratio as a sympathetic activity is found to be declined with increase in BMI, or in other words, neurological development index declined. It is observed that total power and high frequency components are smaller in normal fetus. In consultation with gynecologists and child specialist it has been verified that the new born babies have more neurological problems following deliveries from obese mothers compared with deliveries from non-obese mothers. Gynecologists and child specialist have verified that the new born babies have more neurological problems following deliveries from obese mothers compared with deliveries from non-obese mothers.

III. Heart rate variability has considerable information to assess fetal development during gestation period. HRV technique is used in real-time mode for estimation of fetus condition and serves as an approach to the fetal autonomic nervous system diagnostics by means of maternal abdominal Doppler ultrasound recordings. The different linear and nonlinear parameters evaluated show a particular range for identification of autonomic maturation in the normal developed fetus. It is also observed that the HRV parameters are less random as gestation age increases for normal fetus.

IV. It is also concluded that analysis of fHRV based on the methods of non-linear dynamics might elicit valuable information for the physiological interpretation of HRV and for the assessment of the risk of sudden death. The dispersion of both short (SD1) & Long term (SD2) is smaller in normal weight mother fetus.
9.3 Multiple Regression

I. We have tested the hypothesis that a LF/HF ratio [Nonparametric Fast Fourier Transform (FFT) Based] as an index of fetal sympathetic activity is a function of ten variables, age, gestation week, body mass index, CV\textsubscript{RR}, HR Mean, HR Std, RMSSD, NN50, pNN 50 and non-linear index SD1/SD2 ratio, a multiple regression analysis was performed. The overall model explained 36.12 percent of the variation in LF/HF ratio as an index of fetal sympathetic activity can be explained by ten independent variables. We can also see that age, CV\textsubscript{RR} %, HR mean, HR Std and RMSSD are significant predictors (or significantly related to) of LF/HF ratio [Nonparametric Fast Fourier Transform (FFT) Based] as an index of fetal sympathetic activity. Gestation week, Body mass index, pNN50 and SD1/SD2 index is not a significant predictor of LF/HF ratio [Nonparametric Fast Fourier Transform (FFT) Based] as an index of fetal sympathetic activity. The standardized beta tells us the strength and direction of the relationships (interpreted like correlation coefficients). CV\textsubscript{RR} % is positively related to LF/HF ratio [Nonparametric Fast Fourier Transform (FFT) Based] as an index of fetal sympathetic activity.

II. We have tested the hypothesis that a LF/HF ratio [Parametric (AR) Based] as an index of fetal sympathetic activity is a function of ten variables, age, gestation week, body mass index, CV\textsubscript{RR}, HR Mean, HR Std, RMSSD, NN50, pNN 50 and non-linear index SD1/SD2 ratio, a multiple regression analysis was performed. The overall model explained 46.47 percent of the variation in LF/HF ratio as an index of fetal sympathetic activity can be explained by ten independent variables. We can also see that age, CV\textsubscript{RR} %, HR Std, and RMSSD are significant predictors (or significantly related to) of LF/HF ratio [Parametric (AR) Based] as an index of fetal sympathetic activity. Gestation week, Body mass index, HR Mean, NN50, pNN50 and SD1/SD2 index is not a significant predictor of LF/HF ratio [Parametric (AR) Based] as an index of fetal sympathetic activity. The standardized beta tells us the strength and direction of the relationships (interpreted like correlation coefficients). CV\textsubscript{RR} % is positively related to LF/HF ratio [Parametric (AR) Based] as an index of fetal sympathetic activity.
9.4 Future Work

As future work, it can be extended in the following directions

I. By early measurement of autonomic nervous system activity during gestation period and fetal heart rate variability diagnostics indices relative features, it may be possible to make advanced preventive treatments to overcome the future health problem of child after birth.

II. The effects of mother health problems, their related food and cultural habits on child’s growth can be considered for further statistical findings.

III. The effect of mother nervous system parameters can be related to development of fetus. Further we can study magnetic resonance image (MRI) of mother’s brain. If pressure changes in brain are not proper it can affect fetal nervous system development. Fetal development can be further studied and related with mother’s brain defects by using MRI techniques.

IV. In Indian culture, pregnant women have been restricted to go out during certain days in the month, especially during solar eclipse and no moon day. Reason behind this is that electromagnetic forces have been found to change their strength in these days. The effect of these forces on child growth, fetal nervous system and fetal HRV on these days can be studied in the future.