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STUDY ON CONCURRENT CHARACTERISTICS OF FETAL ECG

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Abstract– Theoretical The foetal electrocardiogram (FECG) signal may contain precise information that might assist doctors in making more appropriate and timely decisions while on the job. Fetal pulse checking is a technique for obtaining vital information about a hatchling's health throughout pregnancy and work by recognising the FECG signal produced by the embryo's core. Clinical analysis and biomedical applications are the conclusive justifications for the interest in FECG signal investigation. Congenital heart failure is one of the most well-known birth defects and the leading cause of birth deformity-related deaths. The morphology of heart electrical signs is affected in the majority of people who have cardiovascular problems. The cost of an effective approach for foetal cardiovascular signals can be offset by the successful method for observing the prosperity of the fetal heart.

Digital signal processing techniques have played an important role in the extraction of foetal ECG signals. The abdominal ECG IV signal (AECG) is thought to be a nonlinear mixture of the maternal ECG, foetal ECG signal, and various interference signals. The foetal ECG is derived from two signals captured on the mother's skin in the thoracic and abdominal zones. To solve the dilemma of the mother and foetus, we apply the FECG technique to calculate the heart rates of both the mother and the foetus by correlating the signals. We use a toolbox called NI Lab VIEW for this, which allows us to correlate and compare signals using data from the PHYSIONET database.

***Index Terms*–**Fetal Electrocardiogram (FEEG), QFC, Correlation, Convolution, Mean Square Error.

I. Introduction

Every year, one out of every a hundred babies is born with a cardiac problem. This occurs as a result of a genetic problem syndrome, an inherited disorder, or environmental variables such as drug abuse and self-help. In any event, regular monitoring of a baby's heart is required prior to birth. As a result, foetal ECG (FECG) signals are critical for monitoring the baby's heart status so that any anomalies can be treated clinically by the relevant specialists.

Prenatal ECG monitoring is a widely utilised tool for foetal abnormality detection and diagnosis. During the pregnancy phase, the physician can simply prepare himself or herself for any foetal anomalies by diagnosing the foetal ECG signal. It's the most straightforward non-invasive way for diagnosing a variety of cardiac conditions. The Fetal ECG (FECG) represents the heart's varied electrical activities and so provides useful information about its physiological conditions. The FECG signal can easily be seen on a pregnant woman's abdomen, whereas the maternal electrocardiogram (MECG) signal can be seen on her chest. The combining of the MECG and the FECG signals is a common annoyance. The FECG signal generated by putting electrodes on the maternal belly provides minute details about the foetal status that are highly important during diagnosis. The abdominal ECG signal comprises several undesired interferences, as well as maternal ECG (MECG) and electromyogram (EMG) signals, while the FECG signal is tainted by various noise and skin distotions. The ECG is a chart that depicts the electrical activity of the heart. The ECG signal is made up of three main wave types. The QRS complex has been discussed in length below. The QRS complex's peaks provide the information about the heart rate of the abdominal ECG (AECG) signal. Hence, it is very crucial for the doctors to sense the heart defects before it causes any damage to the fetus or the mother. When the ECG signal is taken from the abdominal leads, a composite signal is picked[1].

There are assorted methods to extract FECG like wavelet transform, Doppler ultrasound, adaptive filtering, correlation methods, blind source partition method and a amalgamation of blind source unification methods and wavelet analysis. The heart beat rate of the FECG can be resolute by scheming the R-R peaks of the QRS complex . But, as the FECG signal is merged with MECG signal and various interferences, it is very complicated to calculate the heart beat rate from the raw signal.

Hence, the FECG is extracted from the raw signal to get the proper heart rate of the fetal signal[2].

A. Acquisition of EEG

The Fetal ECG was extracted from the maternal abdominal signals obtained by an array of electrodes implanted on the maternal belly. The data is transformed into an audio or video file after the signals are recorded. The Lab VIEW will only accept audio or video files as data, and the toolkit will extract the QRS signals from the audio file. Different strategies for obtaining Fetal ECG have been developed. The toolkit's different algorithms that are transformed into audio files are extracted and displayed on the screen. For unlike circumstances, the algorithms are tested with real abdominal signals. We use the algorithms for abdominal signals in the Physio net. Every piece of information in the Physio Net database is accurate and has been gathered from various hospitals throughout the world. The extracted FECG was estimated and investigated. The FECG is evaluated by comparing the QRS values at the R-R peaks and looking for FECG anomalies. We examine the FECG waveform signals and determine whether the foetal heart rate is normal or abnormal.
The proposed methods are similar. Because the mother rate and the foetal heartrate are compared and the maternal low heartrate signal is eliminated, the comparison is critical in FECG. The comparison can also be used to compare the heartrates of multiple Fetal signals at the same time and determine which signals are normal and which are problematic. The proposed efficient approaches are compared to other current methods. Because the comparison of two signals is done with the most up-to-date technological toolkit VI (Virtual Instrumentation), we can covert the VI results to appropriate software, such as MATLAB, which is one technique of determining FECG normality and irregularities.

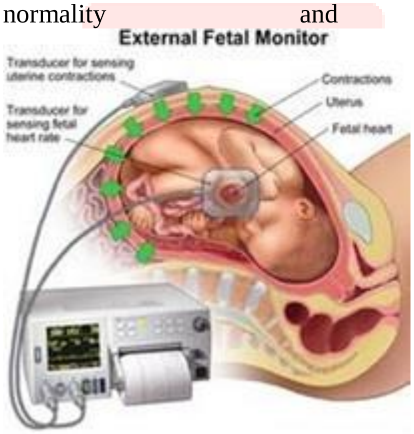


Fig.1. External Fetal Monitor.

II.Signal Mapping Techniques

There are different types of signal mapping techniques.

- Mapped Graphical Representations.
- Functional Representation.
- Tabular Representation.
- sequence illustration.

Graphical Representation

We use list of techniques in the Graphical Representation for Fetal ECG. Those are as follows:

1) FAST FOURIER TRANSFORM (QFC):

A Quick Fourier Change (QFC) is a calculation that examples a sign throughout some undefined time frame (or space) and seperates it into its recurrence parts. These system is single sinusoidal motions at unmistakable frequencies each with their own sufficiency and stage. This transformation is outlined in figure 1. Throughout the time span estimated, the sign contains 3 particular predominant frequencies.Fast Fourier changes are generally utilized for some applications in designing, science, and mathematics[3].

A QFC processes the DFT and delivers the very same outcome as assessing the DFT definition straightforwardly; the main distinction is that a QFC is much faster[4]. (Within the sight of adjust mistake, numerous QFC calculations are likewise considerably more precise than assessing the DFT definition straightforwardly, as talked about beneath.)
Let x0, ..., xN−1 be mind boggling numbers. The DFT is characterized by the recipe

$$X_k = \sum_{n=0}^{N-1} x_n e^{-i2\pi kn/N} \qquad k = 0,\dots,N-1.$$

Applications of QFC:

QFC's significance gets from the way that in signal administration and picture handling it has gotten done with working in recurrence area similarly computationally plausible as working in transient or spatial zone. A couple of the crucial uses of QFC incorporates.

- Fast enormous number and polynomial increase
- Proficient framework vector duplication for Toeplitz, circulant and other organized networks
- Sifting calculations
- Quick calculations for discrete cosine or sine changes (model, Quick DCT utilized for JPEG, MP3/MPEG encoding)
- Quick Chebyshev estimation
- Quick discrete Hartley change
- Settling distinction conditions
- Computation of isotopic distributions.

This QFC is used in the Fetal ECG signal and we will transform the Fetal signal for acquiring the signal and calculating the QRS wave signals.

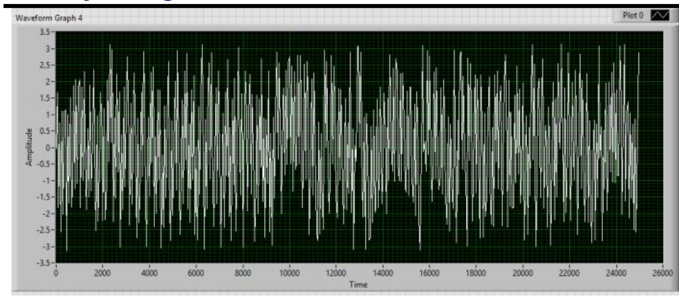


Fig.2. Wave form signal of QFC signal representation

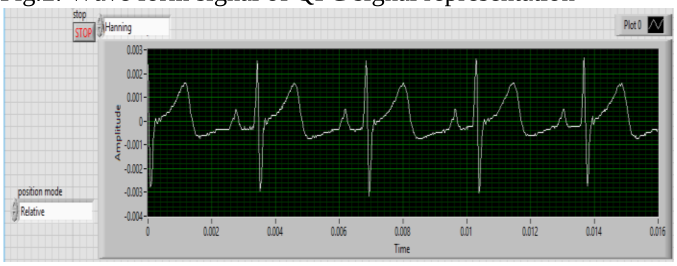


Fig.3. Total FECG heart rate

2)CONVOLUTION:

Convolution is a numerical activity used to communicate the connection among info and result of a LTI framework. It corresponds information, result and drive reaction of a LTI framework as

$y(t)=x(t)* h(t)$

Where y (t) = result of LTI

x (t) = contribution of LTI

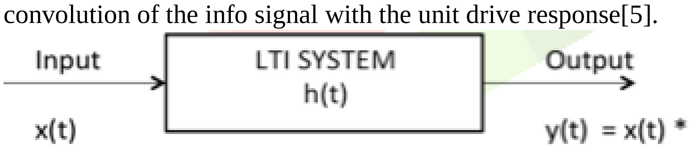
h (t) = motivation reaction of LTI

There are two kinds of convolutions:

- Ceaseless convolution
- Discrete convolution

A. Ceaseless Convolution:

Theoperation of ceaseless time roundabout convolution is characterized to such an extent that it fills this role for limited length and occasional nonstop time signals. For each situation, the result of the framework is the convolution or roundabout convolution of the info signal with the unit drive response[5].



$y(t)=x(t)* h(t)y(t)=x(t)*h(t)$

$=\int\infty-\infty x(\tau)h(t-\tau)d\tau=\int-\infty\infty x(\tau)h(t-\tau)d\tau$

(or)

$=\int\infty-\infty x(t-\tau)h(\tau)d\tau$

B. Discrete Convolution:

A discrete convolution can be defined as a set of capacities based on a set of integers. Convolutional speculations have applications in the fields of mathematical examination and straight polynomial math, as well as the planning and execution of limited drive reaction channels in signal processing[6].

$y(n)=x(n)*h(n)y(n)=x(n)*h(n)$

$=\Sigma\infty k=-\infty x(k)h(n-k)=\sigma k=-\infty\infty x(k)h(n-k)$

(or then again)

$=\Sigma\infty k=-\infty x(n-k)h(k)$

The fundamental utilization of the convolution is to we can track down the ZERO state reaction of the framework.

There are some rundown of properties in the Convolution those are as per the following

- Commutative property
- Distributive property
- Cooperative property
- Moving property
- Convolution and Drive
- Scaling property
- Separation of result

C.CORRELATION:

Connection is a proportion of similitude between two signs. The overall recipe for connection is

$\int\infty-\infty x1(t)x2(t-\tau)dt\int-\infty\infty x1(t)x2(t-\tau)dt$

There are two sorts of connection:

- Auto relationship
- Cross relationship

Auto Relationship Capacity

It is characterized as relationship of a sign with itself. Auto relationship work is a proportion of closeness between a sign and its time deferred rendition. It is addressed with $R(\tau\tau)$.

Consider a signs x(t). The auto relationship capacity of x(t) with its time postponed rendition is given by[7]

$R11(\tau)=R(\tau)=\int\infty-\infty x(t)x(t-\tau)dt$ [+ve shift]

$=\int\infty-\infty x(t)x(t+\tau)dt$ [-ve shift]

Where τ = looking or checking or defer boundary.

On the off chance that the sign is troublesome, auto connection work is given by

$R11(\tau)=R(\tau)=\int-\infty\infty x(t)x*(t-\tau)dt$ [+ve shift]

$=\int\infty-\infty x(t+\tau)x*(t)dt$ [-ve shift]

Properties of Auto-relationship Capacity of Energy Signal

- Auto relationship shows form balance for example $R(\tau\tau) = R^*(-\tau\tau)$
- Auto relationship capacity of energy signal at beginning for example at $\tau\tau=0$ is equivalent to add up to energy of that sign, which is given as:

$$R(0) = E = \int\infty-\infty|x(t)|2dt\int-\infty\infty|x(t)|2dt$$

- Auto correlation function $\infty1\tau\infty1\tau$,

Auto connection work is most extreme at $\tau\tau=0$ i.e $|R(\tau\tau)| \le R(0)\ \forall\ \tau\tau$

Auto connection capacity and energy otherworldly densities are Fourier change matches. for example

$F.T[R(\tau)]=\Psi(\omega)F.T[R(\tau)]=\Psi(\omega)$

$\Psi(\omega)=\int\infty-\infty R(\tau)e-j\omega\tau d\tau$

$R(\tau)=x(\tau)* x(-\tau)$

Auto Relationship Capacity of Force Signs

The auto connection capacity of occasional power signal with period T is given by

$R(\tau)=\lim T\to\infty 1T\int T2-T2x(t)x* (t-\tau)dt$

The properties of the Connection are [8]

Auto connection of force signal displays form evenness for example $R(\tau)=R* (-\tau)R(\tau)=R* (-\tau)$

Auto connection capacity of force signal at $\tau=0\tau=0$ (at origin)is equivalent to add up to force of that sign. for example

$R(0)=\rho R(0)=\rho$

Auto connection capacity of force signal ∞1τ∞1τ,

Auto relationship capacity of force signal is most extreme at ττ = 0 i.e.,

|R(τ)|≤R(0)∀τ|R(τ)|≤R(0)∀τ

Auto relationship capacity and power unearthly densities are Fourier change matches. i.e.,

F.T[R(τ)]=s(ω)F.T[R(τ)]=s(ω)

s(ω)=∫∞−∞R(τ)e−jωτdτs(ω)=∫−∞∞R(τ)e−jωτdτ

R(τ)=x(τ)∗ x(−τ)

Cross Connection Capacity:

Cross connection is the proportion of similitude between two distinct signals.[12]

Consider two signs x1(t) and x2(t). The cross relationship of these two signs R12(τ)R12(τ) is given by

R12(τ)=∫∞−∞x1(t)x2(t−τ)dt[+ve shift]

=∫∞−∞x1(t+τ)x2(t)dt[-ve shift]

In the event that signs are mind boggling then[13]

R12(τ)=∫∞−∞x1(t)x∗ 2(t−τ)dt[+ve shift]

=∫∞−∞x1(t+τ)x∗ 2(t)dt[-ve shift]

R21(τ)=∫∞−∞x2(t)x∗ 1(t−τ)dt[+ve shift]

=∫∞−∞x2(t+τ)x∗ 1(t)dt[-ve shift]

Properties of Cross Connection Capacity of Energy and Power Signs

Auto relationship displays form symmetryi.e. R12(τ)=R∗ 21(−τ)R12(τ)=R21∗ (−τ).

Cross relationship isn't commutative like convolution for example

R12(τ)≠R21(−τ)R12(τ)≠R21(−τ)

In the event that R12(0) = 0 methods, if ∫∞−∞x1(t)x∗ 2(t)dt=0∫−∞∞x1(t)x2∗ (t)dt=0, the two signs are supposed to be symmetrical.

For power signal on the off chance that limT→∞1T∫T2−T2x(t)x∗ (t)dtlimT→∞1T∫−T2T2x(t)x∗ (t)dt, two signs are supposed to be symmetrical.

Cross relationship work compares to the duplication of ranges of one sign to the intricate form of range of another sign. for example

R12(τ)←−→X1(ω)X∗ 2(ω)R12(τ)←−→X1(ω)X2∗ (ω)

For additional subtleties [9]

This additionally called as relationship hypothesis.

Fig.4. Connection sign of FECG

D.Mean Square Mistake:

The normal of the squares of the blunders or deviations—that is, the contrast between the assessor and what is assessed—is managed by the mean squared error (MSE) or mean squared deviation (MSD) of an assessor (of a technique for assessing a concealed amount) in insights. The usual worth of the squared blunder misfortune or quadratic misfortune is the subject of MSE, which is a gambling work. The distinction is made due to irregularities or the assessor's failure to portray facts that could lead to a more precise assessment. [10] The MSE is a proportion of an assessor's nature; it is usually non-negative, and numbers closer to zero are preferable.

The MSE is the succeeding second (around the start) of the blunder, and it consolidates both the assessor's fluctuation and its bias in this way. The MSE is the assessor's difference for an unprejudiced assessor. MSE uses the same units of estimation as the square of the amount being assessed, much like the difference. When comparing MSE to standard deviation, the square base of MSE yields the root-mean-square blunder or root-mean-square deviation (RMSE or RMSD), which has the same units as the amount being assessed; for an unbiased assessor, the RMSE is the square foundation of the difference, known as the standard deviation.

The MSE investigates the characteristics of an assessor (i.e., a numerical capacity that plans an example of data for the population elements from which the information is examined) or an indication (i.e., a capacity planning inconsistent contributions to an example of upsides of some irregular variable). The meaning of an MSE differs depending on whether it is used to refer to an assessor or an indicator.

Indicator:

In the event that Y ̂ is a vector of n expectations, and Y is the vector of noticed upsides of the variable being anticipated, then, at that point, the inside example MSE of the indicator is registered as

MSE=1/n ∑_(i=1)^n(Y_i-Y ̂_i)^2 .[11]

III.Conclusion

As the outcome for the FECG is it is typical or strange to characterize that the Fetal sign. From the information we have taken from the Physio net and mimicked in LabVIEW we can legitimize the Fetal heartrate is ordinary or strange. The signs which are reenacted in VI from the sound documents will give the specific situating of the pinnacles R-R in the complex of QRS[14]. We utilize different relating methods which will think about the maternal heart beat rate and Fetal heart beat rate in the VI and wipe out the maternal heartrate as it is low recurrence heartrate than the Fetal heartrate on the grounds that it goes from 120-150. The fetal heartrate is effectively distinguished and related to ordinariness or anomaly. As the ordinariness or irregularity is observed these charts those are checked by the predefined specialist recognizes the Baby status and gives the precautionary measures prior to quitting any funny business to mother and Hatchling. At last we can legitimize the FECG with looking at the signs and finding the ordinariness and anomaly with correlation signals[15].

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