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Fetal and Mother Health Monitoring System: A Survey

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***Abstract*— The state of health of an expecting mother and her child can be evaluated during pregnancy through a monitoring system. This paper describes about a framework based on IoT which is a prototype of wearable device to check the heart rates of a fetus and mother, along with temperature of an expecting women. Through this system a continuous monitoring of fetal heart rate at a remote place is carried out. The results obtained are being interpreted at the doctor's side and evaluated. This framework helps to provide instant and low cost primary treatment if any problem arises which helps in reducing the infant as well as maternal mortality rates**.

Keywords— Fetal/Mother Health Observing System, Doppler Device, Smart device, Smart Wearable Wireless Sensor

I. INTRODUCTION

Fetal and Mother Health observing framework depends on the examination of the fetal pulse rate signal, notwithstanding mother's heart rate and temperature which is the generally utilized technique for medicinal appraisal of fetal condition during pregnancy. Due to the convoluted shapes of waveform visual examination of FHR gives a noteworthy challenge. Along these lines, computer based fetal checking framework gives number of parameters which are the last results of measurable sensed signals. These parameters are the basis for a subjective investigation of the fetal moment condition. The strategies for the calculations of FHR qualities given by a Doppler gadget are usually used in facilities for estimating the fetal condition. In the event that infant pass on's in the belly of the mother, blood in long duration and maternal draining may lead to cross-clotting disorder (Dickens, scattered intravascular coagulation). For this and so many problems, this study may help to eliminate expanded number of deaths, expulsion and early mediation. This is likewise valuable for the moms-to-be.

Nowadays for the pregnant ladies there are such a large number of hand held Doppler items accessible from e-markets for home use. Step by step in the hand held Doppler items the ceaseless improvement can be seen for information stockpiling, sharing, FHR checking and displaying. However to check or translate the aftereffect of fetal commercial Doppler items do not have ability to recognize the baby's conditions. But it is possible to summarize and detect the fetal conditions as Normal, Atypical/Warning, and Abnormal/Alarm by a framework to mindful doctor of the labor distantly. A savvy e-wellbeing framework enables to track and after tracking report current fetal condition during estimation period. In this way, for the responsible doctor or crisis staff the framework can characterize and caution about the last known status of the fetus.

Today, labor still have to go to hospital for regular screening of the fetal condition after every 15 days or weekly. Yet, in some cases it is troublesome in high risk pregnancies to go to emergency clinics every day or week. Current e-wellbeing frameworks can coordinate the self-safe FHR checking by labor far from facilities and medical clinics.

This paper discuss about the framework which gives the choice to mothers-to-be in resource-poor areas for screening the regular embryo observing, well-being and computing current fetus risk conditions especially for critical pregnancy circumstances via a mobile coordinated small Doppler gadget.

II. LITERATURE SURVEY

The clinical routine with regards to auscultating fetal pulse rate started in 1818. After 1970s, recording of nonstop fetal pulse rate and uterine movement turned out to be generally utilized in obstetric care considerations. The electronic fetal monitoring (EFM) is essential strategy for screening fetal health during labor. In paper [1], Numerical examination of the human fetal pulse: which gives the quality ultrasound records, are introduced by G.S. Dawes, G.H. Visser, J.D. Goodman, and C.W. Redman [2], they portrayed technique for the PC driven numerical analysis of fetal heart periods (beat interims). To isolate the records of Low recurrence and High recurrence segments of the signal this strategy uses digital filter. Along with that a Doppler ultrasound is utilized in remaining 10 weeks of incubation. A framework gives especially helpful adjunct to the investigation of antenatal human fetal pulse records. In paper [3], Improvements in the examination and registration of fetal heart rate can be seen, introduced by G.S. Dawes, C.W. Redman [4], in which a microprocessor based regular Doppler framework is structured with the end goal of online examination of fetus pulse. Accentuation is fundamentally given on the instrumentation and program structure. The framework is tried by checking unusual and typical fetal pulse records. In paper [5], an algorithm based on the Dawes/Redman criteria for computerized fetal pulse checking, is exhibited by L.N. Erika [6], in which the hardware dependent on Dawes/Redman criteria as an item in STAN S31 is used for fetal pulse checking delivered by Neoventa Medical AB in Mlndal.

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III. METHODS FOR CHECKING FETAL HEART RATE AND MOTHER HEART RATE

There are various techniques which are used for checking fetal heart rate and mother heart rate. These techniques for heart rate monitoring can be of two types, they are invasive and non-invasive techniques.
Invasive techniques i.e. inserting an instrument or an object into the body for measuring the heart rate and non-invasive where heart rate is monitored on the body surface.

Table 1 shows the invasive and non-invasive heart rate monitoring techniques.

Table 1
Heart rate monitoring techniques

Invasive FHR techniques	Non-invasive FHR techniques
Fetal scalp electrode	Computerised analysis
	cardiotography
	Fetal electrocardiogram or magnetocardiography
	Doppler ultrasound
	Accelerometer based systems
	Fetal and mother health monitoring system

A. Fetal scalp electrode:

FSE utilizes an electronic transducer associated in contact with the fetal scalp. A wire electrode is joined to the fetal scalp through the cervical opening and is associated with the screen.
It is a hazardous system as it may cause wounds on the fetal scalp and/or uterine infection.

B. Computerised numerical analysis of fetal pulse:

In this technique the beat interims of fetal heart periods are determined that is beat-to-pulse interim difference is checked for. It is the innovation of the information age which is accessible for examination of the fetal-pulse economically research and clinical practice. These frameworks are built with algorithms of neural networks intended to stimulate master knowledge. In order to get full mechanized investigation of the information this system proves helpful. The objective, standardized, and reproducible information is used to inquire about fetal heart pulse reactions in the antepartum and intrapartum setting.

The major advantage of this system is that different records of low frequency and high frequency components is been kept. But eventually it leads to a problem of signal loss.

C. Cardiotography:

The technique of cardiotography is most commonly used antepartum monitoring technique and it also combines the measured fetal heart rate with that of uterine contractions recordings, using a Doppler ultrasound. It is a technical means which records the fetal heart beat along with uterine contractions during pregnancy. The machine which is used to perform all the monitoring is called as cardiotograph as well as electronic fetal monitor (EFM). Two methods are being used to perform cardiotography that is External cardiotography which is used for continuous and intermittent monitoring and Internal cardiotography in which electronic transducer is connected directly to fetal scalp. A CTG reading is printed on paper and it is stored in a computer for future references.

The CTG needs a hospital like setup because it requires presence of an expert or a nurse which can handle, reposition and skilfully place the ultrasound probe. Due to above restriction a continuous monitoring is not performed and hence limited monitoring time allowed by the hospital stay for a routine monitoring.

D. Fetal electrocardiogram (FECG) or magnetocardiography:

As compared to Cardiotography the FECG technique can provide additional information about fetal heart rate, i.e. morphology of P-wave, QRS-complex, QT duration.

The FECG monitoring technique is completely non-invasive and it can be performed over longer period of times. Through the monitoring we get the electrical activity recordings which are collected on the mother abdomen and from the fetal R peaks detection. The results which are shown in the fig 1 and fig 2 are obtained at 35th gestational week. Fig 1(a,b,c) shows three AECG recordings, fig 1(d) shows trace obtained by application of the PCA enhancement method[5]. Fig 2(a,b,c) Shows the FECG signals after application of method described in [6], fig 2(d) PCA enhancement approach result.

The drawback of this technique is that the fetal electrocardiogram has low signal to noise ratio because of many noise sources interference with each other. The maternal electrocardiogram (MECG) contributes majorly to the noise. The oscillation in the maximum amplitude of the QRS from (100 to 150) uV for maternal recording and for fetal recording up to 60 uV can be observed.

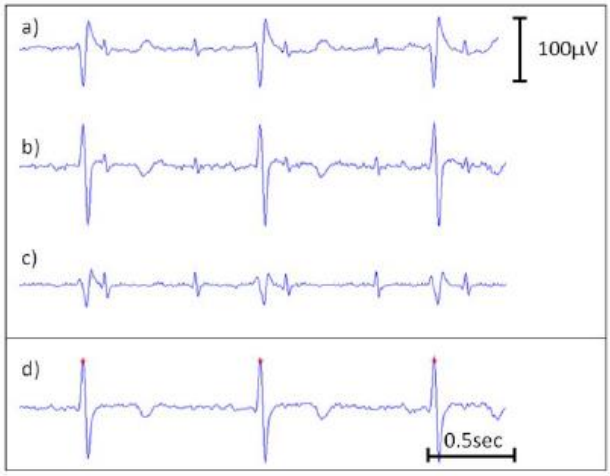

Fig.1 Maternal QRS detection

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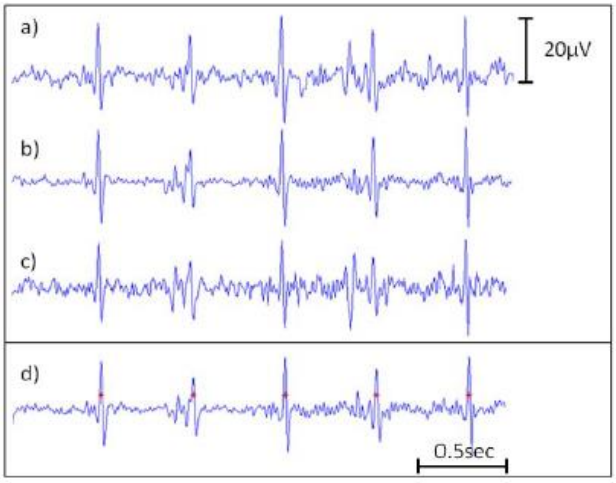

Fig.2 Fetal QRS detection

E. Doppler Ultrasound:

The most common technique for checking the health status of mother and fetus.

Everyone is familiar with this technique because of its widespread use. It relies on high frequency sound waves which are being used to generate an image of the fetus and can be used only for a limited amount of time, because of the safety issues involved in it. But ultrasound can only be performed in hospitals and hence requires physical presence of patient. This may sometimes cause inconvenience to the mother in complicated cases.

Doppler ultrasound is commonly referred to as color Doppler ultrasonography, it is kind of special ultrasound technique which allows a doctor to see and evaluate various parameters. There are types of Doppler ultrasound:

- Color Doppler
- Power Doppler
- Spectral Doppler

F. Accelerometer based systems:

The accelerometer based systems are developed to tackle common issues in ultrasound measurement and enable far away, self-administered monitoring of fetal movement. A single wearable device is placed on the abdomen which uses an accelerometer based system to detect the fetal kicks accurately. Here two methods are used to detect fetal kicks accurately that is a single wearable device which aims to reduce false positives and increase in positive predictive values (PPV) when a reference accelerometer is not present outside the abdominal area.

G. Fetal electrocardiography (fECG) based assessment techniques:

It is the method which effectively ensures the fetal wellbeing. It is a non-invasive technique which ensures minimal patient discomfort and makes the product suitable for wearable applications. A module of noise optimized Analog-Front-End is used for non-invasive fECG monitoring. It requires itinerant, low-power, cheap device, interfaced to a smart-phone and capable of running computationally intensive signal processing algorithms.

H. Fetal and mother health monitoring using mobile phone:

For monitoring health some specifications are considered and they are as shown in the table 2 [7], [8].

TABLE 2
Specifications for monitoring health

Parameters	**normal**	**Critical (above)**	**Critical (Below)**
Fetal heart rate	120 to 160 bpm	>160bpm Tachycardia	<120bpm Bradycardia
Mother heart rate	60 to 100 bpm	>120 bpm May signal as anemia , infection, and elevated thyroid hormone	<40 Insufficient for normal human activity
Temperature	36.5^0C-37.5^0C	>37.5^0C or 38.3^0C hyperthermia	<35^0C hypothermia

With the reference of above specifications a continuous monitoring of the required parameters is performed. About 5 weeks incubation, baby's pulse starts beating. Now, FHR is about as same as mothers HR about 80-85beats per minute (bpm).System comprises of equipment's out of which optical finger base pulse module is used to monitor the mothers HR. By start of the 9th week stretch of pregnancy FHR can be heard by utilizing Doppler, the HB100 sensor is utilized in proposed framework for estimating FHR during this stage ordinary FHR is about 175 bpm. The software on the phone examines the sound of fetal pulse using network module associated to controller to calculate the pulse.

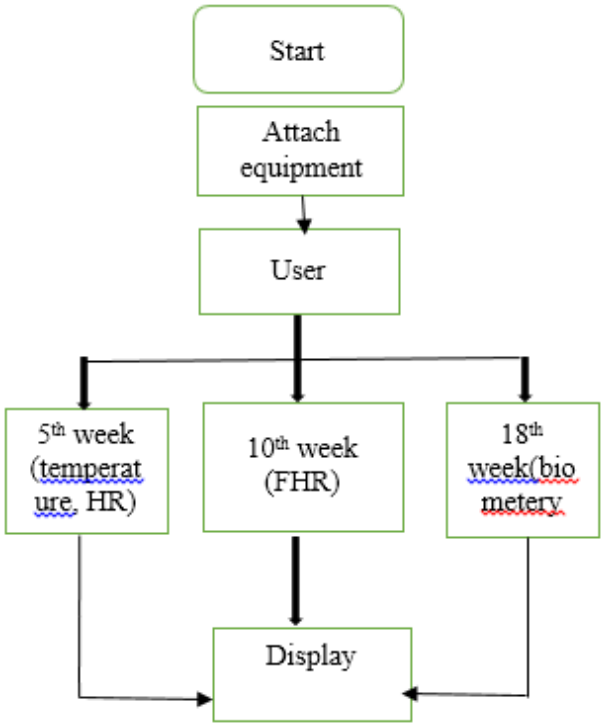

Fig 3: Flow diagram for checking health status

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IV. CONCLUSION

This paper represents a review of the technical implementations in the research area of fetal and mother health monitoring using various invasive and non-invasive techniques. From the literature, there is a trade-off between the two on the basis of accuracy as invasive techniques a precise and accurate. But non-invasive techniques are improving day by day and proving to be more accurate. One advantage is that the instrument is not inserted in the body and hence avoids irritation and infections. Similarly, continuous monitoring of fetal and mother heart rates and other biometry parameters are essential in order to reduce the fetal mortality rates and maternal mortality rates. Most commonly used technique for monitoring is ultrasound but it requires an expectant mother to go to hospital, so a technique which helps Monitoring at the place of residence proves helpful and reduces frequency of visits to hospital. Detection of any abnormalities in early stages helps reduce the fetal as well as maternal mortality rates.

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