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IoT based Fetal Monitoring System for Prenatal Care

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***Abstract*: The World Health Organization has released some disturbing figures concerning maternal fatalities in India. According to their findings, at least one Indian woman dies during pregnancy and delivery every five minutes. "Of the 529,000 maternal deaths that occur each year, 136,000, or 25.7 percent, occur in India." The WHO reported that "the incidence of emergency postpartum hysterectomies is approximately 83 per 100,000, with a maternal mortality rate of 17.7 percent and a perinatal mortality rate of 37.5 percent." The purpose of this research is to present a novel method for monitoring the fetal body with maternal characteristics such as movement (kicks) and heart rate by employing an accelerometer sensor and a heart rate pulse sensor. Because of its relationship with various fetal health issues, monitoring fetal movement (FM) is considered a significant aspect of fetal well-being evaluation. Fetal distress, fetal growth limitation, hypoxia, and other conditions are examples. However, current common techniques of FM measurement, like ultrasonography, and MRI, have limitations in clinical settings. A fetal heart rate (FHR) monitoring gadget is in great demand for monitoring fetal health issues in the home. In this study, the system displays a fetal heart rate and monitors various parameters that are communicated over the Internet of Things and are controlled by a software program that can be loaded on a mobile phone or PC.**

***Keywords*: Pregnancy women, Fetal monitoring system, Heart rate pulse sensor, Accelerometer sensor, Internet of Things, Arduino Uno.**

1. Introduction

The state of a woman's health throughout pregnancy, childbirth, and the immediate postpartum period is known as maternal health. In 2017, there were close to 295,000 pregnancy-related deaths among women; 84% of these deaths took place in poor nations as a result of inadequate treatment and education. Additionally, hypertension in pregnant women is typical and contributes to numerous fatalities globally. Preeclampsia, or chronic hypertension, is another illness that affects 3% to 5% of pregnant women in affluent countries and can result in severe harm or even death. In severe cases, it can lead to eclampsia. The prevalence of stillbirth, maternal mortality, and neonatal death has decreased as a result of prenatal care for expectant mothers. Every typical prenatal appointment includes planning for nutrition and exercise, as well as medical assessments like fetal heart rate monitoring, blood pressure monitoring, weight checks, fundal height measurements, and urine testing. Additionally, depending on the stage of the pregnancy, some appointments include extra physical examinations, such as blood testing and ultrasound imaging, to identify any hazards to the woman or the fetus (such as gestational diabetes and hypertensive diseases) [1].

Medical checks of pregnant women's health and fetal kick count monitoring are crucial to identifying women's health issues. Several hospitals are keeping an eye on pregnant patients. During this period, ensure sure their condition is steady using medical. The participant is required to take any measurements, including blood pressure, weight, baby movement, pulse, and other parameters. This study suggests a software program to automatically track a pregnant woman's health and fetal movement (kick count). People in rural regions are unaware of the appropriate drugs and technology improvements to reduce pregnancy difficulties. For instance, to better understand baby growth, pregnant women should get ultrasound scans at least twice over the course of the pregnancy. Furthermore, timely and appropriate examinations can guarantee a safe delivery. Women in rural regions are unaware of the value of taking the right medications. Additionally, they cannot afford the medical costs. Although there are ultrasonic scanning devices on the market, they are rather pricey [2], [4].

By utilizing its underlying technologies, such as embedded devices, communication protocols, sensor networks, internet protocols, and applications, IoT turns these conventional items into intelligent ones. Using IoT-based systems with global connections, all healthcare-related information, including therapy, diagnosis, recovery, inventory, and medicine, may be conveniently gathered, managed, and shared. Mobility is supported by IoT-based healthcare services since they have wireless interfaces and internet connectivity [3].

We presented the system, which includes a number of sensors, including a heart rate pulse sensor and an accelerometer sensor that counts the fetal kicks. The graphical data and the LCD display may be gathered from these sensors. It utilizes Arduino Uno and IoT technology to communicate the collected data to the software program, which may be loaded on a mobile device or PC. It will promptly alert you via the buzzer if any abnormal values occur.

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2. Related Works

Sarala Ghimire et al., 2022, Pregnant women often have many in-person encounters with medical experts during standard prenatal care, during which fetal and maternal examinations are made. An architectural framework for prenatal care employing a non-invasive, easy-to-use, and affordable Internet of Things (IoT) monitoring system is proposed in this study. The goal is to create an IoT-based architecture that offers frequent prenatal screening tests and acts as a core system for self-imperative care during routine pregnancy check-ups in the comfort of the home. No matter where you are or whether you have access to the internet, the system makes getting treatment simple. For the purpose of monitoring blood pressure, we created a basic architecture [1].

Sarathkumar K.S, Boopathi K, et al., 2015, the foundation of developing and poor countries is their human resources. When compared to cities, rural regions are more populated in emerging countries like India. Due to the lack of hospitals in the region and the necessity to travel great distances even for minor accidents and examinations, people in rural areas don't truly worry about their health. Early in pregnancy, pregnant women from rural regions tend to skip their routine exams. Regular checks can significantly lower the fetal death rate and help prevent the delivery of disabled children. In our system, a pregnant lady has an ultrasound scan, and at the same time, some of her vital signs, including her temperature, heartbeat rate, blood pressure, and ECG, are taken and recorded on a memory card. This data is accessible through the smartphone application, which may also check for emergencies [2],

Rajkumar Ettiyan et al., 2020, Pregnancy is a unique condition in which women face a variety of medical difficulties during the incubation stage. Traditional health monitoring methods are either too limited or too general, making them insufficiently adaptable to pregnant women. In every environment, the Internet of Things ensures safe and effective treatment for pregnant women since it not only eliminates pregnancy risks and bad events but also improves privacy, and religious, legal, and societal difficulties. The motivating attacks of this structure provide a persuasive rationale to a difficult, clinical preliminary to determine if this pregnant women's medical services framework enhances the guidelines of pregnant women's medical care among pregnant women in the network with uncontrolled medical problems. This study gives a thorough examination of women's health monitoring systems [5].

Faruk Aktas et al., 2017, Internet of Things (IoT)-based biomedical applications are now being utilized in a variety of different biomedical systems, including healthcare/telecare, diagnosis, prevention, therapy, and monitoring. Key elements of the Internet of Things (IoT) concept include wireless body area networks (WBANs) and radio frequency identification (RFID) systems. These technologies are sometimes referred to as "enabling technologies." In this research project, a brand-new IoT-based healthcare framework for hospital information systems is developed. This framework is coupled with WBANs and RFID technologies. The plan for a model of the framework has been created and run through simulations with the help of the Riverbed Modeler program. The findings indicate that quality of service standards for data rate and latency requirements of the ISO/IEEE 11073 standard can be fulfilled by implementing the energy-aware system that has been presented. This is also the case. proven that various case studies that were explored for hospital information systems may simply be achieved using the suggested system structure by creating a more efficient and effective setting for simulation [3].

3. Working Process

An Arduino controller is used in this suggested gadget, and it is responsible for controlling a variety of sensors. Some examples of these sensors are a heart rate pulse sensor and an accelerometer sensor. The information that has been gathered from all of the sensors is evaluated with the assistance of an Arduino UNO, and then it is sent with the help of a Wi-Fi module. The outcome has been shown in the software program with the assistance of the Internet of Things.

The term "Internet of Things" refers to the integration of different pieces of hardware and software that are managed with the assistance of the Internet. In addition to this, it was used to link to other devices, swap data (which served as the sensor's input), and act upon things.

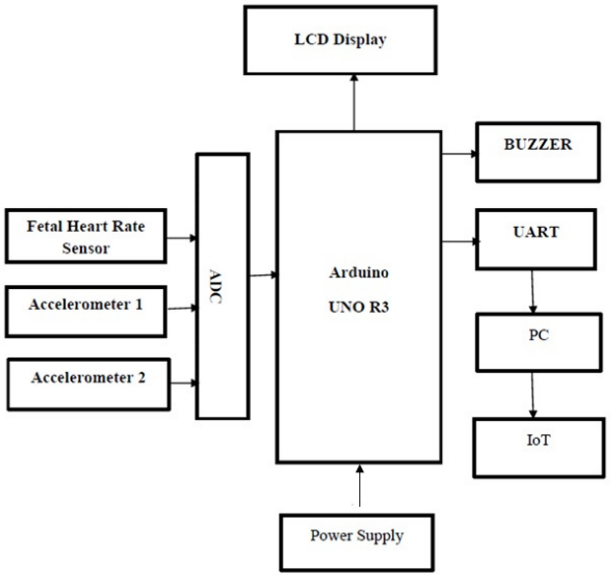

Fig. 1. Block diagram of IoT based fetal monitoring system for prenatal care

The Arduino UNO has an integrated circuit (IC) called R3 that is based on a microcontroller. To begin, we conceived of the programming language and then sent it to the microcontroller by means of a USB cable.

An analog signal representing the data received from the sensor may be sent into an Arduino microcontroller, where it will be processed by an ADC and ultimately turned into a digital signal. After that, the signal is processed by Arduino, which produces a digital output. After that, the output is shown on an LCD, and then the data is sent to a personal computer through USB.

The heart rate pulse sensor is what is utilized to determine whether or not a woman is pregnant or carrying a fetus. The accelerometer sensor is positioned on the mother's abdomen in order to detect the movements (kicks) of the unborn child. This is accomplished by placing the sensor in this location.

The process that is taking place in the microcontroller will first measure and regulate this, and then it will be relayed to the Internet of Things. The threshold values for metrics like heart rate and movement (forces or kicks) are programmed into the microcontroller. This allows the microcontroller to monitor these variables.

On the LCD display, the software program will show graphical representations of the data, and the heart rate and movement will be presented there as well. But with the new method that has been planned, if there are any irregularities that could take place, they will be alerted right away by a buzzer.

4. Hardware Parts

A. Heart Rate Pulse Sensor

During pregnancy, a woman's normally slow heart rate of 70 beats per minute might accelerate to a rapid rate of 90 beats per minute. Therefore, we make use of a heart rate pulse sensor in order to measure the subject's heart rate.

It is an electrical instrument that assists in measuring both the mother's and the unborn child's heartbeats simultaneously. Connecting this sensor to an Arduino board through a human fingertip or ear can get the device to function properly.

It measures 0.625 in diameter. It is 0.125 millimeters thick. The operational voltage is between +5V and +3.3V unless otherwise specified. The microcontroller has an analog-to-digital converter (ADC), which is used to transform the analog signal representing the heartbeat into a digital signal.

Fig. 2. Heart rate pulse sensor

B. Accelerometer Sensor

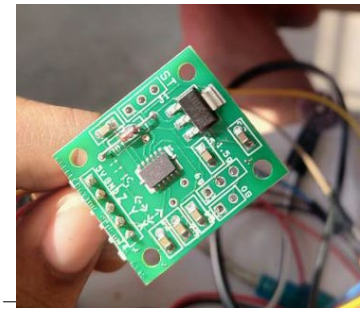

Fig. 3. Accelerometer sensor

We are using two accelerometer sensors to compare the movements of the fetus and mother. Acceleration can occur on one, two, or three orthogonal axes using the accelerometer sensor. This sensor is positioned within the mother's abdomen. Analog inputs on three axes (X, Y, and Z) allow this sensor to detect the force of a baby's movement. The analog signal is then converted to digital by the Arduino UNO's ADC.

C. Arduino Uno

We converted analog sensor input into a digital signal using an Arduino Uno R3 microcontroller. This microcontroller is connected to a USB, which facilitates the transmission of sensor output data.

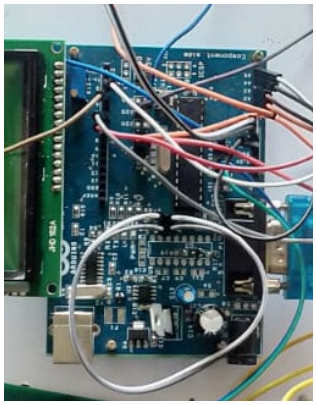

Fig. 4. Arduino UNO R3

D. Buzzer

A buzzer is a device that may be used to make an alert sound in response to any aberrant behavior that may take place.

Fig. 5. Buzzer

E. LCD Display

The fetal heart rate and movement (kick count) can be shown on an LCD to aid in seeing sensor output results in digital form.

Fig. 6. LCD display

5. Result and Discussion

The overview table1 for the fetal and mother's normal heart rate is provided in this section.

Table 1
Normal heart rate of fetal and mother

Category	Normal Heart rate	Output value (BPM)	Condition
Mother	70-130	85	Normal
Fetal	120-160	136	Normal

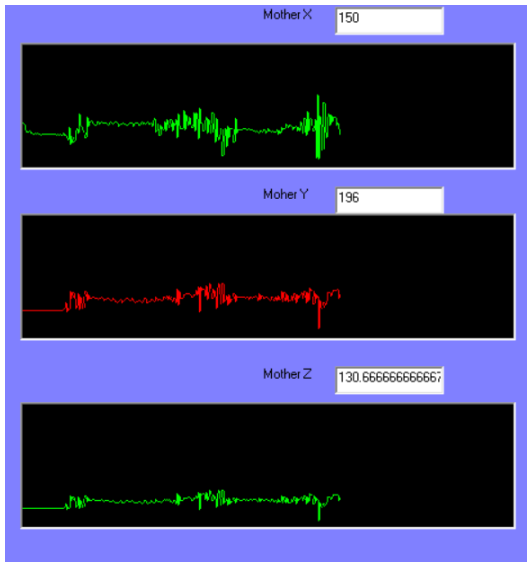

Fig. 7. Graphical representation of pregnancy women's abdominal movement

The fig. 7 shows the movement of the mother in three-dimensional axes (X, Y, and Z).

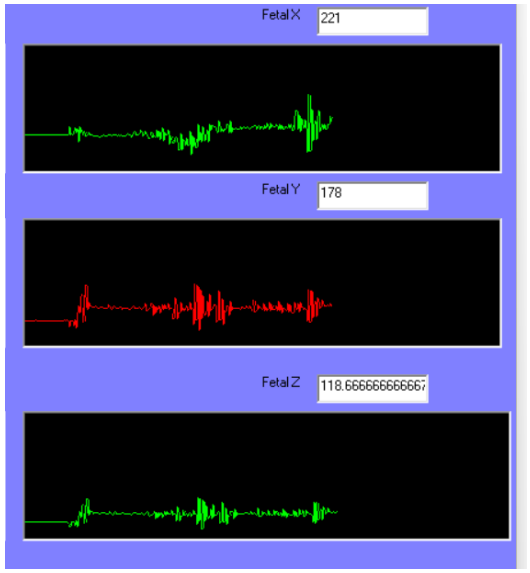

Fig. 8. Graphical representation of normal fetal movement (kicks)

The fig. 8 shows the normal movement of the fetal in the three-dimensional axes X, Y, and Z.

The fig. 9 shows the abnormal movement of the fetal in three-dimensional axes (X, Y, and Z).

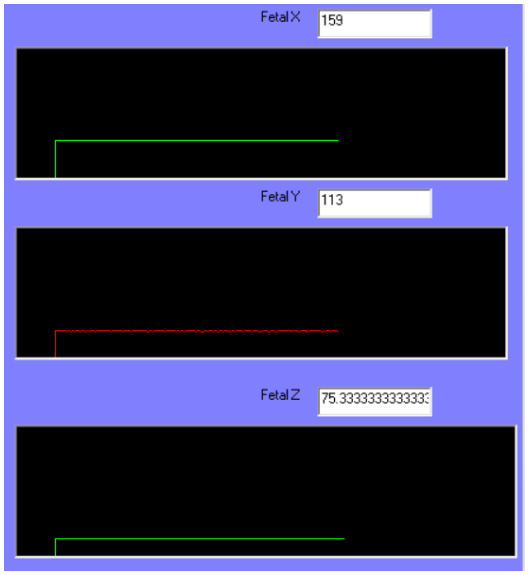

Fig. 9. Graphical representation of abnormal fetal movement (kicks)

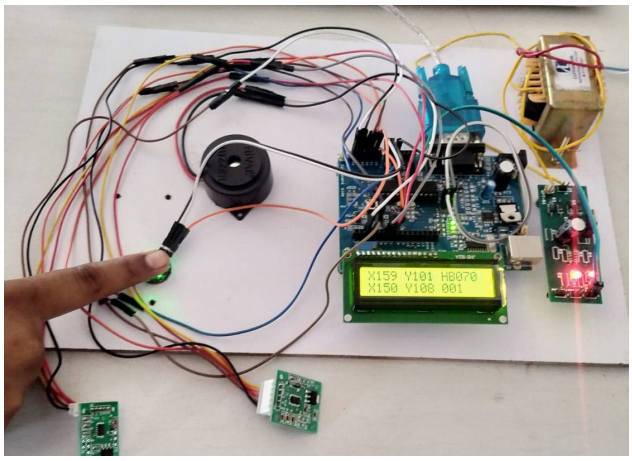

Fig. 10. Final prototype of IoT-based fetal monitoring system for prenatal care

This is the final prototype of our project work. It takes a continuous reading of the heart rate and fetal movement (kick count) with the help of a microcontroller. In the event of any abnormality in heart rate or movement, the buzzer will generate an alarm sound.

6. Conclusion

In today's modern world, a different problem that needs to be addressed is pregnancy. In more rural areas of the world, there are often fewer possibilities for routine examinations. This is due to the high mortality rates and the significant number of deaths that occur among mothers. This concept for a system makes use of a number of sensors to evaluate various aspects of a person's health, such as their heart rate, fetal movement, or kick count, in order to reduce the likelihood of problems. This method is extraordinarily helpful and successful for expecting mothers. These numbers are able to be examined on a computer at the local medical institution by both the mother and the attending physician.

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