Prega Care - A Health Monitoring Device for Pregnant Women

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Abstract

In many countries like India, there are more rural areas as compared to cities. In rural areas, due to the lack of medical facilities, people are not much concerned about their health. Even for a routine check-up, they need to travel a long distance. Pregnancy demands a routine check-up and women in rural areas don't do their regular check-ups at an early stage of pregnancy. A routine check-up can help in reducing the fetal mortality rate and to identify and reduce risks (if any) for the mother and the baby. In this paper, the system allows the interaction of doctors with pregnant women through the mobile application. Some crucial parameters of pregnant women like heartbeat rate, blood pressure, temperature, and fetus movement (kicking) are measured and stored in the cloud. The android application can access this information. Whenever there is any fluctuation that happens from the normal value, an alert message is sent to the doctor's mobile application. Hence, doctors can monitor the health of pregnant women. The purpose of this system is to record the parameters of the pregnant woman and deliver the recorded results to the doctor so that the routine health status of the pregnant woman can be monitored without going to the hospital.

Keywords: MAX30205 sensor ESP8266 Wi-Fi Module, Android application, Firebase, Internet of Thing

1. Introduction

Every year, pregnant women in a million face medical problems like diabetes, hypertension. A significant medical illness is faced by more than 40, 000 pregnant women in the US in a year [1][2].

The foundation for the progress and existence of any nation is human. Human life safety is the most perplexed yet paramount area which is always a matter of discussion. Pregnant woman safety is, therefore, one of the things we have worked for keeping in mind the current situation. The death rate of pregnant women is quite high, especially in rural areas.

According to the facts given by WHO, "Every day in 2017, approximately 810 women died from preventable causes related to pregnancy and childbirth" One out of twelve women in western Europe enter into the pregnancy period with a chronic medical condition that requires pharmaceutical treatment [3].

It is well known by clinicians that the evidence base to determine how to treat the medical conditions of pregnant women is distressingly poor [4]. In rural areas, pregnant women are not much concerned about their health and don't go for routine check-ups. They need to travel a lot due to the lack of proper hospitals and clinics in villages. A routine check-up is very important during pregnancy to identify the health status of the baby and the mother. Fetal movement is a way used to access fetal well-being [5]. Pregnant women may be vulnerable to changes in ambient temperature and warming climates [6]. Hypertensive disorders represent major causes of pregnancy-related maternal mortality worldwide [7]. The various health monitoring system and many movement recognition systems have been developed for human motion capture in virtual reality and biomedical applications including mechanical trackers and health monitoring using smart sensors [8].

In our proposed system, crucial parameters like heartbeat rate, temperature, blood pressure, and kicking are measured with the help of sensors. The information from the sensors is stored in the cloud [9]. The android application can access this information. This application will be present on the mobile of doctors, pregnant women, and her husband. In case of fluctuations in the parameters of women from the normal, an alert message will be sent to the doctor's mobile application and the husband's mobile application using WIFI. Also, the real-time health parameters result will be displayed in the application. The involvement of doctors will make this system more reliable for health monitoring. The concern of the proposed work is to develop a device that can act as a helping hand and take care of the health of the women, especially for rural areas that can't go for a regular check-up.

2. Review of related systems

In [10], the proposed system records some vital parameters like a heartbeat, temperature, and Kicking. It uses a mobile application for displaying all the results and showing the status of pregnant women. It uses LM35 for temperature measurement, heartbeat sensor for The Fetal heart rate. The android application shows the status and acts as a helping guide. The drawback of this system is it can only record the parameters but cannot be a perfect helper for health monitoring. No medical expert is present to monitor the results so completely relying on the application could be a factor of risk. No doctor is involved in keeping the records of the health status of pregnant women. In our paper, doctor advice and guidance are involved.

In [11], this paper deals with the implementation and designing of ECG software applications. Its main aim was to produce a prototype model of this application. It used Bluetooth ECG monitoring devices to fulfill the purpose. It also describes the architecture. Developing an environment and other tools used are also described. Android SDK, Eclipse is used in the development process. The major result was to establish communication between sense devices using Bluetooth. The major drawback of this paper was it takes under consideration only ECG for monitoring and doesn't include other parameters like temperature, heartbeat. In our proposed system we have considered all the vital parameters.

In this paper [12], the design and development of a remote patient monitoring system for pregnant ladies was the main aim of his paper. This system allows interaction between doctors and pregnant women. hence, proper monitoring of the health status can be done. This system measures heartbeat rate and temperature. It uses GSM for giving alerts and updates to the doctor. The limitation is that it doesn't take into consideration other important parameters like blood pressure and kicking which is very important during pregnancy. In our paper, we have considered kicking counts and blood pressure. Also, we have used Wi-Fi technology for the transmission of data using Node Mcu esp8266.

In [13], the paper focuses on certain points. It is based on many facts, one such fact is that strokes and heart attacks are one of the biggest reasons because which elder people are often hospitalized. The probability of their survival increases a great deal if they are treated within an hour. The android healthcare device is used by many. With its help, one can detect the fall of the carrier with the help of an accelerometer using any android Smartphone. Then this android smartphone is connected to a monitoring system with the help of the TCP/IP via Wi-Fi. With this system, the elder and chronically ill patients can lead independent lives. They can live a safe and independent life in the safety of their homes. All this is because their movements are monitored. The only limitation of this system is that it solely considers the elder people as there is a higher probability of sudden (emergency) situations such as stroke and cardiac arrest in their cases. Herein this paper, we have considered various parameters and not solely considering anyone.

3. Proposed system description

In the proposed system, a product idea of a device named 'Prega care' is presented. The care of a woman while pregnant is always a topic of concern. It's obvious to note that if compared to the general people, effective treatments and precautions should be provided to pregnant women [14]. After the evaluation and analysis of what are the impacts of prenatal, neonatal, and obstetric care on the health of infants and the low birth weight, there is evidence showing and indicating there is a need for extra care for pregnant women [15]. If from the early stage, precautions and health monitoring will start, it will be beneficial for the lives of the mother and the baby.

Our device aims at performing health monitoring functions by providing a way of interaction between doctor and woman. Mainly, we have worked on four parameters-Fetus movements, temperature, blood pressure, and heart rate monitoring. Also, a button will be provided in the device which when pressed sent a message alert or alarm indication on the phone of the neighbor or family members. We can also develop an android application where all the recorded details and the results of all the sensors can be easily seen. Android applications from the easiest way of human interface. Other Descriptions of the project in detail are discussed below.
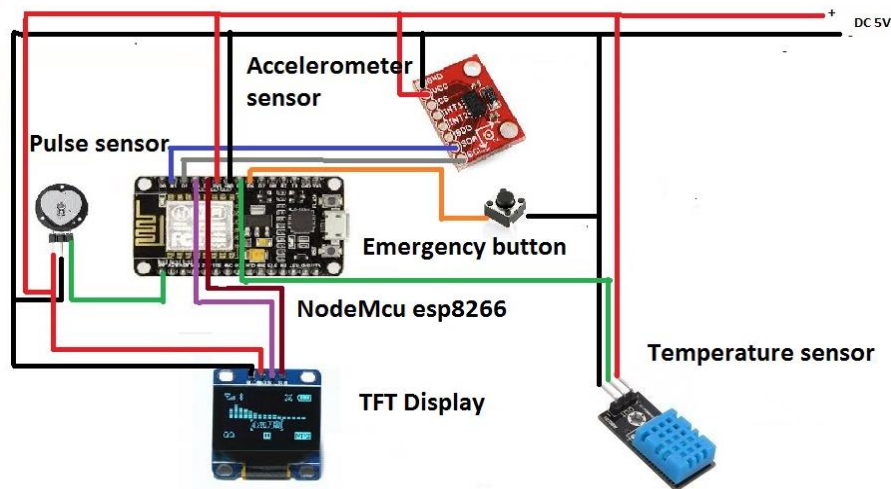

Figure 1. Showing the model of device and components arrangement

3.1. Movement of fetus

On the way to making an accurate and precise device, the selection of the sensors plays an important role. To detect the movements of the fetus, we have used an accelerometer sensor. It can be used to measure acceleration in one, two, and three-axis which is orthogonal. Kicking, which is the fetus's movement, can be detected by these accelerometers. It will be present or held in the outside area of the mother's abdominal area. In the uterus, the fetus's movement is a sign of well being of the baby. It depends greatly on the vascular state of placental insufficiency [16]. It is observed that there is a fetal movement for prolonged periods during the third trimester [17]. Information provided to pregnant women about fetal movements is inconsistent perhaps due to limited knowledge about normal fetal movement patterns in healthy pregnancies [18].

ADXL335 is the sensor type we have used. This is a small, low power, three-axis accelerometer module measuring X Y Z values in the form of analog voltages. ± 3g is the minimum full-scale range of this sensor. The selection for the bandwidth can vary in the range of 0.5 Hz to 1600 Hz for Y, X-axis, and 0.5 Hz to 550 Hz for the Z-axis. It has a wide power range from DC 3V to 5V. It is highly sensitive; hence, we have used it here.

Figure 2. ADXL335

It mainly measures the tilt in the angle to the earth. We too can use vibration sensors but accelerometer sensors show more precise and accurate values. Fetus movement shows that there is a growth in the strength and size of the fetus. Less number of movements in a particular period can be a sign of danger regarding the health of the baby. So keeping in mind the risk involved, it is very important to maintain a record of the movements. From the starting of the fourth month [19], the baby starts kicking (the movement of the fetus which is observed by the mother or by ultrasound technique) usually, but mostly it is not observed by the mother. The prediction of the development and real condition of the fetus is done by clinicians by the measurement of fetal movement.

This device can be used instead of the expensive ultrasound technique. The number of kick counts that can be treated as normal or abnormal is illustrated in the below chart.

Table 1. Fetal movement measurement

Hour Duration	no. of kick counts(Normal)	no. of kick counts(Abnormal)

1 hour	More than 2	Less than 3
2 hour	More than 5	Less than 6
12 hour	11 or greater	Less than 11

3.2. Blood pressure measurement

As we know that among all the other parameters, the most important parameter to be taken care of is blood pressure. Blood pressure variation is harmful to any individual, but for pregnant women, it can be too risky. We have used a Blood pressure sensor to measure the blood pressure of the women. Blood pressure measurement and monitoring are quite necessary for women during the whole period of pregnancy. This could result in dizziness and can also adversely affect the oxygen and nutrients supply of the baby. If the variation goes on without treatment, it can be proved deadly. High blood pressure can be the cause of many serious problems like hypertension [20]. This might also result in many other complications like preeclampsia. Also, if it continues even after 20 weeks of pregnancy, it can adversely affect the organs of women like the brain, kidney [21]. So reducing the risk or the danger of the life of the mother and the baby, we have included this sensor too. Prega care is a complete kit for health monitoring.

Table 2. Blood pressure measurement for different status of health

Status	Systolic mm hg(upper number)	Diastolic mm hg (bottom number)
Normal	less than 120	less than 80
elevated	120-129	less than 80
High blood pressure (Hypertension stage 1)	130-139	80-89
High blood pressure (Hypertension stage 2)	140 or higher	90 or higher
Hypertensive crisis	Higher than 180	higher than 120

3.3. Temperature measurement

The temperature change of the human body is the immune system's reaction [22]. Fever is a sign showing that our immune system is fighting and trying to save our body from some infection. Temperature sensors are used for the measurement of body temperature. Here, we are using it for the body temperature measurement of the mother. During pregnancy, temperature variation is quite common. The reason being the increased metabolism, release of progesterone hormones, due to which the women's body gives out more heat. Early pregnancy and high temperature could be a worrying situation. Also, very low temperature is a sign of serious problems. So to measure the maternal temperature and maintain a proper record of the fluctuations, fatal conditions can be reduced.MAX30205 is the specific sensor we are using so that accurate and precise results can be obtained. It has 8 pins and has a

temperature range of 0-50 degrees Celsius. The voltage range is 2.7-3.3V and low supply current. It also provides an over-temperature alarm to indicate the danger in case of temperature rise. Using a high resolution Analog to Digital Converter (ADC), this sensor converts the temperature measurements to digital form. It has a lockup protected I2C compatible interface and it is the reason that it can be best suited for medical, wearable fitness applications.

Table 3. Temperature ranges for different health status conditions

tatus	Temperature range(in Celsius)	Temperature range (in Fahrenheit)
Hypothermia	< 35.0 °C	95 ° F
Normal	36.5-37.5 ° C	97.7-99.5 °F
Fever/Hyperthermia	>37.5 or 38.3 °c	99.5 or 100.9° F
Hyperpyrexia	>40 or 41.5 °C	104 or 106.7 °F

3.4. Heart rate measurement

During pregnancy, there is variation in the heart rate also. [23]. The heart rate of women declines mostly in pregnancy. Different type of variation is observed at different trimesters of pregnancy.[24] Here for measuring the heart rate we are using pulse sensors. It's a quite well designed, efficient plug-and-play heart rate sensor. Using some jumper cables it can be connected to Arduino and the sensor clips can be placed onto a fingertip or earlobe for the measurement purpose. It includes an open source application for monitoring and showing the results in form of graphs in real-time. The pulse sensor kit contains ear clips, pulse sensors, velcro dots, velcro straps and connecting cables. It is a highly sensitive and portable sensor which is used so that heart rate can be easily monitored and risk factor can be reduced.

Other than the above mentioned, we are using ESP8266 Board which will update the record and will be interfaced with our components. All the information is recorded on the database on the cloud and then send to the doctor also so that he can take care of the complete record and give advice as per the condition if required. IoT is used for fulfilling the same purpose. [25] as is a key playing crucial role in taking care of pregnant women inside and outside the hospitals. It makes things clear and effective by ensuring that efficient environment because many small devices which include sensors, RF tags are with the women and proper monitoring can be easily done from anywhere, anytime. It not only provides a better environment but also reduces the complications that occur during the pregnancy period. Hence, we have also used IoT.

Table 4. Heart rate for a normal pregnant woman according to age

Age of pregnant woman	Normal heartbeat range(beats per minute)
Less than 20 years	140-155

20-29	135-150
30-39	135-145
40 or older	125-140

4. Android application

Our system uses an android application that helps in accessing the information stored in the cloud. The application displays the value of the health parameters. This application will be at three locations: for Wife, Husband & Doctor mobile. The application retrieves Data from one Real-time Database. The application has been designed using XML and developed using JAVA language.

A. Features of the application

1. Real-time Body Temperature monitoring.
2. Real-time Body Temperature Status.
3. Real-time Heart-Rate monitoring.
4. Real-time Blood-Pressure monitoring.
5. Total number of Fetal movements.

Figure 3. Prega care application showing the results recorded

B. Development of the application

Requirement analysis: We wanted an android application that could access the sensor information from the cloud and update it regularly. The application would be present at three locations: doctor, husband and wife's mobile phone.

Defining the project scope: These days, as people become more health-conscious than ever, and lifestyle-related diseases are on the rise, the mobile app can play a significant role in many aspects. For Example, the health mobile app enables the patients to get access to their health data anytime and anywhere. That's why we developed an Android app (PregaCare) for

pregnancy, Hopeful (Pregnant Women) will have a device connected with her body that can share the data with the healthcare specialist, husband and also Hopeful.

On the other hand, the healthcare professionals get rid of maintaining and accessing the printed data as a reference. In a way, the PregaCare app can bring a paradigm shift from print and laptop-based data to mobile-based data. Also, the healthcare sector is broadly based on patient-doctor interaction. The mobile app connects them instantly while blurring the boundaries of countries. Doctors can also communicate securely with other doctors to share important information.

C. Development

Application has been developed using android studio. Designing is done with XML and development is done in Java Language.

D. Stabilization

Open Firebase Project-> Go to test Lab> Open Android Project> Generate Apk File> Browse Apk file in test lab> Processing> Test done> Passed Result.

Hence, our application testing has passed successfully in the Google test lab.
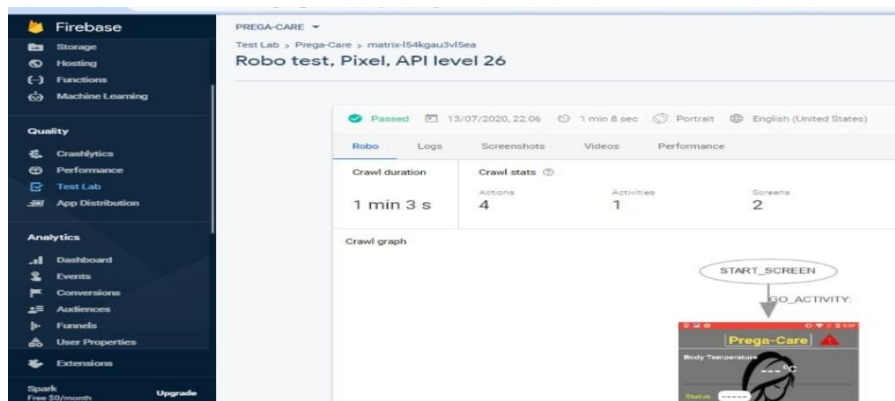
Figure 4. Testing result of Android application on test lab

E. Functional Requirements

Registration Process of SRS (Software Requirements Specification):

● Adding Patients: This app enables the staff at the front desk to include new pregnant women in the system.

Check Out of SRS:

● Deleting Patient ID: The staff in the administration section of the ward can delete pregnant women's IDs from the system.

Report Generation of SRS:

● Information of the Patient: PregaCare generates a report on every pregnant woman regarding various information like pregnant women's name, Phone number, bed number, the doctor's name whom it assigns, ward name, and more.

Database of SRS:

● Mandatory Patient Information: Every pregnant woman has some necessary data like phone number, first and last name, personal health number, postal code, country, address, city, patient's ID number, etc.

● Updating information of pregnant women: PregaCare enables users to update the information of pregnant women as described in the mandatory information included.

F. Non-functional requirements

There are a lot of software requirements specifications included in the non-functional requirements of PregaCare, which contains various processes, namely Security, Performance, Maintainability, and Reliability.

Security:

● pregnant women Identification: The system needs pregnant women to recognize or themselves using the phone.

● Logon ID: Any users who make use of the system need to hold a Logon ID and password.

● Modifications: Any modifications like insert, delete, update, etc. for the database can be synchronized quickly and executed only by the ward administrator.

● Front Desk Staff Rights: The staff at the front desk can view any data in PregaCare, add pregnant women's records to Application but they don't have any rights to alter any data in it.

● Administrator rights: The administrator can view as well as alter any information in the PregaCare.

Performance:

● Response Time: The system provides acknowledgment in just one second once the ' pregnant women's information is checked.

● Capacity: The system needs to support at least 1000 people at once.

● User-Interface: The user interface acknowledges within five seconds.

Maintainability:

● Back-Up: The system offers efficiency for data backup.

● Errors: The system will track every mistake as well as keep a log of it.

Reliability:

● Availability: The system is available all the time.

Figure 5. Use case diagram showing the interaction of app and device

5. Working and block diagram

In our project, the components i.e. the sensors used for the implementation and their respective details have been already mentioned. Now further moving on the implementation so all the data collected from different sensors go to the ESP8266 NODEMCU Wi-Fi module. Due to the simple IP connections, this Wi-Fi module is chosen. It sends the data to the database (cloud) where the data is stored. Now as per our use, the result is displayed on the

android application created by us for the following. We provide the dynamic updates with the help of two main things i.e. the Firebase and the sensor. The doctor can view the updates by using the mobile application.

All the basic functionalities are shown with the help of the block diagram below.
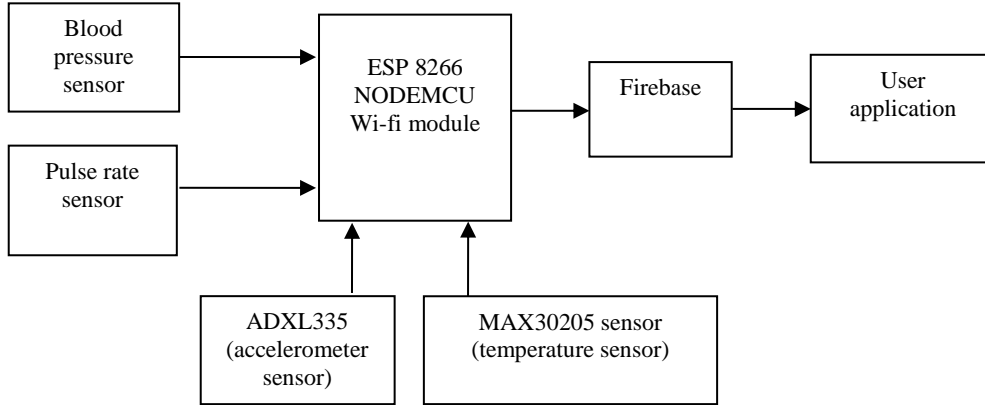

Figure 6. Block diagram of "Prega care" sensors interfacing

6. Conclusion

In this paper, we have shown how our idea of the "Prega care" device can be implemented using different sensors. Keeping in mind the main factors or parameters adversely affecting maternal and baby health, accurate and precise result giving sensors are used. This device can be improved further by adding other features as well, but here we have tried to involve most of the important unavoidable parameters which when taken care of can improve the condition, especially in rural areas where regular check-up and test is not available or possible. Also, in cities, it would reduce the crowd in clinics or hospitals as only selected ladies which have critical conditions or as per the record and doctor's advice come. Hence, it would surely act as a helping hand for pregnant women and the baby. It is just a step towards making health monitoring easier and better than the existing one in some way.

Acknowledgment

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