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**DEPARTMENT OF COMPUTER ENGINEERING**

SCHOOL OF ENGINEERING SCIENCES

COLLEGE OF BASIC AND APPLIED SCIENCES

**FINAL YEAR THESIS**

ON

**DEVELOPMENT OF AN INTEGARTED WEARABLE DEVICE FOR REMOTE MONITORING OF PREGNANT WOMEN IN GHANA**

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DEVELOPMENT OF INTEGRATED WEARABLE DEVICE FOR REMOTE MONITORING OF PREGNANT WOMEN IN GHANA

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# DECLARATION OF ORIGINALITY

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# ABSTRACT

Pregnancy complications are a significant public health concern, especially in developing countries, where over 40% of pregnancies face serious health risks, according to the World Health Organization (WHO). In Ghana, 12% of female deaths (ages 15-49) over the past five years have been attributed to pregnancy complications, with 62% of these deaths resulting from delayed or inadequate medical intervention. Medical experts indicate that more than half of these fatalities could have been avoided through early detection. Timely monitoring of vital parameters during pregnancy can enable the early identification and diagnosis of such complications.

Despite the widespread adoption of smart wearable devices in healthcare over recent times, these alarming statistics highlight the need for further advancements in monitoring and intervention.

To address this, our proposed system uses a wearable device to collect physiological data, which is then processed using fog computing. Fog computing is employed to overcome the computational and energy limitations of wearable devices, as well as the latency issues typically associated with cloud computing in real-time data processing. The proposed IoT-based health monitoring system integrates fog-assisted computing to monitor key physiological parameters such as body temperature, blood pressure, blood glucose levels, oxygen saturation, and heart rate of pregnant women. At the fog node, the system predicts potential pregnancy complications like preeclampsia, anemia, and gestational diabetes. The biomarker values and predictions are then sent to the cloud for further analysis, with access granted based on user authentication roles via a mobile application.

This system aims to reduce the time required to diagnose medical conditions in pregnant women, enabling quicker intervention. Additionally, the patient only needs to visit a healthcare provider in case of an emergency, ensuring a more efficient and timely healthcare process.

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"Coming together is a beginning, staying together is progress, and working together is success."

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# CHAPTER 1 - INTRODUCTION

## Introduction

This chapter begins by providing an overview of the remote monitoring of pregnant women, highlighting its significance and the critical role it plays in ensuring maternal health. It discusses the potential consequences of inadequate monitoring during pregnancy and underscores the benefits of leveraging technology for remote monitoring. The chapter clearly defines the problem, establishing the need for a comprehensive solution. Additionally, it outlines the objectives of the project, detailing its scope and emphasizing its relevance and potential impact on society.

## 1.1 Background

Pregnancy is the most crucial period for a woman, where she needs extra care and has to take precautions for her health as well as the infant’s health. Moreover, the careless attitude of the woman towards her health leads to the occurrence of issues like preeclampsia, eclampsia, which may become the reason for miscarriage or even leads to maternal death. Remote Monitoring of Pregnant Women refers to the use of technology to continuously track and assess the health status and well-being of expectant mothers regardless distance. Remote Patient Monitoring can facilitate effective intervention and early treatment paradigms to prevent the occurrence of pregnancy complications. Potential dangers of not monitoring can lead to critical challenges such as preeclampsia, anemia, low birth weight and developmental delays and ultimately lead to death

Using technology in maternal care enables medical professionals to make informed decisions rather than solely depending on values captured during antenatal visits.

## 1.2 Problem statement

Pregnancy complications represent a significant public health concern, particularly in developing countries, where the World Health Organization (WHO) reports that over 40% of pregnancies face substantial health risks. In Ghana, this issue is starkly highlighted by data indicating that 12% of female deaths among women aged 15-49 in the past five years are attributable to pregnancy-related complications. Alarmingly, 62% of these deaths are linked to delayed or inadequate medical intervention.

Several barriers, including distance, high transportation costs, and time constraints, hinder many pregnant women from accessing regular antenatal care. These obstacles exacerbate maternal risks by delaying the detection and management of pregnancy complications such as preeclampsia and anemia. The infrequent visits to healthcare facilities result in late diagnoses, which significantly lower the chances of survival for both the mother and the baby.

Addressing these challenges requires a focused approach to improve access to timely and regular antenatal care, ultimately reducing the risks associated with pregnancy complications. This thesis aims to explore and develop solutions to bridge the gap in healthcare accessibility and improve maternal health outcomes.

## 1.3 Project objectives

The objectives of this project revolve around the creation of a wearable device bolstered by the integration of machine learning techniques to address the critical issues associated with monitoring pregnant women. The objectives of this work are in three folds:

* To develop an integrated system consisting of a wearable device and a mobile application to continuously monitor, detect and trigger alerts in event of abnormality.
* To train a machine learning model for risk prediction of pregnancy complications like preeclampsia and anemia long before standard detection window.
* To develop a user-friendly interface system to acquire and visualize information for processing by the system.

## 1.4 Significance of project to society

The significance of this project extends beyond the technical innovation it brings; it addresses a critical public health issue by improving maternal health care. The outcome of this project has the potential to significantly reduce maternal health risks, improve healthcare accessibility, and contribute to the overall well-being of mothers and their babies. Below is an exploration of how this project can positively impact society.

* Early detection of pregnancy complications, hence reducing maternal mortality: Early detection of pregnancy complications is a critical factor in reducing maternal mortality, especially in resource-constrained settings. Complications such as preeclampsia, gestational diabetes, anemia, and infections can develop rapidly during pregnancy, posing severe risks to both the mother and the fetus. Timely identification and management of these conditions are essential to prevent progression to life-threatening stages. Early detection allows healthcare providers to intervene promptly, offering appropriate treatments or referrals to higher-level care facilities. Moreover, early detection contributes to better birth outcomes by facilitating proper planning and preparedness for potential complications. This includes scheduling timely cesarean sections for high-risk pregnancies, monitoring fetal growth and well-being, and implementing necessary lifestyle adjustments
* Equip pregnant women with tools to monitor and manage their health: Empowering pregnant women with self-monitoring tools and educational resources is crucial in improving maternal health outcomes and reducing pregnancy-related complications. By providing access to biomarker values such as blood pressure, blood glucose level and oxygen saturation, women can actively track vital health on a regular basis. This proactive approach allows pregnant women adjust their lifestyles as often as possible hence reducing the risk of severe outcomes such as preeclampsia, gestational diabetes, and fetal distress. Knowing that potential issues are being monitored and managed can alleviate anxiety for pregnant women and their families, promoting a more positive pregnancy experience.
* Continuous data collection and visualization empower doctors to make informed, data-driven decisions rather than relying solely on periodic observations: Continuous data collection and visualization empower doctors to make informed, data-driven decisions by providing real-time insights into a patient’s health, rather than relying solely on periodic clinical observations. This approach allows for the continuous monitoring of vital health metrics, such as blood pressure, heart rate, and fetal movements, enabling the early detection of potential complications. Data visualization tools present this information in easily interpretable formats, such as graphs and trend lines, allowing doctors to identify patterns and anomalies quickly. By integrating this continuous data into the healthcare system, doctors can make proactive, personalized care decisions, improving maternal and neonatal health outcomes and reducing the risk of severe complications.
* Ease of pressure on antenatal clinics due to reduced visitations: The ease of pressure on antenatal clinics due to reduced visitations is a crucial benefit of implementing remote health monitoring solutions for pregnant women. By enabling women to track key health indicators like blood pressure, glucose levels, and fetal movements from home, the frequency of in-person visits can be reduced, alleviating the strain on clinics. This helps decrease crowding in healthcare facilities, allowing healthcare professionals to focus more on high-risk pregnancies that require immediate attention. With fewer routine check-ups to perform, healthcare workers can better allocate their time and resources, which also reduces clinician burnout. Additionally, remote monitoring increases accessibility for pregnant women in rural or underserved areas, where traveling to clinics can be difficult. This not only eases the pressure on urban healthcare facilities but also ensures more women receive continuous care. Overall, reducing in-person visits improves the efficiency of healthcare systems, enabling them to prioritize urgent cases while providing better care for all patients.

## 1.5 Organization of Thesis

## This thesis is structured into five chapters, which are outlined as follows:

Chapter 1 provides an overview of the project and its objectives. It includes context, problem statement, Project objectives, and significance of the Project.

Chapter 2 provides literature and relevant existing approach to the project.

# CHAPTER 2 – LITERATURE REVIEW

## 2.1 Introduction

This chapter provides an overview of existing solutions and technologies related to the remote monitoring of pregnant women. It explores the current methodologies and innovations aimed at improving maternal health outcomes through the use of wearable devices, machine learning, fog and cloud computing. By reviewing existing systems and research, this chapter identifies the strengths, challenges, and gaps in current approaches to remote monitoring and early detection of pregnancy complications. The goal is to highlight how these solutions align with or differ from our approach proposed in this thesis, setting the stage for a deeper understanding of the advancements in maternal health care and the potential impact of this project.

**2.2 Survey of existing solutions**

# 2.2.1 Remote Monitoring System for the Detection of Prenatal Risk in a Pregnant Woman

The article presents a system designed for continuous monitoring of vital parameters, including maternal body temperature, blood glucose levels, maternal heart rate, and the frequency of uterine contractions per minute, using a smartwatch worn on the wrist. Additionally, the system allows for manual input of key data such as maternal age, gestational age, weight, height, and blood pressure by the pregnant woman.

The collected data is securely stored on a cloud-based database and analyzed using a Support Vector Machine (SVM) machine learning algorithm. This algorithm compares the data with historical records to predict potential risks, such as preterm labor or stillbirth.

The system also features a mobile application that enables doctors, hospitals, patients, and a designated family member to register and access its functionalities. In the event of a pregnancy-related complication, the system sends both an SMS (Short Message Service) and an email alert to the registered doctor and the emergency contact of the family member.

The mobile app provides a visual representation of the pregnant woman's health status, accessible to both the patient and the family member. Doctors can also monitor the health status of all their patients through a consolidated chart within the app.

This system is highly effective in enabling doctors to make quicker, informed decisions during emergencies, thereby saving valuable time. It also significantly reduces pregnancy risks such as preterm labor, stillbirth, or miscarriage by facilitating timely interventions.[7]

# 2.2.2A System for Remote Monitoring of Pregnant Women's Health State and Pregnancy Complications Prediction

The article describes a system comprising portable medical devices, including a biochemical analyzer, blood clotting analyzer, heart monitor with an automatic tonometer, spirometer, pulse oximeter, and blood glucose meter, are used to monitor the biomedical parameters of pregnant women. Additionally, a questionnaire is employed to gather supplementary information, such as bad habits, allergic reactions, family medical history, and obstetric and gynecological details. This comprehensive data collection supports the accurate diagnosis of pregnancy complications, such as preeclampsia, anemia, thrombosis, and gestational diabetes mellitus.

The captured data from these devices is transmitted to the pregnant woman’s smartphone via Bluetooth and subsequently sent to the medical institution’s server. From there, the results are forwarded to the medical officer responsible for managing the patient’s care. Decision Tree machine learning model is employed, with threshold values defined for each parameter. If any device readings exceed these thresholds, an alert is automatically sent to the medical officer for prompt intervention. [8]

# 2.2.3 A Remote Blood Pressure Data Collection and Monitoring System for Expectant Mothers

This article presents a smartwatch model, GE-W74, was utilized to measure blood pressure and transmit the data to a mobile application via Bluetooth connectivity. Additionally, a Photoplethysmography (PPG) heart rate sensor and an Electrocardiogram (ECG) sensor were employed. The recordings from these sensors were analyzed by medical officers to manually predict the onset of pre-eclampsia, rather than solely relying on blood pressure values recorded during antenatal visits.

The mobile application displayed the collected readings to the pregnant woman and her caregivers. It offered customization options, allowing the expectant mother to set her preferred data collection intervals, determining when data should be sent from the smartwatch to the app. Furthermore, the app included a feature to adjust skin color settings, ensuring the PPG sensors functioned effectively across different skin tones.

A separate mobile application was developed for use by Community Health Volunteers (CHVs), Community Health Extension Workers (CHEWs), and the next of kin. This app was designed to enable these external stakeholders to monitor and intervene when persistent high or low blood pressure readings were detected, providing timely support to the expectant mother.

# 2.2.4 A Remote Healthcare Monitoring Framework for Diabetes Prediction Using Machine Learning

This work outlines an automated smart health monitoring system for diabetes prediction using supervised machine learning algorithms, including K-Nearest Neighbor, Logistic Regression, Gaussian Naïve Bayes, and Support Vector Machines. Data is collected from various healthcare and consumer devices. Among these algorithms, the Support Vector Machine demonstrated the highest accuracy. The PIMA Indian Diabetes Dataset is used for model training and evaluation.

The system incorporates threshold values in the models to detect abnormalities in blood glucose and blood pressure levels, notifying medical professionals via a web application and mobile app in such events. The healthcare devices employed include a Samsung Note 8 smartphone, a Huawei GT 2 smartwatch, an iHealth blood pressure monitor, an iHealth glucometer, and an iHealth pulse oximeter.

The web application provides optional user inputs for parameters such as skinfold thickness, the number of pregnancies, and pre-existing medical conditions. While the primary objective is to predict the likelihood of diabetes, additional risk factors like low activity levels, weight gain, heart rate, sleep patterns, activity types, and durations are also monitored. This holistic approach enables doctors to make informed decisions based on the user’s overall health status.

Captured data from the devices is transmitted to a mobile app via Google Fit APIs. The mobile app forwards this data to a cloud database, where it is stored and analyzed for diabetes prediction. The results are subsequently sent to a dashboard accessible exclusively by medical professionals.

# 2.2.5 Virtual Midwife for Pregnant Women and Alert System

This paper proposes a system consisting of a compact device designed to monitor vital health parameters and send alerts to medical officers and pregnant women when predefined thresholds are exceeded. The system records body temperature, heart rate, and oxygen levels using a temperature sensor, a heart rate sensor, and a pulse oximeter, respectively. The data captured by these sensors is transmitted to a Node Microcontroller Unit (MCU) for processing. Once processed, the data is sent to the cloud for storage and access. If any vital parameters surpass the threshold values programmed into the microcontroller, an alert is sent to the corresponding medical officer, prompting them to contact the pregnant woman.

The data is accessible through two separate mobile applications; one for medical officers and the other for pregnant women. The app for pregnant women allows them to choose their preferred midwife, nurse, or doctor to provide care throughout their pregnancy. Besides notifying them of captured values from the sensors, the app also sends regular reminders to stay hydrated and offers dietary suggestions for a healthier lifestyle. The app for medical professionals is primarily used to view the recorded values from the IoT, alerts if anomaly in event of anomaly in vitals and communicate directly with the pregnant woman.

# 2.2.6 Maternal HealthCare Using IoT-Based Integrated Medical Device: Bangladesh Perspective

This article introduces a remote monitoring system comprising a wearable device equipped with various sensors, an ESP32 module, a cloud platform, and a mobile application. The wearable device collects data from pregnant women, including blood pressure, body temperature, oxygen saturation levels, and heart rate. This data is initially stored in the ESP32 module until a connection with the cloud platform is established.

Once a communication link is active, the data is transmitted to the cloud, where it is analyzed by a machine learning algorithm. The algorithm identifies critical risk conditions and promptly sends notifications to healthcare professionals, enabling them to take necessary preventive measures to mitigate potential pregnancy complications. The processed data is then visualized in the mobile application as graphs, allowing healthcare providers to identify risk levels effectively.

# 2.2.7 IOT Based Wearable Health Monitoring System for Pregnant Ladies Using CC3200

This paper presents a healthcare solution that combines a compact wearable device with a web application. The wearable device measures critical parameters such as body temperature, pulse rate, and blood pressure of pregnant women. These analog signals are transmitted to a CC3200 microcontroller, which features an in-built ADC (Analog-to-Digital Converter) and Wi-Fi module. The microcontroller converts the analog signals into digital data and uploads them to the cloud.

From the cloud, the processed data is forwarded to the doctor's computer via an assigned IP address. If the captured values deviate slightly from the preset normal range, an alert, accompanied by an alarm sound, is sent to the doctor. The doctor can then review the data and send a prescription back to the patient's IP address.

In cases where the values exceed the critical threshold, the doctor will arrange for an ambulance and notify the patient's relatives with an alarm message. This ensures timely intervention in emergency situations.

# 2.2.8 Fuzzy Intelligent System for Patients with Preeclampsia in Wearable Devices

This article discusses a wearable device designed as a watch that measures blood pressure and transmits the data to a mobile application via Bluetooth. The mobile app integrates an AI model trained to predict the likelihood of preeclampsia. The model uses a dataset collected from a hospital in Colombia, comprising information about patients with potential preeclampsia diagnoses.

The dataset includes attributes such as age, body mass index (BMI), pregnancy trimester, blood pressure readings, family medical history, and other relevant factors. Once the watch records a blood pressure reading, this value is combined with other attributes on a row from the dataset. A Decision Tree machine learning model then processes this data to predict whether a pregnant woman is at risk of developing preeclampsia.

# 2.2.9 A novel fog‑computing‑assisted architecture of E‑healthcare system for pregnant women

The proposed framework introduces a smart health monitoring system utilizing IoT and fog-assisted technologies to track the health of pregnant women over a nine-month period. The system integrates various sensors to capture critical health data, including temperature, blood pressure, ECG(Electrocardiogram), and pulse oximeter readings, as well as environmental factors like temperature, humidity, and air quality. These sensors are connected to a customized wrist node, which uses an ATmega 2560 microcontroller to process data from the wrist sensors, while an ATmega 328P microcontroller manages and processes data from the sensors embedded in the foot node. The foot node includes an accelerometer, pedometer, and gyroscope to monitor physical activity and stability, with data transmitted wirelessly using an nRF(Nordic Radio Frequency) module.

Captured data is timestamped and encrypted using quantum hash functions to ensure secure transmission to the fog node. At the fog node, the data undergoes initial processing, and user authentication is performed using iris and face recognition systems. The fog node analyzes the data using a Bayesian Belief Network (BBN) model. Once processed, the data is sent to the cloud for storage. Health recommendations, such as reminders to drink water or take medication, are delivered from the cloud server to the pregnant woman's mobile app dashboard. In cases where critical health conditions are detected, immediate alerts are sent to medical professionals and the patient's app via GSM (Global System for Mobile Communications), ensuring timely medical intervention. The cloud layer manages data storage and provides remote access for doctors and attendants, delivering a comprehensive health monitoring solution that combines real-time data collection with secure and efficient processing, enhancing health management for pregnant women.

# 2.2.10 SAARTHI: Real-Time Monitoring of Patients by Wearable Device

This paper proposes a system that integrates an IoT-based wristband device to monitor and capture real-time data, including acceleration, atmospheric temperature, humidity, heartbeat, and the individual’s location. Clinical data such as blood sugar levels, cholesterol levels, and chest pain type are provided by healthcare facilities. Both the real-time data from the wristband and the clinical data from the hospital are transmitted to the cloud.

A machine learning model analyzes this data to predict the potential presence or absence of heart disease. The predictions are reviewed and verified by a medical expert before being made accessible through a web and mobile application, where patients and their family members can view the results.

Additionally, the system includes an alert manager that continuously compares incoming data with pre-configured critical thresholds stored in the wristband device. If any critical condition is detected, the system sends an alert via SMS to a healthcare provider or a family member, ensuring timely intervention.

## 2.2 Summary of existing solutions

Table 2. 1 Literature review

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Authors** | **Problems** | **Technique(s)**  **Used** | **Performance** | **Limitations** |
| Jacod B.  C et al  [12] | A validation of electrogastrography for uterine activity monitoring during labor | Electrohystero graphy | Sensitivity  94.5% | Because pregnant women must be hospitalized to be observed, the study is not financially viable because it requires hospital equipment, medical personnel, and staff for monitoring. |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  | hypertensive, diabetic, and highrisk pregnant women according to the specialized literature. |  |
| H.  Allahem  et al [15] | Framework to monitor pregnant women with a high risk of premature labor using sensor networks | Data Fusion (Smartphone and Sensor) | The system uses  CPU Power of 40% and Memory of 26.64Mb meaning the application consumes battery charge efficiently | Other pregnant womene might have different thresholds set by the authors which may lead to wrong predictions |
| Lili Chen et al [16] | Deep Neural  Network for Semi-  Automatic  Classification of Term and Preterm  Uterine Recordings | Deep Neural  Network | Accuracy  94.3% | The performance of DNN was not compared with other existing methods which could provide more insight into the strengths and weaknesses of the proposed approach |
| Xiaoxiao  Song et al  [17] | Automatic  Recognition of  Uterine  Contractions with  Electrohysterogram | Zero-Crossing  Rate | Accuracy = 97.3%  Sensitivity = 97.8%  Specificity = 96.8% | Data quality  Limited validation  Limited features extracted |

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|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Signals Based on the Zero-Crossing  Rate |  |  |  |
| Manoara Begum et  al [18] | Preterm Baby Birth  Prediction Using  Machine Learning  Techniques | K-Nearest  Neighbour  Logistic  Regression  Decision Tree  Naïve Bayes | Decision Tree outperformed the other algorithms with the following results    Accuracy = 99%  Recall = 99%  Precision = 99%  AUC-ROC = 99% | Small (3500 samples) and imbalanced datasets  (63.8% not premature and  36.2% premature) |
|  |  |  |  |  |

## 2.3 Proposed solution

Our project involves the integration of a wearable device, a trained machine learning model, and a mobile application to provide continuous monitoring and proactive health management for pregnant women. The wearable device is designed to capture a range of critical physiological data, including body temperature, blood pressure, blood glucose levels, oxygen saturation, and heart rate. This data is continuously collected and transmitted to a fog node, where it undergoes preliminary processing. At this stage, a machine learning model, specifically designed for pregnancy-related health risks, analyzes the data to predict potential complications such as preeclampsia or gestational diabetes. TinyML, a lightweight version of machine learning, is applied to the fog node for efficient, real-time predictions without the need for extensive computational resources.

Once the data is processed and predictions are made, it is sent to the cloud for secure storage. This stored data can be accessed at any time by authorized users through a smart device after successful authentication. The cloud-based storage ensures that healthcare providers can monitor the patient’s health remotely and intervene when necessary, while also providing a centralized data repository for long-term analysis and trend monitoring.

In addition to the real-time data collection and processing, the system is programmed to send personalized health recommendations to the pregnant woman from the cloud. These recommendations are based on the analysis of her health data and aim to improve her overall well-being. For example, the system might suggest dietary adjustments, hydration tips, or physical activity guidelines tailored to her specific needs.

In the event of an emergency or if the system predicts a significant health issue, an immediate alert is sent directly to the mobile app of the pregnant woman. This alert, delivered via GSM (Global System for Mobile Communications), notifies the woman of the potential risks and advises her to visit the antenatal clinic for a more thorough examination. The use of GSM allows the system to send reliable, real-time alerts, even in areas with limited internet connectivity, ensuring that the pregnant woman can receive timely intervention when needed.

Overall, this system aims to enhance maternal healthcare by offering continuous monitoring, early detection of pregnancy complications, and timely interventions. The combination of wearable technology, machine learning, and mobile connectivity empowers pregnant women to take control of their health and receive personalized, data-driven care throughout their pregnancy.

## 2.4 Scope Of Project

The scope of this project involves developing an integrated system that combines wearable technology, cloud-based processing, and machine learning to enhance maternal health outcomes. The system focuses on early detection, continuous monitoring, and proactive intervention to reduce the risk of pregnancy complications. By enabling continuous data collection, offering personalized recommendations, and providing timely alerts, the system aims to improve the quality of care for pregnant women. Below is a comprehensive explanation of the project's components and objectives.

* **Wearable Device and Data Collection**  
  The project includes the development of a wrist-worn wearable device that captures real-time physiological data from the pregnant woman. Key vitals such as body temperature, blood pressure, heart rate, blood glucose levels, and oxygen saturation are continuously recorded by the device. Additionally, supplementary data, such as the presence of protein in urine (a potential indicator of preeclampsia), will be manually inputted by the pregnant woman into a mobile app.
* **Machine Learning for Early Prediction at the Fog Node**  
  The preprocessed data is fed into a machine learning model at the fog node, which has been specifically trained to predict pregnancy complications ahead of the typical detection window. The model analyzes the data in real-time, detecting anomalies in vital signs such as blood pressure and blood glucose levels that may indicate conditions like preeclampsia, gestational diabetes, or other complications. By performing this analysis locally at the fog node, the system can generate immediate predictions and alerts, which are then sent to the cloud for storage and further analysis. Alerts are provided to both the pregnant woman and her healthcare provider, ensuring timely intervention if any anomalies are detected.
* **Data Transmission and Cloud Integration**  
  The captured data from the wearable device, along with the manually inputted information, is sent to the cloud for centralized processing and storage. This enables seamless data access, long-term monitoring, and integration with machine learning models for predictive analysis. The cloud infrastructure ensures scalability and secure storage of sensitive health data, providing the backbone for real-time processing and future data-driven health insights.
* **Mobile App for Visualization and Alerts**  
  A mobile app is developed to serve as the interface for both the pregnant woman and her doctor. The app provides a personalized dashboard where the pregnant woman can view her recorded vitals, receive recommendations, and track her health trends over time. The doctor’s dashboard allows healthcare providers to monitor multiple patients, review real-time data, and receive alerts in the event of an anomaly, facilitating quick decision-making and proactive care.
* **Alerts and Notifications**  
  In the event of a detected anomaly, the pregnant woman receives and alert to visit the antenatal care as soon as possible and her doctor receive immediate alerts of predictions made via the mobile app.. The use of a reliable alert system is crucial for ensuring that health risks are addressed before they escalate into more serious complications.

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