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A Portable Device for Monitoring Fetal Movement Count

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***Abstract*: This prospective study aimed to develop and evaluate a portable fetal movement monitoring device for expecting mothers. The device incorporated movement sensors, wireless connectivity, and user-friendly features to enable convenient monitoring of fetal activity. The results demonstrated the effectiveness and feasibility of the device in providing accurate and real-time monitoring of fetal movements. Participants reported high satisfaction with the device's portability, comfort, and usability. Furthermore, the device facilitated communication between expecting mothers and healthcare providers, allowing for timely intervention in case of any abnormalities.**

***Keywords:* Wireless connectivity, remote monitoring, Sensor technology**

INTRODUCTION

This paper introduces a pioneering fetal movement monitoring system leveraging IoT technology, aimed at revolutionizing prenatal care practices. Integrating an MPU6050 inertial measurement unit (IMU), NodeMCU development board, and force sensor, the system offers a wireless, compact solution for real-time monitoring and analysis of fetal movements.

By harnessing the precision and sensitivity of the MPU6050 IMU alongside the force sensor's ability to detect nuanced pressure changes linked to fetal activity, the system ensures accurate and reliable fetal movement quantification. A robust data processing algorithm effectively distinguishes fetal movements from background noise and maternal activities, facilitating dependable movement counting.

The system's user-friendly interface supports real-time monitoring, empowering users with continuous tracking of fetal movement trends. Furthermore, the system enables data logging and analysis, facilitating longitudinal tracking and retrospective analysis of fetal movement patterns. Clinical validation studies validate the system's efficacy in detecting abnormal fetal movement patterns, underscoring its role in proactive prenatal care management. This innovative system promises to enhance maternal-fetal health outcomes by providing personalized monitoring solutions, exemplifying a significant advancement in fetal monitoring technology.

a) Motivation

The development of a fetal movement monitoring IoT device is motivated by the pressing need to enhance prenatal care practices, improve accessibility to healthcare services, and empower expectant mothers with personalized monitoring solutions. By leveraging IoT technology, advanced sensor capabilities, and data analytics, such devices have the potential to revolutionize prenatal care delivery, ultimately contributing to healthier pregnancies and better outcomes for both mothers and babies.

b) Fetal Movement Counter (FMC)

Incorporating a fetal movement counter into your fetal movement monitoring IoT device holds significant potential for enhancing prenatal care practices and empowering expectant mothers with valuable insights into fetal health and development. This feature allows for the quantification and tracking of fetal movements, providing both healthcare providers and expectant mothers with objective data to monitor fetal activity patterns and identify deviations from normal behaviour.

To implement a fetal movement counter, it is crucial to ensure that the sensors integrated into the IoT device are capable of accurately detecting and measuring fetal movements. The MPU6050, equipped with accelerometer capabilities, can detect changes in acceleration associated with fetal movements, while a strategically placed force sensor can detect pressure changes caused by fetal kicks or movements against the uterine wall.

Real-time monitoring capabilities should be enabled through the IoT device's user interface, such as a mobile app or web dashboard, providing users with visual feedback to track fetal movement trends over time. Customizable alerts for abnormal movement patterns or reminders for regular monitoring sessions can enhance user engagement and facilitate proactive prenatal care management.

In addition to real-time monitoring, implementing functionality to log fetal movement counts along with time stamped data enables long-term tracking and analysis. Historical data can be securely stored locally or in the cloud, allowing for retrospective analysis and trend identification. Data analytics techniques can then be applied to extract insights from the collected data, such as correlations between fetal movement patterns and pregnancy outcomes.

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LITRATURE SURVEY

The literature survey highlights recent advancements and research trends in IoT-based fetal movement monitoring systems. It underscores the importance of continuous monitoring for prenatal care and the transformative potential of IoT technology in improving maternal and fetal health outcomes. Future research should focus on refining algorithms, enhancing device accessibility, and conducting clinical validation studies to further establish the efficacy of these IoT-enabled solutions in prenatal care.

1. Thongprasert A. & Pungpapong V. (2020). A New Fetal Movement Monitoring System for Pregnant Women Using Arduino and Machine Learning. This research introduces a novel system combining Arduino microcontrollers and machine learning algorithms for fetal movement monitoring. The study highlights the potential of low-cost hardware solutions for accurate detection and classification of fetal movements.

2. Larson, J.L., & Rosen, H. (2019). Fetal Movement Monitoring: A New Approach Using Wearable Technology. This research explores wearable technology for fetal movement monitoring, discussing challenges of traditional methods and potential advantages of IoT-enabled devices.

a) Existing System

The existing system for fetal movement monitoring primarily relies on subjective maternal assessments or cumbersome medical equipment, which may not always provide reliable or convenient measurements. Traditional methods often involve manual counting of fetal movements based on maternal perception, which can be influenced by factors such as maternal fatigue, distraction, or fetal sleep cycles. Alternatively, healthcare providers may utilize specialized equipment such as cardiotocography (CTG) or ultrasound for fetal monitoring during clinical visits. While these methods offer objective measurements, they are typically confined to clinical settings and may not provide continuous monitoring capabilities. Additionally, they may be associated with increased costs, logistical challenges, and limited accessibility, particularly in remote or resource-limited settings.

b) Proposed System

This paper introduces an innovative fetal movement monitoring system powered by IoT technology, designed to modernize prenatal care. Combining an MPU6050 IMU, NodeMCU board, and force sensor, the system offers a compact, wireless solution for real-time fetal movement tracking. Leveraging the precision of the MPU6050 IMU and the sensitivity of the force sensor, it ensures accurate movement quantification.

• No need of visiting the hospital for scans every time. This prevents the pregnant women from getting tired as it is more convenient. Cost effective too.

ANALYSIS

a) Software requirement analysis:

- Arduino IDE
- MPU6050 Library
- Wi-Fi Library
- Data Processing and Analysis Algorithms

b) Hardware requirement Analysis:

- NodeMCU Development Board
- MPU6050 Inertial Measurement Unit (IMU)
- Force Sensor
- Power Supply
- Breadboard and Jumper Wires
- Laptop/Desktop

c) Architecture Diagram:

The fetal movement monitoring IoT device architecture comprises the NodeMCU development board as the central processing unit, interfacing with sensors including the MPU6050 Inertial Measurement Unit (IMU) and force sensor. The NodeMCU processes sensor data through embedded firmware code, employing algorithms to detect and count fetal movements while filtering background noise. With built-in Wi-Fi connectivity, the NodeMCU enables real-time transmission of data to remote servers or user interfaces for monitoring and analysis. Optionally, a user interface component allows users to visualize fetal movement trends and receive alerts for abnormal patterns. Server-side software may be deployed for data storage and analysis. This architecture facilitates seamless data flow between hardware and software components, enabling accurate fetal movement monitoring and analysis.

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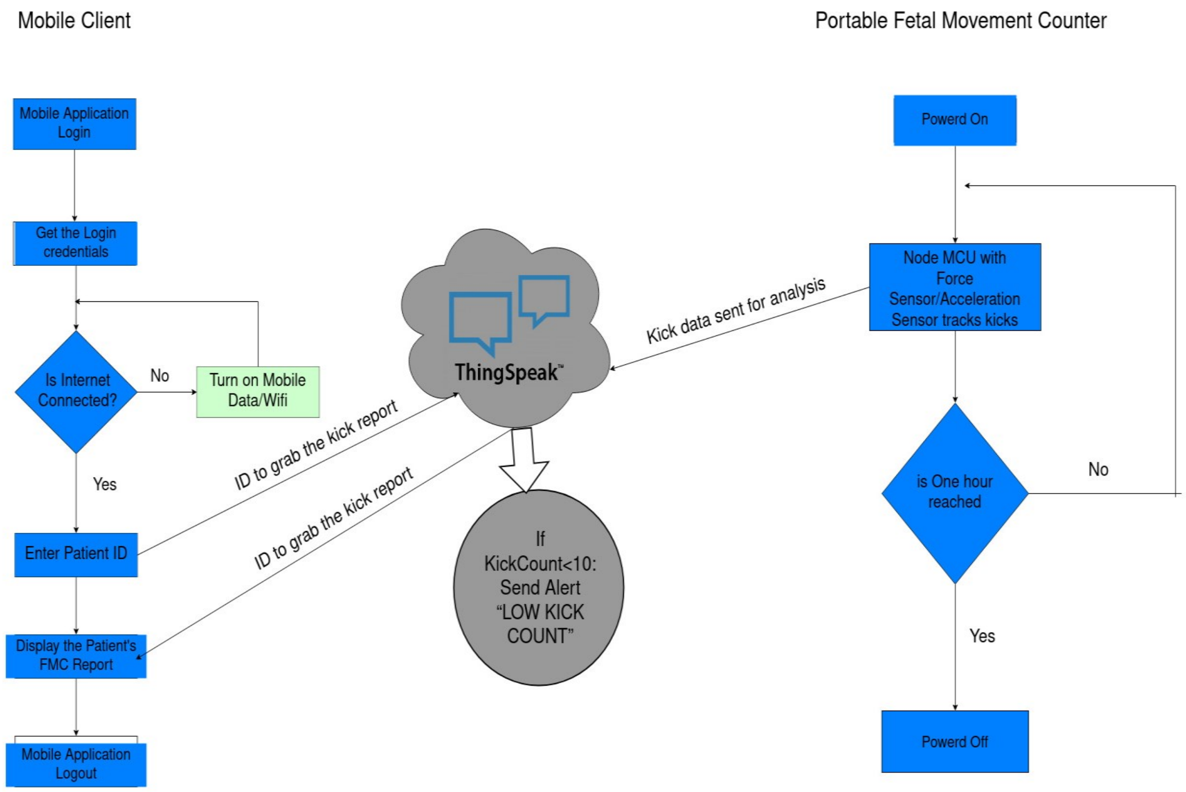

The architecture of the proposed project

DESIGN

a) Hardware Configuration:
Establish connections between the NodeMCU development board, MPU6050 IMU, force sensor, and power source. Design an enclosure to house the components securely while allowing access for maintenance and monitoring.

b) Software Development:
Develop firmware code for the NodeMCU to handle sensor data acquisition, processing, and communication. Implement algorithms for filtering noise, detecting fetal movements, and transmitting data over Wi-Fi. Consider user interface development for monitoring and configuring the device.

c) Integration and Testing:
Assemble the hardware components according to the design specifications and upload the firmware code to the NodeMCU. Conduct comprehensive testing to ensure proper functionality, accuracy of sensor readings, and reliability of communication protocols.

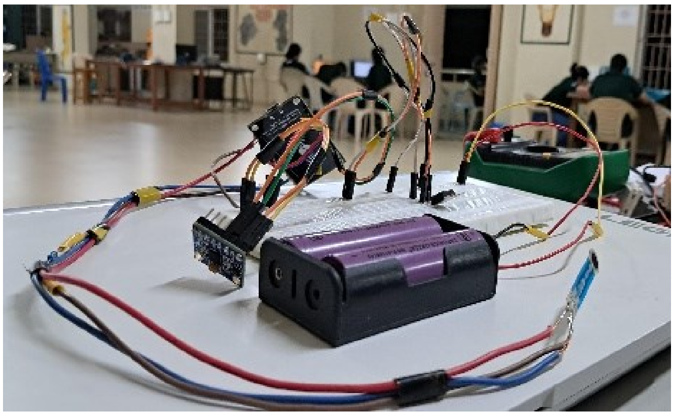

Image of the Functioning Model

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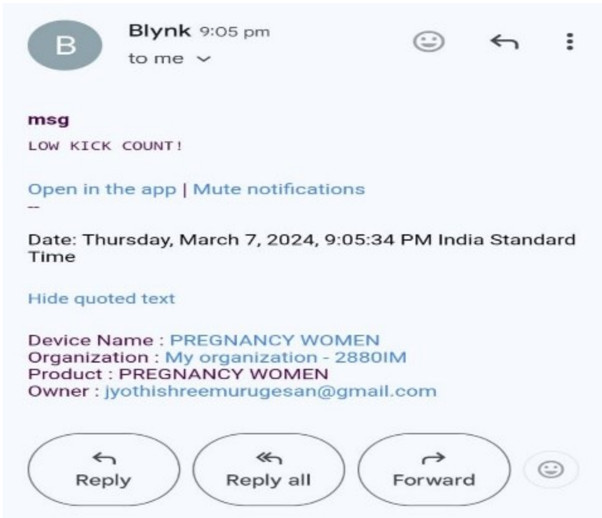
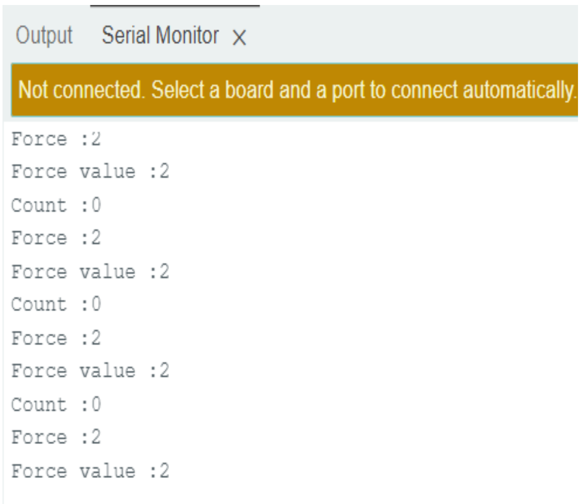
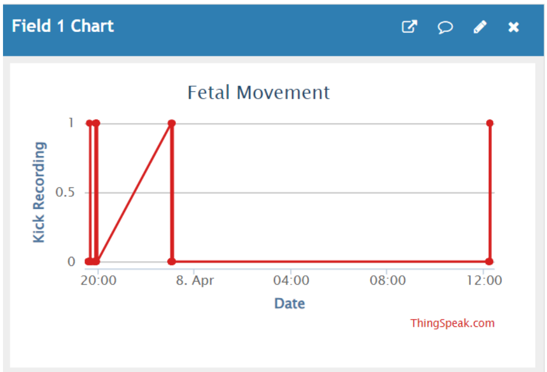
The notification received on the Blynk Application upon low kick count

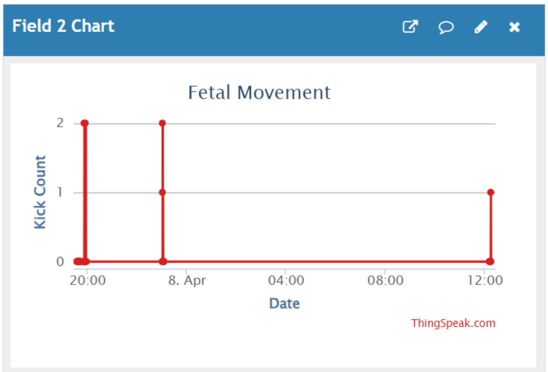


Mail sent through the Blynk application to the concerned parties



Output received on the terminal after compiling the code on Arduino IDE





This graph is typically used to analyse trends, patterns, or changes over time based on the data sent from IoT devices or other sources. The x-axis of the graph usually represents time, showing when data points were recorded, while the y-axis represents the values of the data being measured (kick recording and the kick count). The graph may display real-time updates as new data is added to the channel, allowing users to monitor and interpret the information conveniently. ThingSpeak's graphing capabilities are valuable for understanding and making decisions based on the data received from connected devices or systems.

CONCLUSION

In conclusion, the literature survey highlights the growing interest and advancements in IoT-based fetal movement monitoring systems for improving prenatal care. Studies have demonstrated the feasibility and effectiveness of using IoT technologies, such as accelerometer sensors, Arduino platforms, and machine learning algorithms, to develop accurate and accessible devices for monitoring fetal movements. These IoT-enabled systems offer continuous monitoring capabilities, which are crucial for early detection of fetal distress and abnormalities, ultimately leading to improved maternal and fetal health outcomes.

The reviewed literature also emphasizes the potential of IoT in enhancing remote health monitoring at home, enabling expectant mothers to actively participate in their prenatal care and providing healthcare professionals with valuable data for timely interventions. Challenges such as algorithm refinement, device accessibility, and clinical validation remain areas of ongoing research and development.

Moving forward, further research is needed to optimize IoT-based fetal monitoring systems, refine algorithms for accurate movement detection and classification, and conduct comprehensive clinical trials to validate the efficacy and safety of these devices. Collaboration between researchers, healthcare providers, and technology developers is essential to realize the full potential of IoT in revolutionizing prenatal care and improving pregnancy outcomes. By addressing these challenges and leveraging emerging technologies, IoT-based fetal monitoring systems have the potential to become integral tools in modern prenatal care practices.

FUTURE WORKS

Future work in IoT-based fetal monitoring systems includes optimizing algorithms for improved fetal movement detection and classification using advanced signal processing and machine learning techniques. Additionally, integrating additional sensors like heart rate monitors or uterine contraction sensors can provide a more comprehensive assessment of fetal and maternal health. Continuous user feedback will inform iterative design improvements, and integrating remote monitoring platforms with cloud-based analytics can enable real-time data sharing and proactive intervention. Efforts to design cost-effective and scalable solutions will enhance global accessibility, particularly in underserved communities

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