



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 6, June 2025

Smart Contraction Belt with Safety Airbags

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ABSTRACT: The Smart Contraction Belt with Safety Airbags is an advanced telehealth solution designed to improve maternal and fetal safety during labor. This wearable device combines real-time contraction monitoring, fall detection, fetal heart rate tracking, and emergency alerts to provide continuous healthcare support for expectant mothers. A flex sensor integrated into the belt detects uterine contractions and differentiates between true and false labor based on specific thresholds. False labor contractions have values below 30 mmHg, are irregular, and do not intensify over time, whereas true labor contractions exceed 40 mmHg, occur at consistent intervals, and gradually increase in intensity.

An MPU6050 accelerometer monitors the mother's movements and activates the safety airbags in the event of a potential fall, reducing the risk of injury. Additionally, a fetal heart rate sensor continuously tracks fetal well-being, ensuring that any abnormalities are detected early and allowing for timely medical intervention. The system is controlled by an Arduino Nano microcontroller, which processes data from all sensors and ensures smooth operation. A WiFi module facilitates real-time communication, sending alerts to family members.

The system also includes data storage capabilities, allowing healthcare providers to access real-time maternal-fetal health information remotely. Powered by a rechargeable battery pack, the belt ensures uninterrupted operation. The Smart Contraction Belt supports SDG 3 by ensuring maternal and fetal safety, SDG 9 through IoT-based telehealth integration, and SDG 10 by making advanced maternal care affordable and accessible.

KEYWORDS: Smart Contraction Belt, Uterine Contractions, Fall Detection, Fetal heart rate monitoring, Telehealth Solution.

I. INTRODUCTION

Maternal and fetal health monitoring is essential to ensure a safe pregnancy and childbirth. Traditional methods often depend on hospital visits and self-reported symptoms, which may result in delays in medical care. The Smart Contraction Belt with Safety Airbags is a wearable device designed to improve maternal safety by offering real-time contraction monitoring, fall detection, fetal heart rate tracking, and emergency alerts. A flex sensor measures uterine contractions and differentiates between true and false labor based on intensity. False labor contractions are irregular, with pressure values below 30 mmHg, whereas true labor contractions exceed 40 mmHg and become stronger over time. An MPU6050 accelerometer detects sudden movements and activates safety airbags to prevent injuries, particularly in high-risk pregnancies. Additionally, a fetal heart rate sensor continuously monitors the baby's well-being and sends alerts if abnormalities are detected. An Arduino Nano microcontroller processes sensor data, while a WiFi module ensures real-time communication with caregivers and healthcare professionals. LED indicators and a buzzer provide immediate alerts for user awareness. Powered by a rechargeable battery, the system ensures uninterrupted operation. By integrating advanced monitoring features, this smart belt enhances maternal safety, reduces unnecessary hospital visits, and enables timely medical intervention.

II. RELATED WORK

J. L. Fernandez et al. (2019) introduced a real-time maternal health monitoring system using IoT sensors for tracking pregnancy conditions. This system integrates various sensors, such as accelerometers, pulse oximeters, and temperature sensors, to gather comprehensive maternal health data. The IoT platform enables efficient communication between the monitoring device and healthcare providers, reducing emergency response times. AI-driven analytics can predict pregnancy complications like fetal distress or preterm labor. The study emphasizes the importance of real-time data visualization for healthcare professionals, with future research focusing on multi-sensor fusion for more accurate

diagnostics.

Toshiyo Tamura et al. (2012) developed a wearable airbag system for fall injury prevention. This system incorporates acceleration and angular velocity sensors to detect sudden movements, triggering airbag deployment upon detecting a fall. The study highlights the system's effectiveness in reducing impact forces, particularly for pregnant women and the elderly. The wearable design ensures user comfort and practicality. Experimental results demonstrate the system's ability to minimize injuries such as hip fractures and head trauma.

Kalyani A. et al. (2021) designed a mobile airbag system featuring an integrated alert mechanism that notifies emergency responders upon impact detection. The study underscores the importance of immediate emergency response, with the airbag inflation occurring within milliseconds to mitigate injury severity. The system also includes GPS tracking, enabling rapid location identification and assistance. Future improvements could involve AI-based predictive modeling to assess an individual's fall risk, allowing for preventive interventions and proactive care.

III. METHODOLOGY

Pregnancy is a crucial period that demands continuous health monitoring and care to ensure the safety and well-being of both the mother and the unborn child. Traditional maternal healthcare systems often rely on periodic hospital visits, which may not be feasible for all expectant mothers, particularly those in remote areas. The Smart Contraction Belt with Safety Airbags is an innovative solution designed to provide continuous monitoring, emergency response, and real-time data transmission to enhance maternal and fetal safety.

This system integrates advanced sensor technology, microcontrollers, wireless communication, and artificial intelligence to monitor vital maternal and fetal health parameters. The belt features a flex sensor to detect uterine contractions, an MPU6050 accelerometer for fall detection, a MAX30100 sensor for fetal heart rate monitoring, and an Arduino Nano microcontroller for processing and decision-making. Furthermore, a WiFi module ensures real-time data transmission to family members and healthcare professionals.

1) Contraction Monitoring and Labor Differentiation

One of the primary functions of the Smart Contraction Belt is to monitor uterine contractions and distinguish between true and false labor. Many expectant mothers visit hospitals unnecessarily due to false labor, which can be distressing and inconvenient. The belt integrates a flex sensor that measures contraction intensity and frequency. False contractions occur irregularly, have lower intensity, and do not escalate over time. In contrast, true contractions occur consistently, increase in frequency, and exceed 40 mmHg in intensity. By distinguishing between these two types, the device minimizes unnecessary hospital visits while ensuring that medical attention is sought when needed. If true labor contractions are detected, an automated alert is sent to the family and healthcare provider, ensuring timely medical intervention.

2) Fall Detection and Emergency Response System

Falls during pregnancy can be life-threatening for both the mother and the fetus. The MPU6050 accelerometer and gyroscope are incorporated into the belt to detect sudden movements, loss of balance, or a potential fall. If a fall is detected, the system triggers an automatic response, inflating safety airbags within milliseconds to cushion the impact. A buzzer alarm is simultaneously activated to alert nearby individuals, ensuring immediate assistance. At the same time, an emergency alert is sent via the WiFi module to preconfigured contacts, allowing for a swift response and medical intervention. This feature is particularly beneficial for women with high-risk pregnancies, mobility difficulties, or those who live alone, significantly reducing the risks associated with falls.

3) Fetal Heart Rate Monitoring and Alerts

Fetal heart rate is a critical parameter that helps detect early signs of fetal distress. The Smart Contraction Belt integrates the MAX30100 sensor, a pulse oximetry and heart rate monitoring module, to continuously track fetal heart rate. If the fetal heart rate deviates from the normal range of 120 to 160 beats per minute, the system immediately triggers an alert. Real-time data is transmitted to the cloud, allowing doctors to monitor the fetus remotely and recommend necessary interventions. The system ensures early detection of fetal abnormalities, preventing complications such as fetal hypoxia and distress, and enhancing overall maternal and fetal safety.

4) Microcontroller and Data Processing System

The Arduino Nano serves as the core processing unit of the system, integrating multiple sensor inputs and making real-time decisions. It collects data from the flex sensor, MPU6050, and MAX30100, processes contraction patterns and fall detection signals, and determines whether airbag inflation, buzzer alerts, or emergency messages need to be activated. Additionally, it communicates with the WiFi module to transmit data to cloud storage, enabling real-time monitoring. The system operates autonomously, reducing the need for constant manual intervention, making it user-friendly for expectant mothers who may not have technical expertise.

Wireless Communication and Real-Time Monitoring

The integration of a WiFi module enables seamless data transmission, allowing family members and healthcare professionals to access maternal health information in real time. Remote monitoring allows doctors to track fetal and maternal health data from a hospital or clinic, ensuring they can intervene promptly if necessary. Emergency notifications are sent immediately if contractions indicate true labor, fetal distress occurs, or a fall is detected, ensuring swift action. Additionally, cloud-based data storage allows for the logging of historical health data, aiding in long-term pregnancy analysis and predictive healthcare, improving maternal safety and reducing unforeseen complications.

5) User Convenience and Design Considerations

The Smart Contraction Belt is designed with comfort, portability, and ease of use in mind. It is lightweight and adjustable, made from soft, breathable fabric to ensure prolonged wearability without discomfort. Real-time data on contraction intensity, fetal heart rate, and system status is displayed through LED indicators and an LCD display, making it easy for the user to understand the information. The inclusion of a buzzer ensures that any critical conditions are immediately brought to the user's attention. To ensure continuous operation, particularly in areas where access to healthcare is limited, the device is powered by a rechargeable battery, making it reliable for extended use.

IV. EXPERIMENTAL RESULTS



(A)



(B)

V. CONCLUSION

The Smart Contraction Belt with Safety Airbags is a technologically advanced solution designed to improve maternal and fetal safety by monitoring labor contractions, detecting falls, and tracking fetal heart rate in real time. It effectively differentiates between true and false labor, minimizing unnecessary hospital visits while ensuring timely medical intervention. The built-in airbag system provides protection against falls, particularly benefiting high-risk pregnancies. With WiFi-enabled communication, alerts are instantly sent to caregivers and doctors, enabling prompt responses in emergencies. This innovative approach enhances access to maternal healthcare, especially in remote areas, contributing to safer pregnancies and reducing maternal and infant health risks.

VI. FUTURE SCOPE

As technology advances, the Smart Contraction Belt has the potential for further enhancements. AI-driven predictive analysis could be integrated to predict labor onset based on contraction patterns, allowing expectant mothers and doctors to prepare in advance. The addition of a mobile application would improve usability by enabling mothers to monitor their health metrics, receive doctor consultations, and track pregnancy trends conveniently. With advancements in 5G connectivity, data transmission speed and reliability would significantly improve, ensuring real-time access to critical maternal health information. Further battery efficiency enhancements could be implemented to develop a low-power, long-duration battery system, ensuring longer operational hours without the need for frequent recharging. These future advancements will further solidify the belt's role as a comprehensive maternal healthcare solution, improving the safety and well-being of expectant mothers worldwide.

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