International Journal of Medical Toxicology & Legal Medicine **Volume 28, No. 2s1, 2025**
e-ISSN: 0974-4614
p-ISSN: 0972-0448
https://doi.org/10.47059/ijmtlm/V28I2s1/010

Foetal Position Monitoring and VR Workouts

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Received: 19.11.2024 Revised: 23.12.2024 Accepted: 15.01.2025

ABSTRACT
A serious condition during pregnancy, fetal malposition can lead to issues such as delayed labor, increased discomfort for the mother, and a higher rate of Caesarean section. This study presents a novel, integrated method for tracking fetal position in real time that combines gyroscopes and accelerometers with inertial measurement units (IMUs). Advanced algorithms are used by the system to process continuous movement data, identify fetal postures that are not optimal, and instantly notify pregnant women and medical professionals. Furthermore, a workout program based on virtual reality (VR) is incorporated to facilitate fetal relocation through supervised physical activities. In order to reduce the risks of malposition and improve maternal health outcomes and the possibility of a natural, straightforward birth, the technology combines interactive VR-augmented exercises with real-time fetal position surveillance.

Keywords: Foetal position, Inertial Measurement Unit (IMU),Sensor Fusion,Maternal Health,Wearable Health Monitoring

I. INTRODUCTION

The intricacy of labour and the outcome of the delivery process are significantly influenced by the foetal position. Breech, transverse, or posterior presentations are examples of abnormal foetal positioning that can cause a variety of complications, including prolonged labour, increased discomfort for the mother, and a higher likelihood of the need for medical interventions.[3] These interventions could include more invasive procedures like Caesarean sections or even assisted vaginal deliveries. Understanding the position of the foetus can be aided by the diagnostic information provided by older monitoring techniques like ultrasound imaging.[7] However, the limitations of these methods stem from their inability to provide continuous, real-time monitoring of the fetus's condition; they can only provide periodic measurements.. In order to improve outcomes for both mothers and babies, this lack of prenatal care highlights the urgent need for a novel solution that includes both ongoing monitoring and appropriate corrective interventions.

This study introduces a novel and extremely advanced foetal monitoring system that uses Inertial Measurement Unit (IMU) sensors that are positioned thoughtfully throughout the mother's abdomen[11]. These advanced sensors are in charge of continuously measuring and logging information about the movement and orientation of the foetus. This information is then processed using complex and cutting-edge signal processing algorithms.[4]

The primary goal of this system is to detect any instances of fetal malposition in real time, thereby enabling timely early intervention by means of automated alerts that notify healthcare providers as well as guided maternal exercises that empower pregnant women. Additionally, the system has a Virtual Reality (VR) module that is used to actively involve expectant mothers in interactive, scientifically supported exercise regimens designed to support the best possible foetal positioning. In order to ensure that the suggested corrective actions are both individualised and successful in causing foetal rotation into a position that is favourable for delivery, the VR exercises are dynamically modulated in real-time based on the real-time stream of foetal positioning data [4]. The suggested novel system successfully closes the gap between the domains of passive monitoring and active foetal repositioning techniques by combining real-time foetal position monitoring with virtual reality-directed interventions.[3].

This integration is a priceless addition to the field of contemporary obstetric care since it not only increases labour efficiency and improves maternal comfort, but it also has the potential to drastically reduce the frequency of various birthing complications.[4] With its active and evidence-based approach focused on the health and well-being of both mothers and their unborn children, the anticipated release of such a sophisticated system is likely to transform prenatal monitoring in the future.[5].

II. PROPOSED WORK

To enhance foetal positioning and lessen delivery complications, our system combines interactive virtual reality (VR) intervention with real-time foetal position monitoring using IMU sensors. There are four main parts to the methodology**.**

A. Sensor-Based Fetal Position Monitoring

The mother's abdomen is equipped with IMU sensors (MPU6050) to monitor the orientation and movement of the foetus. An STM32 microcontroller receives the collected data continuously for preprocessing before an AI-based classification model is used for analysis. This makes it possible to track foetal movements in real time and detect suboptimal positioning early.[11]

.B. AI-Based Position Classification and Alerts

Real-time foetal orientation detection is achieved through the processing of sensor data by an edge AI model. Unfavourablefoetal positions are identified by the classification algorithm, which was created using supervised learning and sensor fusion techniques.[9].The system notifies expectant mothers and healthcare professionals to take corrective action when it detects a position that is not optimal.[13]

C. VR-Guided Exercise Intervention

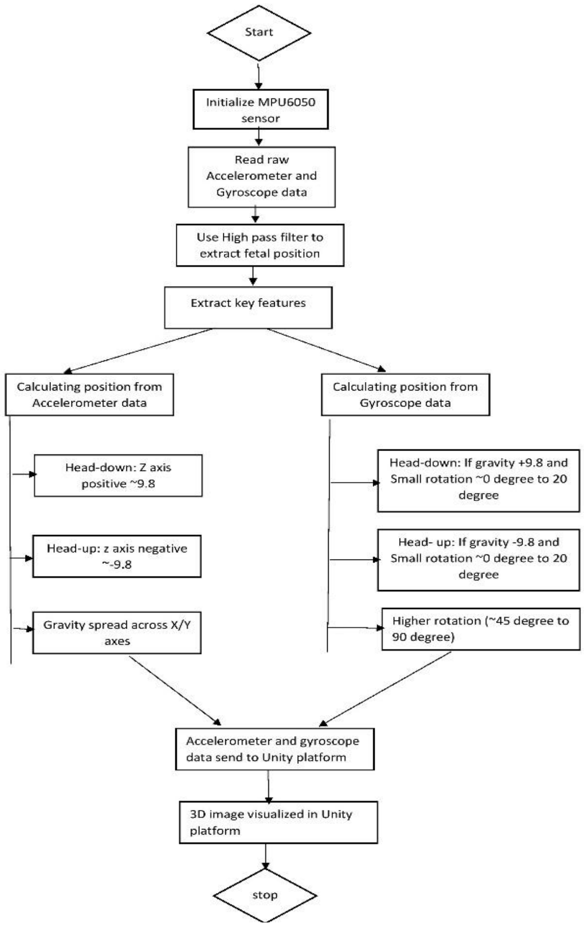
Pregnant women can participate in interactive biomechanics-based training to promote foetal rotation by using a virtual reality module that offers guided exercises based on the detected foetal position. The virtual reality exercises consist of:

• Pelvic tilts and rotations to improve the posture of the mother and encourage movement of the foetus.
• Lunges and squats to open up the pelvis for realignment.
• Yoga-style stretches to promote natural foetal rotation and improve pelvic alignment.
• Techniques for side-lying release to ease tense muscles and facilitate foetaldescent.[4]

D. System Workflow

1. **Data Acquisition**: Foetal movement data is recorded in real time by IMU sensors. [11]
2. **Data processing**: Stable orientation references are created from raw sensor measurements using the Direct Cosine Matrix (DCM). [9]
3**. Real-Time Analysis**: AI systems determine the position of the foetus and issue warnings if it is malposition.[13]
4. **VR-Based Intervention**: To maximisefoetal positioning, customised exercises are advised.
5**. Feedback Loop**: The system dynamically modifies exercise recommendations and updates foetal position data continuously. [13]

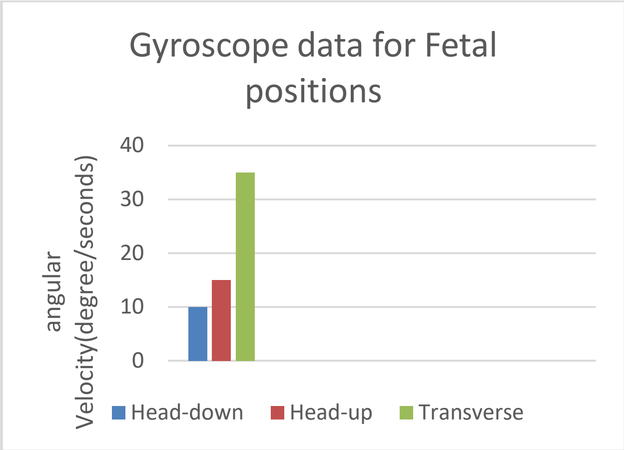
E. Flowchart



F. Table
Calculation table for Fetal position

Fetal Position	Accelerometer (m/s²)	Gyroscope (°/s)	Kick Intensity (m/s²)	Kick Frequency (Hz)	Interpretation
Head-Down (Cephalic)	X ≈ 0, Y ≈ 0, Z ≈ +9.8	Low (0-20)	High (>5)	Moderate (1-3 Hz)	Head down, kicks in upper abdomen
Head-Up (Breech)	X ≈ 0, Y ≈ 0, Z ≈ -9.8	Low (0-20)	High (>5)	Moderate (1-3 Hz)	Head up, kicks in lower abdomen
Transverse (Sideways)	X ≈ ±9.8, Y ≈ 0, Z ≈ 0	High (>30)	Medium (3-5)	High (>3 Hz)	Baby lying sideways, kicks felt on the sides
Head Rotation Detected	Variable	Moderate (>20)	Medium (3-5)	Moderate (1-3 Hz)	Fetal head is shifting position
Kicks Detected	No Change	Low (0-10)	Spike (>10 m/s²)	High (>5 Hz)	Strong fetal movement detected
Low Movement (Possible Concern)	No Change	No Change	Low (<3 m/s²)	Low (<1 Hz)	Reduced fetal activity

G.Graph



III.LITERATURE REVIEW

A thorough analysis of previous research highlights the enormous potential of combining virtual reality (VR) and inertial measurement units (IMUs) in healthcare applications, especially foetal position monitoring and assessment.

Palomino Roldan and Suaste Gomez (2017)investigated the use of gyroscopes and accelerometers to monitor human movement and demonstrated their efficacy in precisely capturing biomechanical movement. **Contreras-Rodríguez et al. (2018)** developed advanced sensor fusion algorithms that address fundamental problems in motion analysis and real-time tracking while increasing the accuracy of 3D orientation estimation. **YuukiShida (2020**) looked into robotic ultrasound technology for non-invasive foetal position estimation using skeletal distribution analysis.

Altini (2020) assessed wearable accelerometers' efficacy in identifying foetal movement, pointing to their capacity for continuous, non-invasive monitoring. In order to support the use of sophisticated sensing techniques for prenatal care,

Paul Hamelmann (2019) conducted extensive research on Doppler ultrasound technology for real-time foetal heart rate monitoring.

VI MATERIALS AND CONSTITUENTS

A. The System's Elements

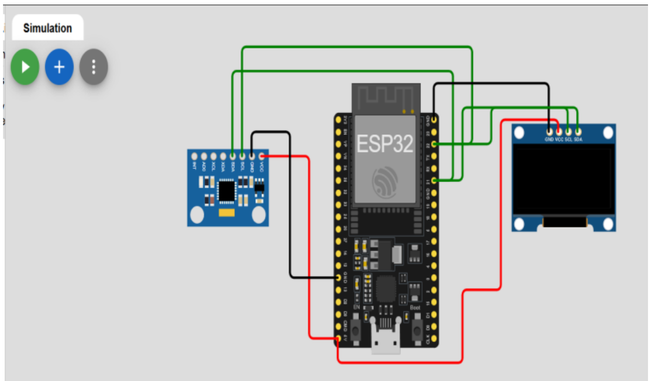
The suggested foetal positioning monitoring system includes the following crucial elements:

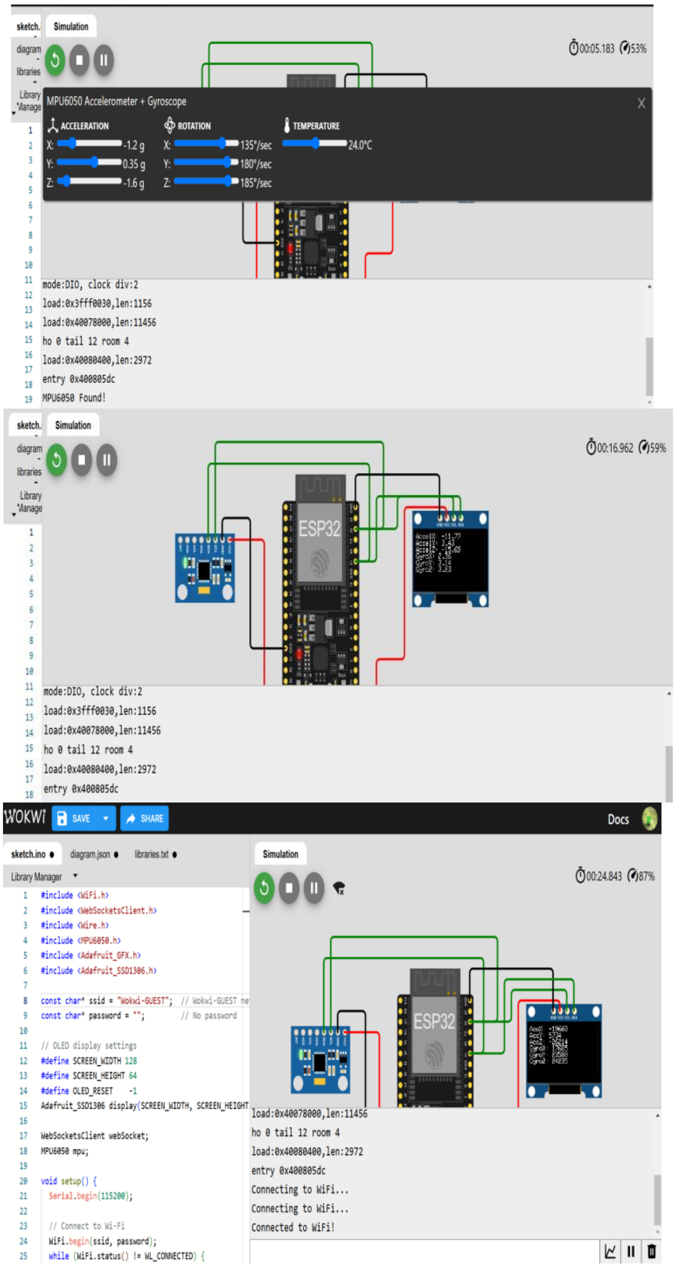
1) IMU Sensor (MPU6050): Contains an accelerometer and gyroscope for precise movement tracking.[11].
2) Microcontroller (STM32F): Offers real-time data processing and wireless communication.
3) Power Source: Battery pack or 5V USB power adapter for system operation.
4) Wires/Connectors: Jumper wires that enable safe connections between the microcontroller and sensors.
5) Visualisation Software: To model and support foetalpositioning exercises, a virtual reality environment platform (Meta Quest version of Unity) is used

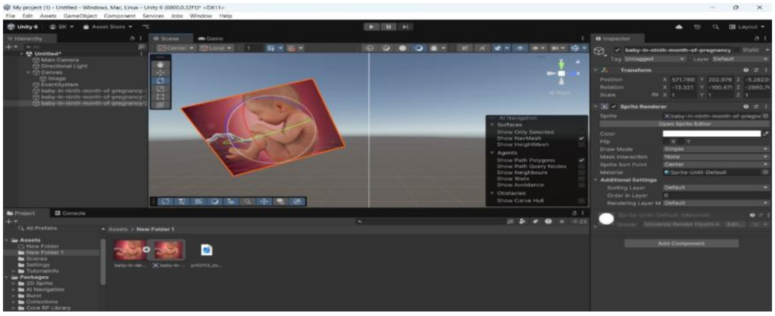
V. SIMULATION MODEL

The ESP32 microcontroller and Wokwi, an online microcontroller simulator, are used in the suggested system to simulate foetal position monitoring. Real-time foetal movement data is recorded by the ESP32's integrated MPU6050 accelerometer and gyroscope. [11]After processing, this data is sent to a visualisation platform built on Unity, where it is used to dynamically render changes in foetal position based on movement variations picked up by the sensor.

By offering a virtual environment for coding, debugging, and simulating hardware interactions prior to physical deployment, Wokwi's integration makes development and testing easier. The ESP32 ensures precise visualisation and analysis by sending real-time motion data to the Unity engine via WebSockets communication. This simulation model is essential for confirming the system's operation, improving sensor calibration, and raising the efficacy of VR-guided maternal care interventions.


Simulation
ESP32


sketch.
Simulation
diagram
libraries
Library Manage
00:05.183
53%
MPU6050 Accelerometer + Gyroscope
ACCELERATION
ROTATION
TEMPERATURE
X: -1.2 g
Y: 0.35 g
Z: -1.6 g
X: 135°/sec
Y: 180°/sec
Z: 185°/sec
24.0°C
mode:DIO, clock div:2
load:0x3fff0030,len:1156
load:0x40078000,len:11456
ho 0 tail 12 room 4
load:0x40080400,len:2972
entry 0x400805dc
MPU6050 Found!
00:16.962
59%
ESP32
WOKWI
SAVE
SHARE
Docs
sketch.ino
diagram.json
libraries.txt
Library Manager
#include <WiFi.h>
#include <WebSocketsClient.h>
#include <Wire.h>
#include <MPU6050.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>
const char* ssid = "Wokwi-GUEST";
const char* password = "";
// No password
// OLED display settings
#define SCREEN_WIDTH 128
#define SCREEN_HEIGHT 64
#define OLED_RESET -1
WebSocketsClient webSocket;
MPU6050 mpu;
void setup() {
Serial.begin(115200);
// Connect to Wi-Fi
WiFi.begin(ssid, password);
while (WiFi.status() != WL_CONNECTED) {
00:24.843
87%
Connecting to WiFi...
Connected to WiFi!



VI. RESULTS AND DISCUSSION

The suggested system effectively tracked the movements of the foetus in real time and gave pregnant women and medical professionals vital feedback. By encouraging adherence to suggested positioning techniques, the use of VR-based exercises greatly increased maternal engagement. High-precision foetal orientation classification was made possible by the integration of Edge AI, which also made it possible to identify malposition early and take prompt action to enhance delivery results. [9]

Foetal rotation into the ideal position was effectively promoted by the VR-guided exercises. Higher participation rates and greater user compliance were the results of the VR experience's immersive and interactive features, which may have decreased the need for medical interventions during labour and delivery.

VII. FUTURE SCOPE

In order to improve foetal movement analysis, future developments in this technology will concentrate on improved pregnancy monitoring by adding more physiological parameters.[12]. Integration of telemedicine will improve accessibility and continuity of prenatal care by enabling remote foetal position tracking, especially for high-risk pregnancies.

Additionally, machine learning models will be used by AI-driven predictive analytics to anticipate possible issues and suggest preventative measures.[8] Comprehensive maternal care will also be aided by the extension of VR applications beyond foetal positioning to include maternal wellness initiatives like postnatal recovery and maternal health education. By guaranteeing safer, more effective, and technologically advanced maternal health solutions, these developments will improve the efficacy of prenatal healthcare.[2]

VIII. CONCLUSION

By combining IMU sensors, Edge AI, and VR-guided exercise interventions, this study offers a revolutionary method of foetal position monitoring. Through interactive virtual reality exercises, the suggested system encourages optimal positioning and makes real-time foetal movement tracking easier.[10] Future developments will increase this technology's efficacy in prenatal healthcare even more, leading to safer and more effective maternal care solutions. Examples of these developments include predictive analytics and remote monitoring capabilities.[3]

IX. ACKNOWLEDGMENT

We would like to express our sincere appreciation to the faculty at Kumaraguru College of Technology's Department of Electronics and Instrumentation Engineering for their expert advice, insightful criticism, and unwavering support during this research project. Their advice and motivation have been invaluable in determining the course of this research.

The authors also want to sincerely thank their families for their unwavering support, encouragement, and patience, all of which have been crucial in propelling this research process.

REFERENCES

1. Simon AE, Uddin SFG. Trends in seeing an obstetrician-gynecologist compared with a general physician among U.S. women, 2000–2015. Obstet Gynecol. 2017:130(4):677–683.
2. Ishikawa T, Ohba H, Yokooka Y, et al. Forecasting the absolute and relative shortage of physicians in Japan using a system dynamics model approach. Hum Resour Health. 2013:11(41):1–10.
3. I Jeya Daisy, B. Vinoth Kumar, M. Krishnamoorthy. "Early-Stage Depression Detector Using IoMT", 2021 International Conference on Advancements in Electrical, Electronics, Communication, Computing and Automation (ICAECA), 2021.
4. Review On Foetal Position Detection Using Different Techniques,IJeya Daisy; G Diyaneshwaran; K Ravivarmaa; S Shobana; M Sneha; N S Monessha.

5. Unveiling the Current State and Future Directions,Labor Pain Sensing Technologies: Jeya Daisy I1,Sreeja G S2,Aakash S3, , Arjun M.
6. Cresswell K, Graham R, Wright A, et al. Managing burnout in obstetrics and gynecology. ObstetGynaecol. 2018:21(1):7–9.
7. Tsumura R, Iwata H. Development of ultrasonography assistance robot for prenatal care. Proc. SPIE 2020:11315.
8. Palomino Roldan G, Suaste Gomez E. Methodology for the registration of human movement using accelerometers and gyroscopes.
9. Contreras-Rodríguez L.A et al. Algorithm for Estimating the Orientation of an Object in 3D Space.
10. YuukiShida. Estimation of Fetal Position and Orientation based on Skeletal Distribution with Robotic Ultrasonography.
11. Altini1. Detection of Fetal Kicks Using Body-Worn Accelerometers During Pregnancy.
12. Paul Hamelmann. Doppler ultrasound technology for fetal heart rate monitoring.
13. Yaosheng Lu. A Computer-aided Analyzing System for Fetal Monitoring Parameters.