Vivekanand Education Society's Institute of Technology

Department of Computer Engineering

Group No.: 38

Date :- 08-08-2024

Project Synopsis (2024-25) - Sem VII

Crucial Need-Real time prenatal health monitoring

Mrs. Nusrat Ansari

Assistant Professor, Department

8/8/2024

Kalpana Gurnani
2021.kalpana.gurnani
@ves.ac.in

Prerna Banswani
2021.prerna.banswani
@ves.ac.in

Madhura Gaval
2021.madhura.gaval
@ves.ac.in

Vanshika Lalwani
2021.vanshika.lalwani
@ves.ac.in

Abstract

The early detection and continuous monitoring of fetal heart health are essential in prenatal care to ensure the well-being of both mother and baby. Current methods, which rely on intermittent clinic-based assessments, can miss transient abnormalities, leading to delayed interventions and increased pregnancy risks. This project proposes a wearable device integrating Gen AI and sensors to provide reliable, continuous, non-invasive monitoring of fetal heart rate, offering real-time data and early detection of potential issues, thereby facilitating timely medical intervention.

This innovative wearable device is designed for comfort and ease of use, enabling expectant mothers to wear it throughout the day and night while continuously collecting and analyzing heart rate data in real-time. The Gen AI system can detect subtle patterns and anomalies, offering early warnings of potential issues and facilitating timely medical intervention. With wireless communication capabilities, the device allows data transmission to a mobile application for instant access to monitoring data, alerts, and historical trends. By providing real-time data and early detection of potential issues, this wearable device aims to significantly improve pregnancy outcomes and provide peace of mind to expectant mothers and their families.

Introduction

Prenatal care plays a vital role in monitoring fetal health and ensuring the safe delivery of a healthy baby. One of the most critical aspects of this care is the continuous monitoring of the fetal heart rate, which provides essential insights into the well-being of the developing fetus. Traditional methods for monitoring fetal heart rate typically involve periodic assessments conducted during clinic visits using ultrasound or Doppler devices. While these methods are valuable, they are inherently limited by their intermittent nature.

The periodic nature of clinic-based assessments means that they can only capture the fetal heart rate at specific moments in time. Consequently, these assessments can miss transient or early-stage abnormalities that may occur between visits. Such missed detections can delay the identification of potential issues, preventing timely medical interventions and increasing the risks associated with pregnancy. This gap in monitoring can be particularly concerning for high-risk pregnancies, where continuous oversight is crucial.

Moreover, the reliance on clinic visits for monitoring can be inconvenient and stressful for expectant mothers, particularly those who need frequent check-ups. It may also place a strain on healthcare resources, making it challenging to provide the intensive monitoring required for high-risk pregnancies. This highlights the need for a more accessible and user-friendly solution that can provide continuous monitoring without the need for constant clinical supervision.

Given these challenges, there is a growing need for a more reliable and comprehensive solution for fetal heart rate monitoring. A continuous monitoring system that provides real-time data would address the limitations of traditional methods, offering a constant stream of information that can detect anomalies as they occur. Such a system would enable early detection of potential issues, allowing for prompt medical responses that can mitigate risks and enhance the overall safety of the pregnancy. This project aims to develop such a solution by leveraging advanced technology to create a wearable device that ensures continuous, non-invasive monitoring of fetal heart rate, thereby improving prenatal care and outcomes for both mother and baby. By integrating Gen AI and advanced sensors, the proposed wearable device promises to revolutionize prenatal monitoring, offering unprecedented levels of accuracy, convenience, and peace of mind for expectant mothers.

Problem Statement

Current fetal heart rate monitoring methods are typically intermittent and clinic-based, potentially missing early signs of abnormalities. These limitations can delay medical interventions, increasing the risk for both the mother and the fetus. A reliable, continuous, and non-invasive monitoring solution is needed to provide real-time data and early detection of potential issues.

Proposed Solution

We propose a cutting-edge wearable device that integrates advanced sensors and Gen AI technology for continuous, non-invasive monitoring of fetal heart rate. Designed for comfort and convenience, this device uses sensors such as ultrasound, Doppler, and ECG to provide real-time, accurate data on the fetal heart rate. The wearable is intended for daily use, ensuring seamless integration into everyday life while continuously collecting and analyzing heart rate information without causing discomfort.

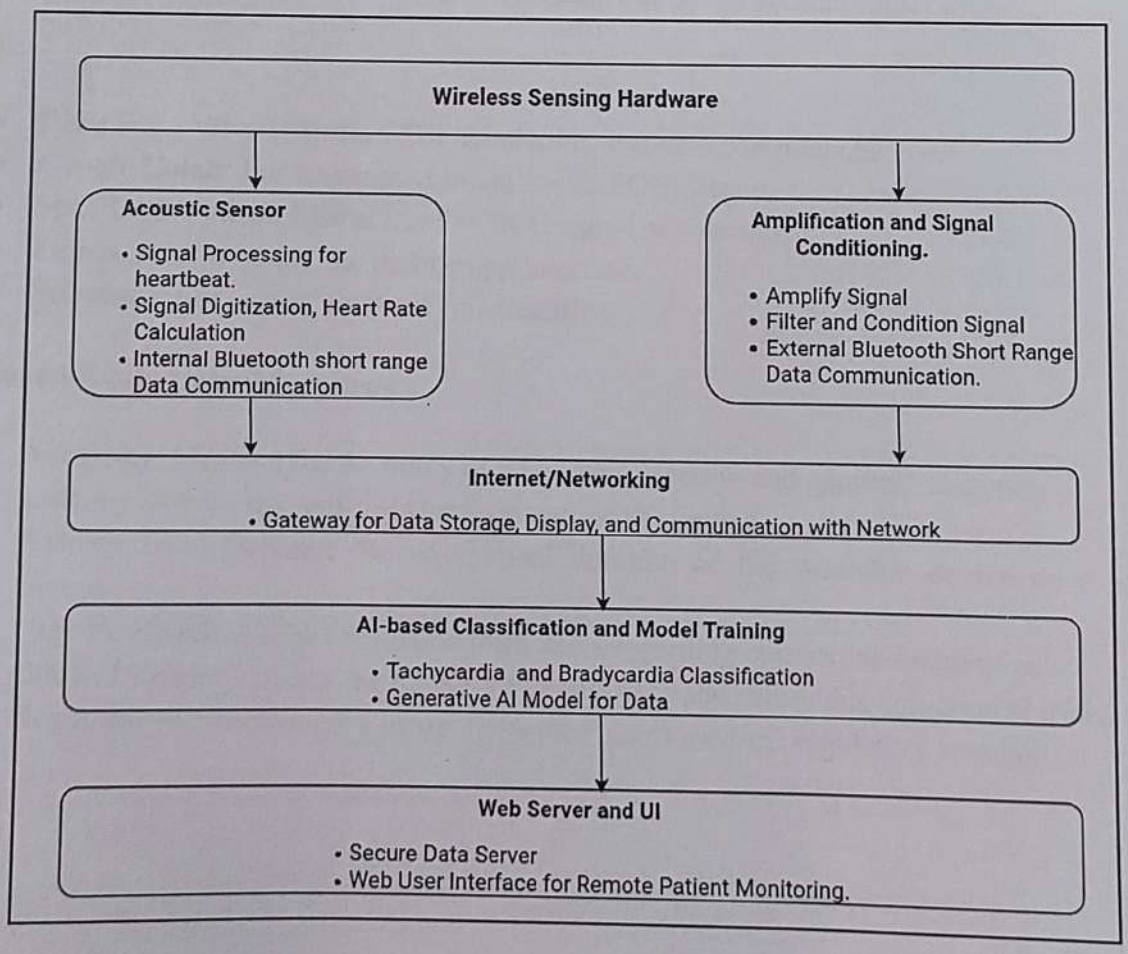
The device leverages Gen AI to process the data and detect subtle anomalies that might be missed by traditional methods. It features a real-time alert system that notifies expectant mothers and healthcare providers immediately when potential issues are detected, enabling prompt medical intervention. With wireless communication capabilities, the device transmits data to a mobile app and cloud platform, offering real-time monitoring, historical data analysis, and comprehensive insights into fetal health. This innovative solution aims to enhance prenatal care by improving monitoring accuracy, increasing convenience, and ensuring timely medical responses.

Methodology / Block Diagram

The development process involves several steps, from conceptualization to deployment:

1. **Conceptualization and Requirement Gathering**: Define key requirements and engage with stakeholders.
2. **Sensor Selection and Hardware Design**: Choose appropriate sensors and integrate them with necessary components.
3. **Data Acquisition and Preprocessing**: Develop algorithms for signal processing and noise reduction.
4. **Gen AI Model Development**: Prepare datasets, train AI models, and validate their performance.
5. **Real-time Monitoring and Analysis**: Implement edge computing for real-time data processing.
6. **User Interface and Application Development**: Develop a mobile app and wearable interface.
7. **Testing and Validation**: Conduct clinical trials and obtain regulatory approvals.
8. **Deployment and Maintenance**: Move to mass production and provide user support.

Block Diagram



Hardware, Software, and Tools Requirements

Hardware:

- **ECG Sensors**: Capture fetal heart electrical signals.
- **Microcontroller (e.g., Arduino, Raspberry Pi)**: Manages data processing and device operations.
- **Wireless Communication Modules (e.g., Bluetooth, Wi-Fi)**: Transmit data to mobile apps and cloud services.
- **Battery and Power Management Unit**: Ensures continuous operation with minimal recharging.
- **Wearable Casing and Straps**: Securely houses sensors and ensures comfort.

Software:

- **Signal Processing Algorithms**: Filter and analyze ECG data for accurate interpretation.
- **Gen AI Models (e.g., LSTM, CNN)**: Detect anomalies and predict issues using ECG data.
- **Mobile Application Development**: Provides real-time data access and alerts on Android and iOS.
- **Cloud Storage and Processing**: Stores data and performs analytics.

Tools:

- **IDEs (e.g., Visual Studio)**: For developing software components.
- **Google Colab**: For training AI models with ECG data.
- **MATLAB/Python Libraries**: For ECG signal processing.
- **Figma**: For designing the mobile app interface.
- **Selenium**: For testing software functionality.

Proposed Evaluation Measures

- **Accuracy**: Measure the accuracy of heart rate detection and anomaly detection.
- **Latency**: Assess the real-time performance of the device.
- **Battery Life**: Evaluate the operational duration of the wearable device on a single charge.
- **User Feedback**: Collect feedback from users regarding comfort and ease of use.
- **Clinical Trials**: Validate the device's effectiveness and safety through clinical trials.
- **Regulatory Compliance**: Ensure the device meets medical regulatory standards.

Conclusion

The proposed wearable device aims to revolutionize prenatal care by providing continuous, non-invasive monitoring of fetal heart health. By leveraging advanced sensors and Gen AI, the device offers real-time data and early detection of potential issues, ensuring timely medical intervention. This innovation holds the promise of significantly improving outcomes for both mothers and their babies.

References

1. Alim, Anika, and Masudul H. Imtiaz. "Wearable sensors for the monitoring of maternal health—A systematic review." Sensors 23, no. 5 (2023): 2411.
2. Runkle, Jennifer, Maggie Sugg, Danielle Boase, Shelley L. Galvin, and Carol C. Coulson. "Use of wearable sensors for pregnancy health and environmental monitoring: Descriptive findings from the perspective of patients and providers." Digital health 5 (2019): 2055207619828220.
3. Maugeri, Andrea, Martina Barchitta, and Antonella Agodi. "How wearable sensors can support the research on foetal and pregnancy outcomes: A scoping review." Journal of Personalized Medicine 13, no. 2 (2023): 218.
4. Wakefield, Colin, Lena Yao, Steve Self, and Martin G. Frasch. "Wearable technology for health monitoring during pregnancy: an observational cross-sectional survey study." Archives of Gynecology and Obstetrics 308, no. 1 (2023): 73-78.
5. Hasan, M. A., M. I. Ibrahimy, and M. B. I. Reaz. "Techniques of FECG signal analysis: detection and processing for fetal monitoring." WIT Transactions on Biomedicine and Health 12 (2007): 295-305.
6. Roham, Masoud, Enrique Saldivar, Srinivas Raghavan, Mark Zurcher, Jonathan Mack, and Mehran Mehregany. "A mobile wearable wireless fetal heart monitoring system." In 2011 5th International Symposium on Medical Information and Communication Technology, pp. 135-138. IEEE, 2011.
7. Signorini, Maria G., Andrea Fanelli, and Giovanni Magenes. "Monitoring fetal heart rate during pregnancy: contributions from advanced signal processing and wearable technology." *Computational and mathematical methods in medicine* 2014, no. 1 (2014): 707581.
8. Skrivanos, Anastasios G., Evangelia I. Kosma, Spyridon K. Chronopoulos, Ioannis Kouretas, Dimitrios Dimopoulos, Georgios Petrakos, Elena Alhazidou et al. "Fetus heart rate monitoring: A preliminary research study with remote sensing." *IEEE Consumer Electronics Magazine* 11, no. 4 (2021): 32-44.
9. Mhajna, Muhammad, Nadav Schwartz, Lorinne Levit-Rosen, Steven Warsof, Michal Lipschuetz, Martin Jakobs, Jack Rychik, Christof Sohn, and Simcha Yagel. "Wireless, remote solution for home fetal and maternal heart rate monitoring." *American journal of obstetrics & gynecology MFM* 2, no. 2 (2020): 100101.

10. Yang, Chenxi, Clarel Antoine, Bruce K. Young, and Negar Tavassolian. "A pilot study on fetal heart rate extraction from wearable abdominal inertial sensors." *IEEE Sensors Journal* 19, no. 22 (2019): 10773-10781.