ISSN 2277-2685
IJESR/April-June. 2026/ Vol-16/Issue-2/1037-1044
J Akhila *et. al.,* / International Journal of Engineering & Science Research
Full Length Article

Abnormal Fetal Detection System

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Accepted 02-06-2026

Abstract
The Abnormal Fetal Detection System is designed to assist healthcare professionals in the early detection of fetal abnormalities using ultrasound imaging and advanced deep learning techniques. Early identification of fetal health issues is essential for ensuring better maternal and neonatal outcomes. The proposed system employs a Convolutional Neural Network (CNN) model to analyze ultrasound images and accurately classify fetal conditions as either normal or abnormal.
The system provides a user-friendly interface through which doctors can upload ultrasound scans, enter patient information, and obtain prediction results. It performs image preprocessing, feature extraction, and automated classification to generate diagnostic reports that support clinical decision-making. Additionally, the application ensures secure storage and management of patient records, promoting efficient healthcare services and data accessibility.
By reducing manual effort and enhancing diagnostic accuracy, the system contributes to improved prenatal care, timely medical intervention, and increased awareness of fetal health risks. The integration of artificial intelligence in fetal monitoring offers a reliable and efficient solution for supporting obstetric diagnosis and healthcare management.
Keywords: *Abnormal Fetal Detection, Ultrasound Images, Deep Learning, Convolutional Neural Network (CNN), Medical Image Processing, Prenatal Care, Fetal Health Monitoring, Artificial Intelligence, Image Classification, Healthcare Management.*

INTRODUCTION

Fetal health assessment is an essential component of prenatal care, as early identification of abnormalities can significantly improve maternal and neonatal outcomes. Fetal abnormalities may develop due to genetic disorders, developmental defects, infections, or environmental factors during pregnancy. If such conditions remain undetected, they can lead to severe complications affecting both the mother and the unborn child.

Advancements in artificial intelligence and medical image processing have created new opportunities for supporting healthcare professionals in prenatal diagnosis. The proposed Abnormal Fetal Detection System utilizes ultrasound images and deep learning techniques to identify potential fetal abnormalities automatically. A Convolutional Neural Network (CNN) model is employed to analyze ultrasound scans and classify fetal conditions as either normal or abnormal. By providing early risk prediction, the system assists healthcare professionals in making informed clinical decisions and initiating timely medical interventions.

The system offers a user-friendly platform through which doctors can upload ultrasound images, enter patient information, and obtain diagnostic predictions. In addition to improving diagnostic efficiency, the proposed solution contributes to enhanced prenatal monitoring and healthcare management.

Existing System

Conventional fetal abnormality detection primarily depends on routine prenatal examinations conducted in hospitals and diagnostic centers. Healthcare professionals evaluate fetal development through physical examinations, ultrasound imaging, and laboratory investigations. These methods play a crucial role in monitoring fetal growth and identifying potential complications during pregnancy.

Ultrasound imaging remains the most commonly used diagnostic technique for detecting structural and developmental abnormalities. However, accurate interpretation requires experienced specialists and advanced medical equipment. Furthermore, diagnosis is often performed during scheduled prenatal visits, which may delay the identification of abnormalities that develop between examinations.

The existing healthcare approach relies heavily on manual observation and expert interpretation, resulting in increased workload for medical professionals and limited accessibility in resource-constrained regions.

Proposed System

The proposed Abnormal Fetal Detection System introduces an intelligent and automated approach to fetal health assessment. The system employs deep learning algorithms to analyze ultrasound images and identify abnormal fetal conditions with improved efficiency and accuracy.

A Convolutional Neural Network is used to automatically extract relevant image features and classify fetal conditions based on learned patterns. The framework integrates image preprocessing, feature extraction, classification, and report generation into a single platform. Doctors can upload ultrasound scans, review prediction outcomes, and maintain patient records through a secure interface.

The proposed system aims to support early diagnosis, improve healthcare accessibility, and reduce dependence on manual image interpretation.

REQUIREMENTS ANALYSIS

The proposed system consists of two primary modules: the Doctor Module and the Admin Module.

The Doctor Module allows healthcare professionals to register and log into the application, upload ultrasound images, enter patient information, view prediction results, generate diagnostic reports, and securely manage patient records. These functionalities support efficient clinical workflow and facilitate prenatal diagnosis.

The Admin Module is responsible for system administration activities. Administrators can authenticate themselves, manage doctor accounts, monitor system operations, and maintain overall application security.

Computational Resource Requirements

The system requires moderate hardware and software resources for development and deployment. The recommended hardware configuration includes an Intel Core i5 processor, 8 GB RAM, and 500 GB storage capacity. From the software perspective, the application operates on Windows 10 and is implemented using Python 3.12. TensorFlow and Keras are utilized for deep learning model development, while NumPy and Pandas support data preprocessing and analysis. HTML, CSS, and JavaScript are employed for interface development, and Firebase serves as the database management platform.

Software Development Life Cycle Model

The development of the proposed system follows the Waterfall Software Development Life Cycle model. This model provides a structured and sequential approach in which each phase is completed before the next phase begins.The project starts with requirement analysis, where system objectives and user requirements are identified. During the design phase, software architecture and technology selection are finalized. The implementation phase focuses on coding and integrating system components. Comprehensive testing is then conducted to verify prediction accuracy and functional correctness. Finally, the system is deployed and maintained to accommodate future enhancements and updates.

SYSTEM DESIGN

Software Architecture

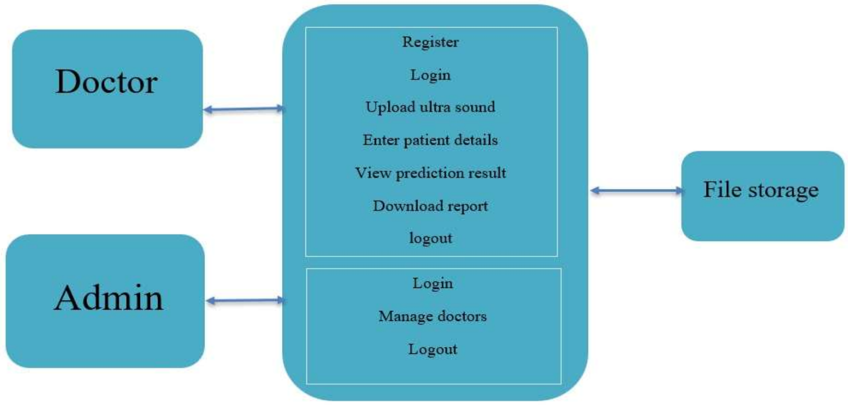

Fig 1 Software Architecture

The software architecture of the Abnormal Fetal Detection System is designed to facilitate seamless interaction between users, machine learning components, and data storage services. The architecture follows a modular approach that separates user management, image processing, prediction generation, and database operations.

When a doctor uploads an ultrasound image, the system performs preprocessing operations to enhance image quality and prepare the image for analysis. The processed image is then forwarded to the CNN-based prediction engine, which extracts features and performs classification. Prediction results are displayed through the user interface and stored in the database for future reference.

This architecture ensures efficient processing, maintainability, and scalability while supporting secure management of patient information.

Technical Architecture

Fig 2 Technical Architecture

The technical architecture integrates multiple technologies to achieve intelligent fetal abnormality detection. The frontend layer is developed using HTML, CSS, and JavaScript, providing an interactive interface for doctors and administrators. The application layer is implemented in Python and contains image processing modules, business logic, and deep learning functionality.

The machine learning layer consists of TensorFlow and Keras frameworks, which facilitate CNN model training and prediction. Data storage and user authentication services are managed through Firebase. Communication among system components occurs through secure interfaces, ensuring reliable data transmission and privacy protection.

The overall architecture enables automated image analysis, rapid prediction generation, and effective healthcare data management, thereby supporting improved prenatal diagnostic practices.

IMPLEMENTATION

System Implementation

The Abnormal Fetal Detection System was implemented using a combination of modern web technologies, machine learning frameworks, and cloud-based database services to provide an efficient platform for fetal abnormality prediction. The primary objective of the implementation phase was to develop a reliable system capable of processing ultrasound images, extracting meaningful features, and generating diagnostic predictions through deep learning techniques.

Python was selected as the core programming language due to its extensive support for artificial intelligence and medical image analysis. The language provides numerous libraries that simplify data preprocessing, image manipulation, model training, and prediction generation. The backend functionality of the system, including image preprocessing, feature extraction, model execution, and report generation, was developed using Python.

The deep learning component of the system was implemented using TensorFlow and Keras. TensorFlow served as the computational framework responsible for performing numerical operations and managing neural network training. Keras was employed as a high-level interface for designing, training, and evaluating the Convolutional Neural Network (CNN). The CNN model was trained to identify distinguishing features from ultrasound images and classify fetal conditions into normal and abnormal categories.

The user interface was developed using HTML, CSS, and JavaScript. HTML provided the structural elements required for displaying forms, image upload facilities, and prediction results. CSS enhanced the visual presentation of the application by improving layout organization, responsiveness, and user experience. JavaScript introduced dynamic functionality, enabling real-time validation, interactive operations, and smooth communication between frontend and backend components.

Firebase was integrated as the database management platform for storing user credentials, patient information, uploaded ultrasound images, and diagnostic reports. The cloud-based architecture ensures secure storage, efficient retrieval, and real-time synchronization of healthcare data. The combination of these technologies resulted in a scalable and user-friendly platform suitable for supporting prenatal healthcare applications.

Algorithmic Workflow

The proposed system follows a structured workflow beginning with user authentication and image acquisition. Authorized healthcare professionals upload ultrasound images through the web interface. The uploaded images are validated to ensure correct format and quality before processing. Invalid or corrupted images are rejected to maintain prediction reliability.After successful validation, the images undergo preprocessing operations designed to improve image quality and standardize the input for the deep learning model. The preprocessing stage includes grayscale conversion, noise reduction through median and Gaussian filtering, histogram equalization for contrast enhancement, resizing to a fixed dimension of 224 × 224 pixels, and pixel normalization. These operations improve feature visibility and enhance model performance.

The processed image is then supplied to the CNN model. During this stage, the network automatically extracts hierarchical image features and performs classification based on previously learned patterns. The prediction score generated by the model is converted into a probability distribution using the Softmax function. Based on the resulting probability values, the system determines whether the fetal condition is normal or abnormal and assigns an appropriate risk level.To improve system efficiency and scalability, prediction tasks are executed asynchronously. Each prediction request is assigned a processing job that manages image analysis, feature extraction, classification, and report generation independently. The asynchronous design prevents system delays and enables multiple users to access prediction services simultaneously. Upon completion of the prediction process, a medical report containing the classification result, confidence score, and risk assessment is generated and stored in the database.

The implementation framework ensures accurate prediction, secure data management, and efficient processing of ultrasound images, making it suitable for real-world healthcare environments.

TESTING

Testing represents a critical phase in the development of healthcare-related software systems, particularly when diagnostic predictions influence clinical decision-making. The Abnormal Fetal Detection System was subjected to comprehensive testing procedures to evaluate its functionality, reliability, performance, and prediction accuracy. The primary objective of testing was to verify that all system components operated correctly and satisfied the requirements defined during the analysis phase.

Because the system processes sensitive medical information and generates diagnostic predictions, ensuring software quality was considered essential. Testing activities focused on validating user authentication, image preprocessing operations, prediction generation, report management, and database interactions. Through systematic verification, potential defects were identified and corrected before deployment.

The testing process also evaluated system usability and security. Healthcare professionals require a reliable and intuitive interface for uploading ultrasound images and reviewing prediction outcomes. Therefore, extensive testing was conducted to ensure that the application provided a smooth user experience while maintaining patient data confidentiality.

Testing Methodology

Multiple testing dimensions were considered to ensure comprehensive system evaluation. Testing was performed across different layers of the application, including the user interface layer, business logic layer, machine learning layer, and database layer. The evaluation process incorporated unit testing, integration testing, system testing, and acceptance testing to verify individual components as well as overall system functionality.

Functional testing was performed to ensure that each module executed its intended operations correctly. Performance testing was conducted to evaluate prediction response time and processing efficiency. Security testing verified the protection of patient records and authentication mechanisms. In addition, manual validation techniques were employed to confirm the correctness of prediction outputs and report generation processes.

Testing Stages

Unit testing was conducted on individual software components, including user authentication, image preprocessing functions, prediction modules, and report generation mechanisms. Each module was tested independently to verify its correctness and reliability before integration.

Following successful unit testing, integration testing was performed to evaluate communication among interconnected modules. Particular attention was given to interactions between image upload functionality, preprocessing operations, CNN-based prediction, and report generation services. The objective was to ensure seamless data flow and consistent system behavior.

System testing involved evaluating the complete application as a unified platform. During this phase, the software was tested against functional and non-functional requirements to confirm that all features operated according to specifications. Prediction generation, database operations, user management, and report handling were assessed under realistic usage conditions.

Acceptance testing represented the final validation stage. Healthcare users evaluated the system to determine whether it satisfied practical requirements and project objectives. Successful completion of acceptance testing indicated that the application was suitable for deployment and operational use.

Testing Techniques

Both black-box and white-box testing techniques were employed during system evaluation. Black-box testing focused on verifying system functionality without considering internal implementation details. Various ultrasound images were supplied as input, and the resulting predictions were examined to determine whether the application behaved as expected from a user perspective.

White-box testing concentrated on the internal logic and structural integrity of the software. This testing method evaluated program control flow, conditional statements, preprocessing functions, and classification procedures. Coverage-based techniques were applied to ensure that critical execution paths were thoroughly validated.

Validation Results

The testing outcomes demonstrated that the proposed system successfully performed ultrasound image analysis, fetal condition classification, and report generation with consistent reliability. User authentication, image preprocessing, CNN prediction, and database operations functioned as expected under normal operating conditions. The system exhibited stable performance during repeated testing scenarios and maintained accurate communication between integrated modules.

The validation process confirmed that the developed framework provides an effective platform for supporting prenatal diagnosis through automated fetal abnormality detection. The combination of deep learning-based image analysis and comprehensive testing contributes to improved reliability, usability, and overall system quality.

Screenshots

Fig. 1 Landing Page

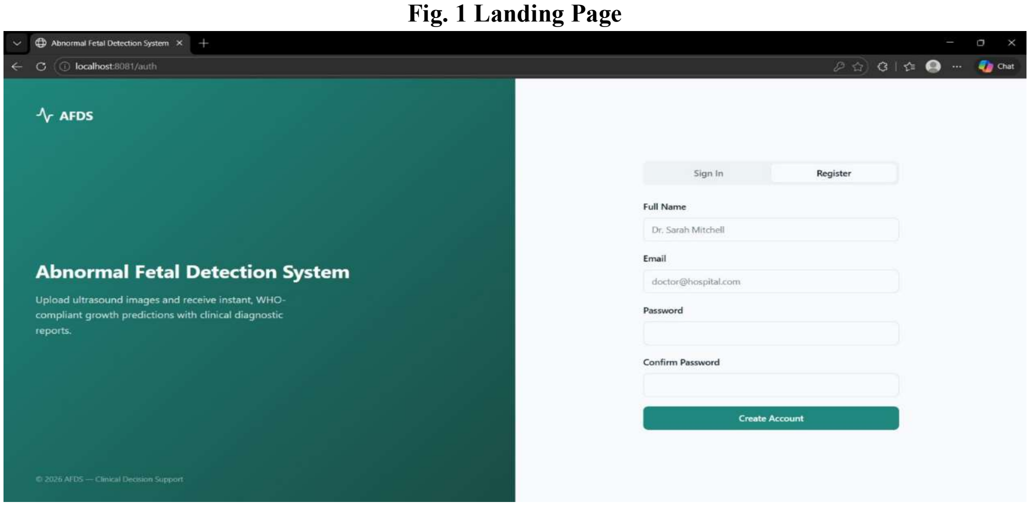

Fig.2 Registration Page

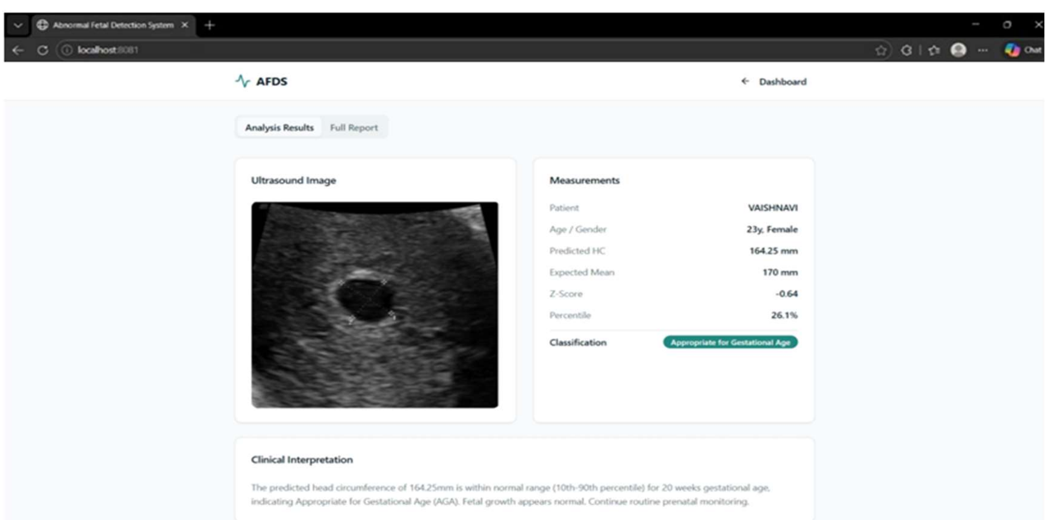

Fig. 3 Full Growth Analysis Report

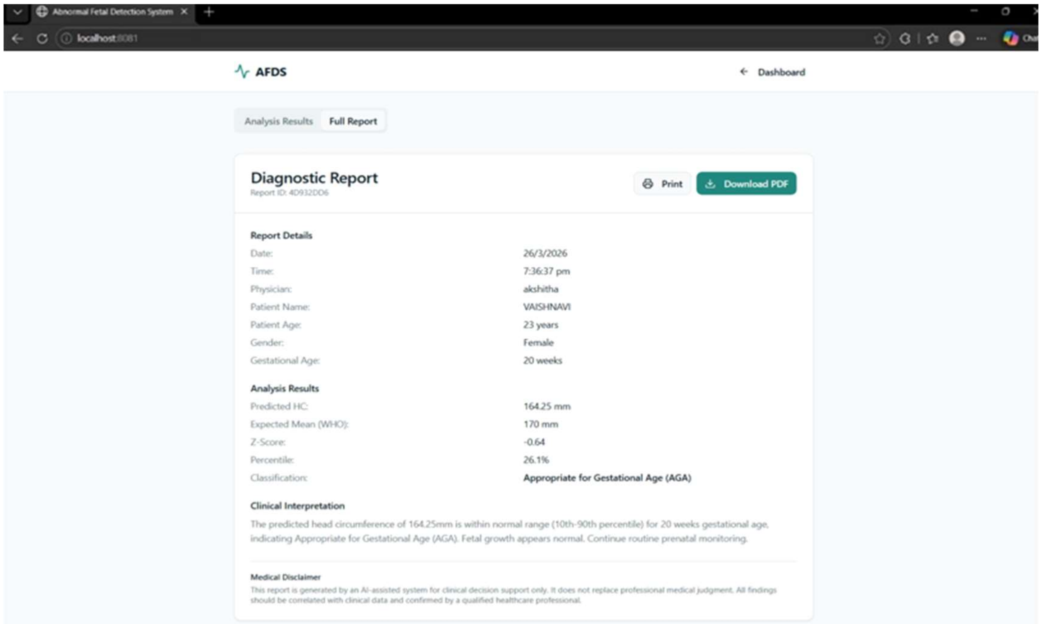

Fig. 4 Diagnostic Report Page

Conclusion

This study presented a deep learning-based Abnormal Fetal Detection System designed to support prenatal diagnosis through automated analysis of ultrasound images. The proposed framework employs a Convolutional Neural Network (CNN) to identify significant image features and classify fetal conditions into normal and abnormal categories. By integrating medical image processing, machine learning techniques, and a web-based interface, the system provides an efficient platform for assisting healthcare professionals in fetal health assessment.

The developed solution addresses several limitations associated with conventional prenatal screening approaches, including dependence on manual image interpretation and delays in risk identification. Automated classification enables faster evaluation of ultrasound scans while maintaining consistency in diagnostic outcomes. The integration of secure data management and report generation functionalities further enhances the practical applicability of the system in healthcare environments.

Experimental implementation and validation demonstrate that deep learning techniques can effectively support fetal abnormality detection and contribute to improved prenatal monitoring. The proposed framework offers a reliable decision-support mechanism that may assist clinicians in identifying potential fetal risks at an earlier stage, thereby facilitating timely medical intervention and improving maternal and neonatal healthcare outcomes. Overall, the research highlights the potential of artificial intelligence to enhance diagnostic efficiency, reduce workload for healthcare professionals, and strengthen the quality of prenatal care services.

Future Scope

Although the proposed system demonstrates promising performance in automated fetal abnormality detection, several opportunities exist for future enhancement and expansion. One important direction involves training the deep learning model using larger, multi-institutional, and more diverse ultrasound datasets. Increasing dataset diversity would improve model generalization and enable more robust performance across different patient populations and imaging conditions.

Future research may also explore advanced deep learning architectures such as Residual Networks (ResNet), EfficientNet, Vision Transformers (ViT), and hybrid CNN-based models to further improve classification accuracy and feature representation. The incorporation of attention mechanisms and explainable artificial intelligence techniques could provide greater transparency in prediction results, thereby increasing clinician confidence in automated diagnostic recommendations.

Another promising extension involves the development of real-time fetal monitoring capabilities. By integrating live ultrasound data processing, the system could support continuous prenatal assessment and immediate risk identification. Additional functionalities such as severity-level visualization, automated clinical recommendations, predictive analytics, and personalized prenatal guidance may further enhance the usefulness of the platform.

From a deployment perspective, cloud-based and mobile healthcare solutions can significantly improve accessibility, particularly in rural and underserved regions where specialist medical services are limited. Integration with electronic health record systems, hospital information management platforms, and telemedicine infrastructures would enable seamless data sharing and collaborative decision-making among healthcare providers. These future developments have the potential to transform the proposed framework into a comprehensive intelligent prenatal healthcare system capable of supporting large-scale clinical applications and advancing maternal-fetal medicine.

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