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FADA: An AI-Enabled Platform for Prenatal Ultrasound Analysis, Clinical Decision Support, and Automated Reporting

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ABSTRACT

Prenatal ultrasound is the primary imaging modality for monitoring fetal development and detecting congenital abnormalities. However, accurate interpretation of fetal brain ultrasound images requires specialized expertise and may be affected by variations in operator experience, image quality, and reporting practices. To address these challenges, this paper presents the Fetal Abnormality Diagnostic Application (FADA), an AI-enabled healthcare informatics platform designed to support fetal brain ultrasound assessment through automated image analysis, clinical decision support, and report generation. FADA integrates image interpretation, clinician interaction, and documentation within a unified workflow. The platform is built upon a curated dataset of more than 3,000 expert-annotated fetal brain ultrasound images, focusing on clinically significant structures such as the Cavum Septum Pellucidum (CSP) and Lateral Ventricles (LV), important indicators of fetal neurological development. Machine learning models utilize these annotations to identify anatomical structures, extract measurements, and detect developmental abnormalities. The platform follows a modular architecture comprising user interaction, clinical data processing, intelligent analysis, and results management. Healthcare professionals can upload ultrasound images, review automated findings, interact with an intelligent clinical assistant, and obtain structured diagnostic reports. The AI analysis pipeline performs anatomical identification, measurement extraction, abnormality assessment, and generation of preliminary findings, which are consolidated into standardized reports suitable for clinical workflows. By combining expert-annotated imaging data, automated anomaly detection, conversational clinical assistance, and report generation, FADA demonstrates how artificial intelligence can be integrated into healthcare information systems to improve the efficiency, consistency, and accessibility of prenatal ultrasound assessment while maintaining clinician oversight throughout the diagnostic process.

Keywords: Prenatal ultrasound, Healthcare informatics, Clinical decision support

INTRODUCTION

Prenatal ultrasound is the primary imaging modality for monitoring fetal development and detecting structural abnormalities during pregnancy due to its safety, accessibility, and real-time imaging capability (Lawrie, 2017). Assessment of the fetal brain is particularly important because abnormalities

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affecting structures such as the Cavum Septum Pellucidum (CSP) and Lateral Ventricles (LV) may indicate underlying neurological developmental disorders (Salomon et al., 2022).

Advances in artificial intelligence have led to significant progress in automated analysis of fetal ultrasound images. Deep learning techniques have been applied to fetal standard-plane detection, anatomical localization, segmentation, biometric measurement, and abnormality identification, demonstrating improved consistency and reduced operator dependence (Baumgartner et al., 2017; Burgos-Artizzu et al., 2020). More recent studies have reported promising results for automated fetal brain assessment and anomaly detection from ultrasound examinations (Yaqub et al., 2017; Yousefpour et al., 2023).

Despite these advances, most existing solutions remain focused on isolated analytical tasks and are typically evaluated as research prototypes. Clinical functions such as workflow integration, decision support, auditability, clinician interaction, and automated report generation are often absent, limiting their practical adoption in healthcare environments (Chen et al., 2021). Consequently, a gap persists between high-performing AI models and operational healthcare informatics platforms that support end-to-end prenatal assessment.

To address this gap, this paper presents the Fetal Abnormality Diagnostic Application (FADA), an AI-enabled healthcare informatics platform for prenatal ultrasound analysis. FADA integrates image processing, anatomical structure identification, measurement extraction, abnormality screening, clinician review, and automated report generation within a unified workflow. Supported by a repository of more than 3,000 expert-annotated fetal brain ultrasound images, the platform focuses on CSP and LV assessment while providing decision-support and documentation capabilities. By combining AI-driven image interpretation with clinical workflow support, FADA aims to improve consistency, efficiency, and traceability in prenatal ultrasound assessment.

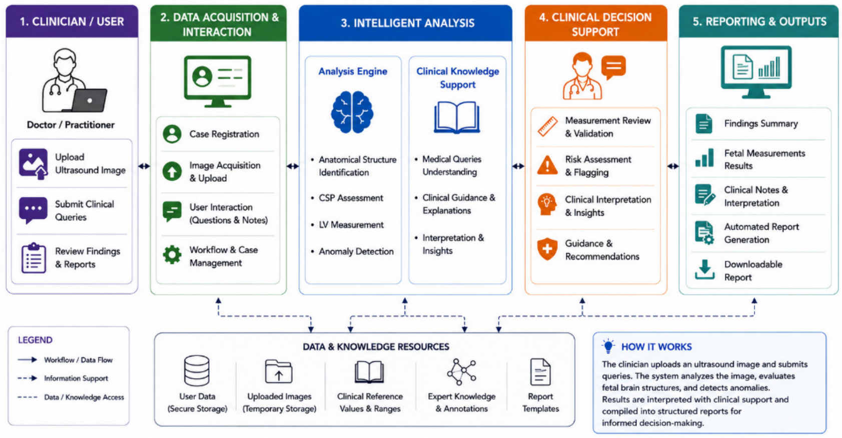


Figure 1: High-level functional architecture and workflow of the FADA platform for fetal anomaly diagnosis, clinical decision support and automated reporting in prenatal care.

FADA: AN AI-ENABLED PRENATAL ULTRASOUND PLATFORM

FADA (Fetal Abnormality Diagnostic Application) is a healthcare informatics platform designed to support prenatal ultrasound assessment through artificial intelligence, clinical decision support, and automated reporting. The platform combines image analysis, clinician interaction, and documentation services within a unified workflow to assist fetal brain abnormality screening and reporting.

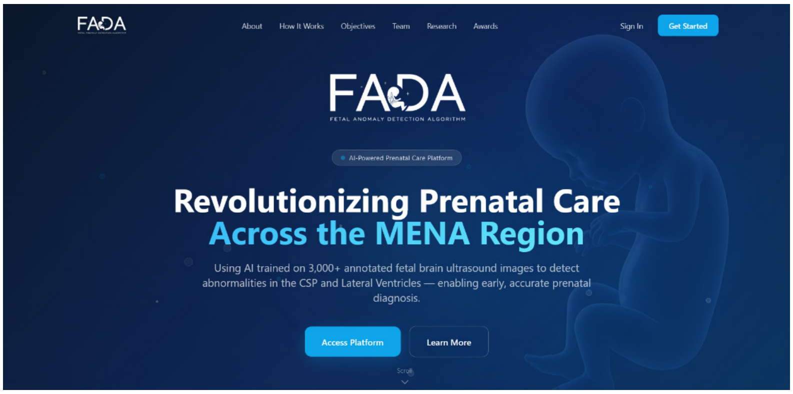


Figure 2: Web view of the FADA platform (HBKU, n.d.).

Dataset and Clinical Context

Accurate AI-assisted diagnosis requires clinically representative and expertly annotated data. FADA is therefore built upon a curated fetal brain ultrasound dataset developed specifically for prenatal neurological assessment. The web view of the FADA platform is shown in Figure 2.

The platform utilizes a repository of more than 3,000 expert-annotated fetal brain ultrasound images. Dataset development focused on clinically significant anatomical structures, particularly the Cavum Septum Pellucidum (CSP) and Lateral Ventricles (LV). The CSP is a fluid-filled midline structure in fetal brain, whose absence may indicate severe neurodevelopmental abnormalities, while enlargement of the lateral ventricles beyond 10 mm is commonly associated with ventriculomegaly and abnormal brain development. Expert annotations provide the reference information required for model training, validation, and performance evaluation.

System Architecture

FADA employs a modular architecture that separates user interaction, application services, AI inference, and data management functions, as shown in Figure 1. This design enables scalability, maintainability, and integration with existing healthcare workflows. Healthcare practitioners access the platform through a web-based interface that supports ultrasound image upload, result visualization, report retrieval, and clinical interaction as shown in Figure 3. The architecture consists of a presentation layer, an application programming interface (API) layer, an AI intelligence layer, and a data management layer.

API Layer: The API layer coordinates communication between platform components, while dedicated AI services perform image analysis and provide clinical guidance. Supporting data assets include trained machine learning models, uploaded ultrasound images, reference measurement datasets, and report-generation templates.

AI Intelligence Layer: The core inference engine uses a YOLOv5s object detection model (~7.2 M parameters, 6.7 MB checkpoint) trained to localize four anatomical targets in the transventricular plane: biparietal diameter (BPD) endpoints, occipitofrontal diameter (OFD) endpoints, cavum septi pellucidi (CSP), and lateral ventricular atria (LV). The model predicts bounding boxes and class labels; BPD/OFD are derived from skull box extents, while CSP length and LV width are measured directly from detected regions. Biometric estimation (gestational age, head circumference, fetal weight) follows established clinical formulas applied to the detected landmarks.

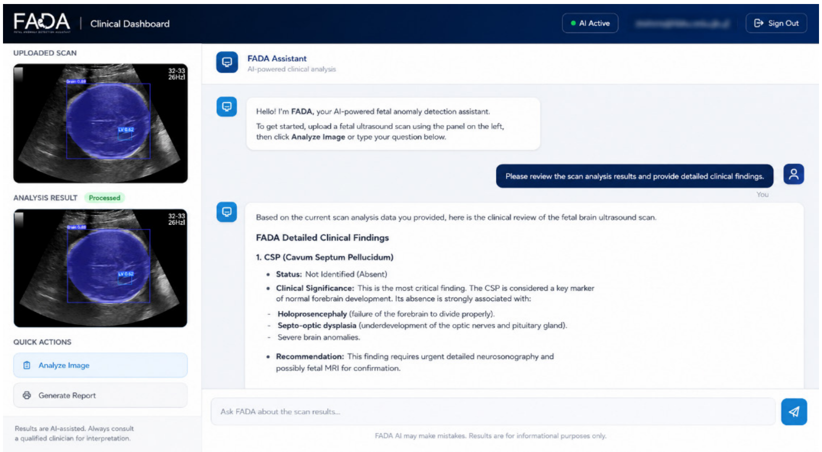


Figure 3: FADA dashboard showing fetal ultrasound analysis and reporting. (HBKU, n.d.).

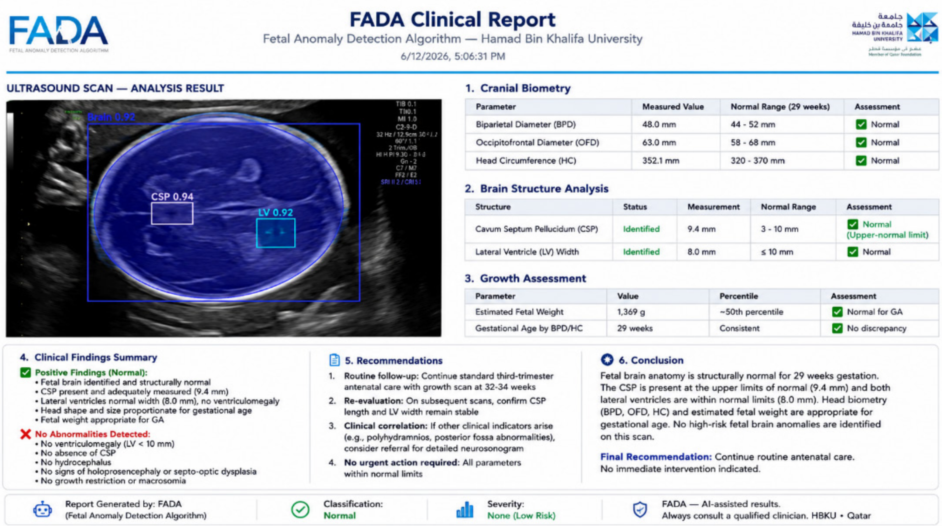
AI Analysis Pipeline

The core functionality of FADA is provided through an automated analysis pipeline that transforms ultrasound images into clinically meaningful findings.

The workflow begins when a clinician uploads a fetal brain ultrasound image through the platform interface as shown in Figure 1. The image is forwarded to the fetal anomaly detection service, where trained machine learning models identify relevant anatomical structures and extract diagnostic measurements. The system evaluates the presence or absence of the CSP, measures ventricular dimensions, and assesses findings against established clinical thresholds. Detected abnormalities and measurement deviations are automatically flagged, producing quantitative outputs that support subsequent clinical assessment and documentation.

Clinical Decision Support and Automated Reporting

Beyond image interpretation, FADA provides decision-support capabilities that assist clinicians in translating analytical outputs into actionable clinical information.



FADA
FETAL ANOMALY DETECTION ALGORITHM

FADA Clinical Report
Fetal Anomaly Detection Algorithm — Hamad Bin Khalifa University
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ULTRASOUND SCAN — ANALYSIS RESULT

Brain 0.92
CSP 0.94
LV 0.92

1. Cranial Biometry

Parameter	Measured Value	Normal Range (29 weeks)	Assessment
Biparietal Diameter (BPD)	48.0 mm	44 - 52 mm	Normal
Occipitofrontal Diameter (OFD)	63.0 mm	58 - 68 mm	Normal
Head Circumference (HC)	352.1 mm	320 - 370 mm	Normal

2. Brain Structure Analysis

Structure	Status	Measurement	Normal Range	Assessment
Cavum Septum Pellucidum (CSP)	Identified	9.4 mm	3 - 10 mm	Normal (Upper-normal limit)
Lateral Ventricle (LV) Width	Identified	8.0 mm	≤ 10 mm	Normal

3. Growth Assessment

Parameter	Value	Percentile	Assessment
Estimated Fetal Weight	1,369 g	~50th percentile	Normal for GA
Gestational Age by BPD/HC	29 weeks	Consistent	No discrepancy

4. Clinical Findings Summary

Positive Findings (Normal):
- Fetal brain identified and structurally normal
- CSP present and adequately measured (9.4 mm)
- Lateral ventricles normal width (8.0 mm), no ventriculomegaly
- Head shape and size proportionate for gestational age
- Fetal weight appropriate for GA

No Abnormalities Detected:
- No ventriculomegaly (LV < 10 mm)
- No absence of CSP
- No hydrocephalus
- No signs of holoprosencephaly or septo-optic dysplasia
- No growth restriction or macrosomia

5. Recommendations

1. **Routine follow-up:** Continue standard third-trimester antenatal care with growth scan at 32-34 weeks
2. **Re-evaluation:** On subsequent scans, confirm CSP length and LV width remain stable
3. **Clinical correlation:** If other clinical indicators arise (e.g., polyhydramnios, posterior fossa abnormalities), consider referral for detailed neurosonogram
4. **No urgent action required:** All parameters within normal limits

6. Conclusion

Fetal brain anatomy is structurally normal for 29 weeks gestation. The CSP is present at the upper limits of normal (9.4 mm) and both lateral ventricles are within normal limits (8.0 mm). Head biometry (BPD, OFD, HC) and estimated fetal weight are appropriate for gestational age. No high-risk fetal brain anomalies are identified on this scan.

Final Recommendation: Continue routine antenatal care. No immediate intervention indicated.

Report Generated by: FADA (Fetal Anomaly Detection Algorithm) | Classification: Normal | Severity: None (Low Risk) | FADA — AI-assisted results. Always consult a qualified clinician. HBKU • Qatar

Figure 4: Clinical report generated by the FADA platform. (HBKU, n.d.).

Analysis results are presented through an interactive dashboard that summarizes detected findings, anatomical measurements, and clinical interpretations, as shown in Figure 3. These outputs are incorporated into automatically generated clinical reports that can be reviewed, downloaded, and integrated into routine documentation processes as shown in Figure 4. The reporting framework standardizes presentation of diagnostic findings while reducing administrative workload. By combining AI-driven image analysis, clinician interaction, decision support, and report generation within a single workflow, FADA functions as a complete prenatal ultrasound assessment platform rather than a standalone image-processing tool.

EVALUATION AND DISCUSSION

This section examines the operational capabilities of FADA, its integration within prenatal ultrasound workflows, and the current limitations that motivate future development. The discussion focuses on platform-level evaluation and practical applicability in clinical environments.

Performance Evaluation

The FADA platform was evaluated using a repository of more than 3,000 expert-annotated fetal brain ultrasound images. Assessment focused on the platform's ability to identify clinically relevant anatomical structures, extract measurements, detect abnormalities associated with CSP and LV assessment, and generate structured outputs for clinician review.

Experimental observations demonstrated that the integrated AI pipeline successfully performed automated image analysis, measurement extraction, abnormality flagging, and report generation within a single workflow. The system could produce consistent outputs across uploaded ultrasound images while reducing the manual effort associated with measurement interpretation and documentation. The evaluation confirmed the feasibility of combining AI-driven fetal brain assessment with healthcare informatics functions in a unified platform environment.

Clinical Workflow Integration

A key objective of FADA is to bridge the gap between AI-based image analysis and routine clinical practice. Unlike conventional research prototypes that terminate at prediction generation, FADA incorporates image upload, automated analysis, clinician interaction, decision support, and report generation within a single operational workflow.

The platform enables healthcare practitioners to upload fetal ultrasound scans, review automated findings, obtain contextual guidance through the integrated clinical assistance module, and generate structured reports without requiring multiple disconnected systems. This workflow reduces administrative overhead and improves consistency in documentation. The modular architecture also supports future integration with electronic health record (EHR) systems, hospital information systems, and telemedicine platforms.

Limitations and Future Directions

Although FADA demonstrates the potential of AI-assisted prenatal ultrasound assessment, several limitations remain. The current implementation focuses primarily on fetal brain analysis, with emphasis on CSP and LV assessment. Additional anatomical structures and fetal abnormality categories remain outside the present scope of the platform.

Furthermore, evaluation has been conducted using curated and expert-annotated datasets. Broader validation across multiple healthcare institutions, imaging devices, patient populations, and clinical settings is required to establish generalizability and robustness. Regulatory, interoperability, privacy, and clinical governance considerations will also require further investigation before large-scale deployment.

Future development will focus on expanding the annotated dataset, incorporating additional fetal anatomical structures, enhancing anomaly detection capabilities, and conducting multi-center clinical validation studies. Planned enhancements also include integration with healthcare information systems, explainable AI mechanisms for improved transparency, and advanced decision-support functionalities to further assist clinicians during prenatal assessment and reporting.

CONCLUSION

FADA is an AI-enabled healthcare informatics platform for prenatal ultrasound assessment that integrates fetal brain image analysis, clinical decision support, and automated report generation within a single workflow. Built upon a repository of more than 3,000 expert-annotated fetal brain ultrasound images, the platform supports assessment of clinically significant structures such as the Cavum Septum Pellucidum (CSP) and Lateral Ventricles (LV). The paper presented the clinical rationale, system architecture, AI analysis pipeline, and workflow integration mechanisms that transform ultrasound images into measurements, abnormality indicators, clinical interpretations, and structured reports. By combining automated image interpretation with clinician-facing decision-support and documentation capabilities, FADA extends beyond conventional algorithm-centric solutions toward practical deployment in prenatal care settings. The platform demonstrates the feasibility of unifying AI-assisted diagnosis and healthcare informatics functions, while future development will focus on broader anatomical coverage, larger multi-institutional datasets, and clinical validation across diverse healthcare environments.

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