AI-DRIVEN REAL-TIME ANALYSIS OF AMNIOTIC FLUID INDEX FOR FETAL HEALTH ASSESSMENT AND DECISION SUPPORT

Project Reference No.: *49S_BE_6323*

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Keywords:

Amniotic Fluid Index (AFI), Ultrasound Imaging, Deep Learning, YOLOv8, Medical Image Segmentation, Random Forest, Fetal Health Assessment, Clinical Decision Support, AI in Healthcare, Prenatal Diagnostics

Introduction:

Amniotic Fluid Index (AFI) is a key diagnostic indicator used in prenatal care to evaluate fetal well-being, detect abnormalities such as Oligohydramnios and Polyhydramnios, and guide timely clinical interventions. The current AFI estimation procedure requires manual measurement of fluid pockets on ultrasound images, a process that is highly dependent on the skill, experience, and judgment of the sonographer or radiologist. The existing approach to calculating AFI requires the fluid pockets to be hand-measured on ultrasound images, which is highly dependent on the skills, experience and discretion of the sonographer or radiologist. Such a manual method brings variability, subjectiveness, and even delays especially in high-risk pregnancies where prompt assessment is essential. The issue of inaccurate diagnosis and poor maternal-fetal outcomes is even exacerbated in most low-resource or remote clinical environments due to insufficient access to trained professionals. The differences in imaging conditions, fetal position, and the quality of the equipment make it difficult to provide constant interpretation and increase the need of automation and diagnostic support with no errors. To address these challenges, there is an urgent necessity of an AI-based solution that will be able to segment amniotic fluid pockets in real-time and comply with automated accuracy and calculate AFI directly based on ultrasound images. Such a system should improve consistency, reduce reliance in the operators and enable quick clinical decision making at the same time ensuring interpretability and clinical reliability. The proposed solution will enhance the results of the prenatal care and simplify it by combining the deep-learning-based processing with the decision-support classification.

Objectives:

1. Develop an AI-driven system for automated estimation of Amniotic Fluid Index (AFI) from ultrasound images.
2. Design and implement a deep learning–based segmentation model to accurately detect amniotic fluid pockets.

3. Compute AFI automatically using geometric measurements from segmented regions.
4. Integrate fetal physiological parameters for fetal condition classification using machine learning.
5. Reduce operator dependency and improve measurement consistency.
6. Enable real-time clinical workflow support for faster diagnosis.
7. Demonstrate the fe asibility of AI-based decision support in prenatal healthcare.

Methodology:

1. The proposed methodology follows a structured pipeline for automated AFI estimation and fetal health assessment. Initially, ultrasound fetal images were collected and annotated using Roboflow to identify amniotic fluid regions as regions of interest (ROI). The dataset was divided into training, validation, and testing sets to ensure reliable model evaluation. Data preprocessing steps included normalization, resizing, and cropping to improve model performance and training efficiency.
2. A YOLOv8 segmentation model was trained to automatically detect and segment amniotic fluid pockets in ultrasound images. The model uses convolutional neural network architecture and is optimized using bounding box, mask, and confidence losses for accurate localization and segmentation. After segmentation, binary masks were processed using OpenCV techniques to extract contours of fluid regions. The longest vertical pocket in each quadrant was computed using geometric analysis, and pixel values were converted into centimeters using scaling factors. The AFI value was then calculated by summing measurements across four quadrants based on standard obstetric practice.
3. To enhance clinical relevance, fetal monitoring parameters such as baseline fetal heart rate, accelerations, fetal movements, uterine contractions, and decelerations were incorporated. A Random Forest classifier was trained using these parameters and AFI values to classify fetal conditions into Normal, Suspect, and Pathological categories. Finally, a chatbot interface was integrated to provide context-aware explanations of results and support clinical interpretation, forming a complete decision-support system.

Result and Conclusion:

1. The developed system demonstrated strong performance across all modules. The YOLOv8 segmentation models achieved high accuracy in detecting amniotic fluid regions, with YOLOv8-s providing the best balance between speed and performance. The segmentation outputs enabled reliable AFI estimation using automated geometric measurements. The AFI computation module showed close agreement with ground truth values, achieving a mean absolute error of approximately 3.55%, indicating high clinical reliability.
2. The Random Forest classifier achieved strong performance with approximately 97% accuracy, effectively distinguishing between normal and abnormal fetal conditions. Overall, the integrated pipeline successfully automated AFI estimation and fetal condition assessment with minimal human intervention. The results demonstrate that

AI-based automation can significantly reduce variability, improve efficiency, and support real-time clinical decision making in prenatal care.

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Future Scope:

The future scope of this project includes:

1. Improve dataset diversity by including ultrasound images from multiple institutions, trimesters, and imaging equipment.
2. Enable real-time integration with ultrasound machines for live AFI measurement during scanning.
3. Explore advanced deep learning models such as Vision Transformers (ViT) and Segment Anything Model (SAM) for improved segmentation accuracy.