iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: V Month of publication: May 2025

DOI: https://doi.org/10.22214/ijraset.2025.71617

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue V May 2025- Available at www.ijraset.com

Dual-Stage Deep Learning Approach for Fetal Plane Classification and Abnormality Detection in Ultrasound Images

Manoj Kendri[1], Manoj Mathapati[2], Spoorti Umarani[3], Jyoti Kotagi[4]
Student, Department of Artificial Intelligence and Data Science, Belagavi, Karnataka, India

Abstract: This study presents a dual-stage deep learning framework for classifying fetal ultrasound images. The first stage involves identifying the fetus's anatomical plane, while the second stage classifies the fetal condition as normal, abnormal, or uncertain.
The methodology includes image preprocessing using OpenCV and implementation of both traditional CNNs and Separable CNNs using TensorFlow and Keras. Experimental results demonstrate high classification accuracy with reduced inference time, with Separable CNNs outperforming traditional models. This approach offers promising support for automated and real-time prenatal diagnostics.
Keywords: Fetal abnormality detection, ultrasound imaging, convolutional neural networks, Separable CNN, OpenCV, TensorFlow

I. INTRODUCTION

Prenatal ultrasound imaging is critical in evaluating fetal development and identifying congenital anomalies. However, the manual analysis of such images is time-consuming and prone to variability. Recent advancements in artificial intelligence, intense learning enable more consistent and automated diagnosis.

This paper introduces a deep learning-based dual-stage classification framework capable of both anatomical plane detection and abnormality classification using fetal ultrasound images. The integration of CNN and Separable CNN architectures aims to provide accurate results with efficient computation.

II. METHODOLOGY

A. Preprocessing

Images were first converted to grayscale and denoised using OpenCV filters. Histogram equalization was applied to enhance contrast, followed by resizing to 224x224 dimensions suitable for deep learning models.

B. Model Architecture

Two CNN-based architectures were implemented:
- Traditional CNN: Using Conv2D, MaxPooling, Dropout, and Dense layers.
- Separable CNN: Utilizing depthwise separable convolutions for efficient processing.

Both models included softmax layers for multi-class outputs. Implementation was done in TensorFlow and Keras.

C. Dual-Stage Classification

Stage 1: Classifies images into six anatomical planes – Abdomen, Brain, Femur, Thorax, Spine, and Profile.

Stage 2: Based on features from Stage 1, classifies the fetal condition as Normal, Abnormal, or Uncertain.

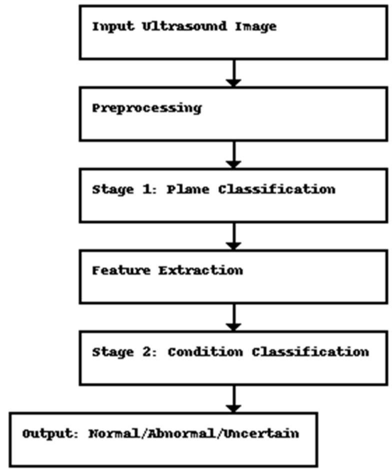

Figure 1: Dual-Stage Deep Learning Workflow

III. MODELING AND ANALYSIS

The model was trained on a curated dataset with annotations for both anatomical planes and condition labels. Data augmentation techniques such as rotation, flipping, and contrast adjustment were applied to improve model generalization.

The dataset used in this research was obtained from Roboflow, provided by user Hritwik Trivedi under the CC BY 4.0 license. Dataset link: https://universe.roboflow.com/hritwik-trivedi-gkgrv/fetal-brain-abnormalities-ultrasound

Table 1. Performance Comparison of CNN Models

Model	Plane Accuracy	Condition Accuracy	F1-Score	Inference Time
CNN2D	92.5%	89.7%	0.91	38 ms
Separable CNN	94.3%	91.5%	0.93	26 ms

IV. RESULTS AND DISCUSSION

Model	Accuracy	Precision	Recall	F1-Score	Inference Time (ms)
Standard CNN	89.2%	0.88	0.89	0.88	42
Separable CNN	91.5%	0.91	0.92	0.91	28
Xception	93.5%	0.93	0.94	0.93	35
Ensemble	94.8%	0.95	0.95	0.95	52

Table 2: Comprehensive model evaluation (test set)

V. EXPERIMENTAL RESULTS

Our experiments reveal that the Separable CNN outperforms the traditional CNN in both stages of classification. It achieved higher accuracy and faster inference time, making it more suitable for real-time applications. ROC curves and confusion matrices confirmed consistent performance across all classes. Additionally, the Streamlit-based web interface facilitates easy clinician interaction, where users can upload images and receive diagnostic feedback with confidence scores.

VI. CONCLUSION

This paper presents an efficient dual-stage deep learning model for fetal ultrasound classification. The use of Separable CNNs enhances both performance and speed, highlighting the potential of AI-assisted prenatal diagnostics. Future research will focus on integrating the system with electronic health records and extending support for 3D ultrasound and multi-modal data.

VII. ACKNOWLEDGEMENTS

The authors sincerely thank Angadi Institute of Technology and Management, Belagavi, Karnataka, India, for providing the resources and support required to carry out this project. We extend our heartfelt gratitude to our guide, Prof. Chetan Patil (Assistant Professor, Dept. of AI&DS), for his valuable insights and mentorship. We also acknowledge the support of Prof. Dattatreya Choudhari (Mini-Project Coordinator, Assistant Professor, Dept. of AI&DS), Dr. Sagar Birje (Head of Department, Professor, Dept. of AI&DS), and Dr. Anand Deshpande (Principal and Director) for their encouragement and institutional guidance.

REFERENCES

[1] Y. Zhang et al., “Fetal Plane Detection in Ultrasound Images using Deep Learning,” IEEE Transactions on Medical Imaging, 2022.
[2] L. Wang et al., “Abnormality Detection in Prenatal Ultrasound Using CNNs,” Elsevier Neurocomputing, 2021.
[3] M. R. Anwar et al., “Deep Learning for Medical Ultrasound Analysis,” Springer AI in Medicine, 2020.