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Automated Early Detection of Fetal Brain Anomalies in First-Trimester Ultrasound Using Deep Learning

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Introduction

Timely detection of fetal brain abnormalities is critical for immediate intervention. First-trimester ultrasonography (US) presents challenges due to small fetal anatomy and variability among operators. This study develops a deep learning model to automate detection of fetal brain anomalies in first-trimester US images using convolutional neural networks (CNNs) and transfer learning.

Methods

A dataset of 548 first-trimester ultrasound scans (514 normal, 34 abnormal) from 2019–2024 was preprocessed by grayscale conversion, thresholding, and region of interest extraction. Class imbalance was corrected by augmenting abnormal images 35-fold (flipping, rotation $\pm 30^\circ$, brightness adjustment) and increasing normal images through duplication. A ResNeXt-50 32x4d CNN pre-trained on ImageNet was fine-tuned using Focal Loss ($\alpha=1$, $\gamma=2$) and trained with the Adam optimizer (learning rate= $1e-4$, batch size=16) in five-fold cross-validation.

Conclusion

This CNN-based approach achieved near-perfect accuracy in detecting fetal brain anomalies from first-trimester ultrasound images. Future work should validate these findings on larger and more diverse datasets, include other anomalies, and assess performance across multiple ultrasound devices. These results highlight AI's potential in early prenatal diagnosis.

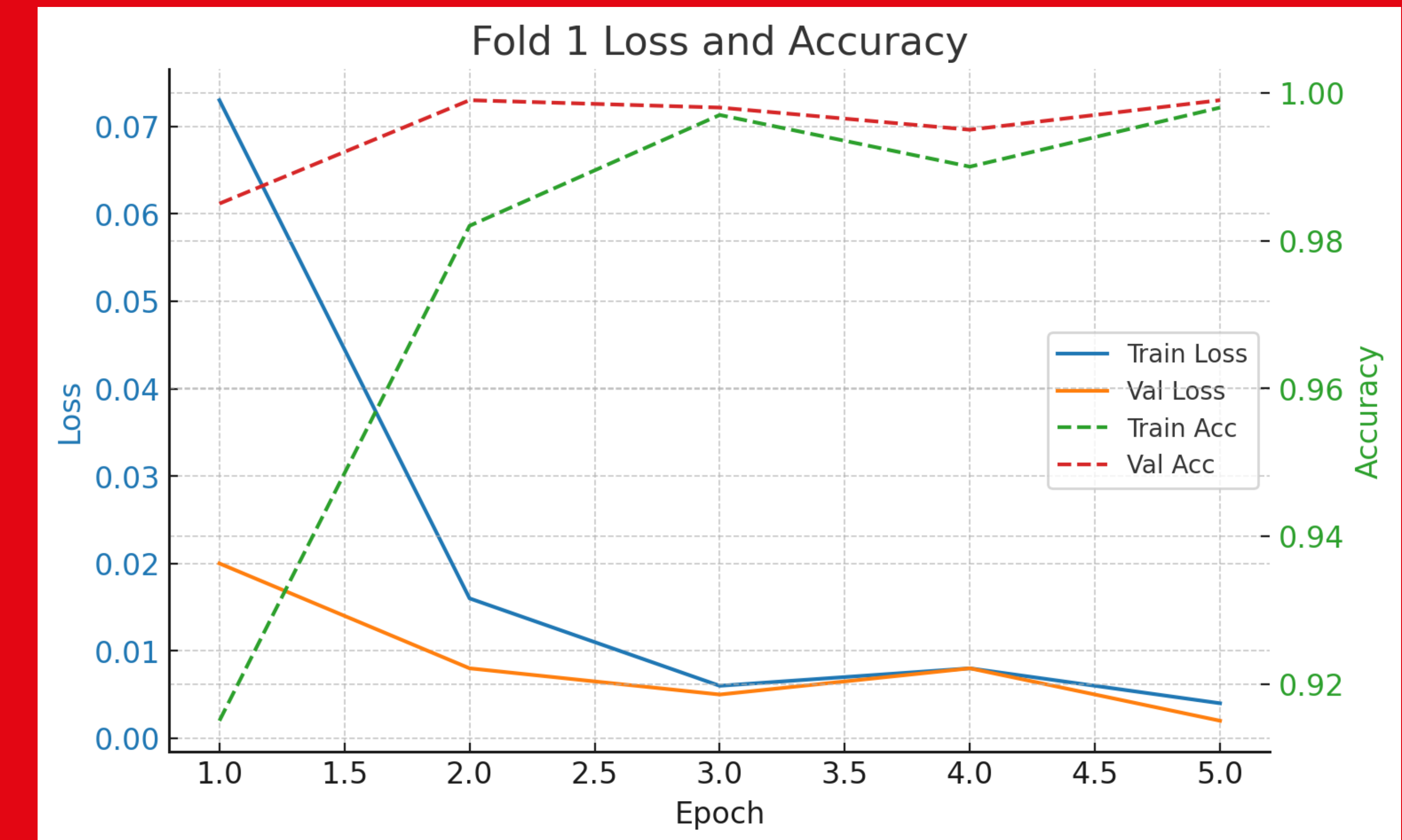


Figure 1. Training and validation loss and accuracy over epochs (Fold 1).

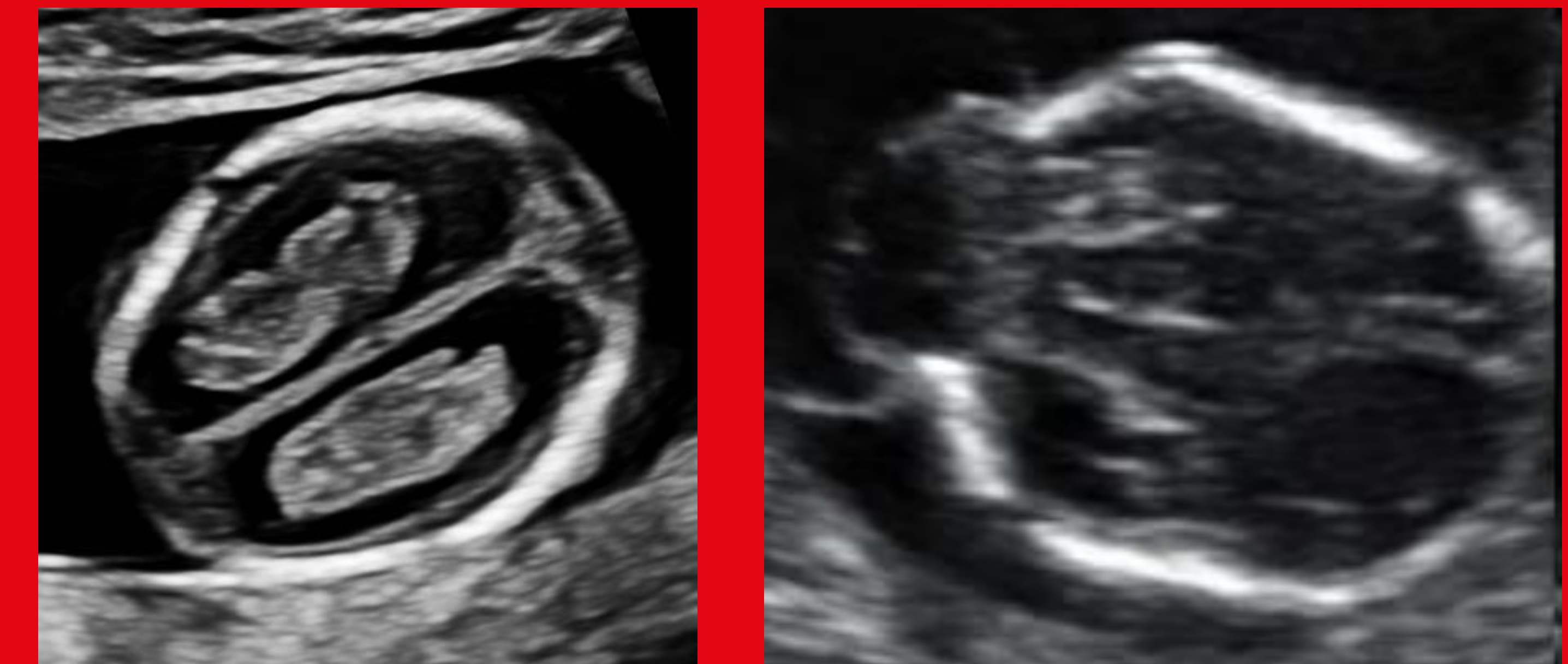


Figure 2. Normal and abnormal ultrasound images of the fetal brain.