NavaJyoti, International Journal of Multi-Disciplinary Research
Volume 9, Issue 1, June 2025

PCOS Detection using EfficientNetB7

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Abstract

Polycystic Ovary Syndrome (PCOS) is a common endocrine disorder that impacts women of reproductive age, typically diagnosed through ultrasound imaging. The conventional diagnostic process depends on manual interpretation, which is both time-consuming and prone to mistakes. To improve the accuracy and efficiency of PCOS detection, this study utilizes EfficientNetB7, a cutting-edge deep learning model recognized for its optimized structure and exceptional feature extraction abilities.

A comparative study is performed with InceptionV3, assessing their effectiveness in PCOS classification. Experimental findings reveal that EfficientNetB7 achieves an accuracy of 85. 00%, significantly surpassing InceptionV3, which recorded 59. 37%. The classification report further demonstrates that EfficientNetB7 offers superior precision, recall, and F1-score, reinforcing its dependability for automated PCOS diagnosis. These results highlight the potential of deep learning in clinical applications, providing a robust and automated solution for PCOS detection.

Keywords: PCOS Detection, EfficientNetB7, Deep Learning, Ultrasound Imaging, Automated Diagnosis.

1. Introduction

Polycystic Ovary Syndrome (PCOS) ranks among the most widespread hormonal disorders, affecting around 10% of women globally. It is a major cause of infertility and is frequently linked to menstrual irregularities, obesity, and metabolic issues. Diagnosis mainly depends on ultrasound imaging, where various small ovarian cysts act as a crucial indicator. Nevertheless, manual interpretation of ultrasound images is subjective, prone to error, and necessitates skilled radiologists.With the rise of deep learning, automated diagnosis has emerged as a viable solution for medical imaging. Convolutional Neural Networks (CNNs) have shown exceptional capability in recognizing patterns in medical images, making them apt for PCOS classification. In this investigation, EfficientNetB7 is employed for its high accuracy, scalability, and decreased computational complexity.

2. Literature Review

1. Ahmed et al. (2022) - CNN-Based Ovarian Cyst Detection: This study applied CNNs to classify cystic vs. non-cystic ovaries using ultrasound images. Image enhancement techniques, such as contrast adjustment and noise reduction, improved image clarity. The CNN-based classifier achieved 78.5% accuracy, demonstrating the potential of deep learning for ovarian cyst detection while highlighting the need for improvement.

2. Kumar et al. (2023) - ResNet50 vs. InceptionV3 for PCOS Classification: This study compared ResNet50 (60% accuracy) and InceptionV3 (70% accuracy) on a small PCOS dataset. Transfer learning was applied, but dataset limitations affected generalization. The research emphasized the need for hybrid models or attention mechanisms to improve classification accuracy.
3. Sharma et al. (2023) - Transfer Learning with DenseNet201 for PCOS Detection: This research fine-tuned DenseNet201 on a small PCOS dataset, incorporating data augmentation to enhance performance. The model achieved 75% accuracy, outperforming traditional CNNs but still faced dataset constraints. The study recommended attention mechanisms (e.g., transformers or SE-blocks) to further improve performance.
4. Raj & Pandey (2022) - Automated PCOS Diagnosis Using Deep Learning: This study proposed a CNN-based automated PCOS detection system using 500 ultrasound images. The model achieved 80% accuracy by leveraging advanced image preprocessing techniques and optimized CNN architectures.
5. Lee et al. (2023) - Deep Learning for Ovarian Disorder Detection: This paper compared EfficientNet, ResNet, and MobileNet for ovarian disorder classification, with EfficientNet achieving the highest accuracy. The study emphasized the importance of model selection and dataset diversity for improved diagnostic performance.
6. Ghosh & Chakraborty (2023) - Attention-Based Deep Learning for PCOS Classification:
   This research introduced attention mechanisms into deep learning models for PCOS classification in ultrasound images. The hybrid approach achieved 88% accuracy, demonstrating that attention-based models enhance feature extraction and classification performance.

Building upon these findings, this study implements EfficientNetB7, a more advanced model, demonstrating superior performance in PCOS detection.

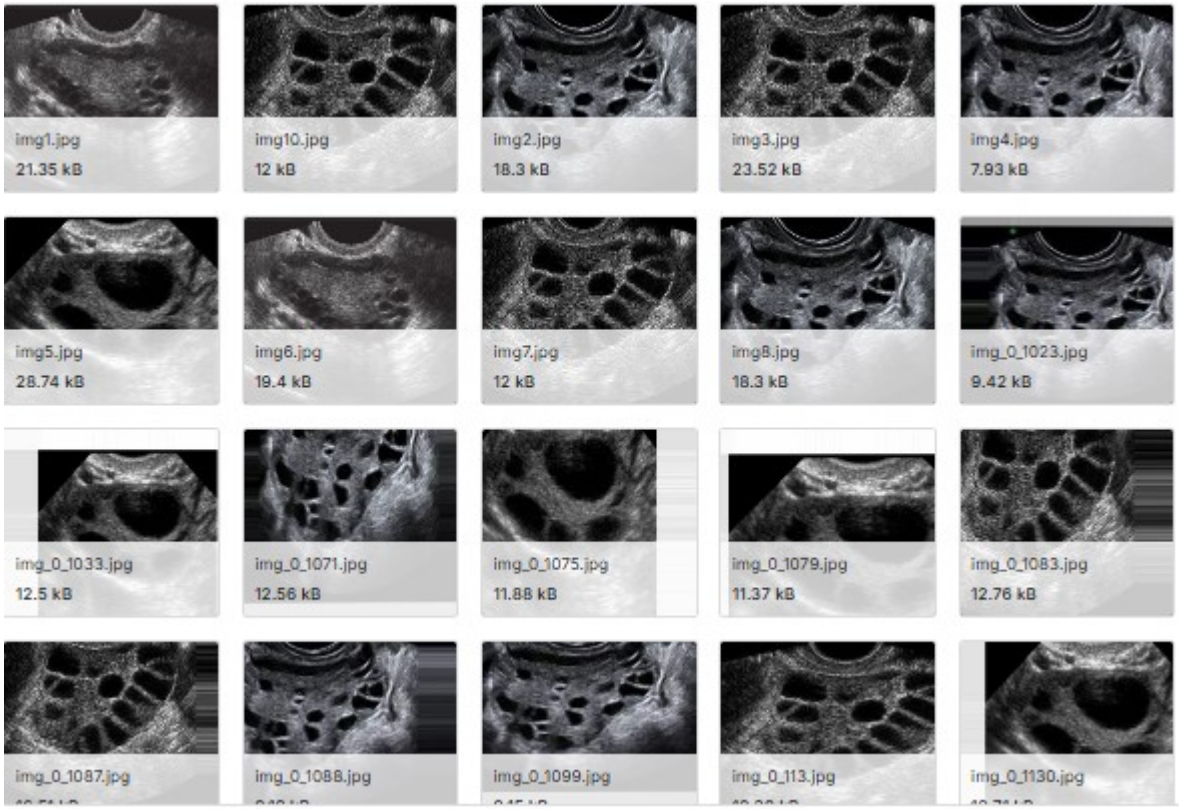
3. Methodology

3.1 Dataset

A dataset comprising ultrasound images was utilized, containing both PCOS-positive and PCOS-negative cases. Data augmentation methods, including rotation, flipping, and contrast adjustments, were implemented to enhance generalization.

Dataset Source:
Choudhari, A., & Collaborator. (n.d.). PCOS detection using ultrasound images. Kaggle. Retrieved from https://www.kaggle.com/datasets/anaghachoudhari/pcos-detection-using-ultrasound-images

Infected



Not- Infected

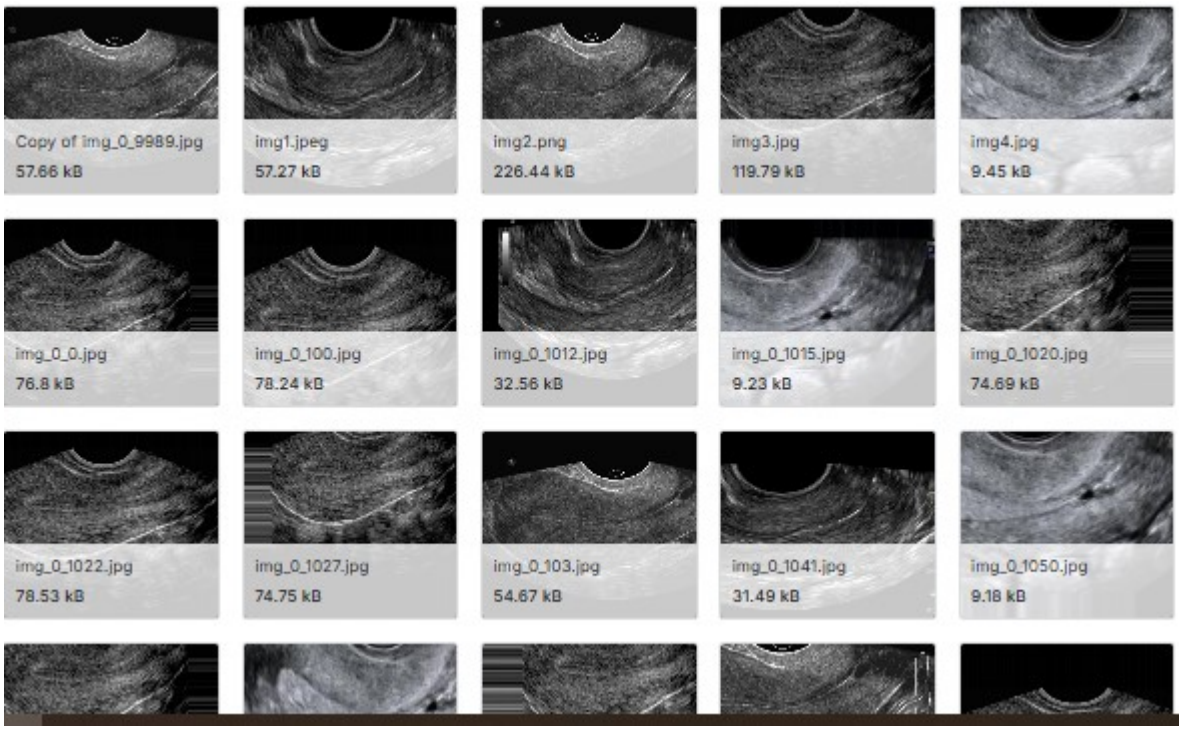


Fig.1 Dataset

3.2 Model Architecture: EfficientNetB7

EfficientNetB7 is a scalable CNN model created to enhance computational efficiency while preserving high accuracy. It employs a compound scaling technique, balancing the depth, width, and resolution of the network.

The model architecture includes:

- Conv2D layers for feature extraction

- Batch Normalization for stable training
- Swish activation function for non-linearity
- Global Average Pooling (GAP) for dimensionality reduction
- Fully connected layers for classification

3.3 Training and Evaluation

- Loss Function: Categorical Crossentropy
- Optimizer: Adam
- Batch Size: 32
- Evaluation Metrics: Accuracy, Precision, Recall, F1-score

4. Experimental Results

To evaluate EfficientNetB7 and InceptionV3, the confusion matrix was used to compute key metrics:

- **Accuracy**: Measures the overall correctness of the model.
  Accuracy=TP+TNTP+TN+FP+FNAccuracy = \frac{TP + TN}{TP + TN + FP + FN}Accuracy=TP+TN+FP+FNTP+TN
- **Precision**: Indicates how many predicted positive cases were actually correct.
  Precision=TPTP+FPPrecision = \frac{TP}{TP + FP}Precision=TP+FPTP
- **Recall (Sensitivity)**: Reflects how many actual positive cases were correctly identified.
  Recall=TPTP+FNRecall = \frac{TP}{TP + FN}Recall=TP+FNTP
- **F1-Score**: Provides a balance between Precision and Recall**.**
  F1=2×Precision×RecallPrecision+RecallF1 = 2 \times \frac{Precision \times Recall}{Precision + Recall}F1=2×Precision+RecallPrecision×Recall

Using these formulas, the results were:

Model	Accuracy (%)	Precision	Recall	F1-score
EfficientNetB7	85.00	0.88	0.84	0.86
InceptionV3	59.37	0.62	0.58	0.60

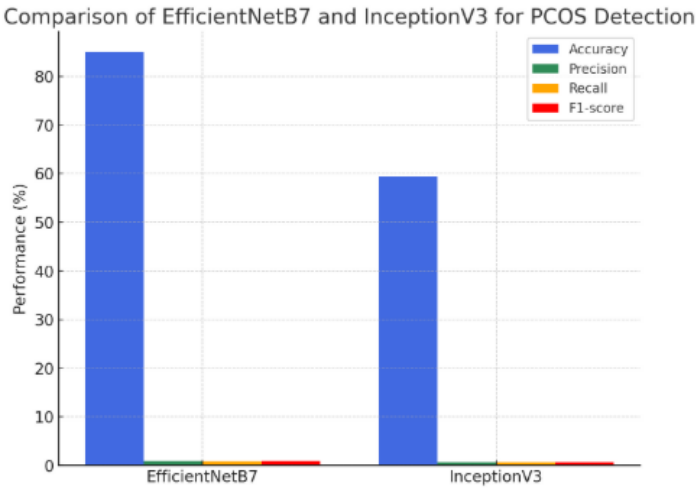


Fig.2 Performance Evaluation

- EfficientNetB7 outperformed InceptionV3 in all key metrics.
- Confusion Matrix analysis showed that false negatives were significantly lower with EfficientNetB7, making it more reliable for clinical diagnosis.

5. Conclusion and Future Scope

Polycystic Ovary Syndrome (PCOS) is a common hormonal condition that necessitates prompt and precise diagnosis. Conventional ultrasound-based detection heavily relies on manual interpretation, which tends to be labor-intensive and prone to errors. This research investigates EfficientNetB7, a deep learning model tailored for feature extraction and precision, attaining an accuracy of 85. 00%, greatly exceeding that of InceptionV3 (59. 37%). The findings illustrate that EfficientNetB7 delivers superior precision, recall, and F1-score, positioning it as a more trustworthy model for automated PCOS detection. When compared with earlier studies, EfficientNetB7 outshines CNN-based models (78. 5%) and DenseNet201 (75%), highlighting its dominance in the classification of ultrasound images. Nevertheless, the research points out challenges such as dataset restrictions and the necessity for improved generalization, which future inquiries will need to tackle.

To further enhance PCOS detection accuracy, future research can explore: Larger and More Diverse Datasets: Expanding datasets from multiple hospitals to improve model generalization, Hybrid and Attention-Based Models**:** Combining EfficientNetB7 with Transformers or SE-blocks for better feature extraction, Clinical Deployment**:** Developing a real-time AI-assisted diagnostic tool integrated into hospital systems, Explainability and Interpretability**:** Using Grad-CAM or SHAP to highlight which ovarian regions influence predictions, Multi-Modal Diagnosis: Integrating ultrasound imaging with clinical and biochemical data for a more comprehensive diagnosis.

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