

Edge AI-Based PCOS Prediction Using Ovarian Ultrasound Images

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ABSTRACT

Polycystic Ovary Syndrome (PCOS) is a common hormonal disorder that affects many women across the world. Accurate analysis of ovarian ultrasound images is important for proper diagnosis. Traditional diagnostic methods are time-consuming and depend heavily on the doctor's experience.

This project presents an Edge AI-based system for predicting PCOS using deep learning techniques. The system automatically classifies ultrasound images as PCOS or non-PCOS. A lightweight Convolutional Neural Network (CNN), specifically MobileNetV2, is used and optimized for edge devices like Raspberry Pi and NVIDIA Jetson Nano.

Image preprocessing techniques such as noise removal, contrast improvement, and region selection are applied to enhance performance. Unlike cloud-based systems, this approach processes data locally, which improves privacy and reduces delay. Explainable AI methods like Grad-CAM are also used to visualize predictions and assist doctors.

The results show high accuracy and real-time performance, making the system suitable for rural and low resource areas. This solution is cost-effective and helps in early detection of PCOS.

KEYWORDS :PCOS, Edge AI, Deep Learning, Convolutional Neural Network (CNN), Ultrasound Imaging, Medical Image Processing, MobileNetV2, Grad-CAM, Edge Computing, Healthcare AI

INTRODUCTION

PCOS is a serious health condition that affects a large number of women globally, but detecting it can be difficult. It may cause hormonal imbalance and cyst formation, and sometimes it is not clearly visible in normal ultrasound scans. Diagnosis usually depends on expert analysis, which may vary between doctors.

Artificial intelligence has shown good results in medical image analysis, so it can also be applied to PCOS detection. However, most AI systems require internet connectivity and cloud processing, which raises privacy concerns and may not work well in rural areas.

Edge AI solves this problem by running the model directly on the device instead of using cloud servers. It provides faster results, better privacy, and works without internet connection. Devices like Jetson Nano and Google Coral can be used to build portable systems that classify ultrasound images in real time.

This system acts as a support tool for doctors, especially in areas where specialists are not available, and helps improve healthcare accessibility.

I LITERATURE REVIEW

Many studies have used artificial intelligence and deep learning for medical image analysis, including PCOS detection. Traditional methods rely on manual interpretation, which can be subjective and less accurate.

Recent research shows that deep learning models such as CNNs (e.g., U-Net and MobileNet) can effectively extract features from ultrasound images and improve diagnostic performance.

Several studies have explored the use of artificial intelligence and deep learning techniques for medical image analysis, particularly in the detection of Polycystic Ovary Syndrome (PCOS). Traditional diagnostic methods rely on manual interpretation of ultrasound images, which is often subjective and dependent on expert knowledge. Recent research has demonstrated that Convolutional Neural Networks (CNNs), such as U-Net and MobileNet, can effectively extract features from ovarian ultrasound images and improve diagnostic accuracy.

Existing AI-based systems primarily utilize cloud computing for processing medical data, offering high computational power but introducing challenges such as increased latency, dependency on internet connectivity, and potential privacy risks. Lightweight deep learning models like MobileNet and EfficientNet have been proposed to address computational constraints, enabling faster and efficient predictions. Additionally, techniques such as Grad-CAM have been widely adopted to provide explainability in medical imaging applications.

However, many existing approaches are limited by high infrastructure costs, lack of real-time processing, and reduced applicability in rural or resource-constrained environments. To overcome these limitations, recent advancements focus on Edge AI, where models are deployed directly on local devices. This approach ensures low latency, enhanced data privacy, and improved accessibility, making it suitable for real-world healthcare applications.

II EXISTING SYSTEM

Doctors currently diagnose PCOS in women through physical examinations and manual review of ultrasound scans. Radiologists must check for large ovaries and many tiny follicles. Problem: It relies too much on who is viewing the screen. Test results vary because every piece of equipment and clinician is different. It takes skill, and if the person isn't an expert, they might not get it right.

Most "smart" systems today use the cloud, sending photos to a remote server for processing. Though strong, these have many drawbacks. Internet is pricey and poor in most rural places. Also, hackers worry people. when they send private medical photos over the internet. Older studies also used very heavy AI programs that can't run on a regular computer in a small clinic. Some systems use old-school math, but they don't work well when the picture is blurry or there is "noise" in it. In general, Current approaches are too expensive, slow, or inaccurate for real-world use.

III PROPOSED SYSTEM

The proposed system is an Edge AI-based solution for automatic detection of Polycystic Ovary Syndrome (PCOS) using ovarian ultrasound images. It performs image preprocessing techniques such as noise reduction, contrast enhancement, and region of interest extraction to improve image quality. A lightweight Convolutional Neural Network (CNN), such as MobileNetV2, is used to classify images into PCOS and non-PCOS categories.

The trained model is deployed on edge devices like Raspberry Pi and Jetson Nano, enabling real-time prediction without relying on cloud services. Additionally, Grad-CAM is used to provide visual explanations of predictions. The system ensures fast, accurate, and privacy-preserving diagnosis, making it suitable for rural healthcare environments.

Advantages of Proposed System

1. Real-time PCOS Detection

The system performs fast inference on edge devices, providing instant results. This reduces waiting time for diagnosis and supports quick clinical decisions. Real-time processing improves efficiency in healthcare environments.

2. Data Privacy

All data processing is performed locally on the device without sending information to the cloud. This ensures patient data remains secure and confidential. It minimizes the risk of data breaches and unauthorized access.

3. No Internet Requirement

The system operates completely offline, eliminating dependency on internet connectivity. This makes it highly suitable for rural and remote areas. It ensures uninterrupted performance even in low-network conditions.

4. Lightweight Model

The use of lightweight CNN models like MobileNetV2 reduces computational requirements. It enables deployment on low-power devices such as Raspberry Pi. This also improves speed and energy efficiency.

5. Improved Accuracy

The deep learning model automatically extracts important features from ultrasound images. This reduces human error in manual diagnosis. It enhances consistency and reliability in PCOS detection.

6. Explainable Results

Grad-CAM visualization highlights important regions in the ultrasound image. This helps doctors understand how the model makes decisions. It increases trust and transparency in AI-based diagnosis.

7. Cost-Effective Solution

The system uses affordable edge devices and open-source tools. It reduces the need for expensive cloud infrastructure. This makes it accessible for small clinics and healthcare centers.

SYSTEM ARCHITECTURE

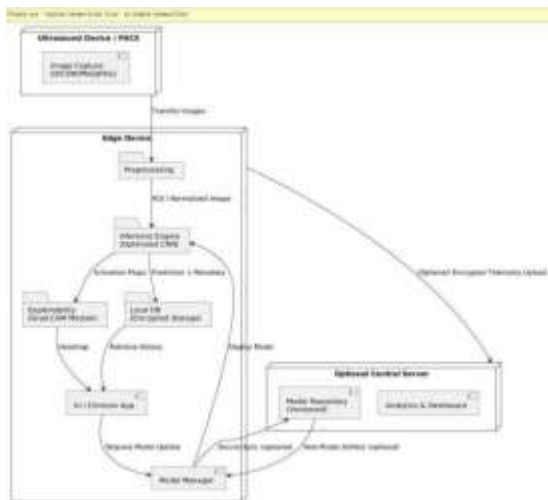


Figure : shows that Architecture Diagram

IV EXPERIMENTAL RESULTS

Before clinical deployment, software testing ensures that the system operates reliably, consistently, and accurately. The proposed system undergoes unit testing, integration testing, and system testing to validate performance.

A. Unit Testing

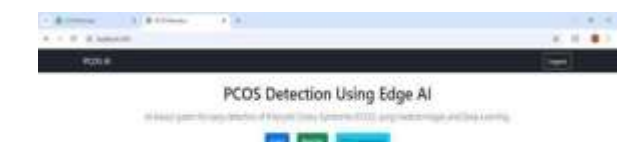
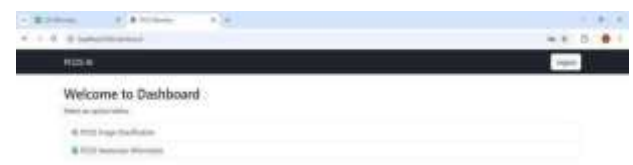
Unit testing verifies individual components such as preprocessing, inference, and user interface logic. Modules tested include grayscale conversion, image denoising, ROI extraction, input validation, model prediction, and heatmap generation. Sample tests ensure correct outputs, such as validating preprocessing results and prediction shapes.

B. Integration Testing

Integration testing evaluates the interaction between system modules. It includes communication between UI and preprocessing, preprocessing and CNN model, CNN and explainability module, and explainability with report generation. The system is tested for handling invalid inputs and maintaining performance with degraded image quality.

C. System Testing

System testing assesses the complete workflow under real-world conditions. Test scenarios include processing diverse ultrasound datasets, handling low-contrast and noisy images, real-time execution on edge devices, and batch processing under heavy workloads. The expected outcomes include stable performance, accurate predictions, and robustness against noise





V CONCLUSION

This project essentially demonstrated that we don't need any of those pricey cloud setups to create a functional "Edge AI" system for identifying PCOS. The system became extremely quick and accurate by employing "lean" AI models and clever methods to clean up the images. Small clinics and rural places with limited funds and technology benefit from it. Everything remains on the device because of the way the system is constructed. This indicates that there is no lag or waiting for the screen to load, and the privacy is very strong. It performed flawlessly on all of the hardware I tested it on, including the Raspberry Pi and the Jetson Nano. Additionally, doctors can actually see the reasoning behind the predictions thanks to the "explainable AI" features, which greatly increases their confidence when using it.

The results show that genuine doctors can employ this strategy. Medical equipment should be provided to all, even those far from large facilities. substantial improvement. It shows how AI can make exams faster, cheaper, and more private for women, improving their health.

FUTURE ENHANCEMENTS

Medical specialists struggle to detect PCOS, a hormone. Ultrasonography can help find this disease, which affects many women. Scans can be very hard to understand. A big expert is needed to look at the pictures right now, and even they make mistakes sometimes. Also, most of "smart" computer programs require a fast internet connection to function, which is a major issue for remote clinics or locations with poor wifi.

In order to address this, my project makes use of "Edge AI." This simply means that I put the computer's intelligent brain inside a small, affordable handheld device like a Raspberry Pi. It's remarkable since it doesn't need the internet. quick and protects all private medical photos on the device instead of in the cloud, where they could be compromised. I employed "lightweight" AI models, which are fast and low-power..

Additionally, the system highlights the areas of the scan that appear to be PCOS so the doctor can see exactly what it's looking at. This increases the doctor's confidence in the device. To make it even more intelligent, we might eventually incorporate data from hormone tests or smartwatches.

VI REFERENCES

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