



Enhanced Prediction of PCOS and PCOD using Deep Learning for Early Diagnosis and Clinical Risk Stratification

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ABSTRACT: Polycystic Ovary Syndrome and Polycystic Ovarian Disease are common endocrine disorders affecting women of reproductive age, often causing infertility, hormonal imbalance, and metabolic issues. Early diagnosis is difficult due to overlapping symptoms and limitations of traditional methods. This study proposes a machine learning–based predictive framework that integrates conventional algorithms with deep learning models such as CNNs and Vision Transformers (ViTs) for accurate early detection and risk stratification. The system identifies hidden patterns and disease indicators that are often missed in manual diagnosis. It also incorporates explainable AI techniques to improve transparency and support clinical decision-making. The framework is deployed as a scalable web-based application using Django, enabling real-time prediction and seamless healthcare integration. Overall, the proposed model improves diagnostic accuracy, supports personalized treatment, and enhances women’s healthcare outcomes through efficient and non-invasive analysis.

KEYWORDS: Deep Learning, Machine Learning, Convolutional Neural Networks, Vision Transformers (ViT), Explainable Artificial Intelligence (XAI), Django Web Framework.

I. INTRODUCTION

Machine Learning (ML), a branch of Artificial Intelligence (AI), enables systems to learn from data and make predictions without explicit programming. In healthcare, ML and Deep Learning (DL) are widely used to analyse medical data and improve disease diagnosis and decision-making. Polycystic Ovary Syndrome and Polycystic Ovarian Disease are common endocrine disorders in women of reproductive age, leading to hormonal imbalance, irregular menstrual cycles, and infertility. Early detection is difficult due to overlapping symptoms and limitations of conventional diagnostic methods. To address this issue, this study proposes a machine learning–based predictive framework integrated with deep learning techniques. The system uses clinical data such as age, BMI, and hormone levels along with ultrasound image analysis using Convolutional Neural Networks (CNNs) to improve prediction accuracy. Explainable AI is also incorporated to make predictions transparent and understandable for clinicians. The proposed system aims to support early diagnosis, improve clinical decision-making, and enhance women’s healthcare outcomes.

II. LITERATURE SURVEY

R. Parvathi and Dr. P. Geetha proposed a system to predict Polycystic Ovarian Disease using Deep Learning models. The system uses medical features like age, weight, hormone levels, and endometrial thickness for analysis. Deep Neural Network (DNN), Convolutional Neural Network (CNN), Recurrent Neural Network (RNN) are used for classification. Among these models, DNN achieved higher accuracy with less computational time and memory usage. This research helps in early detection of PCOD and supports better medical decision-making.[1]

Tanvir Mahmud and S.A Sabbirul Mohosin Naim proposed a system to predict PCOS using SVM. Machine Learning helps systems learn from data and make accurate predictions without explicit programming. The system uses medical datasets with important clinical features for analysis and classification. SVM is used for accurate classification of



PCOS cases. The model performance was evaluated using accuracy, precision, recall, and F1-score. The results showed that the SVM model provides reliable and effective prediction. This research helps in early detection of PCOS and supports better medical decision-making.[2]

Nethra Sai M et al. proposed an advanced diagnosis system for Polycystic Ovary Syndrome using ultrasound images and clinical data. They used the ResNet-50 deep learning model for feature extraction from ultrasound images and applied correlation-based feature selection for clinical data. The extracted features were classified using SVM, Random Forest, and Logistic Regression algorithms to improve the accuracy of PCOS detection.[3]

Natasha Leslie, Angga Aditya Permana, and Analekta Tiara Perdana applied the KNN algorithm to classify Polycystic Ovarian Syndrome based on patient symptoms and characteristics. They tested the model using different training and testing ratios and various K values to find the best accuracy. Their model achieved 100% accuracy with a 90:10 training ratio and K=11 for effective early detection of PCOS.[4]

Ananya Gosh and Kathiravan Srinivasan proposed an ensemble transfer learning model for PCOS detection from ultrasound images. They combined EfficientNetB7 and DenseNet201 with Genetic Algorithm optimization to improve accuracy. Their model achieved better performance than existing methods.[5]

III. PROBLEM STATEMENT

Polycystic Ovary Syndrome (PCOS) and Polycystic Ovarian Disease (PCOD) are complex endocrine disorders affecting a significant number of women worldwide, often leading to infertility, metabolic complications, and psychological stress. Early diagnosis remains a major challenge due to heterogeneous symptoms, lack of standardized diagnostic criteria, and dependence on manual interpretation of clinical and ultrasound data. Existing machine learning and deep learning models, although effective, suffer from limitations such as high computational complexity, poor generalization across diverse populations, and lack of interpretability. Therefore, there is a need for an efficient, scalable, and explainable intelligent system that can integrate multimodal data (clinical, hormonal, and imaging) to provide accurate early detection and risk stratification of PCOS/PCOD, while supporting clinical decision-making with transparent insights.

The proposed system is an intelligent deep learning-based framework for early detection and clinical risk prediction of PCOS and PCOD. It integrates clinical data, hormonal profiles, lifestyle factors, and ultrasound images for comprehensive analysis. CNN and Vision Transformer are used for feature extraction, while XGBoost with hyperparameter tuning is used for accurate classification. SHAP analysis explains the prediction results, and an LLM-based module provides personalized recommendations. The system is deployed as a secure web-based platform using Django.



IV. RESEARCH METHODOLOGY

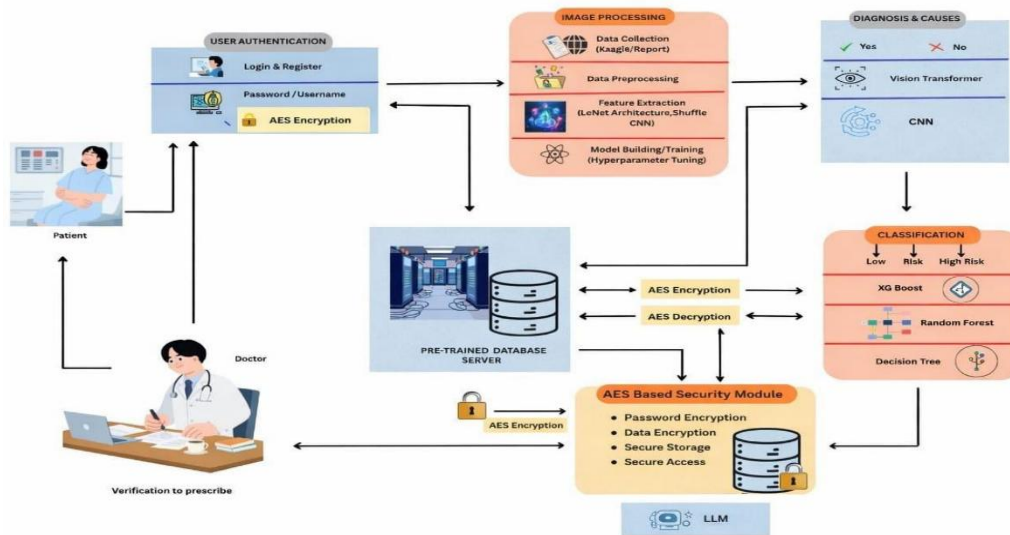


Fig. 1 Architecture of Early Detection and risk stratification of PCOS and PCOD

The system begins with user authentication, where patients and doctors securely log in using encrypted credentials with AES encryption. After authentication, patient data is collected and sent to the image processing module for further analysis. This module performs data collection from sources such as datasets and medical reports. Next, data preprocessing is carried out to clean and normalize the data. The system then performs feature extraction using models like LeNet and Shuffle CNN to identify important patterns. Following this, model training and building is done with proper hyperparameter tuning to improve performance. The processed data is passed to the diagnosis module, where models like Vision Transformer and CNN analyze the condition. Based on the analysis, the system determines whether the patient has risk factors or not. The output is further sent to the classification module, where algorithms like XGBoost, Random Forest, and Decision Tree classify the risk level as low, medium, or high. All sensitive data is stored in a pre-trained database server with AES encryption and decryption for secure access. An additional AES-based security module ensures password protection, secure storage, and controlled data access. The system also integrates an LLM component to assist in Intelligent decision-making and interpretation. Finally, the doctor verifies the results and provides appropriate prescriptions based on the predicted outcomes. The system has the following modules,

1. User Authentication Module

Users can first register and log in to the system using secure credentials such as username, email, and password. During this process, the system verifies the entered details to ensure they are valid and authentic. For security purposes, all sensitive information, especially passwords, is protected using encryption techniques so that medical and personal data cannot be accessed by unauthorized users. Once the user is successfully authenticated, they are allowed to log into the system and securely upload their data for further analysis and processing within the application.

2. Image Processing Module

The system first preprocesses the input image by applying resizing and normalization to ensure uniformity and improve model performance. After preprocessing, important features are extracted using deep learning models such as CNN, LeNet, ShuffleCNN, and Vision Transformer, which help in capturing both basic and complex patterns from the image. These extracted features are then passed to the classification module, where the model analyses them and performs prediction to identify the final output accurately.



Normalization	$X_{norm} = (X - X_{min}) / (X_{max} - X_{min})$
CNN Operation	Output = Activation ($W * X + b$)

Where, X- Input Data
 W- Weights
 b- bias

3. Diagnosis and Classification Module

The system receives the extracted image features from the previous stage and analyzes them using deep learning models such as CNN and Vision Transformer to detect the presence of PCOS or PCOD. To enhance the model's performance and accuracy, hyperparameter tuning is applied by adjusting parameters like learning rate, batch size, and optimization techniques. Based on the analysis, the system classifies the condition into different severity levels such as Low Risk, Medium Risk, or High Risk, helping in early diagnosis and effective medical decision-making.

Sigmoid Function (y)	$1 / (1 + e^{(-x)})$
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Where, y- Sigmoid Function (Output)
 e- Euler's Number

4. Analysis and Remedy Module

Initially, patient symptoms, hormone levels, and medical history are analyzed using machine learning techniques to assess the clinical condition. Based on the analysis results, potential underlying causes of the disorder are identified, and relevant recommendations such as dietary modifications, exercise regimens, and treatment suggestions are generated. A comprehensive report is then produced and submitted to medical experts for validation. Finally, the doctor reviews the system-generated output and confirms the diagnosis, providing the final prescription based on professional clinical judgment.

Accuracy	$(TP + TN) / (TP + TN + FP + FN)$
Precision	$TP / (TP + FP)$
Recall	$TP / (TP + FN)$
F1 Score	$2 * (Precision * Recall) / (Precision + Recall)$

Where, TP- True Positive
 TN- True Negative
 FN- False Negative
 FP- False Positive
 F1- Performance Evaluation Metric

ACCURACY MEASURES

1. Take the values of TP, TN, FP, FN from the confusion matrix
2. Calculate correct predictions
 $TP + TN$
3. Calculate total predictions
 $TP + TN + FP + FN$
4. Apply the formula
 $Accuracy = (TP + TN) / (TP + TN + FP + FN)$



5. Convert to percentage

$$\text{Accuracy} \times 100$$

Sample accuracy measure

$$TP = 50$$

$$TN = 46$$

$$FP = 5$$

$$FN = 5$$

$$\text{Correct predictions} = 50 + 46 = 96$$

$$\text{Total predictions} = 50 + 40 + 5 + 5 = 100$$

$$\text{Accuracy} = 96 / 100 = 0.96$$

$$\text{Final Answer} = 96\%$$

V. RESULT

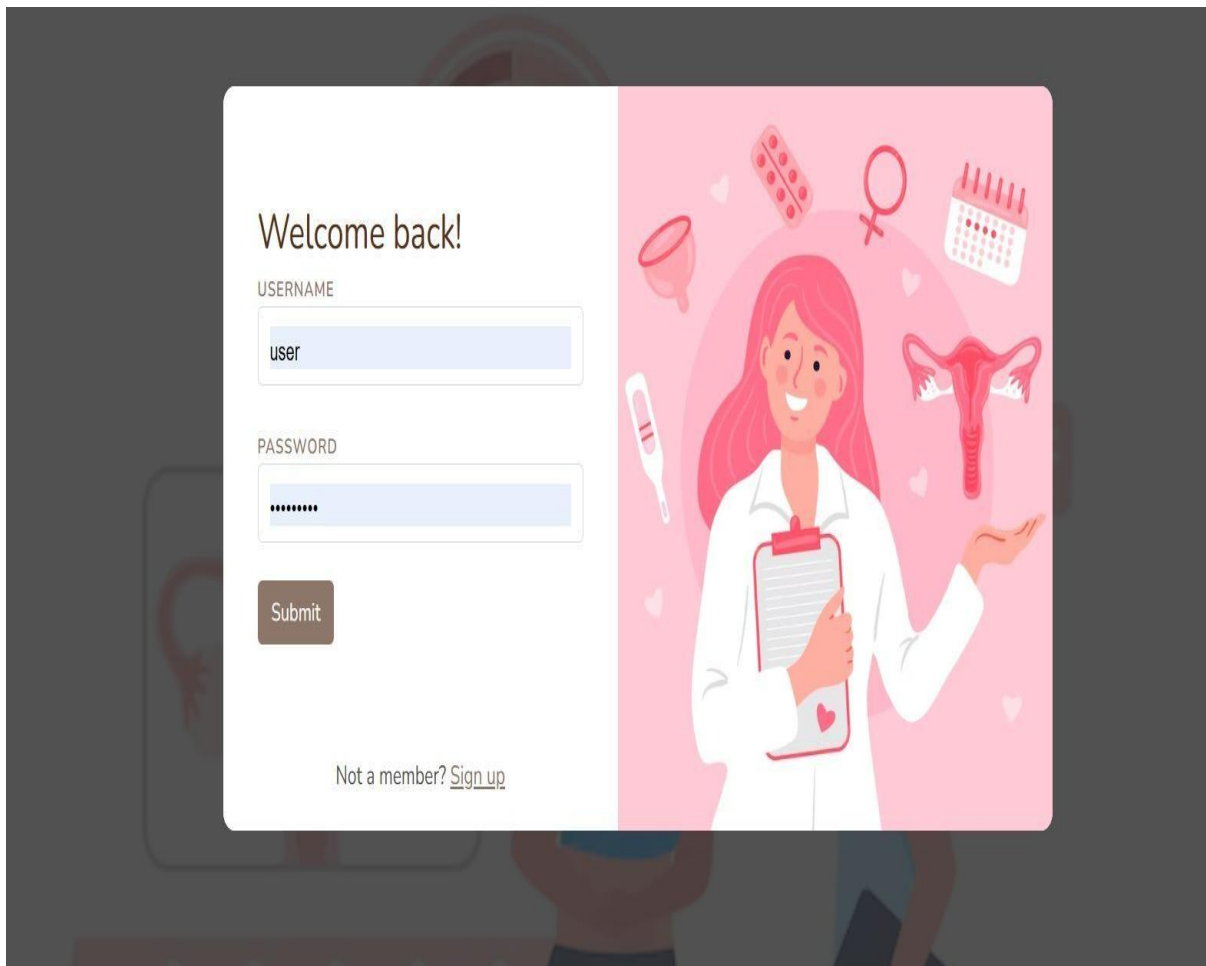


Fig. 2 Login

Fig. 2 shows the Login Page is designed for registered users to securely access their accounts. Users must enter their credentials (username and password) to log in. The system verifies the details and redirects users to the main dashboard upon successful authentication. It ensures privacy and security of user information.

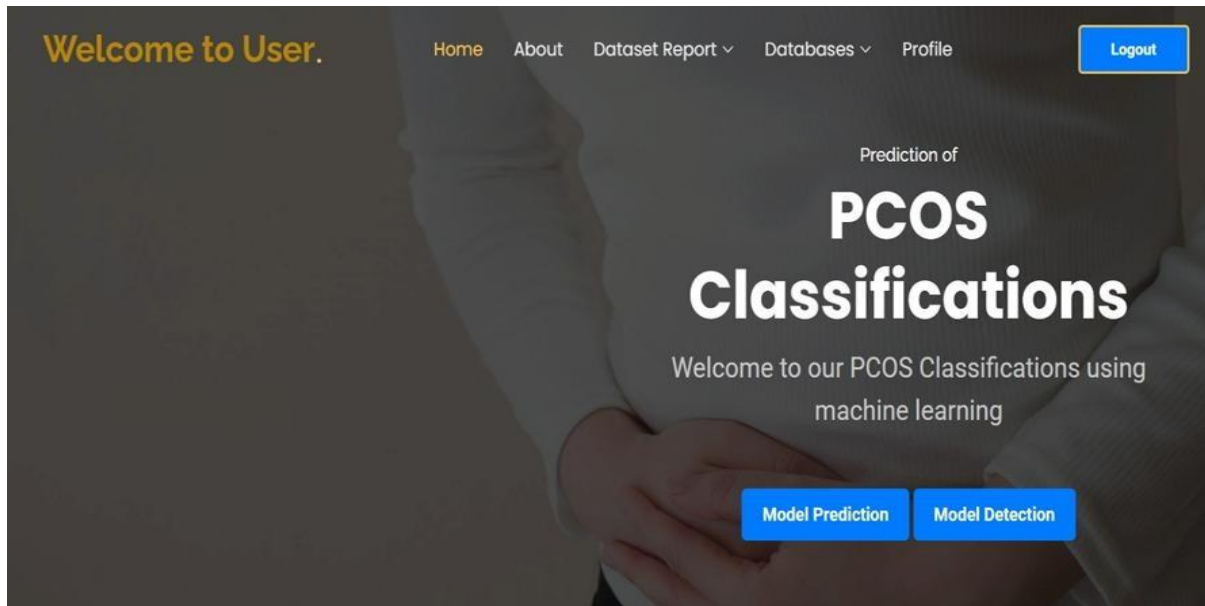


Fig. 3 Home

Fig.3 shows the Home acts as the main dashboard after login. It provides navigation options such as Home, About, Dataset Report, and Profile. This page highlights the core functionality of the system, which is PCOS classification using machine learning. Users can choose options like “Model Prediction” or “Model Detection” to proceed with analysis.

Health Assessment Form

Age

Weight

Height

BMI

Blood Group

Pulse Rate

Fig. 4 Model Prediction

Fig. 4 shows the Health Assessment Form is designed to collect both basic and advanced medical information from the user. It includes parameters such as age, weight, height, BMI, blood group, and pulse rate, along with clinical details like hemoglobin levels, respiratory rate, marital status, pregnancy status, number of abortions, and hormone levels (TSH, PRG). These inputs are used as key features for the machine learning model to analyze and predict the likelihood of PCOS accurately.



No Polycystic Ovary Syndrome (PCOS)

PCOS-Free Image

Description

Polycystic Ovary Syndrome (PCOS) is a common hormonal disorder, but when PCOS is not present, women generally experience regular menstrual cycles and have normal levels of androgens (male hormones). Absence of PCOS means no cysts are present on the ovaries, and symptoms associated with PCOS, such as acne, hirsutism (excessive hair growth), and weight gain, are not observed.

Maintaining Health

Regular Check-ups: Continue with routine gynecological exams to monitor reproductive health and ensure that symptoms of PCOS do not develop.

Healthy Lifestyle: Maintain a balanced diet and regular exercise to support overall well-being and prevent future health issues.

Monitor Symptoms: Be aware of any changes in your menstrual cycle or hormonal balance and consult a healthcare provider if necessary.

Benefits of Not Having PCOS

Regular Menstrual Cycles: Absence of PCOS typically means regular, predictable menstrual cycles, which can be beneficial for reproductive planning.

Reduced Risk of Related Conditions: Women without PCOS may have a lower risk of developing related conditions such as diabetes, heart disease, and endometrial cancer.

Improved Quality of Life: Without the symptoms of PCOS, individuals may experience fewer physical and emotional challenges, leading to an improved quality of life.

Fig. 5 Prediction Result

In the Fig. 5 the result displays the analysis outcome, indicating that the user does not have Polycystic Ovary Syndrome (PCOS). It provides information about normal reproductive health, benefits of not having PCOS, and healthy lifestyle recommendations such as regular check-ups, balanced diet, and exercise to maintain overall well-being.

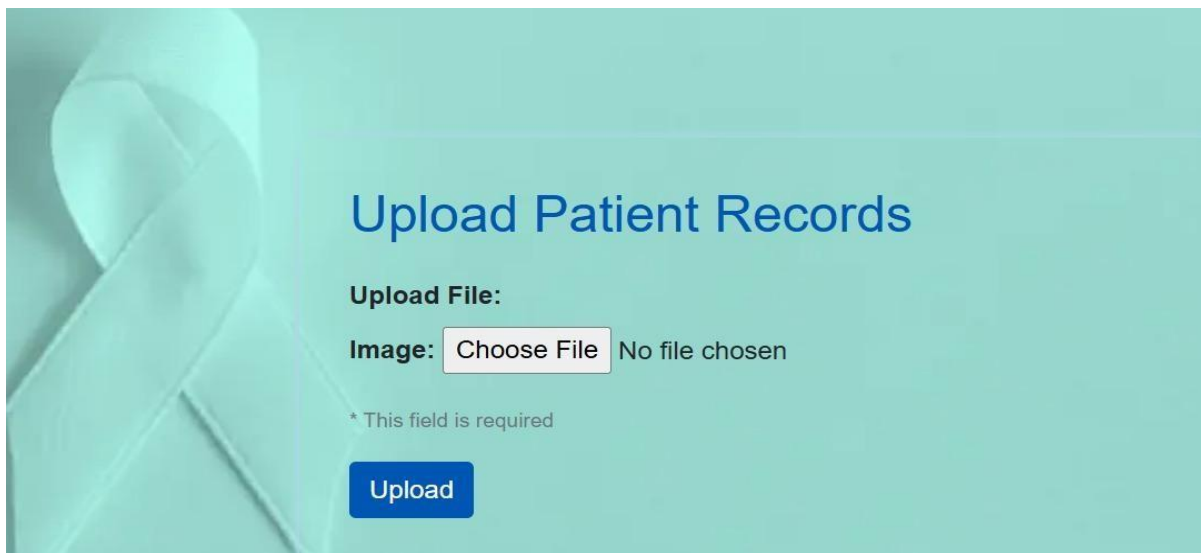
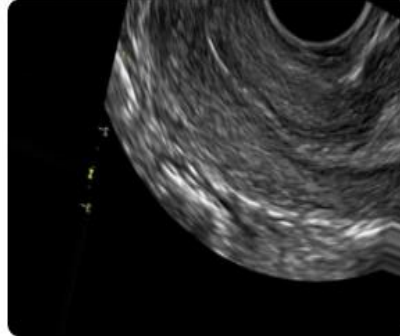


Fig. 6 Model Detection

Fig. 6 shows the Upload Patient Records interface enables secure and efficient submission of patient-related medical data into the system. Users can upload diagnostic images, such as ultrasound scans or clinical reports, through a simple file selection mechanism. The module ensures mandatory validation by requiring a file before submission, thereby preventing incomplete data entries. Once uploaded, the data is stored and made available for further processing, such as analysis, classification, or disease prediction. This component plays a crucial role in maintaining data integrity and streamlining the overall workflow of the healthcare application.



THIS IMAGE DETECTED NOTINFECTED_PCOD

RiskScore: 0%

Fig. 7 Image Classification

Fig. 7 shows the ultrasound image was processed using the proposed deep learning model for PCOD detection. The model classified the input image as “Not Infected (PCOD)” with a risk score of 0%, indicating no detectable features associated with polycystic ovarian disease. The prediction reflects the model’s ability to accurately identify normal ovarian conditions from ultrasound data.

Not Infected PCOD Overview	
Category	Details
Description	Not infected PCOD refers to a condition where ovarian cysts are present but do not cause any significant symptoms or health issues. This indicates that the condition is not currently affecting the body's overall health.
Symptoms	There may be minimal or no symptoms. If symptoms occur, they might include mild irregular menstrual cycles or occasional ovarian cysts that do not lead to severe health problems.
Causes	The causes of PCOD can include hormonal imbalances, genetic factors, or insulin resistance. However, in the case of "not infected PCOD," these factors do not result in significant health concerns.
Prevention	Maintaining a healthy lifestyle, including regular exercise and a balanced diet, can help manage PCOD. Regular check-ups can ensure the condition remains non-infectious and controlled.
Precautions	Regular monitoring through medical check-ups, maintaining a healthy weight, and managing stress are important. Avoiding known triggers that can exacerbate PCOD symptoms is also advised.
Treatment	Treatment may not be necessary if the PCOD is not causing symptoms. If needed, management could involve lifestyle changes, hormonal treatments, or medications to regulate menstrual cycles and manage any minor symptoms.

Fig. 8 Shap Analysis



Fig. 8 displays not Infected PCOD refers to a condition where ovarian cysts are present but do not cause major symptoms or serious health problems. Mild irregular periods or slight hormonal imbalance may occur. It can be managed with a healthy diet, regular exercise, stress control, and routine medical check-ups.

Time of Day	Recommendations
Morning:	Start with a glass of water and a healthy breakfast that includes whole grains and protein. Include fruits such as berries for added nutrients.
Afternoon:	Engage in moderate physical activity like walking. Have a balanced lunch with lean proteins and plenty of vegetables.
Night:	Opt for a light dinner and incorporate relaxation techniques such as gentle stretching or reading to wind down. Ensure adequate sleep to support overall well-being.
Additional Recommendations	Category Recommendations
Physical Activity:	Regular moderate exercise like brisk walking or cycling is beneficial for overall health and can help manage PCOD symptoms.
Yoga:	Gentle yoga poses such as Child's Pose or Cat-Cow stretch can aid in relaxation and support overall hormonal balance.
Vitamins:	Consider a balanced intake of vitamins such as Vitamin D and B-complex to support hormonal health. Consult with a healthcare provider before starting any supplements.
Fruits:	Include a variety of fruits in your diet, such as apples, oranges, and berries, to ensure adequate vitamin and antioxidant intake.

Fig. 9 Recommendation

Fig. 9 shows for managing PCOD, following a healthy daily routine is important. Start the day with water and a nutritious breakfast, stay active with regular exercise or yoga, eat balanced meals with fruits and vegetables, and maintain good sleep. Vitamins and healthy habits can also help support hormonal balance and overall health.

VI. CONCLUSION AND FUTURE ENHANCEMENT

This project presents an intelligent and scalable system for the early detection and risk stratification of PCOS and PCOD using advanced machine learning and deep learning techniques. By integrating multi-modal data such as clinical, hormonal, lifestyle, and ultrasound imaging, the system provides a comprehensive and accurate diagnosis. The use of hybrid models including CNN, Vision Transformers, and XGBoost improves prediction performance and reliability. Additionally, the incorporation of Explainable AI techniques like SHAP enhances transparency, helping clinicians understand model decisions and build trust in AI-assisted diagnosis. The deployment of the system as a Django-based web application ensures real-time accessibility and practical usability in clinical environments. Overall, this system contributes to improving early diagnosis, reducing complications, and supporting personalized healthcare for women.

In the future, this system can be enhanced by integrating with real-time ultrasound scanning devices to provide instant PCOS/PCOD detection during the scanning process itself, which will help doctors make quicker decisions. A mobile application can also be developed to allow both patients and doctors to access the system anytime and anywhere for easy monitoring and consultation. To improve the performance of the system, advanced deep learning models such as Vision Transformers and ensemble techniques can be implemented to achieve higher prediction accuracy and reliability. Furthermore, the system can be extended to support multi-disease detection by identifying other gynecological and reproductive health disorders along with PCOS/PCOD. Finally, deploying the system on cloud platforms can ensure faster processing, secure data storage, and easy accessibility across multiple hospitals and healthcare centers.



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