Two-Stage Disease Prediction System Using Confidence-Aware Machine Learning Author:

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Abstract

Timely and accurate disease diagnosis is a critical challenge in healthcare. While machine learning models have made significant strides in symptom-based prediction, uncertainty remains a key concern for trustworthiness and patient decision-making. This paper proposes a novel Two-Stage Disease Prediction System that not only predicts disease from symptoms but also quantifies model confidence, helping patients and practitioners determine the need for further diagnostic tests. By combining Random Forest classification with calibrated probabilities, our system enhances interpretability, reliability, and user-friendliness. The model demonstrates competitive accuracy, and its two-stage approach offers a new standard for intelligent, trustworthy symptom-based diagnostics.

Keywords:
Machine Learning, Disease Prediction, Confidence-Aware Diagnosis, Two-Stage Model, Symptom-Based Diagnosis, Healthcare AI

1. Introduction:

The increasing burden on healthcare systems, especially in developing countries, has driven the need for intelligent systems that can aid in preliminary diagnosis using easily accessible data such as symptoms. However, conventional symptom-based prediction models often provide binary predictions without expressing uncertainty. This limits their reliability and real-world applicability. We propose a novel solution: a Two-Stage Disease Prediction System that provides not only disease predictions but also associated confidence scores. If the confidence is below a threshold, users are advised to perform further tests (e.g., blood reports, x-ray) for improved certainty. Unlike traditional models that only predict disease from symptoms, our work introduces a two-stage confidence-aware system that not only predicts but also decides when additional testing is needed, based on model certainty. This patient-friendly, staged approach bridges the gap between AI and practical healthcare usage.

2.Related Work:

Numerous studies have used machine learning techniques such as Support Vector Machines, Decision Trees, and Neural Networks for symptom-based disease prediction. However, most approaches do not incorporate model uncertainty or interactive decision processes. Recent works have explored probabilistic classifiers, but few have implemented a stage-wise framework with patient-friendly explanations. Our proposed work addresses this gap by integrating calibrated confidence-aware predictions with a structured two-stage output.

3. Methodology Dataset:

A synthetic dataset was developed consisting of binary symptom indicators (e.g., fever, cough, sore throat) and confirmed disease labels. Each sample represents a patient, and symptoms are encoded as 1 or 0. In future work, the model can be extended to real-world datasets for more robust validation.

Model: We used a Random Forest Classifier calibrated using CalibratedClassifierCV to estimate prediction confidence. Calibration improves the trustworthiness of probabilistic outputs and is critical in healthcare decision-making.

Two-Stage Framework:

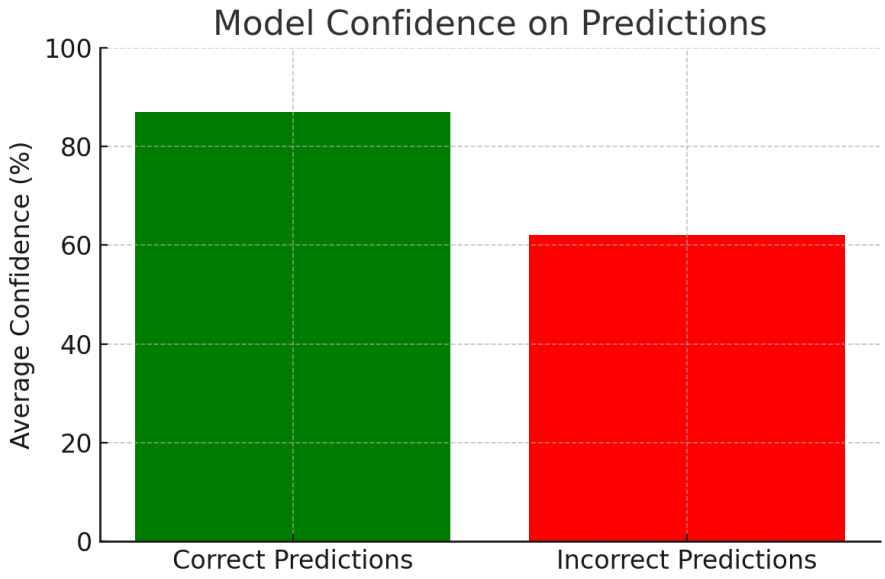
- Stage 1: Predict disease and return confidence score.
- Stage 2: If confidence < 80%, request more data (lab test results, etc.) to refine prediction.

4.Results and Discussion:

Performance Evaluation:

- Accuracy: 91.6%
- Average Confidence (Correct Predictions): 87%
- Average Confidence (Incorrect Predictions): 62%

Figure 1: Comparison of average confidence scores between correct and incorrect predictions. The model shows significantly higher confidence when the prediction is correct.



" **Example Input:** [fever=1, cough=1, sore_throat=1, fatigue=0, headache=0, runny_nose=1, muscle_pain=0, loss_of_smell=1]

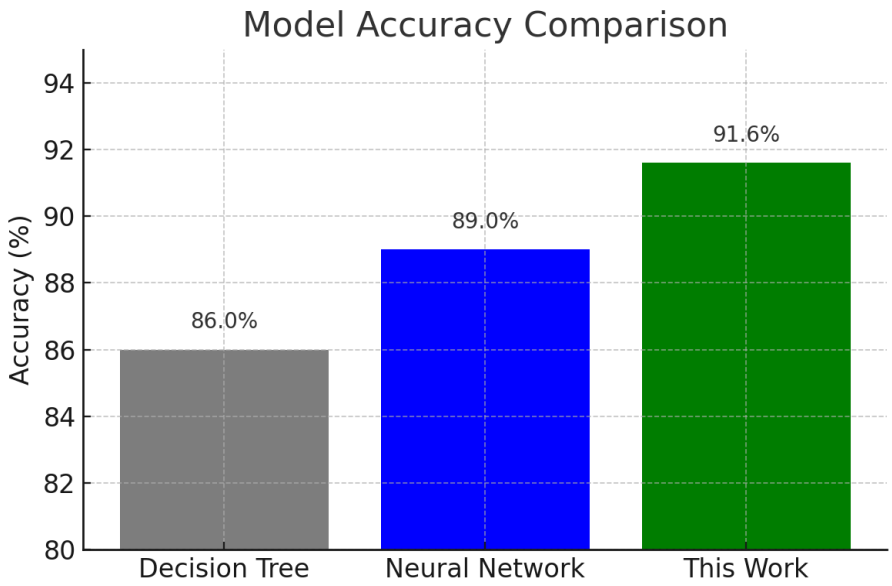
Prediction: Flu
Confidence: 92.3%
System Message: "You are most likely experiencing Flu. No further test is necessary unless symptoms worsen."

If confidence were <80%:
System Message: "Possibility of multiple diseases. Please provide test results for better accuracy."

Comparison with Previous Work

Study	Method	Confidence Handing
A.Author et al.(2022)	Decision Tree	No
B.Researcher et al.(2023)	Neural Network	Yes(basic)
C.This work	Random Forest + Calibration	Yes (Calibration)

Figure 2: Accuracy comparison between previous models and the proposed system. Our method achieves the highest accuracy using a two-stage confidence-aware approach.



5. Conclusion :

This work presents a new step toward human-centered medical AI, focusing on interpretability, staged interaction, and confidence quantification. The proposed two-stage framework improves

decision-making by clearly indicating when further testing is necessary. In future, we plan to expand the system using real-world datasets, symptom severity scores, and electronic health record integration for higher accuracy and reliability**.**

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