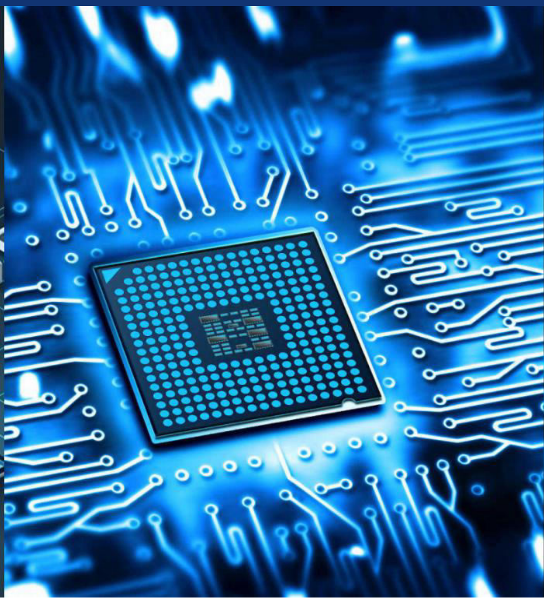
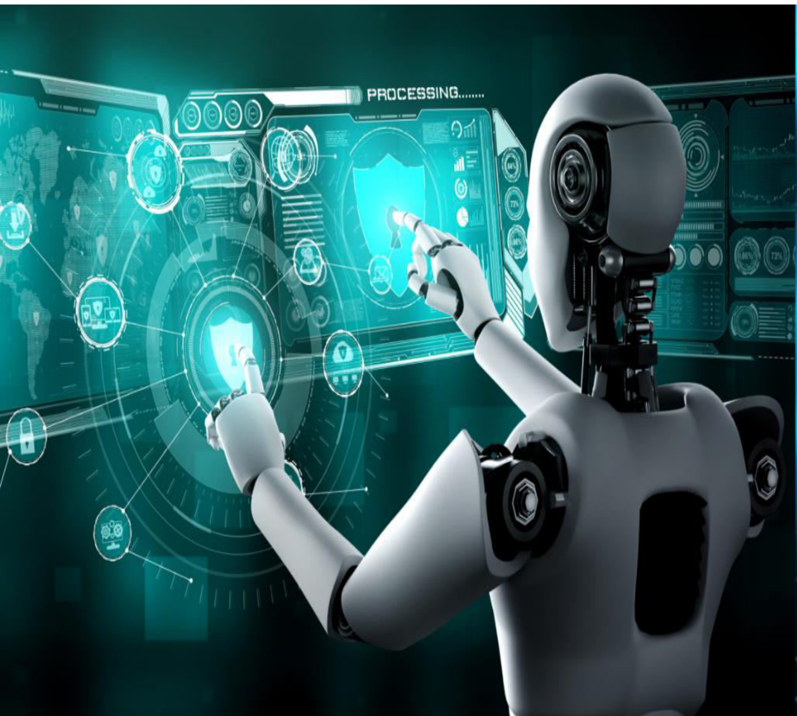
IJIRCCE

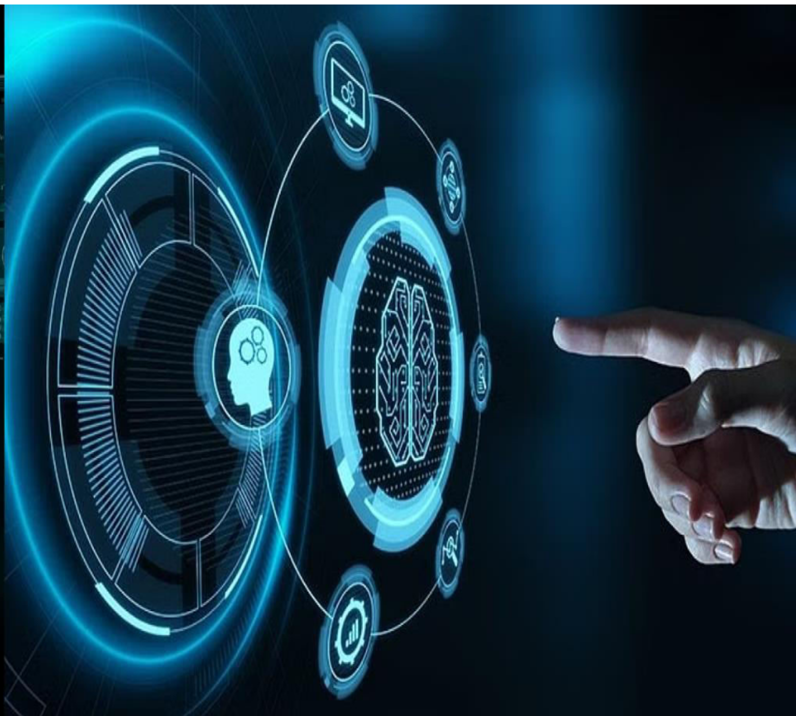
ISSN(O): 2320-9801
ISSN(P): 2320-9798


International Journal of Innovative Research in Computer and Communication Engineering

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)





Impact Factor: 9.927

Volume 14, Issue 5, May 2026

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 9.927| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

XAI Based Heart Disease Prediction System with Feature Importance Visualization: A Survey

Sanket S. Gajare, Prof. Dr. Mrs. S. A. Itkar

Department of Computer Engineering, P.E.S. Modern College of Engineering, Pune, India

Department of Computer Engineering, P.E.S. Modern College of Engineering, Pune, India

ABSTRACT: Heart disease remains the leading global cause of mortality, which makes reliable and actionable prediction systems a clinical priority. Conventional machine learning (ML) models can achieve strong discriminative performance on structured clinical data or biosignals such as ECG, but they often behave as opaque black boxes—limiting clinical adoption where trust, accountability, and auditability are essential. Explainable Artificial Intelligence (XAI) provides a principled set of tools to expose model behavior, attribute contributions, and reduce the risk of spurious associations. This survey synthesizes recent research on XAI-driven heart disease prediction across two major data modalities—clinical tabular features and ECG signals. We review representative studies that apply SHAP-based post-hoc explainability on tree ensembles and gradient boosting, as well as signal-processing pipelines using DWT/EWT feature extraction for ECG followed by interpretable classifiers. We organize the literature by data source, modeling approach, and explanation technique, highlight a practical design that combines clinical and ECG pathways with SHAP-based global and local interpretability, and discuss open challenges in validation, uncertainty communication, and deployment.

KEYWORDS: Explainable Artificial Intelligence (XAI), Heart Disease Prediction, SHAP, ECG Signal Processing, Machine Learning.

I. INTRODUCTION

Cardiovascular diseases (CVDs) account for nearly one in three deaths worldwide. The availability of curated clinical datasets (e.g., UCI Cleveland, Statlog) and open ECG collections (e.g., MIT-BIH, PhysioNet challenges) has accelerated development of predictive models for screening and triage. Yet, two translational gaps persist: (i) high-performing models are frequently non-transparent, particularly boosted trees and deep networks, making it difficult for clinicians to assess failure modes or trust patient-specific predictions; and (ii) modality-specific pipelines (ECG-only or clinical-only) overlook complementary signals and can limit generalization.

XAI addresses these gaps by quantifying the contribution of each input feature to model outputs (local explanations) and by characterizing global importance trends across cohorts. Among XAI methods, SHAP has emerged as a popular, model-agnostic framework that provides theoretically grounded, additive attributions compatible with tree ensembles (TreeSHAP) and other estimators.

II. BACKGROUND AND RELATED WORK

ECG-centered work shows that Empirical Wavelet Transform (EWT) features paired with tree ensembles can deliver competitive AUCs across PhysioNet and MIT-BIH tasks while supporting SHAP-based importance inspection [1]. Tabular studies on UCI/Statlog report that Support Vector Machines, Random Forests, and gradient boosting are strong baselines; however, performance varies with preprocessing and protocol [2], [3], [5]. Optimization threads explore genetic algorithms for hyperparameter tuning [4]. Emerging directions include NLP/LLM pipelines that mine clinical narratives to complement structured variables [6].

© 2026 IJIRCCE | Volume 14, Issue 5, May 2026 DOI: 10.15680/IJIRCCE.2026.1405101

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 9.927| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

III. SURVEY METHOD AND TAXONOMY

We organize the literature along three axes:
(1) Data modality: (a) structured clinical features (age, sex, chest pain type, blood pressure, cholesterol, fasting blood sugar, resting ECG, exercise-induced angina, ST depression, slope, number of vessels, thalassemia) and (b) ECG signals with time-frequency decompositions (DWT/EWT) yielding statistical and spectral descriptors;
(2) Modeling approaches: tree ensembles (Random Forest, XGBoost), kernel methods (SVM), distance-based (KNN), linear models (Logistic Regression), and shallow neural networks (MLP). Optimization strategies (e.g., GA) tune hyperparameters;
(3) Explanation techniques: post-hoc SHAP (global rankings, beeswarm plots, force plots) for both tabular and engineered ECG features, with best support in tree-based pipelines.

IV. REPRESENTATIVE STUDIES AND COMPARISON

Table I below compares representative studies from 2024-2025 across dataset, approach, and key findings.

TABLE I
Representative XAI/ML Studies for Heart Disease Prediction

Study	Data/Method	Key Takeaway
Majhi & Kashyap (2024) [1]	ECG + EWT/DWT + Tree Ensembles + SHAP	Strong AUCs; SHAP clarifies impact
Mandal et al. (2025) [2]	UCI tabular; 12 ML models; SHAP summaries	SVM ~89% accuracy
Daharwal et al. (2025) [3]	RF, KNN, DT	Baseline comparisons; need explainability
Murad et al. (2025) [4]	GA-optimized SVM/KNN	Improved accuracy via tuning
Bouqentar et al. (2024) [5]	Cleveland/Statlog; ML + tuning	Best ~92% with robust CV
Li et al. (2025) [6]	NLP/LLM + RF	Personalized risk via text mining

V. DESIGN BLUEPRINT: HYBRID, SHAP-FIRST WORKFLOW

A pragmatic combined design uses two parallel pipelines—ECG feature extraction and clinical tabular modeling—followed by a late fusion layer to aggregate calibrated probabilities. SHAP explanations are computed on the fused model to surface feature contributions at the patient level (local) and cohort level (global). The proposed architecture consists of the following components:
- **Clinical Data (Tabular):** Preprocessing & Feature Scaling followed by Tree Ensemble / SVM / MLP classifier.
- **ECG Signals (Raw):** EWT/DWT Feature Extraction followed by Tree Ensemble / SVM classifier.
- **Late Fusion Layer:** Combines calibrated probabilities from both pipelines, feeds into XAI Layer (SHAP) for Global + Local Views, and outputs to a clinical Dashboard.

The global feature importance profile (illustrated using SHAP mean |SHAP value| impact) identifies the top contributing features, with chest pain type (cp), maximum heart rate achieved (thalach), and ST depression (oldpeak) ranking among the most influential predictors in the illustrative SHAP summary.

VI. DISCUSSION AND OPEN CHALLENGES

Strengths across the literature include strong discriminative performance of tree ensembles and SVMs on widely used datasets, and the practicality of SHAP for communicating feature influence. Limitations include modest sample sizes, heterogeneous labeling across sources, and limited external validation. ECG pipelines benefit from wavelet features (EWT often exceeding DWT in non-stationary settings), while tabular pipelines are sensitive to preprocessing choices and class imbalance. Dashboard-oriented interfaces that integrate explanations with confidence estimates can improve clinician engagement; however, human-factor evaluations remain sparse.

VII. CONCLUSION

XAI techniques, and SHAP in particular, make heart disease prediction models more transparent and clinically interpretable without forfeiting accuracy. Future work should focus on prospective validation, uncertainty quantification, and rigorous human-centered evaluation to ensure that explanations improve decisions in clinical settings. Hybrid systems—merging ECG, tabular, and text signals—combined with carefully designed dashboards, offer a promising path toward trustworthy, clinician-aligned AI for cardiovascular care.

REFERENCES

[1] B. Majhi and A. Kashyap, "Explainable AI-driven machine learning for heart disease detection using ECG signal," Applied Soft Computing, vol. 167, 2024.
[2] A. K. Mandal, S. Dehuri, and P. K. D. Sarma, "Analysis of machine learning approaches for predictive modeling in heart disease detection systems," Biomedical Signal Processing and Control, vol. 106, 2025.
[3] U. Daharwal, I. Singh, and G. Khekare, "Comparison of Machine Learning Algorithms for Heart Disease Prediction," Procedia Computer Science, vol. 260, pp. 12-21, 2025.
[4] S. H. Murad, N. B. Tayfor, N. H. Mahmood, and L. Arman, "Hybrid genetic algorithms-driven optimization of machine learning models for heart disease prediction," MethodsX, vol. 15, 103510, 2025.
[5] M. A. Bouqentar, O. Terrada, S. Hamida, et al., "Early heart disease prediction using feature engineering and machine learning algorithms," Heliyon, vol. 10, e38731, 2024.
[6] A. Li, Y. Wang, and H. Chen, "AI driven cardiovascular risk prediction using NLP and Large Language Models for personalized medicine in athletes," SLAS Technology, vol. 32, 100286, 2025.

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

9940 572 462 6381 907 438 ijircce@gmail.com

Scan to save the contact details