

Optimized Machine Learning System for Heart Failure Prediction

Chekuri Manmohan

Department of Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Parul Institute of Engineering and Technology
Parul University, Vadodara, Gujarat, India
Email: 2303031460031@paruluniversity.ac.in

K. Hari Sai Venkat

Department of Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Parul Institute of Engineering and Technology
Parul University, Vadodara, Gujarat, India
Email: 2303031460226@paruluniversity.ac.in

K. Jaya Sankar

Department of Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Parul Institute of Engineering and Technology
Parul University, Vadodara, Gujarat, India
Email: 2303031460073@paruluniversity.ac.in

V. Shiva Pranith Sai

Department of Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Parul Institute of Engineering and Technology
Parul University, Vadodara, Gujarat, India
Email: 2303031460176@paruluniversity.ac.in

K. B. N. V. S. G. Dhanush

Department of Computer Science and Engineering
(Artificial Intelligence and Machine Learning)
Parul Institute of Engineering and Technology
Parul University, Vadodara, Gujarat, India
Email: 2303031460085@paruluniversity.ac.in

Jyothi Chowdary

Department of Computer Science and Engineering
Parul Institute of Engineering and Technology
Parul University, Vadodara, Gujarat, India
Under the Guidance of
Assistant Professor

Abstract—Heart failure and cardiovascular diseases are two severe medical problem which needs immediate preventive measures and early recognition of risk factors. Cardiovascular Cardiovascular cardiovascular cardiovascular cardiovascular risk. But, many of the existing prediction systems focus more on developing a risk stratification than providing patient-specific recommendations tailored to their clinical conditions.

In this paper, we propose an Enhanced Machine Learning System for heart failure as well as Personalised Health Recommendation Engine. To discover an effective prediction model, the proposed system collects demographic, clinical and lifestyle-related data, preprocess it, select the features and evaluates various machine learning algorithms. It includes a risk category, prediction probability, confidence data along with Heart Health Score in the output of the prediction.

The main contribution of the proposed system is the Personalised Recommendation Engine which takes machine learning predictions and circadian rhythm parameters (blood pressure, cholesterol, BMI, diabetes status, smoking habits) with physical activity, sleep duration stress level and dietary habits as individual parameters. Instead of issuing the same prevention recommendations to every user in a specific risk group, it produces individualized preventive recommendations based on each user's health profile. Explainable Artificial Intelligence methods can be adopted to ascertain the factors that impact the prediction.

All these services are brought together under one interactive web-based system through the proposed framework. It is interactive, user-centric, user-centric, user-centric, user-centric, user-centric, and user-centric.

Index Terms—Heart Failure Prediction Machine Learning Per-

sonalised Recommendation Engine Heart Health Score Explainable AI Feature Selection XGBoost Random Forest Healthcare Analytics

I. INTRODUCTION

Heart diseases remain a substantial risk for health care systems around the world. Detecting the presence of heart disease in its early stages will allow patients to take preventive measures and receive adequate recommendations from doctors before the condition becomes serious. Medical history, physical examination, laboratory testing, and clinical expertise form the basis of conventional health care assessment. With the availability of health care data, new opportunities have arisen for machine learning-based prediction systems despite the importance of these approaches.

Machine learning algorithms can analyze health parameters at the same time and find complex links between demographic, clinical and lifestyle factors. I have seen machine learning algorithms such as Logistic Regression, Support Vector Machine, Random Forest, Artificial Neural Networks and XGBoost used to predict disease. Machine learning algorithms in learning methods have shown special promise because they can capture non-linear links and interactions, among many variables. These machine learning algorithms help us understand how many factors work together in disease prediction.

Numerous current systems can predict health risks. Often the results are simple labels, like low risk or high risk. This kind of result does not give people the information they need to understand their health. Two people can get the risk label but their situations can be very different. For example one persons higher risk could come from blood pressure. Another persons risk might come from smoking being overweight having diabetes or not exercising enough. Just knowing the risk level is not enough—people need to understand what causes it in order to take the steps. Because of this this study suggests a system that goes beyond machine learning predictions by adding advice. The system looks at each persons information and daily habits. It creates suggestions that fit the persons health situation.

The app has a Heart Health Score that lets the user quickly see how healthy they are.

The system also uses Explainable AI techniques to show the important factors that affect the prediction. It includes elements like prediction history, downloadable health reports, guidance on when to see a doctor and information about nearby hospitals. These features are made to make the app easier to use every day. The app is built to help people understand their health better and to back their health decisions. It is not meant to replace a doctor's diagnosis. Always ask an expert, for advice.

II. LITERATURE REVIEW

Machine learning has become very important in healthcare because it can work with both unstructured data. Many researchers have studied learning methods to make these techniques more effective especially for predicting heart disease.

Earlier studies mostly focused on machine learning algorithms such as Logistic Regression, Decision Trees and Support Vector Machines. I have found that Logistic Regression gives results that're easy to understand but it may not handle complex nonlinear patterns well. Support Vector Machines are good, at classification. They can take a lot of computing power when used with large datasets.

Recent studies have focused on algorithms such as Random Forest and XGBoost. Random Forest and XGBoost combine learning models to make predictions. Random Forest and XGBoost improve the models results. Make them more consistent. Random Forest can manage input variables. Random Forest can find patterns among them. XGBoost uses a method called gradient boosting to improve accuracy and speed. Random Forest and XGBoost work as tools, inside machine learning.

Feature selection has become common in healthcare prediction systems. Medical datasets often contain variables that add value to predictions. Feature selection chooses the key features, which speeds up models and makes them easier to understand. Feature selection also improves the performance of the models.

Techniques for improving performance such as adjusting settings trying options and using automatic methods have been used to find the best setups for prediction models. These

approaches help make models work better and reduce the risk of them becoming too specific, to the training data.

Still when looking at these approaches many systems focus mostly on making predictions more accurate. Not much is done to help people understand what those predictions really mean for them or to offer advice that fits their situations.

The suggested study tackles this constraint by combining machine learning forecasting, a Tailored Recommendation System, a Heart Health Index and Explainable AI. This combination builds a system that I think focuses on the user. The system does more than spot risks. It also helps users understand their health profile and make choices that're important, to them.

III. RESEARCH GAP

The literature shows that machine learning-based cardiovascular risk prediction has made gains. Yet many gaps still exist in machine learning-based risk prediction.

First many current systems try hard to make prediction accuracy high as possible. Accuracy matters, but an accurate prediction by itself is not enough for real healthcare use. Users want explanations, about what factors influence prediction accuracy.

Secondly many systems give a label, such, as low risk or high risk. In the category each user can have different health details and daily habits. Because of that giving the advice to all users in one category does not make the health care experience truly personal.

Third complex machine learning algorithms can act like black-box models. Users and healthcare providers might struggle to understand why a certain prediction was made. This makes it important to use Explainable AI methods that can show which factors had the impact, on the result.

Fourth many prediction systems do not have an user experience. The user experience does not include things like looking at past predictions checking health scores getting personal advice help with talking to a doctor and information, about health services.

The proposed research attempts to address these gaps by integrating the following components:

- Optimized machine learning prediction.
- Personalized Recommendation Engine.
- Heart Health Score.
- Explainable AI.
- Risk probability and confidence information.
- Analysis of predictions and trend evaluation. Analysis helps me spot patterns and learn from history.
- Guidance for doctor consultations. Guidance helps me ask the questions and understand the answers.
- Assistance with hospital locations. Assistance shows me the hospitals and how to get there.
- Health reports available for download. Health reports give me data, about my health.

The key research contribution is about bringing these parts into one complete system. This system is designed to predict what might happen and give suggestions, for every person. It

works by predicting results and offering advice that fits each individual.

IV. PROPOSED SYSTEM

The idea is a website that helps people understand their heart health and gives them advice. People can make an account on the site. They can enter their details, their medical history and information about how they live. The system looks at all the data. It gets the data ready before sending it to a machine learning model.

The machine learning model looks at the information that is given. The model gives an idea of the risk level. The result can be shown with categories like Low Risk, Medium Risk and High Risk. The system can show how likely the prediction is and give information, about how sure the prediction is.

After the prediction the result is sent to the Personalized Recommendation Engine. The Personalized Recommendation Engine looks at factors that affect the users health status and gives personalized suggestions.

For example two people who are both rated as Medium Risk could receive suggestions. One person with cholesterol might be told to watch their diet and track their lipids. Another person who smokes might be given tips on how to stop smoking. The advice changes based on what health issue's most important, for each person.

The proposed system contains the following major modules:

- 1) User Authentication Module.
- 2) Health Data Collection Module.
- 3) Data Validation and Preprocessing Module.
- 4) Machine Learning Prediction Module.
- 5) Risk Classification Module.
- 6) Heart Health Score Module.
- 7) Personalized Recommendation Engine.
- 8) Explainable AI Module.
- 9) Doctor Consultation Guidance Module.
- 10) Hospital Locator Module.
- 11) Prediction History Module.
- 12) Health Report Generation Module.

V. METHODOLOGY

The methodology of the proposed system consists of multiple stages.

A. Data Collection

The system holds organized healthcare information that contains demographic and clinical details. The system may also collect lifestyle information through the application to help provide personalized recommendations.

B. Data Preprocessing

The data that was collected is prepared and organized for machine learning. The missing parts are handled correctly. The categories are changed into a format that can be used. The numbers can be made smaller or adjusted in a way that works best.

C. Feature Selection

Important features are selected using methods or techniques from machine learning that show how important each feature is. Feature selection removes data and makes the system work faster and more efficiently.

D. Model Training

Various machine learning algorithms are. Tested. The models being proposed include Logistic Regression, Support Vector Machine, Random Forest and XGBoost. Each of these algorithms is evaluated to see how well they perform in situations. The goal is to understand which one works best for the given task.

E. Hyperparameter Optimization

The effectiveness of the algorithms that are selected is improved using techniques, like Grid Search or Random Search. The right settings are picked based on what the validation results show.

F. Model Evaluation

The models are evaluated using the following metrics:

- Accuracy
- Precision
- Recall
- F1-Score
- ROC-AUC
- Confusion Matrix

G. Prediction

The performing model is now part of the web application. User health data is. Sent to the trained model to generate a risk forecast.

H. Recommendation Generation

I see the recommendation engine receiving the prediction outcome and the individuals health metrics. I see the recommendation engine using established health-related guidelines to produce tailored recommendations.

VI. SYSTEM ARCHITECTURE

The suggested system uses a -tier setup. It has a frontend layer, a backend layer, a machine learning layer, a recommendation layer and a database layer. The frontend gives users a place to sign up sign in enter health information check forecasts get suggestions and look at reports.

The back end manages user login checking the input is correct talking to application programming interfaces working with the database and connecting with the machine learning model.

The machine learning part receives the cleaned data. Gives a prediction by using the model that has been trained.

The Customized Suggestion System looks at the forecast result and also, at health measurements. It makes recommendations based on known risk factors.

The Explainable AI part finds the things that affect the prediction.

The database keeps user information, prediction records, health files and the reports that are created.

The overall architecture can be represented as:

VII. SYSTEM ARCHITECTURE

User → Frontend → Backend/API → Data Processing → Machine Learning Model → Risk Prediction → Heart Health Score → Explainable AI → Personalized Recommendation Engine → Results and Report

VIII. DATA FLOW DIAGRAM

The data flow diagram shows how patient information moves through the suggested system. A person enters their details health information and lifestyle data. It looks like the text you shared is not complete. Can you please give me the text you want me to rephrase? The system. Gets the input data ready, before starting the feature extraction process.

I see how the outcome of the prediction is used to set the Heart Health Score and categorize the user.

The user is placed into categories of Low, Medium or High Risk. Grounded in the recognized

hazards and influencing health aspects the Customized Suggestion System

produces advice. The Customized Suggestion System can additionally offer doctor advice.

Doctor advice for consultations information, on hospitals and a health document to download account.

IX. USE CASE DIAGRAM

The use case diagram shows how the main participants talk to the proposed system. The main participants are the User, the Physician and the Administrator.

The User can sign up log in enter health data predict heart failure hazard check the Heart Health Score get suggestions find nearby hospitals view past forecasts and download medical reports.

The Physician can see the patient health data. The Administrator can manage the dataset, refresh or train the machine learning model. Supervise the system operators.

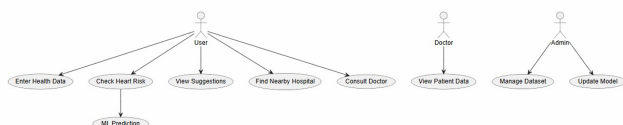


Fig. 1. Use Case Diagram of the Heart Failure Prediction System

X. ACTIVITY DIAGRAM

The activity diagram shows the process of the suggested system.

The procedure starts when the individual provides medical and lifestyle data. The system. Prepares the data before performing feature engineering.

The analyzed data is checked using the machine learning model that was trained. This model helps to predict the chance of having heart failure. The system then calculates the prediction. It also gives a Cardiac Wellness Rating.

Based on the predicted risk level the Customized Suggestion System comes up with the advice. For people who have a risk the system tells them to track their health and see a doctor. The system gives the important advice for people who are at high risk. It also tells them to get help from a doctor and gives them details, about hospitals nearby.

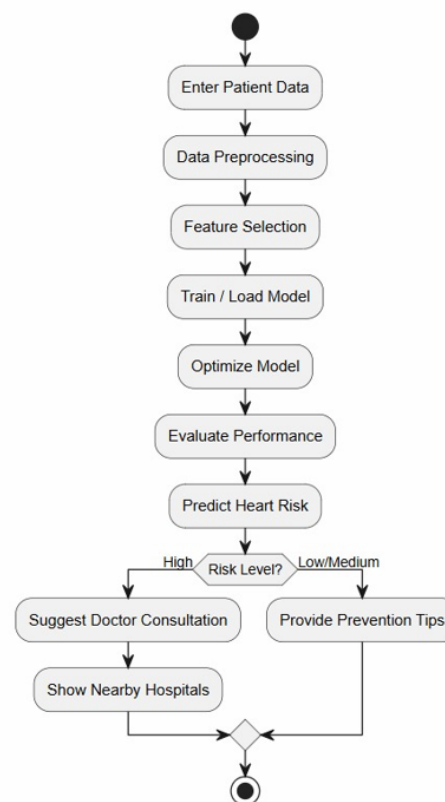


Fig. 2. Activity Diagram of the Heart Failure Prediction Process

XI. MACHINE LEARNING MODEL

The suggested system examines supervised machine learning algorithms to find the best model, for predicting heart health risks.

A. Logistic Regression

Logistic Regression can be used as a baseline model. It is relatively simple and provides interpretable results.

B. Support Vector Machine

Support Vector Machine identifies a decision boundary between different classes and can handle complex classification problems.

C. Random Forest

Random Forest is an ensemble learning algorithm that uses multiple decision trees. It can capture nonlinear relationships and estimate feature importance.

D. XGBoost

XGBoost is a gradient boosting technique designed to provide fast predictive analytics.

It works well with data sets. The models are trained using the dataset and then evaluated using different performance measures. The best model is selected based on effectiveness, reliability, computational efficiency and how well it can generalize to new data.

Hyperparameter tuning helps find the configuration settings. Feature selection can also be used to remove variables that do not add value.

XII. PERSONALIZED RECOMMENDATION ENGINE

The key advancement of the suggested system is the Personalized Recommendation Engine. This engine focuses on giving each user a tailored recommendation experience that matches their tastes. It looks at what the user does. Uses that data to suggest items the user might like. The system learns over time getting smarter with every interaction. It makes sure the recommendations are relevant and helpful. This kind of interaction is what makes the Personalized Recommendation Engine different, from systems.

Traditional prediction systems may provide a result such as:

High Risk

However, the proposed system goes further by analyzing the specific health conditions of the user.

A. Elevated Blood Pressure

If high blood pressure is present the system may recommend monitoring for high blood pressure lowering sodium consumption for high blood pressure adopting healthy lifestyle habits for high blood pressure and seeking proper medical advice, for high blood pressure.

B. High Cholesterol

When cholesterol levels are high the system may suggest reducing saturated intake improving overall eating habits and looking into appropriate follow-up tests, with a medical expert.

C. High BMI

When the users BMI shows that they are obese or carrying weight the system might recommend slowly losing weight by eating a good balance of foods and doing the right kind of exercise. The system might suggest slowly losing weight by eating a balance of foods and doing the right kind of exercise. The system might recommend a diet and proper exercise to help the user manage their weight. The system might suggest a diet and proper exercise to help the user manage their weight. The system might encourage the user to take steps toward better health. The system might encourage the user to take steps, toward better health.

D. Smoking

When smoking is recognized as a risk factor the system can recommend quitting smoking. Give access, to professional support resources.

E. Low Physical Activity

If physical activity is limited, the system can suggest increasing regular activity according to general health recommendations and individual ability.

F. Diabetes

If diabetes is reported, the system can provide general recommendations related to regular glucose monitoring, dietary management, and professional medical follow-up.

The recommendation engine combines multiple factors rather than relying on only one parameter. Therefore, each user can receive a different set of recommendations.

XIII. HEART HEALTH SCORE

The suggested system includes a Heart Health Score that ranges from 0, to 100. This score gives users a way to see how their heart health is doing. It helps them understand their heart health status at a glance. The score is easy to read. Makes it clear what kind of heart health they have.

The score can be generated using a combination of relevant health indicators such as:

- Age
- BMI
- Blood Pressure
- Cholesterol
- Blood Sugar or Diabetes Status
- Smoking
- Physical Activity
- Sleep Duration
- Stress Level
- Diet

The way a high score or a low score is understood needs to be set and used in the exact same way each time in the final system. For example the system might explain that a high score shows the profile is in condition while a low score might show something to be worried, about.

An example explanation could be:

TABLE I
HEART HEALTH SCORE INTERPRETATION

Heart Health Score	Interpretation
80–100	Good Heart Health Profile
60–79	Moderate Attention Required
40–59	Increased Health Risk
Below 40	High Concern

I believe these ranges should be seen as a project-level scoring system not as a validated scale unless they are confirmed by proper medical research.

I think the Heart Health Score allows users to track changes over time and compare their assessment with earlier predictions.

XIV. EXPLAINABLE AI

Explainable Artificial Intelligence helps to make the prediction system easier to understand.

Some machine learning models, ensemble or boosting types can be hard to interpret. The Explainable AI module can use techniques such, as SHAP to discover how specific features influence a prediction.

For example the system might identify these factors that contribute:

- 1) High Blood Pressure
- 2) High Cholesterol
- 3) High BMI
- 4) Smoking
- 5) Low Physical Activity

Instead of only displaying:

Risk: High

The system can display:

Important Factors Affecting Your Result

- Blood pressure is above the expected range.
- Cholesterol is elevated.
- BMI indicates excess body weight.
- Smoking contributes to the risk profile.

This helps users understand the parts that affect their forecast.

Being transparent can build trust. Make the system easier to use by showing a clearer connection, between what the user enters and what the system returns.

However the explanations come from the model. Are not meant to be a medical diagnosis.

XV. RESULTS AND DISCUSSION

The suggested system will check machine learning algorithms using the heart-related dataset. Each model will be. Tested in the same conditions.

The check will focus on accuracy, precision, recall, F1-score and ROC-AUC. A confusion matrix will be used to look at how many instances were correctly and incorrectly classified.

The optimized models performance will be evaluated against algorithms. Choosing the features and adjusting hyperparameters are expected to improve model performance by removing irrelevant features and selecting the best possible settings for the model.

The Personalized Recommendation Engine will be assessed based on its ability to generate suggestions, for users who have different health profiles.

For example two users who are both classified as Medium Risk should not automatically receive the recommendations.

A. Example User A

- Elevated Blood Pressure
- Normal BMI
- Non-Smoker
- Moderate Exercise

The recommendation may focus primarily on blood pressure monitoring and dietary changes.

B. Example User B

- Normal Blood Pressure
- High BMI
- Smoker
- Low Physical Activity

The idea might focus on controlling weight stopping smoking and getting exercise.

This shows the difference, between risk groups and personalized prevention tips.

The final results part needs test results after the model has been trained. Before the model is used and checked numbers should be used as examples of real study results.

XVI. GRAPHS AND TABLES

The following tables and figures can be included in the research paper.

A. System Architecture Graph

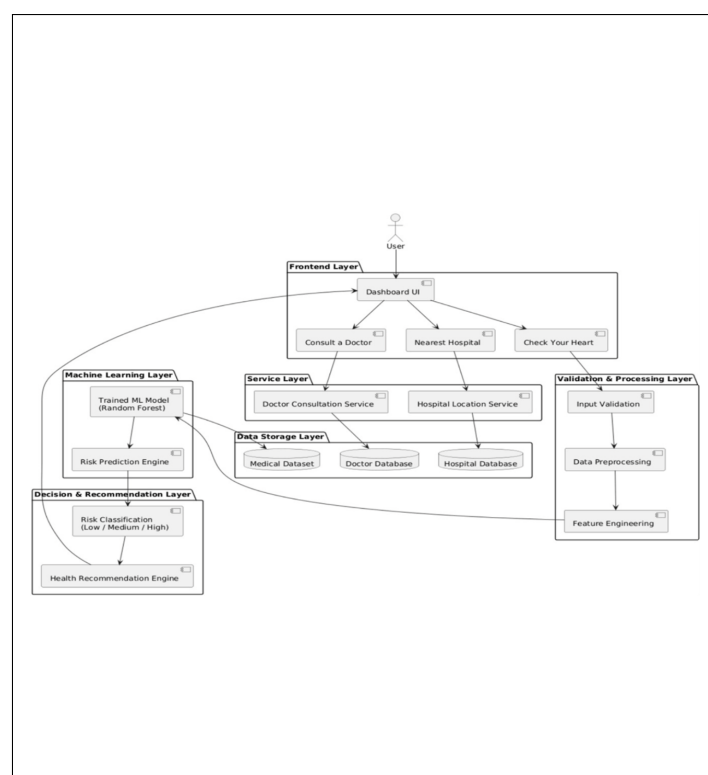


Fig. 3. System Architecture of the Proposed Heart Failure Prediction System

B. Heart Health Score and Clinical Report

The system that was built gives a clinical check based on the users health information. It shows the score for heart disease risk the type of diagnosis important health signs and personal advice. This helps people understand how healthy their heart is, in an clear way.

TABLE II
COMPARISON OF MACHINE LEARNING ALGORITHMS

Algorithm	Accuracy	Precision	Recall	F1-Score	ROC-AUC
Logistic Regression	XX%	XX%	XX%	XX%	XX%
SVM	XX%	XX%	XX%	XX%	XX%
Random Forest	XX%	XX%	XX%	XX%	XX%
XGBoost	XX%	XX%	XX%	XX%	XX%

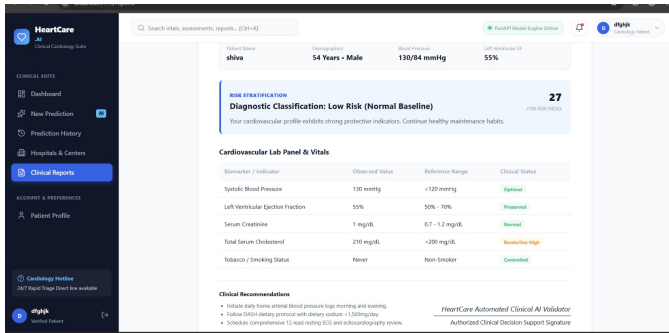


Fig. 4. Heart Health Assessment and Clinical Report

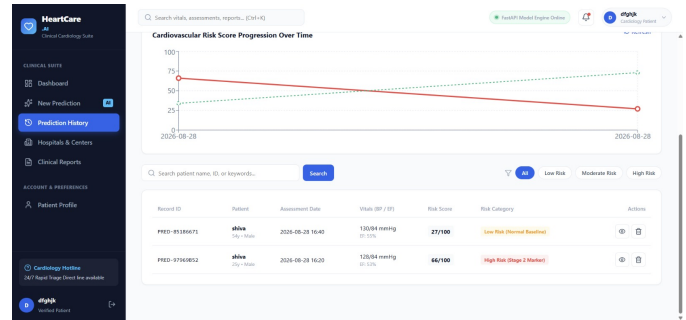


Fig. 6. Prediction History and Risk Classification Records

C. Prediction History Trend

I see that the system keeps evaluations and shows changes, in the cardiovascular risk assessment over time. By looking at trend analysis I can help users keep track of their health progress and spot differences among various evaluations.

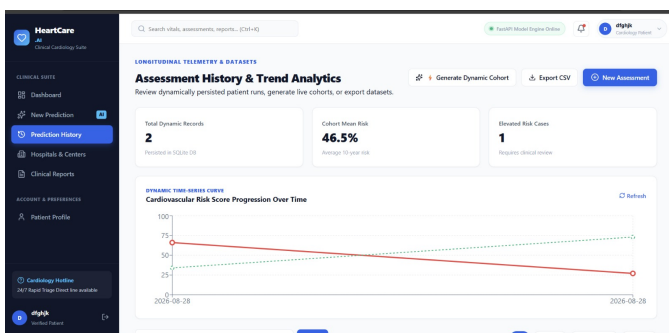


Fig. 5. Cardiovascular Risk Score Progression Over Time

D. Prediction History Records

The part that shows predictions keeps track of old evaluation records. It includes the details, the date of the evaluation important information, the risk score and the danger level. People can look through organize. View their previous predictions.

E. Model Performance Metrics

The effectiveness of the suggested machine learning model was tested using classification metrics. The model achieved an accuracy of 81.82 percent. This shows its ability to correctly classify healthy individuals and those with heart disease. The accuracy was 76.77 percent. The recall or sensitivity was 86.86 percent. This means the model was able to find a percentage of the current cases of heart disease. The model had a specificity of 77.50 percent. The F1-score was 81.51 percent. The ROC-AUC score is 91.70 percent. The high ROC-AUC score means the model has an ability to tell the difference between healthy people and those, with heart disease.

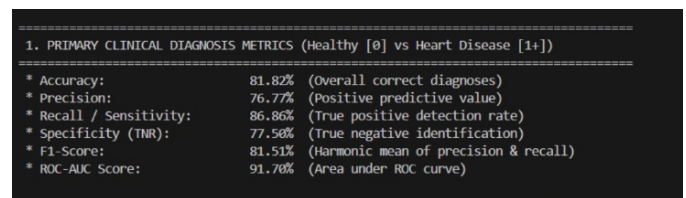


Fig. 7. Performance Metrics of the Proposed Machine Learning Model

F. Binary Confusion Matrix

The binary confusion matrix shows how well the classification performed in terms of accuracy.

Suggested framework for healthy and heart disease instances. The model correctly recognized 124 cases as true negatives and correctly identified 119

instances of heart disease as confirmed positives.

There were 36 instances of positives in which healthy individuals were identified

as being diagnosed with heart disease and 18 false negative instances indicating heart

instances of illness that were missed by the model. The reduced quantity of errors

The importance of cases, in a healthcare prediction system is very important because

Missing a possible case of heart disease could result in serious problems.

2. BINARY CONFUSION MATRIX

	PREDICTED HEALTHY (0)	PREDICTED DISEASE (1+)
ACTUAL HEALTHY (0)	124	36
ACTUAL DISEASE (1+)	18	119

Breakdown:
- True Positives (TP) = 119 (Correctly diagnosed with Heart Disease)
- True Negatives (TN) = 124 (Correctly diagnosed as Healthy)
- False Positives (FP) = 36 (Healthy patients flagged for further check)
- False Negatives (FN) = 18 (Missed cases - minimized due to high sensitivity)

3. 5-CLASS MULTI-STAGE SEVERITY CONFUSION MATRIX (STAGES 0 TO 4)

	Pred Stage 0	Pred Stage 1	Pred Stage 2	Pred Stage 3	Pred Stage 4
Actual Stage 0 (Healthy)	124	29	4	2	1
Actual Stage 1 (Mild)	17	11	10	5	11
Actual Stage 2 (Moderate)	0	7	6	9	13
Actual Stage 3 (Severe)	1	2	3	13	16
Actual Stage 4 (Critical)	0	1	2	4	6

Fig. 8. Binary and Multi-Stage Confusion Matrix of the Proposed Model

G. Multi-Class Severity Classification and Algorithm Comparison

Alongside predicting heart disease with outcomes the suggested system was assessed.It was evaluated for -level severity classification that includes five stages: Healthy, Mild, Moderate, Severe and Critical. The confusion matrix shows how the model placed cases into these severity levels.

The results show that the Healthy category had performance compared to the more serious severity levels. When looking at the multi-class classification the accuracy reached 53.87

The comparison of algorithms was carried out using machine learning techniques. The models that were evaluated include Random Forest, Gradient Boosting, Logistic Regression, Decision Tree Support Vector Machine and K-Nearest Neighbors algorithm. Among all the models tested Logistic Regression achieved the accuracy of 85.33

3. 5-CLASS MULTI-STAGE SEVERITY CONFUSION MATRIX (STAGES 0 TO 4)

	Pred Stage 0	Pred Stage 1	Pred Stage 2	Pred Stage 3	Pred Stage 4
Actual Stage 0 (Healthy)	124	29	4	2	1
Actual Stage 1 (Mild)	17	11	10	5	11
Actual Stage 2 (Moderate)	0	7	6	9	13
Actual Stage 3 (Severe)	1	2	3	13	16
Actual Stage 4 (Critical)	0	1	2	4	6

4. DETAILED CLASSIFICATION REPORT (PRECISION, RECALL, F1-SCORE)

	precision	recall	f1-score	support
Stage 0 (Healthy)	0.8732	0.7750	0.8212	160
Stage 1 (Mild)	0.2200	0.2037	0.2115	54
Stage 2 (Moderate)	0.2400	0.1714	0.2000	35
Stage 3 (Severe)	0.3939	0.3714	0.3824	35
Stage 4 (Critical)	0.1277	0.4615	0.2000	13
accuracy			0.5387	297
macro avg	0.3710	0.3966	0.3630	297
weighted avg	0.5907	0.5387	0.5582	297

5. ALGORITHM PERFORMANCE COMPARISON (BENCHMARK ON CLEVELAND DATASET)

Algorithm	Accuracy	Precision	Recall	Specificity	F1-Score	ROC-AUC
LightGBM (best_lgbm_3m_model.joblib)	81.82%	76.77%	86.86%	77.50%	81.51%	91.70%
Random Forest Classifier	82.67%	84.38%	77.14%	87.50%	80.60%	93.07%
Gradient Boosting (XGB style)	82.67%	82.35%	80.00%	85.00%	81.16%	88.79%
Logistic Regression (L2)	85.33%	85.29%	82.86%	87.50%	84.06%	94.79%
Decision Tree (CART)	74.67%	78.57%	62.86%	85.00%	69.84%	72.93%
Support Vector Machine (SVM)	68.00%	72.00%	51.43%	82.50%	60.00%	80.46%
K-Nearest Neighbors (KNN)	65.33%	65.52%	54.29%	75.00%	59.38%	73.96%

[OK] EVALUATION COMPLETE & VERIFIED

Fig. 9. Multi-Class Severity Classification Results and Machine Learning Algorithm Performance Comparison

XVII. CONCLUSION

This study introduces a Better Machine Learning System for Guessing if Someone Might Have Heart Failure and Giving Personal Health Tips. The system combines the ability to predict health risks using machine learning with advice that is aimed at helping people stay healthy.

Many different machine learning methods are tested to find the one for making predictions. The system also uses ways to pick the important information and adjust settings to make the predictions more accurate and the computer work faster. The results from the system include things like risk groups, chance of getting sick proof of the prediction and a score, for heart health.

The main contribution of the suggested system is the Customized Recommendation Engine. Unlike systems that only place users into risk categories this system looks at personal clinical details and lifestyle choices to give recommendations that fit each individual.

The use of AI makes the system more transparent by showing which factors affect the prediction results. Additional features such as prediction history, guidance for talking with doctors support, for finding hospital locations and health report generation make the system easier to use in life.

In short the suggested framework goes beyond a disease prediction model. It turns into a personalized heart health awareness and support system. This system is designed to help people make decisions about their health. The system focuses on heart health. The system is meant to help people make decisions. The system is all about heart health. The system is designed to help people make decisions, about their health.

The system is personalized. The system is detailed. The system is focused on heart health.

XVIII. FUTURE SCOPE

The suggested system has the ability to improve in different ways. Further research can use data sets to make the machine learning model more reliable and more useful when it is used in real life. Connecting the system to Electronic Health Records can help in handling health information while making sure that rules about privacy, safety and who can access the information are followed. Small devices that people wear can also be added to gather data like heart rate, daily activities and sleep patterns. This would make it possible to track health. Give the Heart Health Score regular updates.

I think that new versions could use Explainable AI methods to make predictions along, with explanations. Deep learning methods can also help in looking at health data sets.

I think the Personalized Recommendation Engine can get better by using feedback-driven recommendation ways. People can set health goals like raising activity levels or cutting down smoking and the Personalized Recommendation Engine can watch how they do over time.

The app might act as a hub that gives alerts, reminders, health trends and live tracking. Before using the app to make choices it is crucial to check it with health experts and real data sets.

REFERENCES

- [1] S. Nikhar and A. M. Karandikar, "Prediction of heart disease using machine learning algorithms," *International Journal of Advanced Engineering, Management and Science*, vol. 2, no. 6, 2016.
- [2] N. Chandrasekhar and S. Peddakrishna, "Enhancing heart disease prediction accuracy through machine learning techniques and optimization," *Processes*, vol. 11, no. 4, p. 1210, 2023.
- [3] M. Ahmed, M. H. Sulaiman, M. M. Hassan, and T. Bhuiyan, "Predicting the classification of heart failure patients using optimized machine learning algorithms," *IEEE Access*, 2025.
- [4] A. M. Qadri, A. Raza, K. Munir, and M. S. Almutairi, "Effective feature engineering technique for heart disease prediction with machine learning," *IEEE Access*, vol. 11, pp. 56214–56224, 2023.
- [5] Additional research papers related to machine learning, explainable artificial intelligence, heart disease prediction, feature selection, and personalized healthcare recommendations can be added based on the final literature review.