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Artificial Intelligence Based Solution for Prediction of Cardiovascular Disease

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ABSTRACT: Cardiovascular diseases are a class of diseases that are causing death across the globe according to WHO. Early detection of such diseases can help patients to take care of their health and reduce death rate. Due to emergence of Artificial Intelligence (AI) based methods in terms of machine learning, it became an important area to solve problems in healthcare domain. Towards this end, in this paper we proposed an AI enabled framework with a set of ML models to detect CVD automatically. We proposed an algorithm known as AI based CVD Prediction (AI-CVDP) which exploit a pipeline of different models. The algorithm exploits different ML models in pipeline and has its iterative process to train classifiers from the given training data. Then all the ML models are evaluated using test data. Performance is observed in terms of precision, recall, F1 score and accuracy. We built a prototype for empirical study to evaluate the proposed model. Experimental results revealed that, the Random Forest (RF) model achieved highest accuracy with 90%.

KEYWORDS: Cardiovascular Disease Prediction, Artificial Intelligence, Machine Learning, Feature Importance

I. INTRODUCTION

Machine learning proves to be effective in assisting in making decisions and predictions from the large quantity of data produced by the health care industry. This project aims to predict future Heart Disease by analyzing data of patients which classifies whether they have heart disease or not using machine-learning algorithm. Machine Learning techniques can be a boon in this regard. Even though heart disease can occur in different forms, there is a common set of core risk factors that influence whether someone will ultimately be at risk for heart disease or not. By collecting the data from various sources, classifying them under suitable headings & finally analyzing to extract the desired data we can say that this technique can be very well adapted to do the prediction of heart disease.

There are many existing methods for CVD prediction as found in the literature. Konstantinos et al. [5] explored ECG based approach using AI methods for CVD management. Umar et al. [6] proposed a methodology for predicting heart disease using different risk factors. It is based on genetic neural network approach. Georga et al. [7] explored AI based methods for mining patient data to find possible risk of CVD. Nawaz et al. [17] focused on intelligent methods used for prediction of CVD with the help of Gradient Descent Optimization. Dorado-Díaz et al. [18] investigated on AI based applications and their utility in cardiology. Kim [19] proposed a methodology using ML by taking inputs from smart watch to predict CVD automatically. Rahim et al. [19] focused on making an integrated ML based framework for improving CVD prediction performance while Chayakrit et al. [20] explored ML based meta-analysis for CVD detection. From the literature, it is ascertained that there is need for improving ML based approach towards CVD prediction. Our contributions in this paper are as follows.

1. We proposed an AI based framework for automatic detection of cardiovascular diseases.
2. We proposed an algorithm known as AI based CVD Prediction (AI-CVDP) which exploit a pipeline of different models.
3. We built a prototype for empirical study to evaluate the proposed model.

The remainder of the paper is structured as follows. Section 2 review literature on different methods used for CVD detection covering AI methods as well. Section 3 presents the proposed methodology and the underlying algorithm. Section 4 presents experimental results and evaluation of the proposed AI model. Section 5 concludes our work and gives scope for future work.

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II. RELATED WORK

This section reviews literature on existing methods for CVD prediction. Karthik et al. [1] proposed AI based method for discovering CVD medicine related information. Barti et al. [2] used different ML algorithms with comparative study used for detection of heart diseases. Rajamhoana et al. [3] proposed neural network-based approach towards automatic detection of heart diseases. Xuan et al. [4] focused on AI based intelligent methods used for detection of cardiovascular and heart diseases. Konstantinos et al. [5] explored ECG based approach using AI methods for CVD management. Umar et al. [6] proposed a methodology for predicting heart disease using different risk factors. It is based on genetic neural network approach. Georga et al. [7] explored AI based methods for mining patient data to find possible risk of CVD. Benjamins et al. [8] investigated on the useful AI methods for cardiovascular medicine research. Dorrer et al. [9] exploited AI methods to study the human response system for CVD related ailments. Krittanawong et al. [10] proposed a methodology to incorporate AI based techniques towards precision cardiovascular medicine. Amma and Bhuvaneswari [11] explores neural network and genetic algorithm combination to achieve CVD prediction. Lopez-Jimenez et al. [12] studied the current academic thinking on CVD prediction using AI and future possibilities.

Swathy and Saruladha [13] analyzed different ML and deep learning techniques used for CVD prediction. Jin et al. [14] focused on adaptive ML approach to monitor real time ECG of patients to detect CVD probability. Pankaj et al. [15] investigated on CVD detection methods linked to ML and AI towards clinical decision support system. Dinesh et al. [16] used different ML algorithms and evaluated their performance in CVD prediction. Nawaz et al. [17] focused on intelligent methods used for prediction of CVD with the help of Gradient Descent Optimization. Dorado-Díaz et al. [18] investigated on AI based applications and their utility in cardiology. Kim [19] proposed a methodology using ML by taking inputs from smart watch to predict CVD automatically. Rahim et al. [19] focused on making an integrated ML based framework for improving CVD prediction performance while Chayakrit et al. [20] explored ML based meta-analysis for CVD detection. From the literature, it is ascertained that there is need for improving ML based approach towards CVD prediction.

III. PROPOSED METHODOLOGY

We proposed a ML based framework for automatic detection of CVD. It is based on supervised learning that exploits training samples in order to predict CVD for given patient. A pipeline of different ML algorithms is used in order to have performance analysis in CVD prediction. Figure 1 shows the architecture of the proposed framework. Each ML model used in the proposed architecture has its modus operandi in prediction process. The classification models used in the empirical study have their underlying methodology for learning and perform learning-based prediction of CVD.

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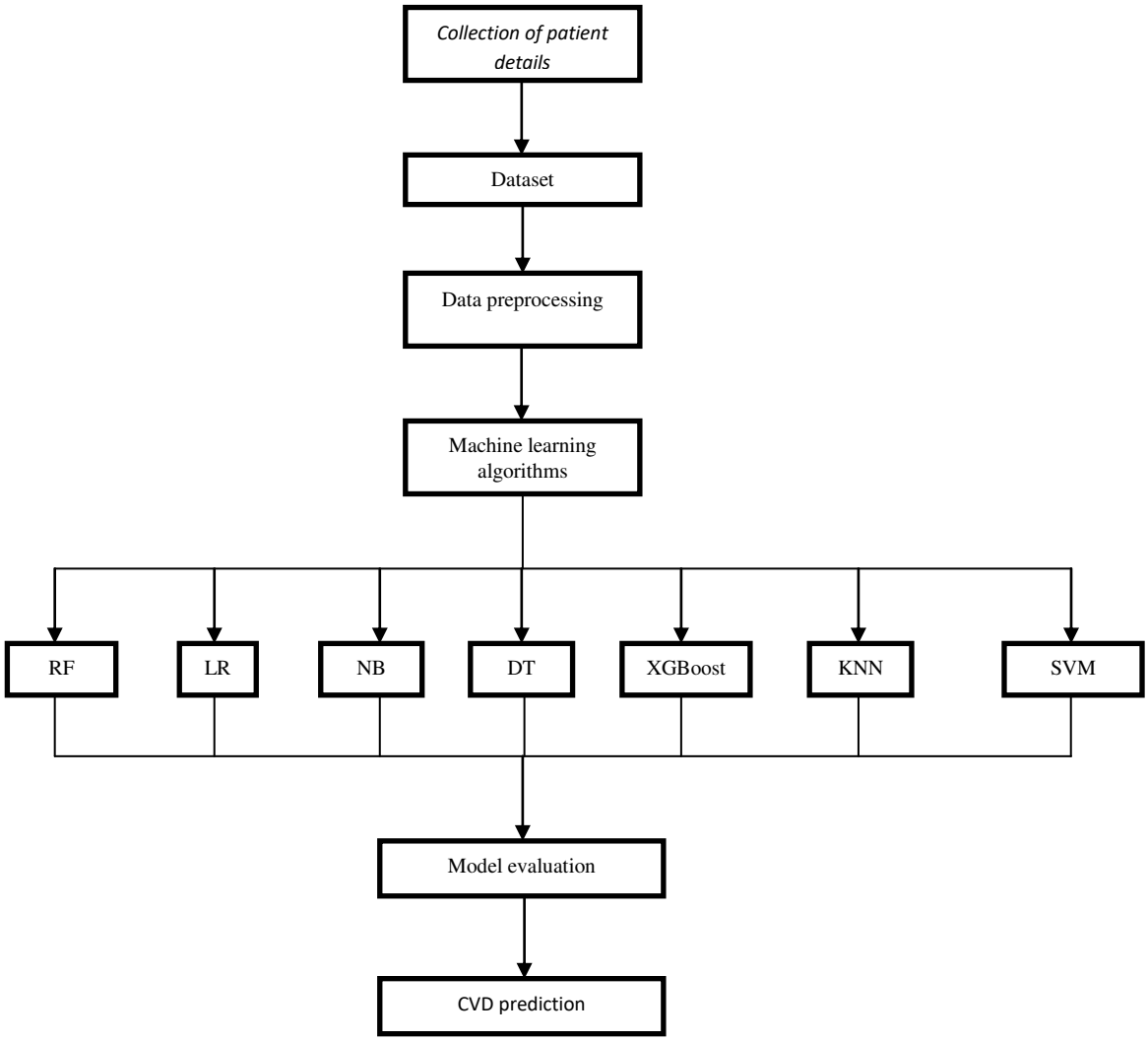

Figure 1: Proposed Architecture

As presented in Figure 1, the given dataset is subjected to pre-processing where the data is divided into training set and test set. A pipeline of many ML models is used in order to learn from the training set. After learning from the training data, the algorithms gain required knowledge model in order to predict CVD on test data which is unlabeled data. Then model performance is evaluated with different performance metrics.

Algorithm: AI based CVD Prediction (AI-CVDP)
Inputs: patient dataset details as P, machine learning models as M
Output: results as R

1. Start
2. Input patient dataset, P
3. Pre-processing
4. Splitting data
5. Extract features from training set()
6. For each model m in M
7. Train the model m
8. End For

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9. For each model m in M
10. Use model for testing
11. Evaluate
12. Display results
13. End For
14. Save the model()
15. Predict the disease

Return R

Algorithm 1: Proposed algorithm

As presented in Algorithm 1, it takes dataset as input and performs feature extraction and train each model in an iterative fashion besides performing prediction process. The saved prediction models are evaluated with testing process. Confusion matrix is the basis for deriving performance evaluation metrics in many ML based problems. Confusion matrix is widely used as explored in [2], [3], [7] and [10]. It has two correctly predicted cases (TP and TN) and two incorrect predictions such as FP and FN.

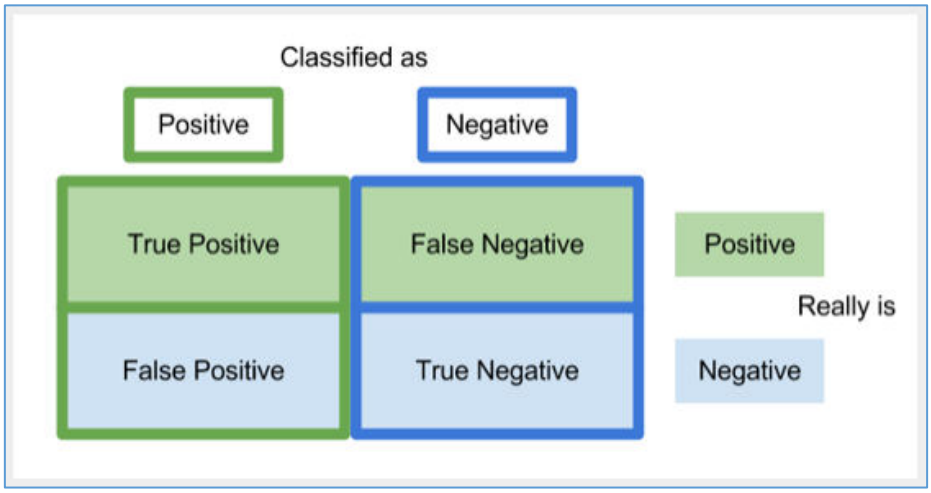

Figure 2: Confusion matrix model

As presented in Figure 3, different cases in the confusion matrix are used to arrive at the performance measures. The performance metrics are expressed in Eq. (4) to Eq. (7).

$$\text{Precision} = \frac{TP}{TP+FP} \quad (4)$$

$$\text{Recall} = \frac{TP}{TP+FN} \quad (5)$$

$$\text{F1-measure} = 2 * \frac{(precision * recall)}{(precision+recall)} \quad (6)$$

$$\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN} \quad (7)$$

These metrics result a value between 0 and 1 reflecting lowest and highest possible performance. Higher value refers to better performance.

IV. RESULTS

This section presents experimental results in terms of feature importance and performance evaluation in terms of precision, recall, F1 score and accuracy.

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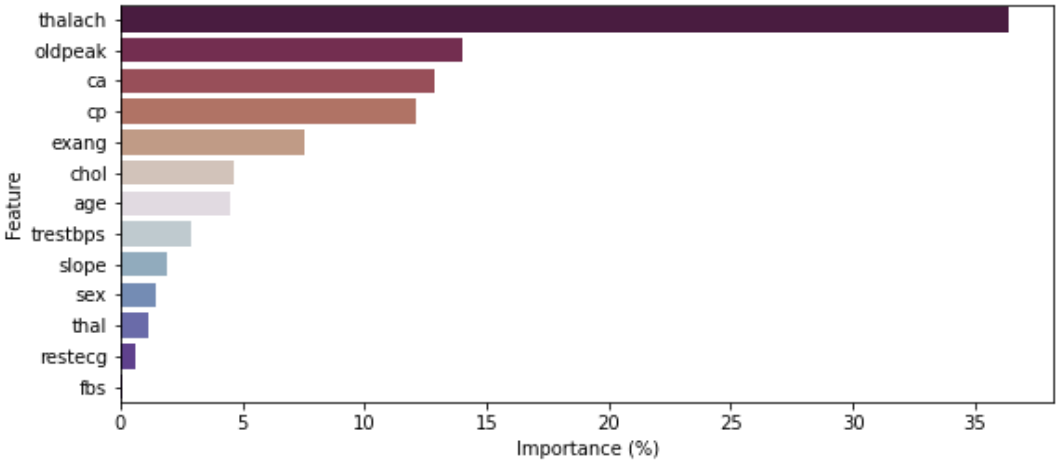

Figure 3: Feature importance

As presented in Figure 3, feature importance is computed in order to use only important features in training in order to improve quality of training.

Logistic Regression

	precision	recall	f1-score	support
0	0.85	0.81	0.83	27
1	0.86	0.88	0.87	34
accuracy			0.85	61
macro avg	0.85	0.85	0.85	61
weighted avg	0.85	0.85	0.85	61

KNN CLF

	precision	recall	f1-score	support
0	0.67	0.59	0.63	27
1	0.70	0.76	0.73	34
accuracy			0.69	61
macro avg	0.68	0.68	0.68	61
weighted avg	0.69	0.69	0.69	61

SVM CLF

	precision	recall	f1-score	support
0	0.71	0.56	0.63	27
1	0.70	0.82	0.76	34
accuracy			0.70	61

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macro avg	0.71	0.69	0.69	61
weighted avg	0.71	0.70	0.70	61

NAÏVE BAYES CLF

precision	recall	f1-score	support
0	0.88	0.78	0.82	27
1	0.84	0.91	0.87	34
accuracy			0.85	61
macro avg	0.86	0.84	0.85	61
weighted avg	0.85	0.85	0.85	61

RANDOM FOREST

precision	recall	f1-score	support
0	0.92	0.85	0.88	27
1	0.89	0.94	0.91	34
accuracy			0.90	61
macro avg	0.90	0.90	0.90	61
weighted avg	0.90	0.90	0.90	61

XG BOOST

precision	recall	f1-score	support
0	0.81	0.78	0.79	27
1	0.83	0.85	0.84	34
accuracy			0.82	61
macro avg	0.82	0.82	0.82	61
weighted avg	0.82	0.82	0.82	61

Decision Tree

precision	recall	f1-score	support
0	0.79	0.85	0.82	27
1	0.88	0.82	0.85	34
accuracy			0.84	61
macro avg	0.83	0.84	0.83	61
weighted avg	0.84	0.84	0.84	61

Figure 4: Presents experimental results

As presented in Figure 4 accuracy of Logistic Regression model is 85%, KNN 69%, SVM 70%, Naïve Bayes 85%, Random Forest 90%, XGBoost 82% and Decision Tree 84%. Highest performance for CVD prediction is exhibited by Random Forest with 90% accuracy.

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V. CONCLUSION AND FUTURE WORK

In this paper we proposed an AI enabled framework with a set of ML models to detect CVD automatically. We proposed an algorithm known as AI based CVD Prediction (AI-CVDP) which exploit a pipeline of different models. The algorithm exploits different ML models in pipeline and has its iterative process to train classifiers from the given training data. Then all the ML models are evaluated using test data. SVM, Decision Tree, Random Forest, Naïve Bayes, Logistic Regression, XGBoost and KNN are applied on the dataset. Performance is observed in terms of precision, recall, F1 score and accuracy. We built a prototype for empirical study to evaluate the proposed model. Experimental results revealed that, the Random Forest (RF) model achieved highest accuracy with 90%. In future we intend to improve our frameworkwith deep learning models to leverage CVD prediction performance further.

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