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Cleveland Heart Data Detection Using Ensemble Models

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ABSTRACT:- In the web application, the CVD is recognised and shown. The UCI provided the data for Cleveland Heart. Five algorithms are employed in this application, together with an Ensemble model. For detecting purposes, Random Forest, Logistic Regression, Decision Tree Algorithm, Multinomial nb, Support vector machine, and Ensemble model are used. Following the implementation of the algorithms, they are then deployed in the Python Flask framework for a graphical user interface and the prediction's target outcome to be displayed in the app. The research gaps highlighted in the literature lead to the following three goals: Develop Hybrid Data Classification Algorithms that are accurate. Create an effective ensemble model for reliable CVD prediction. Deploy the models you've built for real-time use. The goal of the proposed research project is to develop and improve an algorithm for accurately classifying CVD. Various machine learning models will be built as part of this effort to provide precise measurements for CVD categorization. Furthermore, for reliable CVD prediction, the Ensemble model will be incorporated among machine learning models and deployed for production. Deploy the models you've built for real-time use.

Key words:- CVD, Random Forest, Logistic Regression, Decision Tree Algorithm, Multinomial_nb, Support vector machine, Ensemble model.

1.INTRODUCTION

Heart disease is a big issue all around the world. In cases of sudden death, early identification of heart problems and prompt medical treatment can save lives. According to the World Health Organization (WHO), over 17 million people worldwide die each year as a result of cardiovascular illnesses. This accounts for roughly 31% of all deaths worldwide. Cardiovascular disease (CVD), often known as heart disease, affects the human body's blood and heart. Myocardial infarction (commonly known as a heart attack) is a kind of CVD. Coronary Heart Disease (CHD) is another type of heart disease in which a material called plaque builds up in the coronary arteries. Healthcare centres retain a large quantity of data in their databases that is exceedingly complex and difficult to analyse due to the rapid growth of digital technology.

In medical centres, data mining techniques and machine learning algorithms are critical in the analysis of various data. The approaches and algorithms can be applied directly to a dataset to create models or make important findings and inferences. Machine learning understanding and clinical practise in the realm of disease prediction are becoming increasingly thorough as computer technology advances. Family history, smoking, high LDL cholesterol levels, high blood pressure, age, and uncontrolled diabetes are all risk factors for coronary heart disease.

Exercise stress tests, chest X-rays, heart scans (CT), cardiac magnetic resonance imaging (MRI), coronary angiograms, and electrocardiograms are currently utilised to diagnose the severity of heart disease in patients (EKG).

Early detection of coronary heart disease can be difficult, hence computer-assisted approaches for detecting and diagnosing heart disease in individuals have been developed. Machine learning, a technology that analyses clinical data, evaluates it, and delivers diagnoses for medical diseases, is becoming more widely used among computer-aided detection methods in medical facilities. Machine learning is required in cardiovascular medicine. The major distinction between statistical and machine learning methods is that the former primarily aids in the understanding of relationships between a small number of variables, whereas the latter aids in the identification and engineering of features from data as well as prediction.

Machine learning methods thus supplement and extend conventional statistical methods by providing tools and algorithms for deciphering patterns in vast, complex, and diverse datasets. Machine learning approaches are adaptable and generalizable across a number of data sources and enable analyses and interpretation across complicated variables, whereas classical statistical methods are capable of both discovery and prediction. Machine learning techniques, on the other hand, often make fewer assumptions and produce superior and more reliable predictions.

From the various existing systems it is understood that there is a need for the following:

1. There is a need to develop hybrid classification algorithms.
2. There is lack of technique to develop efficient ensemble model for accurate prediction of CVD.
3. There is a need to deploy the constructed models for the real time use

Table 1: Different types of heart disease

Arrhythmia	The heart beat is improper whether it may irregular, too slow or too fast.
Cardiac arrest	An unexpected loss of heart function, consciousness and breathing occur suddenly.
Congestive heart failure	The heart does not pump blood as well as it should, it is the condition of chronic.
Congenital heart disease	The heart's abnormality which develops before birth.
Coronary artery disease	The heart's major blood vessels can damage or any disease occurs in the blood vessels.
High Blood Pressure	It has a condition that the force of the blood against the artery walls is too high.
Peripheral artery disease	The narrowed blood vessels which reduce flow of blood in the limbs, is the circulatory condition.
Stroke	Interruption of blood supply occur damage to the brain.

The online application detects and displays the system CVD. The UCI provided the data for Cleveland Heart. There are 303 examples in this dataset, with 76 attributes/features. Out of the 76 features, 13 are used. Five algorithms are employed in this application, together with an Ensemble model. For detecting purposes, Random Forest, Logistic Regression, Decision Tree

Algorithm, Multinomial nb, Support vector machine, and Ensemble model are used. Following the implementation of the aforementioned algorithms, they are then deployed in the Python Flask framework for a graphical user interface and the prediction's target outcome to be displayed in the app.

The research gaps identified in the literature gives rise to three objectives as follows:

1. Develop accurate Hybrid Data Classification Algorithms.
2. Develop an efficient ensemble model for accurate prediction of CVD.
3. Deploy the constructed models for the real time use.

II.METHODOLOGY

A system requirements specification is a description of a software system to be developed. It lays out functional and non-functional requirements, and may include a set of use cases that describe user interactions that the software must provide. System requirements specification establishes the basis on what the product is to do as well as what it is not expected to do. It permits a rigorous assessment of requirements before design can begin and reduces later redesign. It should also provide a realistic basis for estimating product costs, risks, and schedules. Used appropriately, it can help prevent software project failure.

Functional requirements are specific functionality that define what a system is supposed to accomplish. Functional requirements are supported by non-functional requirements (also known as quality requirements), which impose constraints on the design or implementation (such as performance requirements, security, or reliability). Generally, functional requirements are expressed in the form "system must do <requirement>".

Table 2: Functional Requirements.

Functionality	Description
User Roles	➢ User should be able to login the system. ➢ User should be able to enter the patients' health information to predict CVD. ➢ User should be able to view the probability of CVD according to the health information entered in the system. ➢ User should be able to get the result accurately.
System Roles	➢ The system should be able to authenticate users ➢ The system should be able to fit patient's health data into various machine learning models and ensemble model. ➢ All the algorithms implemented should have accuracy of more than 75 percent. ➢ The system should fit the patient's health information in the machine learning models separately. ➢ The system should be able to predict the result and display it to the use.

Non-functional requirement in software system engineering, a software requirement that describes not what the software will do, but how the software will do it, for example, software performance requirements, software external interface requirements, design constraints, and software quality attributes. Non-functional requirements are difficult to test therefore, they are usually evaluated subjectively. Generally, non-functional requirements are "system shall be <requirement>".

III.IMPLEMENTATION

CVD PREDICTION:

The term “heart disease” is often used interchangeably with the term “cardiovascular disease”. Cardiovascular disease generally refers to conditions that involve narrowed or blocked blood vessels that can lead to a heart attack, chest pain (angina) or stroke. Other heart conditions, such as those that affect your heart’s muscle, valves or rhythm, also are considered forms of heart disease.Machine learning (ML) proves to be effective in assisting in making decisions and predictions from the large quantity of data produced by the healthcare industry.

Algorithms Implemented:

SVM classifier:

The objective of the support vector machine algorithm is to find a hyperplane in an N-dimensional space (N — the number of features) that classifies the data point.

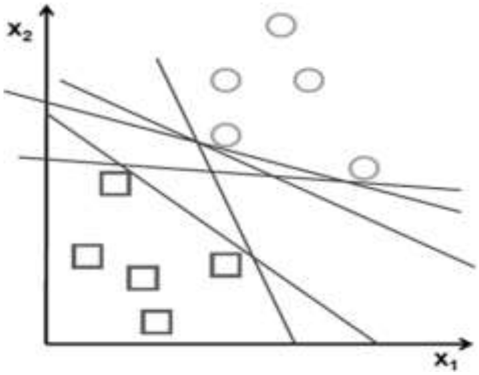


Figure : Possible Hyperplanes

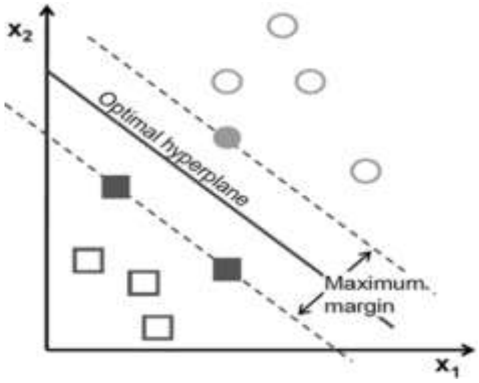


Figure: Optimal Hyperplane

To separate the two classes of data points, there are many possible hyper planes that could be chosen. Our objective is to find a plane that has the maximum margin, i.e the maximum distance between data points of both classes. Maximizing the margin distance provides some reinforcement so that future data points can be classified with more confidence. Support vectors are data points that are closer to the hyper plane and influence the position and orientation of the hyper plane. Using these support vectors, we maximize the margin of the classifier. Deleting the support vectors will change the position of the hyper plane. These are the points that help us build our SVM.

Kernel SVM: Simple SVM algorithm can be used to find decision boundary for linearly separable data. However, in the case of non-linearly separable data, such as the one shown in Fig. 2, a straight line cannot be used as a decision boundary. It is method of using linear classifier to classify non-linear data points. Mathematically, it is Mercer's theorem, which maps non-linear input data points into higher dimension where they can be linearly separable. And kernel is a function which actually perform the above task for us. There are different types of kernel like 'linear', 'polynomial', 'redial basis function' etc. Selecting a right kernel which can best suit your data is obtained by cross-validation.

Logistic regression classifier:

Logistic regression is a classification algorithm used to assign observations to a discrete set of classes. Unlike linear regression which outputs continuous number values, logistic regression transforms its output using the logistic sigmoid function to return a probability value which can then be mapped to two or more discrete classes.

Types of logistic regression

- Binary (Pass/Fail)
- Multi (Cats, Dogs, Sheep)
- Ordinal (Low, Medium, High)

In this project, binary logistic regression is used as there are only two class labels (1 or 0).

Binary logistic regression:

Sigmoid activation: In order to map predicted values to probabilities, we use the sigmoid function. The function maps any real value into another value between 0 and 1.

Math: $\boldsymbol{S(z) = \frac{1}{1+e^{-z}}}$

- s(z) = output between 0 and 1 (probability estimate)
- z = input to the function (your algorithm's prediction e.g. mx + b)
- e = base of natural log

Graph:

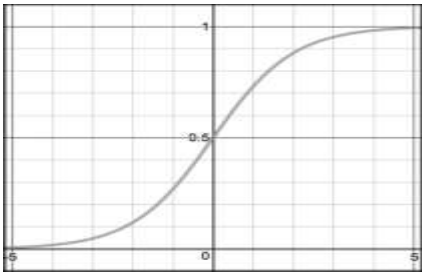


Figure : Logistic Regression Curve

Decision boundary:

Our current prediction function returns a probability score between 0 and 1. In order to map this to a discrete class (true/false, cat/dog), we select a threshold value or tipping point above which we will classify values into class 1 and below which we classify values into class 2. i.e, if $p \geq 0.5$, class=1 and if $p< 0.5$, class=0.

Making predictions:

Using our knowledge of sigmoid functions and decision boundaries, we can now write a prediction function. A prediction function in logistic regression returns the probability of our observation being positive, True or "Yes". We call this class 1 and its notation is P (class=1). As the probability gets closer to 1, our model is more confident that the observation is in class 1.

Random Forest classifier:

Random forest is a supervised learning algorithm which is used for both classification as well as regression. But however, it is mainly used for classification problems. As we know that a forest is made up of trees and more trees means more robust forest. Similarly, random forest algorithm creates decision trees on data samples and then gets the prediction from each of them and finally selects the best solution by means of voting. It is an ensemble method which is better than a single decision tree because it reduces the over-fitting by averaging the result

Working of Random Forest Algorithm:

We can understand the working of Random Forest algorithm with the help of following steps:

- **Step 1** − First, start with the selection of random samples from a given dataset.
- **Step 2** − Next, this algorithm will construct a decision tree for every sample. Then it will get the prediction result from every decision tree.
- **Step 3** − In this step, voting will be performed for every predicted result.
- **Step 4** − At last, select the most voted prediction result as the final prediction result.

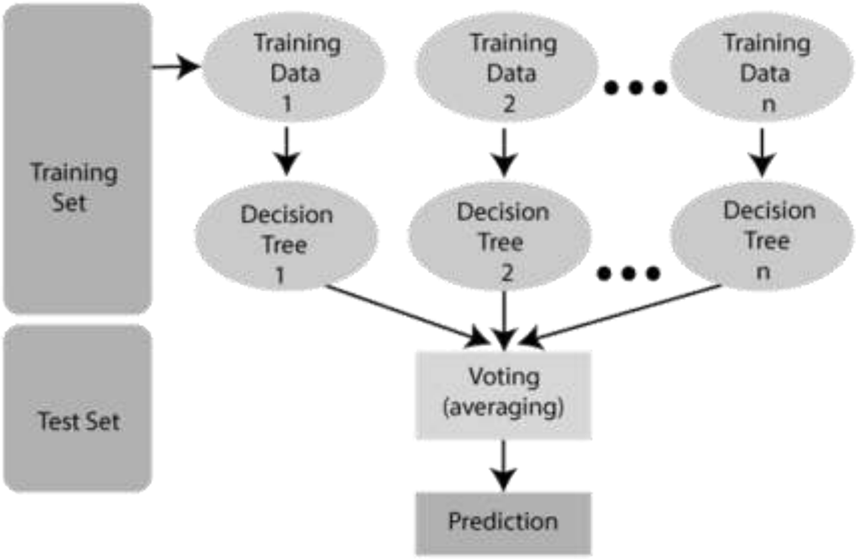


Figure :Random Forest Algorithm

Decision Tree Classifier:

Decision Trees (DTs) are a non-parametric supervised learning method used for classification and regression. The goal is to create a model that predicts the value of a target variable by learning simple decision rules inferred from the data features.

Decision tree working:

The decision of making strategic splits heavily affects a tree's accuracy. The decision criteria are different for classification and regression trees. Decision trees use multiple algorithms to decide to split a node into two or more sub-nodes. The creation of sub-nodes increases the homogeneity of resultant sub-nodes. In other words, we can say that the purity of the node increases with respect to the target variable. The decision tree splits the nodes on all available variables and then selects the split which results in most homogeneous sub-nodes.

Steps in ID3 algorithm:

1. It begins with the original set S as the root node.
2. On each iteration of the algorithm, it iterates through the very unused attribute of the set S and calculates **Entropy (H)** and **Information gain (IG)** of this attribute.
3. It then selects the attribute which has the smallest Entropy or Largest Information gain.
4. The set S is then split by the selected attribute to produce a subset of the data.
5. The algorithm continues to recur on each subset, considering only attributes never selected before.

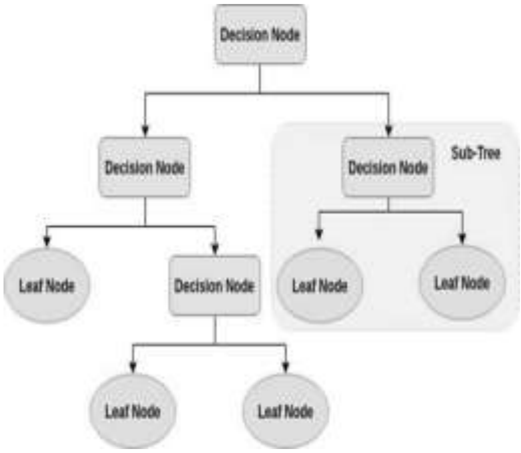


Figure: Decision tree classification

Multinomial Naïve Bayes classifier:

MultinomialNB implements the naive Bayes algorithm for multinomially distributed data, and is one of the two classic naive Bayes variants used in text classification (where the data are typically represented as word vector counts, although tf-idf vectors are also known to work well in practice). The distribution is parameterized by vectors $\theta_y = (\theta_{y1}, \ldots.., \theta_{yn})$

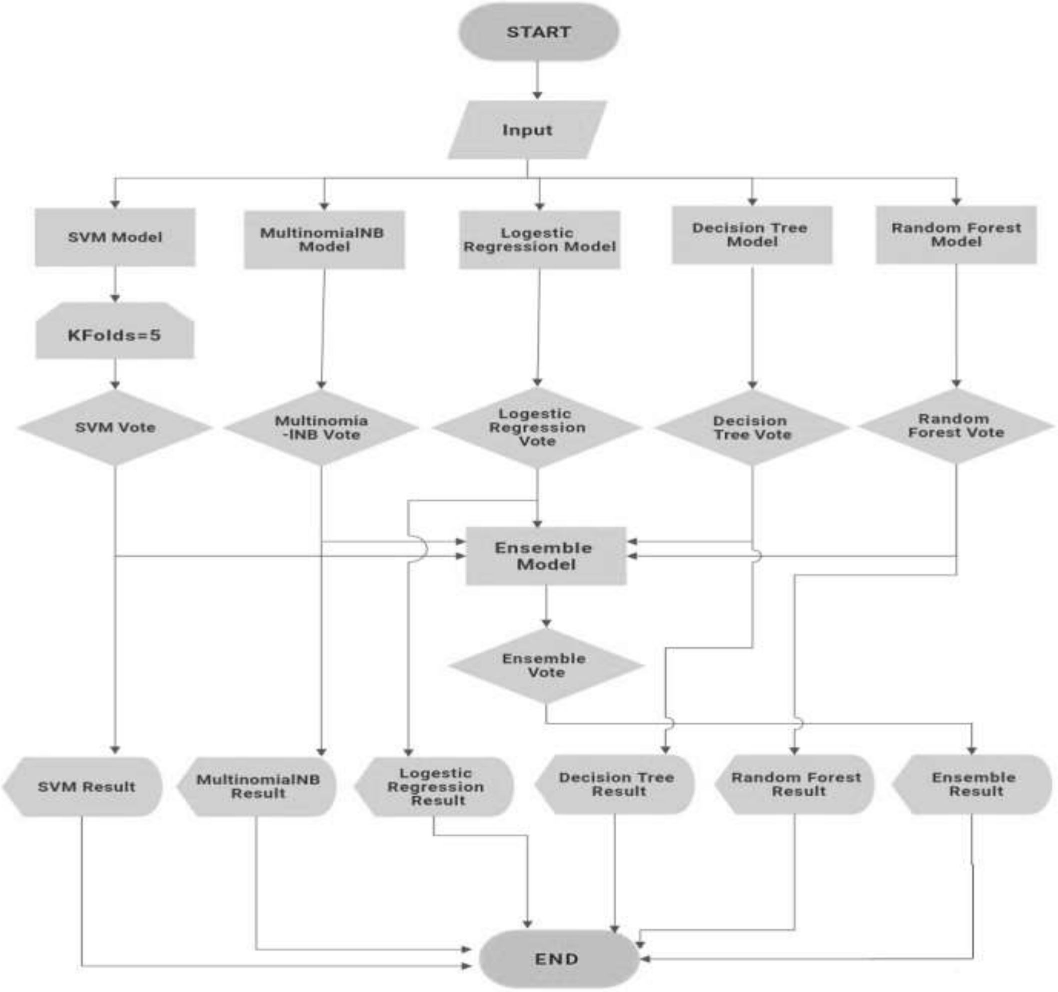
For each class y, where n is the number of features (in text classification, the size of the vocabulary) and $\theta_{yi}$is the probability $P(x_i|y)$ of feature$i$appearing in a sample belonging to class

y.The parameters $\theta_y$is estimated by a smoothed version of maximum likelihood, i.e. relative frequency counting:

$$\boldsymbol{\hat{\theta}_{yi} = \frac{N_{yi} + \alpha}{N_y + \alpha n}}$$

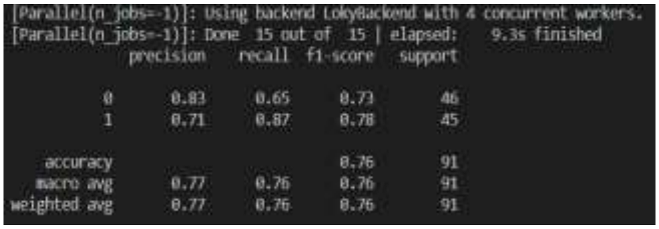
Where $N_{yi} = \sum_{x \in T} x_i$ is the number of times feature i appears in a sample of class $y$in the training set T , and $N_y = \sum_{i=1}^{n} N_{yi}$ is the total count of all features for class y.

The smoothing priors α ≥ 0 accounts for features not present in the learning samples and prevents zero probabilities in further computations. Setting α = 1 is called Laplace smoothing, while α < 1 is called Lidstone smoothing.



V.RESULTS

Support vector machine classifier:



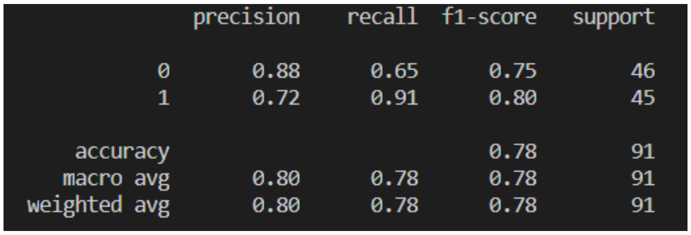
```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent workers.
[Parallel(n_jobs=-1)]: Done  15 out of  15 | elapsed:    9.3s finished
              precision    recall  f1-score   support

           0       0.83      0.65      0.73        46
           1       0.71      0.87      0.78        45

    accuracy                           0.76        91
   macro avg       0.77      0.76      0.76        91
weighted avg       0.77      0.76      0.76        91
```

Figure: SVM Classification Report

Logistic regression classifier:



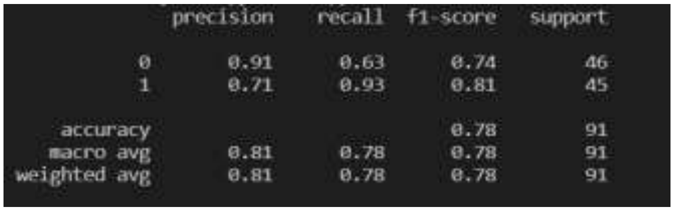
```
              precision    recall  f1-score   support

           0       0.88      0.65      0.75        46
           1       0.72      0.91      0.80        45

    accuracy                           0.78        91
   macro avg       0.80      0.78      0.78        91
weighted avg       0.80      0.78      0.78        91
```

Figure: Logistic regression Classification Report

Random Forest classifier:



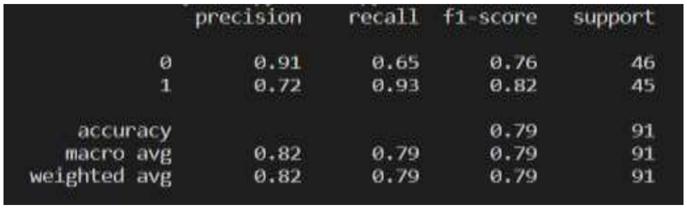
```
              precision    recall  f1-score   support

           0       0.91      0.63      0.74        46
           1       0.71      0.93      0.81        45

    accuracy                           0.78        91
   macro avg       0.81      0.78      0.78        91
weighted avg       0.81      0.78      0.78        91
```

Figure: Random Forest Classification Report

Decision Tree Classifier:



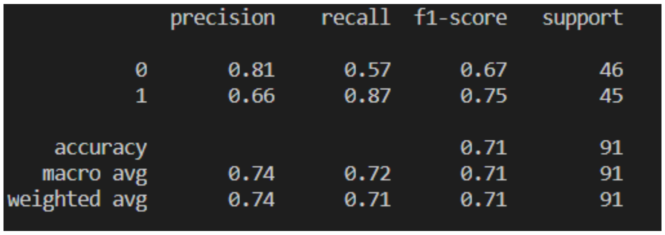
```
              precision    recall  f1-score   support

           0       0.91      0.65      0.76        46
           1       0.72      0.93      0.82        45

    accuracy                           0.79        91
   macro avg       0.82      0.79      0.79        91
weighted avg       0.82      0.79      0.79        91
```

Figure:Decision Tree Classification Report

Multinomial-NB Classifier:



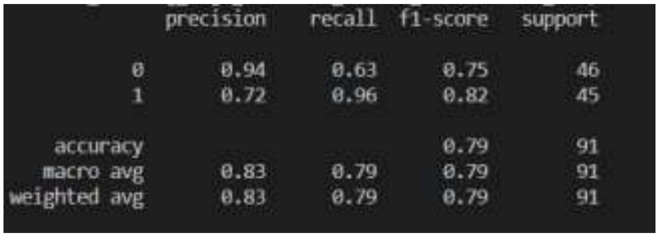
```
              precision    recall  f1-score   support

           0       0.81      0.57      0.67        46
           1       0.66      0.87      0.75        45

    accuracy                           0.71        91
   macro avg       0.74      0.72      0.71        91
weighted avg       0.74      0.71      0.71        91
```

Figure: Multinomial-NB Classification Report

Ensemble model:



```
              precision    recall  f1-score   support

           0       0.94      0.63      0.75        46
           1       0.72      0.96      0.82        45

    accuracy                           0.79        91
   macro avg       0.83      0.79      0.79        91
weighted avg       0.83      0.79      0.79        91
```

Figure : Ensemble model Classification Report

VI.CONCLUSION

In this article, we used a variety of machine learning methods to solve the issue of cardiovascular heart disease prediction, including Support Vector Machine, Logistic regression, Random Forest classifier, Decision Tree Classifier, and Multinomial Nave Bayes classifier. For accurate CVD prediction, several kinds of in-built functions have been developed. Our project's primary goal was to make an accurate forecast based on the available data. One of the major contributions of our work is to define this job as a constraint-based combinatorial optimization problem and to offer techniques for solving it using an ensemble learning approach that use the max voting technique to integrate all five models stated above. In this research, machine learning models offer personalised prediction based on different performance metrics. We focused this project on developing a web application utilising a variety of web technologies to create a usable graphical user interface. The database activities in the proposed application are handled by MongoDB. Finally, the web application displays the prediction results.

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