Heart disease prediction with SVM algorithm

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Abstract *- Cardiovascular disease, commonly known as heart disease, stands as a pervasive cause of mortality globally, presenting a substantial menace to public health. Data from the World Health Organization reveals that in 2017 alone, cardiovascular disease precipitated a staggering 17.9 million fatalities worldwide. Regrettably, the toll of cardiovascular disease continues to escalate annually, particularly in emerging nations. Reports indicate that nearly 80% of fatalities attributed to cardiac ailments transpire within middle and low-income countries, where the average age at which these fatalities occur is notably younger than in their high-income counterparts. Within the realm of medicine, discerning the presence of heart disease poses a formidable challenge.*

This intricate task hinges upon the meticulous analysis of extensive clinical and pathological datasets. Consequently, there has been a surge of interest among both researchers and clinical practitioners in devising more efficient and precise methodologies for predicting heart disease.

The imperative of timely and accurate diagnosis in the early stages of cardiac ailments cannot be overstated, given the paramount importance of time in mitigating adverse outcomes. As the leading cause of mortality worldwide, the prognostication of heart disease assumes profound significance when undertaken preemptively.

In recent years, machine learning has emerged as a dynamic and dependable ally in the medical domain, furnishing invaluable tools for disease prediction through rigorous training and testing protocols. The focal objective of this endeavor is to scrutinize various prediction models for heart disease, with a particular emphasis on discerning pivotal cardiac features utilizing the SVM algorithm.

Keywords *- Machine Learning, Heart disease, Data Analysis, Chest Discomfort, Blood pressure, Sugar levels, Logistic Regression, Decision tree, K Nearest Neighbor, Accuracy, Precision, Recall, Heart disease prediction.*

1. Introduction

The heart, a vital muscular organ, orchestrates the circulation of blood throughout the body, serving as the linchpin of the intricate cardiovascular system, which also encompasses the lungs. This network is further augmented by an intricate web of blood vessels, including veins, arteries, and capillaries, facilitating the distribution of blood across the entirety of the organism. Perturbations in this circulatory equilibrium precipitate a spectrum of cardiac maladies collectively referred to as cardiovascular diseases (CVDs), which stand as primary contributors to global mortality rates.The gravity of heart-related afflictions is underscored by statistics from the World Health Organization (WHO), indicating that an alarming 17.5 million individuals succumb annually to heart attacks and strokes. Strikingly, more than three-quarters of these fatalities are concentrated in middle and low-income nations, with a staggering 80% attributed specifically to strokes and heart attacks. Thus, the early identification of cardiac irregularities and the deployment of predictive tools hold profound potential to avert countless fatalities, empowering clinicians to tailor efficacious treatment regimens that curtail the scourge of cardiovascular diseases.

Advancements in healthcare infrastructure have engendered a wealth of patient data, epitomized by the burgeoning reservoirs of information encapsulated within Electronic Health Record Systems, commonly referred to as Big Data. Leveraging the principles of data mining and machine learning, this abundance of information can be harnessed to forge predictive models tailored to forecasting cardiovascular diseases. Data mining, an iterative process of extracting latent insights from vast datasets, is poised to revolutionize the medical landscape by unveiling hidden patterns and correlations embedded within clinical repositories.

Against this backdrop, this paper advocates for the adoption of a machine learning algorithm for the development of a robust heart disease prediction framework, validated using publicly available datasets. By harnessing the prowess of data mining techniques, this initiative aims to unravel the intricate tapestry of cardiac pathologies, thereby charting a course towards proactive intervention and improved patient outcomes within the clinical domain.

The heart, paramount for sustenance, often falls victim to neglect amid prevalent unhealthy lifestyles, precipitating a surge in cardiac afflictions, with heart attacks standing as a predominant cause of mortality globally. To mitigate this burgeoning crisis, we devised a predictive model geared towards discerning the presence of heart disease. This model leverages 14 key medical attributes including health status, gender, cholesterol levels, and blood pressure, aiming to preemptively identify individuals susceptible to cardiac ailments. Motivated by distressing reports of premature cardiac fatalities, our initiative seeks to intervene early, forestalling untimely demises.

Machine learning, a ubiquitous force across diverse domains, finds particular utility in healthcare, where it amalgamates with artificial intelligence to prognosticate a spectrum of maladies. By harnessing patient data supplied by medical institutions, we train our model to discern subtle indicators of heart disease, employing algorithms such as K-Means, Linear Regression, and Logistic Regression. Rigorous data preprocessing, including various transformations to rectify anomalies, precedes the division of data into training and testing sets, culminating in a comparative analysis of algorithmic accuracies.

As the specter of heart disease looms ominously, predictive interventions assume paramount importance, offering multifaceted benefits to individuals and healthcare systems alike. Logistic Regression emerges as the most efficacious among our array of algorithms, alleviating the diagnostic burden on healthcare professionals and empowering proactive patient care. This predictive framework not only augments medical efficacy but also curtails healthcare expenditures, embodying a transformative stride towards comprehensive cardiac care. In essence, this endeavor furnishes invaluable insights, equipping us with the tools to prognosticate and preemptively address heart disease, thereby advancing the cause of public health.

Cardiovascular diseases have emerged as the predominant cause of global mortality in recent years, with statistics from the World Health Organization indicating an alarming annual toll of over 17.9 million deaths attributed to these ailments. Notably, a staggering 80% of these fatalities are linked to coronary artery disease and cerebral stroke. An intricate interplay of various habitual and genetic factors contributes to the predisposition toward heart disease. Lifestyle habits, encompassing both personal and professional spheres, alongside genetic predispositions, exert substantial influence in this regard.

2. Related work

Senthilkumar Mohan Proposed a Hybrid Random Forest with Linear Model (HRFLM) [5], which combines elements of both Random Forest and Linear algorithms. This amalgamation yielded highly precise predictions, exhibiting fewer errors compared to alternative algorithms under scrutiny. Utilizing the UCI machine learning database, which comprised 303 records and involved the utilization of 13 out of the 76 available features, the HRFLM achieved an impressive accuracy score of 88.7%.

Mrudula Gudadhe Colleagues introduced a decision support mechanism aimed at heart disease classification [6]. Central to this system were the methodologies of Support Vector Machine (SVM) and Artificial Neural Network (ANN). Notably, a Multilayer Perceptron Neural Network (MLPNN) with three layers served as the cornerstone for crafting a diagnostic tool for heart disease. This MLPNN underwent training via the back-propagation algorithm, renowned for its computational efficiency.

The outcomes demonstrated the efficacy of utilizing MLPNN with the back-propagation technique in effectively diagnosing heart disease, underscoring its potential as a valuable tool in medical diagnostics.

Manpreet Singh Proposed a pioneering heart disease prediction framework predicated on Structural Equation Modeling (SEM) and Fuzzy Cognitive Map (FCM). Leveraging the Canadian Community Health Survey (CCHS) 2012 dataset, [4] they meticulously examined twenty pivotal attributes. SEM served as the bedrock for generating the weight matrix essential for the FCM model, thereby prognosticating the likelihood of cardiovascular ailments.

The SEM model was meticulously constructed, elucidating correlations between CCC 121 (a variable denoting the presence of heart disease) and the aforementioned twenty attributes. Subsequently, to instantiate the FCM, a weight matrix delineating the strength of causal relationships between concepts was meticulously crafted. Transitioning from SEM to FCM necessitated the integration of requisite components, including the weight matrix, concepts, and causality.

The dataset underwent a meticulous partitioning, with 80% allocated for training the SEM model and the remaining 20% reserved for testing the FCM model. The culmination of this approach yielded an impressive accuracy rate of 74%, underscoring the efficacy of this novel predictive model.

Asha Rajkumar Embarked on the endeavor of diagnosing heart disease utilizing a supervised machine learning approach based on classification techniques [1]. The Tanagra tool, renowned for its prowess in data analysis, served as the linchpin for classifying the data. Employing a robust evaluation strategy, the researchers leveraged 10-fold cross-validation to meticulously scrutinize the dataset, with ensuing results subjected to thorough comparison.

Tanagra, a commendable tool in the realm of data mining, stands as a beacon for academic and research pursuits, offering a gamut of data mining methodologies spanning explanatory data analysis, statistical learning, machine learning, and database management. The dataset was judiciously partitioned, with 80% allocated for training purposes and the remaining 20% reserved for rigorous testing.

Among the triad of techniques scrutinized, Naïve Bayes emerged as the frontrunner, boasting a diminished error ratio and demonstrating swiftness in execution.

K. Cinetha Introduced a pioneering decision support framework aimed at averting coronary heart disease through the application of fuzzy logic [3]. This innovative system endeavors to prognosticate the likelihood of heart disease development in a patient over the ensuing decade. By meticulously collecting data from both normal individuals and those afflicted with coronary heart disease, the researchers aimed to ascertain potential factors contributing to the onset of this ailment.

The mitigation of risk factors is meticulously analyzed through the integration of fuzzy logic and decision trees within the framework. With a dataset comprising 1230 instances, decision trees serve as the cornerstone for establishing fuzzy rules and diagnosing coronary heart disease. Employing this methodology, clustered data is generated, and subsequent extraction of rules from these clusters is facilitated through the Least Square Error (LSE) approach.

Determination of the optimal cluster is achieved via fuzzy techniques, with variant analysis conducted during the testing phase. Smaller values of variant boundaries are deemed optimal for clustering purposes. Remarkably, when applying the selected rules to the TSK inference order-1 method, the system attains a remarkable accuracy rate of 97.67%.

Shanta Kumar. B Embarked on a quest to extract pivotal patterns from a comprehensive heart disease database to facilitate heart attack prognostication [8]. Despite the vast reservoirs of healthcare data amassed, the latent insights crucial for predicting heart attacks often remain untapped. In this pursuit, the authors proffered the MAFIA algorithm (Maximal Frequent Item set Algorithm), leveraging the robust capabilities of Java.

The data undergoes meticulous preprocessing, followed by clustering utilizing the k-means algorithm to delineate two clusters, with a focus on isolating the cluster pertinent to heart attacks. Subsequently, frequent patterns are diligently mined from the item set, and the significance weightages of these patterns are meticulously computed. Drawing upon these attribute weightages—such as age, blood pressure, and cholesterol—patterns of paramount importance in the context of heart attacks are discerned.

V.V. Ramalingam Advocated for the utilization of Alternating Decision Trees coupled with Principal Component Analysis (PCA), a strategy that demonstrated noteworthy competence in comparison to conventional Decision Trees, which exhibited subpar performance [9]. Their approach entailed employing PCA for feature extraction from the dataset, with subsequent feature selection executed via Correlation-based Feature Selection (CFS). Additionally, their experimentation revealed that Support Vector Machines exhibited exceptional performance in their testing endeavors. The paper also delved into the exploration of other methodologies, including Ant Colony Optimization, thus broadening the spectrum of methodologies under consideration.

Jaymin Patel Recommended the adoption of the J48 technique, which yielded commendable outcomes while exhibiting expedited construction time [2]. Leveraging the capabilities of WEKA and the UCI Cleveland dataset, comprising an extensive array of 76 features and 303 entries, they scrutinized various attributes such as diagnosis classes, gender, age, and the severity of chest pain. Employing the 10-fold Cross Validation methodology in conjunction with the J48 technique, they meticulously assessed the efficacy of *the model.*

Furthermore, their investigation encompassed two variants of Reduced Error Pruning: Post pruning and online pruning. Notably, the J48 technique demonstrated a test error rate of 0.1666667, underscoring its robustness and reliability in predictive modeling endeavors.

Youness Khourdifi Concluded that the efficacy of each algorithm varied depending on specific circumstances. Notably, Random Forest, K-Nearest Neighbor, and Neural Networks emerged as the top-performing models with the dataset under scrutiny [10]. Their findings also underscored the significant enhancement in predictive accuracy achieved through the optimization hybrid approach, particularly noteworthy in medical datasets.

Furthermore, they proposed two distinct dataset optimization methodologies: Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO). By synthesizing a hybrid approach incorporating elements from both methodologies and integrating it with K-Nearest Neighbor, they achieved remarkable *accuracies of* 99.65% and 99.6% with Random Forest. The dataset *utilized in* their study was sourced from the UCI machine learning repository.

Harshit Jindal Implemented a fusion of three Machine Learning algorithms: KNN, Logistic Regression, and Random Forest. Their amalgamated model yielded an impressive accuracy rate of 87.5% [7]. They ascertained that this notable accuracy primarily stemmed from the augmentation of medical attributes utilized in their analysis. Notably, they integrated 13 attributes into their model, encompassing vital metrics such as blood pressure, age, cholesterol levels, fasting sugar levels, chest pain severity, and gender, among others. The dataset under examination comprised a total of 304 entries

Table 1. Attributes used are listed

S .No	Attributes	Description	Value
1.	Age	Values Patients age in years	Continuous
2.	Sex	Sex of subject (male-0,female-1)	Male female
3.	CP	Chest pain type	Four types
4.	Trest bps	Resting blood pressure	Continuous
5.	Chol	Serum cholesterol in mg/d1	Continuous
6.	FBS	Fasting blood pressure	<or> 120 mg/d1
7.	Restecg	Resting Electrocardiograph	Five values
8.	Thalach	Maximum heart rate achieved	Continuous
9.	Exang	Exercise Induced angina	Yes/No
10	Oldpeak	ST Depression introduced by exer.	Continuous

3. Methodology

Within this model, four distinct algorithms are harnessed to prognosticate the outcome, discerning whether an individual harbors heart disease or not. These algorithms encompass

3.1. Logistic Regression

Logistic regression, a statistical modeling technique tailored for binary classification quandaries, intricately delineates the relationship between predictor variables and the binary outcome. Employing the logistic function, this method aptly maps the linear amalgamation of predictors onto a probability continuum ranging between 0 and 1.

3.2. KNN (K-nearest neighbors)

KNN, a non-parametric classification paradigm, adjudicates the class of a novel instance grounded on its closest neighbors within the training dataset. By means of majority voting among its K nearest neighbors, the algorithm decisively assigns a class label to the test instance. The parameter K stipulates the quantity of neighbors considered for the classification decision.

3.3. Decision Tree

Decision trees, hierarchical constructs of decision-making process, pivot upon a nexus of conditions or rules. This arboreal framework is painstakingly erected through recursive partitioning of the data, predicated on the most salient features. At each node, a feature coupled with a threshold value is judiciously selected to bifurcate the data, thereby engendering branches that foster predictive clarity.

3.4. Random Forest

Random Forest, an ensemble learning methodology of notable efficacy, amalgamates multiple decision trees into a cohesive unit. Through the strategic sampling of the training dataset with replacement (bootstrapping) and the random selection of feature subsets, this method engenders a plethora of decision trees. During the prediction phase, the ultimate outcome is adjudicated by aggregating the predictions proffered by each constituent decision tree, typically through mechanisms such as voting or averaging.

3.5. SVM algorithm

It's important to note that while SVM can be effective for heart disease prediction, the choice of algorithm should be based on the specific characteristics of the dataset and the problem at hand. Other machine learning algorithms like logistic regression, decision trees, or ensemble methods may also be suitable for this task.

Diffwalk encapsulates any difficulties the individual may experience while walking. Education serves as a metric representing the quality of the individual's educational background, while Inc s their financial earnings. Collectively, these v prise a comprehensive r assessin tanding various facets of s health ar

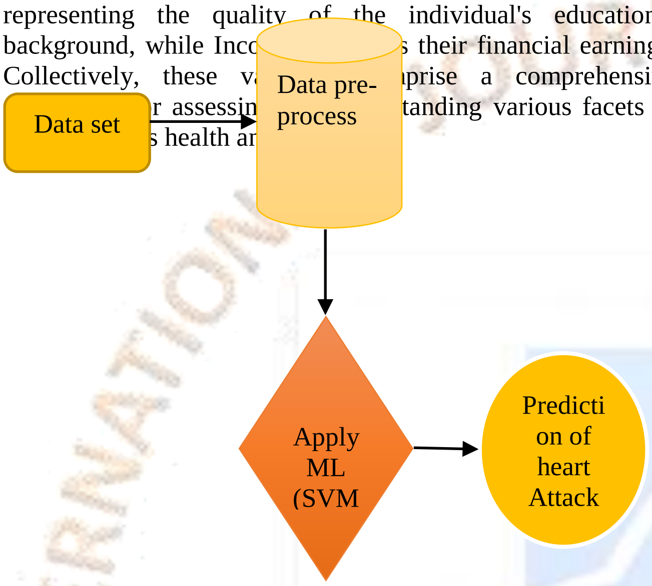

Fig. 1 Proposed Model for Heart Disease Prediction

Fig 1. The proposed model discussed in this article employs Support Vector Machine (SVM) methodology to achieve enhanced accuracy. In contrast to prior implementations and studies, the models investigated in this article offer superior optimization, yielding more refined outcomes.

Table 1. Analysis of previous Methods and results

Approach	Year	Method used	Results
Vincy Cherian et a	2017	Naïve Bayes	86%
Rani et al,	2021	Logistic Regression,	86.60%

However, the researchers in question evince certain inadequacies, which are remedied by the methodologies employed within this article. SVM, a sophisticated computer algorithm, serves as the cornerstone of this study's approach towards predicting coronary heart disorder. Notably, SVM has been adeptly harnessed across a burgeoning array of biological applications, demonstrating its versatility and efficacy. Its utility extends to diverse classification quandaries, including those encountered in bioinformatics, where it stands as a potent machine learning technique. Moreover, this article introduces a refined machine learning model tailored specifically for heart disease prediction.

3.6. Proposed system

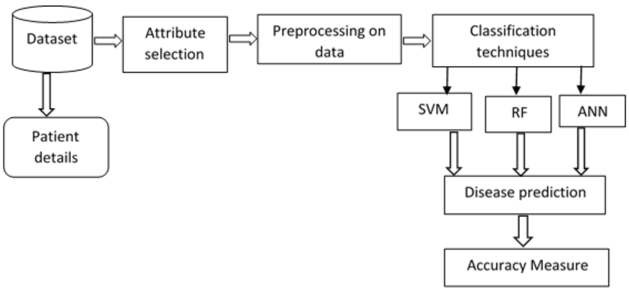

Fig.2 proposed system using (SVM), (RF), and (ANN)

4. EXPERIMENTS AND RESULTS

The primary objective of this investigation is to assess the efficacy of diverse classification algorithms with the aim of identifying the most precise algorithm for forecasting the likelihood of a patient developing heart disease. Employing methodologies encompassing Logistic Regression, Naïve Bayes, Support Vector Machine, K-Nearest Neighbor, Decision Tree, Random Forest, and XG Boost, this study was conducted utilizing the UCI dataset. Subsequently, the dataset underwent division into training and test subsets, whereupon models were trained and accuracy was gauged utilizing Python. Below, a comparative analysis delineates the performance of these algorithms, elucidating their respective accuracy scores in the provided table.

Various machine learning techniques utilize distinct datasets with unique specifications. In the study, a total of 50 test cases are employed for heart disease prediction. Among these cases, there are 6 false negatives, 1 false positive, 18 true positives, and 25 true negatives. The dataset is derived from retrospective studies on cardiovascular diseases, utilizing recordings from multichannel MCG. Within the database, there are 227 individuals diagnosed with coronary stenosis and 347 individuals classified as healthy. Additionally, there are 16 instances of NSTEMI (non-ST-elevation myocardial infarction) within the sample. For the ischemic subgroup, coronary angiography is conducted, revealing 227 patients with IHD (left anterior descending).

To train the proposed method predictor, numerous random tests and cross-validation assessments are conducted on 125 samples from the training dataset. For an in-depth exploration of heart disease recognition using machine learning, two heart disease datasets (Cleveland and Stat log, denoted as datasets I and II) are utilized. While the original dataset comprises 79 raw attributes and 303 subjects, only 13 attributes are utilized, with one attribute serving as the output class.

Table 2. Accuracy comparison of algorithms

Algorithm	Accuracy
Logistic Regression	775.41%
Naïve Bayes	77.05%
Support Vector Machine	73.77%
K-Nearest Neighbour	57.83%
Decision Tree	77.05%
Random Forest	86.89%
XG Boost	78.69%

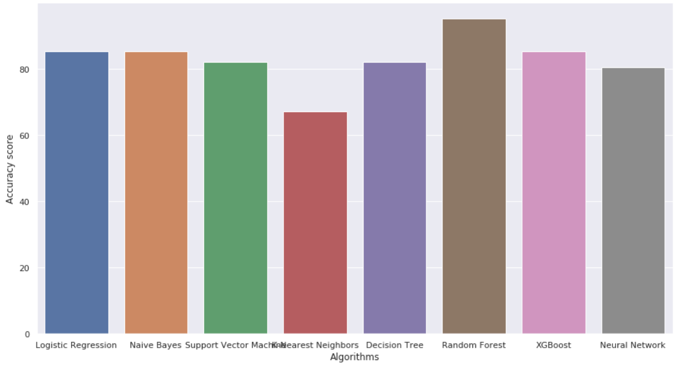

Fig.3 Accuracy comparison of algorithms

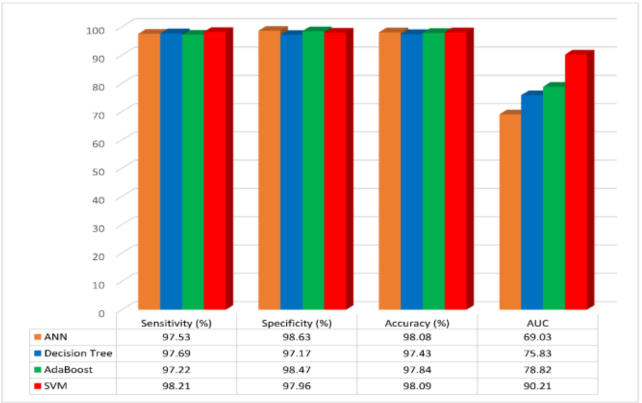

Fig 4. Prediction of heart disease based on machine learning using jellyfish optimization algorithm

The Jellyfish Optimization Algorithm is a method inspired by jellyfish behavior that helps computers find the best solution to a problem by changing settings bit by bit. In this study, it's likely used to make the heart disease prediction model work better.

5. Future work

Numerous avenues for enhancing the scalability and precision of the present prediction system warrant exploration. However, constrained by temporal constraints, the following areas necessitate future investigation:

Experimentation with diverse discretization methodologies, alongside the implementation of multiple classifiers such as the Voting technique and various Decision tree variants including information gain, gain ratio, and Gini index. For instance, a study is imperative to evaluate the efficacy of Equal Frequency Discretization in conjunction with Gain Ratio Decision Trees through nine distinct Voting schemes, aiming to elevate the accuracy and efficacy of heart disease diagnosis.

The current study advocates a framework leveraging a combination of support vector machines, logistic regression, and decision trees to furnish accurate heart disease predictions. Subsequent research endeavors entail the formulation of a system employing the aforementioned methodology to rectify imbalances inherent in other data mining models.

An exploration into alternative rule-based approaches such as Association, Clustering, and K-means is warranted to ascertain heightened efficiency and streamlined simplicity.

Implementation of the Multivariate Decision Tree approach warrants investigation across varying datasets of both diminutive and expansive sizes, to discern its applicability and efficacy.

The primary objective of this model revolves around discerning an individual's susceptibility to heart disease, while its prospective scope extends to the early detection of individuals predisposed to such ailments. By identifying at-risk individuals promptly, the aim is to mitigate the incidence of fatal heart attacks. Furthermore, efforts will be directed towards refining the model to enhance its precision in determining an individual's propensity for heart disease.

This paper presents a comprehensive survey on machine learning technology-based models for detecting heart disease. Four distinct approaches utilizing ML models are scrutinized: Naïve Bayes with a weighted approach, two SVMs integrated with XG Boost, an enhanced SVM (ISVM) employing duality optimization (DO), and XG Boost independently. The analysis of results underscores the supremacy of the XG Boost algorithm in terms of accuracy, precision, recall, and F1-measure parameters, with Naïve Bayes exhibiting comparatively lower accuracy. Notably, the precision, recall, and F1-measure values are diminished in the SVM with duality optimization (DO) model. This survey paper serves as a valuable resource elucidating diverse machine learning-based methods for heart disease detection.

Future research endeavors could entail augmenting the heart disease dataset with additional attributes to enhance its efficacy and user interaction. Moreover, there is potential for transforming this research into a mobile application, optimizing computing time and simplifying complexity. Additionally, integration with hospital databases stands as a viable approach to enhance system functionality and utility.

6. CONCLUSION

In this endeavor, we present an innovative framework for forecasting heart disease, employing diverse classification methodologies. Specifically, we investigate the efficacy of Random Forest and Logistic Regression algorithms in this predictive pursuit. Our meticulous analysis reveals that Random Forest outperforms Logistic Regression in terms of accuracy. Our overarching aim is to enhance the efficacy of Random Forest by meticulously culling extraneous attributes from the dataset, retaining only those deemed most salient for the classification endeavor.

From the preceding implementation, it is evident that we leverage state-of-the-art algorithms to prognosticate heart conditions at an incipient stage, facilitating timely preventive measures to mitigate the risk of cardiovascular ailments. Through rigorous testing, it is discerned that Logistic Regression attains the pinnacle of accuracy at 85%. Moreover, its Economic2w feasibility renders it accessible to individuals across socio-economic strata, including the lower and middle classes. Furthermore, amalgamating this algorithm with two others yields superior results, surpassing prevailing models in the market in terms of accuracy. Thus, employing this model holds promise in diminishing mortality rates attributable to cardiac complications.

This project delves deeply into the realm of machine learning methodologies tailored for the classification of cardiovascular maladies. Given the pivotal role classifiers play within the healthcare sector, their outcomes serve as critical inputs for devising tailored treatments for patients. Through a comprehensive examination and juxtaposition of existing techniques, the quest for efficient and precise systems is pursued ardently. Machine learning algorithms exhibit a profound capacity to bolster the accuracy of cardiovascular risk prognostication, thereby enabling early disease detection and facilitating the administration of preemptive interventions to patients. It is evident that the realm of machine learning harbors immense potential in the realm of predicting cardiovascular ailments or other heart-related afflictions.

Within the domain of disease prognosis, machine learning assumes a paramount position. This study explores diverse machine learning methodologies in the context of forecasting heart disease. Empirical findings showcase that the Random Forest algorithm attains the zenith of accuracy at 91.8%, thereby effectively advancing the goal of augmenting predictive precision. Future endeavors are poised to delve deeper into evolutionary computation techniques pertinent to the addressed issue, scrutinizing their efficacy meticulously.

Upon scrutinizing the experimental findings, it is deduced that the J48 tree technique emerges as the preeminent classifier for heart disease prognostication, exhibiting superior accuracy and the shortest total construction time. Evidently, the J48 algorithm, augmented by reduced error pruning, manifests the highest accuracy, followed by LMT and Random Forest algorithms. Notably, the employment of reduced error pruning bolsters the performance of J48, whereas its absence results in diminished efficacy. Remarkably, the J48 algorithm, utilizing UCI data, showcases the highest accuracy at 56.76%, with a mere 0.04 seconds required for model construction, while the LMT algorithm registers the lowest accuracy at 55.77%, necessitating 0.39 seconds for model construction.

In summation, as elucidated in the literature review, it is apparent that only marginal strides have been made in the development of predictive models for heart disease prognosis. Thus, it is imperative to explore combinational and intricately structured models to enhance the accuracy of early heart disease prediction.

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