An Experimental Investigation Towards the Detection of Cardiovascular Disease at an Early Stage by Employing Techniques of Machine Learning and Deep Learning.

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ABSTRACT:

Human body prioritizes the heart as the second most important organ after the brain. Any disruption in the heart ultimately leads to disruption of the entire body. Being the members of modern era, enormous changes are happening to us on a daily basis that impact our lives in one way or the other. A major disease among top five fatal diseases include the heart disease which has been consuming lives worldwide. Therefore, the prediction of this disease is of prime importance as it will enable one to take a proper and needful approach at a proper time. Data mining and machine learning are taking out and refining of useful information from a massive amount of data. It is a basic andprimary process in defining and discovering useful information and hidden patterns from databases. The flexibility and adaptability of optimization algorithms find its usein dealing with complex non -linear problems. Machine Learning and deep learning techniques find its use in medical sciences in solving real health-related issues by early prediction and treatment of various diseases. In this paper, five machine learning algorithms are used and a deep learning algorithm is used which are then compared accordingly based on the evaluation of performance. The primary aim of this research study is to analyze comparatively the various machine learning algorithms and a deep learning algorithm for heart disease prediction. The various algorithms used for the study are: Support Vector Machine (SVM), Linear Regression (LR), Naïve Bayes (NB), Decision Tress (DT), Artificial Neural Networks (ANN) and Convolutional neural networks (CNN). After analysis, CNN outperforms over other algorithms with a testing accuracy of 98.24%.

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Introduction:

The muscular organ known as the heart may be found in the middle of the chest, and it has a small leftward tilt. It transports all of the blood that is depleted of oxygen to the lungs, where it is transformed into blood that is rich in oxygen and the body exhales carbon dioxide [1]. After that, the oxygenated blood is sent to the rest of the body via the lungs through the circulatory system. The heart circulates approximately 72,000 liters of blood throughout the body in a 24-hour period, and it pulses 3 billion times [1]. The heart's job is not limited to just pumping blood, however; it also has to circulate other fluids. These fluids include nutrients and hormones that are created by the body's tissues.

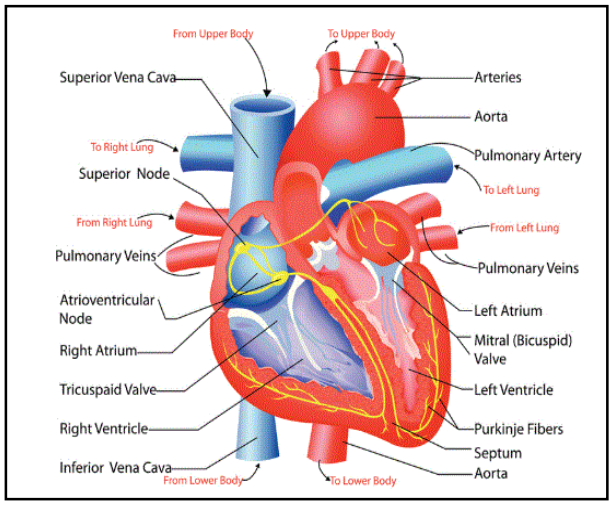

Fig 1: Anatomy of Heart

Economic Impact of Heart Diseases: When compared to other countries in the same region, India has a much greater prevalence of heart disease. A prevalence rate of 11% is concerning [3], despite the fact that India has a very large population. This is due to the fact that India has a very high population density. The prevalence rate sheds light on emerging patterns of sickness occurrence. It is estimated that cardiovascular disease, stroke, and diabetes would cost 1% of world GDP, which is equivalent to USD 236.6 billion, between the years 2005 and 2015 [4]. It was projected in the year 2000 that adult Indians had lost a total of 9.2 billion years of productive life, which contributed to the overall economic loss. According to research conducted in 2015, the average lifespan of an Indian man is estimated to be 67.3 years, whilst the average lifespan of an Indian woman is estimated to be 69.9 years [3]. It was projected in the year 2000 that adult Indians had lost a total of 9.2 billion years of productive life, which contributed to the overall economic loss. As a result, India contributes to the growing population of people who are affected with heart disease as a result of the increased number of elderly people who are prone to developing the condition. An essential medications list (EML) is a project that the World Health Organization (WHO) is working on to enhance healthcare systems in countries with low and intermediate incomes. Age, modifications in lifestyle and diet, and rapidly expanding social issues, such as hospitalization, all have an influence on the likelihood of acquiring heart-related disorders and the advancement of preexisting conditions. Research indicates that heart disease is responsible for 80% of fatalities and 85% of disabilities in countries with poor and intermediate incomes. The forecasts of total deaths attributable to cardiovascular disease that are shown in Table 1 include the period between the years 2000 and 2030. The treatment of expensive illnesses like heart disease takes up a significant portion of a family's total income and may be rather pricey. As a result, hospitalization is often necessary [5] since the patients need extensive therapy for their conditions.

Table 1: Estimates of Total Deaths

Country	**2,000**		**2030**	
	Quantitative measure o mortality	Estimated Annualize d Rate per One Hundred Thousand	Quantitative measure o mortality	Estimated Annualize d Rate per One Hundred Thousand
India	8,221,165	3,172	16,937,070	2,570
Brazil	1.040.840	2,021	1,641,620	1,857
China	5,656,890	1,395	10,350,030	1,653

LITERATURE REVIEW:

Numerous studies have been conducted using machine learning, deep learning, and data mining tools and methodologies to predict cardiac disease. Researchers have employed a variety of datasets, algorithms, and procedures; the findings they have seen thus far and future work will be used to determine the most effective techniques for diagnosing cardiovascular disease. For the past ten years, there has been substantial research in the development of prediction models for the diagnosis of CVD. Cardiovascular disease automated diagnosis is a significant real-world medical issue. Early heart disease detection is essential for effective therapy. Machine Learning and Deep Learning, the main components of predictive analytics, are required to do this. Researchers from all across the globe have tried a variety of techniques for early illness detection.

The major goal of this study is to create a predictive model with a small chance of success for people with heart disease. Weka was used for the experiment, and the Cleave Land UCI dataset underwent the following processing steps during training: pre-processing, classification, regression, clustering, association, and visualization. WEKA's Explorer mode is employed to try out classification tools. For the analysis, decision tree classifiers including J48, the Logistic Model Tree Algorithm, and Random Forest were used, along with 10-fold cross validation and reduced error trimming. The j48 algorithm with decreased error pruning has the highest accuracy

overall. If alternative discretization approaches, multiple classifiers, voting strategies, and additional decision tree algorithms (Gain ratio, Gini index) were used, the accuracy may be increased [6]This study proposes prediction of heart disease using Naïve Bayes and k-mean clustering. K-mean clustering have been used to improve the efficiency of the desiredoutput and used for grouping of attributes followed by Naïve Bayes algorithm for prediction of the disease. Naïve Bayes is mainly used when the inputs are generally high but gives no absurdity when the inputs are low. This study answers the complex queries with respect to interpretation and accuracy [7].

This project's major purpose is to automate a method for diagnosing heart disease using historical data and information. The purpose of this paper is to discuss numerous knowledge abstraction methodologies leveraging data mining techniques, as well as their advantages and disadvantages. Data mining makes use of the Decision Tree Algorithm, the Neural Network Algorithm, and the Naive Bayes Algorithm. By calculating Shannon entropy, the ID3 Algorithm builds trees of decisions. Due to the constraints of building a short tree decision tree from set off learning data, we use Quinlan's C4.5 and C5.O calculations to flow the data. Nave Bayes surpasses the aforementioned strategies since it is not dependent on any input attributes. Future study and implementation of other ways to alleviate the problem of high [8] overfitting is possible.

In this study, for development of effective heart disease prediction Multilayer Perceptron with back propagation neural network is employed. The dataset contains303 records in which 40% is used for training using Multilayer Perceptron neural network and remaining is used for testing using back propagation algorithm. The experiment was conducted using Weka 3.6.11. Based on the actual desired output obtained from Learning Algorithm; in each neuron the back propagation algorithm calculates the error followed by the calculation of the output for each neuron which in turn results to improve weights during the whole processing. The whole system developed shows the accuracy of 100%[9].

The system that was created is made up of two different parts. A first automated method for the production of weighted fuzzy rules is developed via the use of weighted fuzzy rules in conjunction with specified attributes. Constructing the fuzzy system is also being done. The development of fuzzy rule-based decision support systems is the second phase in the process. Experiments are carried out using the dataset that is supplied by the UCI Machine Learning repository. When it comes down to it, the overall performance is measured against that of neural networks in terms of its accuracy, sensitivity, and specificity. The research indicates that the overall accuracy is improved by 10% when compared to the fuzzy-based system and by 20% when compared to the neural network-based technique [10].

In the current investigation, the subject of restricting and summarizing the many data mining approaches that are used in the field of medical prediction is investigated. The dataset was analyzed using the naive bayes, KNN, and decision tree algorithms, which are all different supervised machine learning methods. The Tangra tool and 10-fold cross validation are used in this step, and afterward, the findings are compared in order to accomplish the categorization of the dataset. Thirteen different characteristics were employed for the comparing and contrasting. The accuracy of the decision tree is the highest at 99.2%, followed by the accuracy of the Nave Bayes method at 96.5% and the accuracy of the classification using clustering at 8.83% [11].

The major goal of this study was to create a prediction model for the detection of heart disease using transthoracic echocardiography using data mining techniques. For this research, 7,339 cases were extracted and pre-processed using data gathered at PGI, Chandigarh between 2008 and 2011. Using the Weka 3.6.4 machine learning software, three unique supervised machine learning techniques were applied to a model of a pre-processed Transthoracic echocardiography dataset. These methods are named J48 Classifier, Nave Bayes, and Multilayer Perception. The distribution frequency was used to check for noise, inconsistency, and missing data, while box plots were used to locate outliers. The effectiveness of the models was evaluated using standard metrics including accuracy, precision, recall, and F-measure. Random selection of training and test data samples was performed using 10 cross validations. With a classification accuracy of 95.56 percent, the J48

classifier is the most successful in predicting heart disease based on the specified parameters. To enhance classification accuracy and forecast particular kinds of heart disease, researchers will need to conduct additional tests with a larger number of data sets in the future [12].

This research entails: Predicting cardiovascular disease using a different method is offered. In order to successfully forecast heart attacks using data mining, the focus of this study is on the use of a wide variety of approaches, as well as combinations of a large number of target criteria. A number of supervised machine learning strategies, such as Nave Bayes and Neural Network, as well as weighted association Apriori algorithm and Decision algorithm, have been utilized for the purpose of conducting an analysis of the dataset. These strategies were used in order to accomplish this goal. For the purpose of this investigation, the data mining program Weka, version 3.6.6, is being used. All of the tools that are necessary for the pre-processing of data, as well as classification, regression, clustering, association rules, and visualization, are linked to WEKA. The Decision Tree algorithm has outperformed with an accuracy of 99.62% while using 15 criteria. In addition, the accuracy of the Decision Tree and Bayesian Classification increases even further when the genetic algorithm is used to minimize the actual data size in order to get the ideal subset of characteristics that are required for predicting heart disease. This is because the genetic algorithm is able to find the ideal subset of attributes that are necessary for making the prediction. This helps to ensure that the Decision Tree and Bayesian Classification produce the most accurate results possible. We used the Association Classification approach in addition to the Apriori algorithm and the Mafia algorithm [13].

Data mining's potential applications in medicine, especially for treating heart disease, take center stage. The purpose of the research presented in this article is to uncover buried information obtained from heart disease patients. Decision trees, Naive Bayes, and Neural Networks are just few of the algorithms that have been put into place. From the UCI machine learning repository and the Hungarian institute of cardiology, two datasets were extracted. The merged dataset has a total of 597 occurrences after the merger of the two datasets. WEKA selects characteristics using the breadth-first search approach. During the investigation, many performance measures, including accuracy, precision, F-measure, ROC value, TP rate, and FP rate, were considered in order to assess the performance rate of the algorithms in question. In the first case, all characteristics were collected, however in the second instance, just certain attributes were collected. The findings indicate that the Nave Bayes classification method has the greatest accuracy at 82.914 percent. Future data reduction techniques [14] may be used to enhance the categorization of diverse datasets.

The objective is to enhance the performance of the Naive Bayes classifier by eliminating undesired and superfluous features from the dataset and picking only those that are relevant for classification. Only 19 of the 303 entries and 76 variables from the Clear Land Heart Disease Database were selected for analysis. To achieve the same objective, the Selective Nave Bayes Classifier technique is employed to create c4.5 trees. Among the classifiers tested here, Naive Bayes and Decision Trees that include Information Gain calculations performed the best. The findings show that decision trees are more precise than Nave Bayes [15] because of the greedy nature of the induction technique.

This study Proposed arrangement and progress of tool for heart disease (MRI) images by employment of machine learning. Heart disease identification, including conditions like global hyper kinesis, which might lighten the load, is a priority at present. The MRI data in the form of dicom images is taken from IGMC Shimla. Work was done over total of 60 patients in whicheach patient has an MRI report of 900-1200 images. All of this was carried out by collecting data, extracting features from that data, creating a model, vetting that model, and then putting it all into practice. The main software's used were cell profiler and cp_charm for feature extraction and cast off for model building usingMRI images. With the help of software glade_3 for python, designing part of tool was done. By merging imaging using AMIDE 90% accuracy is achieved and 80-85%of accuracy is achieved using the same model with 25 image set. Using this tool, it becomes easy for doctors and radiologists to predict the disease in an efficient and easy manner [16].

This article provides a novel idea to recognize individuals with a heart attack in color photos by

identifying heart attack-related postures. Images of persons in infarction-free conditions and those who may be experiencing one were combined to create a data set. Convolutional neural networks are used in the process of recognizing infarcts. A total of 1520 photos, 760 of class "Infarct" and 760 of class "No Infarct," were included in the first image data collection. These have been practiced on a series of specifically created photos that feature people acting out heart attacks. The classification of infarcts shows encouraging results with 91.75% accuracy and 92.85% sensitivity [17].

This study suggests a method dubbed Cardio Help that uses convolutional neural networks, a type of deep learning algorithm, to predict the likelihood that a patient would have cardiovascular illness (CNN). The suggested approach focuses on modelling temporal data while applying CNN for early-stage HF prediction. This study employs convolutional neural networks and a cutting-edge dataset from the UCI library to predict a potential cardiac ailment (CNN). Some heart test parameters as well as typical human behaviors are included in this dataset. According to experimental findings, the proposed method performs better than the current methods in terms of performance evaluation measures. The proposed method's attained accuracy is 97%[18].

In this study, the traditional methods of Logistic Regression, K-Nearest Neighbors, Naive Bayes, Support Vector Machines, and Neural Networks are contrasted with CNN's recommended prediction model. The proposed model has an output layer in addition to two dropout layers, two convolutional layers, and one more dropout layer. Predictions about cardiovascular disease (CVD) using the dataset from the UCI machine learning repository are correct 94% of the time [19].

This report presents research on completely novel planning techniques used to predict the potential of each individual, supported by age, sexual orientation, constraint per unit zone, cholesterol, and heart rate. They effectively predicted the heart illness using naive bayes and image processing. In the training phase, the suggested naive bayes model was able to appropriately handle 77 of the input instances. It displayed accuracy of 85% during the validation phase, recall of 85% during the testing phase, and an average accuracy of 79% during the regression phase [20].

METHODODLOGY ADAPTED: The whole procedure, from data collection through the production of useful outcomes, is shown in Figure 2 below.

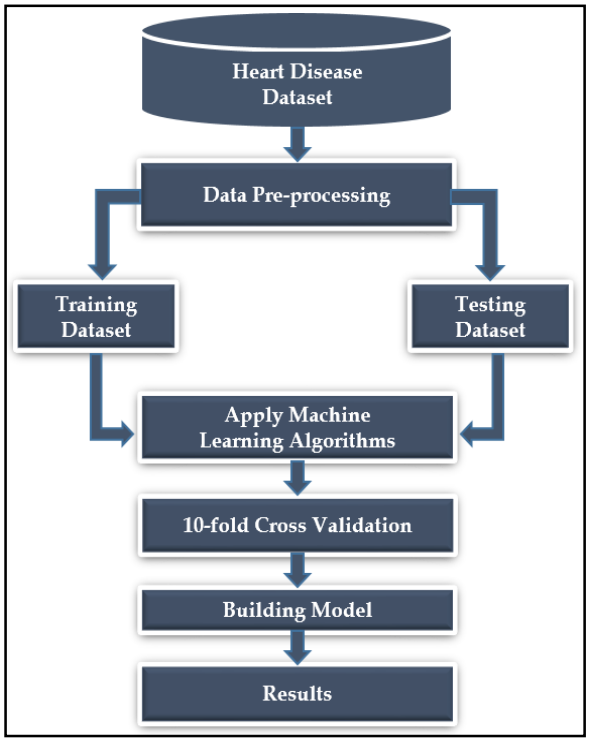

Fig 2: Methodology Adapted

The data set's detailed information: The dataset was collected from the UCI which is a machine learning application repository. The first dataset has 1026 occurrences and 14 characteristics, whereas the second dataset contains 303 samples and 14 characteristics. Hence, the outcome of integrating the datasets is a dataset with 1329 occurrences and 14 characteristics. Table 2 provides a description of the characteristics:

Table 2: Description of Dataset

S.No	Attribute Name	Description
01	Age	Yrs old
02	Gender	Either of the sexes(F/M)
03	Cp	Constructive pericarditis
04	Trestbps	The patient's blood pressure reading at rest when admitted to the hospital, in millimeters of mercury
05	Chl	Total serum cholesterol in milligrams per deciliter
06	Fbs	High blood sugar when fasting (above 120 mg/dl). Logic: 1 = true, 0 = false.
07	Rstecg	Electrocardiogram recorded during rest results.values:0=normal, 1=having ST-T wave abnormality.
08	Thlch	Maximum heart rate has been reached.
09	Exang	The angina that may be triggered by exercise value:1=yes,0=no
10	Oldpk	St melancholy brought on by activity in comparison to rest
11	Slp	Peak workout ST segment slope value:1=up sloping, 2=flat, 3=down sloping.
12	Ca	Number of Fluoroscopically-Colored Major Vessels (0–3)
13	Thl	Inherited blood condition that causes your body to have fewer HB than usual. Three indicates normal condition, six indicates a permanent abnormality, and seven indicates a reversible defect.

Machine Learning Toolkit: All experimental data was analyzed using Anaconda [21]. Anaconda is a public and licensed accessible version of the popular Python and R language skills for scientific computing, designed to streamline deployment and package management (machine learning and data science applications, pre-processing of massive amounts of data, predictive analysis, etc.). Software for data scientists is now offered for the three most widespread OS platforms. It is developed and run by Anaconda, Inc., which was created in 2012 by Peter Wang and Travis Oliphant. The Anaconda Individual Edition is a standalone version of the software that is also known as the Anaconda Distribution**.**

Algorithms Used:

The ability of machine learning algorithms to progression a large bulk of heterogeneous datasets from various sources is far greater than that of humans. Better outcomes, reduced healthcare costs, and more patient satisfaction are ultimately the results of the transformation of data into clinical insights that support clinicians in planning and delivering care. The experiment made use of the algorithms listed below. The experiment employs the following machine learning algorithms:

1) Support vector machine
2) Logistic Regression
3) Decision tree
4) Naïve bayes
5) Artificial Neural Network
6) Convolutional Neural Networks.

EXPERIEMENTAL RESULTS:

Histogram: Histogram is a machine learning technique of data visualization. It depicts the continuous variable distribution for a given interval of time. Through histogram, thedata gets plotted by dividing into sections called bins. The main use of histogram is to inspect the underlying distribution of frequency as in case of normal distribution, skewness, outliers and so on. The figure 3 below represents the histogram for each attribute separately to analyze their distribution.

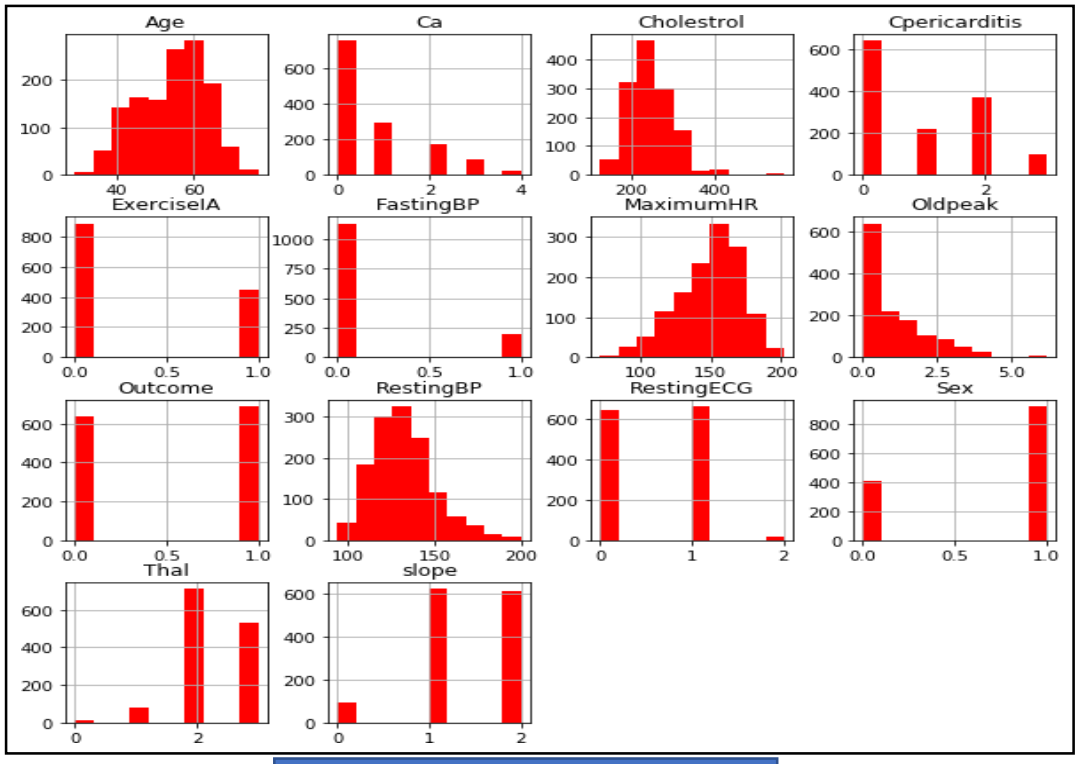

Fig 3 : Histogram

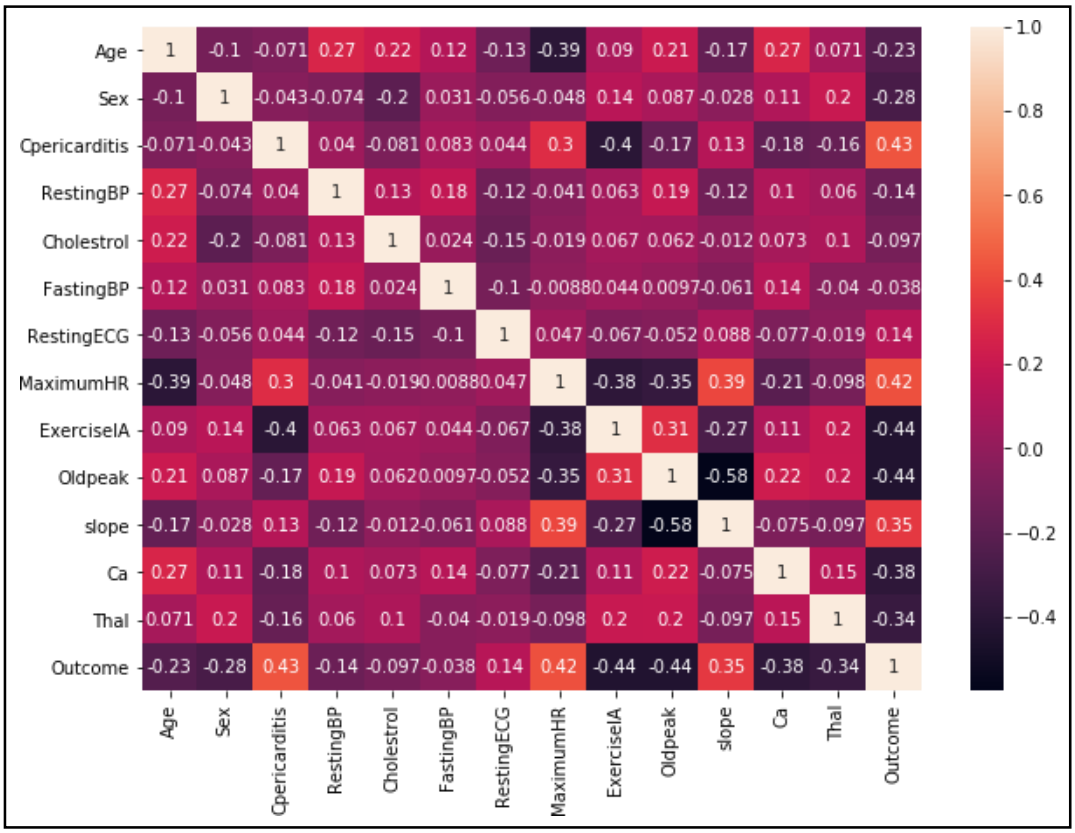

Fig 4; Heatmap

Heat Map: A graphical figure, in which matrix values that are individual are presented as colors is called Heatmap. It is used in visualization of concentration of values between twodimensions of matrix. It is also helpful in pattern finding and hence gives a perspective of depth. In the figure 4 below, we used color() function in order to create colors for Heatmap and added labels (row/column) to this. The Heatmap given below indicates how one attribute is co-related to another attribute that is whether it is negatively or positively correlated.

Tabular Representation of Performance Measures

The counter 3 below displays the performance measures of all the classifiers used forthe study during the testing.

Classifier	Accuracy	Precision	Recall	Specificity	F1-score	FPR	FNR	NPR
SVM	85.12	0.776	0.900	0.816	0.833	0.183	0.100	0.920
LR	85.87	0.776	0.916	0.819	0.840	0.180	0.833	0.934
NB	83.80	0.819	0.83	0.836	0.829	0.163	0.160	0.855
DT	94.25	1.00	0.969	0.950	0.931	0.02	0.030	0.951
ANN	85.67	0.839	0.859	0.854	0.849	0.145	0.140	0.873
CNN	**98.246**	**1.00**	**0.984**	**1.00**	**0.992**	**0.00**	**0.154**	**0.985**

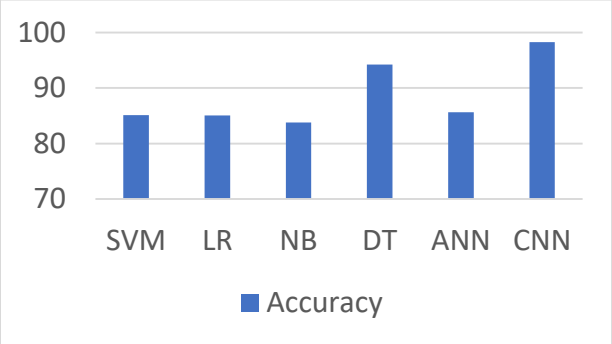

Fig 5: Accuracies of different algorithms

Also, the accuracies of the above given algorithms is shown graphically as below in fig 5:

Conclusion: A comparison of a number of ML systems for early CVD prediction was the key contribution of this paper. To enhance the quality of the dataset, preparation steps were employed. These approaches primarily focused on the management of corrupted and missing information, as well as the elimination of outliers. In order to predict the sickness, in complement to using a deep learning algorithm, five other machine learning algorithms were used, a range of statistical indicators were utilized to compare the findings. The results of the experiments show that the CNN model has the highest accuracy of all the classifiers for our dataset. With a training set accuracy of 100% and a testing set accuracy of 98.24%, the CNN model excels in terms of precision. The robustness validation of the LR, NB, SVM, DT, and ANN algorithms was validated by using a 10-fold cross-validation technique. CNN's model performed well in terms of a range of performance criteria, including accuracy, recall, and f1-score, amongst others. The model's predictions were successful.

Future scope:

In order to regulate, the ML classifiers' potential for improved heart disease prophecy, they will need to be trained and tested on big datasets in the future. The present study still leaves room intended for additional research, since data collection to result visualization, to raise the caliber of the research. In future, this study can be extended by developing web application based on CNN Model using primary and larger datasets to get optimal results that would help medicos while predicting the heart disease in an efficient manner. Medical Imaging: The existing work can be moved to other **d**eap learning techniques in which the images would be used as input instead of numerical or textual data.

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