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Cardiovascular Disease Prediction Using Data Mining Techniques: A Review

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ABSTRACT

Cardiovascular disease represents various diseases associated with heart, lymphatic system and circulatory system of human body. World Health Organisation (WHO) has reported that cardiovascular diseases have high mortality rate and high risk to cause various disabilities. Most prevalent causes for cardiovascular diseases are behavioural and food habits like tobacco intake, unhealthy diet and obesity, physical inactivity, ageing and addiction to drugs and alcohol are to name few. Factors such as hypertension, diabetes, hyperlipidemia, Stress and other ailments are at high risk to cardiovascular diseases. There have been different techniques to predict the prevalence of cardiovascular diseases in general and heart disease in particular from time to time by implementing variety of algorithms. Detection and management of cardiovascular diseases can be achieved by using computer based predictive tool in data mining. By implementing data mining based techniques there is scope for better and reliable prediction and diagnosis of heart diseases. In this study we studied various available techniques like decision Tree and its variants, Naive Bayes, Neural Networks, Support Vector Machine, Fuzzy Rules, Genetic Algorithms, and Ant Colony Optimization to name few. The observations illustrated that it is difficult to name a single machine learning algorithm for the diagnosis and prognosis of CVD. The study further contemplates on the behaviour, selection and number of factors required for efficient prediction.

Keywords: Data Mining, Cardiovascular Disease (CVD), Communicable (C), maternal (M), perinatal (P) and Nutritional conditions (NC).

INTRODUCTION

Cardiovascular diseases remain the foremost causes of preventable deaths globally and continue to grow in prominence, because of their attendant burden, disparities, and costs. Evidence indicates that cardiovascular diseases are already epidemic in low- and middle-income as well as high-income regions of the world and have become deep-rooted in most societies in recent decades. Heart disease and stroke kills some 17 million people a year, which is almost one-third of all deaths globally. By 2020, heart disease and stroke will become the leading cause

of both death and disability worldwide, with the number of fatalities projected to increase to over 20 million a year and by 2030 to over 24 million a year[1]. The detection of CVD from various factors or symptoms is a multilayered issue which is not free from wrong diagnosis and is often accompanied by unpredictable effects. The huge amounts of data generated by healthcare transactions are too complex and voluminous to be processed and analyzed by traditional methods. Hence data mining is used to extract the useful patterns/knowledge from medical databases for correct diagnosis and/or prognosis.

In health care, data mining is becoming increasingly popular if not increasingly essential. Data mining is a general term which encompasses a number of techniques to extract useful information from (large) data files, without necessarily having preconceived notions about what will be discovered. Although a large proportion of CVDs is preventable they continue to rise mainly because preventive measures are inadequate. Out of the 17.3 million cardiovascular deaths in 2008, heart attacks were responsible for 7.3 million and strokes were responsible for 6.2 million deaths[2]. As shown in below given fig 1.

METHODOLOGY

The methodology followed for this paper was the survey of journals and publications in the field of healthcare, computer science and engineering, international journals of advanced computer science and applications. To get more details book chapters on heart disease, working papers and conferences were also reviewed.

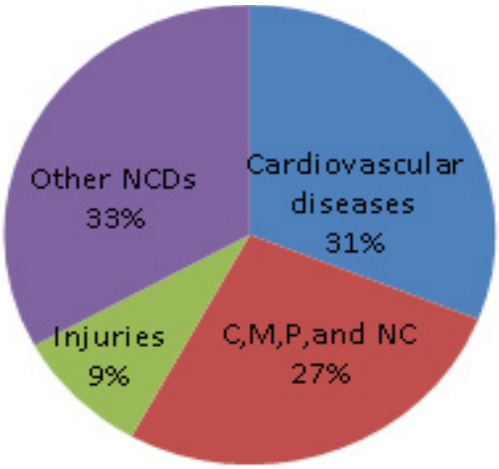

Fig. 1: Distribution of major causes of deaths including CVDs

Literature Review

Over the years, numerous works have been done related to heart disease prediction system using different data mining algorithms by different authors. They tried to achieve efficient methods and accuracies in finding out diseases related to heart by their work including datasets and different algorithms along with the experimental results and future work that can be done on the system to achieve more efficient results. This paper aims at analyzing different data mining techniques that has been introduced in recent years for heart disease prediction system by different authors. Researchers have been investigating the use of data mining techniques to help practitioners in accurate diagnosis. Works done by various researchers in heart disease diagnosis using different data mining techniques with various performance measures are discussed below:

- Aqeel Ahmed and Shaikh Abdul Hanan (2012) in their study combined 4 datasets of 920 records with 72 attributes to predict heart disease using different data mining technique. Only 13 attributes were shortlisted and used in their study, it was reported that Decision tree and SVM were most effective to predict heart disease[48].
- Nidhi Bhatla and Kiran Jyoti (2012) pointed out only 4 attributes for heart disease detection with Dataset of 100 patients, all attributes were first converted into categorical form and discrepancies were resolved. Mean absolute error for Decision Tree is 0 and that of Naive Bayes =0.0072[21].
- Alladoumbaye Ngueilbaye and Lin Lei Hangzhi Wang (2013) described the classification algorithms to predict heart disease from the collected hospitals databases with 315 instances using 14 clinical features. Naive Bayes algorithm outperformed SVM with accuracy measures as 91.42% and 89.56%[6].
- Kantesh kumar oad, et. al. (2014) used only 6 medical attributes to diagnose the CVD disease by using the fuzzy rule based expert

system. The performance of the system matched with Neural Network and J48 Decision Tree Algorithms[7].

- Nidhi Sharma and Purushattam Sharma (2014) in their research work added two more medical attributes namely Obesity and Smoking to detect heart disease with much accuracy. Neural Network algorithm claimed 100% accuracy with 15 attributes which was only 99.25 in case of 13 medical attributes[8].
- Lalita Sharma and Vineet Khanna (2014) for heart disease detection used 13 medical attributes and have grouped those attributes together into homogenous sub groups. Before sampling, the strata were mutually exclusive and every attribute was assigned to only one stratum. Researchers used Naive Bayes algorithm to predict the diagnosis of the patient with the better accuracy[9].
- Atual Kumar Pandey, et al. (2014) analyzed simple K-Means, PART and PART Based on K-Means Clustering Algorithms with accuracies of 80.858, 79.538 and 93.0693 and used 10 fold cross validation method to measure the unbiased estimate of the prediction model[15].
- D Ratnam, et al. (2014) Developed CCDSS using Naive Bayes algorithm with 12 medical attributes for the prediction of heart disease and the dataset used was case sheet heart disease patients of KIMS Hospital Hyderabad, India[20].
- Aditya Methaila, et al (2014) used classification modelling techniques along with Weighted Association Apriori Algorithm and MAFIA algorithm in heart disease prediction. Dataset of 909 records from Cleveland heart disease database with 15 medical attributes was used. Decision Tree has outperformed with 99.62% accuracy and further improves after applying genetic algorithm[18].
- G.Karthiga, et al. (2014) found that K-Means based MAFIA, K-Means based MAFIA with ID3 and K-Means based MAFIA with ID3 and C4.5 attains accuracies of 74%, 83% and 89% using the concept of informative entropy with 12 attributes[16].
- B. Venkatalakshmi and M.V.Shivsankar (2014) compared the performance of Decision Tree and Naive Bayes using 13 clinical heart diseases attributes with accuracies of 85.03% and 84.01% using WEKA 3.6.0 tool[14].
- Deepali chandan (2014) Mentioned in her research that feature selection methods are used to lessen the amount of features in the dataset prior to initiation of the mining method. Research work showed how information method, Feature Selection Technique can be used in collaboration with Adaptive Neuro Fuzzy Inference System in diagnosing new patient[19].
- Ms. Preeti Gupta and Ms. Punam Bajaj (2014) analyzed neural network and swarm intelligence techniques for diagnosis of heart disease using heart rate data set. Swarm intelligence optimization i.e. Genetic Algorithm has been used and applied for optimizing the neural network[51]
- Prof. Gondkar Mayura D and Prof. Pawar Suvarna E. (2014) projected to find out the heart attack type through data mining techniques. The main objective was to build intelligent heart disease prediction system that gives diagnosis of heart disease using historical heart database with only 13 medical attributes[49].
- Animesh Duby, et al (2014) provided an Ant Colony Optimization approach for heart disease prediction so that it can be prevented in the earlier stages. Generated support is being used as a weight of the symptom for the initial pheromone value of the ant. Based on the observations and iterations it was found that in each subsequent iteration the detection rate of heart disease increases. ACO can be used to improve the detection rate and it is helpful in proper heart attack detection. Researchers presented the combination of data mining and Ant Colony Optimization techniques to improve detection rate[50].
- Aswathy Wilson, et al (2014) did comparative study of different data mining algorithms and found that k means clustering with decision tree gives high accuracy[53].
- M.A Nishara Banu and B. Gamathy (2014) Analyzed Association Rule Mining, Classification, and Clustering to predict heart disease. The results showed that the designed prediction system is capable of predicting the heart attack successfully[52].
- Shabana Asmi P and Dr. S. Justins Samuel

(2015) added more attributes to predict the heart disease with high accuracy using association rules. Final results showed that association rules implemented on dataset produces better accuracy[17].

- Moloud Abdar, et al (2015) applied and compared data mining techniques to predict the rise of heart disease using five different algorithms such as C5.0, Neural Bayes, Support vector Machine, Neural Network and Logistic Regression with accuracy measures as: 93.02, 86.05, 88.37, 85.22 and 80.23 using 13 medical attributes[10].
- Ms. Shinde Swati B, et al. (2015) described the diagnosis of heart disease using Naive Bayesian and K- Nearest Neighbours with accuracy measures of 84% and 76 % using 13 medical attributes[11].
- Jyoti Rohilla and Preeti Gullia (2015) implemented various data mining algorithms for the diagnosis of CVD with their accuracy measures. 10 fold cross validation method was used to measure the unbiased estimate. The performance of Naive Bayes, Bagging, J48, Simple Cart, Logistic Regression, Reptree, and ID3 algorithms were recorded as 80%, 80%, 84%, 82%, 82%, 84% and 88%[3].
- Beant Kaur and Dr. Williamjeet Sing (2015) used data mining techniques and Genetic algorithm for heart disease prediction. The observations revealed that Genetic Algorithm with 14 attributes showed accuracy of 73.46% with Elapsed Time of 0.04172s and Energy of 1285.99 joules[4].
- V. Subha, et al. (2015) analyzed the performance of SVM classifier and Ensemble classifier methods for Heart Disease Prediction. The experimental results showed that Boosting method performs better when compared to other techniques in view of performance measures with Accuracy, Sensitivity and Specificity as: 83.22%, 83.00% and 82.12%[5].
- G.Purusothaman and P.Kirshnakumari (2015) had cited various data mining prediction models namely Decision Table, Association Rule, KNN, Artificial Neural Network, SVM, Naive Bayes and Hybrid models with accuracies as 76%, 55%, 58%, 85%, 86%, 69% and 96%. Hybrid data mining has outperformed other data mining heart disease diagnosing techniques[54].
- K.Aravintan and Dr. M. Vanitha (2016) did a comparative study on prediction of heart disease using cluster and rank based approach. Naive Bayes Algorithm, J48 Algorithm, Neural Network Algorithm were used on 305 instances with 14 medical attributes. The accuracy measures of Naive Bayes, J48 and Artificial Neural Network are as 81.3021%, 80.099%, and 82.56[22].
- Sonam Nikhar and A.M Karandikar (2016) provided a detailed description of Naive Bayes and Decision Tree classifier that are applied in the prediction of heart disease. Records set with medical attributes were obtained from the Cleveland heart disease database[12].
- Ashwini Shetty A and Chandra Naik (2016) analysed Neural Network and Genetic Algorithm for heart disease prediction using 13 medical attributes with accuracy measures of 84% and 89%[13].
- K.Aravinthan and Dr.M.Vanitha (2016) developed a Decision support system in Matlab using Naive Bayes algorithm having 13 medical attributes with Accuracy rate of 83.6296 and Error rate of 16.3703[47].
- K.Manimekalai (2016) did comparison of various data mining tools and techniques in which Naive Bayes gave 99.52% accuracy in the WEKA tool followed by Neural Networks accuracy of 96.56% in .Net data mining tool and fuzzy logic's accuracy of 83.85% in Tanagra tool[46].
- K.Manimekalai (2016) in her paper "Prediction of heart disease using data mining techniques" cited 9 data mining techniques used by different authors from years 2012-2016 with different accuracies.SVM classifier with Genetic Algorithm attain the highest accuracy of 95% followed by Fuzzy mechanism and C5.0 algorithms with accuracies of 94.11% and 93.02%[46].
- Meenu Singla and Kawaljeet Singh (2016) presented various clustering techniques k-Means, EM technique and the Farthest First Clustering Algorithm for the prediction of heart disease. It was found that Farthest First is the best algorithm. The System can be improved by using more number of input attributes and can be further expanded by including more

number of clusters[41].

- Ankita R.Mokashi, et al (2016) analyzed improved K-Means and Artificial Neural Network techniques for improving accuracy of heart disease with 13 number of medical profile parameters using 303 records of Cleveland database. As per results Artificial Neural Network performed best[40].
- Basheer M. Al Maqaleh and Ahmad.M.G.Abdullah. (2016) developed a prototype for heart disease diagnosis using four experiments on data set of IBB hospital YEMEN and for all experiments two situations were considered one with 11 attributes and other with only 3 selected attributes. The accuracy measures with selected attributes of J48, Naive Bayes and Neural Network were as 100%, 99.08% and 100%[44].
- Ayon Dey, et al (2016) used minimum number of attributes for heart disease prediction with 303 instances .Researchers implemented SVM, Naive Bayes and Decision Tree with and without using PCA on the dataset. SVM outperforms Naive Bayes and Decision Tree[55].

Discussions and Suggestions

Literature survey showed that the authors Nidhi Bhatia's and Kiran Jyoti's (2012) experiment provided an accuracy rate of 100% with less number

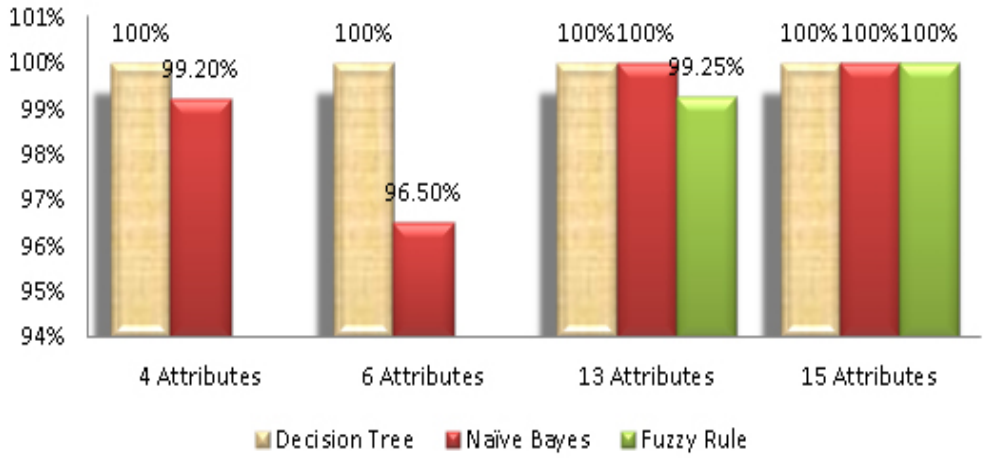

Chart 1: Shows Algorithms with different attributes producing efficient results

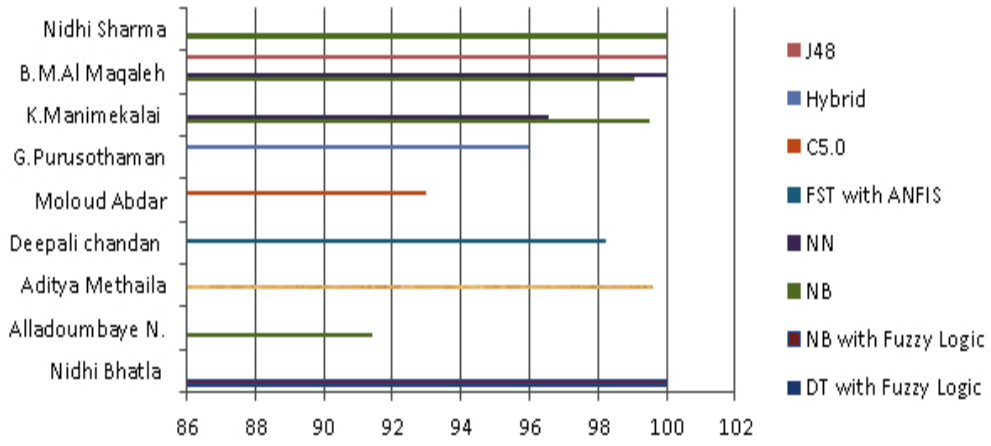

Chart 2: shows authors with attained accuracies

of attributes using Decision Tree and Naive Bayes algorithms. Further the authors Kantesh kumar oad,xu dezhi & pinial khan butt (2014) Used only 6 major medical attributes to diagnose the CVD disease with best results and the authors Nidhi Sharma, Purushattam Sharma (2014) added two more medical attributes namely Obesity and Smoking in their research work and have used Neural Network algorithm claiming 100% accuracy with 15 attributes which was only 99.25 in case of 13 medical attributes. The accuracy results with number of attributes and algorithms used is shown in below given chart 1.

From results an assumption can be derived that the accuracy of a heart disease predictive model depends upon the data mining technique used, data set used and number of influential attributes used, which can be described as:

Accuracy = Algorithm(S) Used * Dataset used + Number of valid Attributes. Below given chart 2 show the accuracy attained by various authors using different data mining techniques. UCI machine learning repository was used by majority of researchers for heart disease diagnosis with few vital medical attributes. Observations showed that there are some algorithms that surely gave best accuracies but couldn't reduce the number of heart disease detection attributes. Reduced number of attributes used in heart disease detection will automatically reduce the number of tests which are required to be taken by a patient. The performance of algorithms can be improved by removing unnecessary and irrelevant attributes from the dataset and only picking those that are most informative for the diagnosis.

CONCLUSION

The paper presents automated and effective heart attack diagnosis and/or prognosis using data mining techniques and methods that have significant success in improving the health of patients and overall quality of medical services. It has been analyzed that there is no single classifier which produces best result for every dataset and not a single data mining technique which give consistent results for all types of healthcare data. Hybrid or integrated Data Mining technique such as fusion of different classifiers, fusion of clustering with classification or association etc. can be used to achieve better performances. Finally, the experimentation was carried out on the UCI machine learning repository and the results in risk prediction ensured that the proposed clinical decision support system improved significantly compared with the network- based system in terms of accuracy, sensitivity and specificity.

Although significant progress has been made in the diagnosis and treatment of heart disease further investigation is still needed because the availability of huge amounts of medical data leads to the need for powerful data analysis tools to extract useful knowledge. From this study it can be concluded that attributes can be further reduced and correct accuracy can be achieved.

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