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Review on Heart Disease Prediction through Machine Techniques

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Abstract: Heart disease is one of the main sources of demise around the world and it is imperative to predict the disease at a premature phase. The computer aided systems help the doctor as a tool for predicting and diagnosing heart disease. The objective of this review is to widespread about Heart related cardiovascular disease and to brief about existing decision support systems for the prediction and diagnosis of heart disease supported by data mining and hybrid intelligent techniques.

Keywords: Cardiovascular Disease, Decision Support System, Data Mining, Hybrid Intelligent System

1. Introduction:

Data mining is the technique of knowledge discovery in which the knowledge is gathered by examining the data which might be hidden in extremely large sources, these sources are analyzed from several perspectives using different techniques and then the extracted information is summarized into useful information. It is a process in which information from past records are extracted for making important decisions for future predictions. Data mining techniques are becoming an important area of research for effective analysis of large data as the complexity and size of the data increases [1]. Data mining is used in many domains i.e. image mining, opinion mining, web mining, text mining, graph mining, medical data systems. It has become an important medical research area for finding unknown patterns in medical data. Medical professionals can examine the diseases on prediction analysis given by prediction model. In medical field data mining technique plays a vital role to predict different diseases. In many cases doctors may not be able to predict whether patient is suffering from one or more diseases at the same time. With the advent of new developments in the field of medication, a lot of data about different diseases have been gathered and are accessible to the research community [2]. Many challenges and opportunities are faced, according to the data mining perspective, mining big data has opened many new challenges and opportunities. A small number of data mining applications have been effectively provoked in different areas like extortion identification, retail, astronomy, social insurance, social media, money, banking, media transmission, climate modeling, medical, telecommunication, and hazard analysis etc. are not many to name [3]. In healthcare huge amount of data is being generated so, processing and analysis is required for knowledge extraction from such huge data. Mining algorithms predict the disease of patients using suitable learning strategy. Diseases like chronic kidney disease (CKD), hepatitis, cancer disease and diabetes have become a worldwide health issue and therefore prediction of such type of diseases is the concerned area for researchers. Our work mainly focuses on analyzing classification algorithms like Naive Bayes (NB) and Artificial Neural Network (ANN), J48, REF Tree for different life threatening diseases like CKD. Mining techniques used in health care are described in fig1. There are two main categories of data mining known as supervised and unsupervised [4]. Both approaches have different applications and efficiency for analyzing and predicting the diseases. These techniques mentioned above are used in medical field accordingly to predict diseases and for making decision for treatment of patients. Classification is a supervised technique in which objects are assigned in a collection to target classes. Decision tree, ANN, SVM, NB, etc are approaches of classification. Different approaches are used for different purposes in healthcare. In clustering similar types of objects are categorized in the same group. K-means, K- medoids, agglomerative, divisive, DBSCAN etc are some of the techniques of clustering. Association is the possibility of occurrence of objects in a set. Further classification of Apriori is association.

2. Related Work:

Shaikh Abdul Hannan et al. [5] used a Radial Basis Function(RBF) to predict the medical prescription for heart disease. About 300 patient's data were collected from the Sahara Hospital, Aurangabad. RBFNN (Radial Basis Function–Neural Network) can be described as a three-layer feed forward structure. The three layers are the input layer, hidden layer and output layer. The hidden layer consists of a number of RBF units (nh) and bias (bk). Each neuron on the hidden layer uses a radial basis function as a nonlinear transfer function to operate on the input data. The most often used RBF is usually a Gaussian function. Designing a RBFNN involves selecting centres, number of hidden layer units, width and weights. The various ways of selecting the centres are random subset selection, k-means clustering and others. The methodology was applied in MATLAB. Obtained results show that radial basis function can be successfully used (with an accuracy of 90 to 97%) for prescribing the medicines for heart disease.

AH Chen et al. [6] presented a heart disease prediction system that can aid doctors in predicting heart disease status based on

the clinical data of patients. Thirteen important clinical features such as age, sex, chest pain type were selected. An artificial neural network algorithm was used for classifying heart disease based on these clinical features. Data was collected from machine learning repository of UCI .The artificial neural network model contained three layers i.e. the input layer, the hidden layer and the output layer having 13 neurons, 6 neurons and 2 neurons respectively. Learning Vector Quantization (LVQ) was used in this study. LVQ is a special case of an artificial neural network that applies a prototype-based supervised classification algorithm. C programming language was used as a tool to implement heart disease classification and prediction trained via artificial neural network.The system was developed in C and C# environment.The accuracy of the proposed method for prediction is near to 80%.

Mrudula Gudadhe et al.[7] presented a decision support system for heart disease classification. Support vector machine (SVM) and artificial neural network (ANN) were the two main methods used in this system. A multilayer perceptron neural network (MLPNN) with three layers was employed to develop a decision support system for the diagnosis of heart disease. This multilayer perceptron neural network was trained by back-propagation algorithm which is computationally an efficient method. Results showed that a MLPNN with back-propagation technique can be successfully used for diagnosing heart disease.

Manpreet Singh et al. [8] proposed a heart disease prediction system based on Structural Equation Modelling (SEM) and Fuzzy Cognitive Map (FCM).They used Canadian Community Health Survey (CCHS) 2012 dataset. Here, twenty significant attributes were used. SEM is used to generate the weight matrix for the FCM model which then predicts a possibility of cardiovascular diseases. A SEM model is defined with correlation between CCC 121(a variable which defines whether the respondent has heart disease) along with 20 attributes. To construct FCM a weight matrix representing the strength of the causal relationship between concepts must be constructed first. The SEM defined in the previous section is now used as the FCM though they have achieved the required ingredients (i.e. weight matrix, concepts and causality).80% of the data set was used for training the SEM model and the remaining 20% for testing the FCM model. The accuracy obtained by using this model was 74%. Carlos Ordonez [9] has studied association rule mining with the train and test concept on a dataset for heart disease prediction. Association rule mining has a disadvantage that it produces extremely large number of rules most of which are medically irrelevant. Also in general, association rules are mined on the entire data set without validation on an independent sample. In order to solve this, the author has devised an algorithm that uses search constraints to reduce the number of rules. The algorithm then searches for association rules on a training set and finally validates them on an independent test set. The medical significance of discovered rules is then evaluated with support, confidence and lift. Search constraints and test set validation significantly reduce the number of association rules and produce a set of rules with high predictive accuracy. These rules represent valuable medical knowledge.

Prajakta Ghadge et al. [10] have worked on an intelligent heart attack prediction system using big data. Heart attack needs to be diagnosed timely and effectively because of its high prevalence. The objective of this research article is to find a prototype intelligent heart attack prediction system that uses big data and data mining modeling techniques. This system can extract hidden knowledge (patterns and relationships) associated with heart disease from a given historical heart disease database. This approach uses Hadoop which is an open-source software framework written in Java for distributed processing and storage of huge datasets. Apache Mahout produced by Apache Software Foundation provides free implementation of distributed or scalable machine learning algorithms. Record set with 13 attributes (age, sex, serum cholesterol, fasting blood sugar etc.) was obtained from the Cleveland Heart Database which is available on the web. The patterns were extracted using three techniques i.e. neural network, Naïve Bayes and Decision tree. The future scope of this system aims at giving more sophisticated prediction models, risk calculation tools and feature extraction tools for other clinical risks.

Asha Rajkumar et al. [11] worked on diagnosis of heart disease using classification based on supervised machine learning. Tanagra tool is used to classify the data, 10 fold cross validation is used to evaluate the data and the results are compared. Tanagra is a free data mining software for academic and research purposes. It suggests several data mining methods from explanatory data analysis, statistical learning, machine learning and database area. The dataset is divided into two parts, 80% data is used for training and 20% for testing. Among the three techniques, Naïve Bayes shows lower error ratio and takes the least amount of time.

K. S. Kavitha et al. [12] modelled and designed an evolutionary neural network for heart disease detection. This research describes a new system for detection of heart diseases using feed forward neural architecture and genetic algorithm. The proposed system aims at providing easier, cost effective and reliable diagnosis for heart disease. The dataset is obtained from UCI repository. The weights of the nodes for the artificial neural network with 13 input nodes, 2 hidden nodes and 1 output node are once set with gradient descent algorithm and then with genetic algorithm. The performances of these methods are compared and it is concluded that genetic algorithm can efficiently select the optimal set of weights. In genetic algorithm tournament selection is a method of selecting an individual from a population of individuals. This work finds that more members are coming from the offspring population. It is an indication for generation of fitter offsprings which leads to greater diversity and exploration of search space. With the help of this work, expert disease prediction systems can be developed in the future.

K. Sudhakar et al. [13] studied heart disease prediction using data mining. The data generated by the healthcare industry is

huge and "information rich". As such, it cannot be interpreted manually. Data mining can be effectively used to predict diseases from these datasets. In this paper, different data mining techniques are analyzed on heart disease database. Classification techniques such as Decision tree, Naïve Bayes and neural network are applied here .Associative classification is a new and efficient technique which integrates association rule mining and classification to a model for prediction and achieves maximum accuracy. In conclusion, this paper analyzes and compares how different classification algorithms work on a heart disease database.

Shantakumar B. Patil et al. [14] obtained important patterns from heart disease database for heart attack prediction. Enormous amount of data collected by the healthcare industry is unfortunately not 'mined' properly to find concealed information that can predict heart attack. Here, the authors have proposed MAFIA algorithm (Maximal Frequent Itemset Algorithm) to do so using Java. The data is preprocessed first, and then clustered using k-means algorithm into two clusters and the cluster significant to heart attack is obtained. Then frequent patterns are mined from the item set and significance weightages of the frequent data are calculated. Based on these weightages of the attributes(ex- age, blood pressure, cholesterol and many others), patterns significant to heart attack are chosen. This pattern can be further used to develop heart attack prediction systems.

Sairabi H. Mujawar et al. [15] predicted heart disease using modified k-means and Naïve Bayes. Diagnosis of heart disease is a complex task and requires great skills. The dataset is obtained from Cleveland Heart Disease Database. The attribute "Disease" with a value '1' indicates the presence of heart disease and a value '0' indicates the absence of heart disease. Modified k-means works on both categorical and combinational data which we encounter here. Using two initial centroids we obtain two farthest clusters. It finally gives a suitable number of clusters. Naive Bayes's creates a model with predictive capabilities. This predictor defines the class to which a particular tuple should belong to. This predictor has 93 % accuracy in predicting a heart disease and 89% accuracy in cases where it detected that a patient doesn't have a heart disease.

S. Suganya et al. [16] predicted heart disease using fuzzy cart algorithm. Fuzziness was introduced in the measured data to remove the uncertainty in data. A membership function was thus incorporated. Minimum distance CART classifier was used which proved efficient with respect to other classifiers of parametric techniques. The heart disease dataset is initially segregated into attributes that increase heart disease risk. Then fuzzy membership function is applied to remove uncertainty and finally ID-3 algorithm is run recursively through the non-leaf branches until all the data have been classified. The proposed method is implemented in Java.

Ashwini Shetty A et al. [17] proposed different data mining approaches for predicting heart disease. Their research work analyses the neural network and genetic algorithm to predict heart diseases. The initial weight of the neural network is found using genetic algorithm which is the main advantage of this method. Here, the neural network uses 13 input layers, 10 hidden layers and 2 output layers. The inputs are the attribute layers (here 13 attributes are used namely age, resting heart rate, blood pressure, blood sugar and others). Levenberg-Marquardt back propagation algorithm is used for training and testing. Optimization Toolbox is used to implement this system. 'configure' function is used with neural network where each weight lies between -2 to 2.Fitness function that is being used in the genetic algorithm is the Mean Square Error (MSE). Genetic algorithm is used for adjustment of weights. Based on MSE, fitness function will be calculated for each chromosome. Once selection is done, crossover and mutation in genetic algorithm replaces the chromosome having lower adaption with the better values. Fitter strings are obtained by optimizing the solution which corresponds to interconnecting weights and threshold of neural network. The resulting lower values those are close to zero, represent the generalized format of the network which is ready for classification problem. The system calculates accuracy using MATLAB. Preprocessing is done using WEKA. The results show that the hybrid system of genetic algorithm and neural network works much better than the performance of neural network alone.

K Cinetha et al. [18] proposed a decision support system for precluding coronary heart disease using fuzzy logic. This system predicts the possibility of heart disease in a patient for the next ten years. Data from normal and coronary heart disease patients were collected and it was observed whether a normal person developed coronary heart disease or what factors could have led to the onset of coronary heart disease. Prevention of risk factors are analyzed using fuzzy logic and Decision tree.The dataset contains 1230 instances. Decision tree is implemented for the establishment of fuzzy rules and the diagnosis of coronary heart disease. The method is used to produce the clustered data. Next, the fuzzy rule is obtained by extracting rules from the cluster using the Least Square Error (LSE). Determination of the best cluster is selected using fuzzy technique and variant analysis is performed during testing. Smaller values of variant boundaries are ideal for clustering. The best accuracy of the system for selected rules when applied to the TSK inference orde-1method is 97.67%.

Indira S. Fall Dessai [19] proposed an efficient approach for heart disease prediction based on Probabilistic Neural Network (PNN) technique. The data set containing 13 medical attributes was obtained from the Cleveland Heart Disease Database. It is clustered using k-means. Probabilistic Neural Network is a class of radial basis function (RBF) network which is useful for automatic pattern recognition, nonlinear mapping and estimating probabilities of class membership and likelihood ratios. An evaluation of the existing algorithms such as decision tree, Naïve Bayes, BNN for prediction is compared with PBN. This is done using Receiver Operating Characteristic Convex Hull (ROCCH) method. Results show that the proposed system gives 94.6% correct predictions.

Mai Shouman et al. [20] worked on the application of k-Nearest-Neighbors (k-NN) in diagnosis of heart disease. This

paper shows that k-NN has higher accuracy compared to neural network ensemble. However, applying integrating voting could not enhance the k-NN accuracy in the diagnosis of heart disease patients, unlike Decision tree classifiers where voting increases accuracy. Voting is an aggregation technique which is used to combine decisions of multiple classifiers. K-NN without voting gave the highest accuracy of 97.4%. However the accuracy for k-NN with voting reduced to 92.7%.

Serdar AYDIN et al. [21] have studied and compared various methods of data mining for diagnosing heart disease. Techniques used are Bagging, AdaBoostM1, Random Forest, Naive Bayes, RBF Network, IBK and NN. The data has been collected from Long Beach VA Hospital. It includes 200 samples, each containing 14 features. The techniques are analyzed using WEKA software. Results show that RBF Network has the accuracy of 88.20%,making it the most accurate classification technique in the diagnosis of heart disease.

G Purusothaman et al. [22] have surveyed and compared different classification techniques for heart disease prediction. Instead of applying a single model such as Decision tree, artificial neural network and Naïve Bayes, the authors focus on the working of hybrid models i.e. models which combines more than one classification technique. They have surveyed the works of researchers who studied about the effectiveness of hybrid models. The performances of single models such as Decision tree, artificial neural network and Naïve Bayes are 76%, 85% and 69% respectively. However, hybrid approaches show an accuracy of 96%. Therefore, hybrid models lead to reliable and promising classifiers for predicting heart diseases with good accuracy.

Deepali Chandna [23] has incorporated a hybrid approach to merge a learning algorithm and a feature selection technique. The dataset is obtained from UCI. Among the 76 attributes in the set, only 14 attributes are selected using k-nearest neighbor's algorithms. This approach also uses information gain and Adaptive Neuro-Fuzzy Inference System (ANFIS). ANFIS is the combined effect of neural network and fuzzy inference system. Information gain is used for selection of quality of attributes. The accuracy for the proposed approach is 98.24%.

S. Pravabathi et al. [24] presented an overview of research being carried out using DNFS (Decision tree based Neural Fuzzy System). The data mining techniques were used to enhance the heart disease diagnosis and prediction which include Decision trees, Naive Bayes classifiers, k-nearest neighbour classification (k-NN), support vector machine (SVM) and artificial neural networks techniques. Genetic algorithm was applied to improve the learning of neuro-fuzzy system which combined the adaptability of fuzzy inputs with neural network for accurate prediction. C4.5 Decision tree algorithm and RIPPER (Repeated Incremental Pruning to Produce Error Reduction) were used for classification.C4.5 classifier performed better than other data mining techniques for diagnosis like support vector machine and neural networks. Naïve Bayes classifier is also a better option. They concluded that Decision trees and Naïve Bayes classifiers are prominent for cardiovascular disease diagnosis with an accuracy reaching more than 95%.

Jaymin Patel et al. [25] compared different algorithms of Decision tree classification for better performance in heart disease diagnosis using WEKA. J48 algorithm, logistic model tree and random forest algorithms were compared. Datasets were taken from UCI repository consisting of 303 instances and 76 attributes, out of which 13 attributes were chosen to perform the tests.J48 is an open source, reliable Java implementation of the C4.5 algorithm in the WEKA.It uses divide and conquer approach to construct the tree, and attributes at each node are chosen such that it can further classify the part into samples. But here the greatest disadvantage is size, which increases linearly with the examples. Logistic model tree is a Decision tree structure with logistic regression function at the leaves. The algorithm has the choice of overseeing parallel and multi-class target variables, numeric and nominal attributes along with missing qualities as well. However, Logistic Model Tree(LMT) take longer time to be produced. Random forest is an ensemble classifier consisting of many Decision trees. Individual trees represent the output of the classes. It constructs Decision trees with controlled variations.

Vikas Chaurasia et al. [26] presented a new model that enhanced the Decision tree accuracy for identifying heart disease in patients. Decision tree algorithms here include CART (Classification and Regression Tree), ID3 (Iterative Dichotomized 3) and C4.5 build model. CART model recursively separates observations in the branches to construct a tree for the purpose of improving prediction accuracy. It builds classification and regression trees to predict continuous dependent variables (regression) and categorical predictor variables (classification).ID3 (IterativeDichotomized3) uses iterative inductive approach to identify the root at first and then construct the binary tree. Decision tables (DTs) are tabular representations to describe and analyse decision situations. In this study data is used from the Cleveland Clinic Foundation. Only 11 attributes were chosen from the 76 raw attributes. It was analysed and implemented in WEKA tool. CART provided the highest accuracy of 83.49% followed by DT and ID3.

Gunsai Pooja Dineshgar et al. [27] surveyed on the current techniques of knowledge discovery in databases using data mining techniques and built a prototype of intelligent heart disease prediction system that gave diagnosis of heart disease using historical heart database. The data mining clustering techniques like k-means and k-medoid algorithms are analysed to achieve global optimality in partitioned-based clustering. PAM(Partitioning Around Medoids) uses iterative optimization that combines relocation of points between perspective clusters with re-nominating the points as potential medoids and CLARA(Clustering LARge Applications) which used random search to generate neighbours by starting with an arbitrary node and randomly checking max neighbour

neighbours which are the versions of k-medoid algorithm. The k-means algorithm partitions a set of n objects into k desired cluster. After analysing the previous works did not used k-medoid algorithm, the authors have proposed to incorporate this method to classify data sets for predicting heart disease in an efficient and cost effective manner.

Jyoti Soni et al. [28] evaluated that the Weighted Associative Classifier (WAC) performed well as compared to other already existing Associative Classifiers. They designed a GUI to accept the patient's test results and predicted the presence of heart disease using CAR rules generated by WAC in Java platform. Weighted ARM uses weighted support and confidence framework to find out association rule from data repository. The WAC has been proposed as a new technique to get the exact significant rule instead of being flooded with insignificant relation. Experimental results show that WAC outperforms other associative classifiers such as CBA, CMAR and CPAR in terms of average accuracy. Maximum accuracy achieved is 81.51% with a support value 25% and confidence of 80%.

3. Conclusion

Heart diseases when aggravated spiral way beyond control. Heart diseases are complicated and take away lots of lives every year. When the early symptoms of heart diseases are ignored, the patient might end up with drastic consequences in a short span of time. Sedentary lifestyle and excessive stress in today's world have worsened the situation. If the disease is detected early then it can be kept under control. However, it is always advisable to exercise daily and discard unhealthy habits at the earliest. Tobacco consumption and unhealthy diets increase the chances of stroke and heart diseases. Eating at least 5 helpings of fruits and vegetables a day is a good practice. For heart disease patients, it is advisable to restrict the intake of salt to one teaspoon per day.

References:

[1] Nidhi Bhatla, and Kiran Jyoti, Oct. 2012,"An Analysis of Heart Disease Prediction using Different Data Mining Techniques", International Journal of Engineering Research & Technology (IJERT), Vol. 1, Issue 8, ISSN: 2278-0181, pp. 1-4.

[2] Sumitra Sangwan, and Tazeem Ahmad Khan, Mar. 2015,"Review Paper Automatic Console for Disease Prediction using Integrated Module of A-priori and k-mean through ECG Signal",International Journal For Technological Research In Engineering, Vol. 2, Issue 7, ISSN(Online): 2347-4718, pp. 1368-1372.

[3] Rishi Dubey, and Santosh Chandrakar, Aug. 2015,"Review on Hybrid Data Mining Techniques for The Diagnosis of Heart Diseases in Medical Ground" ,Vol. 5, Issue 8, ISSN: 2249-555X, pp. 715-718.

[4] Ashish Chhabbi,Lakhan Ahuja,Sahil Ahir, and Y. K. Sharma,19 March 2016,"Heart Disease Prediction Using Data Mining Techniques", International Journal of Research in Advent Technology,E-ISSN:2321-9637,Special Issue National Conference "NCPC-2016", pp. 104-106.

[5] Shaikh Abdul Hannan, A.V. Mane, R. R. Manza,and R. J. Ramteke, Dec 2010,"Prediction of Heart Disease Medical Prescription using Radial Basis Function",IEEE International Conference on Computational Intelligence and Computing Research (ICCIC), DOI: 10.1109/ICCIC.2010.5705900 ,28-29 .

[6] AH Chen, SY Huang, PS Hong, CH Cheng, and EJ Lin,2011, "HDPS: Heart Disease Prediction System",Computing in Cardiology, ISSN: 0276-6574, pp.557-560. [7] Mrudula Gudadhe, Kapil Wankhade, and Snehlata Dongre, Sept 2010,"Decision Support System for Heart Disease Based on Support Vector Machine and Artificial Neural Network",International Conference on Computer and Communication Technology (ICCCT),DOI:10.1109/ICCCT.2010.5640377, 17-19.

[8] Manpreet Singh, Levi Monteiro Martins, Patrick Joanis, and Vijay K. Mago,2016, "Building a Cardiovascular Disease Predictive Model using Structural Equation Model & Fuzzy Cognitive Map",IEEE International Conference on Fuzzy Systems (FUZZ),pp. 1377-1382.

[9] Carlos Ordonez,2006, "Association Rule Discovery With the Train and Test Approach for Heart Disease Prediction", IEEE Transactions on Information Technology in Biomedicine (TITB), pp. 334-343, vol. 10, no. 2.

[10] Prajakta Ghadge,Vrushali Girme, Kajal Kokane, and Prajakta Deshmukh, 2016,"Intelligent Heart Attack Prediction System Using Big Data", International Journal of Recent Research in Mathematics Computer Science and Information Technology,Vol. 2, Issue 2, pp.73-77, October 2015–March.

[11] Asha Rajkumar, and Mrs G. Sophia Reena, 2010, "Diagnosis of Heart Disease using Data Mining Algorithms",Global Journal of Computer Science and Technology,Vol. 10,Issue 10, pp.38-43, September.

[12] K. S. Kavitha, K. V. Ramakrishnan, and Manoj Kumar Singh, September 2010,"Modelling and Design of Evolutionary Neural Network for Heart Disease Detection" ,International Journal of Computer Science Issues (IJCSI), Vol. 7, Issue 5, pp. 272-283.

[13] K.Sudhakar, and Dr. M. Manimekalai, January 2014, "Study of Heart Disease Prediction using Data Mining", International Journal of Advanced Research in Computer Science and Software Engineering, Vol. 4, Issue 1,pp. 1157-1160.

[14] Shantakumar B. Patil,and Dr. Y. S. Kumaraswamy, February 2009, "Extraction of Significant Patterns from Heart Disease Warehouses for Heart Attack Prediction", IJCSNS International Journal of Computer Science and Network Security, Vol. 9 , No. 2,pp. 228-235.

[15] Sairabi H. Mujawar, and P. R. Devale, October 2015,"Prediction of Heart Disease using Modified k-means and by using Naive Bayes", International Journal of Innovative Research in Computer and Communication Engineering(An ISO 3297: 2007 Certified Organization) Vol. 3, Issue 10, pp. 10265-10273.

[16] S. Suganya, and P.Tamije Selvy, January 2016, "A Proficient Heart Disease Prediction Method using Fuzzy-Cart Algorithm", International Journal of Scientific Engineering and Applied Science (IJSEAS), Vol. 2, Issue1,ISSN: 2395-3470.
[17] Ashwini Shetty A, and Chandra Naik, May 2016,"Different Data Mining Approaches for Predicting Heart Disease", International Journal of Innovative Research in Science,Engineering and Technology(An ISO 3297: 2007 Certified Organization), Vol. 5, Special Issue 9, pp. 277-281.
[18] K Cinetha, and Dr. P. Uma Maheswari, Mar.-Apr. 2014,"Decision Support System for Precluding Coronary Heart Disease using Fuzzy Logic.", International Journal of Computer Science Trends and Technology (IJCST), Vol. 2, Issue 2, pp. 102-107.
[19] Indira S. Fal Dessai,2013,"Intelligent Heart Disease Prediction System Using Probabilistic Neural Network", International Journal on Advanced Computer Theory and Engineering (IJACTE),Vol. 2, Issue 3, pp. 38-44.
[20] Mai Shouman, Tim Turner, and Rob Stocker, June 2012,"Applying k-Nearest Neighbors in Diagnosing HeartDiseasePatients",International Journal of Information and Education Technology, Vol. 2, No. 3,pp. 220-223.
[21] Serdar AYDIN, Meysam Ahanpanjeh,and Sogol Mohabbatiyan,February 2016, "Comparison And Evaluation of Data Mining Techniques in the Diagnosis of Heart Disease",International Journal on Computational Science & Applications (IJCSA), Vol. 6,No.1, pp. 1-15.
[22] G. Purusothaman, and P. Krishnakumari, June 2015,"A Survey of Data Mining Techniques on Risk Prediction: Heart Disease", Indian Journal of Science and Technology, Vol. 8(12), DOI:10.17485/ijst/2015/v8i12/58385, pp. 1-5.
[23] Deepali Chandna, 2014,"Diagnosis of Heart Disease Using Data Mining Algorithm", International Journal of Computer Science and Information Technologies (IJCSIT), Vol. 5 (2), pp. 1678-1680.
[24] S. Prabhavathi, and D. M. Chitra, Jan. 2016, "Analysis and Prediction of Various Heart Diseases using DNFS Techniques", International Journal of Innovations in Scientific and Engineering Research(IJISER), Vol.2, Issue 1, pp. 1-7.
[25] Jaymin Patel, Prof. Tejal Upadhyay, and Dr. Samir Patel, Sep 2015-Mar 2016, "Heart Disease Prediction using Machine Learning and Data Mining Technique", Vol. 7, No.1, pp. 129-137.
[26] Vikas Chaurasia, and Saurabh Pal, 2013, "Early Prediction of Heart Diseases Using DataMiningTechniques",Caribbean Journal of Science and Technology, ISSN: 0799-3757, Vol.1, pp. 208-218.
[27] Gunsai Pooja Dineshgar, and Mrs. Lolita Singh, February 2016, "A Review on Data Mining for Heart Disease Prediction",International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE), Vol. 5, Issue 2, pp. 462-466.
[28] Jyoti Soni, Uzma Ansari, Dipesh Sharma, and SunitaSoni,June 2011, "Intelligent and Effective Heart Disease Prediction System using Weighted Associative Classifiers", International Journal on Computer Science and Engineering (IJCSE), Vol. 3, No. 6, pp. 2385-2392.
[29] Kamal Kant, and Dr. Kanwal Garg,2014, "Review of Heart Disease Prediction using Data Mining Classifications",International Journal for Scientific Research & Development(IJSRD), Vol. 2, Issue 04, ISSN (online): 2321-0613, pp. 109-111.
[30] Sharan Monica L, and Sathees Kumar B,February 2016, "Analysis of Cardiovascular Heart Disease Prediction Using Data Mining Techniques", International Journal of Modern Computer Science (IJMCS), ISSN: 2320-7868(Online), Vol. 4, Issue 1, pp. 55-58.