Heart disease classification using various heuristic algorithms

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ABSTRACT

In the health sector, the computer-aided diagnosis (CAD) system is a rapidly growing technology because medical diagnostic systems make a huge change as compared to the traditional system. Now a day huge availability of medical data and it needs a proper system to extract them into useful knowledge. Heart disease accounts to be the leading cause of death worldwide. Heuristic algorithms have been exposed to be operative in supporting making decisions and classification from the large quantity of data produced by the healthcare sector. Classification is a prevailing heuristic approach which is commonly used for classification purpose some heuristic algorithm predicts accurate result according to the marks whereas some others exhibit limited accuracy. This paper is used to categorize the attendance of heart disease with a compact number of aspects. Original, 13 attributes are involved in classifying heart disease. A reasonable analysis of these techniques was done to conclude how the cooperative techniques can be applied for improving prediction accuracy in heart disease. Four main classifiers used to construct heart disease prediction based on the experimental results demonstrate that support vector machine, artificial bee colony (ABC), bat algorithm, and memory-based learner (MBL) provide efficient results. The accuracy differs between 13 features and 8 features in the training dataset is 1.9% and in the validation, dataset is 0.92% of vector machine which is the most accurate heuristic algorithm.

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1. INTRODUCTION

Medical data design in healthcare is one of the important and complicated tasks because as a result, it must show accuracy and efficiency in its performance. Computer-aided diagnosis (CAD) becomes a very useful tool that attempts to solve real-world health problems in the diagnosis and treatment of disease [1]. In present years, heuristic systems have found their significant hold in every field comprising health care. Medical history data includes a number of tests prescribed to diagnose a specific disease [2]. Clinical databases are elements of the domain where the route of heuristic technique has advanced into an inevitable aspect due to the measured incline of medical and clinical research data. It is possible for the healthcare industries to gain an advantage of the heuristic technique by employing the same as an intelligent investigative tool. The report of heuristic technique is high accuracy and absorbing rate in this field. Normally, many health care organizations are encrustation a major defy to offer high-quality provisions, like analyzing patients appropriately and organizing treatment at sensible costs [3], [4]. The heuristic technique has been widely used to mine information from medical databases. In the heuristic technique, a classification is a form of learning that can be used to design models describing important data classes. Using those heuristic techniques can provision researchers or physicians in making medical verdicts and they can answer significant and connected questions regarding health care. It is problematic to recognize heart disease because of several contributory risk issues such as diabetes, high blood pressure, high cholesterol, abnormal pulse rate, and many other factors [5], [6]. The rest of this paper is organized as: The necessary background for the heart disease is discussed in section 2. Section 3, presents the related work in this section. In section 4, the statistical analysis and limitations are presented. In Section 5, we present the outstanding issues of heuristic algorithms for heart disease prediction and their result. Section 6, presents the conclusion. For the comfort of readers, we provided a list of the most frequently used acronyms in the paper are mentioned in Table 1.

Table 1. List abbreviations

Abbreviations	Meaning	Abbreviations	Meaning
HD	Heart diseases	Bat	Bat algorithm
PH	Predication approach	ABC	Artificial bee colony
MBL	Memory-Based Learner	DP	Deep learning
SVM	Support vector machine	M.SVM	Modified support vector machine
WHO	World Health Organization	UCI	University of California Irvine
CAD	Computer-aided diagnosis	MBL	Memory-based learner

2. DISEASES

The disease is a particular term that is used for the abnormal condition, or this term is used in healthcare conditions that part of an organism. Various diseases are known by their symptoms, signs, and knowledge and therefore it is necessary to optimize disease forecaster. According to a survey by World Health Organization (WHO), heart disease has been the main cause of death in the world. Heart attack in different countries due to exertion, work overload, mental stress, food, and so on the treatment and diagnosis is complicated therefore it is an important step to design a systematic system for diagnoses [7], [8]. The main prevention of this disease is to make an early prediction. Heart disease risk factors the main elements which make a personal risk factor for this disease are. Age factors: Normally men face heart attack at age of 65 and women face this kind of attack after. Climacteric but as compared to women, men face more heart attacks. Family history; normally it is seen that the family faces this kind of problem and it inherits from family to family heart disease cause. Smoking factor a chemical in tobacco smoke that developed blood clots and also increase the cause of heart attacks now a day it is more in the young generation due to the use of smoke weight; if the body increases then it makes the chance of heart disease. These people who carry extra body facts give chance to these diseases. To reduce this kind of numerous problems any kind of factor can be used [9], [10].

3. RELATED WORK

Different researchers have proposed several heuristic algorithms and techniques to predict heart disease accurately some of them are. Agostino *et al*. [11], designed a neural network algorithm known as self-organizing piecewise aggregate approximate (SOPAA). This algorithm is used for electrocardiogram (ECG) signal classification and performed to diagnose heart disease. According to their result, 97% better than other techniques used. Researchers implement a genetic algorithm in a neural network for heart disease prediction. They use 12 parameters such as sex, age, blood, and cholesterol. The algorithms calculate the number of hidden layer nodes and architecture to calculate the parameter result. According to their result, it gives up to 98% accuracy16. According to [12], design a scheme that is known as a prototype intelligent heart disease prediction system (IHDPS) using deep learning technique, namely decision trees. ID3. By using medical profiles of patients such as age, gender, blood pressure and blood sugar, chest pain, and an electrocardiogram (ECG) graph, it can predict the likelihood of patients getting a heart disease or not and make 82% effectually working in necessity. Concurring to [13], design a multilayer perceptron model for analytical detection of heart disease severity based on various factors. The author also organizes a novel principle attribute analysis to understand the direction of the attributes emotional the results. The final effect of this work is to explore the heart disease severity based on the planned multilayer perceptron model conferring the result it 97% accurate.

Ullah *et al*. [14] designed a scheme known as a decision tree and grabbing algorithm used for the reduction of blood and oxygen supply to the heart leads to heart disease. Used disparate attributes to associate with other algorithms and the result shows a 96% increment in this scheme [15], proposed for the diagnosis of coronary artery disease the decision tree is used to select the most significant attributes, and the output is converted into crisp if-then rules. The crisp sets of rules are transformed into the fuzzy rules and these rules constitute the fuzzy rule base. The performance of the proposed system is analyzed using various parameters like classification accuracy, sensitivity, and specificity and it is observed that that this system achieves better accuracy about 98% than the existing systems [16]. Author applied and compared several data mining techniques to predict heart diseases. They used models based upon five algorithms including C5.0, neural network, support vector machine (SVM), k-nearest neighborhood (KNN), and logistic regression. C5.0 decision tree was able to build a model with greatest accuracy of 93.02% whereas KNN, SVM, neural network had the accuracy of 88.37%, 86.05%, and 80.23% respectively [17]. Summary of the related work are mention in Table 2.

Table 2. Related work summary

Heuristic Algorithms	Year	Disease	Dataset	Simulation	Accuracy rate
Bayes Net/ FT 84.5%	2015	Coronary artery disease	UCI	WEKA	84.5%
Naive Bayes/SVM					
Naive Bayes/ J48	2015	Heart Disease	UCI	WEKA	85.1
Bagging/ SVM	2018	Heart Disease	UCI	WEKA	84.2
UCI	2019	Heart disease	UCI	WEKA	84.95
ANN	2019	Dengue Disease	UCI	WEKA	85.56
MFNN	2019	Dengue Disease	UCI	WEKA	84.56
C4.5	2019	Dengue Disease	UCI	WEKA	84.56
Feed forward NN with Back propagation	2019	Dengue Disease	UCI	WEKA	84.56
CART	2019	Dengue Disease	UCI	WEKA	82.56
K Star	2019	Dengue Disease	UCI	WEKA	83.56

4. PROPOSED APPROACHES

In this section, we present all those classifiers of heuristic algorithms which are used for heart disease prediction in this paper. Clevel and University of California Irvine (UCI) repository dataset for heart disease classification process offers an easy-to-use visual representation of the dataset, working situation, and building the analytical analytics. Applying the machine learning technique start from pre-processing phase followed by post-processing steps.

5. CLASSIFIER EVALUATION MEASURES

In this research, the context selection technique is determined by using the weight of the lower-level context technique. Rather than using the learning weights through heuristic algorithms. In this section, we collect the information from each gain of the attribute as its weight. The basic concept of this study comes from the SVM classification technique and it is used the concept of information gain as the criteria for selecting an attribute process [18], [19]. SVM is justly used for story set selection so the technique applied consists of computing the SVM for each field. SVM gives attribute X with respect to the class attribute Y is the reduction in uncertainty about the value of Y when we know the value of X, I (Y; X). The uncertainty about the value of Y when we know the value of X is given by the conditional entropy of Y given X, H (Y, X) [20]. Figure 1 presents the proposed approaches.

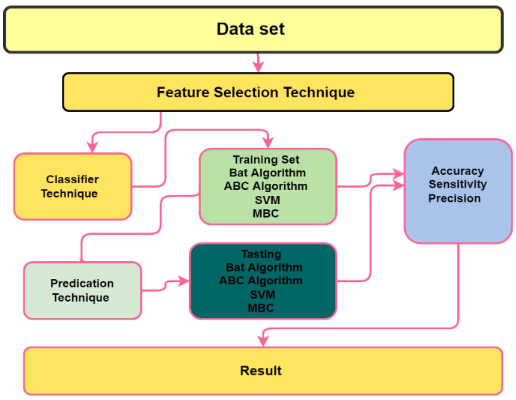

Figure 1. Proposed approaches structure

5.1. Support vector machine (SVM)

SVM has proven to be a supervised machine learning method, commonly used to provide data analysis for regression and classification problems. Generally, this method is used as a classifier, based on the principle of making a plot of n dimensions in space, where the value of each entity also presents the value of the specified coordinate. Subsequently, find the ideal hyperplane that made it possible to differentiate the two created classes [21], [22]. Like other machines, the SVM takes input, performs input manipulation, and then provides an output, which can later categorize new examples. SVM classifier used for binary classification of feature space by hyperplane-based linear separation of data. Normally used for nonlinear regression and pattern classification purposes, SVM work on the following base rule [23], [24].

$$Sgn(f(x,wb) \quad f(x,w,b) = (w.x) + b \tag{1}$$

Where x is the example to be classified and the maximum margin with a hyper plane (w, b) represent the complex problem w within the specified constraints [25], [26].

$$yi(w.xi) + b) \geq 1 \tag{2}$$

$$(w.x) + b) = 0 \quad \omega \, \alpha R^n, b\varepsilon \; R \tag{3}$$

5.2. Memory-based learner (MBL)

The memory-based learner also known as instance-based this approach works on the nearest neighbor that classifies the attributes based on training labels (K) as the neighbor in the feature space. A distance function is used to identify the nearest neighbors. The type of distance function is contingent on the data type of nominated attributes [27], [28].

$$d(xi, xj) = \sum_{q\alpha Q}(X_{iq} - X_{iq})^2 + \sum_{C\varepsilon c} L_c\,(X_{ic} - X_{jc}) \tag{4}$$

Where Lc represents the M × M matrix used to describe the distance between two categorical attributes, Let Ni represents the set of k nearest neighbors for an instance xi having the distance of d, T [29]–[33].

$$V_i(t) = \sum K\varepsilon N_i(t, yk)) \tag{5}$$

5.3. Bat algorithm

Bat algorithm generates the new solution now it time to speed at which bat searches for prey in the dimension present as dimension. These equations are used for the classification process.

$$V_{id}^{t} = v_{id}^{(t-1)} + \; f_i(x_{id}^{(t-1)} - x_d^*) \tag{6}$$

The given equation d presents the dimension of the search space V_{id}^{t} and $v_{id}^{(t-1)}$ denote the flight speed of the bat i and $t-1$ respectively $x_{id}^{(t-1)}$ denote the position of bat i at time $t-1$ and x_d^* represent the best position in the population up to the t iteration so far [34], [35].

5.4. ABC algorithm

All the directions of the inhabitants of food causes, *xm*→'s, are initialized (*m* = 1...*SN*, *SN*: population size) by scout bees and regulator parameters are set. Since each food source, *xm*→, is a solution vector to the optimization problem, each *xm*→ vector holds *n* variables, (*xmi*, *i* = 1...*n*), which are to be enhanced so as to minimize the classification purpose.

6. DATA PRE-PROCESSING

Dataset for this study Cleveland dataset (UCI, 2016) used which are under the control of UCI machine learning repository used for heart disease dataset. The dataset consists of 303 instances of the patient but 6 of them are conation missing values and Table 3 shows the dataset attributes with their definition [36], [37].

Table 3. Dataset features information and description

Feature name	Feature code	Description	The domain of values (minimax)
Age	AGE	Age in yrea	20<age>80
Sex	SEX	Female =1, Male 0,	0,1
Resting blood pressure	RBP	mm Hg admitted at the hospital	94–200
Type of chest pain	CPT	1. atypical angina 2. typical angina 3. asymptomatic 4. nonagonal pain	1 2 3 4
Fasting blood sugar >120 mg/dl	FBS	Fasting blood sugar >120 mg/dl (1 _ true; 0 _ false)	10 00 12
Serum cholesterol	SCH	In mg/dl	120–564
Resting electrocardiographic results	RES	having ST-T 1 hypertrophy 2	1 2
Maximum heart rate achieved	MHR	-	71–202
Exercise-induced angina	EIA	1 _ yes 0 _ no	1 0
Old peak _ ST depression induced by exercise relative to rest	OPK	-	0–6.2
Slope of the peak exercise ST segment	PES	1. up sloping 1 2. .at 2 3. down sloping	1 2 3
Number of major vessels (0–3) colored by horoscope	VCA	-	1 2 3
Thallium scan	THA	3.normal 6.£xed defect 7. reversible defect	3 6 7

7. RESULTS AND DISCUSSION

In this section, we present the result of different proposed classifiers in heuristic algorithms taking UCI dataset. Before discussing the result, these results are evaluated by using evaluation measures which areas:

In this study we evaluated the accuracy rate of prediction of proposed different models on heart disease datasets are mentioned: i) Classification error: it is used for the measurement of incorrect classification in the classification model which is measured as; ii) Classification accuracy: used to check the overall result of the performance of different classification and it will be measured as; iii) Accuracy = $\frac{(TP + TN)}{(TP + FP + TN + FN)} * 100$ [38], [39]; iv) Sensitivity is the process which shows the positive fraction or confirms that diagnostic test is positive and the test result for which process has find and it can be written as; v) Sensitivity/rec call /true positive rate =Sensitivity = $\frac{TP}{(TP + FN)} * 100$; vi) Specificity is diagnostic test is negative and person is healthy and can be present as: $\frac{TN}{(TN + FP)} * 100$; vii) Precision can be: $\frac{TP}{(TP + FN)} * 100$; viii) True Positive rate= TP / (TP + FN); ix) False Positive rate = FP / (FP + TN) [40]–[42].

8. EXPERIMENTS

In this study, Jupiter notebook software was used for heart disease prediction taking, cleverly and heart disease dataset. Here, the diagnostic performance is evaluated in terms of accuracy, precision, sensitivity, and specificity, taking different heuristic algorithms. The factors contributing to these are discussed, see Table 4 and Table 5.

Figure 2 shows the result of different machine learning approaches in terms of accuracy performance for heart disease prediction. Based on the result SVM classifier provide the best result and its accuracy rate is 98.91% best case and worst case. Memory-based learner and its result was 93.62%. Table 6 presents the result of the proposed technique (Classification) results in terms of instances.

Table 4. Assessment of heuristic approach for heart disease prediction

Parameter	Accuracy	Sensitivity	Specificity	TP Rate	FP Rate
Memory-Based Learner	81.08%	86.25%	75.82%	0.8625	0.2410
Bat	84.08%	86.25%	75.82%	0.8625	0.2410
ABC	79.05%	83.12%	74.26%	0.8312	0.2573
SVM	98.90%	97.45%	90.20%	0.92897	0.2175

Table 5. Result of different classifier

Classifiers	Performance
Memory-Based Learner	90.74%
Bat	93.62%
ABC	98.089%
SVM	98.91%

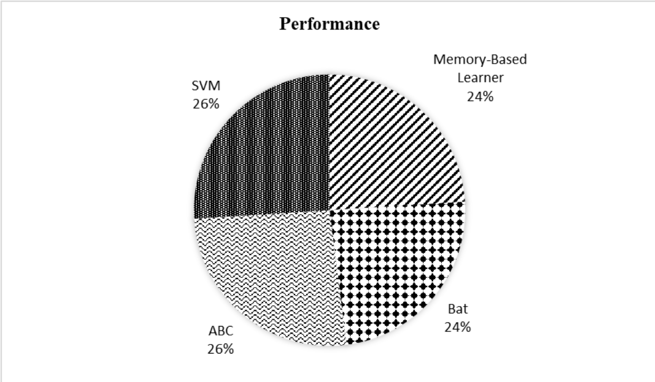

Figure 2. Rust of different classifier

Table 6. Proposed classifier rest

	TP Rate	FP Rate	Precision	Recall	F-Measure	ROC Area
Incorrectly Classified Instances	0.312	0.092	0.571	0.312	0.404	0.695
Correctly Classified Instances	0.908	0.688	0.571	0.908	0.834	0.695
Weighted Average	0.74	0.52	0.714	0.74	0.712	0.695

Table 6 shows the training section of proposed classifier approaches where different instances are checked based on missing or incorrect and correct forms. To measure these instances different element is used to check which are recalled, and the receiver operating characteristic (ROC) area-based on all parameter the value of the correctly classified instance is better and proved good result by the different classifier during the simulation process. Figure 3 present the result of all heuristic classifier that is used in the training and testing section of the study. Taking different elements three main sections of the dataset are checked which are correct instances and correct, average instance based on the result the different proposed approach provides the good result and most of the instance is correct. Table 7 show the result of the classifier in term of time. Table 7 present the one of most important parameters of classification which is time consumption based on the table SVM and radial basis function network is the best case in term of time and accuracy used.

Mean absolute error (MAE) section for time measurement in the processing system. This is primarily because it takes only a few milliseconds to calculate the accuracy purpose. Figure 4 present the time consumption of different machine learning classifier during the processing system and Table 8 present the overall time of all classifier taking different data range.

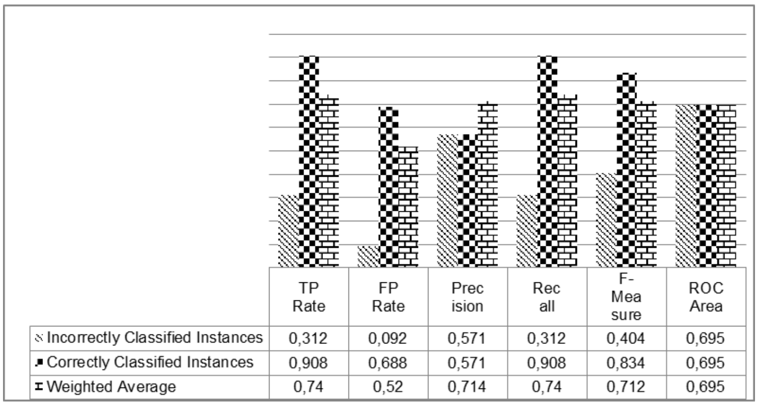

Figure 3. The result of the classifier

Table 7. Time comparison of classifier

Classifiers	Performance	Time of construction	MAE
Memory-Based Learner	90.5	0.02	0.044
Bat	91.2	0.08	0.00019
ABC	88.3	0.06	0.117
SVM	99.2	0.02	0.044

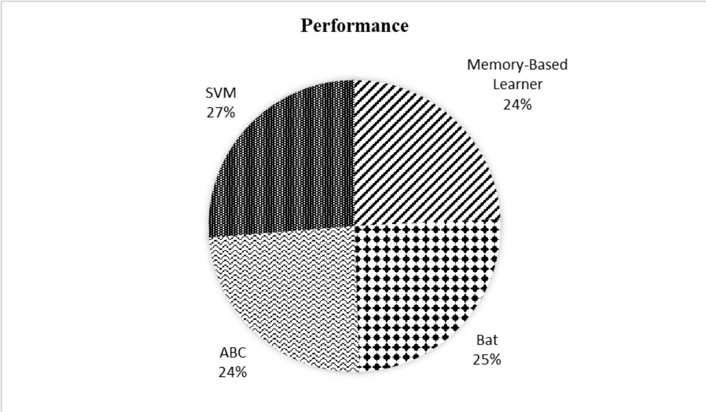

Figure 4. Time-based comparison of classifier

Figure 5 and Table 8 present the overall time consumption of the heuristic technique all the model is good and improve the performance of every base classifier by providing accurate predictions of heart diseases. The overall time is well based on the classifier result so are at the position we can say machine learning approaches are good for a medical dataset.

Table 8. Overall time consumption

Classifiers	Performance	Time for construction
Memory-Based Learner	52.33%	609 ms
Bat	52%	719 ms
ABC	45.67%	700 ms
SVM	97.67%	600 ms

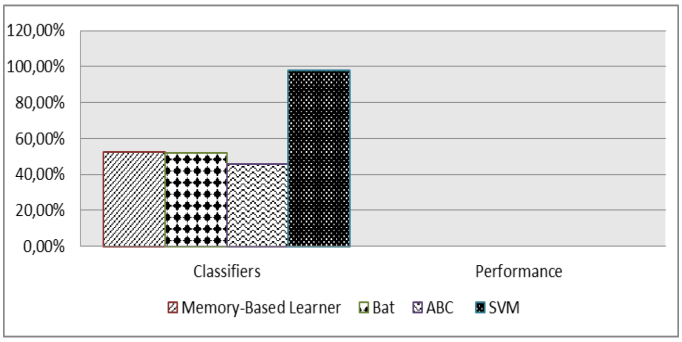

Figure 5. Overall time consumption of heuristic algorithms

9. CONCLUSION

In this paper, we analyze the accuracy of prediction of heart disease using machine learning algorithm classifiers taking a dataset from UCI. The different classifiers of machine learning algorithms are exploited for training and testing purposes. The main classifiers used are, support vector machine, bat, ABC, and memory-based learner based on these results has achieved an accuracy of SVM 97.90% with 90.96% sensitivity and 98.83% specificity the most accurate classifier among all of them. Future research directions include weighted voting-based classifier ensemble and application of the proposed algorithm on different diseases like diabetes and cancer for classification and prediction.

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