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Early Prediction of Cardiac Arrhythmia using Novel Bio-inspired Algorithms

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***Abstract*—** Cardiovascular disease is one of the world's most dangerous problems since it cannot be seen with the naked eye and strikes suddenly when its levels are reached. Cardiovascular disease (CVD) has reached the top of the list of non-infectious and non-transmissible disease deaths worldwide. Arrhythmias are a set of cardiovascular disorders described by irregular heartbeats that can be slow, rapid, or both. Cardiac arrhythmias are responsible for a large number of cardiac arrests and sudden deaths. They can happen on their own or in combination with other heart conditions. Some significant arrhythmias can happen out of nowhere, resulting in sudden death, stroke, heart failure, and coronary artery disease. Many of the medical procedures used to treat cardiac arrhythmias are traditional. Especially when contrasted to costly procedures that may be required if detection and therapy are delayed and the patient has advanced illness stages. To deliver an early, effective, prediction of CVDs, health systems need to be further strengthened. A computer-assisted automated prediction and classification of heart diseases using Bio-Inspired Optimization Algorithms is suggested in this research work. Extraction, classification, and diagnostic sections would be part of the proposed method. This work helps in diagnosis of cardiac arrhythmias. This study also helps effectively and accurately to diagnose the heart condition, which could help the doctor to treat and manage the disease effectively.

Keywords: *Heart Disease, Cardiovascular Diseases, Bio Inspired Algorithms, Arrhythmia.*

I. Introduction

Heart disease remains the leading cause of death in the United States, according to the Centers for Disease Control and Prevention (CDC). In the United States, heart disease kills about one in every four people, and it affects people of all ages, races, and ethnicities. According to the World Health Organization, heart disease kills 17.9 million people worldwide each year. CVDs, which stand for cardiovascular disease and blood vessel diseases, include coronary heart disease, cerebrovascular disease, rheumatic heart disease, and other illnesses. The normal heart and the congested heart are depicted in Figure 1.

Heart disease is one of the world's most serious problems, as it cannot be seen with the naked eye and attacks quickly when its limits are reached. Cardiovascular disease (CVD) has overtaken infectious and transmissible disease as the main cause of death worldwide. Arrhythmias are a significant group of cardiovascular illnesses that are defined by irregular, sluggish, or rapid heartbeats. Numerous cardiac arrhythmias are implicated for cardiac arrests and abrupt fatalities. They may manifest themselves independently or in conjunction with other cardiovascular illnesses. Certain severe arrhythmias may also occur abruptly, resulting in sudden death, stroke, heart failure, and coronary artery disease.

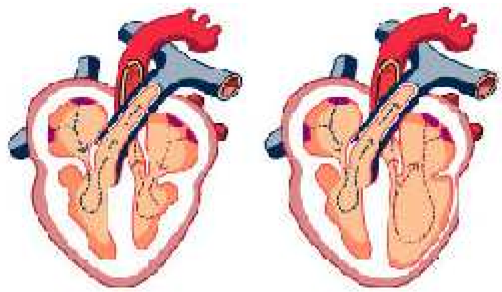

Fig 1. Normal Heart (Left) and Congested Heart (Right) [1]

II. Literature Review

A system for predicting cardiac disease based on data mining approaches was created by researchers S.R. Voleti and K.K. Reddi [2]. On the UCI data set, they compared the performance of SVM, NB, KNN, and Back Propagation classifiers to see which performed the best. The SVM classification algorithm outperformed all other classification algorithms in terms of accuracy, sensitivity, precision, low specificity, mean absolute error, and computation time across all feature combinations. The most significant disadvantage of this strategy is that the datasets utilized for algorithm training and testing were not sufficiently disclosed in the literature.

With the help of supervised machine learning algorithms, Anitha S[3] presented a way for predicting heart illness. The framework is made up of techniques such as the Support Vector Machine (SVM), the K-Nearest Neighbor (KNN), and the Naive Bayes (NB). Specifically, they made use of Cleveland datasets obtained from the machine learning collection at the University of California, Irvine (UCI). There were 303 cases and 76 features in each of these datasets. It was validated by the study's findings that the NB classifier outperformed the SVM and KNN in terms of accuracy in predicting heart disease, with an accuracy of 86.6 percent.

Dakun Lai [4] studied the possibility of early diagnosis of sudden cardiac death by applying a machine

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learning approach based on measurable arrhythmic risk factors in order to reduce the risk of mortality. The overall time necessary to develop machine learning models, as well as the final classification accuracy on the UCI test datasets, were all compared between Auto Machine Learning strategies, he found. In their research, five markers are used as inputs to KNN, SVM, DT, NB, and RS classifiers, as well as to other classifiers. It outperforms all other classifiers when compared to the RF classifier. The Auto-ML model is inefficient and slow, resulting in an increase in the amount of time required to build a classifier.

Saman Parvaneh et al.[5] proposed a method for detecting cardiac arrhythmias based on deep learning by extracting and classifying high-level features. Convolutional Neural Networks (CNNs) are used to solve complicated image processing tasks by performing feature extraction or selection and categorization within the deep network is accomplished automatically. Algorithms based on deep learning demonstrated exceptional performance on a variety of benchmark datasets. the major drawbacks are utilizing deep learning models, pre-processing and feature engineering efforts are reduced. Deep learning model interpretation is complex and requires vast datasets.

Zicong Li and Henggui Zhang [6] created a framework for Automatic Cardiac Arrhythmia Detection Using Frame Blocking Preprocessing and Residual Networks, which was published in IEEE Transactions on Pattern Recognition. They used the ResNet topology to generate a one-dimensional residual CNN with 13 layers, which was then trained. When adopted to solve the degradation issue associated with a deeper neural network, residual convolutional neural networks (CNNs) have exhibited greater performance in image classification. Because of the massive amount of annotated training data required in this scenario, the neural network method is heavily dependent on a significant amount of time and effort.

Ali Haider Khan and Muzammil Hussain [7] use a deep neural network to follow the mapping approaches for arrhythmia classification methodologies that they developed. Primary goal is to examine the evolution of arrhythmia classification algorithms over time, using a machine learning and deep learning strategy to accomplish this goal. Arrhythmia categorization procedures are thoroughly examined, and much work is expended in the development of an automated system that achieves high accuracy. The proposed system has the potential to serve as a clinical support system for healthcare practitioners, however it has a number of drawbacks.

The majority of the systems that were chosen are restricted to the following features. I The majority of ECG databases are not tailored to a specific clinical setting. It is not clear whether these ECGs were obtained from a specific patient population, as described in (ii). This is critical in understanding the technique and clinical utility in the setting of the study. (iii) the algorithms are trained on specific contexts, and general techniques are not taken into consideration.

III. Research Gap

Classical machine learning algorithms make use of feature extraction techniques that have been extensively designed by manually. For this to be done successfully, subject expertise as well as signal preprocessing skills are necessary to be applied. The most difficult challenge to overcome is one that involves accuracy. The use of imbalanced data for classification as the primary concern, and the use of imbalanced data for classification as the secondary concern, are all found to have a negative impact on arrhythmia detection systems, according to current research. The most significant negative impact is found to be caused by I manual feature selection, (ii) feature extraction techniques, and (iii) classification algorithms.

Because many different types of cardiac issues have morphological traits that are similar, auto-detection of multiple heart ailments using ECG is a difficult challenge to complete successfully. Another key hurdle in the field of early risk prediction is the amount of time it takes to create an effective classifier. As a result, it is still undergoing development. This opens the door to further research into improved categorization and prediction approaches, as well as higher accuracy. Fundamental to this investigation is the development of a viable technique for predicting Arrhythmia heart disease before it reveals itself in the patient. Incorporating past cardiac data sets may enable the system to detect and extract newly undiscovered knowledge related with cardiovascular disorders, which would otherwise be impossible. An important objective of this research is to develop a ground-breaking bio-inspired algorithm that will improve the categorization and prediction of cardiac arrhythmias, which is currently in its early stages. The Major parameters considered to predict the heart diseases are accuracy, recall, precision, F-measure, and Receiver Operating Characteristic curve (ROC).

Accuracy is a significant measure for classifier. Deter mine how many people are categorized correctly. Recall is the percentage of relevant instances that have been recovered from the total number of relevant occurrences. It is also known as the F1-score to assess the mean precision and recall in an experiment. The efficiency of a classification algorithm at all classification thresholds is shown graphically by the receiver operating characteristic curve (ROC).

V. Bio Inspired algorithms in Heart disease Prediction

Researchers are now employing machine learning and deep learning approaches to forecast the development of cardiovascular disease. Bio-inspired computing is a field of study which seeks to solve computer science problems using models of biology. When it comes to computer science, bio-inspired computing has a relationship with AI and machine learning. It is also considered a major subset of neural computation, according to some experts. Bio-inspired computing differs from typical artificial intelligence in that it takes a biologically inspired approach to computer learning. Bio-inspired computing uses an evolutionary approach while traditional AI uses a creationist approach. Different bio-inspired algorithms are depicted in Figure 2

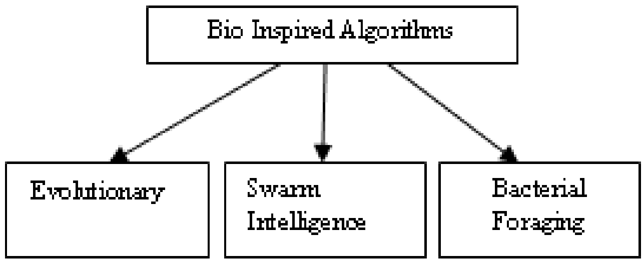

Fig 2. Classification of Bio Inspired Algorithms

P. Kora et al. [8] created two BAT algorithms to predict myocardial infarction (MI) using a Levenberg–Marquardt neural network to improve the accuracy of the prediction (LM NN). Using cuckoo search and the fuzzy logic system, R. Gadekallu [9] created a model with two strategies: feature reduction through cuckoo search and disease prediction using the fuzzy logic system. Curious birds, not only because of their beautiful songs but also because of their aggressive breeding methods, cuckoos are a fascinating species to study. The Cuckoo Search algorithm is an optimization technique that solves optimization problems by employing meta-heuristics. A.M. Usman and colleagues [10] investigated the use of filter-based feature selection approaches in the prediction of cardiac disease. They proposed two algorithms that were inspired by cuckoos. The Cuckoo Search Algorithm (CSA) surpassed the Cuckoo Optimization Algorithm (COA) in terms of performance (COA).

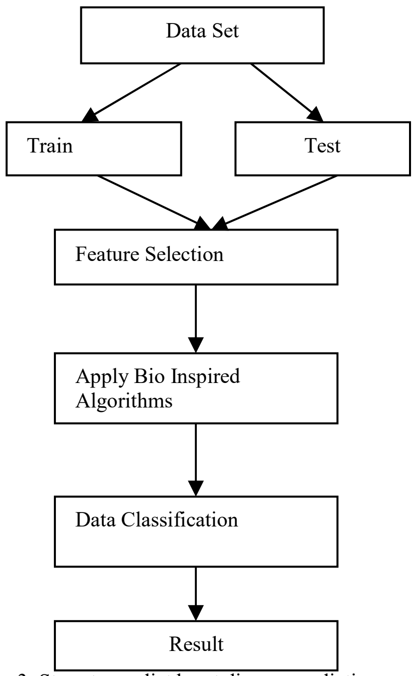

Fig 3. Steps to predict heart disease prediction

S. Narayan and colleagues [11] created a hybrid classifier that combines the cuckoo search technique with both fuzzy and decision tree classifiers to improve classification accuracy. G. Manjula et al [12] proposed the Firefly—Binary Cuckoo Search bacterial foraging optimization (BFO) function, which was utilized in conjunction with the bacterial foraging optimization (BFO). Khan and colleagues [13] created an IoMT framework that incorporates Modified Salp Swarm Optimization (MSSO) and an Adaptive Neuro-fuzzy Inference System (ANIS) (ANFIS). The authors [14] suggested a particle swarm optimization (PSO)-a based technique using an upgraded stacked sparse auto encoder network (SSAE) to predict cardiac disease using a particle swarm optimization (PSO)-based technique. Figure 3 illustrates the measures to be taken to forecast heart disease.

V. Comparisons of Bio inspired algorithms

Table 1. Shows comparisons of different bio inspired algorithms used in heart disease predictions.

Table 1. Comparisons

References	Algorithm	Accuracy
P. Kora et al	IBA+LM NN	98.9%
P. Kora et al	BA+LM NN	58.7%
A.M Usman et al	Cuckoo Search Algorithm (CSA) - Filter based	91.50%
A.M Usman et al	Cuckoo Optimization Algorithm (COA) - Filter based.	94.22%
T. R. Gadekallu et al	Cuckoo Search algorithm + fuzzy logic system	87.5
M. A. Khan et al	MSSO-ANFIS	99.45%
I. D. Mienye et al	PSO+SSAE	97.3

VI. Conclusion

Due to hypertension and nutrition, heart disease is the most deadly disease on the biosphere. Many lives are lost as a result of this. To accurately predict the disease, a better predictive method is required. Many recent studies have shown that using the Bio Inspired algorithm improves prediction and classification performances. When compared to other algorithms, the MSSO - ANFIS mechanism delivered 99.45% of the outcomes. The most difficult aspect of prediction is applying algorithms to a variety of data sets and creating a unique framework to automate the process. The second task is to use filters or fuzzy logic to improve the performance of existing algorithms**.**

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