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Original Article

Design and Development of Optimized Cardiovascular Disease Prediction Model using Artificial Intelligence

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Abstract: *The medical industry is expanding quickly as new ailments are discovered daily, necessitating the development of effective treatment options. The muscular heart, which is about the size of a clenched human fist, is in charge of blood circulation. Although heart/cardiac disease is the term used to describe conditions that generally affect the heart, there are numerous conditions that fall under this umbrella term, including coronary artery disease (CAD), cardiomyopathy, cardiovascular disease (CVD), and others that depend on blood flow throughout the body. The heart disease data prediction has been made to analyse medical data with clinical expertise in order to assist clinicians in the diagnosis of heart disease. The accuracy of heart disease diagnostic decisions can be improved by the development of these predictive algorithms. The prognosis of heart illness depends heavily on data mining. The Naive Bayes (NB), C4.5, and Artificial Neural Network (ANN)-Back Propagation (BP) methods are employed in this work. These age-old techniques are used to forecast cardiac disease. The NB classifier approach, which is based on the Bayesian theorem, is employed when the input's dimensionality is extremely high. It performs better than other protocols despite being straightforward. The C4.5 protocol use data entropy perception to create decision trees from a training data set. It is a widely used procedure also referred to as the statistical classifier. ANN has been used as a method for resolving a variety of decision modelling issues in common situations. Modelling, pattern recognition, data processing, and sequence recognition systems are examples of applications where ANNs are used.*

Keywords: *Classifier, Swarm Optimization, AI, Cardiovascular Disease, ANN*

I. INTRODUCTION

Health is everyone's most fundamental requirement. According to figures from the World Health Organisation, heart disorders account for one-third of all fatalities worldwide and 24% of deaths in India. Of the approximately 17 million fatalities from cardiovascular illness that occurred in 2016, 31% were fatal heart attacks and strokes. The biggest cause of death worldwide is heart disease, which ranks first on the list of the main factors. According to World Health Organisation (WHO) studies, cardiovascular diseases are to account for 16.9 million annual fatalities. According to this figure, 21% of all deaths worldwide. India has become the front-runner in this regard as a direct outcome of the survey's findings. With 1.6 million fatalities in 2016, cardiovascular disease was the main cause of death in India. Ailment is a condition that robs a person of both their identity and their ability to preserve their financial stability, according to the conclusions of study on the global burden of disease that was finished in 2016 and published that same year. It would ultimately have a much greater influence than the others. According to projections made by the World Health Organisation (WHO), between the years 2005 and 2016, heart-related ailments are expected to have directly caused economic losses for India that may have reached as high as $230 billion. Therefore, strategies for predicting heart-related disorders must be developed. The most crucial component of any live organ is the human heart. Heart failure might result in risky circumstances. It is challenging for heart experts to accurately anticipate heart disease at the correct time. Many people do not believe that the conventional medical history is a trustworthy way to diagnose heart disease in particular. Non-invasive procedures based on IoT are effective and trustworthy for classifying healthy persons who have heart disease. The realm of medicine can benefit from these prediction approaches. Along with maintaining a healthy diet and lifestyle, early diagnosis is crucial. Risk factors for heart disease include age, high cholesterol, sex, high blood pressure, smoking, obesity, family history, physical inactivity, poor diet, diabetes, alcohol consumption, and hereditary factors [2]. [5]. Angina pectoris, congestive heart failure, cardio-myopathy, congenital heart disease, arrhythmias, and myocarditis are additional types of heart disorders in addition to coronary heart disease. Pain in the arms and chest is one of the most typical signs of heart disease. Numerous things, such as an improper diet, smoking, overindulging in sweets, being overweight, or having extra body fat, might contribute to this discomfort. [3].

Table 1: Heart Dieses Type [4]

Cardiac Disease	Analysis
Arrhythmia	There is something wrong with the rhythm of the heart, which might be that it is irregular, too slow, or too rapid.
Cardiac arrest	Suddenly, the individual loses awareness as well as the ability to breathe and heart function.
Congestive heart failure	It is a disorder known as chronic that causes the heart to pump blood less effectively than it should.
Congenital heart disease	The malformation of the heart that is present from birth forward
Coronary artery disease	Damage to the heart's main blood vessels or illness that affects the blood vessels may occur at any time.
High Blood Pressure	It is a condition in which the force of the blood on the walls of the arteries is very high.
Peripheral artery disease	This cardiovascular disorder is characterized by constricted blood vessels that lead to decreased blood flow in the limbs.
Stroke	The brain suffers harm whenever there is a disruption in blood flow.

II. LITERATURE REVIEW

Accuracy measures analysis done on synthetic dataset using various ML, DL classifiers, and IOT environment.

Table 2: Comparative Analysis of Machine Learning and Deep Learning Classifiers

Sr no.	Author	Year	Dataset Used with Sensors	Algorithm used	Accuracy
1	Amin UlHaq et. al.[9]	2018	UCI Cleveland heart disease	Logistic regression with 10-fold cross-validation selected by Feature Selection algorithm Relief	89 %
2	Kathleen H. et. al.[15]	2018	UCI Cleveland heart disease	Enhanced DNN	83.67 %
3	Senthilkumar Mohan et. al. [8]	2019	UCI Cleveland heart disease	HRFLM (Hybrid random forest linear model)	88.67%
4	Mohd Ashraf et. al. [14]	2019	UCI Cleveland heart disease	Deep neural network	87.64
5	N. Sowri Raja Pillai et. al.[21]	2019	Dataset from patients	RNN with Genetic algorithm	92%
6	Li Yang et. al.[10][3]	2020	29930 patients with high-risk of CVD were selected from 101056 total people in 2014, a regular follow-up was conducted using ECH (Electronic Health Record System)	Random Forest	78.7%
7	Sumit Sharma, Mahesh Parmar[16]	2020	Heart disease dataset from kaggle	Taloshy per-parameter optimization algorithm (hybrid)	90.78%
8	AsmaBaccouche et. al. [17]	2020	Dataset from Medica Norte Hospital in Mexico includes 800 records and 141 indicators such as age, weight, glucose,	Ensemble-learning classifier combining BiLSTM or	91%

			blood pressure rate, and clinical symptoms.	BiGRU and CNN	
IOT AND ML BASED SYSTEMS					
9	ShadmanNashif et. al. [2]	2018	1. Cleveland Heart Disease dataset[19] consists of 303 records and 2. Statlog Heart Disease dataset consists of 270 records. Body temperature sensor, heartbeat, humidity, blood, Pressure.	Support Vector Machine	97.5
10	M.Ganesan and Dr. N. Sivakumar[22]	2019	for heart disease is created utilizing the UCI Repository dataset.ECG sensor, pulse sensor, temperature sensor.	J48 classifier	91.48
11	AKM Jahangir and AlamMajumder et. al. [23]	2019	Heart disease dataset from the UCI Repository. a pulse sensor, and a temperature sensor.	Noise removal of ECG signal with decision tree	83.3%
12	Dr.Yogesh Kumar et al.[42]	2019	Real-time monitoring patient dataset. Temperature sensor (LM35), ECG sensor, Heart Rate sensor, Raspberry Pi, GS module.	Naïve Bayes and Q-learning(Hybrid) classifier	98.3%
13	Sunil S.Khatal et al. [42]	2020	1. Heart disease dataset from the UCI Repository. 2. Real-time dataset from IOT device. Temperature sensor (LM35), ECG sensor, Heart Rate sensor.	RNN	Better than others shown graphically.
14	MohmAyoub Khan et. al.[24] [20]	2020	3 datasets were used: 1. Heart disease dataset from UCI repository, 2. Framingham dataset from kaggle and 3. Public health and sensor data. Heart monitoring device and smartwatch are attached to the patient which monitors the ECG and blood pressure.	Modified Deep Convolutional Neural Network	98.2 %

III. FRAMEWORK

Data, information, and knowledge are the three technical terminologies used in data mining. Facts, numbers, or phrases that can be processed by a computer are all considered to be data. Many organisations amass a vast amount of data in numerous databases and forms. Then, patterns, associations, or relations are used to present this information. The information gathered in this way is transformed into pattern knowledge. The ability of data mining tools to anticipate outcomes can be used in the medical profession to provide services at a set price. Giving patients the right diagnosis and treatment is the only thing that constitutes quality care. The healthcare systems produce a lot of data, which might take the form of text, figures, charts, and images [35]. The creation of data mining apps can aid in calculating the effectiveness of medical care. By comparing causes, symptoms, and treatment options, data mining has the ability to identify actionable courses of action that will prove successful. The data mining applications employed in real-world situations are noteworthy because they bring a unique set of challenges to data-miners. Dealing with databases pertaining to cardiac patients is one of these practical problems. A complex problem, using different characteristics or signs to diagnose an illness might lead to erroneous conclusions with unpredictable outcomes. Therefore, it is preferable to leverage the expertise and experience of many specialists to gather databases to aid in the diagnosis process, and the same is advised [36].

A. K-Nearest Neighbor Algorithm (KNN):

Using the categorization of instances that are closest to an unknown instance, the K-nearest neighbour classification process is a common technique. By using distance metrics like Euclidean, Manhattan, maximum dimension distance, and others, the basic KNN classification method finds K training instances that are close to the unknown instance. The algorithm then determines the class for the unknown case by selecting the class that occurs the most frequently among the nearby K instances. [39].

B. Neural Networks:

Cells in neural networks that are highly coupled to one another excite the human brain. A perceptron with one neuron and a learning strategy has the simplest architecture. With one or more neurons connected at different layers, multi-layered neural networks have more complex architecture. Neural networks can be used to learn a categorization task and forecast diseases.

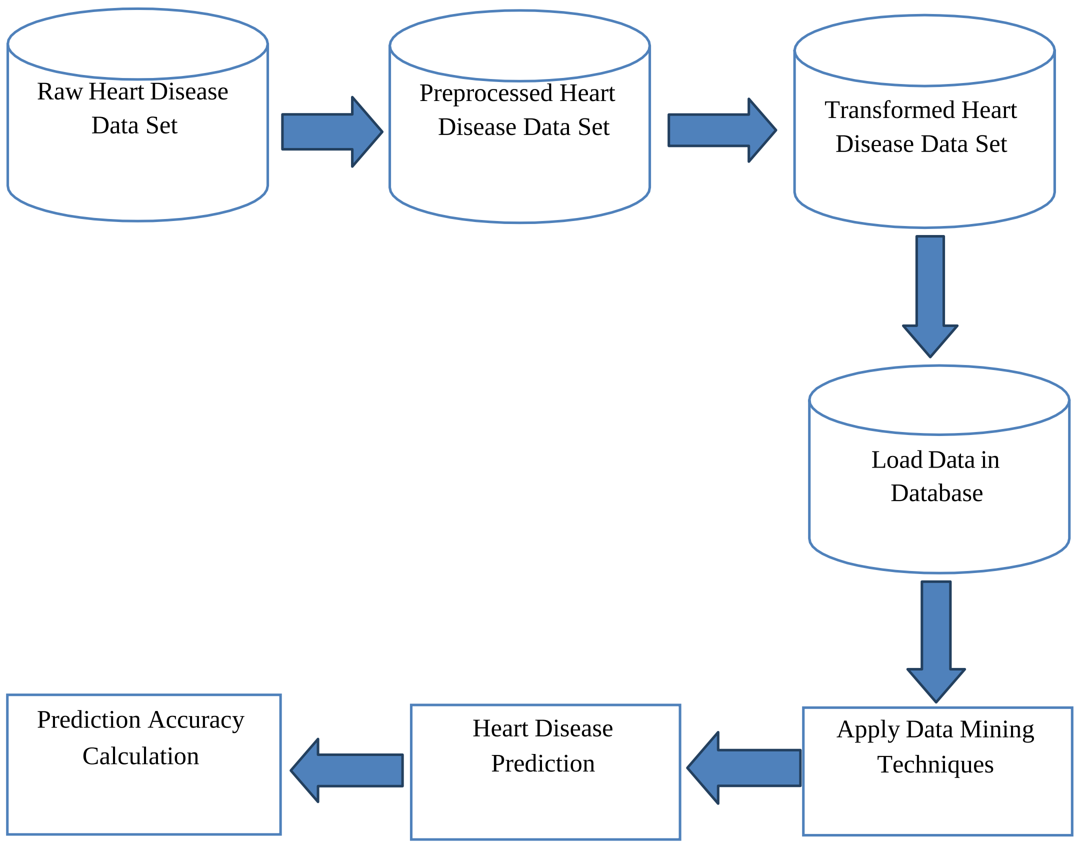

Figure 1: Prediction System [38]

C. Decision Trees:

Finding a better answer for classification problems can be aided by using the decision tree approach. These methods consist of two steps: creating a tree and applying it to the dataset. The CART, ID3, C4.5, CHAID, and J48 decision tree algorithms are the most widely used ones. This system uses the J48 method, which employs a pruning technique to lower the size of the tree by removing overfitting data that results in subpar prediction accuracy. The J48 algorithm is used to classify data recursively until the proper classification is achieved. By using training data, this strategy maximises accuracy. This is based on the general idea of forming a tree, which offers a balance of accuracy and flexibility [40].

D. K-Mean Clustering:

The k-means algorithm got its name from the way it worked. This algorithm divides the data into k groups, where k is the input parameter. The information is then grouped based on how close an observation is to the cluster's mean. The cluster's mean is computed, and the procedure continues. In the field of medical imaging and other fields that are related, this is one of the simplest clustering approaches that is frequently employed. [41].

E. Particle Swarm Optimization:

In most cases, the particle swarm optimisation (PSO) algorithm seeks to find x* such that f (x*) = f (x) for all n-dimensional real vectors x in order to solve an unconstrained continuous minimization problem. The fitness function is the objective function f: Rn -> R. PSO is a swarm intelligence meta-heuristic that draws inspiration from animal social behaviour, such as fish schools and bird flocks. It is a population-based approach, much like genetic algorithms (GAs), in which the algorithm's state is represented by a population that is iteratively changed until a termination requirement is reached. The population P = p1,..., pn of the possible solutions is frequently referred to as a swarm in PSO algorithms. Particles are any viable solutions p1,..., pn. In order to solve real-world problems, the PSO approach perceives the set Rd of potential solutions as a "space [1] where the particles move." The number of particles is often set between 10 and 50.

F. Optimization Methods in Heart Disease:

The term "PSO" refers to a new family of EAs that is employed to find the best answers to numbering issues involving a particle population. Eberhart and Kennedy (1995) created the PSO method, which is a population study based on the stochastic optimisation approach. This was inspired by the social interactions of bee hives, fish schools, and flocks of birds. Muthukaruppan & Er (2012) proposed using the fitness value as a performance evaluation measure to direct the particle search process.

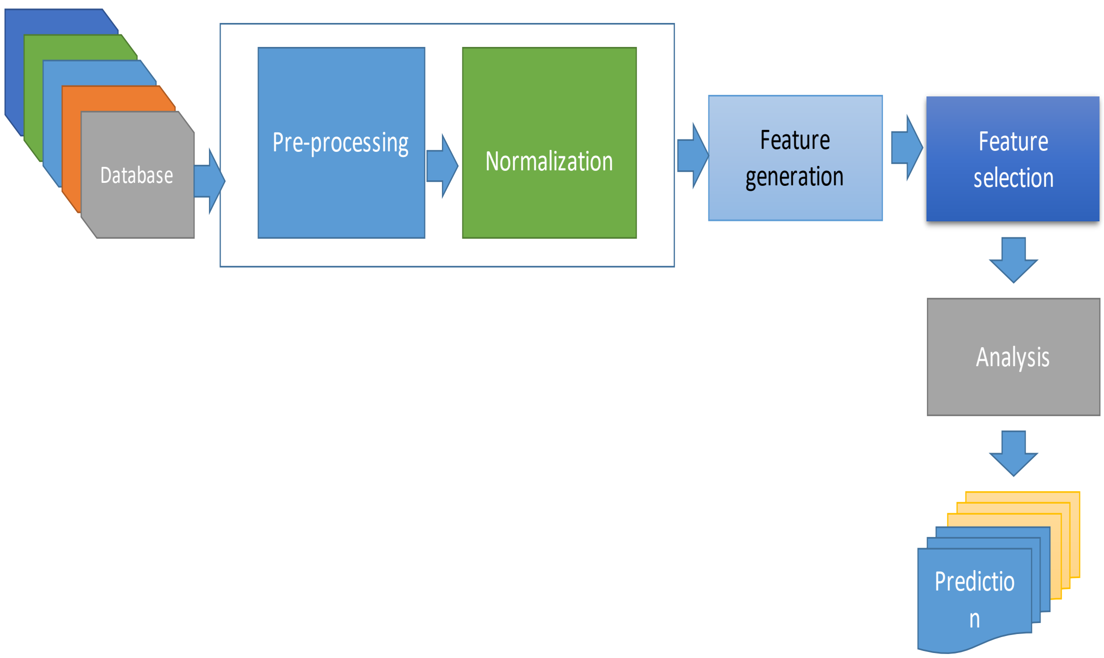

Figure 2: Proposed methodology

IV. METHODOLOGY

When products are arranged in a shelf arbitrarily, like in a supermarket, it can be difficult to shop because classifications generally make life easier. Data mining uses a variety of categorization approaches, and ANN is one of them. The ANN architecture, the precise number of codes to be selected, and how the weights between the nodes must be set during training and result evaluation are all fully discussed. Along with learning rate, momentum, and pruning, the role of activation is also discussed. A well-known ANN algorithm that was demonstrated by Cilimkovic (2015) is the BP algorithm. The ANN can handle errors better than traditional computer programmes (for example, in the case of a programme error that may stop everything when the ANN can handle faults better). The GSO and PSO are also suggested in this paper along with the optimised ANN-BP.

A. Particle Swarm Optimization (PSO) Algorithm

The PSO is a common technique for optimisation issues that is semi-robotic and based on the flocking social behaviour of birds. PSO will be inspired by how the creatures and their behavioural patterns coexist in sizable groups. The PSO can be set up more easily this way. Each PSO particle adjusts to the velocity of its companions inside the search space as well as their flight memory. The particle swarm in a simple PSO consists of "n" particles, each of which represents a potential solution in the D-dimensional space. Both the individuals and the potential solutions move through the hyperdimensional search space. With particle swarm, this learned information or experience with the varied influences of neighbours will tend to alter. Three additional steps are included in the PSO and are repeated up until the halting condition is satisfied. They are:

- Evaluation of fitness of each of the particles.
- Updating of the individual as well as the global best functions.
- Updating of the velocity and the position of each specificparticle.

In this procedure of the PSO, a pseudo code is as per Figure 3 designed by Anbarasi & Saleem Durai (2016),

The PSO approach, which is suitable for managing nonlinear and non-convex design spaces and dis-continuities and is resilient and converges quickly, is used to solve global optimisation problems. The proposed approach will make use of PSO trained ANN (PSO-ANN), which can deal with the prediction issue in the context of cardiac disorders. The method will combine the global opposition-based PSO scheme with a standard momentum-based BP protocol's local search capability. The protocol has two different kinds of elements: opposition-based and arbitrary perturbation approaches. This protocol's ability to conduct a search will be improved by the addition of a time-variant social and cognitive aspect. Another variable that ensures convergence and overfitting, the issue, acquires additional specifications during training is the constraint factor.

```
For each particle
Initialize particle
End
Do
For each particle
Calculate fitness value
If the fitness value is better than the best fitness value (pBest) in history
set current value as the new pBest
End
Choose the particle with the best fitness value of all the particles as the gBest
For each particle
Estimate particle velocity
Update particle position
End
While when maximum number of iterations reached
or lowest error conditions y is not achieved
```

Figure 3: The PSO algorithm

V. RESULTS AND DISCUSSION

In this section, the ANN-BP, PSO-ANN-BP and GSO-ANN-BP methods are used. The classification accuracy, specificity, sensitivity and f measure as shown in Table 4.1 and Figure 4.6 to 4.9.

Table 3: Summary of Results

S. No.	Particulars	PSO
1	Classification Accuracy	0.8778
2	Specificity	0.8779
3	Sensitivity	0.8742
4	F measure	0.8757

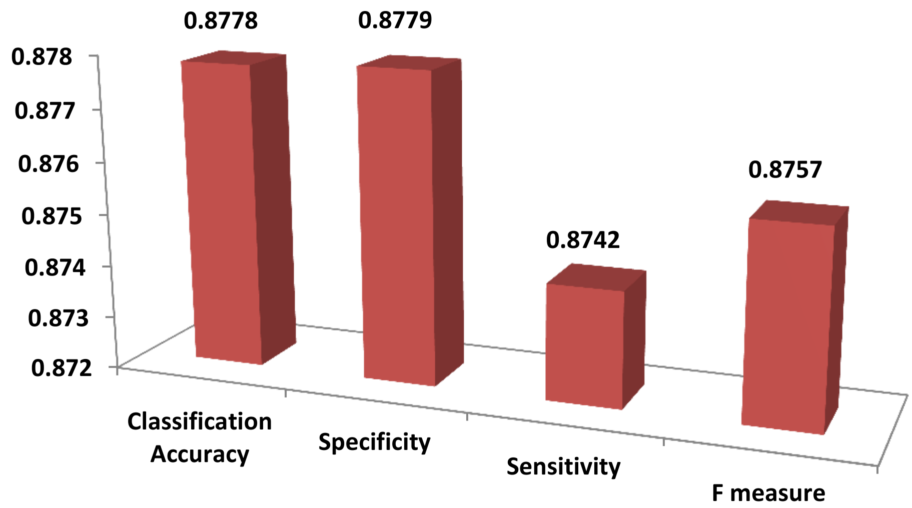

Figure 4: Different Properties of PSO

A. Findings

Figure 4 shows that the classification accuracy for PSO is approximately 87.78%. Additionally, it is noted that F is estimated to be around 87.57%, Specificity is about 87.79%, and Sensitivity is about 87.42%.

VI. CONCLUSION

Heart disease prognosis is meant to aid cardiologists in making a diagnosis. This approach is suggested for categorising the information on heart conditions. The medical histories of the patients and their symptoms as determined by data mining will be a key factor in choosing the technique for dataset reduction. If redundant and unrelated structures are eliminated from the data, the choice of the structure will aid in improving how the learning models are presented when the less amount of data is used for categorization. The PSO approach is employed for this task. A robust and active PSO that is based on swarm movement will be a population-based stochastic optimisation system. The PSO will be used to facilitate the training in order to provide practical results that meet real-world criteria. The tool aids in addressing challenges with continuous augmentation. Results indicate that the classification is accurate.

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