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RECENT TRENDS IN DISEASE DIAGNOSIS USING SOFT COMPUTING TECHNIQUES: A REVIEW

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ABSTRACT

Disease Diagnosis is one of the most complicated processes and requires sophisticated techniques to overcome complexities. Soft computing techniques came into existence to deal effectively with the emerging problems related to medical diagnosis. As medical diagnosis which is totally based on human abilities, uncertain factors, ambiguous symptoms, high accuracy and bulk of medical records, soft computing techniques prove to be a more effective solution. This paper aims to present a brief outline on the disease diagnosis system of various diseases in related areas and the use of soft computing and artificial intelligence networks to overcome the errors in diagnosis and attain a high performance.

Keywords: Artificial Neural Network, Disease Diagnosis, Fuzzy Expert System, Genetic Algorithm, Particle Swarm Optimization, Soft Computing

I. INTRODUCTION

Today life is being continuously threatened by various harmful diseases, some of which are even incurable. Recently the rate of diseases is increasing rapidly with the increase in the change of symptoms of each disease. Proper diagnosing and identifying a disease from those specific symptoms has become too complex. As traditional or orthodox approach use of medical diagnosis consisted of non-specific presentation of the disease, improper management system as well as unavailability of trained and skilled medical experts, it has gone obsolete as it resulted in considerable errors affecting the patients and often wrong diagnosis leaded to unnatural death. Improper disease diagnosis also possesses a continuous threat to human life due to inaccurate and untimely diagnosis procedures employed by the medical system.

In recent years, the ratio of the patients to the doctor number is increasing day to day, so manual diagnosis can no longer be efficient. This is where technology comes into play. Diagnosis through computer aided design can serve large number of patients in less time and being affordable. Due to inadequate healthcare facilities and scarcity of medical experts, the use of Soft Computing and Artificial Intelligence has become popular in disease diagnosis techniques.

The term" Soft Computing" was introduced by Lofti A. Zadeh, Professor of the University of California, Berkely, U.S.A. According to Zadeh, Soft Computing deals with imprecision, uncertainty and partial truth [1].Soft Computing plays a vital role in medical field also. In disease diagnosis where the entire diagnosis is basically based on the human abilities involving a number of uncertain and ambiguous factors, soft computing mechanisms are very useful and effective. The vague and imprecision features make the overall situation too complex and critical in disease diagnosis which is now efficiently dealt with soft computing and intelligent

techniques. Especially, with the increase in the general array of diseases complexities and threats being imposed on human beings are rising exponentially. Due to this medical field today is experiencing the impertinent sighting of new disease patterns that are changing almost every day and making the prognosis of these diseases even much more complex for the medical practitioners. Compared to the traditional medical systems recently doctors are using more advanced information system to control the disease diagnosis patterns so that there is limited scope of error and abnormality in predictions. This will generally result as a cost advantage for the patients as the ease of technology will increase the accuracy of identification of the disease they are daring, increase in the performance and subsequent reduction in the time per patient index. So the medical technology is integrated with Soft Computing techniques and expert systems to assist the doctors in every possible ways. Modern intelligent systems and techniques give access to vast sources of knowledge base as well as virtual database most of which are self-updating.

The objective of this paper is to introduce briefly the various Soft computing techniques and to present various applications by analysing and reviewing last five years reports based on disease diagnosis. Though there are various Soft Computing techniques which have been proposed but this paper eventually presents Artificial Neural Network (ANN), Fuzzy Expert System (FES), Particle Swarm Optimisation (PSO) techniques to have an idea about the recent trends in disease diagnosis. ANN was used because it has the ability to solve complex and non-linearity problems related to diagnosis. Fuzzy Expert System is used to tackle imprecision and uncertainty. GA is used to optimise the extracted features and PSO is eventually used for decision making system to recognise the diseases from the selected features.

Rest of the paper is organised as Section 1 presents a detail review of ANN in disease diagnosis, Section 2 describes about the Fuzzy Expert System in disease diagnosis. Genetic Algorithm in disease diagnosis is illustrated in Section 3 and Section 4 illustrates the use of Particle Swarm Optimisation (PSO) in the field of disease diagnosis. Finally Section 6 gives the conclusion.

II. ARTIFICIAL NEURAL NETWORK IN DISEASE DIAGNOSIS

Artificial Intelligence (AI) is concerned with the design of intelligent computer system and now it is not new in research field-Artificial Neural Network is one of the effective computational modelling tool in AI techniques. In modern era ANN concentrated upon many complex problems like pattern recognition, forecasting, control system which have been a serious concern in many industrial applications. During the last two decades ANN is considered as one of the major technology in soft-computing and significantly been used in medical applications and research in disease diagnosis system.

It is well known that ANN have been motivated from biological nervous system and brain structure, has the capability to learn and acquire knowledge to solve the complex problem. The first mathematical model of biological neuron was proposed by McCulloch and Pitts in 1943. Neural Networks (NN) consist of highly interconnected neural computing elements that possess the capability to generalise, can predict new outcomes and process the information just like a human brain performs[2].Neural Networks basically consists of three layers in its architecture: First layer is known as the input layer which receives the input signals from external world: Second layer also known as intermediary layer or hidden layer performs computations according to the function provided: and the last layer known as the output layer, generates the output after receiving the output

signal[5]. Through these layers data or knowledge is propagated and are stored as the synaptic weights between the neurons. There are different types of Neural networks available but Multilayer Neural Network or Multilayer Perceptron(MLP) using Back propagation algorithm[4] are the most popular in today's world as it consist of multiple hidden layers which helps in solving complex problems and has a good application potential. In this regard, because of some useful characteristics of Neural Network like fault tolerance, generalisation and the capability to learn from the environment Artificial Neural Network has been successfully implemented in various disciplines and also became a popular tool for disease diagnosis system.

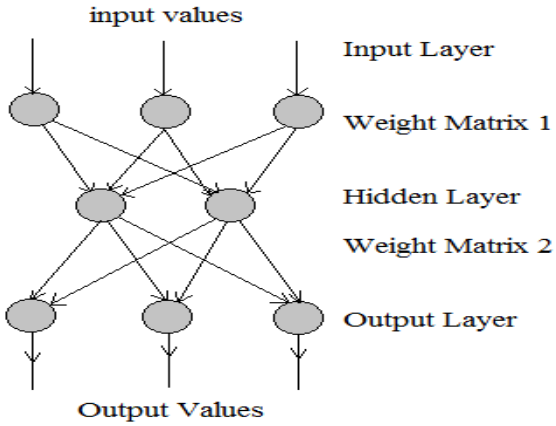

Fig.1 A Typical Neural Network

In this respect, by reviewing various articles we have seen innumerable ways by which ANN is impairing the diagnosis of different diseases. ANN has recently been implemented in diagnosing Alzheimer's disease. Alzheimer's disease is one of the neuro-degenerative disorder in which the death of the brain cells causes memory loss and cognitive declines. The people aged above 65 mainly suffer from this disease. Shih-Tnig Tang et al. [2010] presented a computer aided diagnosis to analyse and identify the volumetric and shape features of hippocampus related to Alzheimer's disease. Principle Component Analysis (PCA) and Back propagation Artificial Neural Network algorithm was utilised in this work for the feature classification. The segmentation and identification involved complicated data and thus time consuming but ANN proved itself a challenging tool for the diagnosis of this disease [9] and achieved an accuracy of 92.17%. In reference to [10] the authors presented a comparative study of the chest disease using MLP, Learning vector optimisation and generalised regression. S.Karthik et al.[2011] proposed a method in diagnosing the liver diseases like hepatitis, cirrhosis, liver cancer by using ANN and Multilayer Perceptron(MLP)algorithm[6]. Y.Unal et al. in 2011 made a research on [7] wavelet based ANN to diagnose intervertebral degenerative disc disease. In case of this disease the fluid which acts as a shock absorber gets reduced. Diagnosis of this disease becomes more complex and time consuming if done by conventional methods and also chances of inexperience and wrong diagnosis can be possible. So to prevent these disadvantages feature vectors were passed as an input to the MLP and MRI (Magnetic Resonance Imaging) is used to identify the degenerative images of the intervertebral disc. The authors concluded that the proposed diagnosis system acts as the supporting tool for the radiologists and can be improved further.

Huang Zhao Ming et al. [8] in 2013, presented a new method of clinical diagnosis for cardiovascular disease. Back propagation Neural network (BPNN) is used and resulted a feasible solution for clinical application.

Karthik Kalyan et al. in 2014[3] also illustrated that ANN with MLP and Neural network classifier is a best soft computing techniques which provides a framework to increase the accuracy of liver disease diagnosis. The features where selected from liver ultrasound images and employed in MLP to study the presence of the diseased condition of the liver at early stage.The authors in ref.[12] presented a hybrid intelligent system i.e. ANN coupled with ANFIS(Adaptive Neuro–Fuzzy Inference System).They investigated that the hybrid intelligent system performed better and enhanced the diagnosis of the heart disease than other diagnosis methods. Their results depicted that by using this system accuracy obtained was 97.5% compared to case-based methods achieving 60% accuracy. ANN was also used in medical diagnosis disease like acute nephritis and heart disease. Irfan Y Khan et al. proposed this paper and studied two diseases: acute nephritis and heart disease [4]. Maryam Molany et al. in 2013 used ANN for the diagnosis of Thyroid disease [13]. Mr.Deepak Dhanwani and Prof. Avinash Wadha presented a paper on hybrid Genetic Algorithm using ANN for the diagnosis of the stroke disease. To diagnose the disease at early stage, the model used in this paper was neural network along with the genetic algorithm to work with data mining extracting knowledge from a large data source [14]. The Table 1 below presents a brief study of the review papers in which ANN performs better in disease diagnosis ordered based on the publication year (ascending).

Table: 1

Authors[Year]	Domain	Methods used	Result
Shih-Tnig et al. [2010]	Alzheimer's disease diagnosis	PCA AND BPNN	ANN performs better with an accuracy of 92.17%.
O.Er,N.Yumsusak et al.[2010]	Chest disease diagnosis	MLP(Multilayer Perceptron),LVO(Vector Optimization)	ANN performs better
S.Karthik et al.[2011]	Liver disease diagnosis	ANN based on MLP	ANN performs better with an accuracy of 76.5%.
Y.Unal et al. [2011]	Intervertebral degenerative disc disease diagnosis	MLP and MRI(Magnetic Resonanse Imaging)	Training performance was 99.79% and classification rate was 100%
Huang Zhao Ming [2013]	Cardiovascular disease diagnosis	BPNN	ANN performs better
MaryanMolany et al. [2013]	Thyroid disease diagnosis	MLP using Back propagation learning algorithm	ANN resulted a best solution with an accuracy of 98.6%
KarthikKalyan et al. [2014]	Liver disease diagnosis	MLP	Training dataset yielded 90% and Testing dataset yielded 95%

Mohammad A.M.Abushariah et al.[2014]	Heart disease diagnosis	ANN and ANFIS	ANN yields 90.74% and ANFIS yields 100% accuracy
IrfanY Khan et al. [2015]	Acute nephritis and heart disease diagnosis	Feed-Forward Back Propagation Neural Network	ANN performs better

III. FUZZY EXPERT SYSTEM IN DISEASE DIAGNOSIS

Among all soft computing techniques Fuzzy Logic (FL) also resembles human decision making and has the capability to handle uncertainty, imprecision and incomplete information. In real world, fuzzy logic helps in solving some kind of problem by analysing the past and predicting the future [11] which can be implemented in both hardware and software. Professor Lofti A.Zadeh proposed the concept of Fuzzy logic in 1965 Fuzzy logic involves 'linguistic variables' based on membership function which takes the truth values that ranges between 0&1. The use of fuzzy logic problem solving methodology has been illustrated and elaborated by the experts so that the classical approaches of problem solving due to lack of information can be settled [15].

One of the main applications of the fuzzy logic is Fuzzy Expert System (FES) which comprises of fuzzy logic to accept the imprecise data and provides an exact output. It has the ability to work from approximate reasoning and can provide ultimately a precise solution to the given problem. The distinctive features that differentiates Fuzzy expert system from other mathematical models are:(a) it has the ability to co-operate with heuristic knowledge,(b) Initiates expert problem solving by accumulating or gathering experience and skills(c) ability to deal with uncertain, vague, ambiguous knowledge. In respect to these characteristics, FES has captured a vast area not only in industrial applications but also in medical diagnosis. In an attempt to overcome the limitations of the conventional computer aided diagnosis, for obtaining appropriate medical information needed for the medical practitioners FES has been chosen as a powerful tool for diagnosing different types of diseases. Mainly expert systems plays a crucial role in those areas where experienced and skilled experts are limited or not readily available[16].Almost every medical organisations is growing a special interest and looking forward to these expert systems for the excellence and effective disease diagnosis.

The process behind diagnosing the diseases using fuzzy logic involves certain stages:

(1) Fuzzification of the input variables like signs, symptoms, clinical data etc.
(2) Generating fuzzy rule base
(3) The fuzzy inference engine builds a decision making logic based on the fuzzy rules
(4) Defuzzification of the generated output to crisp values.

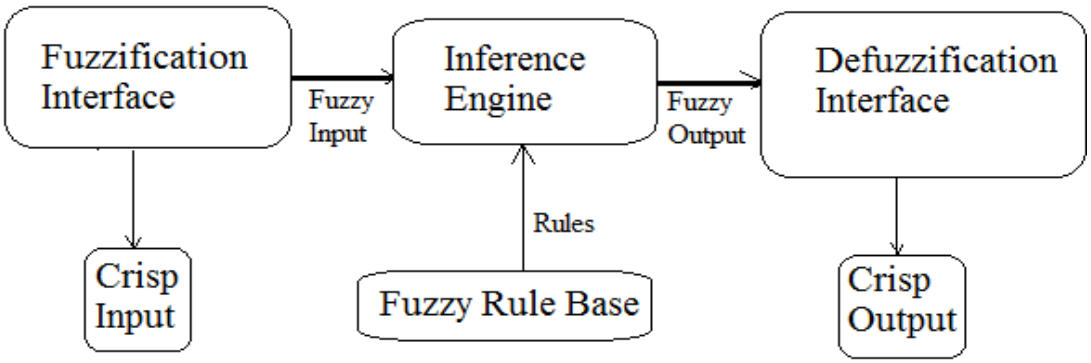

Fig.2Basic architecture of fuzzy expert system

In this paper the recent use of FES for the diagnosis of different types of diseases has been reviewed and studied and also conducted a review regarding the usage of different fuzzy tools and algorithms used. In [17], authors designed a fuzzy expert system for the diagnosis of the heart disease. In this design Mamdani Inference method was used. 13 attributes were taken as input variables and a single output variable was referred to the presence of the heart disease in the patient. The result obtained was correct to 94% when compared to Cleveland Foundation database.

In 2012, Nidhi Bhatla et al. [2012] performed heart disease diagnosis by reducing the number of attributes and the number of tests undertaken by the patients. Decision tree and Naive-Bayes using fuzzy logic was used [18]. E.P.Ephzibah et al. [2012] also framed Neuro-Fuzzy expert system for heart diagnosis with only 6 attributes. They analysed that using Neuro-Fuzzy classifier is much more efficient and effective in detecting cardiovascular disease than any other classifier used earlier [19]. In ref. [20] fuzzy expert system for the management of Malaria has been proposed. Malaria which has been identified as a predominant environmental health problem in several parts of the world, this system provided a suitable platform for the researchers to diagnose the disease accurately. Ref. [21] presented a decision support system for diagnosis of malaria and dengue in 2013.This system used fuzzy logic for the uncertainty and imprecision information involved in the symptoms of the diseases. Y Niranjana et al. [2014] presented an evolutionary Fuzzy expert system for the diagnosis and therapy of the Coronary Artery Disease (CAD).The proposed system used fuzzy rules constituting fuzzy rule base and to optimise the membership functions Genetic Algorithm was used [22]. Vishal Chandra et al. [2014] used methodology for the development of a web based fuzzy expert system for the management of the hypertension using fuzzy logic approach. Several attributes like systolic blood pressure, diastolic blood pressure, age, body mass are taken as inputs. The data was based on M.G.M Hospital, Jamshedpur [24]. In ref. [25] Arthritis disease was diagnosed using Fuzzy logic controller (FLC), a successful application of fuzzy set theory. As three-fourth of the patients recently suffering from Osteoarthritis and Rheumatoid arthritis so the main focus of this paper is to detect the symptoms of the arthritis at early stage without delay. AkinyokunO.C et al. [2015] proposed a fuzzy logic driven expert system for the diagnosis of heart failure disease [26]. Table 2 presents the brief study of the review papers where Fuzzy Expert System performed better in disease diagnosis system. A.V.Senthil Kumar et al.[2012] presented a powerful tool for the diagnosis of heart disease. ANFIS and Fuzzy Resolution Mechanism is used.

Table: 2

Authors[Year]	Domain	Methods used	Results
Ali Adeli et al. [2010]	Heart disease diagnosis	FES(Fuzzy Expert System) using Mamdani Inference method	Obtained 94% correct result when compared with the data in the Cleveland dataset
X.Y.Djam et al. [2011]	Malaria disease diagnosis	Root Sum Square method for Fuzzy Inference System	FES performs better
NidhiBhatla et al. [2012]	Heart disease diagnosis	Decision Tree and Naive-Bayes classifier using fuzzy logic	The proposed system resulted 100% with 4 attributes
E.P.Ephzibah et al. [2012]	Heart disease diagnosis	Neuro-Fuzzy classifier	The proposed classifier proved efficient and effective in detecting the disease
A.V.Senthil Kumar et al. [2012]	Heart disease diagnosis	ANFIS using MATLAB, FuzzyResolutionMechanism	Achieved91.83% accuracy
S.Singh et al. [2012]	Arthritis disease diagnosis	Fuzzy Logic Controller (FLC) based on Fuzzy set theory	The proposed system performed better
Priyanka Sharma et al. [2013]	Malaria and Dengue	Fuzzy logic Tool used- MAT LAB	The proposed system performs better
Y.Niranjana et a.l [2014]	Coronary Artery Disease diagnosis	FES constituting fuzzy rules and Genetic Algorithm	The proposed system yields an accuracy of 88.79%
Vishal Chandra et a.l [2014]	Hypertension(High Blood Pressure)	Fuzzy Expert System using fuzzy logic	The proposed system performed better
AkinyokunO.C et al. [2015]	Heart failure disease diagnosis	Expert System based on fuzzy logic, Root sum square Inferential mechanism	The proposed system resulted in accurate solution when several decision variables are involved

IV. GENETIC ALGORITHM IN DISEASE DIAGNOSIS

Today, clinical diagnosis is identified as one of the most critical process in medical diagnosis system. Analysing and synthesizing of data from the patients requires in-depth knowledge skills and reduction in the number of attributes related to the occurrence of a particular disease. Genetic Algorithm is considered as a tool for this purpose.

Genetic Algorithm (GA) is an unorthodox approach and an adaptive heuristic search algorithm based on biological evolution process. It is one of the optimization algorithm premised on the evolutionary ideas of natural genetics and natural selection over the recent decades [27], where the solution is expressed in terms of objective function, also referred to as a fitness function [28].Generally, Genetic Algorithm is very much different from most of the traditional optimization approaches as it is good in taking larger, probably huge

search spaces and then exhibiting the optimal combinations of the search. Basically GA operates upon binary strings which are similar to that of chromosomes considered as strings of DNA. Based on the rule of Darwin's survival of fittest, GA is a form of information exchange system. Therefore, Genetic Algorithm uses a form of natural behaviour where the total population consist of binary strings [29] each of these strings signifies solution to the existing problem[30].Strings are assigned a value of fitness which describes the intensity in terms of affectivity. The best attributes with the highest values are cross-brided with other individual binary strings in the population. As a result totally new population of feasible solution is generated in terms of the goodness of fit from the current generated population. The steps are repeated and the characteristics observed are better than those of the previous solution.

Especially, in the recent years GA emerged as a best optimisation algorithm and have been found extensive acceptance in many disciplines including disease diagnosis system. In case of disease diagnosis each attributes are coded with binary strings and the cluster of these strings are crossed over and mutated to generate more specific and reduced number of attributes. The objective function is evaluated and then applied upon every data that being processed on. The fitness function of the binary strings represents the total number of patterns in the dataset and identifies the patterns that are matching. By reviewing the recent articles it has been noted that people are mostly suffering from neurological disorder and cardiovascular diseases.

S.Mokaddem et al.[2013], focused on the feature selection for the diagnosis of the Coronary Artery Disease (CAD) using Genetic Algorithm. The dimension of data is reduced with the help of GA wrapped BN to generate a subset of features.BN classifier is used to measure the accuracy and 10-fold cross validation is used to validate the model. Other algorithms used earlier were: SVM (Support Vector Machine, MLP andC4.5. This paper suggested that the dataset resulting after the application of the feature selection is extremely concentrated and thereby can predict the heart disease in advance and accurately [31] when compared with other diagnosis system. Mohammad Shahbakhi et al. [2014] presented a diagnosis of speech analysis of Parkinson's disease. Parkinson disease is a neurological disease which is most common after Alzheimer's disease. Genetic Algorithm was used to select the optimised features from all extracted features and a network based on SVM is used [32].In 2013,Alzheimer's disease was also diagnosed using GA with logistic regression. The motive behind this paper is to identify the symptoms of the disease before it gets worsened to prevent slow progression. As Alzheimer disease is a combination of multiple risk factors so this paper aimed to predict the multiple factors affecting the present state of the person suffering from Alzheimer's disease and this is done by formulating Genetic Algorithm [33]. Cardiovascular disease which has become one of the life threatening disease and also becoming costlier day by day, recently a powerful tool i.e. Neuro-fuzzy system coupled with Genetic algorithms proposed by the researchers. In this approach, the use of Neuro-Fuzzy system records and holds the patterns of each symptom through neural network and predicted the correct condition and state of the patient every time the symptoms are repeated and weight optimization is done by Genetic Algorithm [23]. Table 3 presents the brief study of the review papers where Genetic Algorithm performed better in disease diagnosis system.

Table: 3

Authors[Year]	Domain	Methods used	Results
S.Mokaddem et al. [2013]	Coronary Artery Disease	Genetic Algorithm with BN classifier	Accuracy achieved was 85.50%
Piers Jhonson et al. [2013]	Alzheimer's disease	Genetic Algorithm with Logistic regression	Performed efficiently for searching the subset of variables.
Mohammad Shahbakhi et al. [2014]	Speech Analysis of Parkinson's disease	Genetic Algorithm and SVM(Support Vector Machine)	Classification accuracy was 94.50% for 4 optimised features.
Prof.AmarjaAdgaonkar et al. [2014]	Cardiovascular disease diagnosis	Neuro-Fuzzy system and Genetic Algorithm	Proposed Intelligent system yielded high accuracy

V. PARTICLE SWARM OPTIMIZATION (PSO) IN DISEASE DIAGNOSIS

Particle Swarm Optimization (PSO) is one of the evolutionary computation method for optimization and almost similar to Genetic Algorithm. It was developed by Kennedy and Eberhart in 1995.This technique is based on stochastic optimisation strategy and one of the best choices for space search problem, inspired from the social behaviour of bird flocking, school of fish and swarm of bees. PSO algorithm does not include the genetic operators like crossover and mutation where the main difference between the GA and PSO is depicted [34].

PSO mainly works by simultaneously maintaining a number of candidate solutions, considered as a population of particles to find the best and optimal solution. Each of these particles is associated with a objective function and in each of the iterations the performance evaluation parameter called fitness value is calculated. Similar to Genetic Algorithm, at first, in this algorithm population of random solutions are initialised in the search space and by applying the objective function, fitness value of each particle are generated.PSO requires only the information about the fitness values of the particles in the population.

All individuals consist of a location vector (X_i) and a velocity vector (V_i).The calculated fitness value associated with the particles are stored and known as personal best or pbest(P_i) and when a particle takes overall particles in the population, the best value is known as the global best or gbest(P_g).The values of pbest and gbest are updated each time which influences the co-operation between the particles and the search spaces[35].

The steps for implementing the PSO algorithm are as follows:

1. Each particle within the feature space is generated randomly.

2. The success of each particle using the fitness function is evaluated.

3. If the success of the current particle is better than the success of the pbest(P_i), then determine P_i as the current particle.

4. If the success of the current particle is better than the success of the gbest(P_g),then determine $P_g$as the current particle.

5. The velocity and the position of pbest and gbest are updated.

6. Steps from 2 to 5 are repeated until the maximum iteration is reached.

PSO is relatively a new paradigm applied in many research fields for solving optimisation problem and also took its place in disease diagnosis system. Considering the widespread application in disease diagnosis system, S.Muthukaruppan et al. in 2012 proposed particle swarm optimization based fuzzy expert system for the diagnosis of Coronary Artery Disease (CAD).The authors employed the PSO algorithm to tune the fuzzy membership function and yielded an accuracy of 93.27%. Dataset were based on Cleveland & Hungarian Heart disease. This system implied a promising result when compared with other approaches [36]. Mehdi Neshat et al. in 2012 integrated a hybrid method for the diagnosis of hepatitis disease using PSO and CBR (Case-Based Reasoning).CBR method was used for clustering and PSO used for classifying the selected features and recognises the disease. The proposed method achieved an accuracy of 93.25% [37].

In ref. [38] authors implemented a hybrid classification method for the diagnosis of Coronary Artery Disease. PSO with K-nearest neighbour classifier (PSOkNN) is used in the diagnosis system. The accuracy obtained was 92.49%. Gunasundari Selvaraj et al.[39] used improved feature selection based on particle swarm optimization for liver disease diagnosis. Binary Particle Swarm Optimization (BPSO) was used to get the best reduced feature set. Fuzzy c-Mean clustering and Probabilistic Neural Network was also used. Table 4 presents the brief study of the review papers where Particle Swarm Optimization (PSO) performed better in disease diagnosis system. Table 4 presents the brief study of the review papers where Particle Swarm Optimization performed better in disease diagnosis system.

Table: 4

Authors[Year]	Domain	Methods used	Results
S.Muthukaruppan et al .[2014]	Coronary Artery Disease diagnosis	PSO based FES	Yields an accuracy of 93.27%
Mehdi Nishat et al. [2012]	Hepatitis disease diagnosis	PSO and CBR(Case -Based Reasoning)	Acheived an accuracy of 93.25%
Ismail Babaoglu et al. [2012]	Coronary Artery Disease diagnosis	PSO with k-Nearest Neighbor classifier(PSOkNN)	Accuracy obtained was 92.49%
Gunasundari Selvaraj et al. [2014]	Liver disease diagnosis	BPSO Fuzzy C-mean clustering &PNN	PSO performed better

VI. CONCLUSION

The motive of this paper is a small effort to present a review of some of the Soft Computing techniques carried out by various researchers in the field of development of Expert systems, new algorithms and tools used for the diagnosis of different disease.

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