Soft Computing Techniques: ABrief Analysis

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Abstract

Soft computing is a branch that deals with making intelligent machines that can simulate human behavior by taking decisions very consciously, logically and intuitively. It is a collection of techniques that aim to exploit tolerance for imprecision,uncertainty, and partial truth to achieve robustness, tractability and total low cost.

Soft computing is the integration of various computing paradigms like neural networks, fuzzy logic, Evolutionary Computation, Machine Learning and Probabilistic Reasoning. These techniques are biologically inspired by behavior of human beings and laws of nature and modeled to make intelligent machines. Here the boundary is not hard but soft in contrast to hard computing that deals with accurate and precise model.Soft computing techniqueshave brought revolutions in the field of automation and can solve complex and computationally hard tasks.They are used in wide range of applications ranging from domestic, medical, to nuclear and scientific. Today it has become a very important area of engineering research attracting researchers and scientists from across the globe. This paper gives an overview of three important soft computing techniques i.e. neural networks, fuzzy logic and genetic algorithm.

Keywords: *fuzzy logic, genetic algorithm, neural network, soft computing,techniques.*

I. Introduction

Traditional computing models based on hard computing require precise model built on accurate data without any uncertainty and gives precise, exact solutions without any ambiguity. But there are some problems which cannot be accurately and preciselystated and hence are difficult to solve using by these conventional mathematical models.[1][2]These complex real world problems require intelligent systems that possess human like expertise, can adapt themselves in changing environmentsand take decisions logically.Soft computingis an approach that simulates the notable property of human brain to learn and respond in an environment of uncertainty and imprecision. It's remarkable properties such as intelligent control, nonlinear programming, optimization, and decisionmaking support, soft computing is finding important applications in solving complex real worlds problems that were otherwise difficult with conventional computing(hard computing) approaches.Soft computing offers better solution than traditional time-consuming and complex [3] hard computing techniques that makesthe problem almost infeasible, with more intelligent processing techniques in a cost efficient manner.TodaySoft computing techniques are used in wide range of applicationslike

[4]engineering, control, data mining, banking, medicine,energy, food industry, industrial production, software engineering, logistics, agriculture and environmental and so on.
Soft Computing [5] is a multi-disciplinary field with a variety of statistical, probabilistic and optimization tools like Neural Networks, Evolutionary Computation, Fuzzy Logic, Machine Learning and Probabilistic Reasoning. Figure1 [4] shows schematic diagram of traditional(hard) computing approaches and Figure 2 [4] shows soft computing approaches.

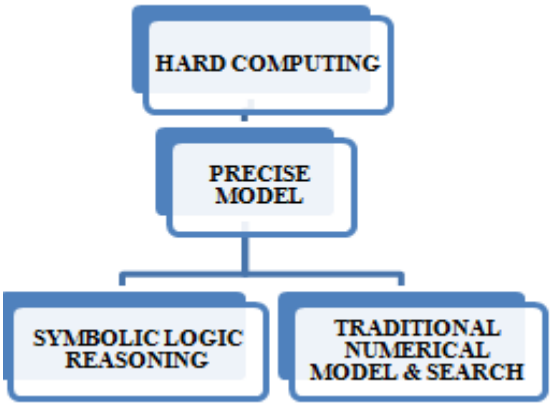

Figure 1. Approaches To Hard Computing

Source: Omolaye et al. (2017), A Holistic Review of Soft Computing Techniques. Applied and Computational Mathematics, 6(2), 93-110.Retrieved from http://www.sciencepublishinggroup.com/j/acm.

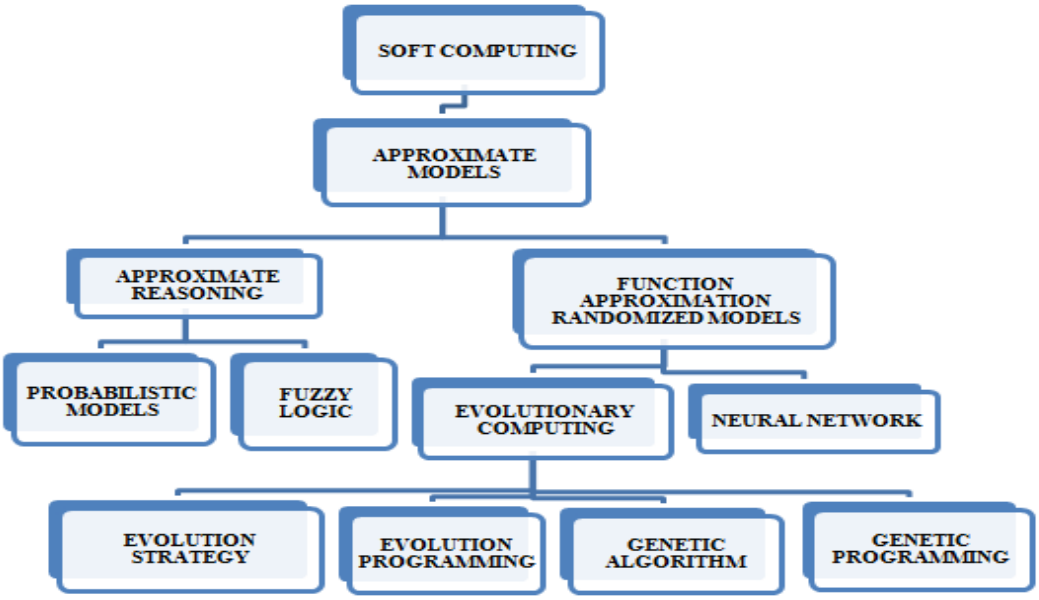

Figure 2. Approaches To Soft Computing

Source: Omolaye et al. (2017), A Holistic Review of Soft Computing Techniques. Applied and Computational Mathematics, 6(2), 93-110. Retrieved from http://www.sciencepublishinggroup.com/j/acm

[5]Among various techniques of soft Computing, Neural Networks, Genetic Algorithms and Fuzzy Logic are the important methodologies and are commonly used for real world applications. Soft Computing techniques offer low cost solutions to imprecisely formulated problems and attempt to mimic the behavior and learning ability of human beings into computers. These techniques have their own strength and work synergistically to solve a given problem. They are considered complementary[4] instead of competitive. As a result, these techniques can be combined to form hybrid systems that can solve real problems very effectively which is also an emerging area of research.Soft computing techniques are broadening and becoming increasingly popular because of time saving and fault tolerant[5] computational tools.

This paper is organized into five sections. Section II gives an overview of neural networks. Section III discusses about fuzzy logic and Section IV briefs about genetic algorithm. Conclusion and future prospects are highlighted in section V.

II. Neural Networks

Neural networks are information processing models inspired by the way human brain functions. They use mathematical formulations to model nervous system operations.It is a collection of a large number of highly interconnected processing elements called neurons(analogous to neurons present in human brain) working in synch with each other to solve specific problems. ANN can be trained to learn by examples and can perform a wide variety of tasks like pattern recognition, feature extraction and selection from large and complex data sets that are beyond the computational capability of mathematical and traditional procedures.The property of human brain to learn from experience is simulated in neural networks. Whereastraditional mathematical models are programmed, [4] neural networks learns the relation between selected inputs and outputs and can process many inputs in parallel and encode the information in a distributed fashion i.e. parallel processing which it makes it very fast.Their ability to learn by examples and extensive computational capability has made them replace experts in particular fields. Today they are used in wide areas of applications like:

- Credit card fraud detection
- Prediction of road traffic accidents
- Prediction of students performance
- Face recognition
- Air traffic control
- Photos and handwriting recognition
- Speech recognition
- Strategies for games, business and wars
- Market segmentation
- Stock exchange prediction
- Diagnosis of deadly diseases
- Criminal sentencing
- Music composition
- Weather prediction
- Target prediction using echo patterns from sonar, radar and magnetic instruments

- Machinery control
- Criminal sentencing
- Information security

Their area of applications is not limited. They can replace experts in any field.

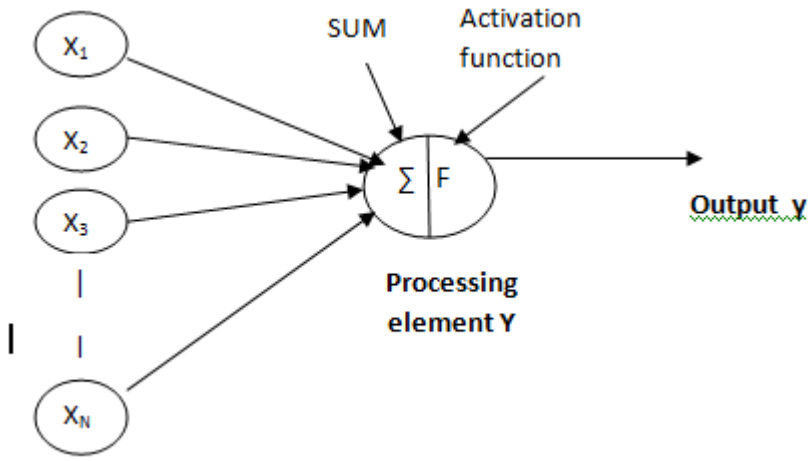

Figure 3. Simple Artificial Neural Network

Figure 3 depicts a simple model of artificial neuron where $x_1, x_2, x_3 \ldots\ldots x_n$ are input neuron which receive the input signals and $w_1, w_2, w_3 \ldots\ldots\ldots\ldots w_n$ are the corresponding weights that represent the strength of connection link from input neuron to the output neuron Y .Neuron Y calculates the net input y_{in} as sum of all the weighted inputs as shown in equation 1.

$$y_{in} = x_1 w_1 + x_2 w_2 + \cdots \ldots \ldots \ldots \ldots \ldots x_n w_n \quad (1)$$

The activation function f is applied over the net input to calculate the output y,as sown in equation 2.

$$y_{out} = f(y_{in}) \quad (2)$$

In an ANN processing elements (neurons) are highly interconnected to other processing elements (neurons) to form layers. So depending on this, neural networks can be single layer or multi layer. A single layer neural network is made up of only two layers: input and output as shown in figure 3. The input layer neurons receive the input signals and pass it on to the output layer for processing. The input layer has no processing capability that is why it is called single layer neural network inspite of having two layers. A schematic diagram of single layer neural network is shown in figure 4.

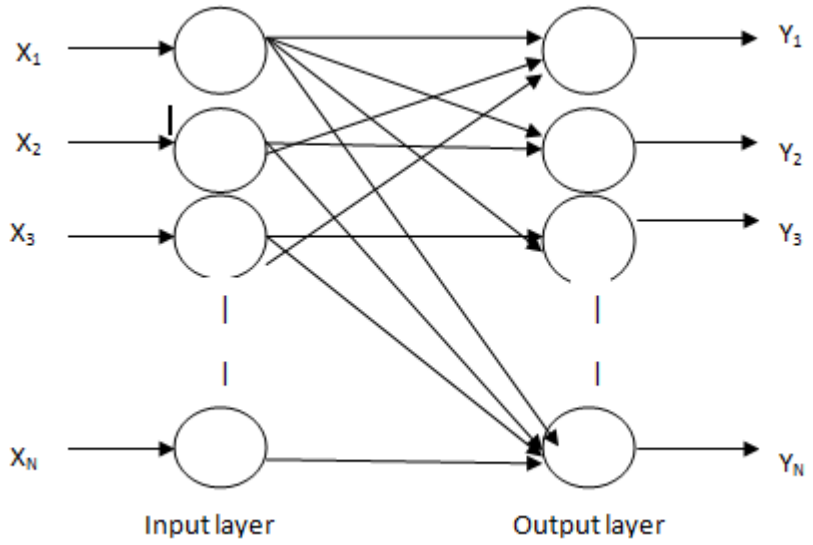

Figure 4. Single Layer Neural Network

A multi layer neural network has one or more layers present between the input and output layer which are called hidden layers.Figure 5 shows a simple multilayer neural network having one hidden layer between the input and output layer. There can be several hidden layers between input and output layer.

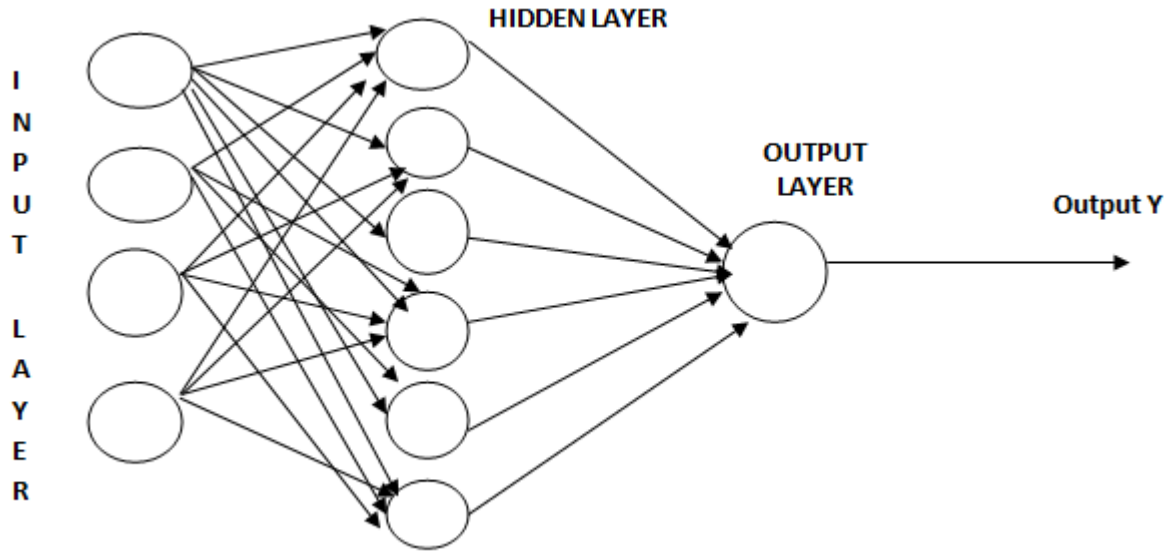

Figure 5. Multilayer Neural Network

Now depending upon the direction of signal flow, neural networks can again be categorized as feed forward neural networks and feedback neural networks.
A feed forward neural network is a network in which the direction of flow of signals is only in forward direction i.e. from input through hidden layer to output layer. There is no flow of signal from output layer back to the same or preceding layer. A feedback neural network is a

network in which the outputs can be directed back as feedbacks to the same or previous layers i.e. it allows flow of signals both in forward and backward directions.

III. Fuzzy Logic

The concept of Fuzzy Logic (FL) was proposed by Lotfi Zadeh in 1965, a professor at the University of California at Berkley, and presented[6] not as a control methodology, butas a way of processing data using partial set membership rather than crisp setmembership or non-membership. Fuzzy logic is a superset of traditional (Boolean) logic that has been extended to deal with the concept of partial truth -- truth values between "completely true" and "completely false". Fuzzy logic provides systematic calculus[1] to handle imprecise and incomplete information and performs calculation using linguistic labels predetermined by membership functions.
The fuzzification[7] interface transforms the crisp input value into a fuzzy linguistic value. Fuzzification is always necessary in a fuzzy logic system since the input values from existing sensors are always in crisp numerical form and must be convereted to fuzzy form. The inference engine takes the fuzzy input .These inputs are then fed to the fuzzy rule base.The fuzzy rule base which consists of "IF-THEN" rules generates fuzzy outputs.. The final step in fuzzy logic system is the defuzzification process which produces crisp outputs. A simple architectureof fuzzy logic system is shown in below figure 6[7].

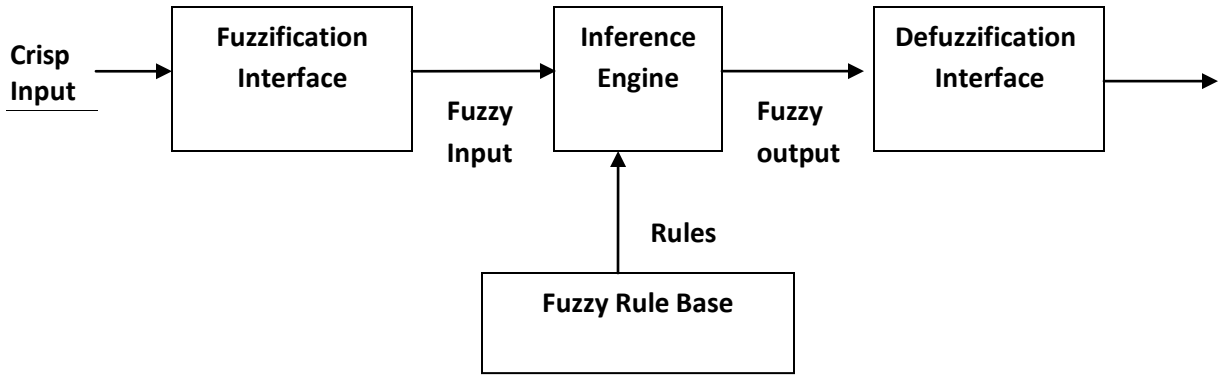

Figure 6. Fuzzy Logic System
Source: Ibrahim, D. (2016), An overview of soft computing (Vol. 102, pp. 34-38),Elsevier B.

III.Genetic Algorithm

Genetic algorithm (GA) [8] is a set of techniques, mainly used for problems of optimization. The idea behind GA is inspired by natural selection. In GA each possible solution from search space corresponds to some individual in a population. Population evolves until it reaches the desired solution or wastes all available resources (time, material or maximum number of generations).
[9]Genetic algorithms are stochastic algorithms. They consist of evolutionary optimization based on genetic mechanism and Darwin's theory of evolution of species in 1960 with concepts like 'mutation', 'cross over', 'survival of the best fittest', 'natural selection'. Genetic algorithm (GA) [10]is the one of the most popular evolutionary or metaheuristic algorithms. The main idea of algorithm is in a population of individuals or chromosomes, where each individual represents candidate solution. Evolution process of GA consists of a number of

steps – generations. At each generation of algorithm, individuals inside the population are updated by using several mechanisms: mutation (random change inside one individual); crossover (generation of child solution from two parent solutions); selection (the removal of the least adapted individuals). Fitness function is used to evaluate individuals and determine the best and worst solutions. The GA works with 'parameters coding'. Once genes codified, the identification process begins and follows the process as shown in figure 7[9]:

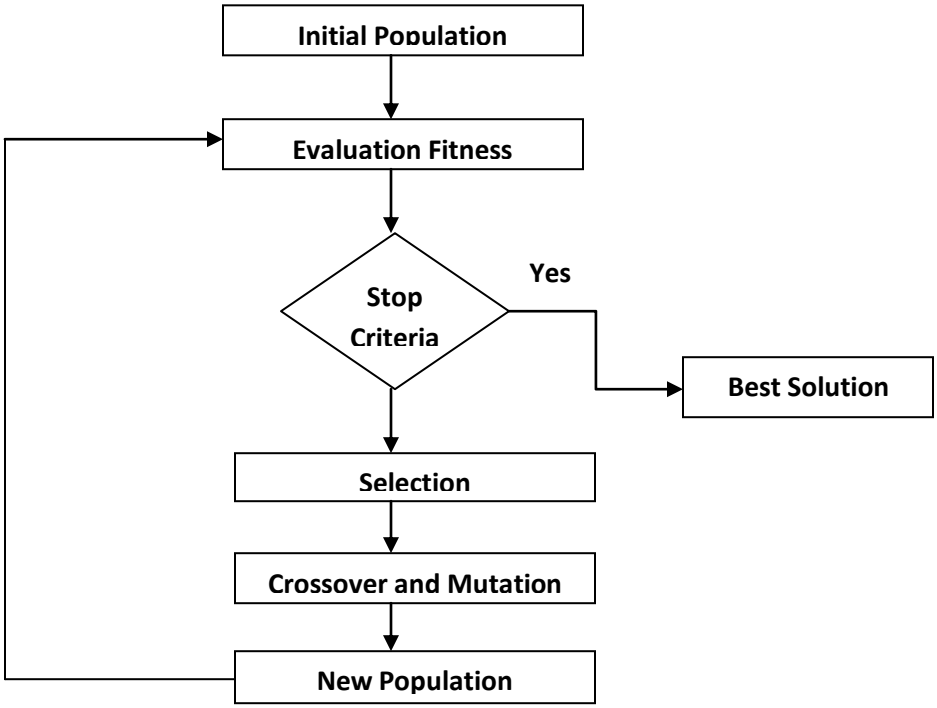

Figure 7. Genetic Algorithm Process

Source: Hergli et al. 2017 (in press) Identification of Preisach hysteresis model parameters using genetic algorithms. Journal of King Saud University – Science.

This process of selection, crossover and mutation is repeated and it is again subjected to an evaluation of the solution until the solution reaches the global optimum in a fixed iteration number.

GA can be used to solve complex problems. It is one of the most practical approaches [9] since it is independent of the choice of initial population. Today they are used in a wide variety of applications like Mining Internet of Things for intelligent objects [11], music variation on genom platform[8],image encryption [12], pyrolysis of typical polymers [13], bankruptcy forecasting[14] etc.

V. Conclusionand Future Prospects

Soft computing which combines probabilistic, statistical and optimization techniques into the computing environment can solve complex real world problems which cannot be accurately and precisely stated and hence are difficult to solve using by traditional mathematical models. The hybrid approach resulting from the combination of these methodologies [4]has given a new dimension to computing, in which human traits of reasoning, intuition, consciousness

and wisdom can be inculcated in machines through software programming. With the increasing demand of high power and low cost computing devices soft computing techniques are becoming increasingly popular and their area of applications is broadening every day. Soft computing techniques aid decision making process and offer low cost optimum solution to complex problems in an environment of ambiguity, uncertainty and imprecision. It has become a key area of research and with continuous effort of researchers in this area,soft computing techniques will definitely surpass human intelligence and wisdom.

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