SOFT COMPUTING AND ITS COMPONENTS

MOHD TABISH KHAN

Abstract- Soft Computing plays a vital role in creation of intelligent machines. Almost all the techniques that constitute Soft Computing are inspired by natural processes. The following paper explores all such techniques and gives a nutshell of their working.

Keyword- **Soft Computing, Neural Networks, Evolutionary Algorithm, Bayesian Network**

I.   Introduction

Soft Computing is a new multidisciplinary field that was proposed by Dr Lotfi A. Zadeh, whose goal was to construct a new generation Artificial Intelligence. This idea of Soft Computing was initiated in 1981 when Dr Zadeh published his first paper on Soft Data analysis.

Soft Computing is the fusion of methodologies that were designed to model and enable solutions to real world problems, which are not modelled or too difficult to model, mathematically. Soft Computing is applied to a field within Computer Science which is characterised by the use of inexact solution to computationally hard task such as the solution of NP-Complete problems, for which there is no known algorithm that can compute an exact solution in polynomial time. Unlike hard computing scheme, which strives for exactness and full truth, soft computing techniques exploit the given tolerance of impression, partial truth and uncertainty for a given problem.

Soft computing techniques resemble biological processes more closely than traditional techniques. The learning ability of the human brain provides us with a new toll for designing a cognitive machine that can learn and recognise complicated pattern like human faces, to understand distorted speech, decipher sloppy handwriting and comprehend nuance of natural languages. It imitates the human mind to effectively employ modes of reasoning that are approximate rather than exact.

The computing tools that are the major constituents of soft computing includes neural networks, fuzzy systems, neuro-fuzzy systems, evolutionary algorithm, swarm intelligence and Bayesian Network. All these components will be discussed briefly in this paper.

Mohd. Tabish Khan

Institute of Engineering and Technology, Indore

India

II.   Artificial Neural Networks

A neuron is a cell in the brain whose principal function is the collection, processing and dissemination of electrical signals. The brains information processing capacity is thought to emerge primarily from networks of such neurons. This is the main reason behind employing the artificial neural networks for information processing.

Artificial Neural Network use learning algorithm by our understanding of how the brain learns. It is a simplified model of the biological neural system. It consists of highly interconnected neural computing elements that have the ability to learn and thereby acquire knowledge and making it available for use. Their practical application includes speech recognition, objective recognition, image retrieval and the ability to recommend products that a user will like. Neural Network aims at finding similarity between human and artificial information processing system.

.   An artificial neural network consists of an interconnected group of artificial neurons called nodes working in a parallel way to solve the problem related to the aspect of classification. The nodes can be seen as computational units. They receive inputs, and process them to obtain an output. This processing might be very simple (such as summing the inputs), or quite complex (a node might contain another network...)

The connections determine the information flow between nodes. They can be unidirectional, when the information flows only in one sense, and bidirectional, when the information flows in either sense. The interactions of nodes though the connections lead to a global behaviour of the network, which cannot be observed in the elements of the network. This global behaviour is said to be emergent. This means that the abilities of the network supercede the ones of its elements, making networks a very powerful tool.

The most intriguing part of neural networks is its paradigms of learning. Their types include supervised learning in which it learns to predict an output when given an input vector, Reinforcement learning in which it learns to select an action to maximise payoff and unsupervised learning under which it discovers a good internal representation of the input.

The type of Neural Network includes Feed-forward neural network and Recurrent Neural Network etc. Feed-forward neural network are the commonest type of neural network in practical application. It has a layered system in which the first layer is the input and the last layer is the output and the remaining are the hidden layers. If there are more than one hidden layer then it is called deep neural network.

Recurrent Network have directed cycles in their connection. These are relatively more natural ways to model sequential data. They are equivalent to very deep nets with one hidden layer per time slice and also have the ability to remember information in their hidden state for a long time. But it is very hard to train them to use this potential.
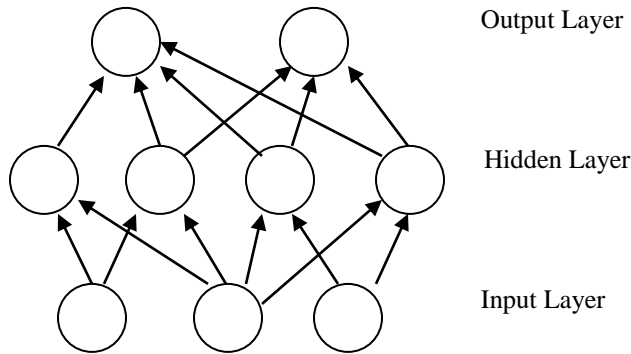

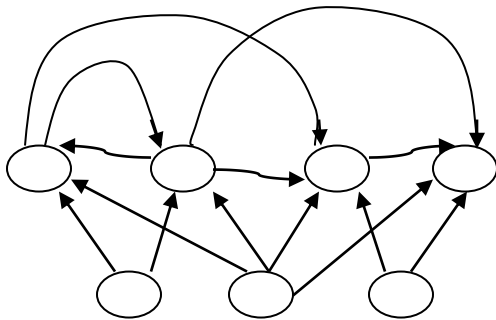Figure 1 Feed-forward Neural Network

Figure 2 Recurrent Network with multiple hidden layers

III. Fuzzy Systems

The fuzzy sets theory was initiated by Lofti A. Zadeh, in 1965. Fuzzy systems play a leading role in soft computing and this stems from the fact that human reasoning is not crisp and admits degrees. The notion central to fuzzy systems is that truth values (in fuzzy logic) or membership values (in fuzzy sets) are indicated by a value on the range [0, 1], with 0 representing absolute Falseness and 1 representing absolute truth. Fuzzy systems are based on fuzzy logic (FL). Fuzzy Logic is a form of many-valued logic or probabilistic logic; it deals with reasoning that is approximate rather than fixed and exact. Fuzzy Logic incorporates a simple, rule-based IF X AND Y THEN Z approach to a solving control problem rather than attempting to model a system mathematically. FL provides a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy, or missing input information. Fuzzy logic has the advantage that the solution to the problem can be cast in terms that human operators can understand, so that their experience can be used in the design of the controller. This makes it easier to mechanize tasks that are already successfully performed by humans.

IV. Neural Fuzzy System

Neural-fuzzy System refers to combinations of artificial neural networks and fuzzy logic. Neural-fuzzy system was proposed by J. S. R. Jang. Neural-fuzzy hybridization results in a hybrid intelligent system that synergizes these two techniques by combining the human-like reasoning style of fuzzy systems with the learning and connectionist structure of neural networks. The reasons behind combine these two paradigms is to overcome the difficulties and inherent limitations of each isolated paradigm. Neural networks introduce its computational characteristics of learning in the fuzzy systems and receive from them the interpretation and clarity of systems representation.

V. Evolutionary Computation

Evolutionary programming was introduced by Lawrence J. Fogel in the US. It is an area of computer science that uses ideas from biological evolution to solve computational problems in an optimized manner because optimization is at the heart of many natural processes including Darwinian evolution. Evolutionary computation uses iterative progress, such as growth or development in a population. This population is then selected in a guided random search using parallel processing to achieve the desired end.

Evolutionary computing techniques mostly involve metaheuristic optimization algorithms. These include fields like evolutionary algorithm, swarm intelligence. The common underlying idea behind all these techniques is the same, given a population of individuals the environmental pressure causes natural selection (survival of the fittest) and this causes a rise in the fitness of the population. Given a quality function to be maximized we can randomly create a set of candidate solution i.e., elements of the function's domain, and apply the quality function as an abstract fitness measure – the higher the better. Based on this fitness, some of the better candidates are chosen to seed the next generation by applying recombination and/or mutation to them. Recombination is an operator applied to two or more selected candidates (the children). Mutation is applied to one candidate and result is one new candidate. Executing recombination and mutation leads to a set of new candidates (the off springs) that compete – based on their fitness (and possibly age)- with the old ones for a place in the next generation. This process can be iterated until a candidate with sufficient quality (a solution) is found or a previously set computational limit is reached. A simple algorithm to define the functioning of evolutionary computation can be given by:

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BEGIN
  INITIALISE population with random candidates solution;
  EVALUATE each candidate;
  REPEAT until termination condition is satisfied
      SELECT parents;
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RECOMBINE pairs of parents;

MUTATE the resulting offspring;

EVALUATE new candidates;

SELECT individuals for the next generation;

OD

END

A. *Evolutionary Algorithm*

Evolutionary Algorithms are a kind of stochastic search and optimization heuristics. Today these are successfully used for solving numeric problems, such as optimization, automatic programming and so on. Evolutionary Algorithm have a conceptual base of simulating the evolution of individual structure by well known processes such as selection, mutation and reproduction. Their importance is coming from their ability in optimizing complex function.

B. *Swarm Intelligence*

Swarm intelligence is the collective behaviour of decentralized, self-organized systems, natural or artificial. The concept is employed in work on artificial intelligence. The expression was introduced by Gerardo Beni and Jing Wang in 1989, in the context of cellular robotic systems. Swarm Intelligence (SI) is the property of a system whereby the collective behaviours of (unsophisticated) agents interacting locally with their environment cause coherent functional global patterns to emerge. SI provides a basis with which it is possible to explore collective (or distributed) problem solving without centralized control or the provision of a global model. It exploits the emergent collective intelligence of groups of simple agents.

This inspiration has comes from nature, especially biological systems like ant colonies, bee hives and so on The Ants form and maintain a line to their food source by laying a trail of pheromone, i.e. a chemical to which other members of the same species are very sensitive. They deposit a certain amount of pheromone while walking, and each ant prefers to follow a direction rich in pheromone. This enables the ant colony to quickly find the shortest route. The first ants to return should normally be those on the shortest route, so this will be the first to be doubly marked by pheromone (once in each direction). Thus other ants will be more attracted to this route than to longer ones not yet doubly marked, which means it will become even more strongly marked with pheromone.

The main advantages of employing the swarm intelligence includes performance optimization and robustness self-organized control and cooperation (decentralized) division of labour and distributed task allocation indirect interactions.

VI.   Bayesian Network

The term "Bayesian networks" was coined by Judea Pearl in 1985. Most commonly, BNs are considered to be representations of joint probability distributions. A Bayesian network is a graphical structure that allows us to represent and reason about an uncertain domain. The nodes in a Bayesian network represent a set of random variable nodes that take discrete values. Two nodes should be connected directly because if one affects or causes changes to other, the arc indicates the direction of the effect. Also the values should be both mutually exclusive and exhaustive,

A Bayesian Network has the following components

- a set of nodes, one per variable
- a directed, acyclic graph (link = "directly influences")
- a conditional distribution for each node given its parents:

Given by: $P(X_i | Parents (X_i))$

Applications of Bayesian network include decision making maximizing expected utility, adaptive testing. It may also be used to update beliefs about states of certain variables when some other variables were observed, i.e., computing conditional probability distributions.

Conclusion

In this research paper an overview of the constituents of soft computing is studied. The soft computing plays a very significant role in machine learning. Thus for the process of making the machines intelligent and inducing in them the human like thinking characteristics, the soft computing could be very helpful.

Acknowledgment

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