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Application of Soft Computing Techniques: Fuzzy logic and Genetic Algorithms

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ABSTRACT

In this paper we describe soft computing techniques, fuzzy logic and genetic algorithms, Artificial Neural Networks and Expert System. Soft computing techniques have mainly two important advantages. Firstly, to solve the non-linear problems and second is to introducing the human knowledge such as recognition, learning, understanding and various others field of soft computing. These techniques are capable of dealing with inexact and imprecise problem domains and have been demonstrated to be useful in the solution of classification problems.

Keywords: *Soft Computing, Genetic Algorithm. Fuzzy Logic, Artificial Neural Network*

I. INTRODUCTION

Soft computing is a wide ranging term encompassing such varied techniques as fuzzy systems, rough sets, neural networks, genetic algorithms, simulated annealing etc. In this paper we are using only Fuzzy Logic (FL) and Genetic Algorithm (GA) Techniques. FL and GAs have been successfully used for supply chain modeling (2008) and are particularly appropriate for this problem due to their capacity to tackle the inherent vagueness, uncertainty and incompleteness of the data used. A GA (1975) is a heuristics search technique inspired by evolutionary biology. Selection, crossover and mutation are applied to a population of individuals representing solutions in order to find a near optimal solution. FL is based on fuzzy set theory and provides methods for modeling and reasoning under uncertainty, a characteristic present in many problems, which makes FL a valuable approach. It allows data to be represented in intuitive linguistic categories instead of using precise (crisp) numbers which might not be known, necessary or in general may be too restrictive. For example, statements such as the "cost is about n the speed is high" and "the book is very old" can be described. These categories are represented by means of a membership function which defines the degree to which a crisp number belongs to the category. Soft Computing Techniques (Artificial Neural Networks, Genetic Algorithms, Fuzzy Logic Models, and Expert System) have been recognized as attractive alternatives to the standard, well established "hard computing" paradigms. Traditional hard computing methods are often too cumbering some for today's problems. They always require a precisely stated analytical model and often a lot of computational time. Soft computing techniques, which emphasize gains in understanding system behavior in exchange for unnecessary precision, have proved to be important practical tools for many contemporary problems. These are universal approximates of any multivariate function because they can be used for modeling highly nonlinear, unknown, or partially known complex systems, plants, or processes. Genetic Algorithm and Particle Swarm Optimization Techniques have emerged as potential and robust optimization tools in recent years. The course contents will be taught by eminent experts in the field, having adequate teaching and research experience. This course will be beneficial to faculty from all engineering disciplines as a potential computing tool in their research activities. This course is aimed at newly recruited teachers (Less than five years Experience), designed from the basic concepts to application and reviews.

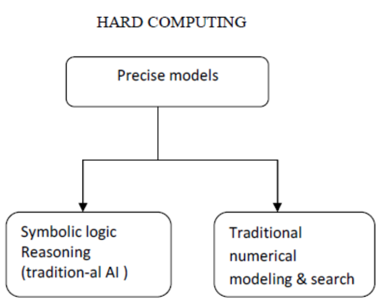
II. SOFT COMPUTING

Soft Computing became a formal Computer Science area of study in early 1990s. Earlier computational approaches could model and precisely analyze only relatively simple systems. More complex systems arising in biology, medicine, the humanities, management sciences, and similar fields often remained intractable to conventional mathematical and analytical methods. That said, it should be pointed out that simplicity and complexity of systems are relative, and many conventional mathematical models have been both challenging and very productive. Soft computing deals with imprecision, uncertainty, partial truth, and approximation to achieve practicability, robustness and low solution cost. Components of soft computing include: Generally speaking, soft computing techniques resemble biological processes more closely than traditional techniques, which are largely based on formal logical systems, such as sentential logic and predicate logic, or rely heavily on computer aided numerical analysis (as in finite element analysis). Soft computing techniques are intended to complement each other.

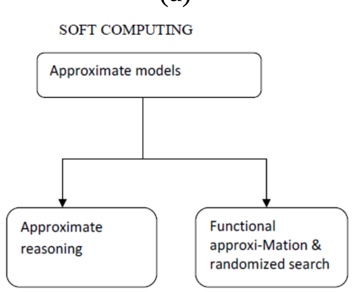
The two major problem-solving technologies include:

- Hard computing
- Soft computing

Hard Computing deals with precise models where accurate solutions are achieved quickly. On the other hand, soft computing deals with approximate models and gives solution to complex problems. The two problem solving technologies are shown in the figure. Hard computing schemes, which strive for exactness and full truth, soft computing techniques exploit the given tolerance of imprecision, partial truth, and uncertainty for a particular problem. Another common contrast comes from the observation that inductive reasoning plays a larger role in soft computing than in hard computing.



(a)



(b)

Figure 1: Problem-solving technologies.

III. ARTIFICIAL NEURAL NETWORK

Artificial neural network usually called neural network (NN), is a mathematical model or computational model that is inspired by the structure and/or functional aspects of biological neural networks. A neural network consists of an interconnected group of artificial neurons, and it processes information using a connectionist approach to computation. In most cases an ANN is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. Modern neural networks are non-linear statistical data modeling tools. They are usually used to model complex relationships between inputs and outputs or to find patterns in data. These networks are also similar to the biological neural networks in the sense that functions are performed collectively and in parallel by the units, rather than there being a clear delineation of subtasks to which various units are assigned (see also connectionism). Currently, the term Artificial Neural Network (ANN) tends to refer mostly to neural network models employed in statistics, cognitive psychology and artificial intelligence. Neural network models designed with emulation of the central nervous system (CNS) in mind are a subject of theoretical neuroscience and computational neuroscience.

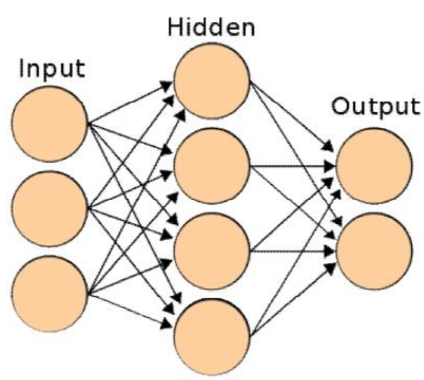


Figure 2: Artificial Neural Network

IV. INTRODUCTION OF GENETIC ALGORITHM

The Genetic Algorithm (GA) was introduced in the mid 1970s by John Holland and his colleagues and students at the University of Michigan.3. The GA is inspired by the principles of genetics and evolution, and mimics the reproduction behavior observed in biological populations. The GA employs the principal of “survival of the fittest “in its search process to select and generate individuals (design solutions) that are adapted to their environment (design objectives/constraints). Therefore, over a number of generations (iterations), desirable traits (design characteristics) will evolve and remain in the genome composition of the population (set of design solutions generated each iteration) over traits with weaker undesirable characteristics. The GA is well suited to and has been extensively applied to solve complex design optimization problems because it can handle both discrete and continuous variables and nonlinear objective and constrain functions without requiring gradient information.

When it is applied to problem solving, the basic premise is that we can create an initial populations of individuals representing possible solution to a problem we are trying to solve. Each of these individuals has certain characteristics that make them more or less fit as members of the populations. The more fit members will have a higher probability of matting and producing offspring that have a significant chance of retaining the desirable characteristics of their parents than the less fit members. This method is very effective at finding optimal or near-optimal solutions to a wide variety of problems because it does not impose many limitations required by traditional methods. It is an elegant generates and–test strategy that can identify and exploit regularities in the environment, and results in solutions that are globally optimal or nearly so. Genetic Algorithms are adaptive computational procedures modeled on the mechanics of natural genetic systems. They express their ability by efficiently exploiting the historical information to speculate on new offspring with expected improved performance. Genetic Algorithms are executed iteratively on a set of coded solutions, called populations, with three basic operators: selection/reproduction, crossover and mutation. They use only the payoff i.e. objective function information and probabilistic transition rules for moving to the next iteration. They are different from most of the normal optimization and search procedures in the following four ways:

- GAs work with the coding of the parameter set, not with the parameter them.
- GAs work simultaneously with multiple points, not a single point.
- GAs search via sampling using only the payoff information.
- GAs search using stochastic operators, not deterministic rules.

V. FUZZY LOGIC

The concept of fuzzy logic (FL) was introduced by Lotfi Zadeh, a Professor at the University of California at Berkeley. An organized method for dealing with imprecise data is called fuzzy logic. The data are considered as fuzzy sets. In a narrow sense, fuzzy logic refers to a logical system that generalizes classical two-valued logic for reasoning under uncertainty. In a broad sense, fuzzy logic refers to all of the theories and technologies that employ fuzzy sets, which are classes with unsharp boundaries. Fuzzy logic is a technology for developing intelligent control and information systems. Fuzzy logic achieves machine intelligence by offering a way for representing and reasoning about human knowledge that is imprecise by nature. Even though fuzzy logic is not the only technique for developing AI systems, it is unique in its approach for explicit representation of the impreciseness in human knowledge and problem solving techniques. In addition to achieving artificial intelligence, fuzzy logic also benefits from learning techniques because they can be used to construct fuzzy systems automatically. Neural
Networks and Genetic algorithms are two machine learning techniques that are particularly useful for this purpose.

Fuzzy logic offers a practical way for designing nonlinear control systems. It achieves nonlinearly through piece-wise linear approximation. The basic building blocks of a fuzzy logical control system are set of fuzzy if-then (i.e., fuzzy rule based models) that approximate a functional mapping. In fact, fuzzy rule-based models are useful not only for control systems, but also for decision making and pattern recognition.

VI. EXPERT SYSTEM

Imagine a piece of software that runs on your
PC which provides the same sort of interaction and advice as a career counselor helping you decides what education field to go into and perhaps what course to pursue. Or a piece of software which asks you questions about your defective TV and provides a diagnosis about what is wrong with it. Such software, called *expert systems*, actually exists. Expert systems are a part of the larger area of Artificial Intelligence.

Components of an Expert System

A typical expert system consists of five components

- the user interface
- the working memory

- the knowledge base
- the inference engine
- and the explanation system

Working Memory

The working memory represents the set off acts known about the domain. The elements of the WM reflect the current state of the world. In an expert system, the WM typically contains information about the particular instance of the problem being addressed. For example, in a TV troubleshooting expert system, the WM could contain the details of the particular TV being looked at.

The working Memory

The knowledge base (also called rule base when *If-then* rules are used) is a set of rules which represents the knowledge about the domain. The general form of a rule is: **If** cond1 **and** cond2 **and** cond3 ...**then**
action1, action2,...
The conditions cond1, cond2, cond3, etc., (also known as antecedents) are evaluated based on what is currently known about the problem being solved (i.e., the contents of the working memory.

Inference Engine

The inference engine is the program part of an expert system. It represents a problem solving model which uses the rules in the knowledge base and the situation-specific knowledge in the WM to solve a problem.

Explanation System

Expert systems typically need to be able to provide explanations regarding the conclusions they make. Most expert systems provide a mechanism whereby the user can ask questions about:

- why a particular question is being asked
- how the system came to a particular conclusion

VII. CONCLUSION

In this paper we have presented a review on the role of Soft Computing techniques. In global optimization scenarios, GAs often manifests their strengths: efficient, parallelizable search; the ability to evolve solutions with multiple objective criteria; and a characterizable and controllable process of innovation. More research needs to be concentrated on the development of hybrid design alternatives for its efficiency enhancement.

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