Chapter 18
Soft Computing and its Applications

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ABSTRACT

Soft Computing is a relatively new computing paradigm bestowed with tools and techniques for handling real world problems. The main components of this computing paradigm are neural networks, fuzzy logic and evolutionary computation. Each and every component of the soft computing paradigm operates either independently or in coalition with the other components for addressing problems related to modeling, analysis and processing of data. An overview of the essentials and applications of the soft computing paradigm is presented in this chapter with reference to the functionalities and operations of its constituent components. Neural networks are made up of interconnected processing nodes/neurons, which operate on numeric data. These networks posses the capabilities of adaptation and approximation. The varied amount of uncertainty and ambiguity in real world data are handled in a linguistic framework by means of fuzzy sets and fuzzy logic. Hence, this component is efficient in understanding vagueness and imprecision in real world knowledge bases. Genetic algorithms, simulated annealing algorithm and ant colony optimization algorithm are representative evolutionary computation techniques, which are efficient in deducing an optimum solution to a problem, thanks to the inherent exhaustive search methodologies adopted. Of late, rough sets have evolved to improve upon the performances of either of these components by way of approximation techniques. These soft computing techniques have been put to use in wide variety of problems ranging from scientific to industrial applications. Notable among these applications include image processing, pattern recognition, Kansei information processing, data mining, web intelligence etc.

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1. INTRODUCTION

The field of *Soft Computing* is a synergistic integration of essentially three computing paradigms, viz. neural networks, fuzzy logic and evolutionary computation entailing probabilistic reasoning (belief networks, genetic algorithms and chaotic systems) to provide a framework for flexible information processing applications designed to operate in the real world. Bezdek (92) referred to this synergism as *computational intelligence* (Kumar, 2004). Soft computing technologies are robust by design, and operate by trading off precision for tractability. Since they can handle uncertainty with ease, they conform better to real world situations and provide lower cost solutions.

The three components of soft computing differ from one another in more than one way. Neural networks operate in a numeric framework, and are well known for their learning and generalization capabilities. Fuzzy systems (Zadeh, 65) operate in a linguistic framework, and their strength lies in their capability to handle linguistic information and perform approximate reasoning. The evolutionary computation techniques provide powerful search and optimization methodologies. All the three facets of soft computing differ from one another in their time scales of operation and in the extent to which they embed *a priori* knowledge.

Of late, rough set theory has come up as a new mathematical approach to model imperfect knowledge, crucial to addressing problems in areas of artificial intelligence. Apart from the fuzzy set theory pointed out in the previous paragraph, rough set theory proposed by Pawlak (Pawlak, 82) presents still another attempt to handle real world uncertainties. The theory has attracted attention of many researchers and practitioners all over the world, who have contributed essentially to its development and applications. The rough set approach seems to be of fundamental importance to artificial intelligence and cognitive sciences, especially in the areas of machine learning, knowledge acquisition, decision analysis, knowledge discovery from databases, expert systems, inductive reasoning and pattern recognition. The main advantage of rough set theory in data analysis is that it does not need any preliminary or additional information about data – like probability in statistics, or basic probability assignment in Dempster-Shafer theory, grade of membership or the value of possibility in fuzzy set theory.

2. NEURAL NETWORKS

A neural network is a powerful data-modeling tool that is able to capture and represent complex input/output relationships similar to a human brain. Artificial neural networks resemble the human brain in the following two ways:

- A neural network acquires knowledge through learning.
- A neural network's knowledge is stored within inter-neuron connection strengths known as *synaptic weights*.

The true power and advantage of neural networks lie in their ability to represent both linear and non-linear relationships and in their ability to learn these relationships directly from the data being modeled.

Artificial Neural Network

An artificial neural network (Haykin, 99), as the name suggests, is a parallel and layered interconnected structure of a large number of artificial *neurons*, each of which constitutes an elementary computational primitive. The distributed representation of the interconnections through massive parallelism achieved out of the inherent network structure, bestows upon such networks properties of graceful degradation and fault tolerance. These network structures differ from one to another in the topology of the underlying interconnections as well as on the target problem they are put to.