Chapter 1
Artificial Intelligence Techniques for Modern Energy Applications

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ABSTRACT

Artificial intelligence (AI) techniques are becoming useful as alternate approaches to conventional techniques or as components of integrated systems. They have been used to solve complicated practical problems in various areas and nowadays are very popular. They are widely accepted as a technology offering an alternative way to tackle complex and ill-defined problems. They can learn from examples, are fault tolerant in the sense that they are able to handle noisy and incomplete data, are able to deal with non-linear problems and once trained can perform prediction and generalization at very high speed. AI-based systems are being developed and deployed worldwide in a wide variety of applications, mainly because of their symbolic reasoning, flexibility and explanation capabilities. They have been used in diverse applications in control, robotics, pattern recognition, forecasting, medicine, power systems, manufacturing, optimization, signal processing and social/psychological sciences. They are particularly useful in system modeling such as in implementing complex mappings and system identification. This chapter presents a review of the main AI techniques such as expert systems, artificial neural networks, genetic algorithms, fuzzy logic and hybrid systems, which combine two or more techniques. It also outlines some applications in the energy sector.

DOI: 10.4018/978-1-60566-737-9.ch001

1. INTRODUCTION

Artificial Intelligence (AI) is a term that in its broadest sense would indicate the ability of a machine or artifact to perform the same kind of functions that characterize human thought. The term AI has also been applied to computer systems and programs capable of performing tasks more complex than straightforward programming, although still far from the realm of actual thought. According to Barr and Feigenbaum (1981) AI is the part of computer science concerned with the design of intelligent computer systems, i.e., systems that exhibit the characteristics associated with intelligence in human behavior-understanding, language, learning, reasoning, solving problems and so on (Kalogirou, 2003; 2007). Several intelligent computing technologies are becoming useful as alternate approaches to conventional techniques or as components of integrated systems (Medsker, 1996).

In the early 1950s Herbert Simon, Allen Newell and Cliff Shaw conducted experiments in writing programs to imitate human thought processes (Krishnamoorthy and Rajeev, 1996). The experiments resulted in a program called Logic Theorist, which consisted of rules of already proved axioms. When a new logical expression was given to it, it would search through all possible operations to discover a proof of the new expression, using heuristics. This was a major step in the development of AI. The Logic Theorist was capable of solving quickly thirty-eight out of fifty-two problems with proofs that Whitehead and Russell had devised (Newell *et al.*, 1963). At the same time, Shannon came out with a paper on the possibility of computers playing chess (Shannon, 1950). Though the works of Newell *et al.* (1963) and Shannon (1950) demonstrated the concept of intelligent computer programs, the year 1956 is considered the start of Artificial Intelligence.

One representative definition is pivoted around the comparison of intelligence of computing machines with human beings (McCarthy, 1980; Haugeland, 1985). Another definition is concerned with the performance of machines, which "historically have been judged to lie within the domain of intelligence" (Kurzweil, 1990; Newell and Simon, 1972). None of these definitions or the like has been universally accepted, perhaps because of their references to the word "intelligence", which at present is an abstract and immeasurable quantity. Therefore, a better definition of AI calls for formalization of the term "intelligence". Psychologist and cognitive theorists are of the opinion that intelligence helps in identifying the right piece of knowledge at the appropriate instances of decision-making (Rich and Knight, 1966). The phrase "AI" thus can be defined as the simulation of human intelligence on a machine, to make the machine efficient to identify and use the right piece of "Knowledge" at a given step for solving a problem. A system capable of planning and executing the right task at the right time is generally called rational (Russel and Norvig, 1995). Thus, AI alternatively may be stated as a subject dealing with computational models that can think and act rationally (Luger and Stubblefield, 1993; Winston, 1994; Schalkoff *et al.*, 1992). A common question then naturally arises. Does rational thinking and acting include all possible characteristics of an intelligent system? If so, how does it represent behavioral intelligence such as machine learning, perception and planning? A little thinking, however, reveals that a system that can reason well must be a successful planner, as planning in many circumstances is part of a reasoning process. Further, a system can act rationally only after acquiring adequate knowledge from the real world. Therefore, perception that stands for building up of knowledge from real world information is a prerequisite feature for rational actions. One-step further thinking envisages that a machine without learning capability cannot possess perception. The rational action of an agent (actor) calls for possession of all the elementary characteristics of intelligence. Therefore, relating AI with the computational models capable of thinking and acting rationally has a pragmatic significance (Konar, 1999). AI has been used