Chapter 81
Artificial Intelligence Techniques for Solar Energy and Photovoltaic Applications

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ABSTRACT

Artificial intelligence (AI) techniques play an important role in modeling, analysis, and prediction of the performance and control of renewable energy. The algorithms employed to model, control, or to predict performances of the energy systems are complicated involving differential equations, large computer power, and time requirements. Instead of complex rules and mathematical routines, AI techniques are able to learn the key information patterns within a multidimensional information domain. Design, control, and operation of solar energy systems require long-term series of meteorological data such as solar radiation, temperature, or wind data. Such long-term measurements are often non-existent for most of the interest locations or, wherever they are available, they suffer of a number of shortcomings (e.g. poor quality of data, insufficient long series, etc.). To overcome these problems AI techniques appear to be one of the strongest candidates. The chapter provides an overview of commonly used AI methodologies in solar energy, with a special emphasis on neural networks, fuzzy logic, and genetic algorithms. Selected AI applications to solar energy are outlined in this chapter. In particular, methods using the AI approach for the following applications are discussed: prediction and modeling of solar radiation, seizing, performances, and controls of the solar photovoltaic (PV) systems.

INTRODUCTION, REVIEW OF AI TECHNIQUES

Intelligence is the ability to think, to imagine, create, memorize, understand, recognize patterns, make choices, adapt to change and learn from experience. Artificial intelligence is a human endeavor to create a non-organic machine-based entity that has all the above abilities of natural organic intelligence. Hence it is known as 'Artificial Intelligence' (AI). AI emerged as a computer science discipline in the mid1950s. Since then, it has produced a number of powerful tools, many

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of which are of practical use in engineering to solve difficult problems normally requiring human intelligence. Artificial Intelligence (AI) has been defined as the study of how to make computers do things which at the moment, people do better (Haugeland, 1985, Rich and Knight, 1991). An Expert System (ES) is a computer program that assimilates and reasons with knowledge obtained from some expert(s) with a view to solving problem(s) or giving advice. Thus expert systems are software packages which translate human expertise into computer programs. Portability of software makes the use of expert systems very attractive where human expertise is scarce or costly or is likely to be lost through mobility. Applications of AI techniques to power and renewable energy systems has been an active area of research for over three decades and significant successes have been achieved. Among the AI techniques, artificial neural networks, fuzzy logic, expert or knowledge based systems have been the most successful.

AI techniques play an important role in modeling, analysis and prediction of the performance and control of renewable energy processes. AI techniques have been used to solve complicated practical problems in various areas of engineering and technology and are become increasingly popular. AI systems can be used as 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/or incomplete data, are able to deal with non-linear problems, and once trained can perform prediction and generalization at high speed. AI systems have been used in diverse applications in control, robotics, pattern recognition, forecasting, power systems, manufacturing, optimization, signal processing, or medical, and social sciences. They are particularly useful in system modeling such as in implementing complex mappings and system identification. AI systems comprise areas like, expert systems, artificial neural networks, data mining, genetic algorithms, fuzzy logic and various hybrid systems, combining two or more techniques. Results presented in various papers, are testimony to the potential of artificial intelligence as a design tool in many areas of energy and renewable energy engineering. For the modeling, prediction of performance and control of renewable energy processes, analytic computer codes are often used. The algorithms employed are usually complicated involving the solution of complex differential equations, requiring large computer power and need a considerable amount of time to give accurate predictions. Instead of complex rules and mathematical routines, AI systems are able to learn the key information patterns within a multi-dimensional information domain.

The use of the AI techniques in the environmental and renewable energy applications has increased with recognition of its potential. Many of the renewable energy problems are exactly the types of problems, and issues for which AI approach appears to be most applicable. In these models of computation, attempts are made to simulate the cognitive and sensory functions of the human brain and to use this capability to represent and manipulate knowledge in the form of patterns. Based on these patterns, ANNs, for example, model input-output functional relationships and can make predictions about other combinations of unseen inputs. The AI techniques have the potential for making better, quicker and more practical predictions than any of the traditional methods. On the other hand, data from the renewable energy processes, being inherently noisy, are a good candidate to be handled with AI systems. In the following subsections of this chapter short introduction to the AI techniques is presented, as well as their advantages and disadvantages.

ARTIFICIAL NEURAL NETWORKS

Artificial Neural Networks (ANNs) are information-processing systems inspired by models formulated from the workings of the brain. An ANN consists of interconnected layers of neurons