Chapter 9
Artificial Intelligence for Renewable Energy Systems and Applications: A Comprehensive Review

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ABSTRACT

Artificial Intelligence technology has advanced tremendously in recent years, and it is now widely used in a variety of fields, including energy, agriculture, geology, information processing, medicine, defence systems, space research and exploration, marketing, and many more. The introduction of artificial intelligence technology has ushered in a new era of renewable energy systems and smart power grid modernization. It assists in attaining the intended system availability, reliability, power quality, efficiency, and security goals through optimal resource utilization and cost-effective electricity. Automated power generation systems, energy storage control, wind turbine aerodynamic performance optimization, power generator efficiency enhancement, health monitoring of renewable energy generation systems, and fault detection and diagnose in a smart grid subsystem are just a few of the applications. The main aim of this proposed chapter is to demonstrate how artificial intelligence techniques play a significant role in renewable energy systems with their diverse applications.

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1 INTRODUCTION

Artificial Intelligence (AI) is a phrase, in its usual context, refers to a machine's or artifact's ability to accomplish functions similar to those that characterise human intellect. The term artificial intelligence has been applied to systems and programmes that can execute tasks that are more complicated than simple programming. But they are still far from the world of true cognition. Expert Systems (ES) and Artificial Neural Networks (ANN) are the two important fields of AI. Expert systems are logics that allow the computer systems to make conclusions from data by analysing it and choosing from a set of options (Ricalde et al., 2011; Kalogirou et al., 2014). Automated power generation systems, energy storage control, wind turbine aerodynamic performance optimization, power generator efficiency enhancement, health monitoring of renewable energy systems (RES), and fault detection and diagnose in a smart grid subsystem are just a few of the AI based smart applications. It is worth noting that, of all AI techniques, Neural Networks are currently receiving the most attention for potential applications. With the emergence of efficient and affordable application specific neural network microchips, widespread AI applications are expected to bring about a new sort of good industrial revolution in the future. AI applications have the potential to improve renewable energy by increasing efficiency, which will boost industry growth and, ideally, accelerate adoption. To analyse data, expert systems use a technique called rule - based inference. Considering their development, systems are still incapable of approaching the level of complexity that truly intelligent thought requires. The most dependable future option is emerging as being renewable energy.

Artificial neural networks are made up of a number of small, interlinked processing elements. Interconnections allow data to flow between these entities. There are two values connected with an incoming connection: an input value and a weight value. The unit's output is a function of the total value (Chakrabortty & Bose, 2019; Zhang et al., 2022). ANNs are utilised to perform jobs on computers, although they are not programmed to do so. Instead, they are trained on data sets until they recognise the patterns that are presented to them. After they have been trained, new patterns may be presented to them for prediction or categorization. The following techniques are used in modern AI technologies:

§ Artificial Neural Networks (ANNs)
§ Expert System Techniques (XPS)
§ Fuzzy logic systems (FL)
§ Genetic Algorithm (GA)

These are the key artificial intelligence technique families that are taken into account in the field of modern power systems. The notion of neural network analysis was found approximately 50 years ago, but applications to manage specific issues has just been developed in the recent 20 years. They are particularly useful for jobs involving inadequate data sets, ambiguous or missing information, and very complicated and ill-defined situations, where humans typically make decisions based on intuition. They also have a high level of robustness and fault tolerance. ANNs have been successfully used in a wide range of domains, including maths, medicine, neurology, engineering, economics, agriculture and many more businesses. Image and speech recognition, the study of electromyographs, the detection of military targets, and the monitoring of bombs in passenger baggage are only a few of the most essential. They have also been used in anticipating weather and market patterns, predicting underground mining sites, predicting thermal and electrical load, adaptive and robotic control, and many other applications.