Chapter 4
AI-Powered Antennas and Microwave Components

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ABSTRACT

In wireless communication systems, high-performance antenna, microwave, and radio frequency design systems are essential to meet end-user requirements. As demand for these components increases, it's crucial to design optimized structures in a short amount of time with guaranteed best results. This has led to the need for a higher level of intelligence in the design process. Artificial intelligence (AI) techniques such as evolutionary algorithms (EAs), machine learning (ML), deep learning (DL), and knowledge representation have been widely used to find parameter values of antenna and microwave components, leading to optimized designs in minimum processing time and overcoming long processing times and poor results. This chapter focuses on the major AI methods in the area of antenna, microwave, and other radio frequency (RF) components, including phase shifters, intelligent reflective surfaces (RIS), waveguides, filters, stubs, etc. The chapter discusses different EAs and ML algorithms and their use in optimizing antenna and microwave designs.

DOI: 10.4018/978-1-6684-7702-1.ch004

1. INTRODUCTION

In today's fast-paced world, AI is playing a significant role in the development field of microwaves, antennas, and radio frequency (RF) systems, becoming an integral part of the RF front-end in wireless communication systems. AI techniques in antenna design, including gain, radiation pattern, half power-beamwidth, and S-parameters estimation, provides optimized and accurate results compared to conventional rules based on design experience or computationally long simulations (Weiland et al., 2008).

Traditionally, optimizing sub-optimal antenna and microwave component designs involved a time-consuming process of parameter tuning based on hit and trial methods with no guaranteed results. To address these issues and reduce market time, automation of antenna and microwave component optimization is necessary to obtain nearly optimal designs in the shortest time possible. Antenna structure optimization can be done through local or global optimization methods, with the latter using EAs as the major group of AI for antenna design.

ML algorithms are widely used in many antenna applications. These algorithms have replaced computationally expensive electromagnetic simulations, saving time and effort. In addition, knowledge representation is also used in antenna design through the use of semantic web technologies such as the Ontology Web Language (OWL) illustrated in Figure 1. The concept of ontologies is the first step in automated machine-based antenna and microwave system designs (Goudos et al., 2022).

Figure 1. Categories of AI
Source: Goudos et al. (2022)