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Evolution of Particle Swarm Optimization Technique in Microstrip Patch Antenna Design: A Review Analysis

Isika Ghosh[1], Anurima Majumdar[1], Himadri Bose[1], Jiya Singh[1], Antara Ghosal[1], Suparna Biswas[1]
[1]Department of Electronics and Communication Engineering
Guru Nanak Institute of Technology, Kolkata, West Bengal

Abstract: *Through exploring swarm optimization techniques like Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), and Grey Wolf Optimization (GWO) in the context of microstrip patch antenna (MPA) design, I've gained an appreciation for their powerful ability to solve complex multi-objective optimization problems. These algorithms stand out in modern antenna design, especially in the high performance needs of 5G and IoT applications, by optimizing key parameters such as bandwidth, resonant frequency, gain, and impedance matching. The integration of swarm-based methods with advanced simulation tools like CST Studio Suite and Ansys HFSS amplifies their potential, delivering remarkable improvements in antenna performance, efficiency, and overall design outcomes. One of the key takeaways is how swarm optimization techniques significantly enhance optimization efficiency, cutting down the design time compared to traditional trial-and-error methods. These techniques also provide excellent global search capabilities, avoiding the pitfalls of getting stuck in local minima, which is common in gradient-based methods. With their ability to handle complex, nonlinear problems, swarm algorithms are not only robust but also versatile, making them ideal for a wide range of antenna designs, from multi-band to reconfigurable antennas. Overall, swarm optimization proves to be a transformative approach in antenna design, enabling better performance and cost-effective manufacturing.*

Keywords: *Particle Swarm optimization, Microstrip Patch antenna, Review*

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