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EVOLUTIONARY OPTIMIZATION OF REFLECTARRAYS WITH STEERING BEAM BY FEEDER ROTATION FOR SATELLITE ANTENNAS

Abstract

In the constant request for the advancement of satellite communication systems, in particular efficiency and bandwidth, it is fundamental to have an effective method for optimizing antenna performance. Reflectarrays, well known and adopted in space applications for their compact designs, have become a focus of research and development. Obtaining beam steering through the movement of the feeder is notable for its potential to reduce mechanical complexity and improve overall system reliability for achieving an effective method to adjust beam direction. In addition, by minimizing the electronics required compared to electronically steered counterparts, this approach offers the prospect of significant cost reduction and improved fault tolerance.

Optimization of reflectarray designs poses significant challenges due to the nonlinear and complex nature of these systems. Traditional optimization methods often encounter limitations, especially when high gain and high angles in beam steering are required. In contrast, evolutionary optimization techniques offer a robust solution, that can systematically explore the design space, discovering configurations that not only optimize antenna performance but also conform to specific design constraints.

The objective of this work is to study the optimization of the reflector design by means of evolutionary optimization, with beam steering via feeder rotation, in the context of satellite communication systems. The proposed methodology uses a cross-shaped patch configuration operating at GigaHertz frequencies, providing a solid basis for achieving the desired beam characteristics.

Through a combination of extensive simulations and experimental validations, the research demonstrates significant improvements in antenna agility, gain and reliability compared to traditional designs. In addition, the inherent flexibility of evolutionary optimization allows antenna parameters to be refined to meet the requirements of diverse and dynamic communication scenarios. The implications of this research go beyond immediate improvements in antenna technology. The results underscore the inherent potential of evolutionary optimization as a transformational tool for the advancement of satellite communication systems.