Machine Learning-Driven State Selection Method for Millimeter-Wave Reconfigurable Array Antenna with 360° Beam Scanning

Reconfigurable antennas can enhance 5G network coverage and capacity by dynamically adapting their characteristics to overcome propagation challenges in millimeter-wave (mmWave) environments. In this paper, we first present a singlefed cylindrical conformal antenna with beam-steering capabilities to support full 360° azimuthal scanning. The antenna has eight cascading 4×2 subarrays (i.e., a 4×16 array) operating at 28 GHz and is fed by a reconfigurable feeding network, which enables electrical switching between the subarrays to generate eight distinct radiation beams (states). The switching mechanism is implemented through the integration of PIN diodes within the antenna’s feeding network, modeled as a lumped RLC boundary in the full-wave simulation. Next, machine learning (ML) techniques are integrated into the state-selection optimization method based on the simulation data to select or predict the optimal beam that enhances network performance. We developed a low-complexity, fast-converging state-selection algorithm suitable for real-time applications and capable of adapting to dynamic environments. Using ray-tracing simulations, we modeled a single-user, single radio frequency (RF) chain mmWave communication system, where only one antenna state can transmit at a time. The received power at each antenna state was then used as the reward metric for the state-selection algorithm.