Movable Antenna (MA) Aided Wireless Communications: Opportunities and Challenges

Movable antenna (MA) has been recently recognized as a promising technology for enhancing wireless system performance by exploiting wireless channel spatial variation via antenna movement at the transmitter and/or receiver. In this talk, we provide a comprehensive overview of MAs, including their historical development, practical architectures and implementation methods, contemporary applications in wireless communications and sensing (ISAC), as well as mathematical models, design issues (such as channel estimation, continuous/discrete movement optimization) and promising approaches to solve them. In particular, we present a new field-response-based channel model, which greatly facilitates the analysis, design and optimization of MA-aided wireless systems. Based on this model, various performance advantages of MAs over conventional fixed-position antennas (FPAs) are demonstrated, in terms of spatial diversity/multiplexing, interference mitigation, flexible beamforming, and wireless sensing. Furthermore, a general six-dimensional MA (6DMA) system is introduced, which consists of distributed antenna surfaces that can be independently adjusted in terms of 3D position and 3D rotation to achieve the greatest flexibility in movement. We show that by jointly designing the positions and rotations of all 6DMA surfaces equipped at the base station (BS) based on the users' statistical channel information, the wireless network capacity can be significantly improved over the existing BS with FPAs (e.g., sector antenna arrays). Finally, we shed light on the research directions worthy of investigation in future work to unleash the full potential of MAs for wireless networks.