

The logo for RADemics, featuring the text "RADemics" in white on a blue arrow-shaped background pointing to the right. The arrow is part of a larger blue graphic element on the left side of the page.

RADemics

# AI-Assisted Antenna Systems for Autonomous Vehicles and UAV Communication Networks

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**R. Sundar, Padma Madham, P. Sumathi**

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ENGINEERING AND TECHNOLOGY

# AI-Assisted Antenna Systems for Autonomous Vehicles and UAV Communication Networks

<sup>1</sup>R. Sundar, Associate Professor, Department of Marine Engineering, AMET Deemed to be University, 135, ECR Road, Kanathur, Chennai – 603112. [sundar.r@ametuniv.ac.in](mailto:sundar.r@ametuniv.ac.in)

<sup>2</sup>Padma Madham, Head of Department, Department of Microbiology, Aurora 's Degree &PG College, Chikadapally, Hyderabad- 500020. [padmamicro16@gmail.com](mailto:padmamicro16@gmail.com)

<sup>3</sup>P. Sumathi, Assistant Professor, Department of Artificial Intelligence and Data Science, J J College of Engineering and Technology, Ammapattai, Trichy-620009. [sumathip@jjcet.ac.in](mailto:sumathip@jjcet.ac.in)

## Abstract

The rapid evolution of autonomous vehicles (AVs) and unmanned aerial vehicles (UAVs) has highlighted the need for advanced communication systems capable of supporting high-speed, low-latency, and reliable data exchange. Traditional communication solutions face significant challenges in dynamic and complex environments, where mobility, interference, and environmental factors continuously affect network performance. This chapter explores the integration of Artificial Intelligence (AI) with cutting-edge antenna technologies, particularly focusing on AI-assisted antenna systems, beamforming, and MIMO techniques, to enhance communication in AV and UAV networks. AI-driven approaches enable real-time adaptation of antenna parameters, facilitating optimal performance in the face of changing conditions. Furthermore, dynamic spectrum management and interference mitigation, powered by AI, offer solutions to spectrum congestion and interference in crowded communication environments. The chapter also addresses the challenges of implementing reconfigurable antennas in autonomous systems, considering factors such as hardware limitations, data reliability, and power consumption. Through a detailed examination of current research, case studies, and emerging trends, this chapter provides a comprehensive overview of the transformative role of AI in autonomous communication systems. The discussion emphasizes the potential of AI-enhanced antenna systems to ensure seamless connectivity, reduce communication disruptions, and support the next generation of autonomous transportation networks.

Keywords: Autonomous Vehicles, Unmanned Aerial Vehicles, Artificial Intelligence, Antenna Systems, Beamforming, Interference Mitigation.

## Introduction

The proliferation of autonomous vehicles (AVs) and unmanned aerial vehicles (UAVs) has ushered in a new era of mobility, where communication systems play a pivotal role in ensuring seamless operation [1]. As these autonomous systems become more integrated into urban and rural environments, the demand for high-speed, low-latency, and reliable communication networks intensifies [2]. Traditional communication technologies often struggle to address the complexities of autonomous operations due to the highly dynamic and unpredictable nature of these environments [3]. In response, AI-assisted antenna systems are emerging as an effective solution

to optimize communication in real-time, enabling AVs and UAVs to adapt to their environment and maintain robust connectivity even in the most challenging conditions [4]. This chapter explores the potential of AI-driven antenna systems in enhancing the performance of AV and UAV communication networks, focusing on their ability to dynamically adjust to changing conditions such as vehicle movement, interference, and network congestion [5].

At the core of autonomous vehicle and UAV communication is the need for adaptive antenna systems that can maintain high-quality links across diverse operating scenarios [6]. Traditional static antenna designs are ill-suited for dynamic environments where vehicle speeds, network loads, and interference from surrounding systems constantly fluctuate [7]. AI-powered antennas, which can adjust parameters such as gain, beam direction, and frequency, offer significant advantages over conventional systems [8]. By leveraging machine learning algorithms, AI systems can continuously analyze real-time data from sensors and network conditions to optimize antenna configurations [9]. This real-time adaptability enables AVs and UAVs to maintain optimal communication performance even in highly mobile and interference-prone environments, thus ensuring safer and more efficient autonomous operations [10].

One of the key challenges that AI-assisted antenna systems aim to address is the interference that arises in densely populated communication environments [11]. As AVs and UAVs operate in urban landscapes or during large-scale UAV swarm operations, the risk of signal congestion and interference from other wireless devices becomes more pronounced [12]. AI-based interference mitigation techniques allow for real-time spectrum management and dynamic channel allocation, ensuring that autonomous systems can maintain clear communication links [13]. By continuously monitoring the spectrum, AI systems can detect and respond to interference, shifting to optimal frequency bands or adjusting transmission parameters to minimize signal degradation [14]. These capabilities are particularly critical in environments where multiple autonomous systems are operating simultaneously, as they allow each system to communicate without disrupting others, thereby increasing overall system efficiency and reducing the potential for communication breakdowns [15].