

Revolution of Airport Connectivity and Security: A Case Study on RIS-based 6G Wireless Network

In the evolving landscape of wireless communication, Reconfigurable Intelligent Surfaces (RIS) integrated into 6G wireless networks present a groundbreaking opportunity for enhancing connectivity and security in future airports. This case study delves into the transformative potential of RIS application, offering a glimpse into a future where airport operations are significantly advanced by cutting-edge wireless networks.

RIS technology, a novel concept in wireless communication, manipulates electromagnetic waves to improve signal strength and quality. Coupled with the ultra-fast, low-latency capabilities of 6G wireless networks, RIS promises unparalleled connectivity in complex environments like airports. This application is not only about speed, but also about creating a seamless, secure, and efficient operational ecosystem, benefiting passengers, staff, and airport managers.

AeroRIS, as a sophisticated RIS-based 6G wireless network tailored for airport environments, stands at the core of our research. It leverages Deep Reinforcement Learning (DRL) for optimizing RIS reflection, enabling adaptive wave manipulation. For privacy preservation, AeroRIS incorporates Differential Privacy Federated Learning (DPFL), ensuring that sensitive channel information remains secure. In that case, robust channel model is accessible only to authorised users, thereby maintaining a powerful and private communication network. This feature is particularly crucial in airports, where secure and high-speed data transmission is vital for both operational efficiency and passenger convenience.

The phased rollout began with a literature review about RIS-based 6G wireless networks by mid-2022. Our current focus is on developing a novel RIS-based 6G network empowered by Edge Federated Learning (EFL) and Deep Reinforcement Learning (DRL). The final stage is the deployment phase, where we are motivated to implement our EFL-DRL framework in a real airport environment. This project will provide valuable insights into the practicality and scalability of AeroRIS, informing refinements and potential expansions. Besides, this project is a collaborative venture between NCC Group and our research team at Cranfield University. This partnership brings together the expertise of NCC Group in cybersecurity and digital service with our research team in wireless communication.

Our aim is to revolutionise airport wireless communication with the imperative robustness and security. Our vision is to create a system that not only copes with the high demand of future airports but also improves the efficiency and reliability of airport communications. This system is expected to enhance both operation efficiency and passenger experience in future airport.

My involvement stems from a fascination with the nexus of technology and aviation security. The prospect of addressing real-world problems with innovative solutions drives my dedication to this research, making collaboration with NCC Group, and the Department for Transport.

This project was born out of a shared recognition of the need for advanced wireless communication solutions in the rapidly evolving landscape of airport operation. The initial concept took shape during a series of brainstorming sessions between our research team and experts from the NCC Group. These discussions highlighted the potential of integrating RIS with emerging 6G communication to address the challenges from airports.

Over the recent years, this project has witnessed significant advancements. The initial phase focused on DPFL structure. In the first year, we develop a new intrusion detection system (IDS) in smart airports, empowered by DPFL and knowledge distillation. Since this year, we have been motivated to propose a novel DRL framework, so as to increase the robustness of 6G data rate in smart airports. In addition, we intend to combine this DRL framework with the previous DPFL structure, which will guarantee both robustness and privacy of wireless communication in smart airports.

The core of this project lies in the novel EFL-DRL framework, which is dedicated to optimizing RIS for enhanced signal reflection in 6G wireless networks. EFL enables decentralised data processing, crucial for managing the massive 6G channel model in airport wireless network, while ensuring the privacy of them. On the other hand, DRL is targeted with intelligently adjusting the RIS configuration in dynamic airport radio environment. The fusion of EFL and DRL represents a significant leap in creating a smart, adaptive, and efficient wireless network, perfectly suited for the complex and demanding environment of airports.

This project has made notable advancements in the integration of RIS with 6G networks. By manipulating electromagnetic waves, RIS can drastically improve signal quality and coverage in airports, a venue where conventional wireless networks often face challenges like interference and signal blockages. The compatibility of RIS with 6G has been a focal point of our research, ensuring that the system can support massive data transmission and ultra-reliable low latency communications, which is essential for future airport operation.

Currently, the project is transitioning from simulations to real-world implementation. Our EFL-DRL framework is being fine-tuned with promising result in connectivity and security. The upcoming phase involves deploying this framework in a real 6G network for validation.

Throughout this project, we have gained valuable insights, particularly in harmonising cutting-edge technologies with practical airport applications. One key lesson is the importance of flexible and adaptive systems in dynamic environments like airports. For example, various stakeholders of smart airports are each vulnerable to distinct cyber threats. Individual cybersecurity strategies for each would lead to excessive computational overhead, hindering the evolution of future airport security. In that case, the deployment of Rate-Splitting Multiple Access (RSMA) is being considered. This strategy would segregate the airport's data stream into common and private messages, optimizing the use of scarce resources while providing stakeholders with the most effective cybersecurity measures tailored to their specific needs. The next step involves fine-tuning the system based on real-world feedback, with ambitions to extend AeroRIS beyond airports, setting new benchmarks in wireless communication and security of channel model. Given that simulations often fail to capture the myriad of dynamic real-world factors, leveraging feedback from actual deployments will be crucial. This process will enable further enhancements to our algorithm, making it more responsive and versatile in the face of evolving challenges. The project signifies a leap towards redefining connectivity in the age of 6G and Beyond.