Adaptive Trajectory Optimization of 6G-Enabled Drones Integrating Multi-Access Edge Computing for Border Surveillance

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Research Project

Background
Border security is a critical global concern requiring innovative technological solutions to ensure effective surveillance and threat mitigation. Drones equipped with advanced sensors and communication capabilities have emerged as invaluable assets in border surveillance, offering real-time monitoring and rapid response capabilities. The advent of 6G communication technologies, characterized by ultra-low latency, high bandwidth, and robust connectivity, coupled with Multi-Access Edge Computing (MEC) infrastructure, presents a transformative opportunity to enhance the capabilities of drone-based surveillance systems. This project proposes the integration of 6G-enabled drones and MEC infrastructure to achieve adaptive trajectory optimization, ensuring intelligent, efficient, and reliable border surveillance.

Aim/Objectives
The project aims to design and develop a cutting-edge surveillance system by integrating 6G communication technologies with MEC-enabled drones, focusing on adaptive trajectory optimization to enhance situational awareness, responsiveness, and resource efficiency.

Key Objectives:

1. **Adaptive Trajectory Optimization and Mobility Management**: Design and develop algorithms for real-time trajectory planning and optimization, enabling drones to adapt their flight paths dynamically based on environmental factors, mission objectives, and constraints. Integrate mobility management techniques to ensure seamless connectivity and minimize disruptions as drones transition between MEC coverage zones.
2. **6G Communication and Edge-Assisted Data Processing**: Investigate the capabilities of 6G networks to provide robust, low-latency, high-bandwidth communication for drones. Develop edge-based processing mechanisms that offload computational tasks from drones to MEC servers, enabling real-time analytics for object detection, anomaly tracking, and security threat response.
3. **Dynamic Resource Allocation and Optimization**: Implement advanced resource allocation strategies to distribute computational and communication resources adaptively among drones, considering network conditions and mission-critical requirements. Explore machine learning

approaches, such as reinforcement learning and optimization techniques, to enhance overall system efficiency and scalability.

4. **System Integration and Validation**: Integrate the developed algorithms, communication protocols, and MEC capabilities into a prototype drone-based surveillance system. Conduct extensive field trials in realistic border scenarios to evaluate system performance, scalability, and operational impact.

Impact and Contribution

- **Enhanced Border Security**: The proposed system will significantly improve the detection and mitigation of security threats, increasing situational awareness and operational responsiveness in border surveillance.
- **Advancing Technology**: By leveraging 6G networks and MEC, this project will contribute to advancements in drone-based surveillance technology, influencing domains such as disaster management, environmental monitoring, and infrastructure inspection.
- **Broader Implications**: The innovations developed in this project, including adaptive trajectory optimization and edge-assisted communication, will serve as foundational technologies for future autonomous systems.

Project Timeline

The project spans four years, starting with foundational work on adaptive trajectory optimization and 6G protocols in **Year 1**. **Year 2** focuses on implementing mobility management and edge-assisted data processing, validated through simulations. **Year 3** involves developing resource allocation strategies, system integration, and prototype testing. In **Year 4**, extensive field trials will refine the system, with results disseminated through publications and the final thesis.

Supervision Environment

The Networked and Ubiquitous Systems Engineering Group at the School of Computing offers an exceptional environment for conducting groundbreaking research in this field. As the home of the National EdgeAI Hub, the group provides access to outstanding research facilities, including state-of-the-art Multi-Access Edge Computing (MEC) infrastructure, advanced drone platforms, and cutting-edge 6G communication simulators. This hub fosters collaboration among experts in wireless communication, artificial intelligence, and autonomous systems, creating a unique interdisciplinary research focus. Regular collaboration with industry partners and defence organizations will provide practical insights and enhance the project's applicability.

Applicant skills/background

The ideal candidate should possess:

- A strong background in computer science, electrical engineering, or a related field.
- Knowledge of wireless communication protocols, particularly 5G/6G technologies.
- Experience with machine learning, particularly reinforcement learning and optimization algorithms.
- Proficiency in programming languages such as Python, C++, or MATLAB.
- Familiarity with drone technologies and edge computing will be an advantage.