Abstract

Full-Stack U-Space Airtaxi Path Planning with Microservice Architecture: Performance Analysis and Visualization

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The integration of airtaxis into urban airspaces demands robust, scalable, and modular path planning systems capable of handling the complexity of U-space environments. This ongoing master's thesis project presents the development of a full-stack path planning system based on a microservice architecture, aimed at enabling safe and efficient airtaxi operations in structured low-altitude corridors.

The architecture includes a global path planner using an A* algorithm to compute optimal 3D routes through predefined air corridors (Fig. 1). A local planner based on potential fields is also being considered to enable dynamic obstacle avoidance. The microservice-based approach promotes modularity and independent scalability of each functional component, enabling future extensions such as obstacle data fusion, adaptive replanning, or integration with real-time surveillance feeds without disrupting existing services.

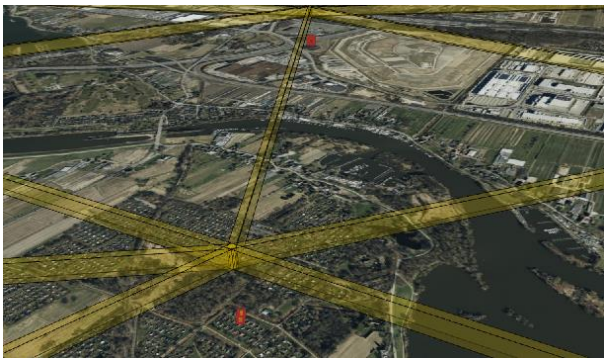

Fig. 1: Schematic of the air corridor network used for global path planning.

The system is implemented using Python and Java SpringBoot with standardized web interfaces. A key part of the evaluation involves analyzing system scalability and latency, including a breakdown of delays across different service stages.

A frontend developed using CesiumJS provides 3D visualization of the generated 4D trajectories. The project, expected to conclude by September 2025, aims to offer a scalable and transferable architecture for IAM stakeholders, including traffic managers, service providers, and municipalities.

By focusing on real-world deployability and integration with smart mobility infrastructure, this work contributes to bridging the gap between U-space theoretical frameworks and operationally viable airtaxi management systems. The architectural approach is inspired by prior work demonstrating the advantages of microservice architectures in UAV applications [1].

Keywords: U-space, airtaxi, microservices, path planning, urban air mobility, CesiumJS

[1] L. Matlekovic and P. Schneider-Kamp, “From Monolith to Microservices: Software Architecture for Autonomous UAV Infrastructure Inspection,” in Embedded Systems and Applications, Mar. 2022.

Biography

Sukhbir Singh

Sukhbir Singh is a master’s student at the Technical University of Munich specializing in flight system dynamics and aerial mobility. His thesis focuses on developing a microservice-based U-space path planning architecture for airtaxi operations, with an expected completion in September 2025.