Master Thesis Topic

Demand-driven Vertiport Siting by Machine Learning and Agent-based Transport Simulation for UAM Network Expansion

Background

Urban Air Mobility (UAM) is a novel concept that aims to minimize travel time and environmental impact while traveling to and from significant locations in and around metropolitan areas. The "AMI AirShuttle" project is being conducted by the Chair of Transportation Systems Engineering (TSE) and its partners to investigate and assess the essential requirements and solutions for integrating electric vertical take-off and landing aircraft (eVTOL) into the infrastructure of commercial airports, with a specific focus on Munich Airport.

Problem statement

The effective integration of Urban Air Mobility (UAM) is contingent upon the strategic selection of vertiport locations. Considering the substantial costs associated with the development of UAM infrastructure, including vertiports, budget constraints will likely limit the number of stations. Specifically, during the second phase of UAM deployment, it is probable that operators in certain regions will aim to expand their networks by constructing additional vertiports. The process of selecting suitable vertiport sites must account for a variety of factors, such as demand, land utilization, costs, and operational efficiency (Mendonca et al., 2022). Predominantly, existing research emphasizes demand as the principal consideration in vertiport placement decisions. **The willingness of residents to utilize UAM services significantly affects the determination of vertiport locations within a region. As the UAM network expands, the demand and performance of existing networks will serve as critical criteria for the identification of new vertiport sites.** Moreover, advancements in machine learning are enhancing the precision of demand forecasts for UAM services.

Core components and methodologies

This master's thesis requires the application of innovative methodologies, with a specific focus on developing a new Mobility as a Service (MaaS) framework. The framework will consist of the following components:

1. Transportation Simulation with MATSim

Utilize the Multi-Agent Transport Simulation (MATSim) toolkit, incorporating existing extensions like the UAM extension, to model multimodal MaaS services. This simulation will help in understanding the current dynamics of urban mobility and the integration of UAM into the existing transport system.

2. Machine Learning Model for UAM Demand Prediction

Objective: Develop a machine learning model to predict the demand for UAM services, focusing on understanding the factors influencing residents' willingness to choose UAM and forecasting demand in areas not yet covered by UAM services.

Methodology:

- **Data Collection:** Extract data on UAM trips from the transportation simulation, including traveler-related features (age, income, etc.), travel cost, travel time, and access/egress legs.
- **Feature Engineering:** Identify and engineer features that are likely to influence the choice of UAM as a transport mode. This may involve creating new variables or transforming existing ones to better capture the dynamics influencing UAM demand.

- **Model Selection:** Evaluate different machine learning models (e.g., regression, decision trees, neural networks) to determine the most effective approach for predicting UAM demand. Consider using ensemble methods or advanced neural network architectures for improved accuracy.
- **Model Training and Validation:** Train the selected model(s) using a portion of the collected data, and validate the model's performance using a separate validation set. Employ cross-validation techniques to ensure the model's generalizability.
- **Demand Prediction:** Apply the trained model to predict UAM demand in areas not currently served by UAM. Analyze the model's predictions to identify potential hotspots for UAM expansion and to guide strategic decisions regarding UAM infrastructure development.

Expected results

The expected outcomes of this master's thesis are to utilize MATSim to determine the future vertiport locations given the current UAM network. Besides, machine learning models for predicting UAM demand should be developed. The model should be used to determine the new vertiport locations in the uncovered areas.

Key skills

1. Fluency in English. German language is not required but could be considered a plus.
2. Able to work independently for 6 months.
3. Completion of the course "Statistical Learning and Data Analytics for Transportation Systems" or equivalent courses.
4. Previous experience with MATSim and **Machine learning** in Python.

Relevant work

Mendonca, N., Murphy, J., Patterson, M. D., Alexander, R., Juarex, G., & Harper, C. (2022, June 27). Advanced Air Mobility Vertiport Considerations: A List and Overview. *AIAA AVIATION 2022 Forum*. AIAA AVIATION 2022 Forum, Chicago, IL & Virtual. https://doi.org/10.2514/6.20224073

For additional information regarding the “AMI-AirShuttle” research project, please visit the following link: https://www.mos.ed.tum.de/en/vvs/research/projects/ami-airshuttle/

Starting date

As soon as possible

How to apply:

If you are interested, please email your **resume** and **start date** to Tao Guo (tao2000.guo@tum.de) or Hao Wu (wu.hao@tum.de).