TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Verkehrswissenschaften „Friedrich List“

Institut für Luftfahrt und Logistik

Professur für Technologie und Logistik des Luftverkehrs

Research Task in Air Transport and Logistics

Topic 04: Energy Consumption Modeling for UAVs Based on Flight Data and Mission Parameters

Background

Accurately predicting the energy consumption of UAVs is essential for safe and efficient mission planning — particularly when operating near endurance limits or planning energy-constrained return-to-home (RTH) trajectories. Flight-data-based energy models support trajectory optimization, mission feasibility checks, and real-time monitoring. In this task, students will analyze recorded flight data and develop both a physics-based and a data-driven model that estimate energy consumption as a function of flight and environmental parameters. The models will then be validated and compared in terms of accuracy, interpretability, and potential use in energy-aware path planning.

Tasks

1. **Data analysis and feature extraction**
   Examine the provided UAV flight datasets containing e.g. position, velocity, altitude, acceleration, and battery status. Structure the data into representative flight segments (e.g., climb, hover, cruise, descent) and extract key features such as displacement, speed, acceleration, altitude change, and wind influence.
2. **Physics-based energy model**
   Derive a simple analytical model linking power consumption to thrust, drag, climb rate, and UAV mass. Formulate relationships between mechanical power, aerodynamic efficiency, and battery power draw, and estimate parameters from available data.
3. **Data-driven energy model**
   Train a regression-based estimator (e.g., linear regression, random forest, or neural network) that predicts energy consumption from the extracted features. Tune the model using a subset of data and evaluate prediction accuracy on held-out samples.
4. **Model validation and comparison**
   Compare measured vs. predicted energy for both models using standard metrics (MAE, RMSE, MAPE). Discuss differences in accuracy, interpretability, and generalization to new flight conditions or UAV types.
5. **Application to energy-aware mission planning**
   Demonstrate how the developed models can be used to estimate energy demand along a sample trajectory. Discuss how such estimations could support RTH decision logic or feasibility checks for extended missions.

Implementation Note

MATLAB or Python may be used. All calculations and models should be clearly documented, with explicit assumptions and units. The analysis can be based entirely on the provided datasets; additional experiments are optional.

Provided Resources

- **Flight data:** Several datasets recorded during UAV test flights, including timestamped position, velocity, altitude, acceleration, battery status.

Deliverables

- **Research paper** (10–12 pages, ≥20 references) submitted as PDF in OPAL.
- Three **presentations** according to course schedule.
- **Code repository** (e.g., Git) containing all analysis and modeling scripts.

Milestones & Workload

- **Initial:** Scope + literature review on UAV energy modeling
- **Mid-term:** Implementation and first validation of both models; error metrics established; comparison framework drafted.
- **Final:** Complete evaluation, application example, and discussion of model limitations and planning relevance; paper finalized.

Team of five; total workload approximately **150 hours per student** (data analysis, modeling, validation, and documentation combined).