Autonomous UAV Networks Simulator

Aerospace-Accurate Edition — User Guide

Overview

This simulator models autonomous UAV mesh networks with aerospace-grade accuracy. It incorporates real RF pathloss, jamming, eavesdropping, and propulsion physics — inspired by Sarkar & Gul (2023). The system allows testing different MAC schemes (TDMA, NOMA, RSMA) and visualizing 3D orbital layers (LEO/MEO/GEO).

Core Modules

1. **Physics Layer:** Implements realistic free-space pathloss and shadowing models with adjustable exponents. 2. **Network Layer:** Builds a dynamic directed graph for source – relay – sink topologies. 3. **Threat Layer:** Includes jammer and eavesdropper entities to simulate hostile network conditions. 4. **Energy Model:** Computes propulsion energy based on aerodynamic drag ($\propto$ speed ^{3}) for each timestep. 5. **Visualization Layer:** Provides 2D and 3D map views with a clean monochrome interface.

User Interface Controls

The sidebar contains all configuration inputs: - **Scenario Setup:** UAV count, number of sources/sinks, simulation steps, area dimensions. - **Radio / RF:** Transmission power, gains, bandwidth, and receiver noise figure. - **Channel & Link:** Frequency, pathloss exponent, shadowing variance, and MAC protocol. - **Propulsion:** Defines aerodynamic efficiency and speed – power scaling. - **Visualization:** Option to enable a real-time 3D orbit view.

Simulation Engine

Each UAV iteratively updates its position and power usage per timestep. The directed graph updates dynamically, recalculating link capacities and routing paths. Throughput, eavesdrop risk, and battery depletion metrics are tracked for every iteration.

Outputs

- **Final UAV Positions:** Displayed in a clean 2D map with labeled nodes. - **Network Graph:** Highlights active data links and throughput magnitudes. - **3D Orbit View:** Depicts UAV topology relative to orbital layers for visual context. - **Metrics Table:** Provides per-step statistics for throughput, average battery, and eavesdrop risk.

Aerospace Accuracy Highlights

- Free-space pathloss (FSPL) formula with MHz – km scaling. - Boltzmann thermal noise baseline with adjustable noise figure. - Power-based propulsion modeling reflecting drag and speed dynamics. - MAC-layer fairness factors based on selected access

schemes (TDMA/NOMA/RSMA).

Recommended Use Cases

• Testing autonomous swarm routing and relay stability. • Evaluating RF performance under jamming or interception. • Visualizing multi-layered airspace coordination. • Researching hybrid communication strategies in contested environments.

References

Sarkar, A., & Gul, M. (2023). *Artificial Intelligence-Based Autonomous UAV Networks: A Survey.* Drones, 7(5), 322. https://doi.org/10.3390/drones7050322