SS 2024-2025, SMT-EXC, DISAL-MP58 Project Summary

Benchmarking a Multi-Robot System Composed of Flying Quadrotors for the Coverage of Known Assets

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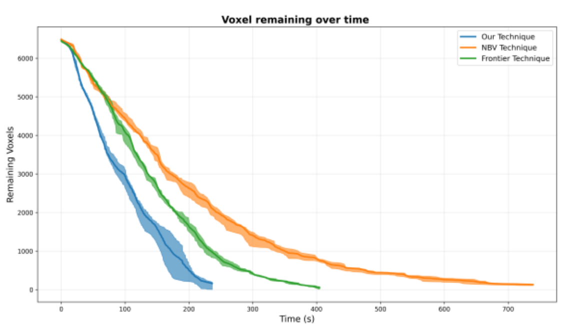
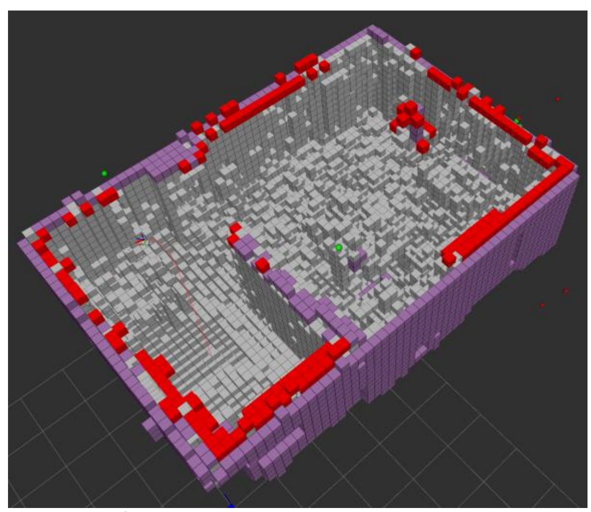
Micro Aerial Vehicles (MAVs) are increasingly used for industrial inspection, surveillance, and emergency response tasks, but traditional coverage path planning techniques often struggle with energy efficiency and computational constraints in multi-robot scenarios. We propose a novel multi-robot coverage path planning approach that uses a PH-tree data structure for real-time identification of unobserved regions. That leads to online task assignment without the computational burden of tracking frontiers or performing Next Best View (NBV) calculations. Our method was checked against top-notch state-of-the-art frontier-based techniques and those of NBV. Each technique was adapted to work under the same conditions to provide a comparison on a similar basis, working with the known geometry of the environment.



Comparison of exploration performance across the three coverage path planning techniques

Demonstrated by our study, our technique is achieving superior performance. Other approaches saw a comparison shake-up, as this one delivers energy efficiency better by three times, up to. We also observe higher speeds of coverage while keeping optimal scalability across assets, all varying in complexity The energy-aware task assignment strategy and efficient unobserved region identification through PH-tree data structure enable real-time multi-robot coordination with reduced computational overhead and shorter path lengths. The obtained results by simulations has been verified with real experiment that demonstrates the capability of our technique to work in real scenarios. As a complementary contribution, we developed an unknown environment exploration framework based on the use of a multi-thread pipeline architecture that integrates a voxel map system for environment representation and a robot system for frontier selection and trajectory planning.. Hence, the system is able to do two things at once - map out the unknown while also navigating at the same time. This takes place safely within environments not known previously, all while ensuring that memory access is safe and all components of the system can securely access it. The path planner is based on the use of an enhanced version of RRT* algorithm that use a TSDF-informed sampling. This sampling method favors open areas and ensures a quicker convergence to what is considered to be the optimal path.



Our system's obtained exploration map

We produced simulations consisting of two separate environments differing in complexity levels. Since it discovers all part of the environment in a decent interval of time, the system proves and shows the framework's effectiveness for an energy-constrained system. This research provides a foundation for energy efficient autonomous exploration systems for known and unknown environments advancing multi-robot exploration capabilities beyond state-of-art techniques.