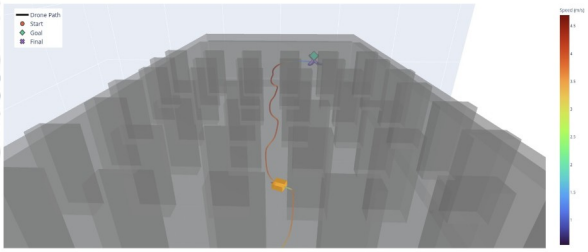
Projeto de Formatura – 2025 – Press Release
PCS - Departamento de Engenharia de Computação e Sistemas Digitais
Engenharia de Computação

Tema: VFF-Nav: Autonomous Drone Navigation using Virtual Force Fields

USP Engineering Students Develop Novel Autonomous Navigation System for Drones Using Virtual Force Fields.

São Paulo, 01/12/2025 – A team of Computer Engineering students at the University of São Paulo's Polytechnic School (Poli-USP) has developed an innovative autonomous navigation system with obstacle avoidance for drones. The project, named VFF-Nav, successfully implements a Virtual Force Field (VFF) algorithm, enabling Unmanned Aerial Vehicles (UAVs) to navigate complex environments and avoid obstacles using genetically tuned parameters.

The project addresses the core challenge of creating a robust, computationally efficient navigation system that operates in real-time. While methods like Virtual Force Fields are promising, their performance is highly sensitive to parameter tuning. The VFF-Nav project overcomes this critical limitation via the usage of a heuristic-based calibration software — leveraging on genetic programming—that automatically finds the optimal parameters for the force field algorithm.



The system is built with a modern architecture divided in three parts:
First, a high-fidelity simulation environment (ROS 2/Gazebo) that mimics real-world physics using a PX4 drone model.
Second, a heuristic-based callibration optimization module that performs a targeted search to identify the most effective parameters for the navigation algorithm.
Finally, the core VFF-Nav controller, which guides the drone by calculating attractive forces toward goals and repulsive forces from obstacles, analogous to static electric forces applied to charged bodies.

This research directly addresses the challenge of making autonomous systems more reliable and accessible. By automating the complex tuning process, the VFF-Nav system paves the way for the wider adoption of drones in critical applications such as infrastructure inspection, precision agriculture, and search-and-rescue operations, where safe and dependable navigation is essential.

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