1. The goal of this work is to develop a whole-body control framework that tightly couples the dynamics of a quadrotor and its onboard robotic arm, allowing the system to perform stable and precise in manipulation tasks.

This type of system has broad applications in \*\*\*\*\* where both mobility and flexibility are required.

2. In traditional systems, the quadrotor and the manipulator are controlled separately.  
But during dynamic tasks — like moving the arm while flying — the interaction forces can cause instability or loss of control.

These failures make the system unsuitable for real applications, where both flight stability and manipulation precision are required at the same time.

That’s why we need a whole-body control approach, which treats the entire platform as a single, tightly-coupled dynamic system.

3. Several works have explored advanced control strategies for aerial systems.  
For example, Acosta they proposed a nonlinear controller for outdoor drones with better stability.  
Saska et al. introduced an MPPI-based controller that allows agile UAV maneuvering.

However, most of these efforts focus only on the drone, without considering manipulator dynamics, especially in real-world conditions.

In this project, we aim to fill this gap by developing a whole-body control strategy and validating it both in simulation and physical environments.

4. This system combines a custom quadrotor with a lightweight robotic arm, modeled in URDF and controlled using ROS and Python, with simulation in Gazebo.

We designed two control strategies: a simple PID controller as baseline, and an MPPI controller for optimal whole-body coordination.

As shown in the diagram, sensor data flows through a state estimator into the MPPI planner, which then outputs commands refined by a low-level PID layer.

5. This timeline shows the complete development roadmap from early June to the end of August.  
In the first two weeks, I’m focusing on finalizing the manipulator design and completing its URDF model in the simulation environment.

Starting mid-June, I will develop and test a PID baseline controller, and then move on to implementing a whole-body MPPI controller for the integrated system.

The second half of July will be dedicated to hardware integration and real-world deployment.

In August, I’ll conduct physical experiments to validate the control strategy, and reserve the final two weeks for detailed evaluation and report writing.

6. This project explores a whole-body control approach for aerial manipulation, where the drone and manipulator act as a single dynamic system.

Such systems could support environmental inspection, object delivery, and maintenance in hard-to-reach spaces, where both mobility and flexiblity are needed.

Future extensions may include integrating visual feedback, enabling cooperative multi-drone systems, and transitioning from MPPI to real-time MPC for better responsiveness.

Ultimately, this work lays the foundation for intelligent, interactive flying robots capable of physically engaging with their environment.