**1. Introduction**

Our project focuses on enhancing drone control by incorporating advanced mathematical models that uses nonlinear control strategies to improve the stability of the drone. This involves adapting complex mathematical ideas from other dynamic models such as Pendulums in order to control quadrotors. Our research is crucial in ensuring drones can function reliably in challenging environments.

The team is structured as follows :

**Clarisse :**

**Surabhi :**

**Sai :**

We utilized MATLAB for precise simulations and Python for its robust libraries like NumPy and SciPy, which are good for complex computations required in drone dynamics. Our team uses GitHub to handle code and documentation, which made easier to collaborate and track progress.

Past research studies have investigated many drone control techniques, mostly linear control strategies. But in complex scenarios these approaches frequently failed. Research into advanced nonlinear control systems such as the methods used in ***“Quadrotor Dynamics and Control”*** paper by ***Randal Beard***, has showed progress in overcoming these limitations. This project is based upon this foundational insights from this paper to improve quadrator performance by using sophisticated nonlinear dynamics

We hope to create a powerful and sophisticated drone control system that can meet the practical needs for current drone applications by integrating complex mathematical models and simulations

The table below categorizes and summarizes the different control strategies that have been proposed for quadrator management

| **Control Strategy** | **Application Area** | **Benefits** |
| --- | --- | --- |
| PID Control | General Operation | Simple implementation, effective for stable environments |
| LQR (Linear Quadratic Regulator) | Precision Maneuvers | Optimal performance in predictable conditions |
| Nonlinear Control | Complex Dynamics | Superior handling in unpredictable environments, such as strong winds or rapidly changing conditions |
| Machine Learning-based Control | Adaptive Missions | Real-time learning and adaptation to new challenges |

**Table 1 : Control Strategies for Quadrator management**

**2. Problem Formulation**

**Key Parameters and Variables in Drone Control**

| Parameter/Variable | Description | Importance in Control |
| --- | --- | --- |
| Importance in Control | Mass of the quadrotor | Affects the drone's inertia and control force |
| g | Acceleration due to gravity | Essential for calculating the lift force |
| Jx, Jy, Jz | Moments of inertia on x, y, z axes | Crucial for rotational dynamics |
| K | Feedback gain matrix | Determines the responsiveness to state errors |
| A,B | System and control matrices for linear dynamics | Defines the linear behavior of the system |
| px, py, pz | Position coordinates along x, y, z axes | Targets for navigation and stability |
| u, v, w | Linear velocities along x, y, z axes | Directly influence flight trajectory |
| phi, theta, psi | Roll, pitch, yaw angles | Affect orientation and thus directional control |

#### **Controller Used**

The control strategy employed is a **Nonlinear Feedback Controller** which computes the required control inputs to stabilize the drone and guide it to the target state:

Control = -K @ (X-Xtarget)

Where K is the feedback gain matrix, X is the current state vector, and Xtarget​ is the desired state vector

**Functions Implemented**:

* non\_linear(control): Computes the next state of the drone based on the nonlinear dynamics and current control inputs.
* linear(current\_state, A, B, control): A supplementary function to check the performance with linear approximations.

**3.Experimental Design**