Title

Student: Chao-Hsien Chih **Professor:** Chao-Chung Peng

Intelligent Embedded Control Lab (IEC-Lab)
Department of Aeronautics and Astronautics
National Cheng Kung University
Tainan, Taiwan

November 26, 2024

Outline

Outline

Review of Prior Studies and Literature

The Coaxial Rotor UAV

- 123

The Swashplateless MAV

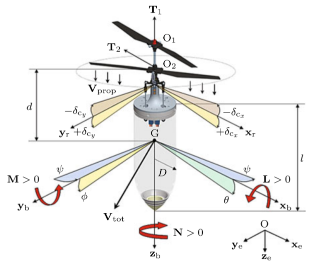
- 123

The Vectored-Thrust Coaxial UAV

- 123

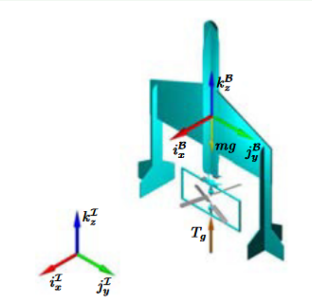
Review of Prior Studies and Literature

The Coaxial Rotor UAV



The Swashplateless MAV

The Vectored-Thrust Coaxial UAV



LM-based Optimal Algorithm

Algorithm 1 LM-based Optimal Control Allocation Algorithm

given an initial value $\mathbf{u}^{(0)}$, $\lambda^{(0)} = 1000$, $\epsilon = 10^{-5}$.
repeat
1. Determine a Jacobian matrix $\mathbf{J}_{\mathbf{r}}^{(k)}$.
2. Update the damping parameter $\lambda^{(k)}$.
3. Update the LM step.
$$\mathbf{d}^{(k)} = -\left(\mathbf{J}_{\mathbf{r}}^{(k)T}\mathbf{J}_{\mathbf{r}}^{(k)} + \lambda^{(k)}\mathbf{I}_4\right)^{-1}\mathbf{J}_{\mathbf{r}}^{(k)T}\mathbf{r}(\mathbf{u}^{(k)}).$$
4. Update the control variables.
$$\mathbf{u}^{(k+1)} = \mathbf{u}^{(k)} + \mathbf{d}^{(k)}.$$
$$k \leftarrow k + 1.$$

until $\|\mathbf{r}\| < \epsilon$ is satisfied, $\mathbf{u}^* = \mathbf{u}^{(k+1)}$.

- In the first iteration step, the initial value $\mathbf{u}^{(0)}$ will be set to zero. After, the initial value is set to the solved result of the previous step.

LM-based Optimal Algorithm

- The condition number $\mathcal{C}$ of the matrix $\left(\mathbf{J}_{\mathbf{r}}^{(k)T}\mathbf{J}_{\mathbf{r}}^{(k)} + \lambda\mathbf{I}_3\right)$ is calculated, and adjust λ adaptively:

$$\lambda = \begin{cases} 1000, & \mathcal{C} \geq 10^5 \\ 0.001, & \mathcal{C} < 10^5 \end{cases} \tag{1}$$

- When the reduction of the cost function is rapid, a smaller value can be applied to accelerate the speed of converting. On the other hand, if the matrix $\left(\mathbf{J}_{\mathbf{r}}^{(k)T}\mathbf{J}_{\mathbf{r}}^{(k)} + \lambda\mathbf{I}_3\right)$ is ill-condition to introduce the numerical errors, the larger value is used to converge with the small gradient step.