Prioritized Control Allocation for Quadrotors Subject to Saturation

Ewoud Smeur, Daan Höppener, Christophe de Wagter

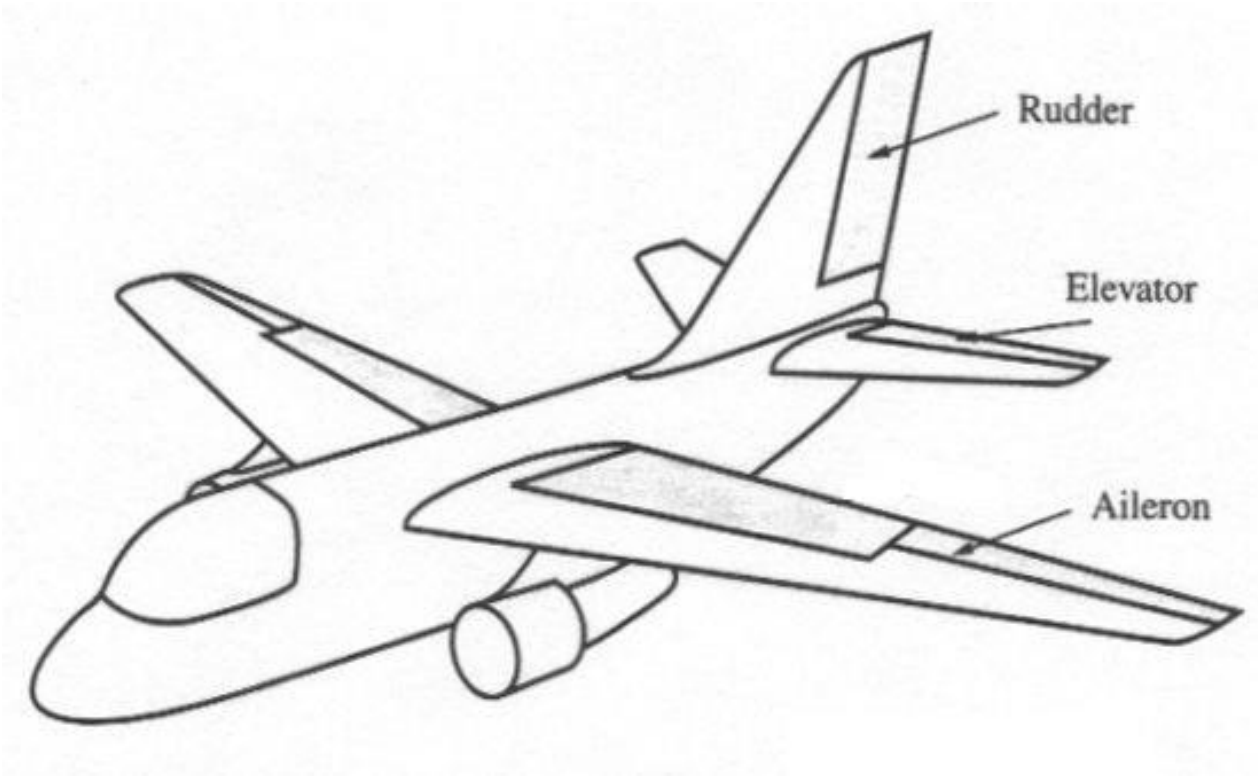
TU Delft

MAVLab

Outline

- Introduction
- Problem formulation
- WLS (Active set method)
- Results
- Conclusion

Introduction



Introduction

TU Delft

Hypothesis

- MAV stability can be improved with the right control *priorities*
- Proposed order: roll, pitch > thrust > yaw

Incremental nonlinear dynamic inversion

$$\begin{bmatrix} \dot{\Omega} - \dot{\Omega}_0 \\ T - T_0 \end{bmatrix} = G(\omega - \omega_0)$$

$$\begin{bmatrix} \Delta\dot{\Omega} \\ \Delta T \end{bmatrix} = G\Delta\omega$$

TU Delft

Problem formulation

$$v = Gu$$

$$u_{\min} \leq u \leq u_{\max}$$

Cost function Weighted Least Squares (WLS):

$$C(u) = \left\| W_u \left(u - u_d\right) \right\|^2 + \gamma \left\| W_v \left(Gu - v\right) \right\|^2$$

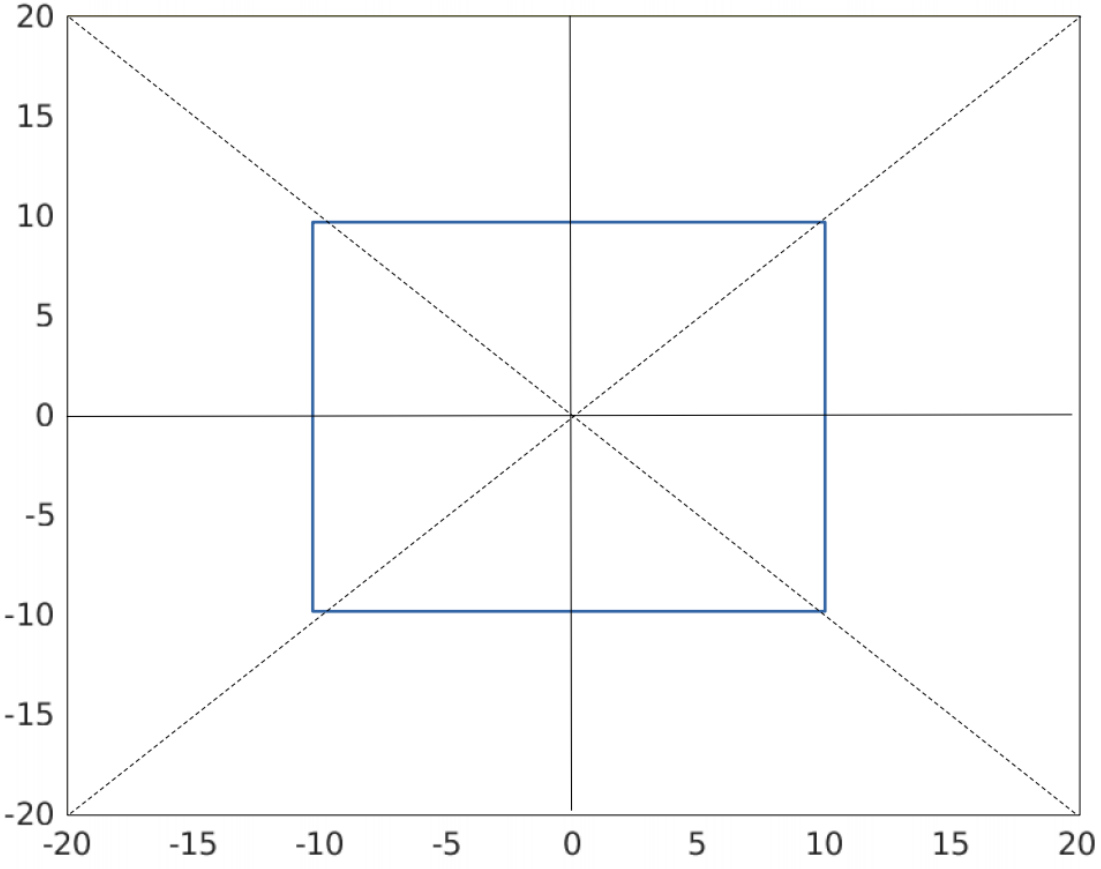
$$C(u) = \left\| \begin{pmatrix} \gamma^{\frac{1}{2}} W_v G \\ W_u \end{pmatrix} u - \begin{pmatrix} \gamma^{\frac{1}{2}} W_v v \\ W_u u_d \end{pmatrix} \right\|^2$$

A * u - b

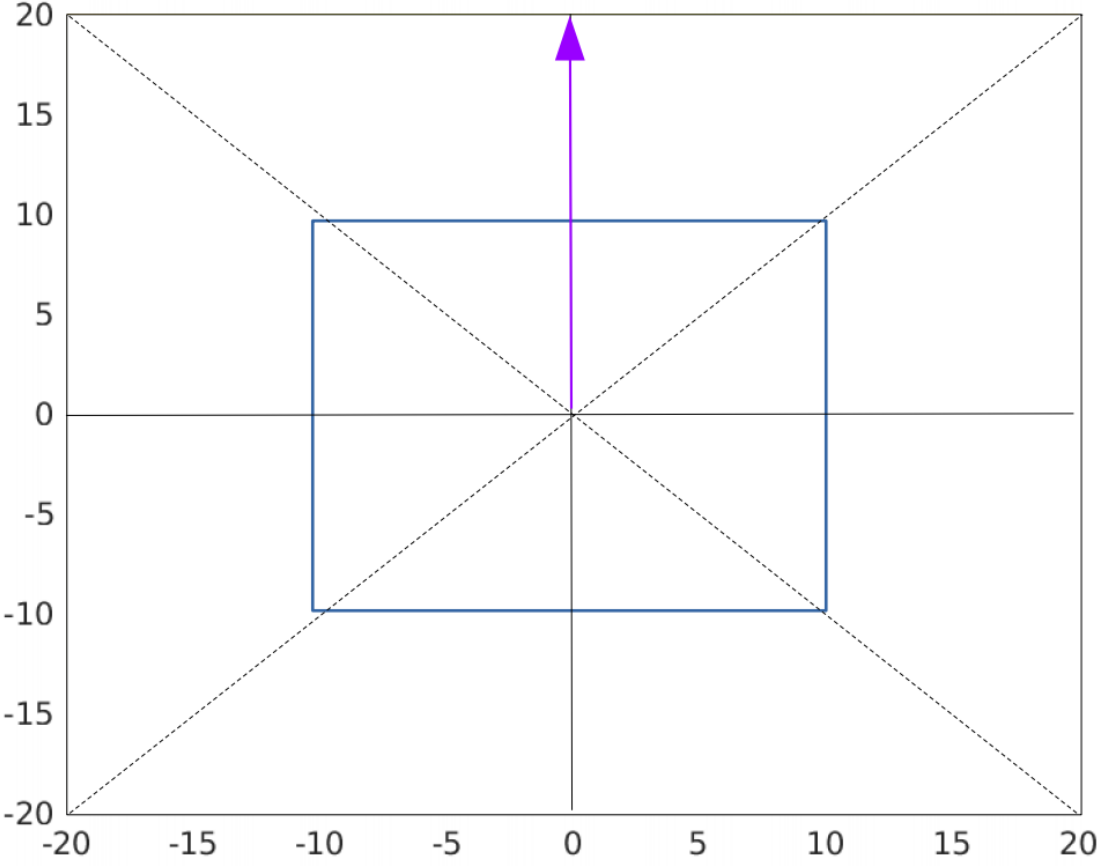
Active set method

- Active set
- Solve unconstrained problem
- Check constraint violations
- Check optimality with Lagrange multipliers

Weighted least squares

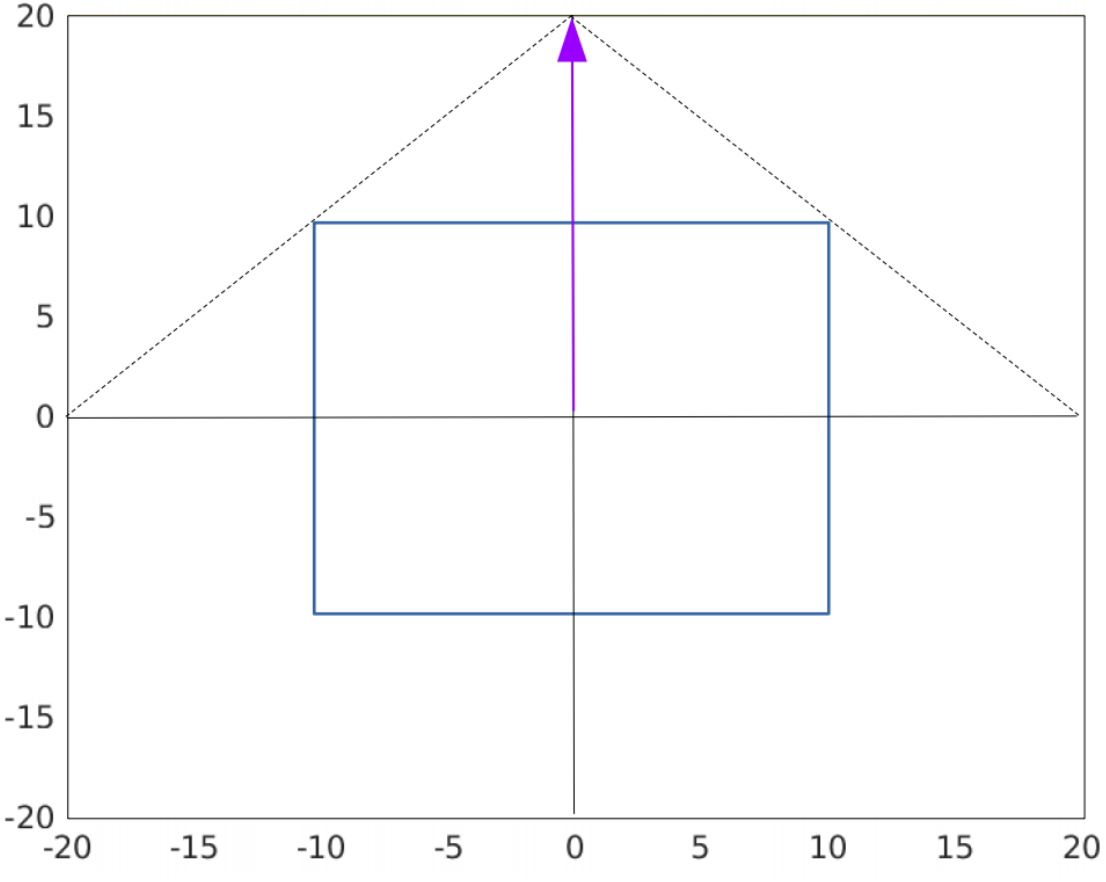


Weighted least squares

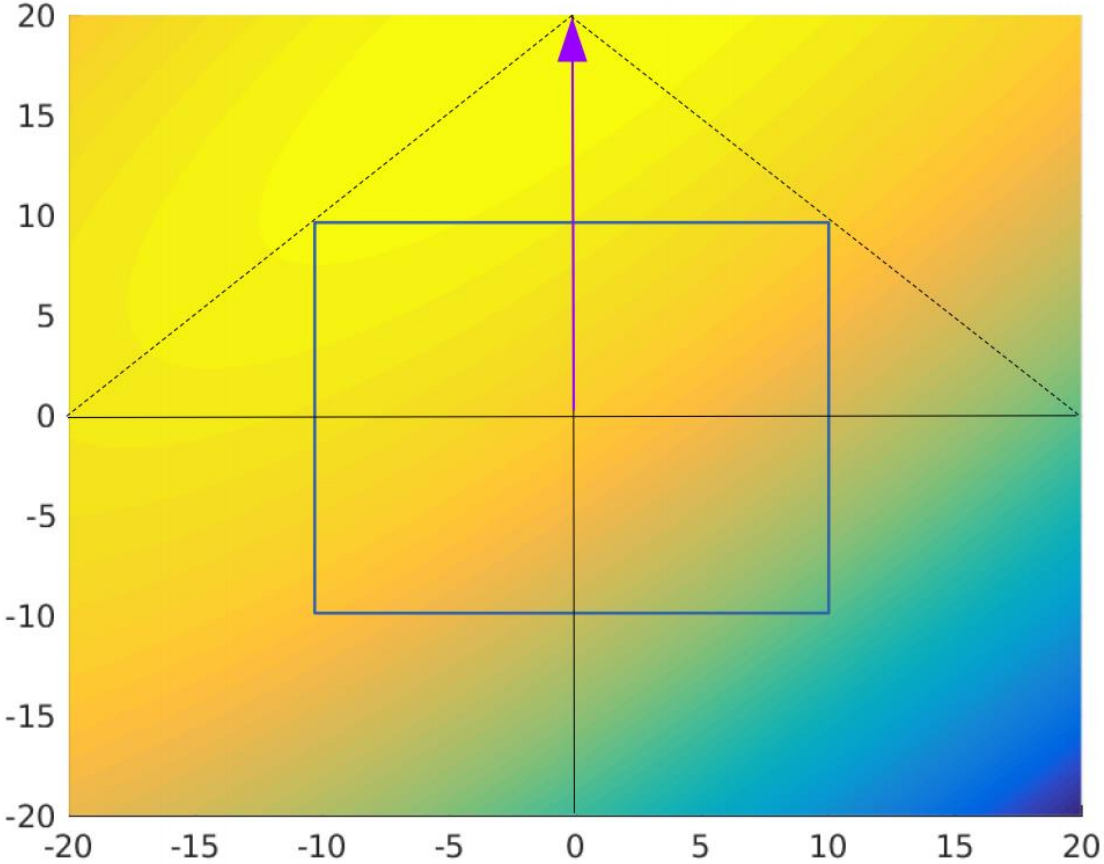


TU Delft

Weighted least squares

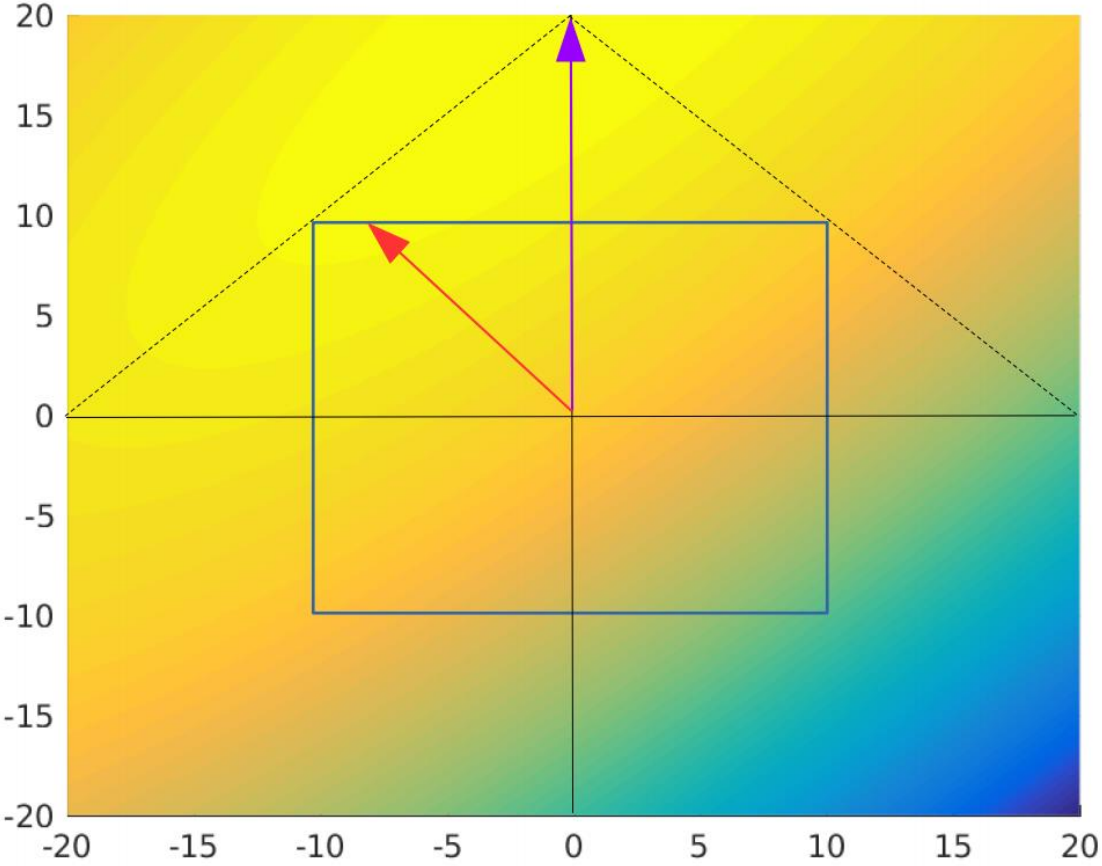


Weighted least squares



TU Delft

Weighted least squares



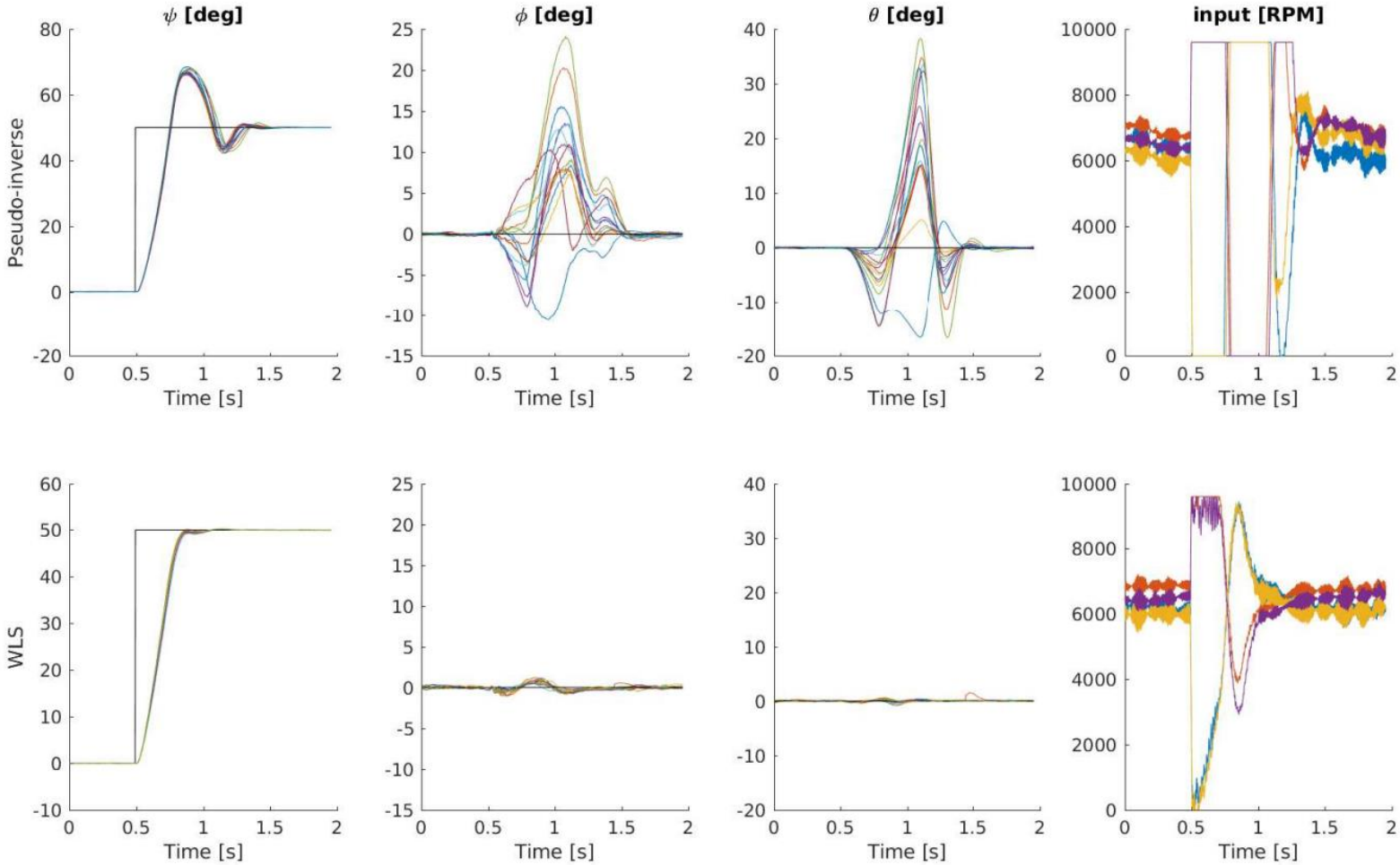
TU Delft

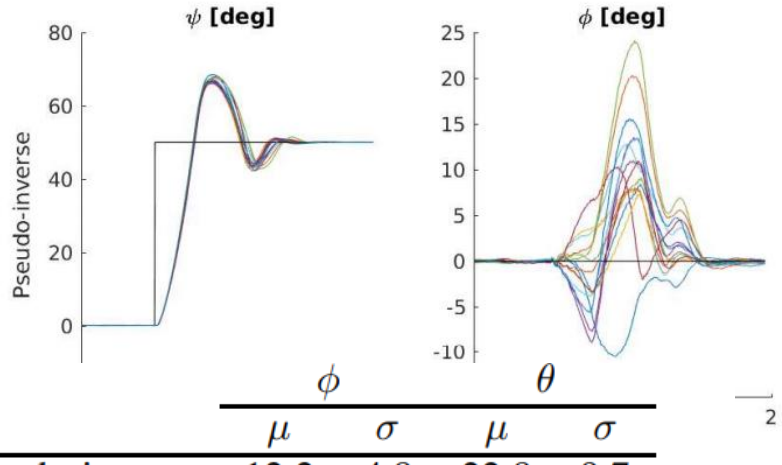
Experiment

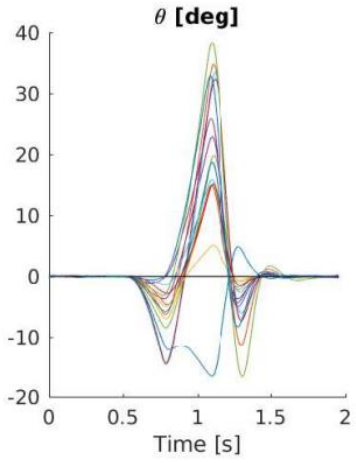
- 90 degrees yaw
- 0 roll and pitch
- Constant thrust

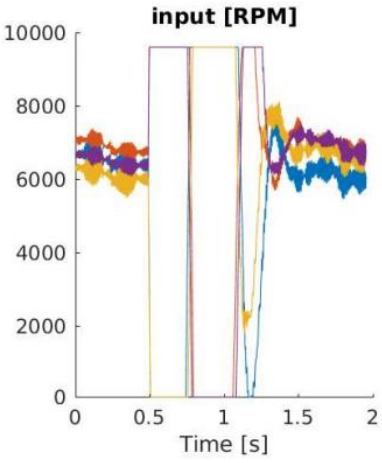
- Priorities: Roll, pitch, yaw, thrust

  1000, 1000, 1, 100

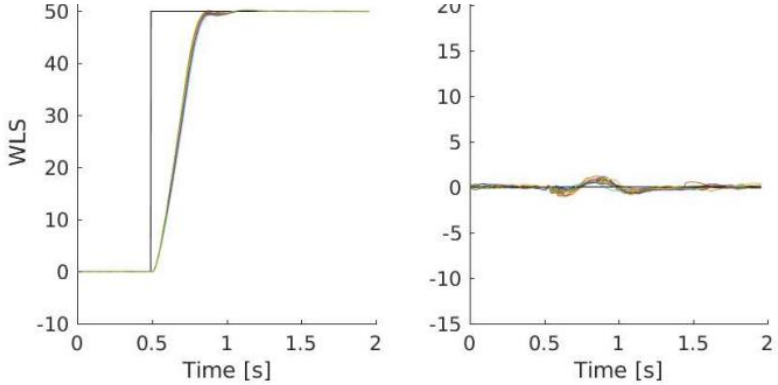

ψ [deg]
φ [deg]
θ [deg]
input [RPM]
Pseudo-inverse
WLS
Time [s]

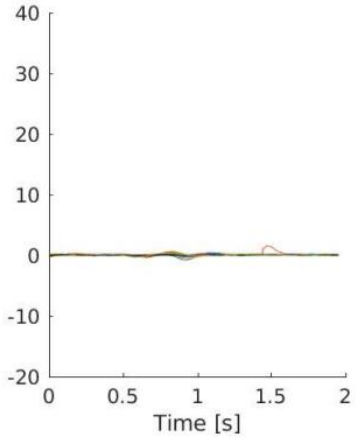


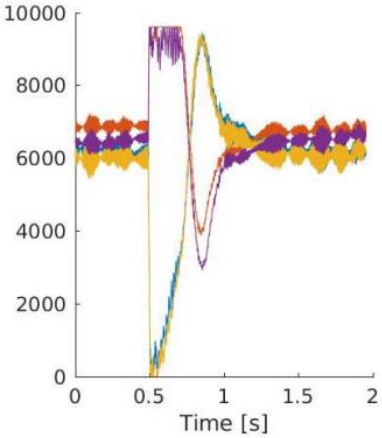




	ϕ		θ	
	μ	σ	μ	σ
Pseudo-inverse	12.2	4.8	22.8	9.7
WLS	0.9	0.2	0.5	0.4







Other types of MAV: Cyclone

Conclusion

- Prioritized control allocation can improve stability of MAVs
- Can be used in combination with incremental control
- Applicable to different types of MAV

Future research

- How to deal with saturations in the guidance loop
- Dealing with actuator faults