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SOLAR THERMAL ENERGY
RESEARCH GROUP

Adaptive control of a quadcopter

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Overview

- Background
- Control Overview
- Controller Design
- Results
- Conclusion

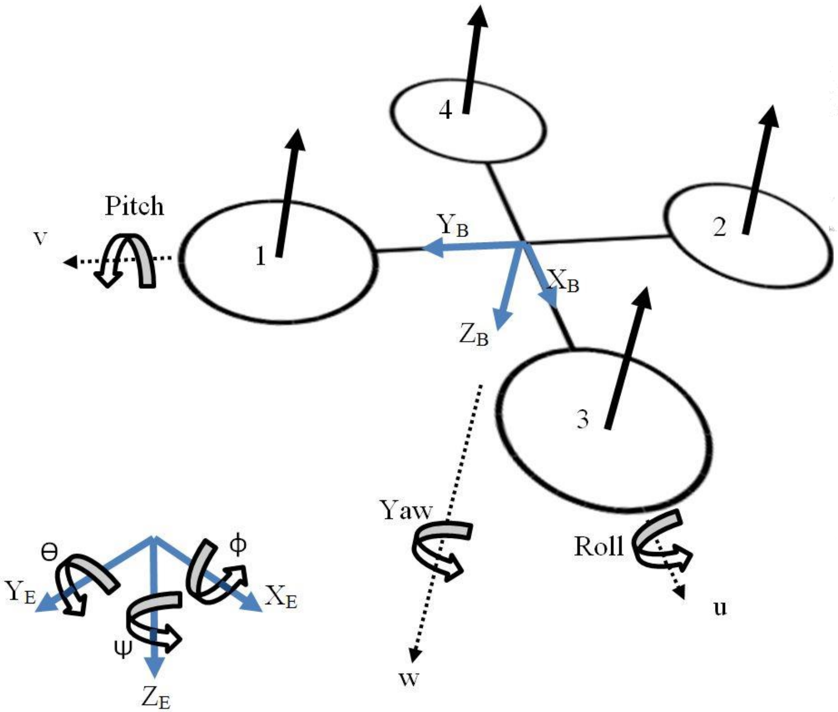
Background

Motivation

- Reduce cost of concentrated solar power (CSP) plants
- Optimizing heliostat calibration will allow for cheaper actuators and gearboxes
- Pair of quadcopters for calibration
- Improve quadcopter control
  - Existing PID controllers are unique to model
  - Compensate for change in model?

Background

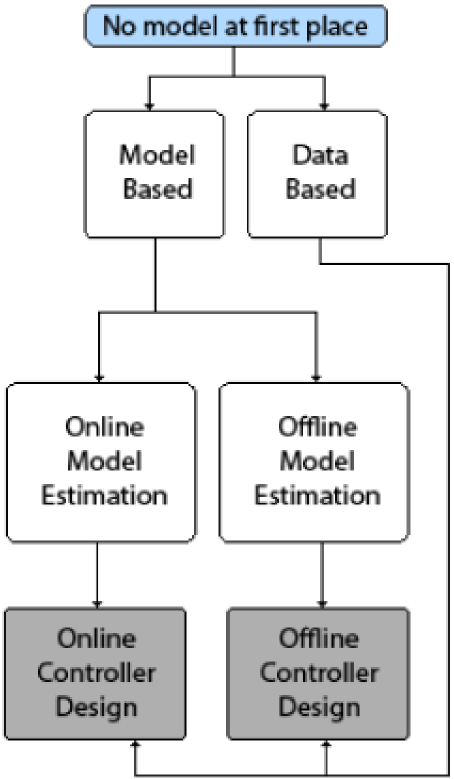
Quadcopters



Control Overview

Approaches

- Construct a mathematical model from data obtained by tests
- Use sensor values to directly find a controller without a model



Control Overview

Choice for project

- Model Reference Adaptive Control
- L1 Adaptive Control
- Multiple Model Adaptive Control
- Neural Networks

Control Overview

Model Reference Adaptive Control (MRAC)

- Uses a reference model to determine desired response
- Adaptive law is used to adjust controller
- System output compared to desired response of reference model
- Drive to zero

$$dH/dt=-K.x_m.e_c$$

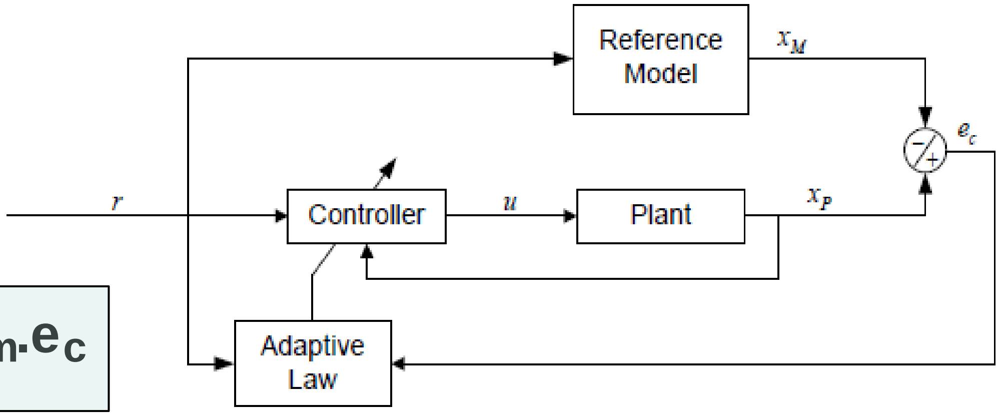
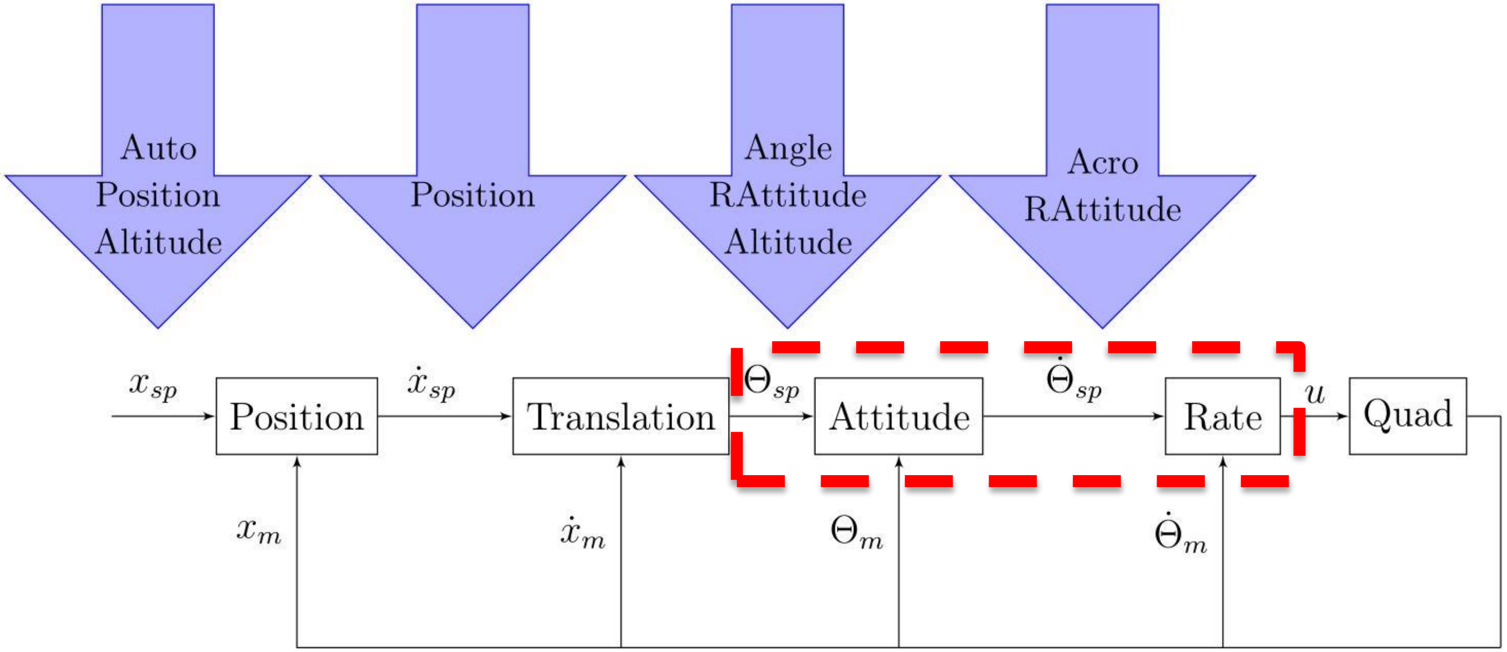


Figure: MRAC Control

Controller Design

Flight modes



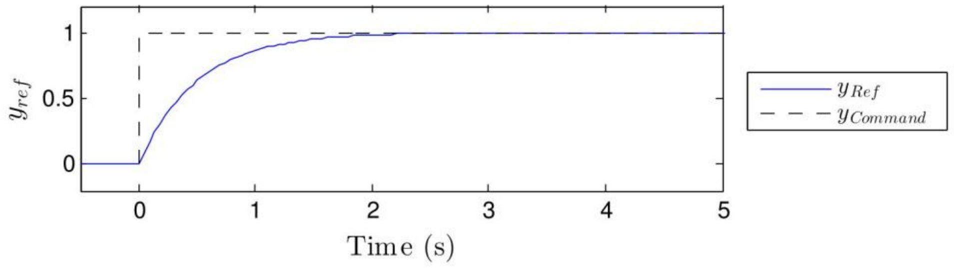
Controller Design

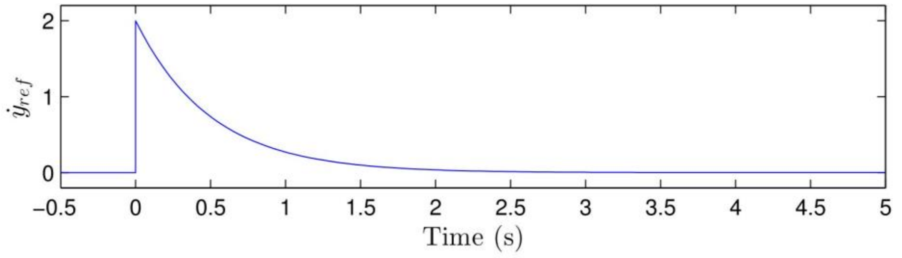
Outer Loop (attitude angles)

- Cascade controller
  - Angle loop (outer)

Angular command in earth frame
↓
Angular velocity in body frame

$$\dot{y}_{ref}(t) = \frac{1}{T}(y_{command} - y_{ref})$$





Controller Design

Inner Loop (attitude angle rates)

$$\dot{p} = \frac{I_{yy} - I_{zz}}{I_{xx}} qr - \frac{J_T P}{I_{xx}} q\Omega + \frac{U_2}{I_{xx}}$$

- Modelled system equation

$$\frac{dx_p}{dt} = A_p x_p + B_p U + \alpha f(x_p) + d$$

- Desired system equation

$$\dot{x}_d = A_d x_d + B_d r$$

- Proposed control law

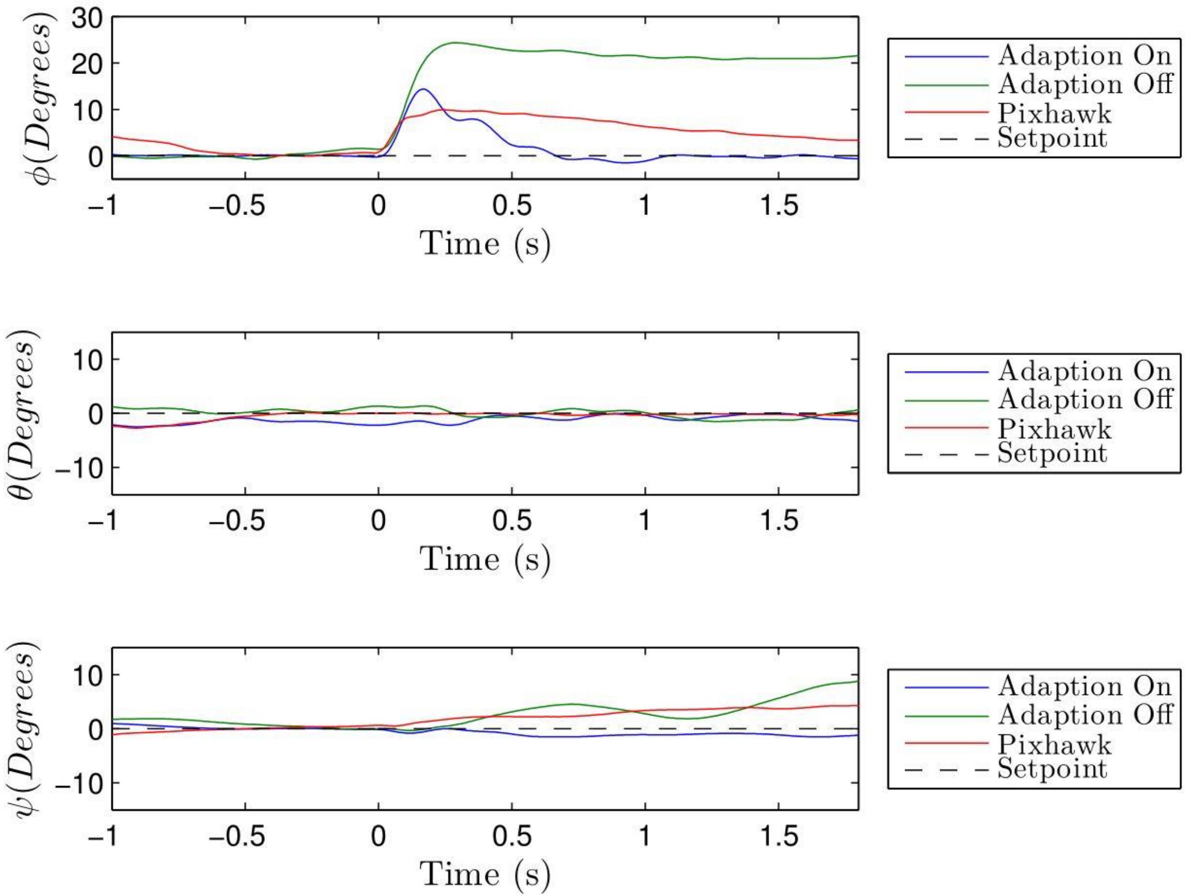
$$u = \Theta_x x_p + \Theta_r r + \Theta_\alpha f + \Theta_d i_{vec}$$

- Cost function

$$V = \frac{1}{2} e^T P e + \frac{1}{2} Tr[\Theta_*^T \Gamma^{-1} \Theta_*]$$

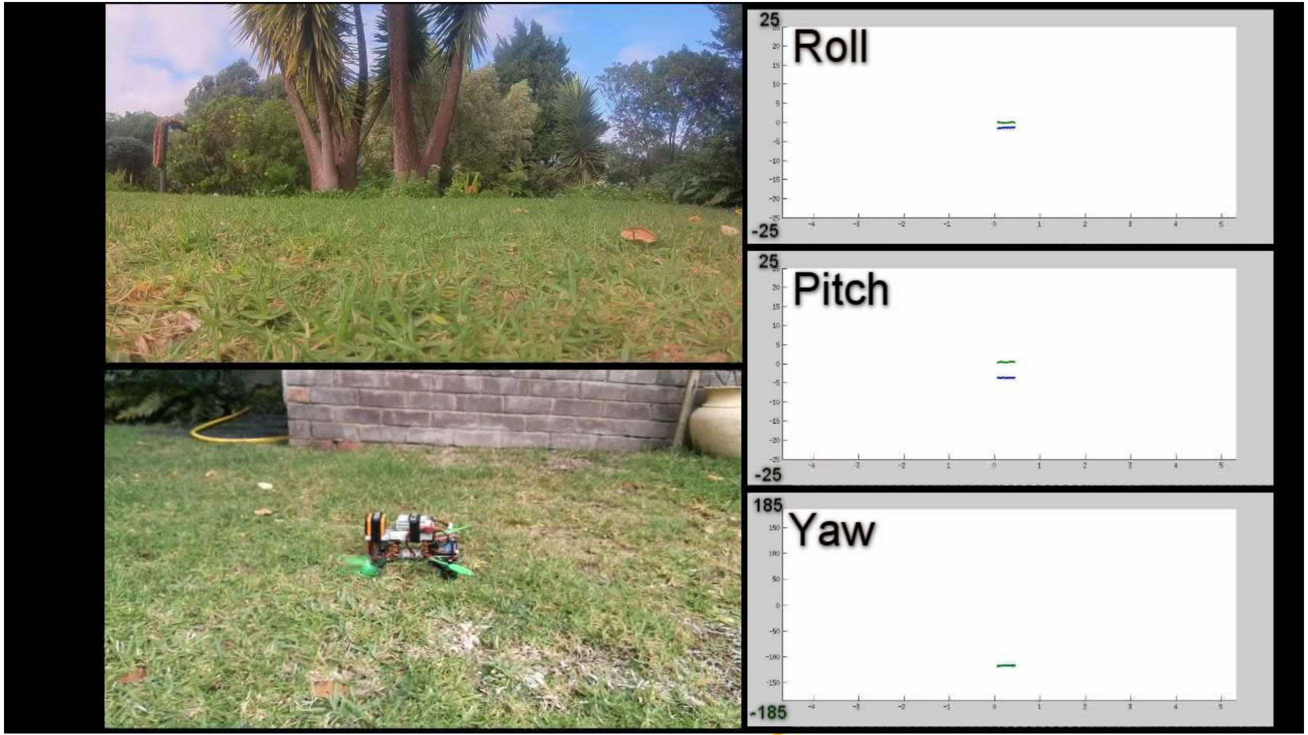
Results

Disturbance



Results

Learning (video)



Conclusion

- Compared to current controller
  - If well tuned, no clear difference in basic flight
  - Better at rejecting disturbances
  - Accommodate a change in model

Thank you

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