ETH zürich

Estimation of Actuation Configuration for a Multi-Actuated Blimp

Final Presentation (Semester Thesis)

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Motivation

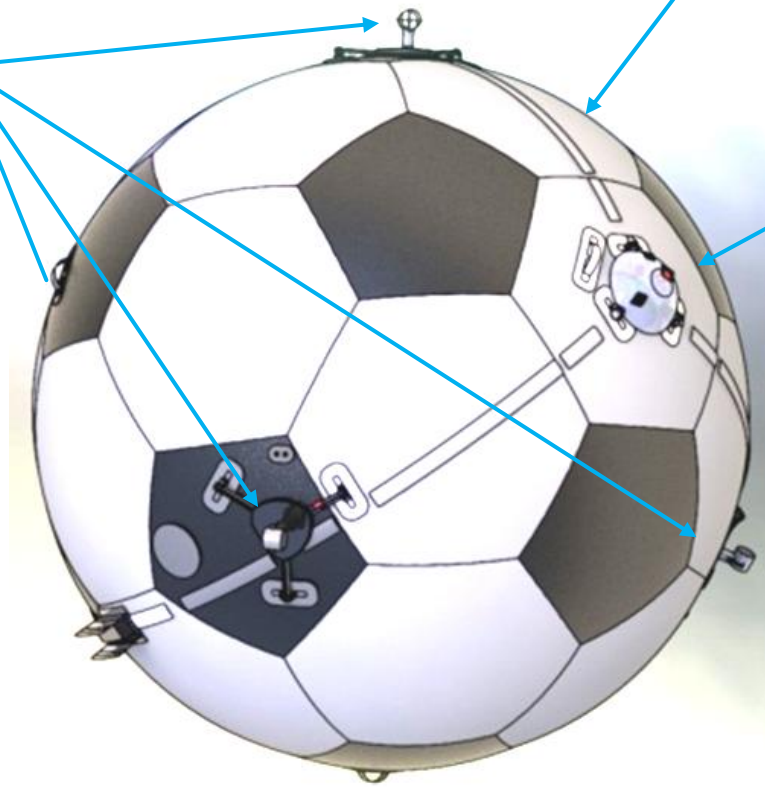
- FANCY SLIDE
- Parameters

System Overview

Spherical Hull filled with Helium

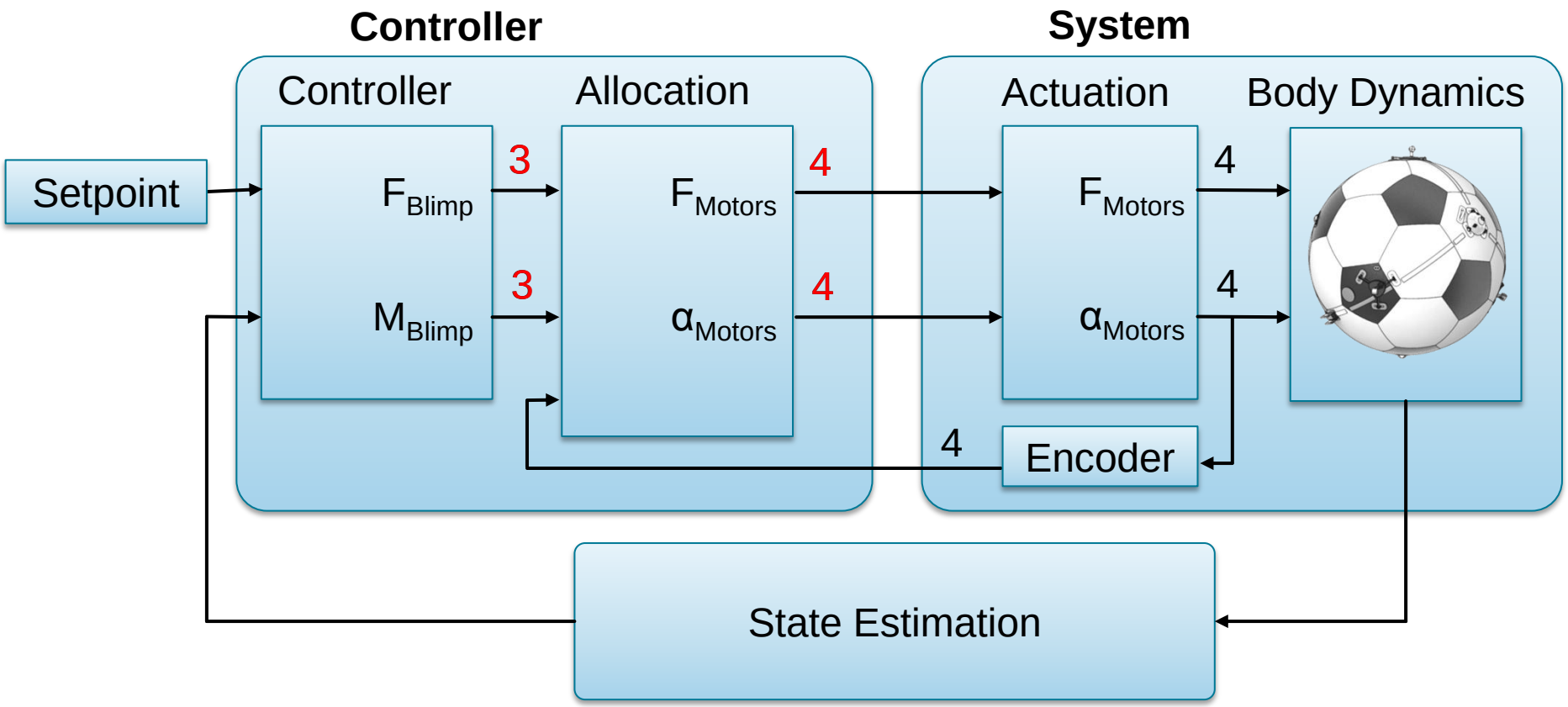
4 Actuation Units (AU)

Electronics:
- IMU
- Controller
- XBee

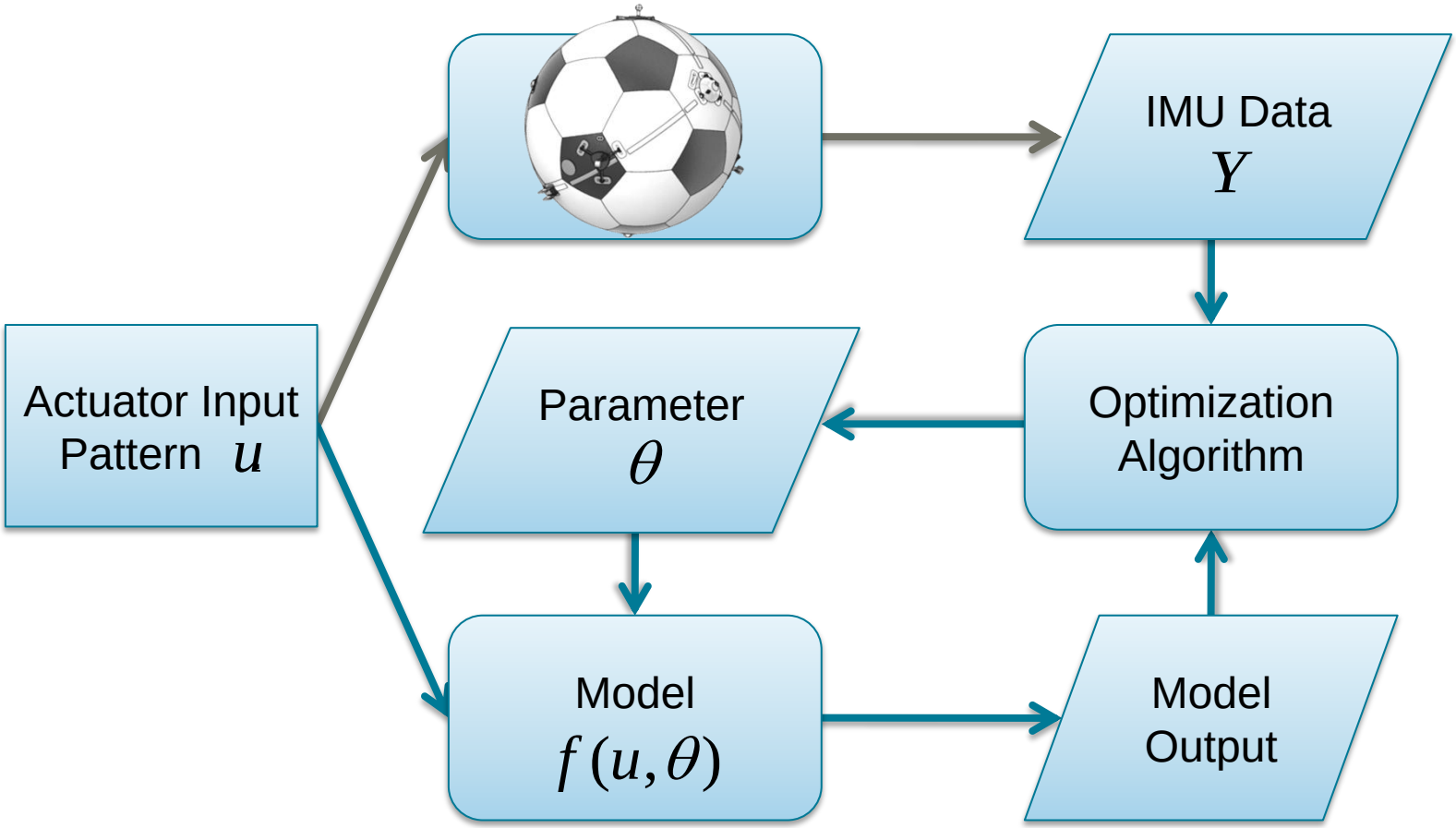


Rotation

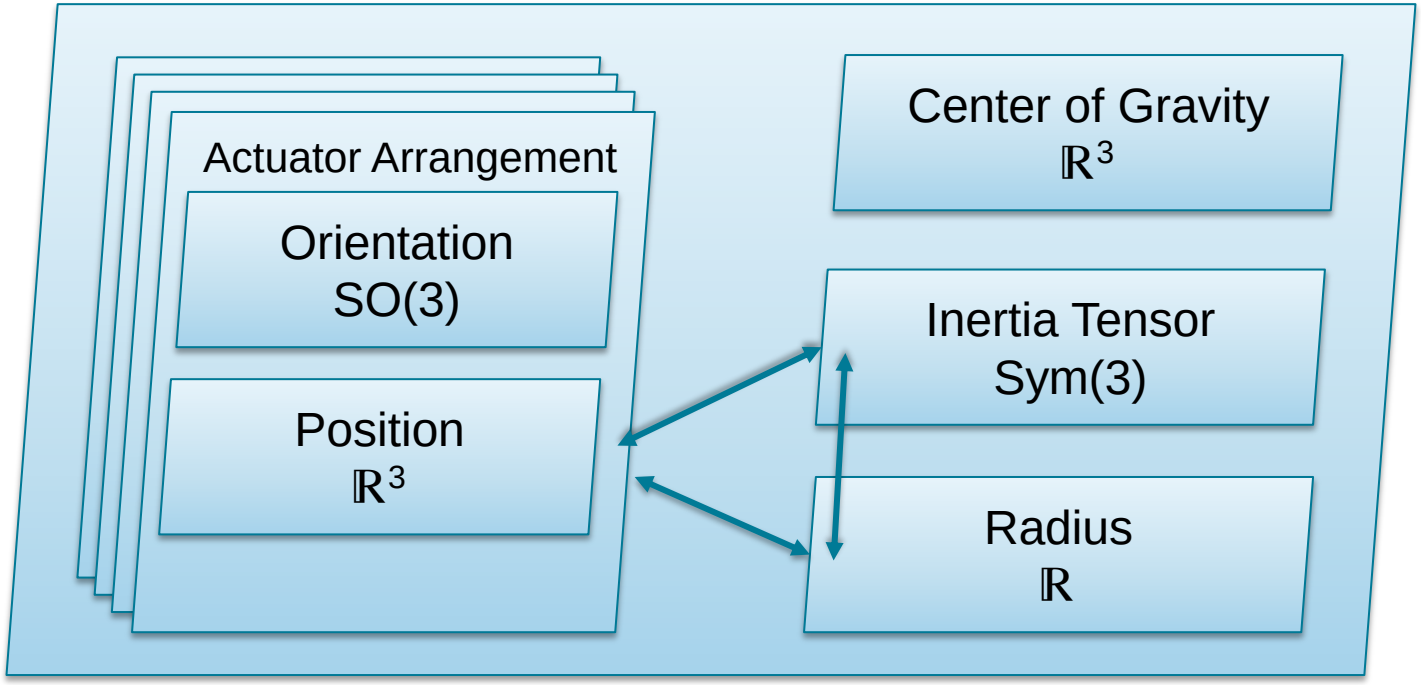
System Overview



Problem Formulation

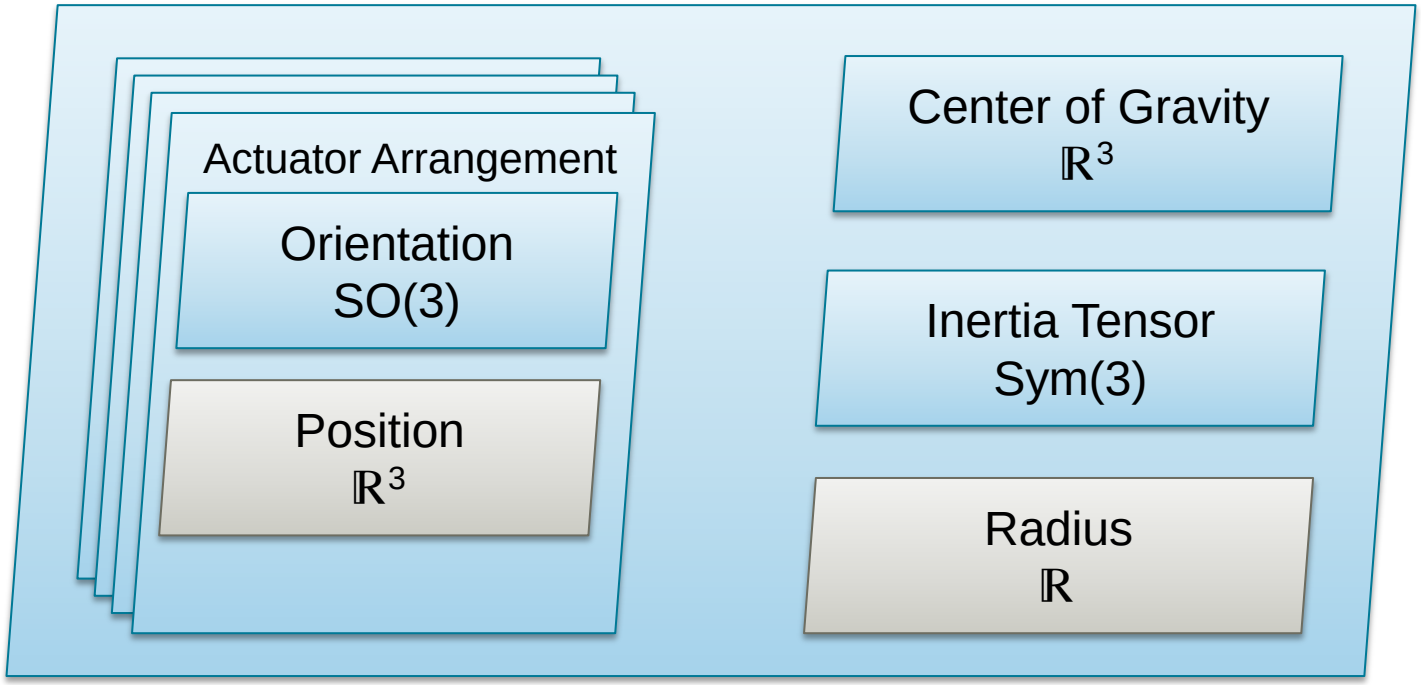


Problem Formulation: Parameters



Full Parameter set is only jointly observable

Problem Formulation: Parameters



Full Parameter set is only jointly observable

Problem Formulation: System Model

- Angular Acceleration

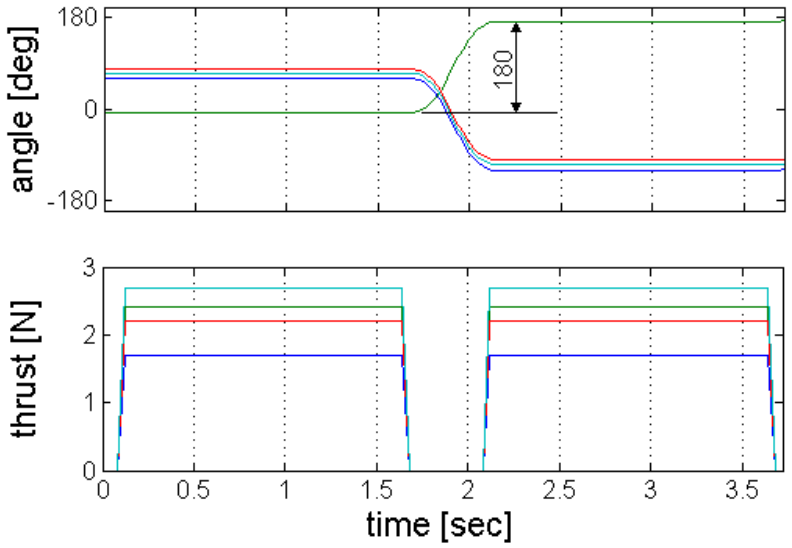
$$\mathbf{f}(\mathbf{x}, \mathbf{u}, \boldsymbol{\theta}) = \hat{\boldsymbol{\alpha}} = \mathbf{J}^{-1}(\mathbf{M} - \boldsymbol{\omega} \times \mathbf{J}\boldsymbol{\omega})$$

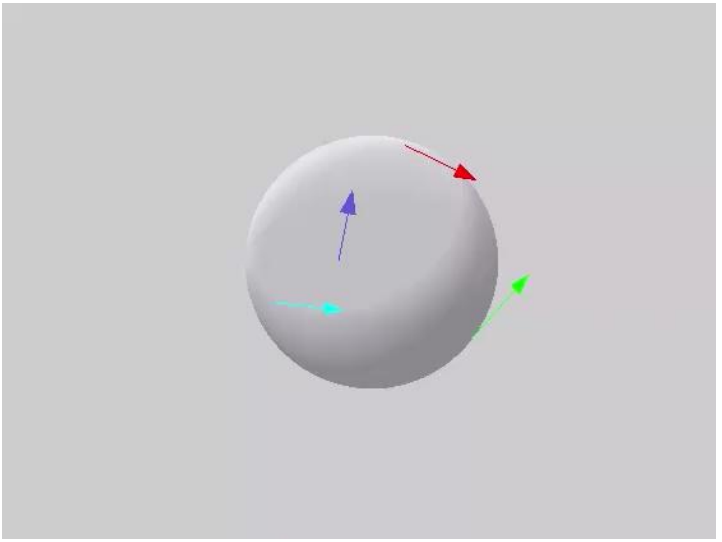
$$\mathbf{M}_b = \sum_{k=1}^{N} \left[\mathbf{C}_{b,m_k} \left(\mathbf{p}_{m_k}^{m_k,cog} \times \mathbf{F}_{m_k}\right)\right] - \left(\mathbf{p}_b^{cob,cog} \times (m\mathbf{C}_{b,w}\mathbf{g}_w)\right)$$

  - Assume constant actuator states
  - Neglect aerodynamic effects on rotation

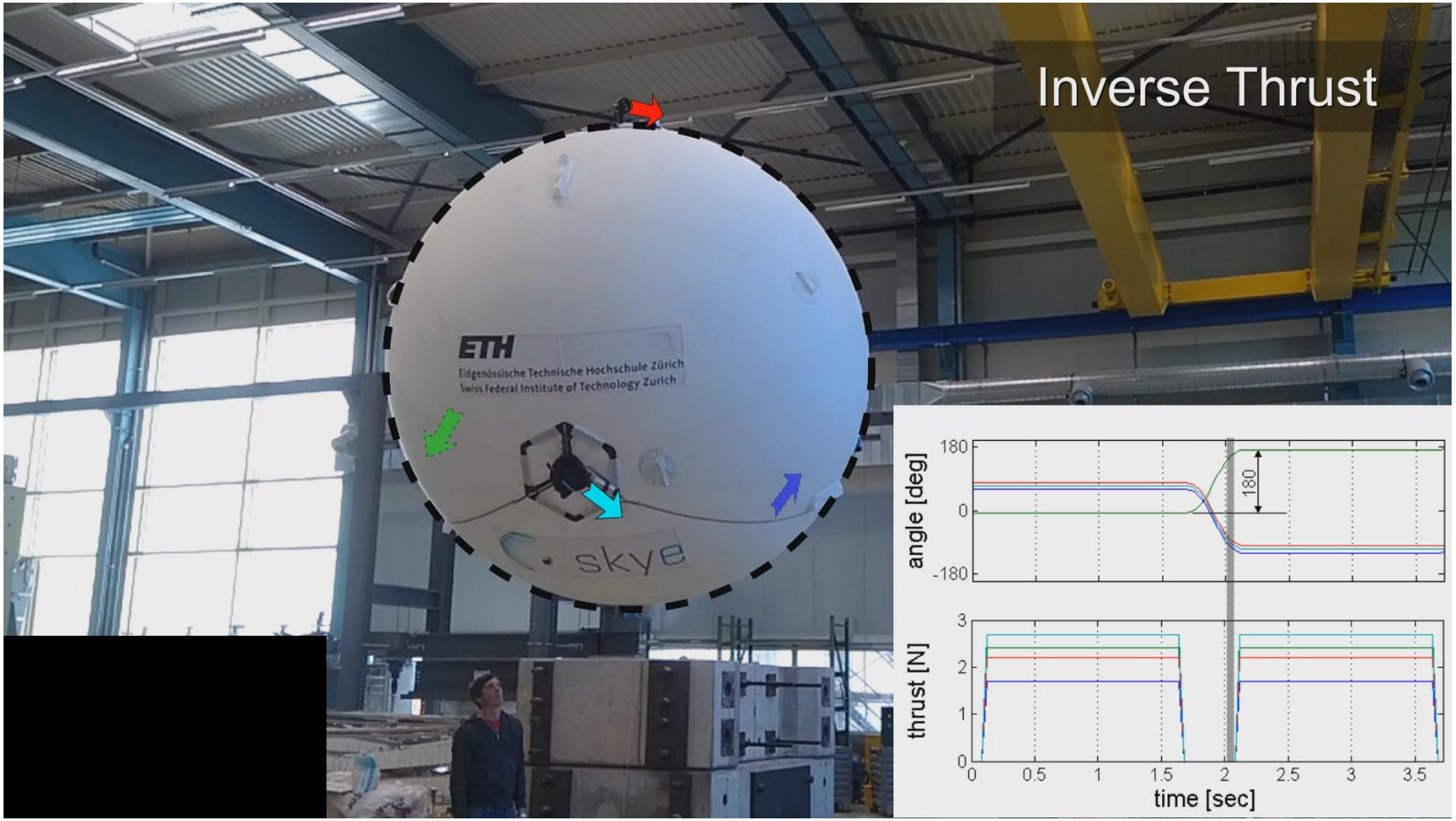
Problem Formulation: Input Pattern

- Inputs must be **applicable** and **sufficiently excited**
  - Apply sequence of **forward/backward** force patterns in **varying directions** for all actuation units
  - Steady state motor dynamics





Problem Formulation: Input Pattern



Problem Formulation: Optimization

- Nonlinear Least Squares

$$S(\boldsymbol{\theta}) = \sum_{i=1}^{N} \|\mathbf{y}_i - \mathbf{f}(\mathbf{x}_i, \boldsymbol{\theta})\|^2$$

- Levenberg-Marquardt
  - Robust and fast gradient based minimization

$$(\mathbf{J}^\top \mathbf{J} + \lambda \mathrm{diag}(\mathbf{J}^\top \mathbf{J}))\boldsymbol{\delta} = \mathbf{J}^\top [\mathbf{y} - \mathbf{f}(\boldsymbol{\theta})]$$

Results

- Simulation
- Experimental Data
- Groundtruth with Leica

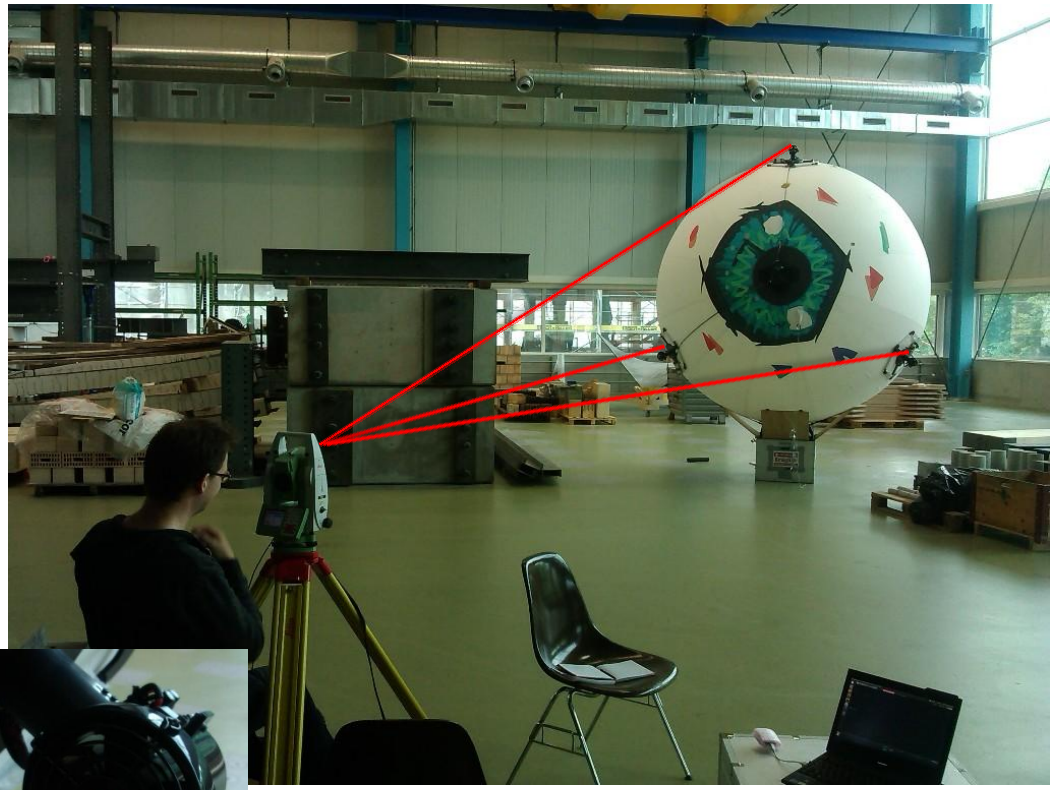
Results: Simulation

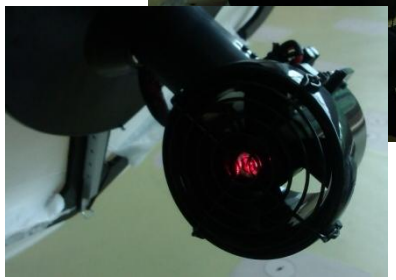
Results: Experiments

Results: „Ground Truth“ (Leica)

- 3 AU‘s visible at once
- Use different views

- Fit data to get tetrahedral‘s edge length
  - Residual below 0.01m

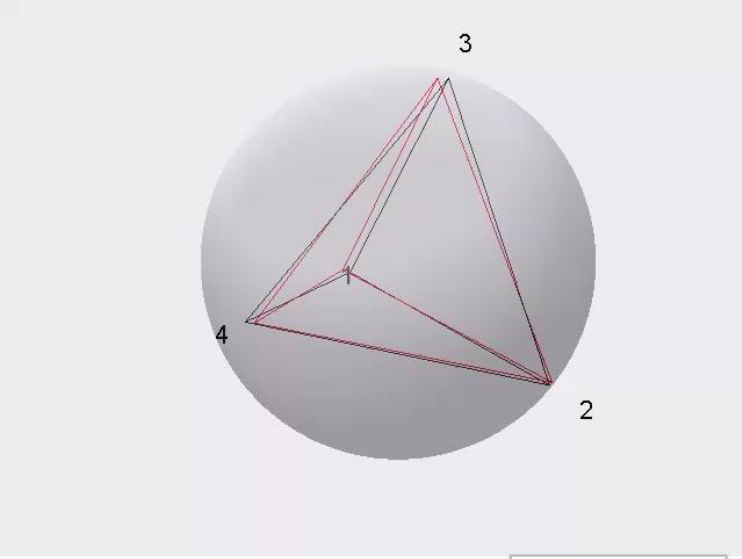




Results: Compare Leica and Batch Solution

- Compare tetrahedral edge length

Relative error of batch solution			
%	AU2	AU3	AU4
AU1	1.68	0.86	2.76
AU2		0.67	2.47
AU3			3.78



Discussion

Outlook