ETH zürich

Estimation of Actuation Configuration for a Multi-Actuated Blimp

Final Presentation (Semester Thesis)

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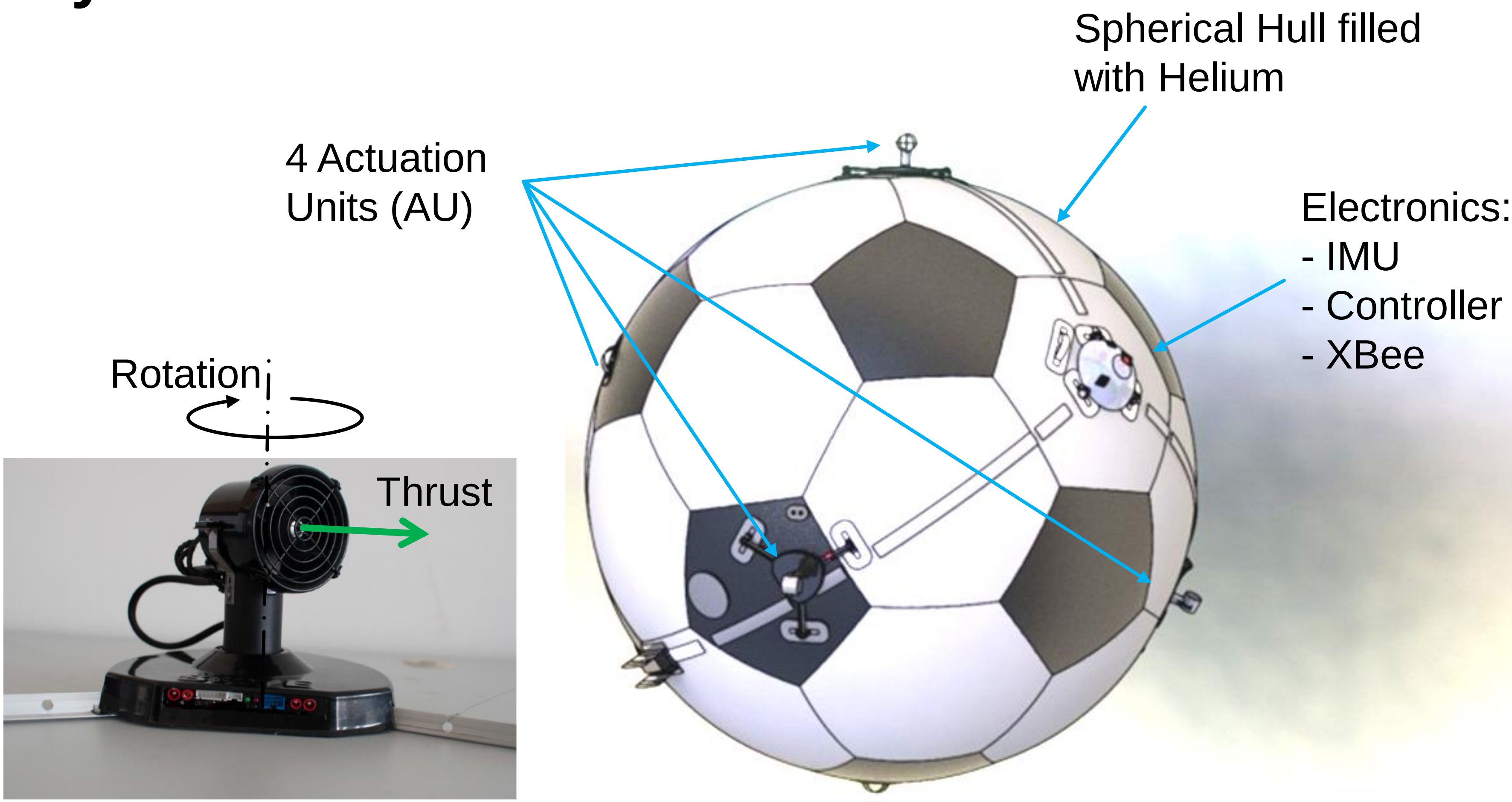
Content

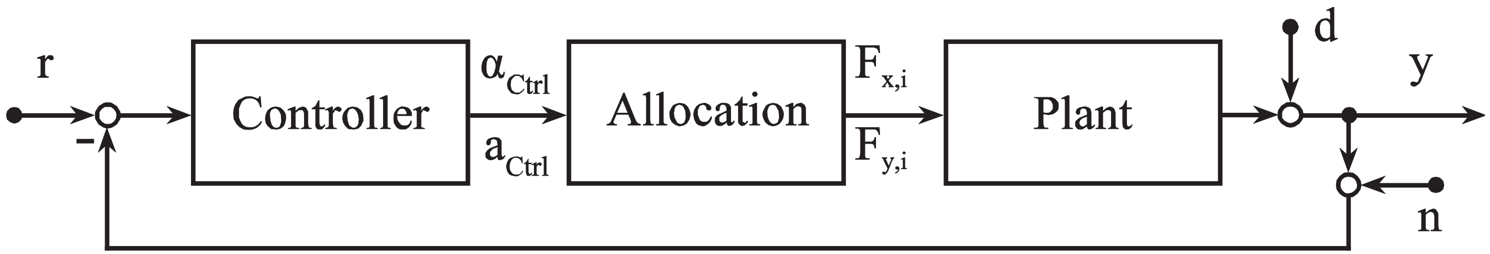
Motivation

- FANCY SLIDE
- Parameters

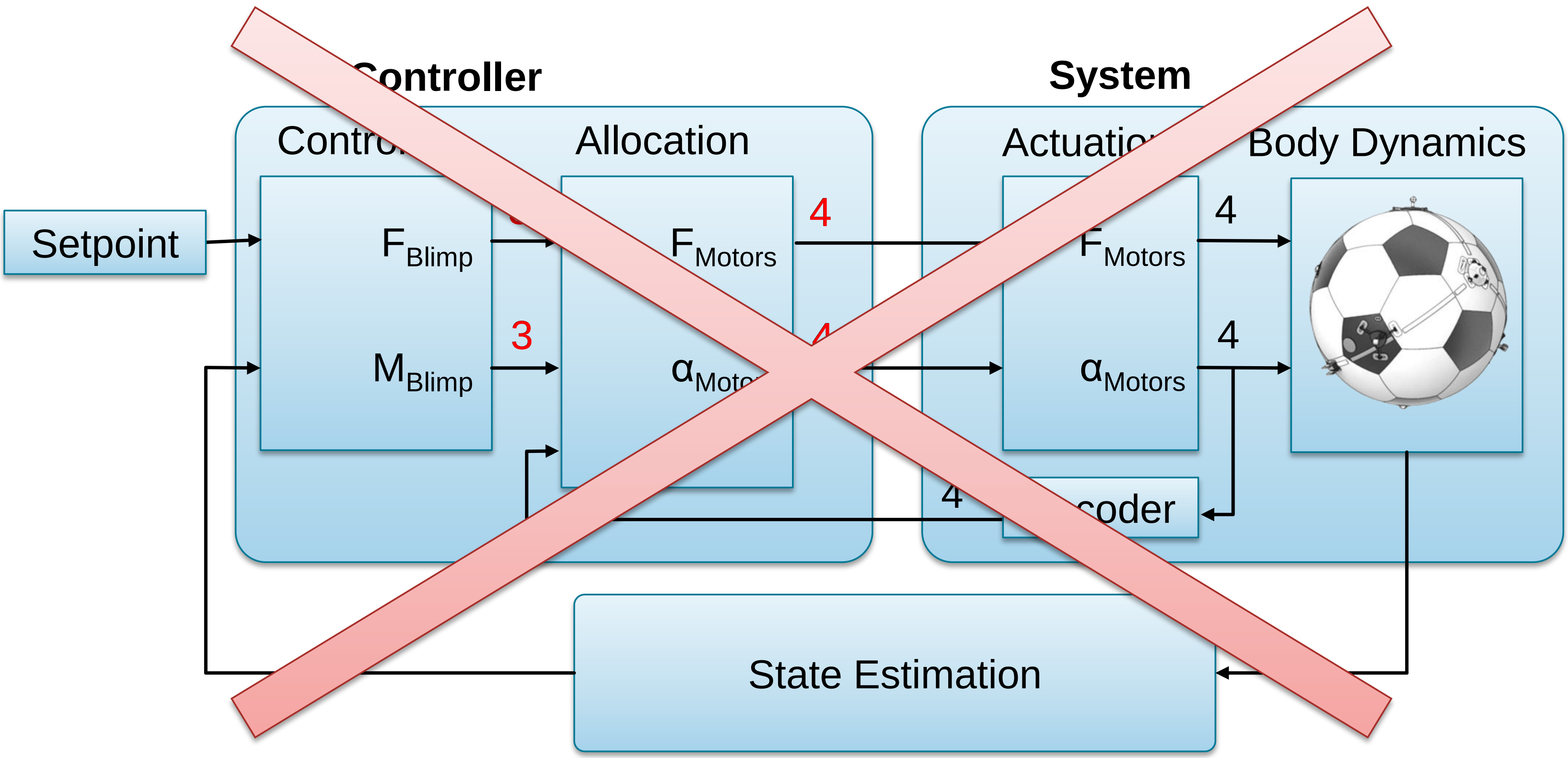
System Overview



System Overview

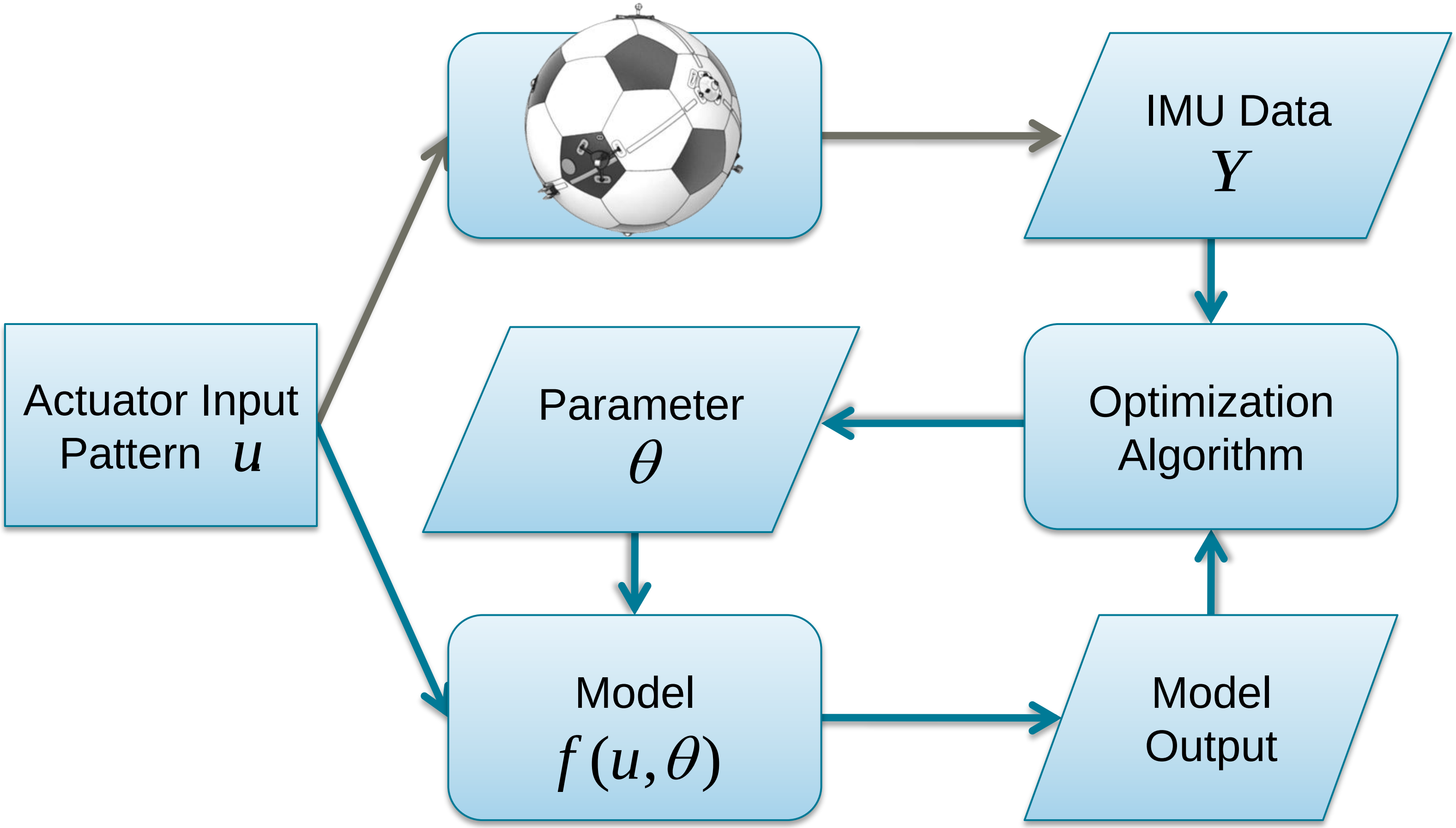


System Overview



Goals

Problem Formulation



Problem Formulation: System Model

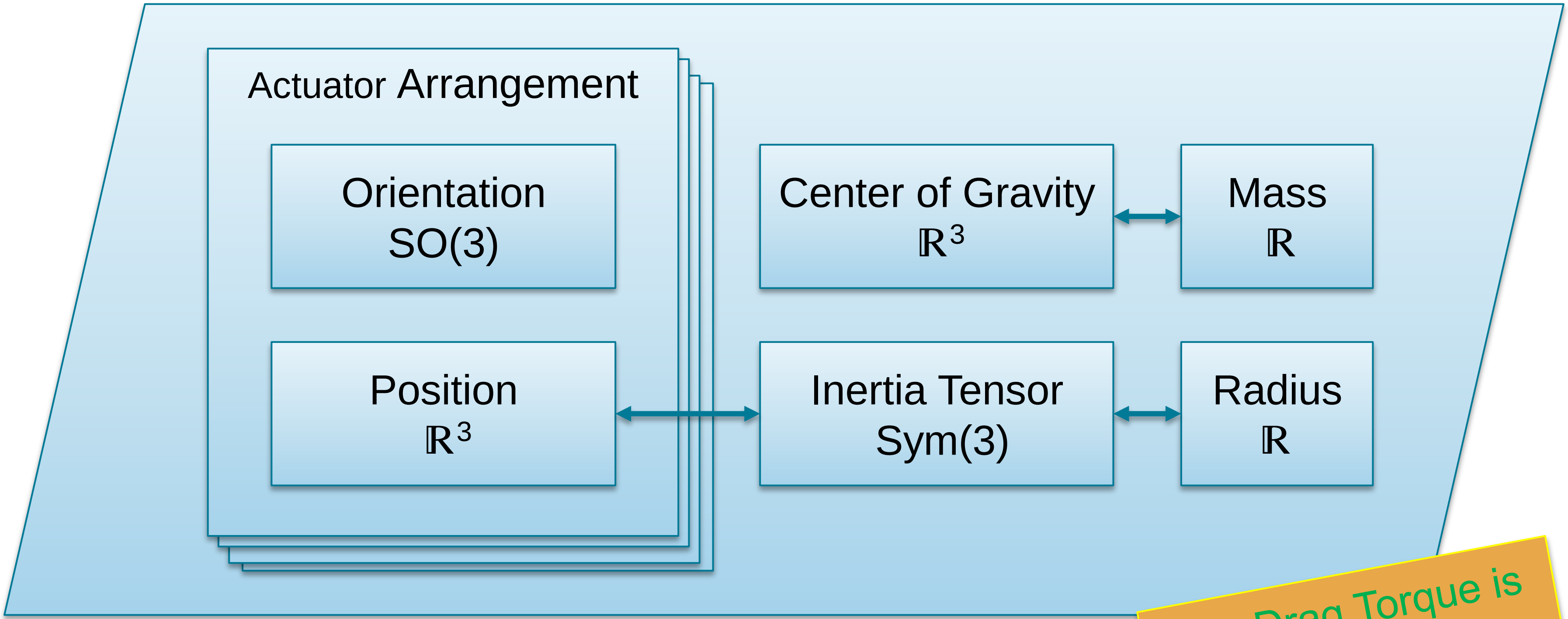
- Angular Acceleration

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

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

  - Neglect aerodynamic effects on rotation

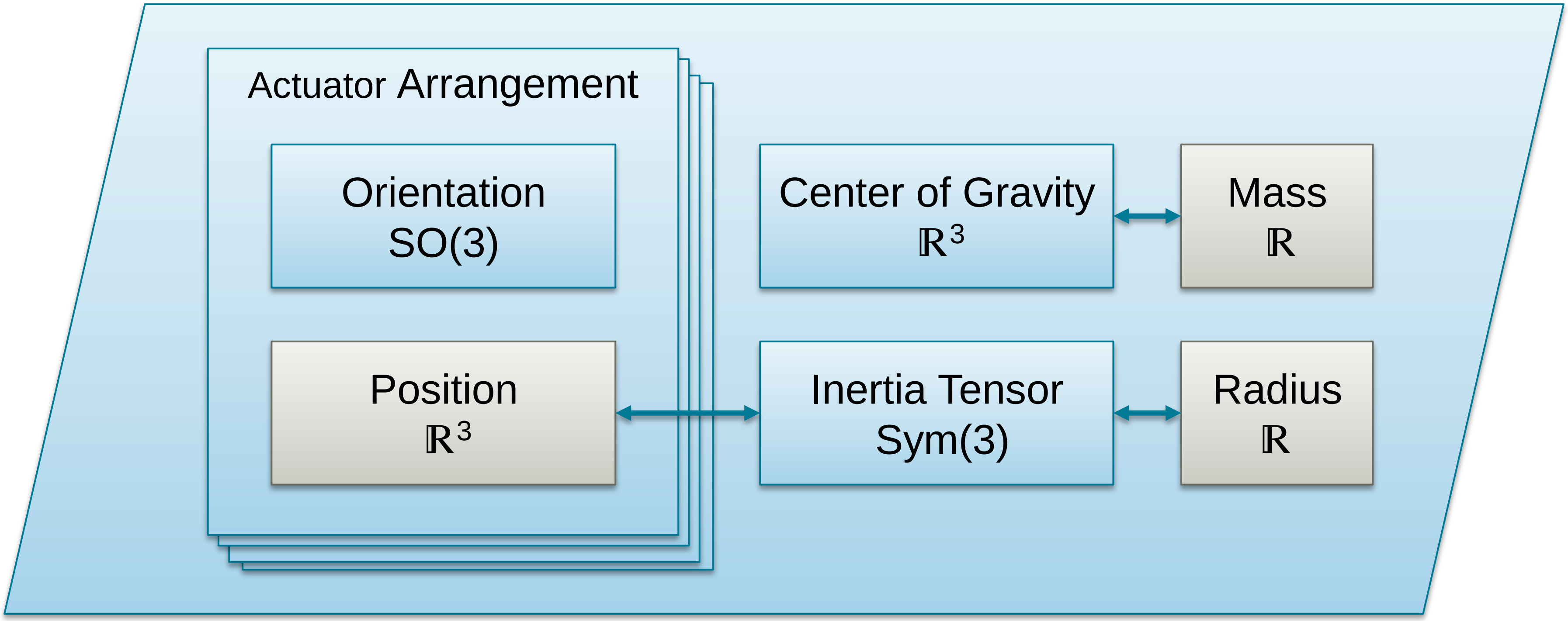
Problem Formulation: Parameters



Full Parameter set is only jointly observable

e.g. Drag Torque is another jointly observable param

Problem Formulation: Parameters



Position is assumed to be on sphere
Radius and mass are fixed (they don‘t influence result)

Problem Formulation: System Model

- Angular Acceleration

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  - Assume perfect knowledge of actuator force (in steady state)

Problem Formulation: Optimization

- Nonlinear Least Squares

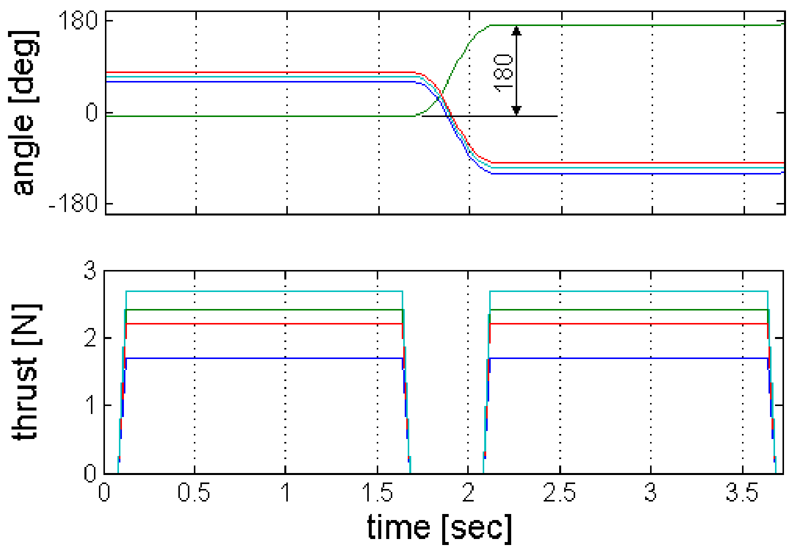
$$S(\boldsymbol{\theta}) = \sum_{i=1}^{N} \left\|\mathbf{y}_i - \mathbf{f}(\mathbf{x}_i, \boldsymbol{\theta})\right\|^2$$

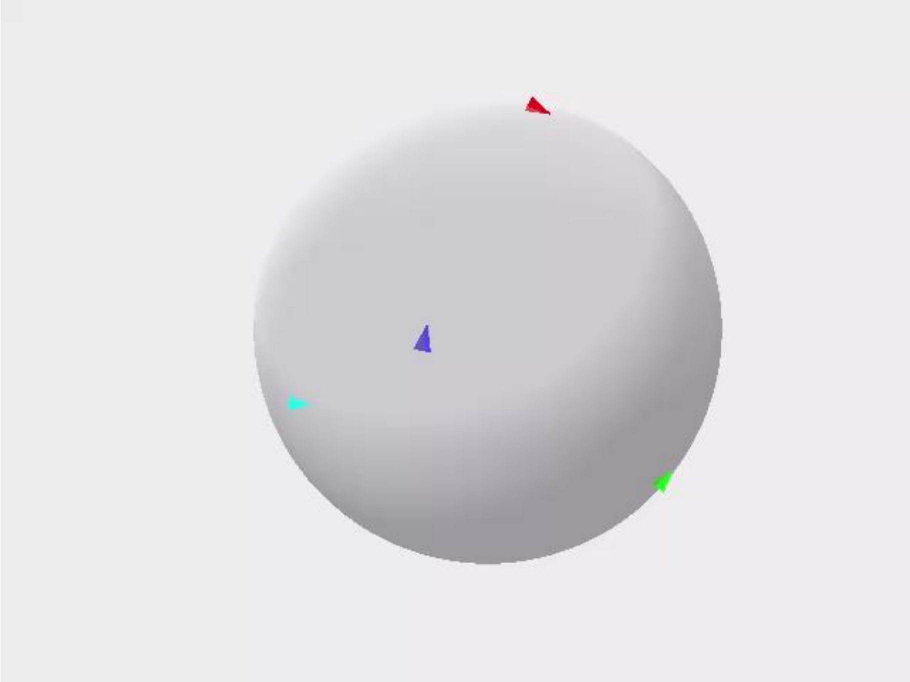
- Levenberg-Marquardt
  - Robust and fast gradient based minimization

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

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





Simulator

Results

- Simulation Results
  - Confidence Region
  - Convergence Region
  - Casestudies (no drag; 1AU; 5AU; COG offset;)

- Experimental Results

- Groundtruth with Leica

Simulation: Confidence Region

- Zeige Konvergenz & Anzahl Iterationen mit LMA

Simulation: Casestudies

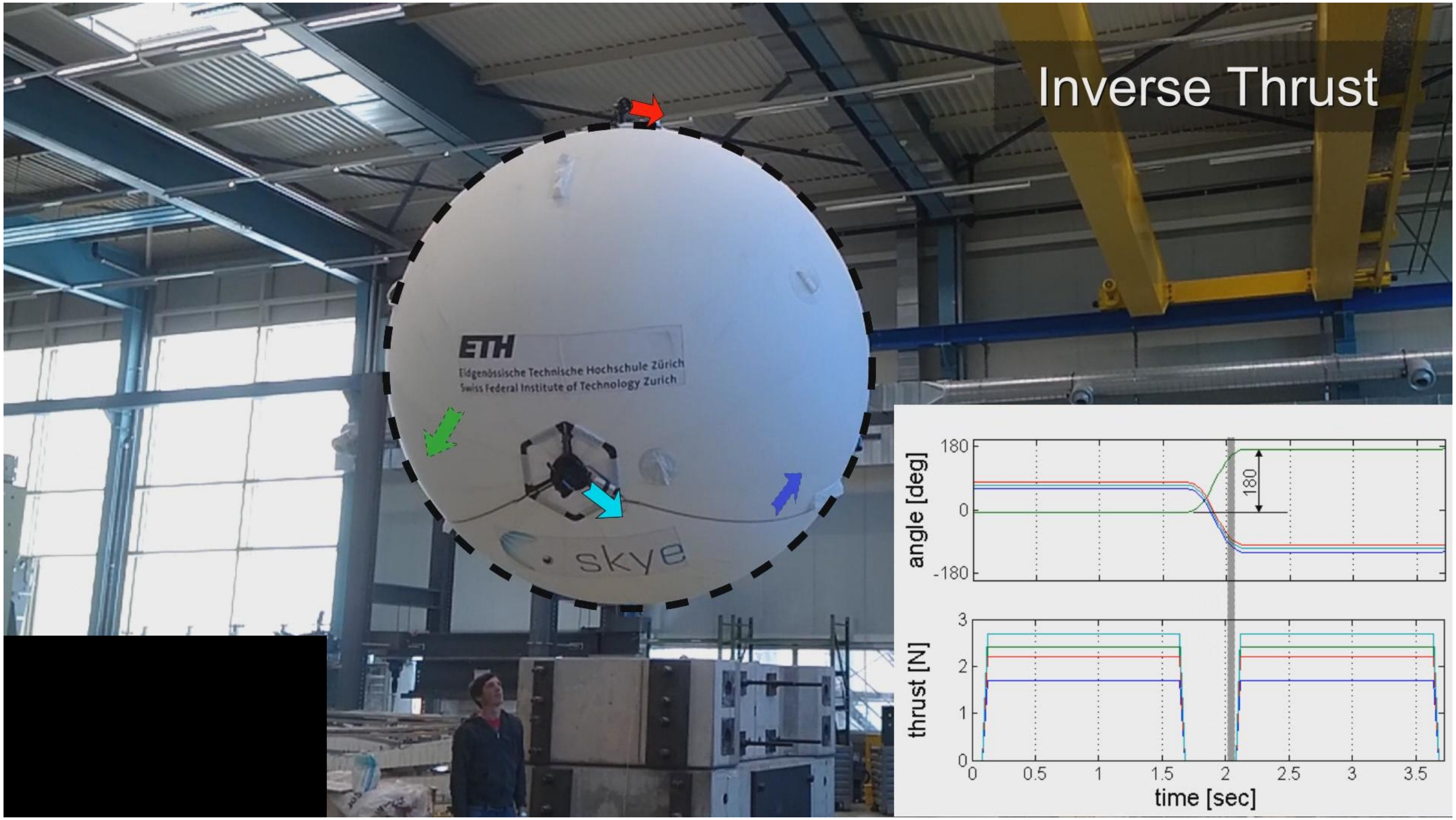
mean	AU4 x	AU4 y	J	cog
Default	6.18e-04	7.66e-04	6.12e-02	6.94e-05
No drag	-4.89e-04	1.38e-03	5.16e-02	1.81e-05

Resnorm [rad/s2]
6.73e-04
6.88e-04

std	AU4 x	AU4 y	J	cog
Default	3.65e-03	7.19e-03	3.00e-02	1.35e-04
No drag	4.29e-03	7.96e-03	3.35e-02	1.21e-04

32 simulations à 2000 raw datapoints

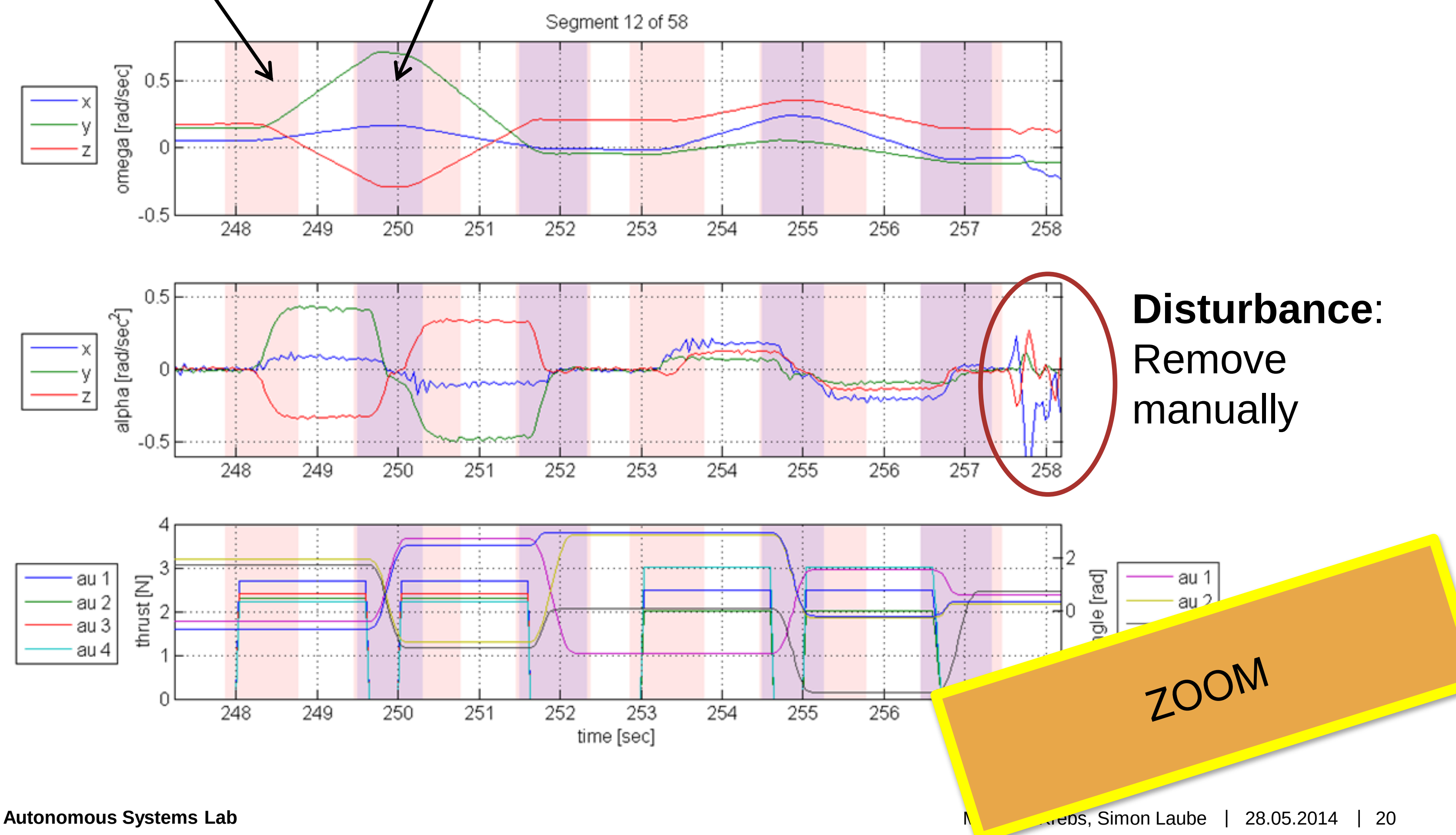
Problem Formulation: Input Pattern



Data Acquisition (Preprocessing)

Start Transient

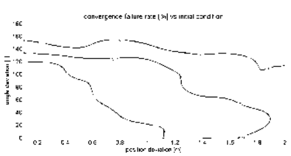
Stop Transient

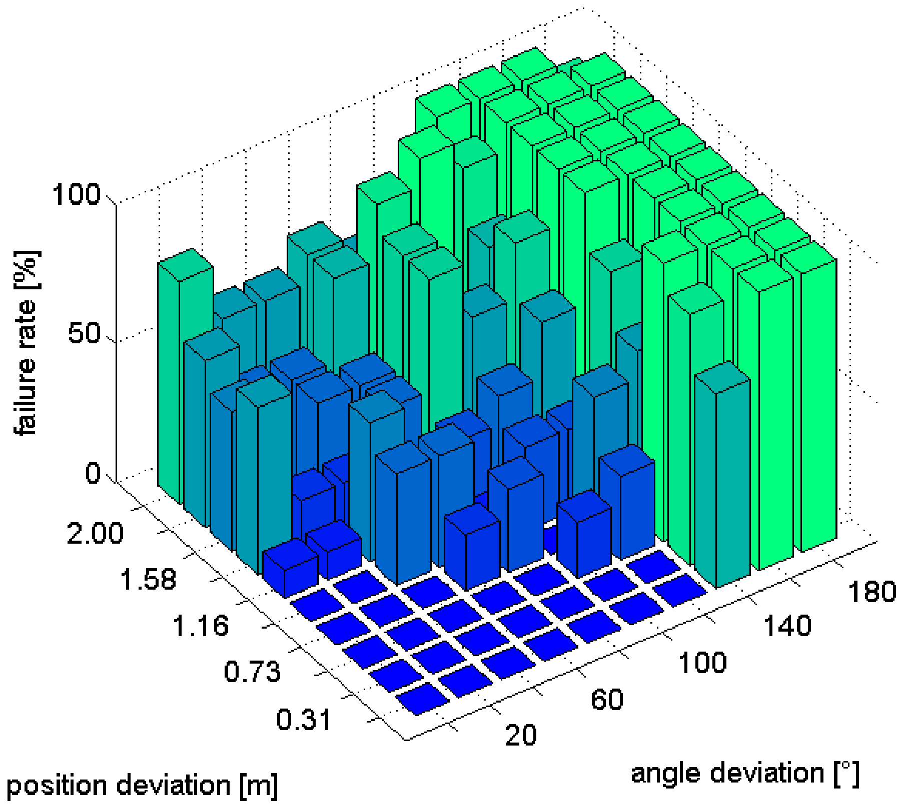


Disturbance: Remove manually

Results: Experiments

Simulation: Convergence Region



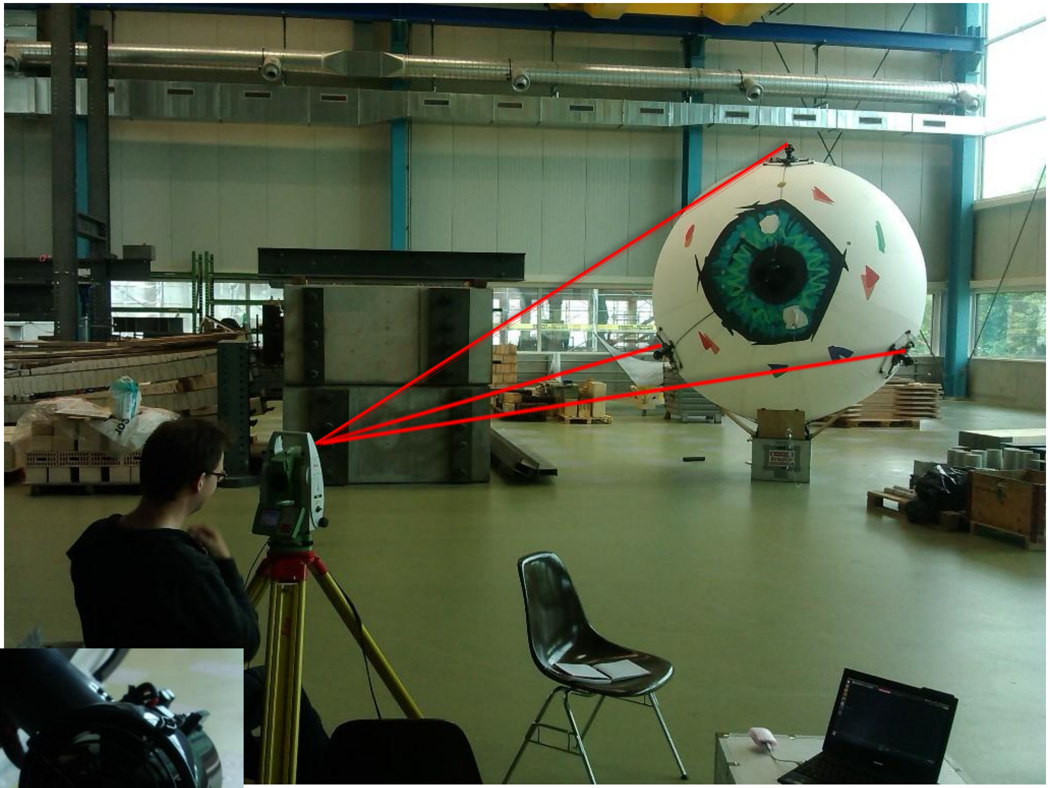


Initial Parameters can be about **1m or 120°** apart of the true value

Results: „Ground Truth“ (Leica)

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

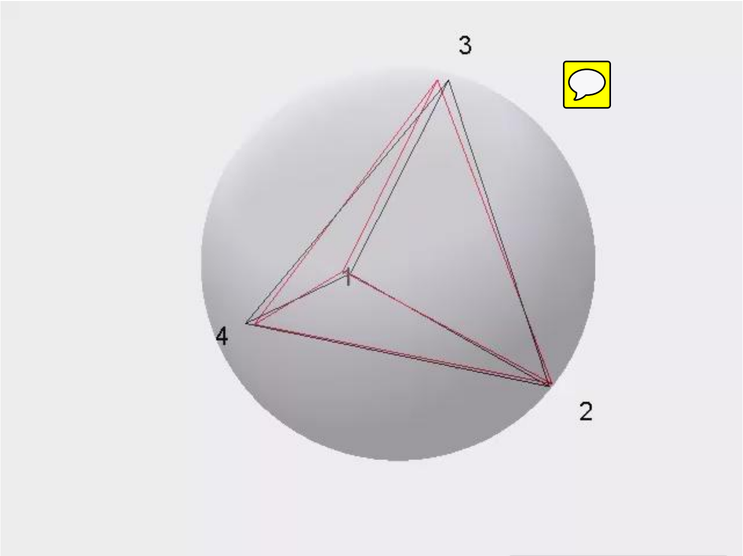
- Fit data to get tetrahedral‘s edge length
  - Residual below 0.01m



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



Leica
Batch

Discussion

Outlook