ETH zürich

Estimation of Actuation Configuration for a Multi-Actuated Blimp

Semester Thesis

Students: Matthias Krebs
Simon Laube

Advisors: Kostas Alexis
Markus Achtelik

ETH zürich

Overview

Problem: Motor to Blimp transformation is essential part of controller

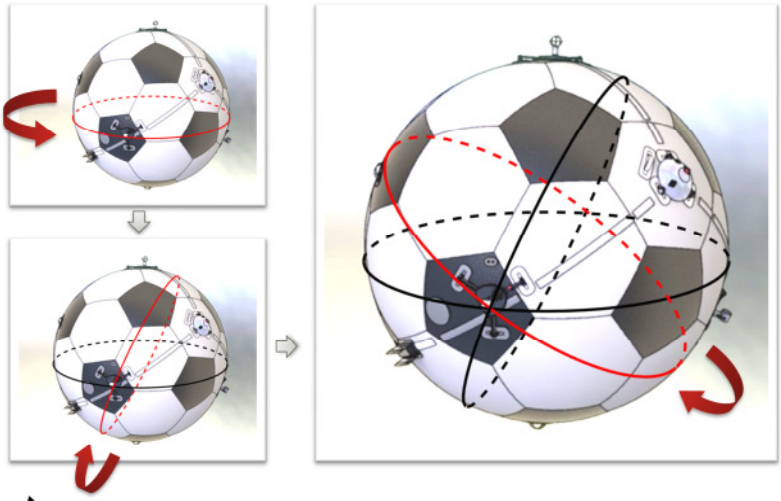
Idea: Create blimp model from Motor transformations and fit this model to the system

How: Actuate blimp and compare measurements with model output

Position of motors is essential for control, but uncertain / unknown

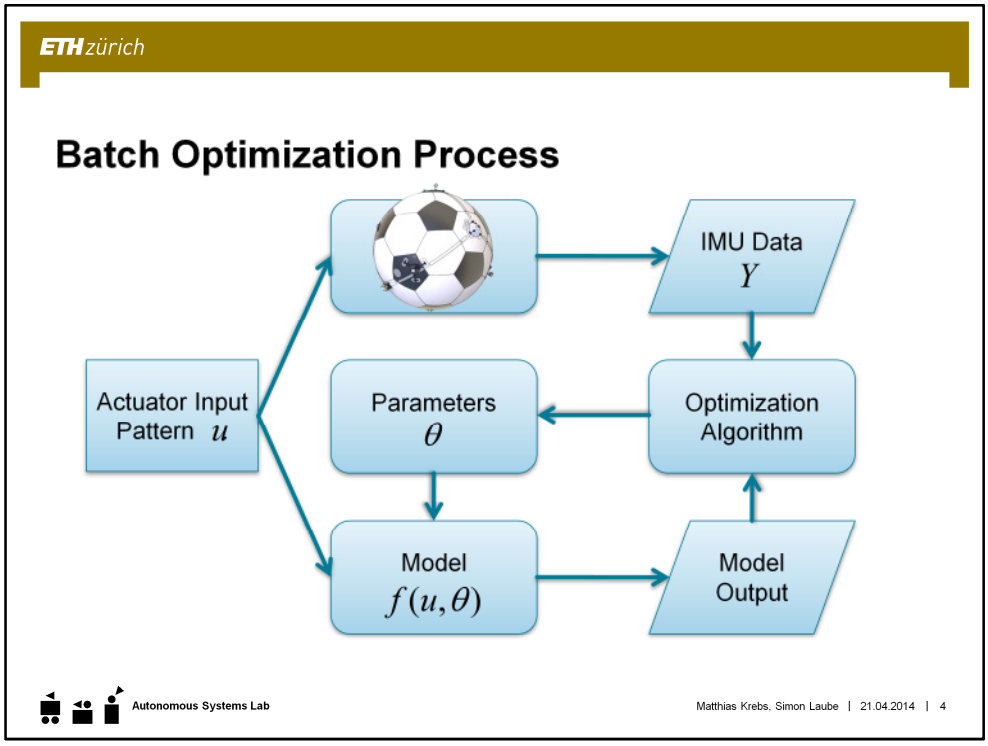
ETH zürich

Concept



Autonomous Systems Lab

Matthias Krebs, Simon Laube | 21.04.2014 | 3



To optimize the model with respect to the actuation configuration we need to make the model dependent on the actuation configuration.
For a spherical blimp the configuration of an actuator is described with a position on the hull surface and a rotation which tells us in which direction the x axis of the actuator is pointing.
It turns out that this actuator configuration can be expressed with a rotation against the blimps center.
For rotations there are a few parameterisations each of them having advantages and disadvantages
we choose the gibbs-rodriguez and quaternion parameterisation, because gibbs-rodriguez are mini

ETH zürich

Model Function

$$\vec{\alpha} = J^{-1}(r\, C(\theta)\, \vec{u} - \vec{\omega} \times J\vec{\omega})$$

$C(\theta)$	Thrust force transformation
$\vec{u}$	Thrust force (input)
$\vec{\omega}$	Angular velocity
$\vec{\alpha}$	Angular acceleration
r	Radius
J	Inertia tensor

Parameterization

Gibbs-Rodriguez (3)
Quaternionen (4)

Autonomous Systems Lab

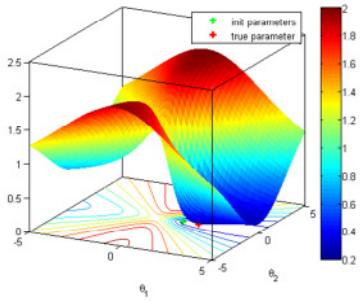
Matthias Krebs, Simon Laube | 21.04.2014 | 5

To optimize the model with respect to the actuation configuration we need to make the model dependent on the actuation configuration.
For a spherical blimp the configuration of an actuator is described with a position on the hull surface and a rotation which tells us in which direction the x axis of the actuator is pointing.
It turns out that this actuator configuration can be expressed with a rotation against the blimps center.
For rotations there are a few parameterisations each of them having advantages and disadvantages. This basically boils down to one trade-off: either you use minimal representation of a rotation and you have to deal with singularities or you use a non-minimal representation and you have to deal with constraints on these parameters.
We decided to use one parameterization which is minimal in the number of parameters and one which does not have the issue of singularities.
we choose the gibbs-rodriguez and quaternion parameterisation, because gibbs-rodriguez are minimal parameters

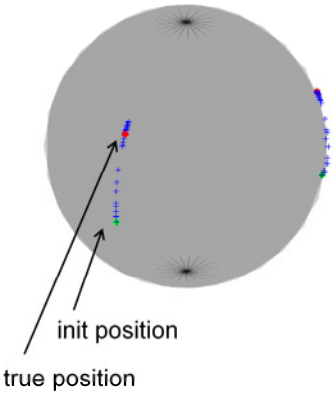
ETH zürich

Current Results

- Gibbs-Rodriguez Parameters



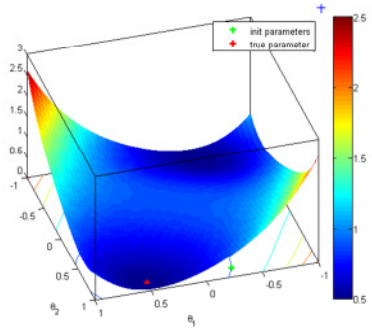
Residual plot in parameter space



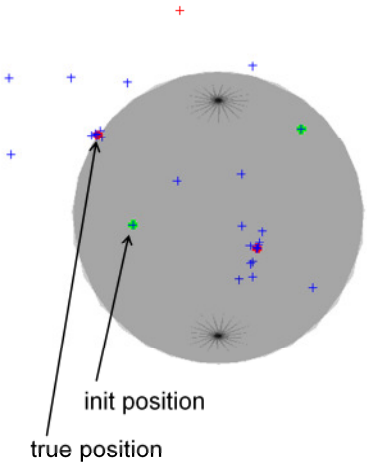
results based on simulator data

Current Results

- Quaternion Parameters



Residual plot in parameter space



Outlook

- Parameterization for radius, inertia tensor
- Actuator input patterns
- Varied simulation data from modular simulation model
- Convergence analysis

Context / General Description

- Control depends on simplified model of blimp
  - Fit paramteres of simplified model s.t. it best fits real system

Problem Formulation

- Nonlinear Least Squares Optimization
  - $S(\theta) = \sum_{u=1}^{n} \{Y_u - f(\xi_u, \theta)\}^2$

  Y_u : Angular acceleration from gyro measurement
  $f(\xi_u, \theta)$: Nonlinear function depending on inputs ξ_u and parameters θ
- Parametrization

Quaternion
No Singularities
Constrained $\|q\| = 1$
Quadratic model

$$q = \begin{bmatrix} \cos(\varphi/2) \\ n \cdot \sin(\varphi/2) \end{bmatrix}$$

Gibbs-Rodriguez
Singularity at $\varphi = \pi/2$
Unconstrained
Nonlinear model

$$\lambda = n \cdot \tan(\varphi/2)$$

Problem Formulation

Quaternion

No Singularities

Constrained $\|q\| = 1$

Quadratic model

$$q = \begin{bmatrix} \cos(\varphi/2) \\ n \cdot \sin(\varphi/2) \end{bmatrix}$$

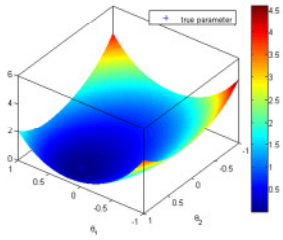
Gibbs-Rodriguez

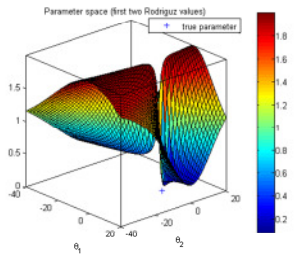
Singularity at $\varphi = \pi/2$

Unconstrained

Nonlinear model

$$\lambda = n \cdot \tan(\varphi/2)$$





Example

- Video?

Outlook

- Inputs bla bla …
- Text Cases …
- Estimate Accuracy of Result ...