Tethered Transportation

Pedro Pereira

April 11th

- Presentation on Tuesday, 11th of April 2017
- Time: 14:00-16:00, Location: Automatic Control
- Presentation will be of 10min (including Q&A)

Background and Biographical Information

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1. 2008-2013: MSc in Aerospace Engineering
   (IST Lisbon + TU Delft, supervisor: Carlos Silvestre)
2. 2014-current: PhD at KTH (supervisor: Dimos Dimarogonas)
   - Licentiate on 2016: Control of Single and Multiple TPS
   - EU project: AEROWORKS

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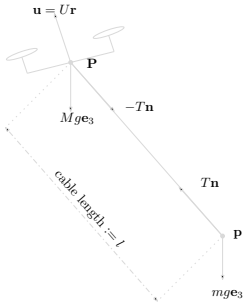
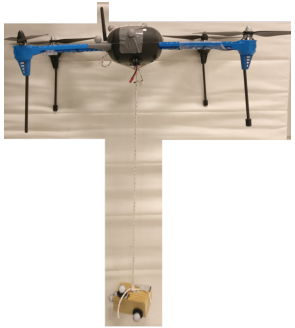
Slung load transportation

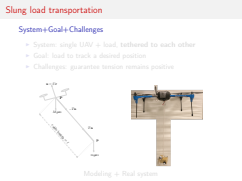
System+Goal+Challenges

- System: single UAV + load, **tethered to each other**
- Goal: load to track a desired position
- Challenges: guarantee tension remains positive





Modeling + Real system



- Remark: load is not attached to auv; uav is not attached to load; they are attached to each other (chicken and egg conundrum).
- Upper bound on attitude gains that guarantee equilibrium remains stable

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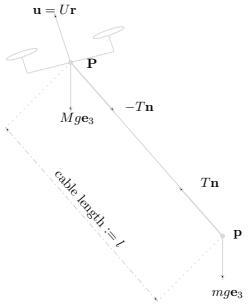

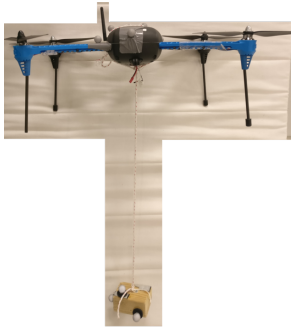

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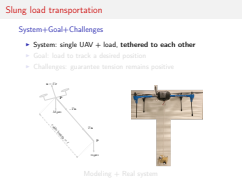

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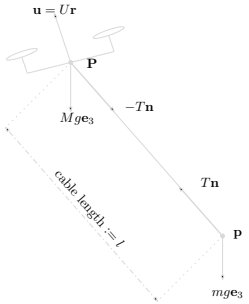

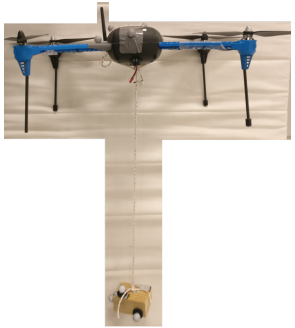

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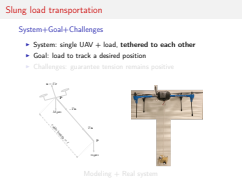

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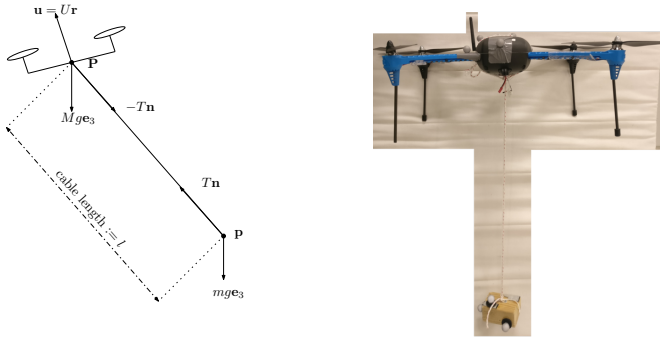

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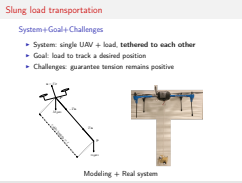

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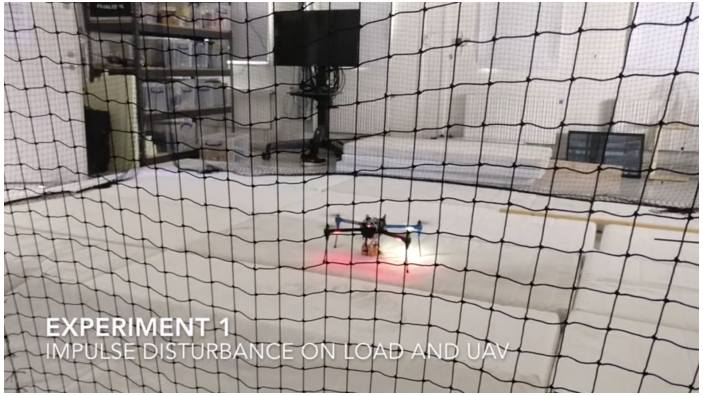
Experiment: slung load transportation



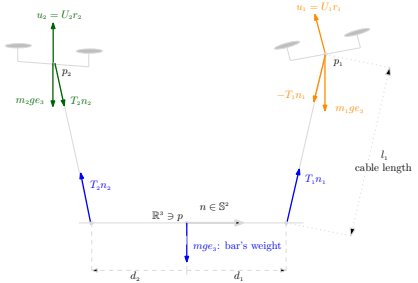
Experiment: slung load transportation

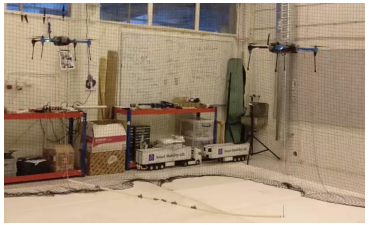
- Testing robustness against disturbances
- Testing performace (checking position tracking error, and cable sway w.r.t. uav)

Collaborative bar transportation

System+Goal+Challenges

- System: **two UAVs + bar**, tethered to each other
- Goal: bar to **track a desired pose** (position + orientation)
- Challenges: guarantee tensions remain positive





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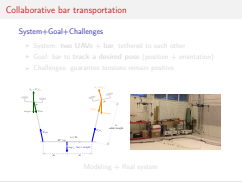

- Modeling the system: 32 states (not generalized coordinates though)
- Find upper bound on attitude gains that guarantee that equilibrium remains stable

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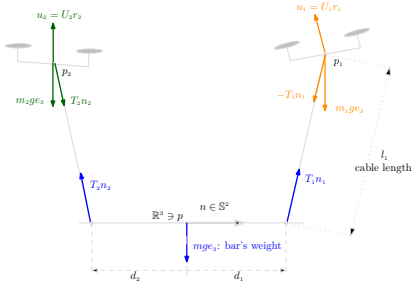

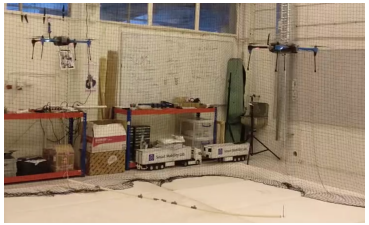

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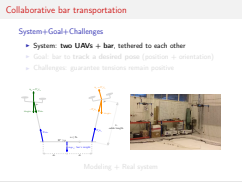

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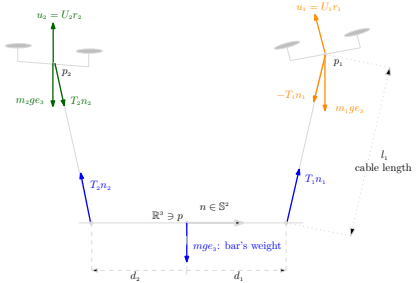

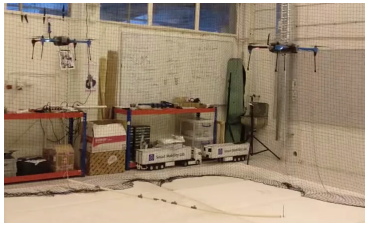

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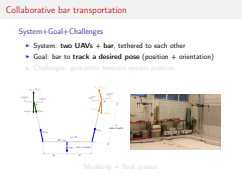

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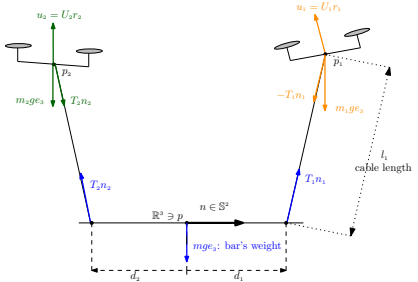

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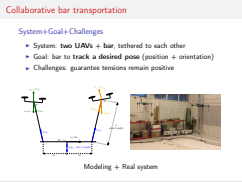

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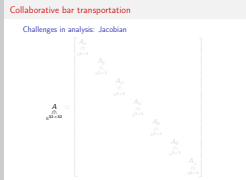
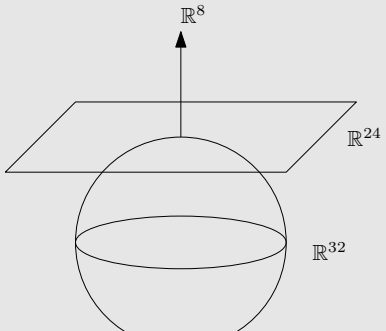
Collaborative bar transportation

Challenges in analysis: Jacobian

$$A \in \mathbb{R}^{32\times 32} \simeq \begin{bmatrix} A_x \in \mathbb{R}^{5\times 5} & & & & & & \\ & A_\delta \in \mathbb{R}^{3\times 3} & & & & & \\ & & A_y \in \mathbb{R}^{5\times 5} & & & & \\ & & & A_\psi \in \mathbb{R}^{5\times 5} & & & \\ & & & & A_z \in \mathbb{R}^{3\times 3} & & \\ & & & & & A_\theta \in \mathbb{R}^{3\times 3} & \\ & & & & & & A_\perp \in \mathbb{R}^{8\times 8} \end{bmatrix}$$



- Studying eigenvalues of jacobian is reduced to studying the eigenvalues of 7 smaller matrices
- 2 matrices for x motion, 2 for y motion, and 2 for z motion (and 1 for directions "orthgonal" to manifold)
- explanation for $A_\perp$



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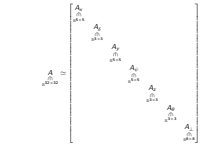

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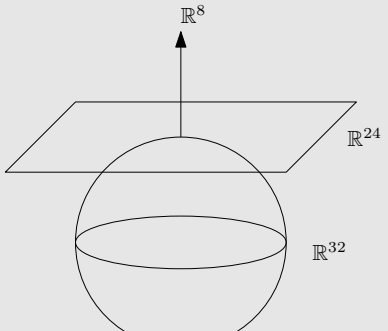

Experiment: bar transportation

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- Testing robustness against disturbances
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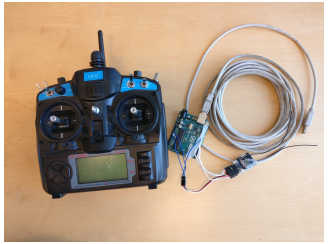
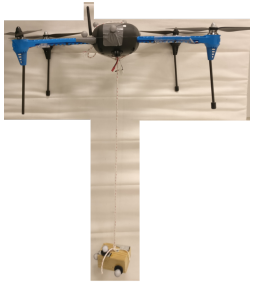
Next steps

User input

- User to control speed of load/bar with joystick
- Compare performance with and without inner loop controller





Control speed of uav with joystick (with and without inner loop)

- Let the user control speed of uav
- Scenario 1: no extra controller (user needs to account for presence of load)
- Scenario 2: extra controller that accounts for presence of load

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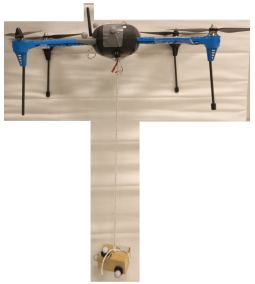

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