# Superquadric Modeling and Grasping with Markerless Visual Servoing

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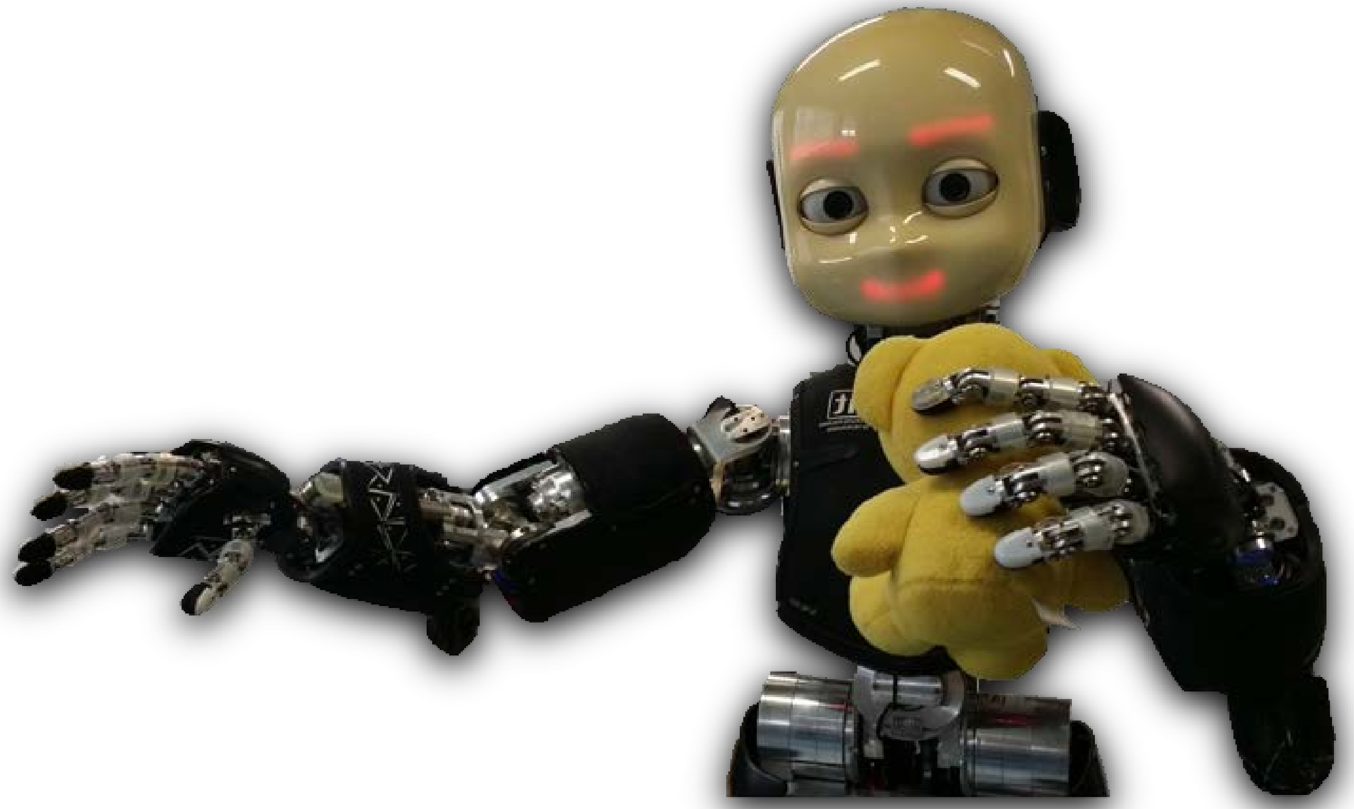
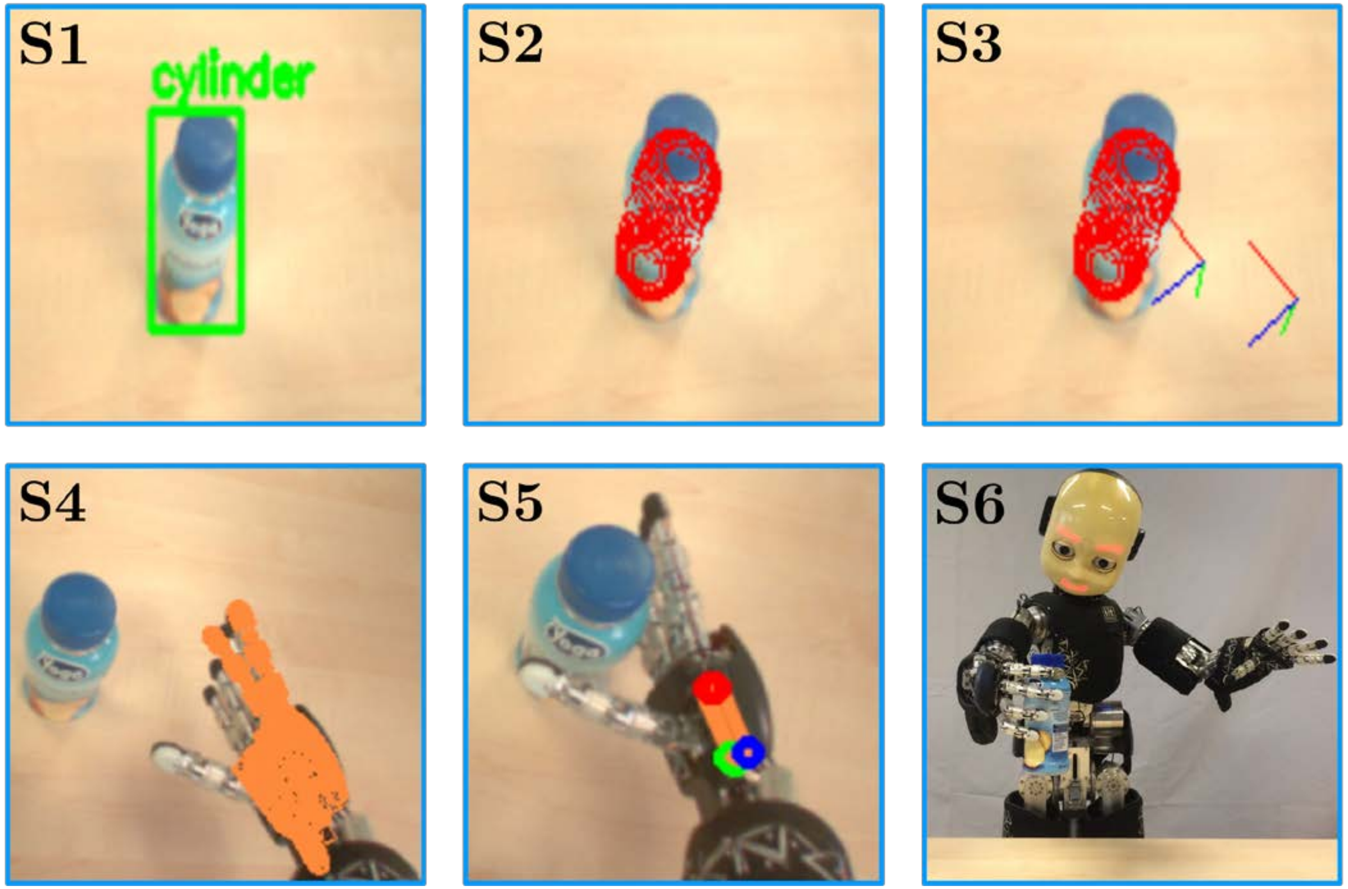


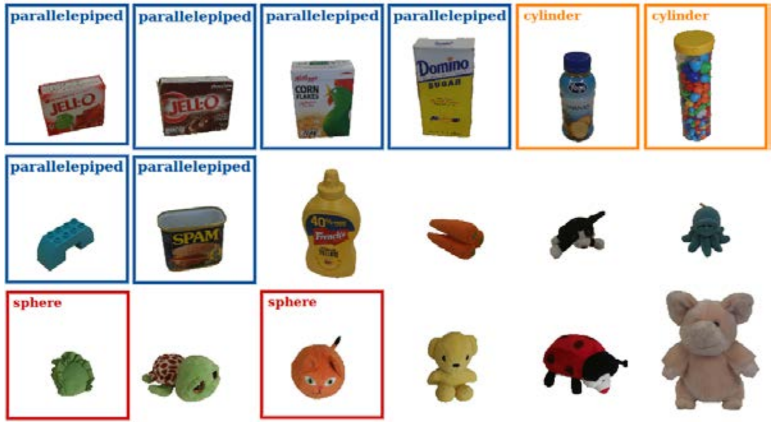
# Pipeline overview



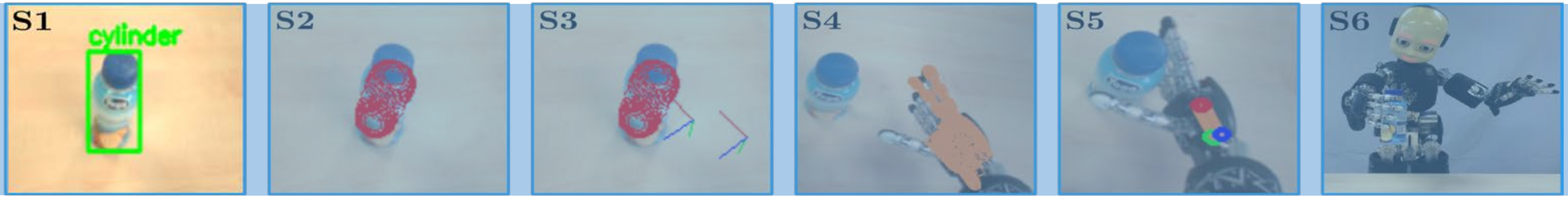

1. Object classification
2. Object modeling
3. Grasping pose computation
4. Hand pose estimation
5. Visual servoing
6. Object grasping

# Object classification for superquadric modeling


Training set: 30 objects




Test set: 18 objects (YCB & iCubWorld)

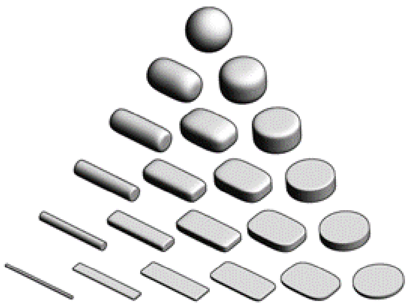


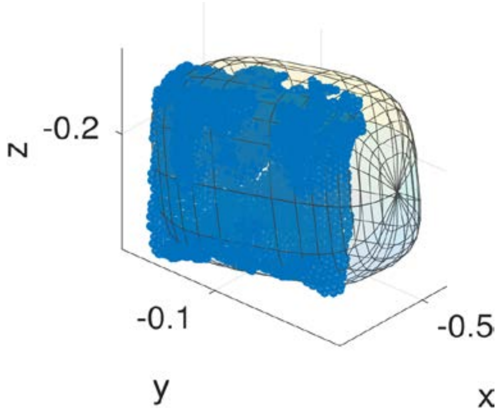
# Superquadric Modeling and Grasping [ICRA2017]

## Superquadric estimation

$$\min_{\boldsymbol{\lambda}} \sum_{i=1}^{N} \left( \sqrt{\lambda_1 \lambda_2 \lambda_3} \left( F(\boldsymbol{s}_i, \boldsymbol{\lambda}) - 1 \right) \right)^2,$$

$$F(x, y, z, \boldsymbol{\lambda}) = \left( \left( \frac{x}{\lambda_1} \right)^{\frac{2}{\lambda_5}} + \left( \frac{y}{\lambda_2} \right)^{\frac{2}{\lambda_5}} \right)^{\frac{\lambda_5}{\lambda_4}} + \left( \frac{z}{\lambda_3} \right)^{\frac{2}{\lambda_4}}$$



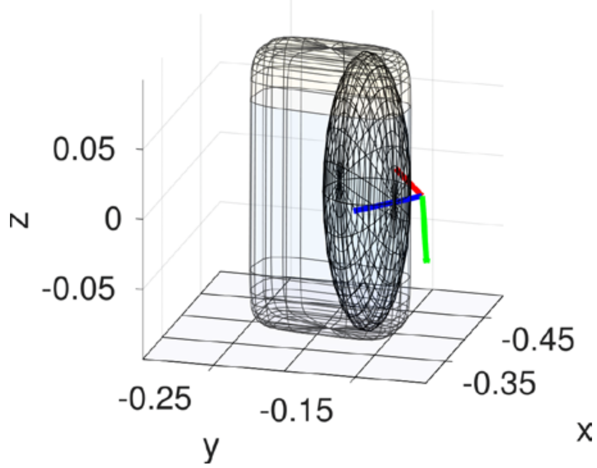


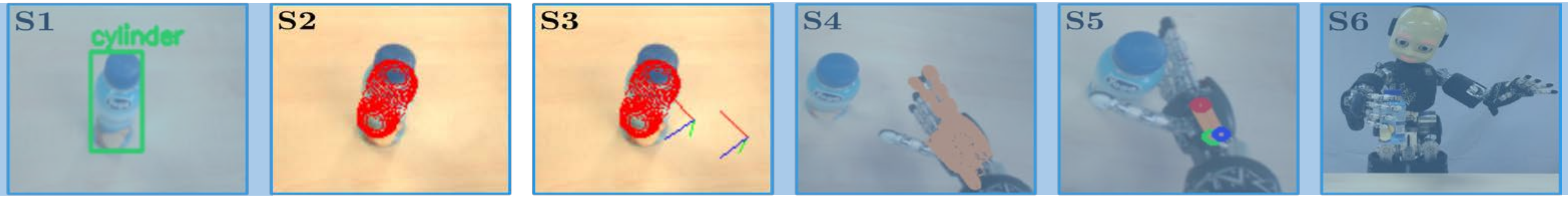

## Grasping pose computation

$$\min_{\boldsymbol{x}} \sum_{i=1}^{L} \left( \sqrt{\lambda_1 \lambda_2 \lambda_3} \left( F(\boldsymbol{p}_i^{\boldsymbol{x}}, \boldsymbol{\lambda}) - 1 \right) \right)^2,$$

subject to:

$$h(\boldsymbol{a}, f(\boldsymbol{p}_1^{\boldsymbol{x}}, \ldots, \boldsymbol{p}_L^{\boldsymbol{x}})) > 0.$$



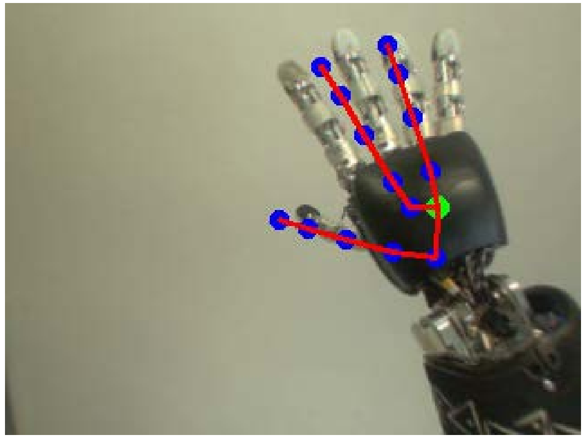
# Fine Pose Reaching for Robust Grasp

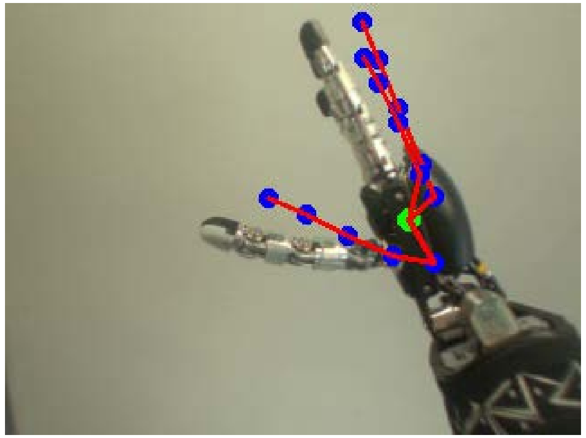
## Problem:

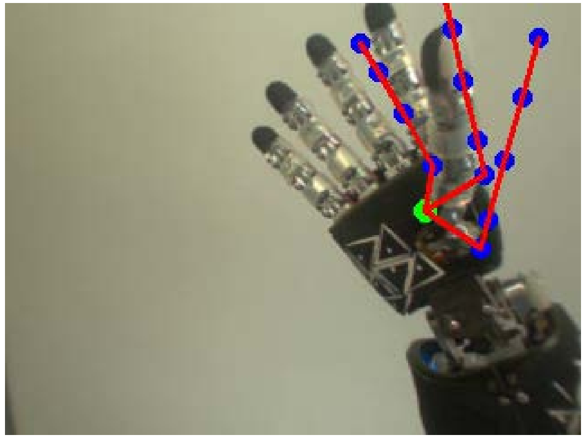
Imprecise kinematics

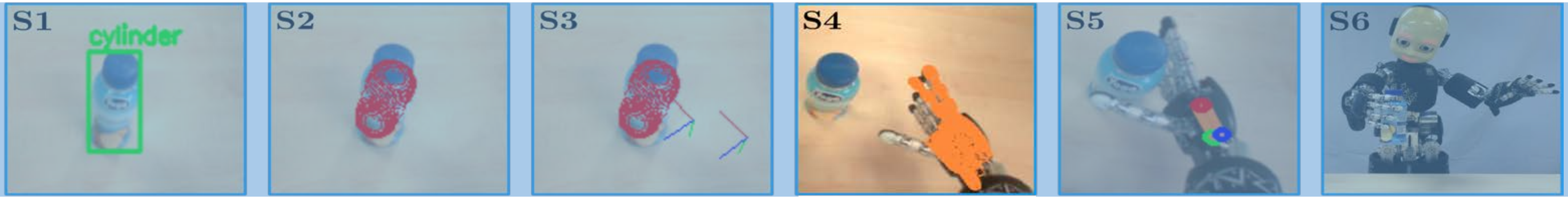
## Goal:

Estimate the 6D pose of the robot end-effector using camera images







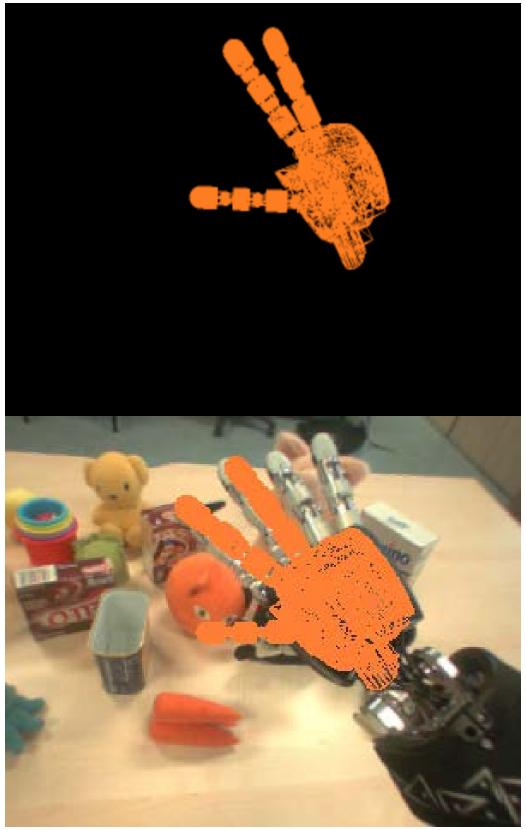


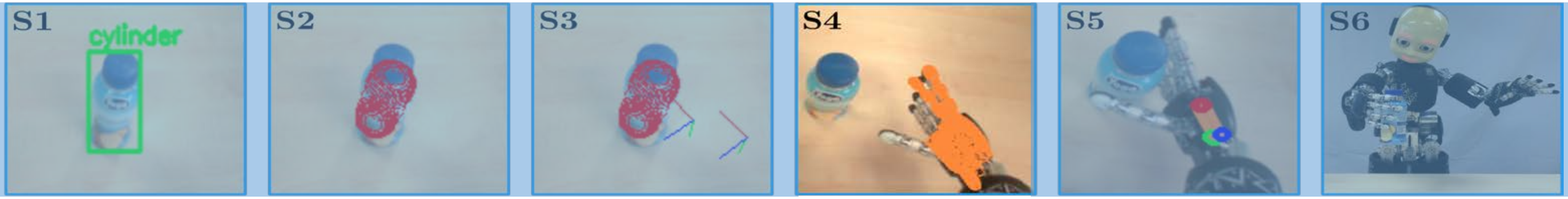
# Visual Particle Filter

*[IROS2017]*

- For each particle, render an image of the end-effector as it would appear from the robot's viewpoints.

- Use this state representation to directly estimate the 6D pose of the end-effector using 2D image descriptors.





# Image Based Visual Servoing

[*sub. to ICRA2018*]

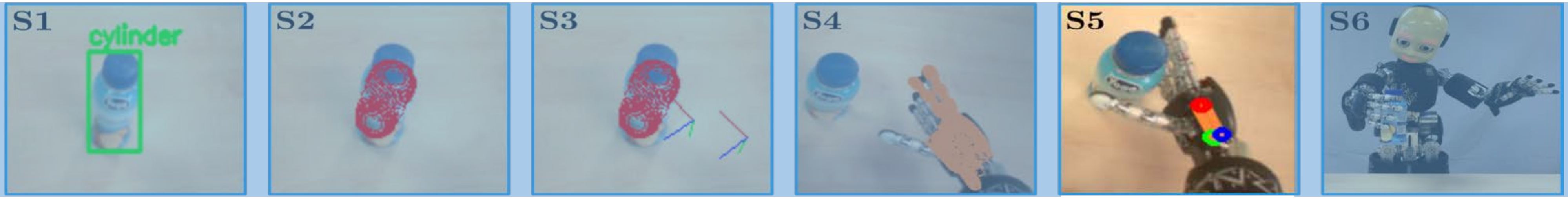
Two image-based visual servoing problems:

1. The  first solves for the translation motion assuming the rotation completed

$$\boldsymbol{x}_t^e \triangleq \left[\boxed{p_x^e, p_y^e, p_z^e,} \boxed{u_x^g, u_y^g, u_z^g, \theta^g}\right]^\top$$

2. The second problem we compute the rotation motion under the assumption of achieved translation

$$\boldsymbol{x}_o^e \triangleq \left[\boxed{p_x^g, p_y^g, p_z^g,} \boxed{u_x^e, u_y^e, u_z^e, \theta^e}\right]^\top$$



# Demonstration