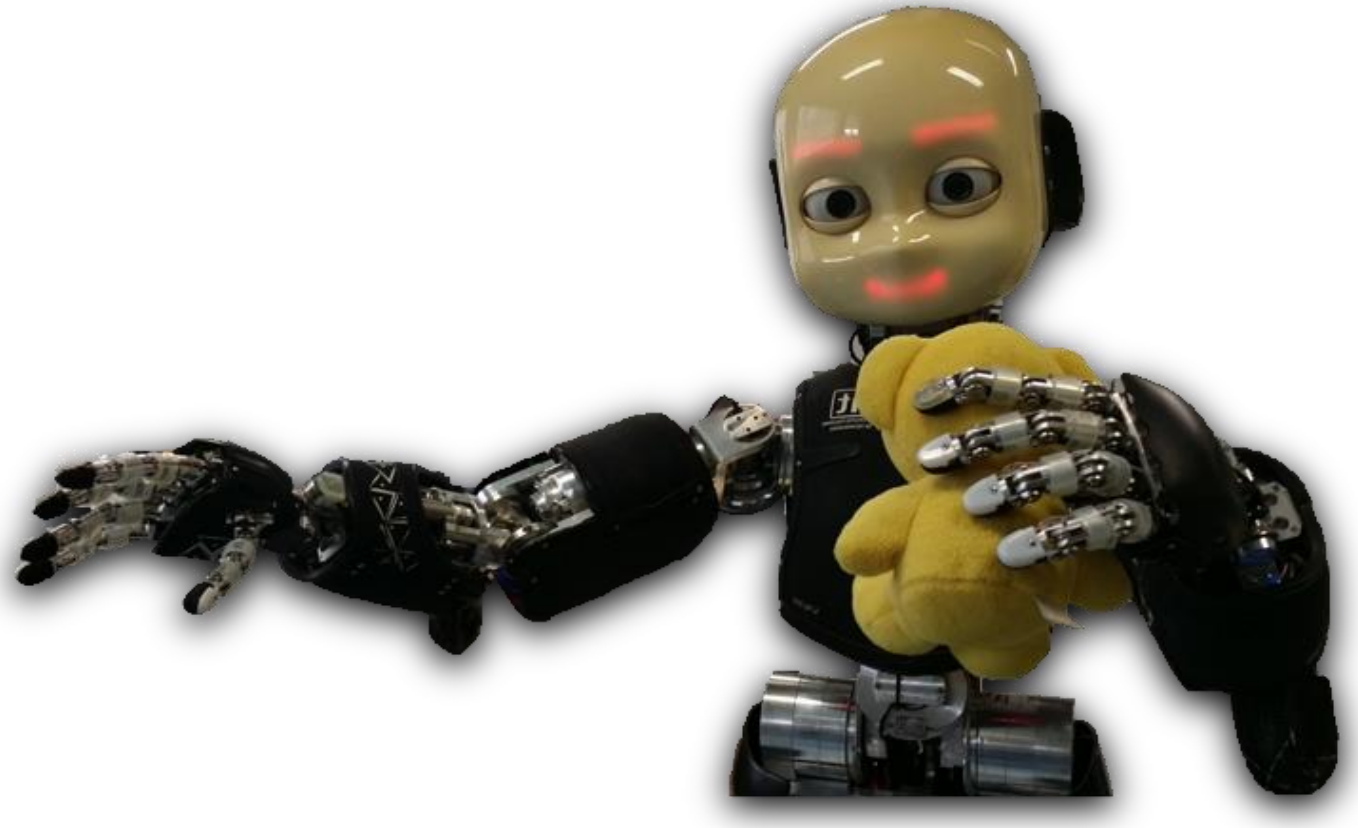
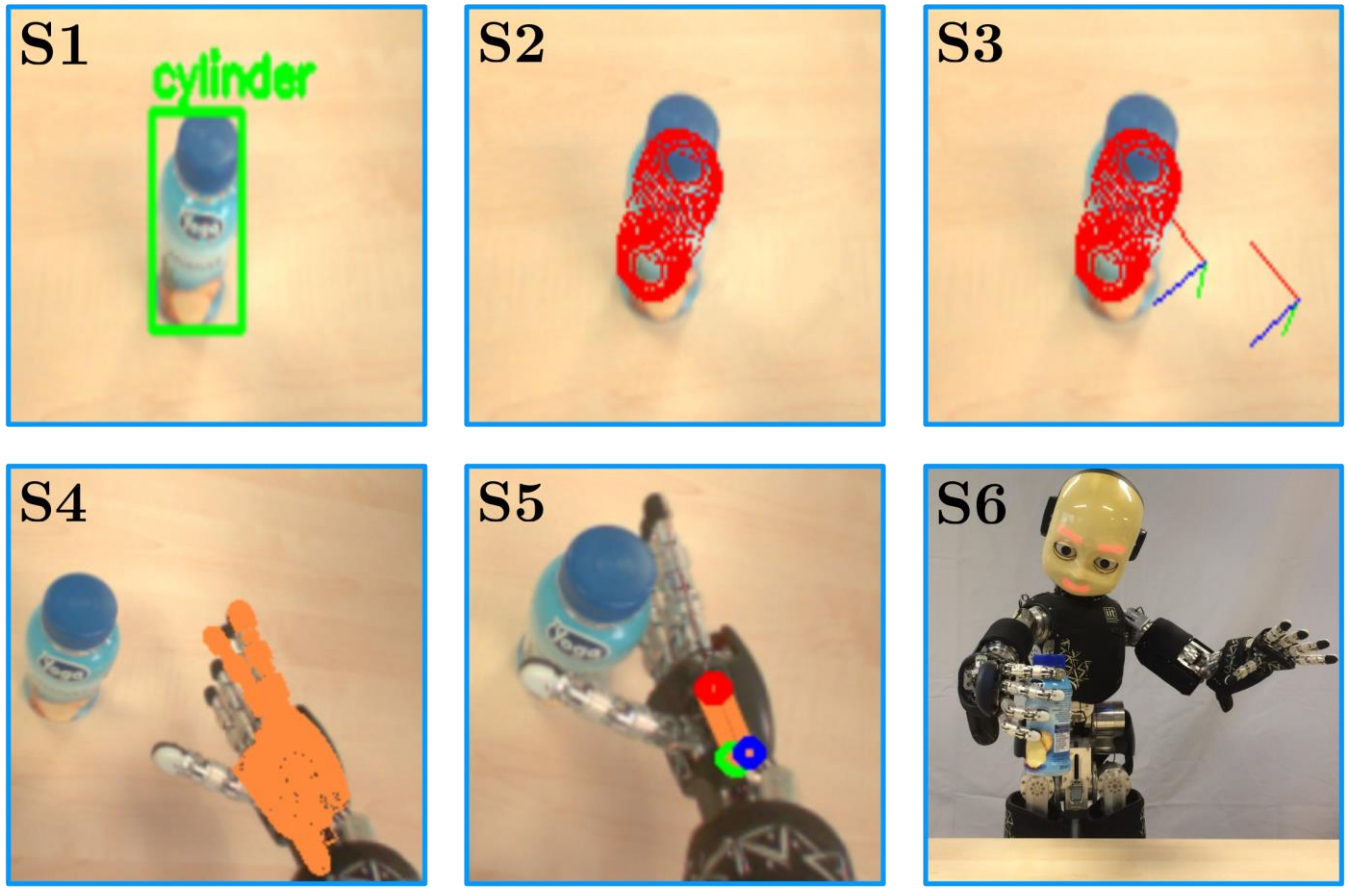
Superquadric Modeling and Grasping with Markerless Visual Servoing

Giulia Vezzani, Claudio Fantacci
Ugo Pattacini, Vadim Tikhanoff
Lorenzo Natale



ISTITUTO ITALIANO
DI TECNOLOGIA

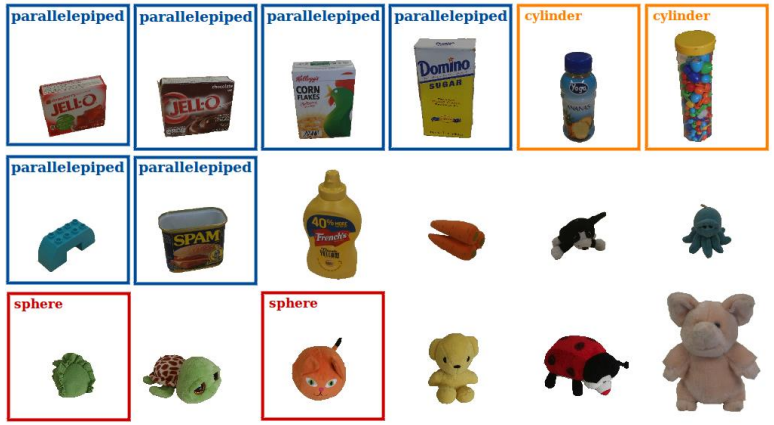
Pipeline Overview



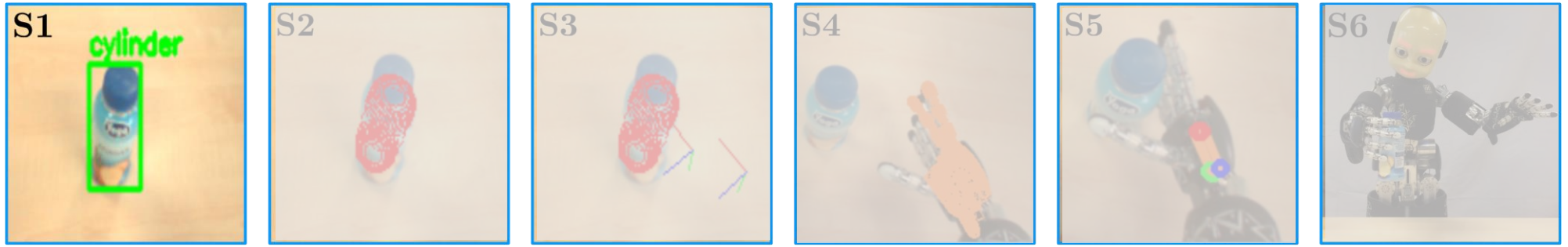
1. Object classification
2. Object modeling
3. Grasping pose computation
4. Hand pose estimation
5. Visual servoing
6. Object grasping

Object Classification for Superquadric Modeling

Training set: 30 objects



Test set: 18 objects (YCB & iCubWorld)



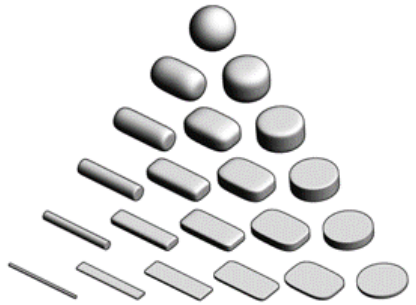
Superquadric Modeling and Grasping

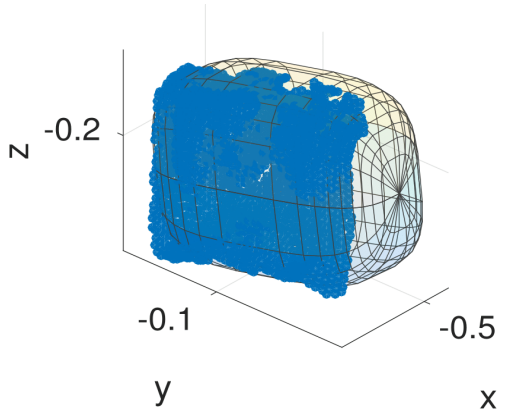
[ICRA2017]

Superquadric estimation

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

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



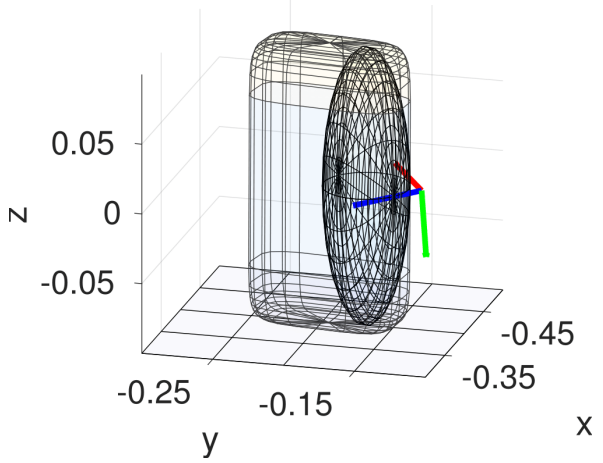


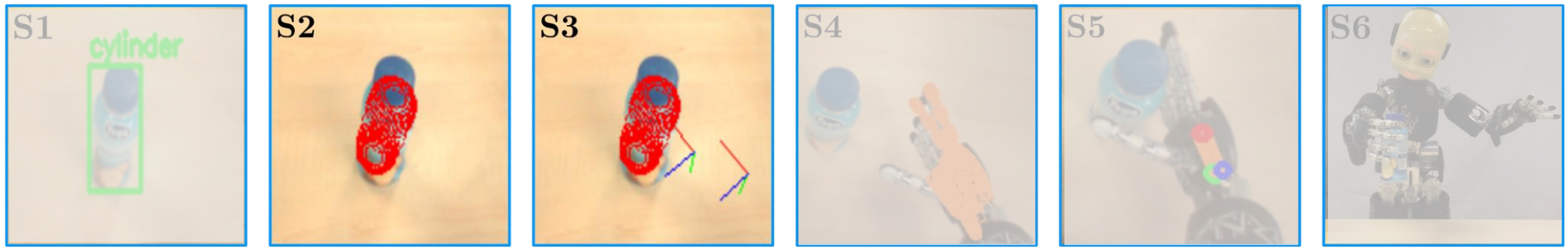
Grasping pose computation

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

subject to:

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





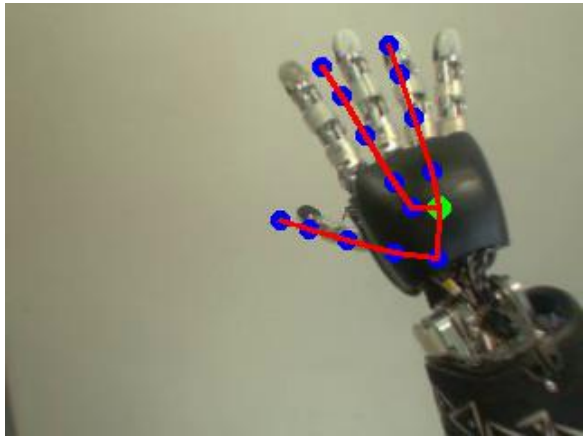
Fine Pose Reaching for Robust Grasp

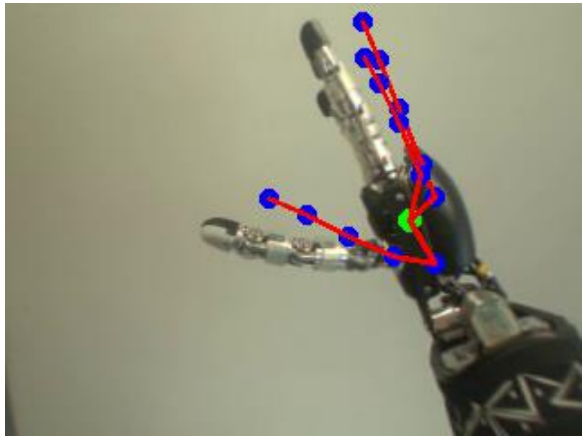
Problem

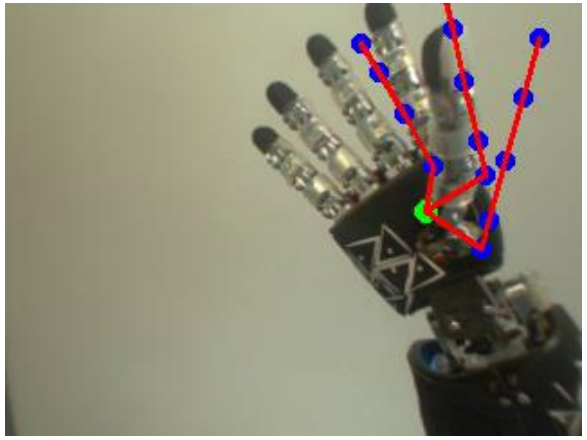
Imprecise kinematics

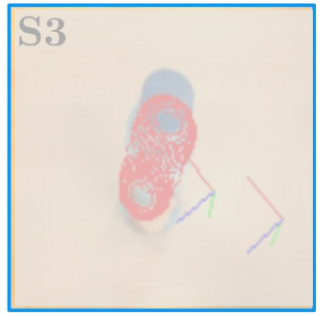
Goal

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





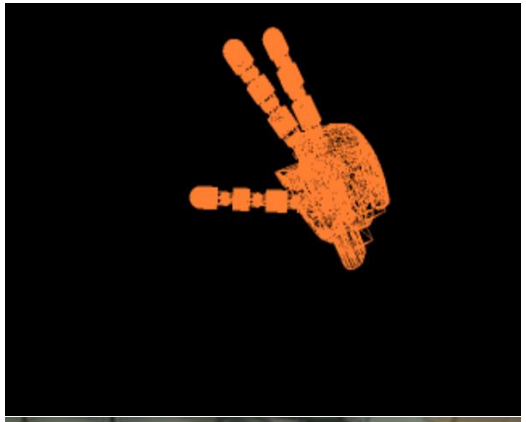




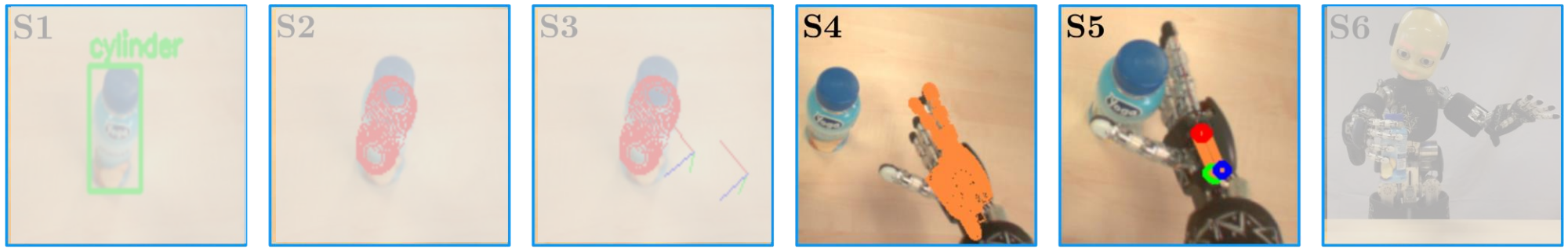
Visual Particle Filter

[*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.



Demonstration