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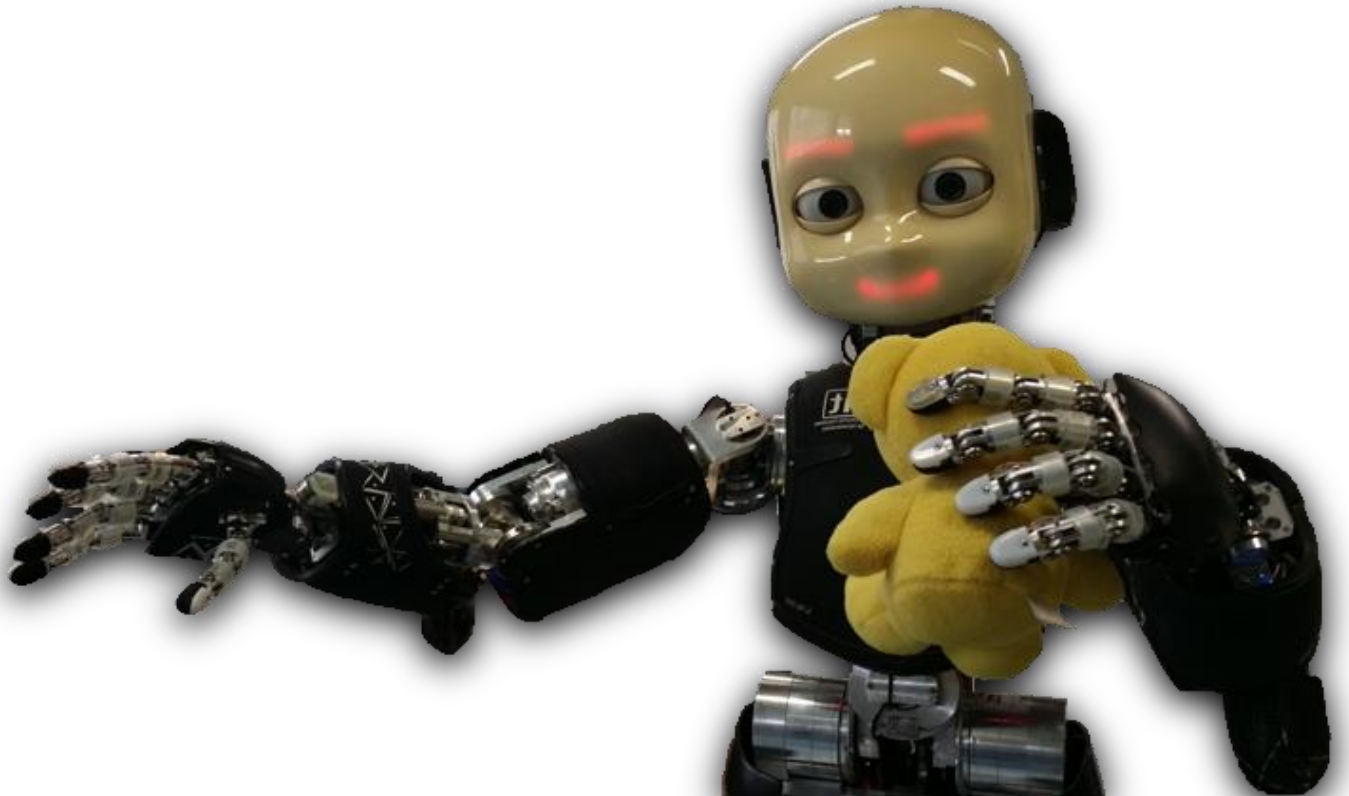
# Object Modeling and Grasping Pipeline based on Superquadric Models

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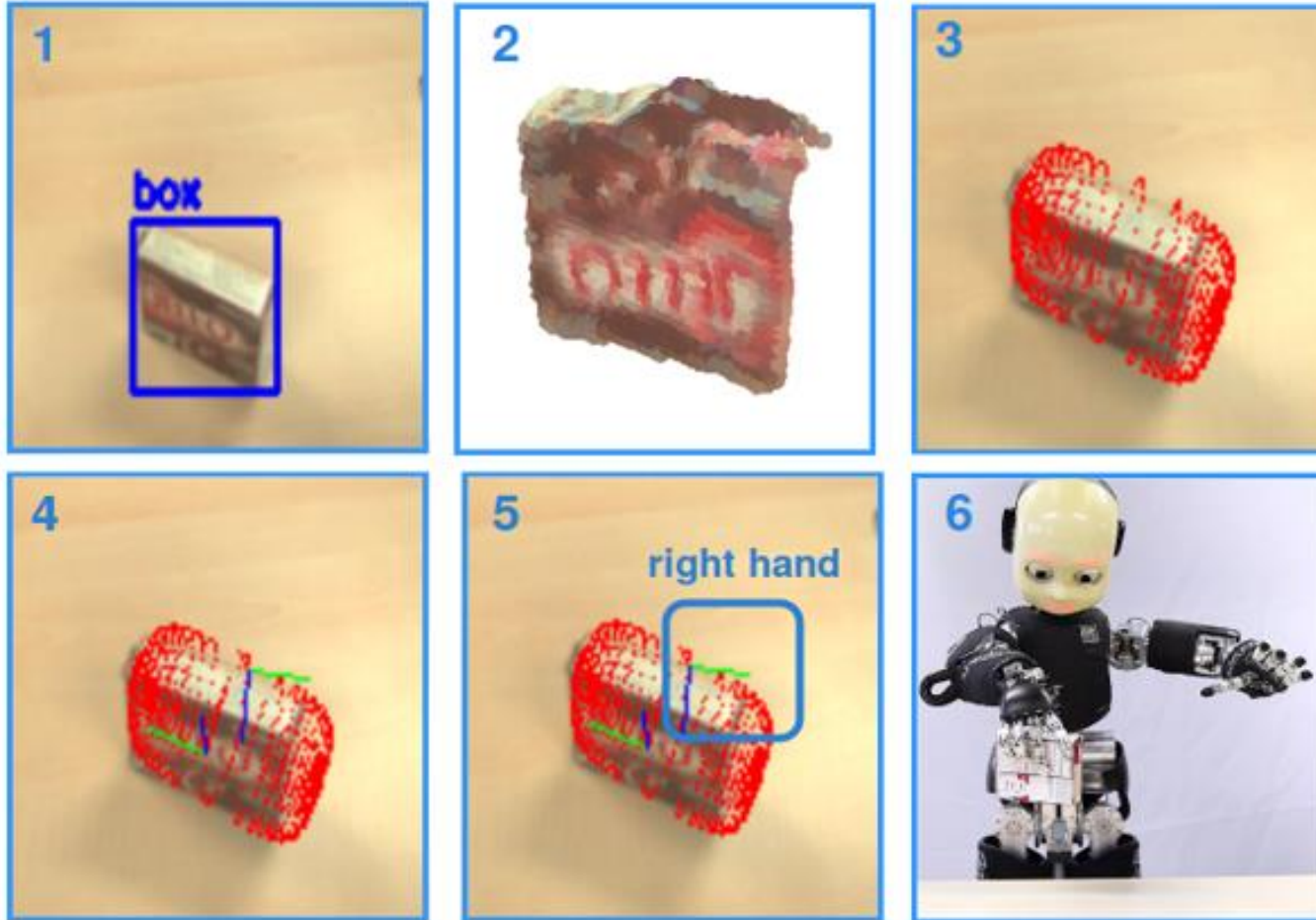


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# Pipeline overview

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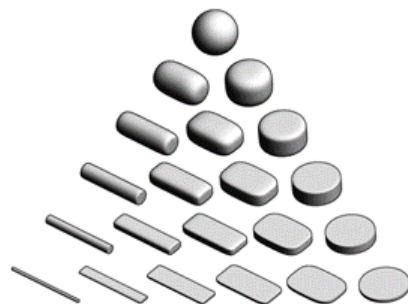
1. Object classification
2. Point cloud extraction
3. Object modeling
4. Grasping pose computation
5. Best hand selection
6. Object grasping

# Superquadric Modeling and Grasping

[ICRA2017]

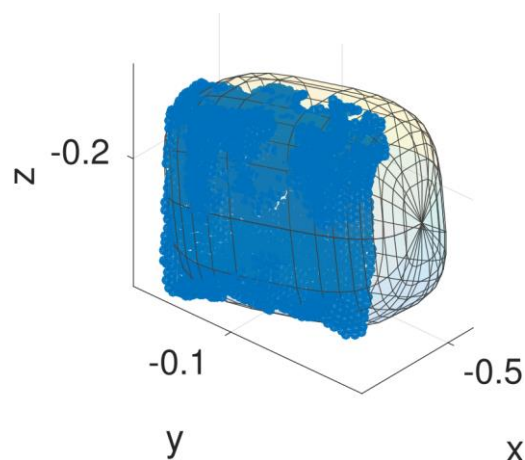
Superquadric function

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



Superquadric estimation

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



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

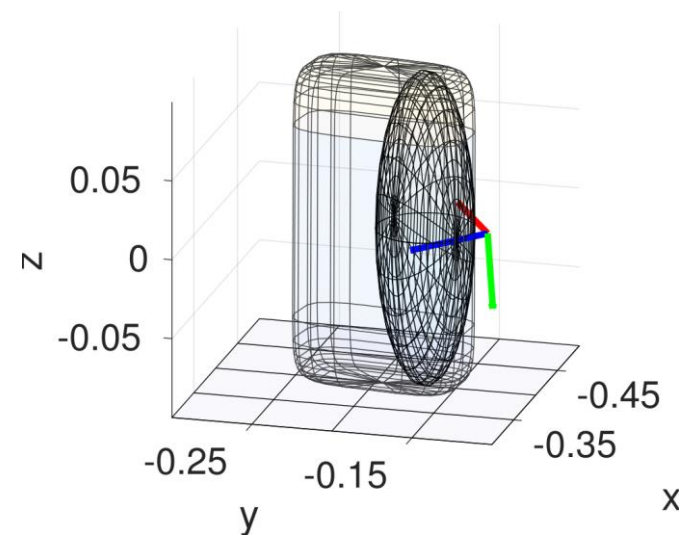
subject to:

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



$$a \bar{p}_{x_p}^{\mathbf{x}} + b \bar{p}_{y_p}^{\mathbf{x}} + c \bar{p}_{z_p}^{\mathbf{x}} + d > 0,$$

with  $(\bar{p}_{x_p}^{\mathbf{x}}, \bar{p}_{y_p}^{\mathbf{x}}, \bar{p}_{z_p}^{\mathbf{x}}) = \arg \min_{\mathbf{p}_{z_p, i}^{\mathbf{x}}} \mathbf{p}_{i, p}^{\mathbf{x}}.$



# Novel pipeline: modeling with prior on object shape

- Object classification: cylinder, sphere, box

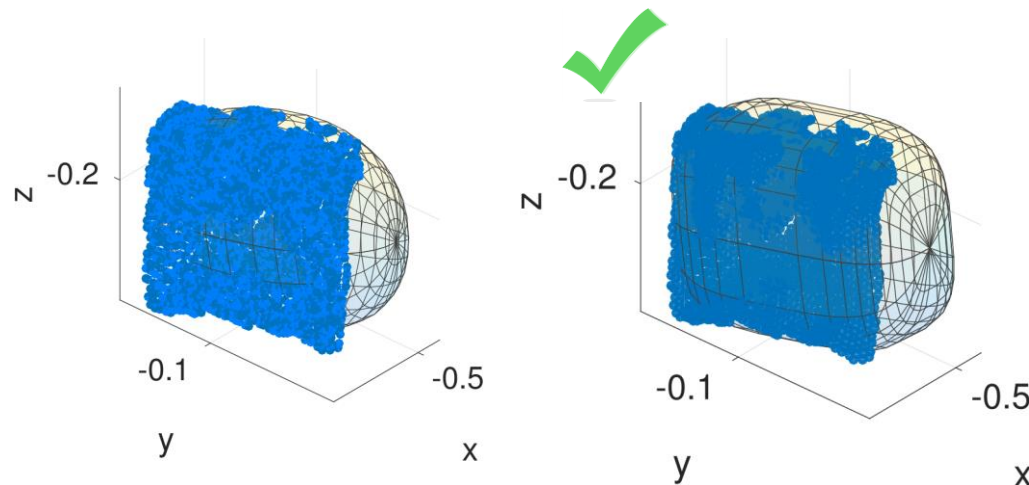


Training set: 30 objects

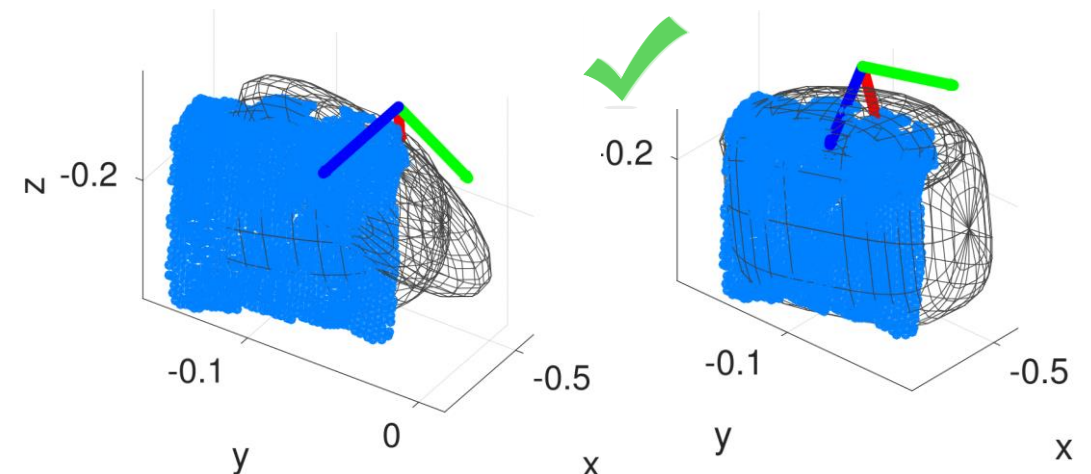


Test set: 18 objects (YCB & iCubWorld)

- Sharp cornered shapes lead to better grasping poses



Models

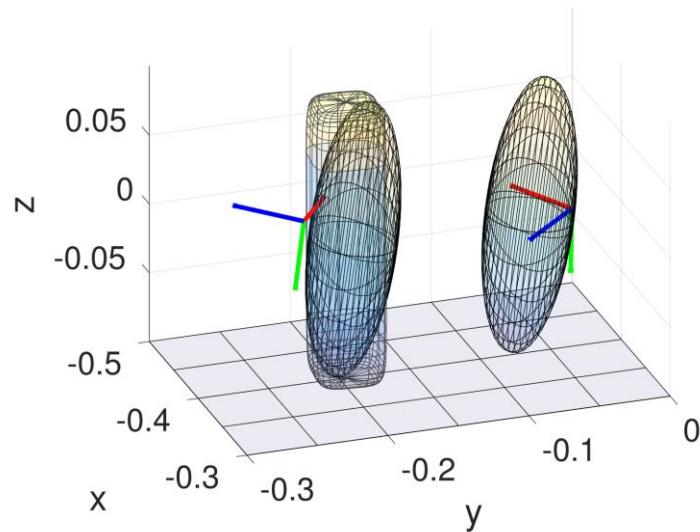


Poses

# Novel pipeline: automatic hand selection

$$\mathcal{I}_{P,hand} = \frac{1}{w_1 F_{f,hand} + w_2 (z_{hand} \cdot z_{root})},$$

Overlapping between object  
and hand model



To favour top and lateral  
grasps

