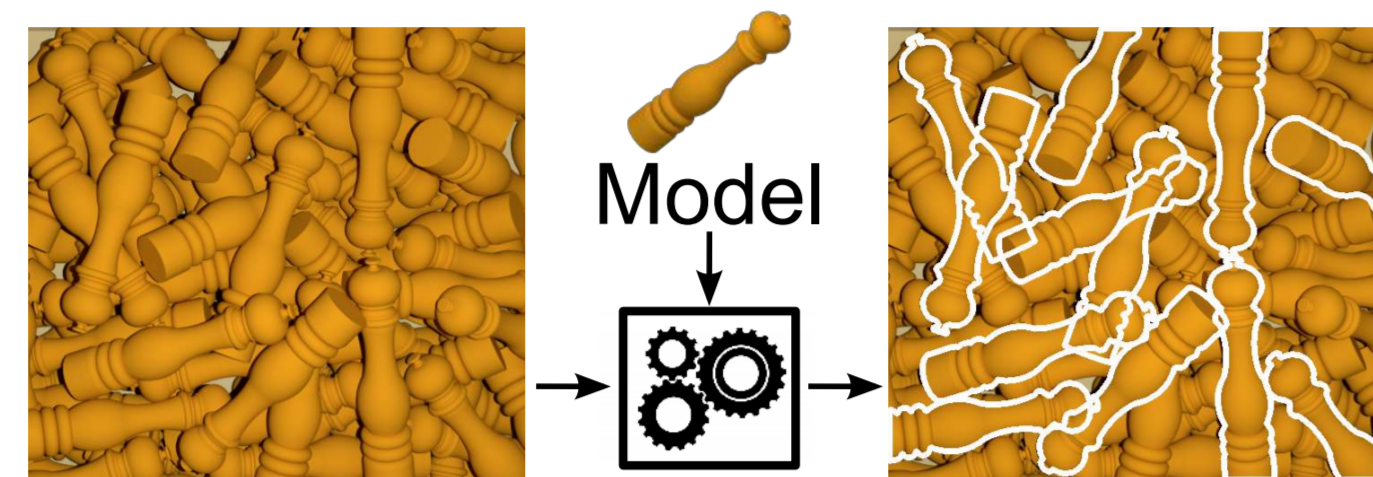


## Summary

Evaluation methodology suitable for:

- Any rigid object.
- Arbitrary poses.
- Many object instances.
- Exact localization.



**Main idea:** Accounting for object's symmetries.

## Limitations of existing approaches

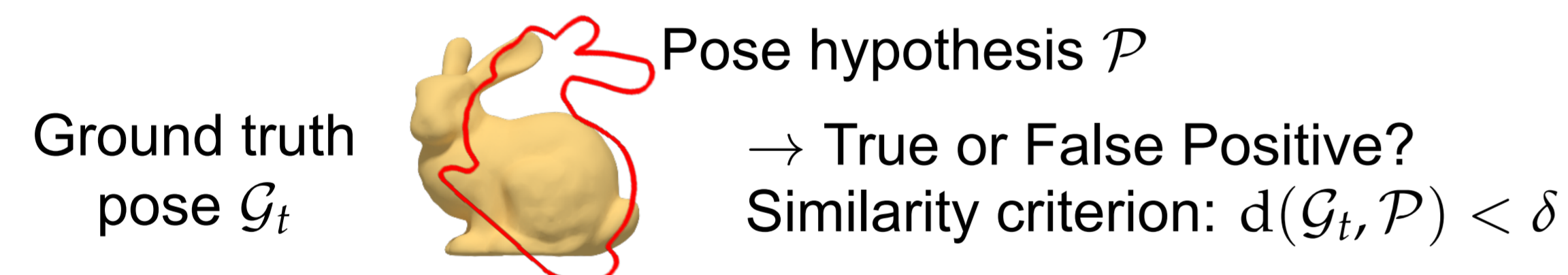
### Existing datasets



Hinterstoisser et al. [2]

- Mainly table-top scenarios.
- **Data redundancy**
  - Hundreds of images from only a few scenes.
  - Cause: pose annotation is tedious.

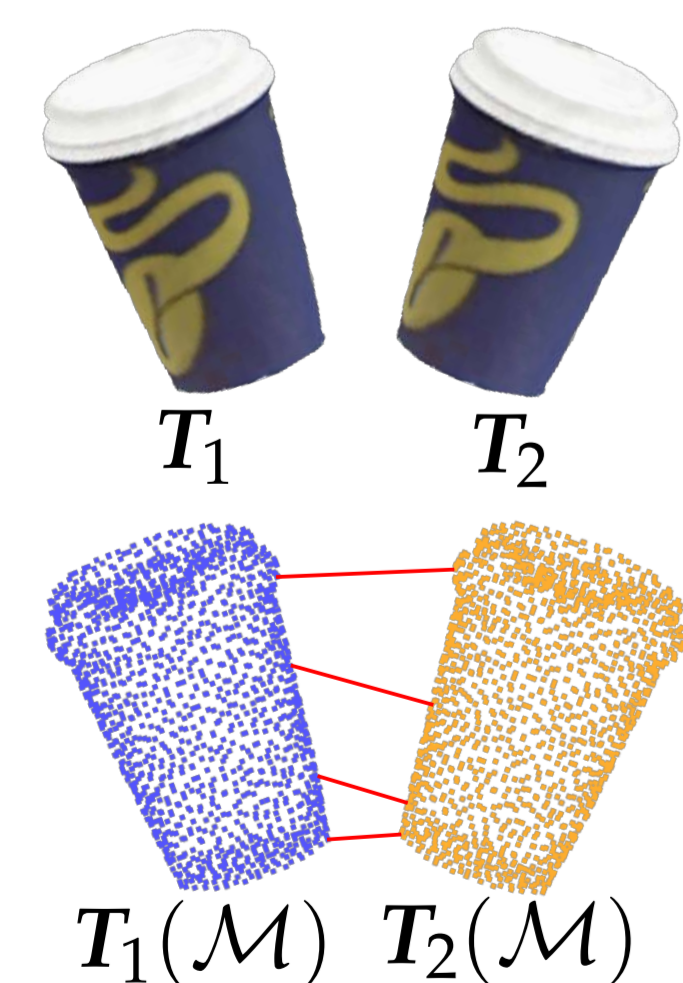
### Results classification



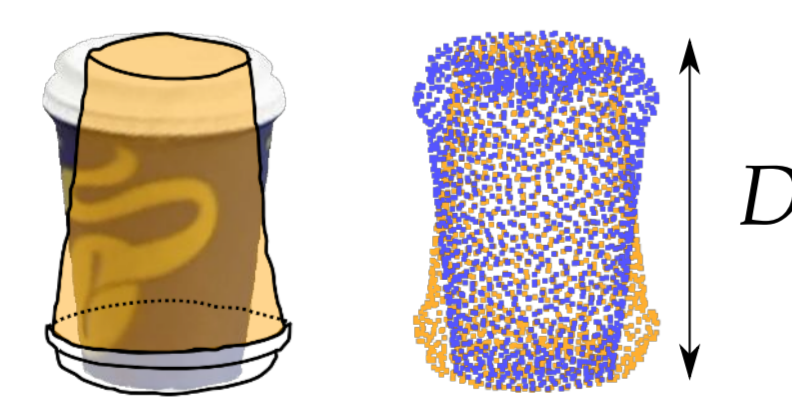
Existing dissimilarity measures  $d$ :

- Rigid transformation distance.
- IoU, Visible Surface Discrepancy [Hodaň et al. 2017].
- Pointset distance [2] for symmetric objects:

$$d_{\text{Hinterstoisser}}(T_1, T_2) \triangleq \text{average} \min_{x_1 \in \mathcal{M}, x_2 \in \mathcal{M}} \|T_2(x) - T_1(x)\|$$



**Issue with poses of similar shapes:**

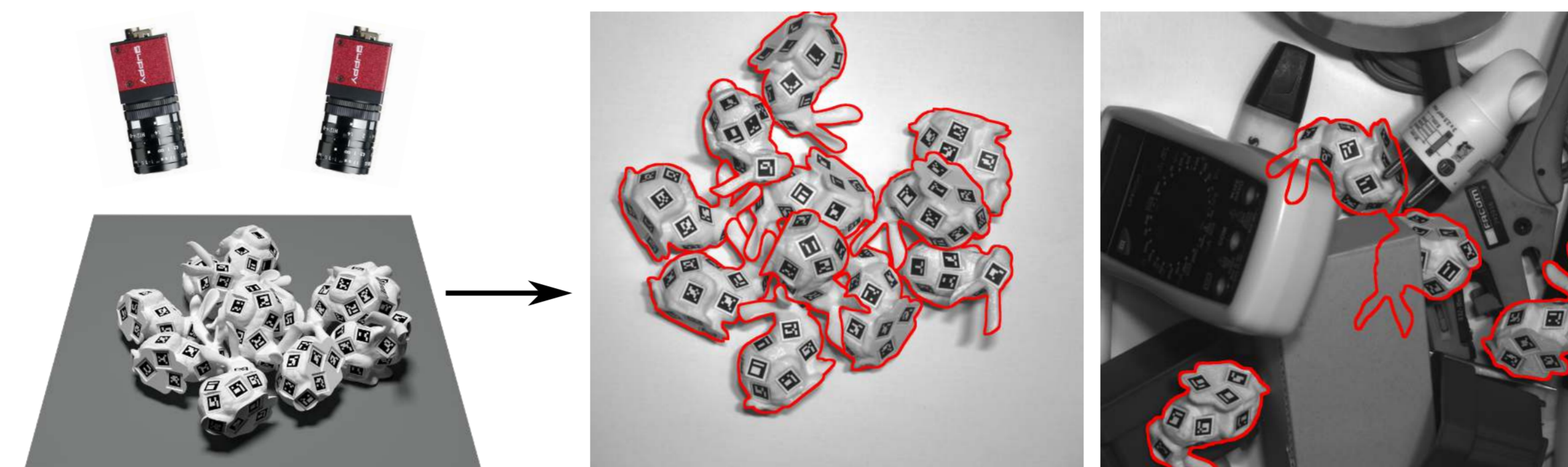


$$d_{\text{Hinterstoisser}}(T_1, T_2) = 4.5\%D < \delta (= 10\%D [2])$$

→ **wrongly classified as True Positive!**

## Generating automatically annotated datasets

### Marker-based pose annotation



Ground truth retrieved by detecting ArUco markers placed on object instances at known locations from multiple viewpoints.

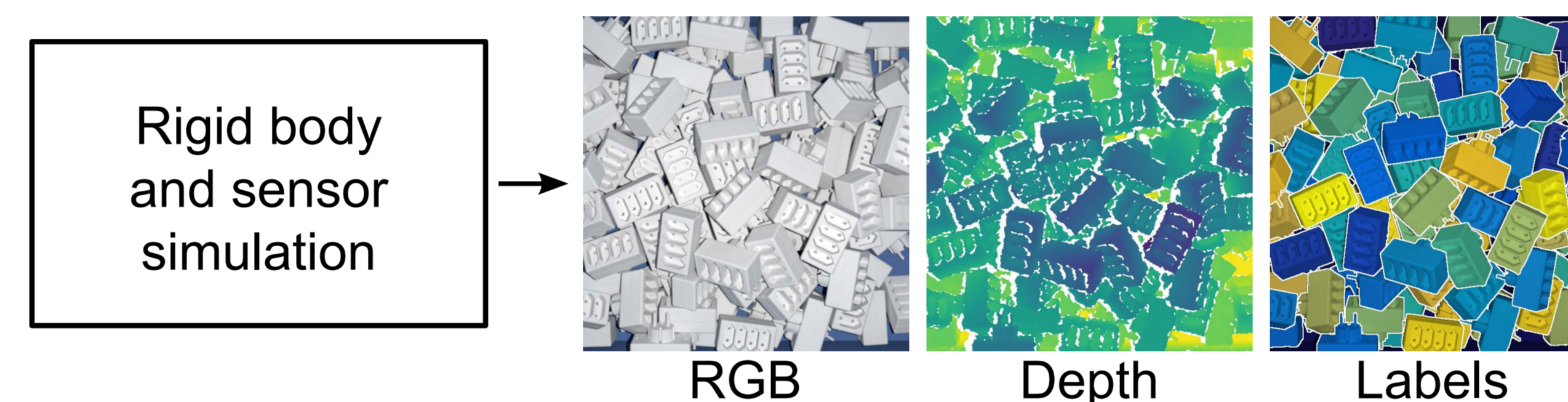
**Pros:**

- Automatic annotation.
- Many instances, arbitrary pose.

**Cons:**

- Intrusive (RGB data).

### Synthetic dataset generation



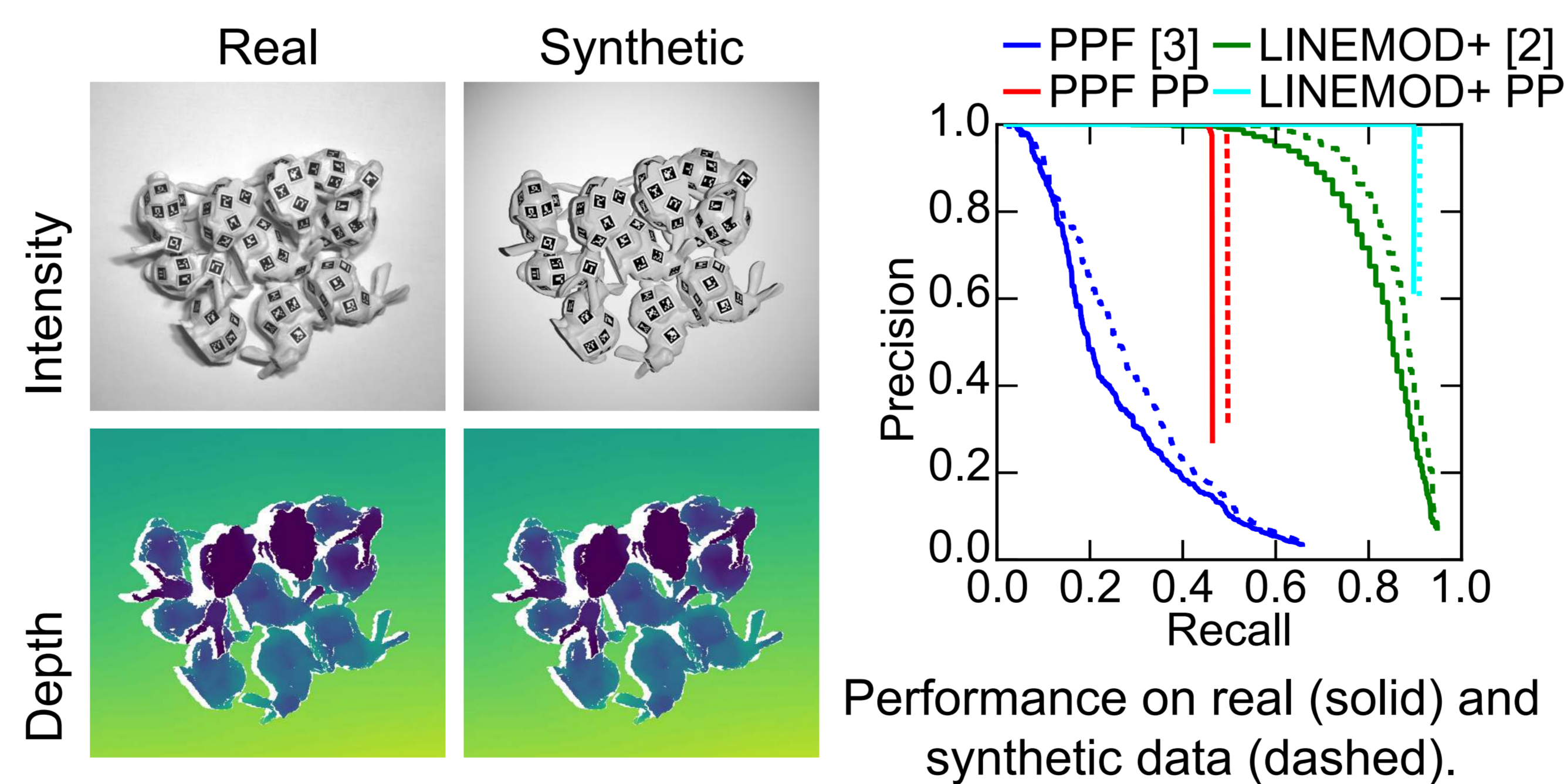
**Pros:**

- Control of every parameter.
- Annotations for free.

**Cons:**

- Synthesis of natural scenes may be challenging.

### Comparison between the two approaches



Dataset and evaluation tools available at [rbregier.github.io/dataset2017](http://rbregier.github.io/dataset2017)

## Accounting for symmetries during evaluation

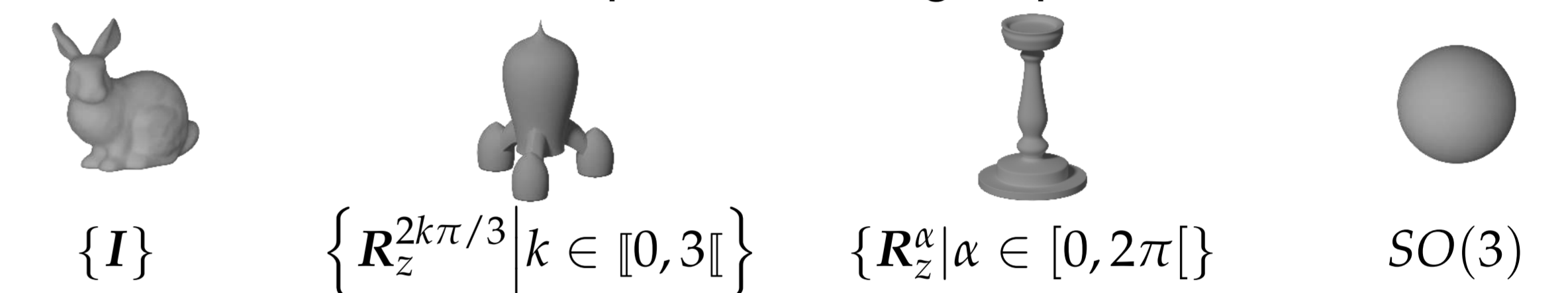
### Pose definition

Pose equivalent to a set of rigid transformations:

$$\mathcal{P} \triangleq \{T \circ G \mid G \in G\}$$

with  $G \subset SE(3)$  the group of proper symmetry of the object.

Examples of such groups:



Which symmetry group for these objects?



→  $G$  is application-dependent.

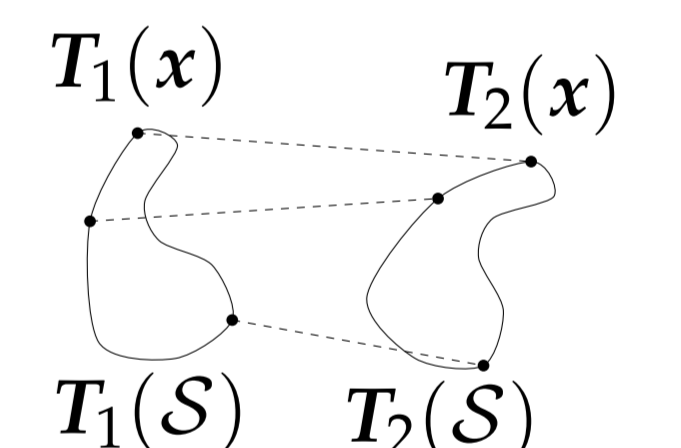
### Proposed dissimilarity criterion: pose distance [1]

Length of the smallest displacement between two poses:

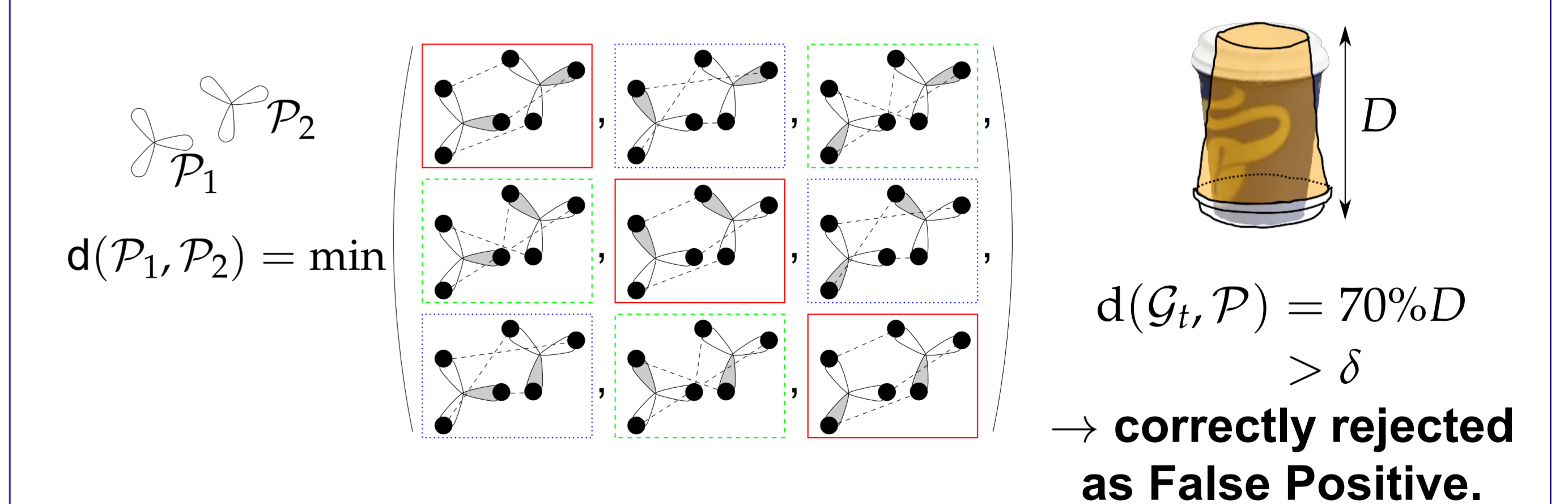
$$d(\mathcal{P}_1, \mathcal{P}_2) \triangleq \min_{G_1, G_2 \in G} d_{\text{no\_sym}}(T_1 \circ G_1, T_2 \circ G_2)$$

where

$$d_{\text{no\_sym}}(T_1, T_2) \triangleq \sqrt{\frac{1}{S} \int_S \|T_2(x) - T_1(x)\|^2 ds}$$



- Positioning error of the object's surface.
- Computation-friendly (15 multiplications, 25 additions).
- Fast neighborhood queries and pose averaging.
  - can be used at test time.
- **Exploiting symmetry at test time improve performance:**
  - +50% AP increase in our experiments.



## References

- [1] R. Brégier, F. Devernay, L. Leyrit, and J. Crowley, "Defining the pose of any 3D rigid object and an associated distance", 2016, under review (available on ArXiv).
- [2] S. Hinterstoisser, V. Lepetit, S. Ilic, S. Holzer, G. Bradski, K. Konolige, and N. Navab, "Model based training, detection and pose estimation of texture-less 3D objects in heavily cluttered scenes", in ACCV 2012.
- [3] B. Drost, M. Ulrich, N. Navab, and S. Ilic, "Model globally, match locally: Efficient and robust 3D object recognition", in CVPR 2010.