T-LESS: An RGB-D Dataset for 6D Pose Estimation of Texture-less Objects

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Jiří Matas[1], **Manolis Lourakis**[2], **Xenophon Zabulis**[2]

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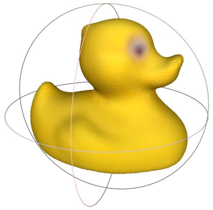
[2] Institute of Computer Science, FORTH, Heraklion, GR

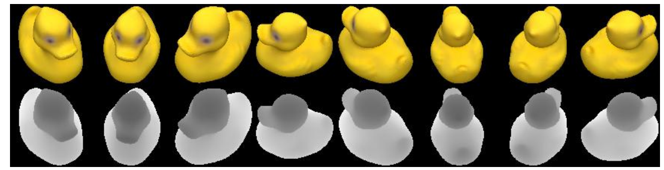
WACV 2017, 28th March 2017, Santa Rosa

6D Object Pose Estimation

Training data



OR

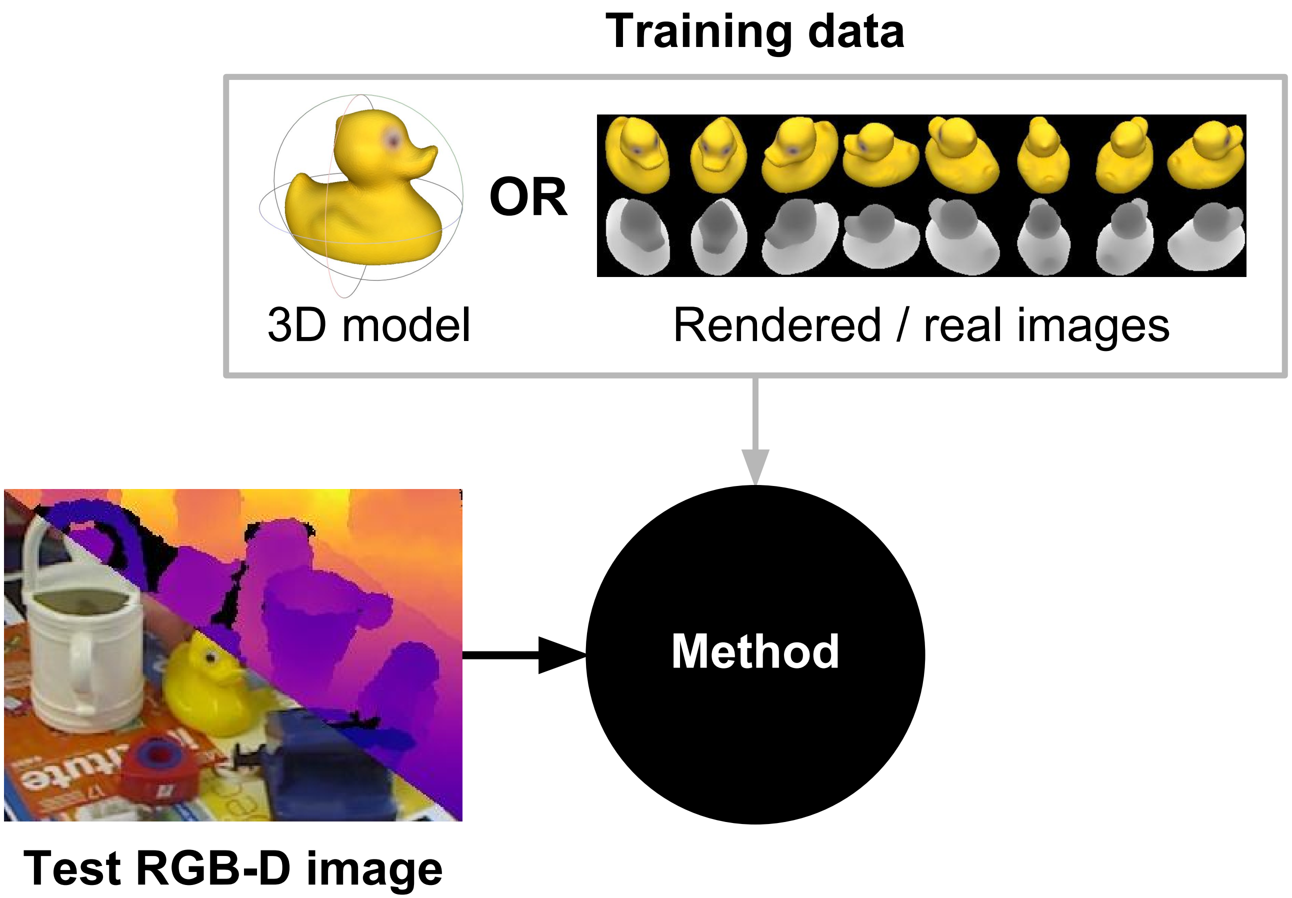


3D model

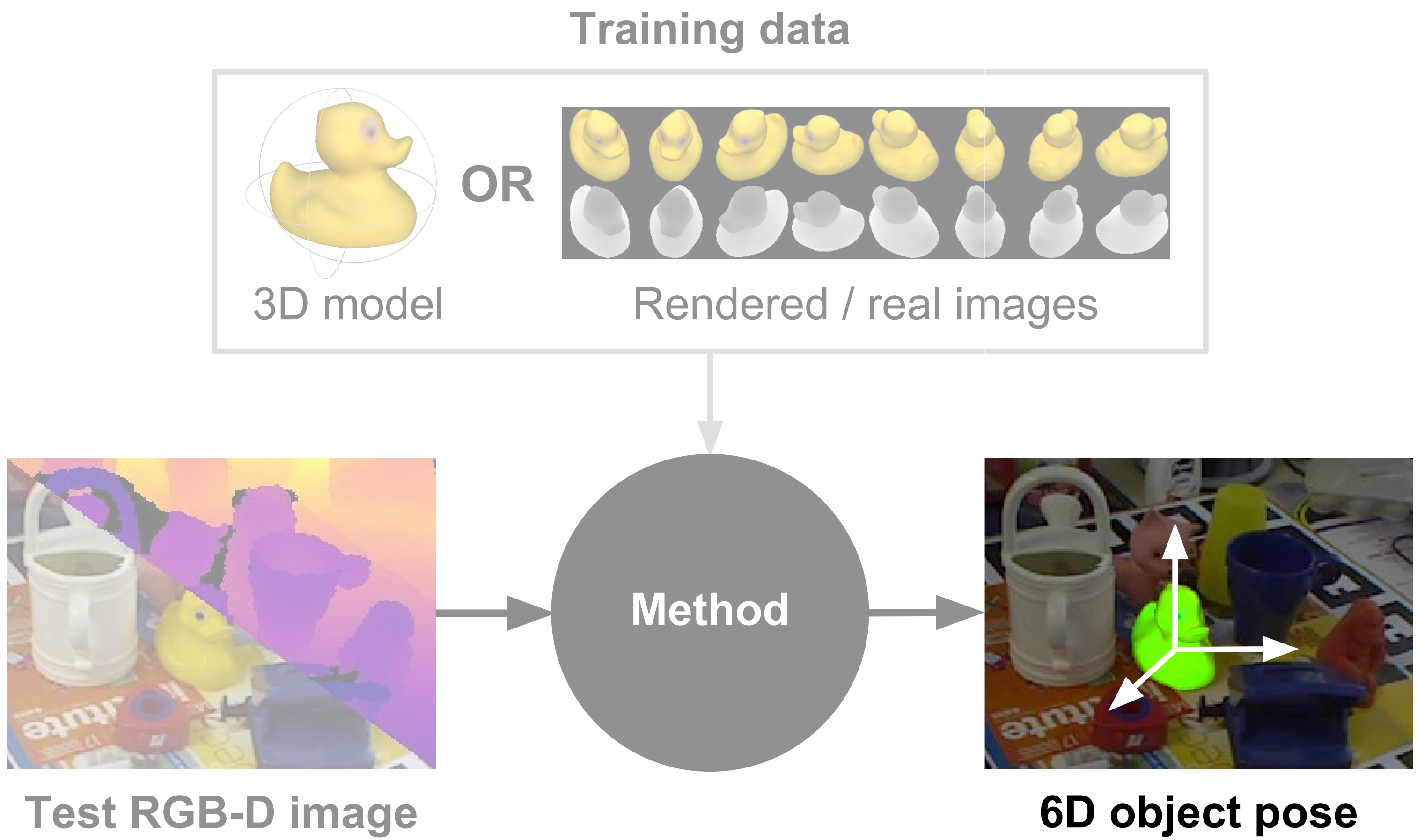
Rendered / real images

Method

6D Object Pose Estimation

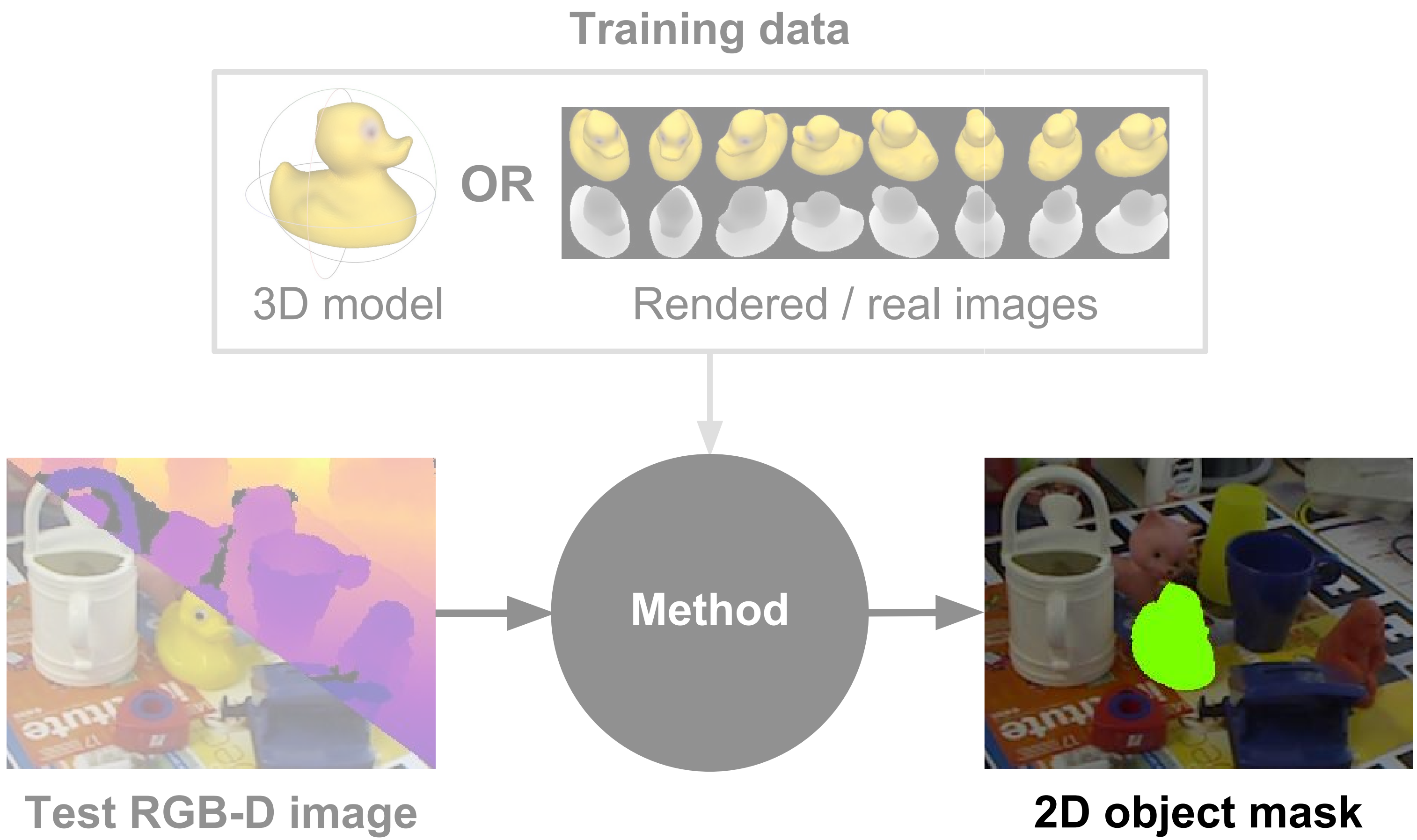


6D Object Pose Estimation



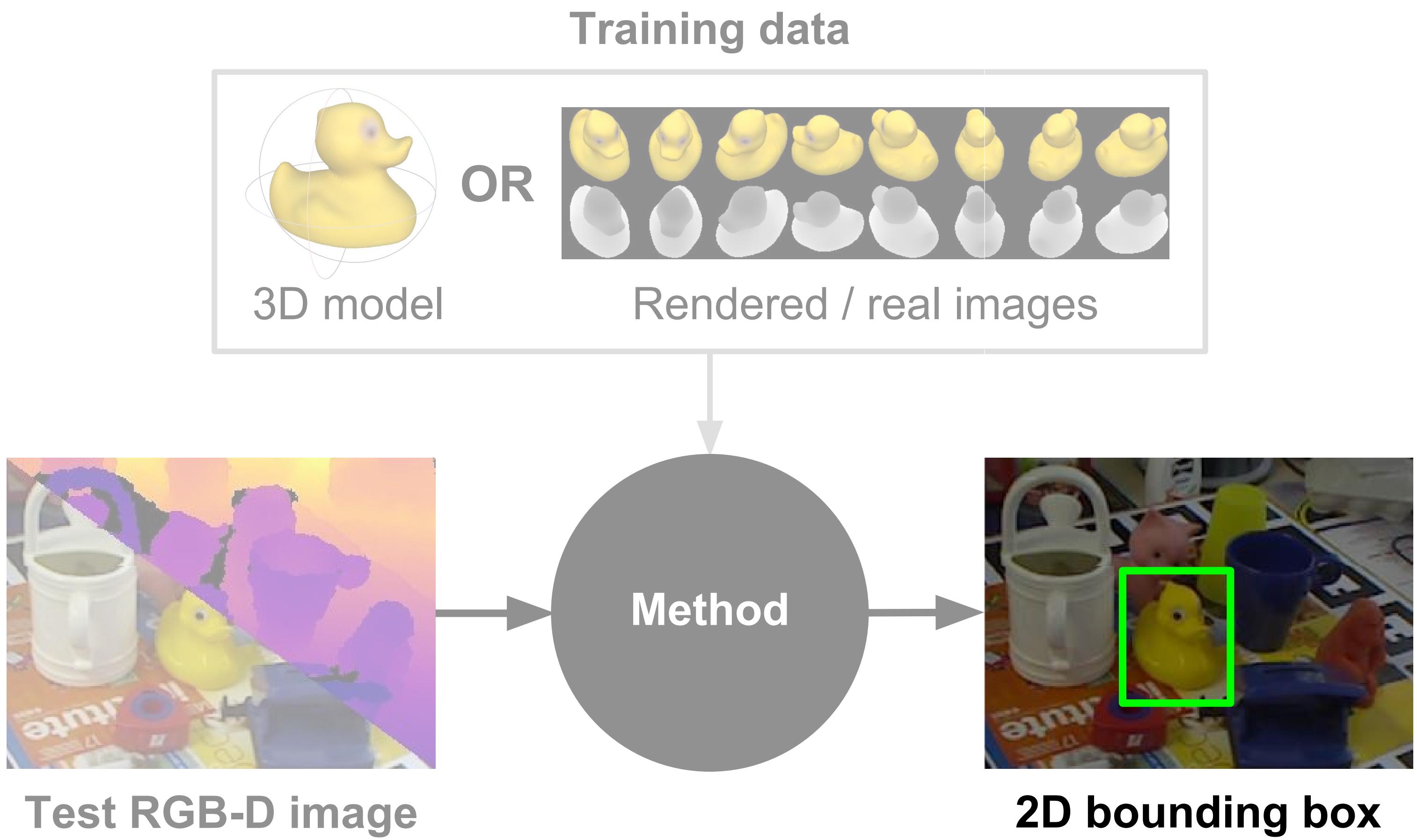
1. **Hinterstoisser et al.** "Model based training, detection and pose estimation of texture-less 3d objects in heavily cluttered scenes." ACCV'12.
2. **Hodaň et al.** "Detection and fine 3D pose estimation of texture-less objects in RGB-D images." IROS'15.
3. **Brachmann et al.** "Uncertainty-driven 6d pose estimation of objects and scenes from a single rgb image." CVPR'16.

2D Object Segmentation



1. **Lai et al.** "A large-scale hierarchical multi-view rgb-d object dataset." ICRA’11.
2. **Richtsfeld et al.** "Segmentation of unknown objects in indoor environments." IROS’12.
3. **Silberman et al.** "Indoor segmentation and support inference from rgbd images." ECCV’12.
4. **Georgakis et al.** "Multiview RGB-D Dataset for Object Instance Detection." 3DV’16.

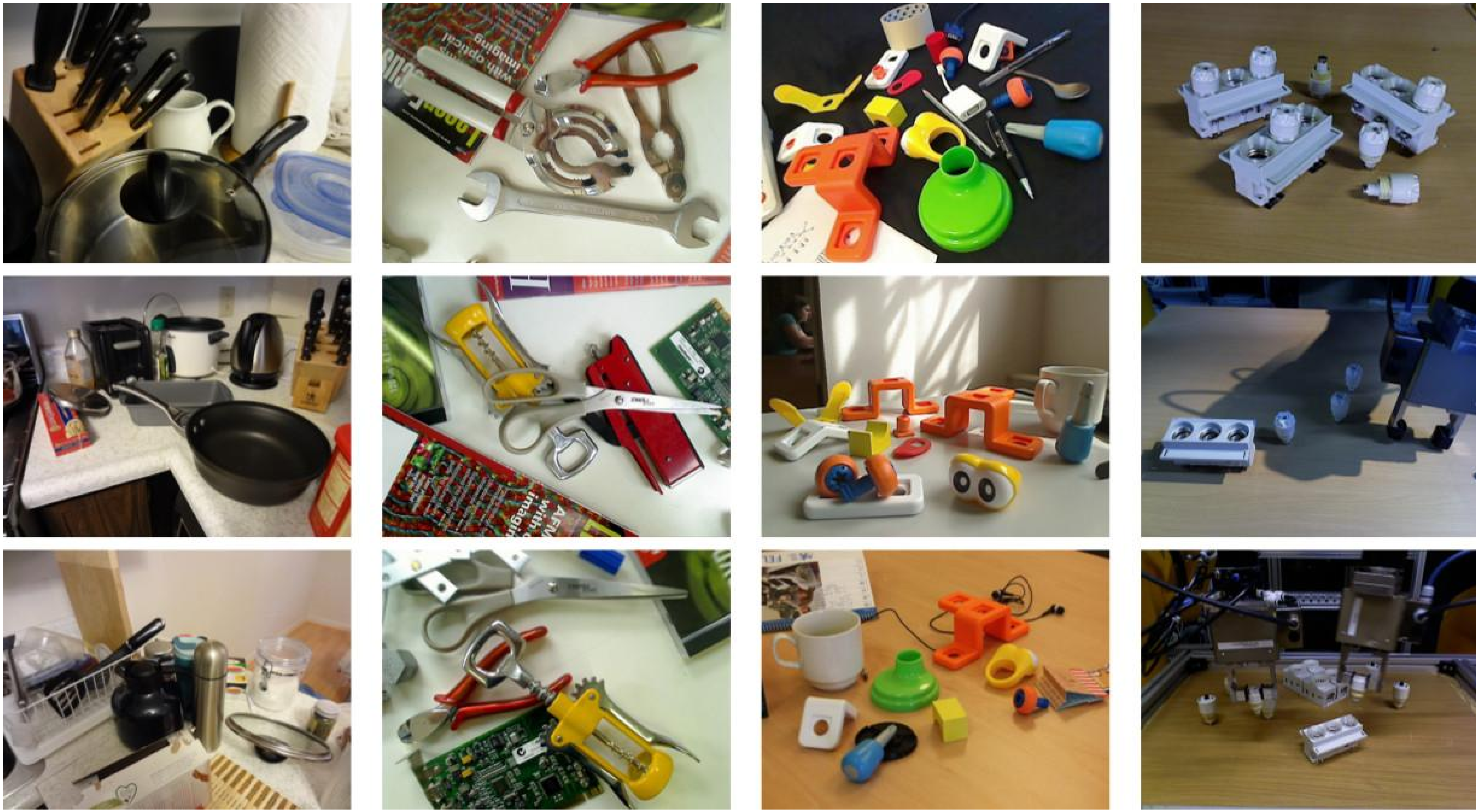
2D Object Detection



1. **Damen et al.** "Real-time Learning and Detection of 3D Texture-less Objects: A Scalable Approach." BMVC’12.
2. **Tombari et al.** "BOLD features to detect texture-less objects." ICCV’13.
3. **Rios-Cabrera and Tuytelaars.** "Discriminatively trained templates for 3d object detection: A real time scalable approach." ICCV’13.

Texture-less Objects

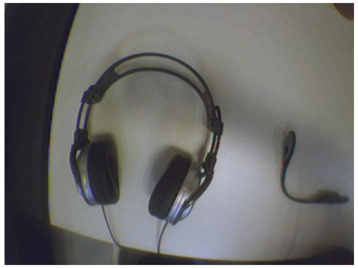
Detection and accurate localization of texture-less objects is often required in **robotics** and **augmented reality**.



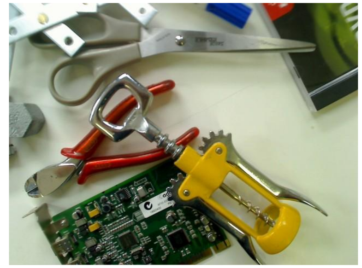
Existing Datasets with Texture-less Objects

RGB datasets:

Cai et al.



Damen et al.



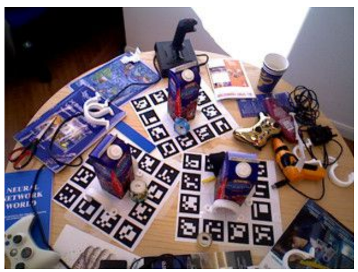
Tombari et al.

Hsiao et al.

Rios-Cabrera et al.

RGB-D datasets:

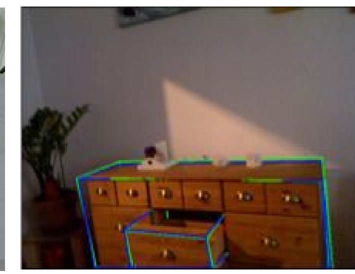
Hinterstoisser et al.



Tejani et al.

Doumanoglou et al.

Walas et al.



Michel et al.

Existing Datasets with Texture-less Objects

RGB datasets: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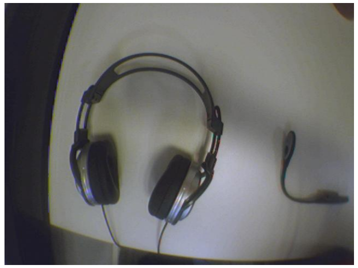
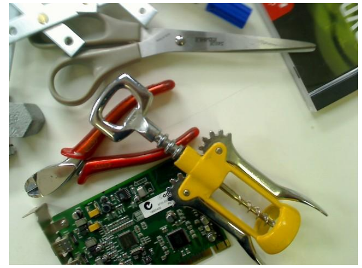

Damen et al.

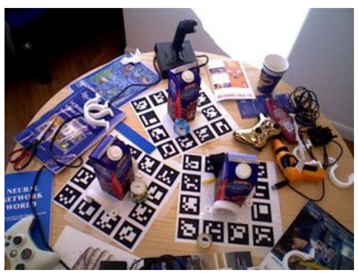

Tombari et al.


Hsiao et al.


Rios-Cabrera et al.

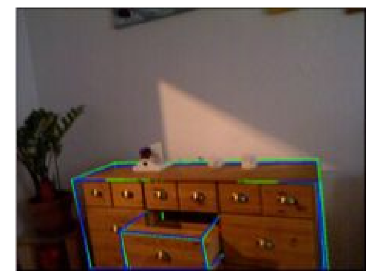
RGB-D datasets:


Hinterstoisser et al.


Tejani et al.

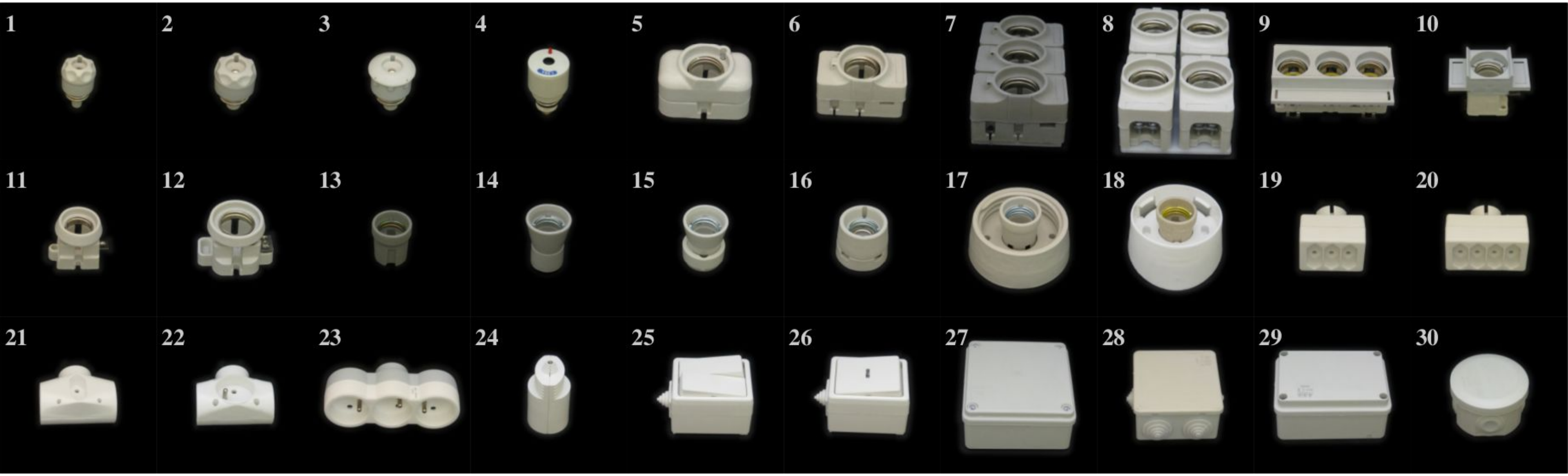

Doumanoglou et al.


Walas et al.

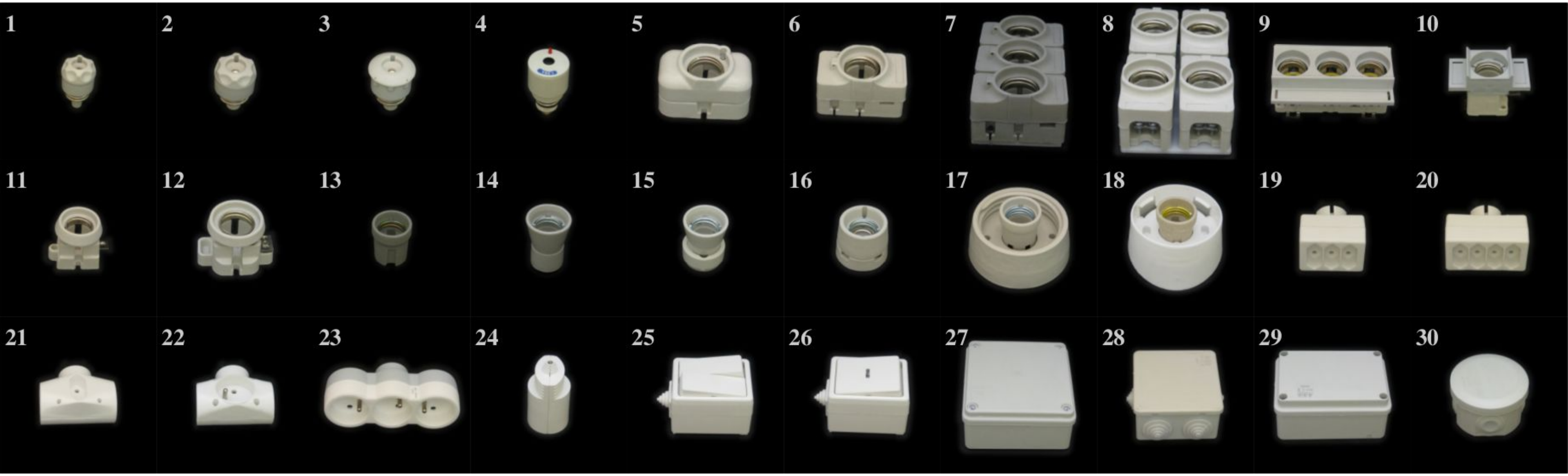

Michel et al.

Common aspect: **objects with discriminative size, shape or color**

30 Industry-relevant Objects in T-LESS

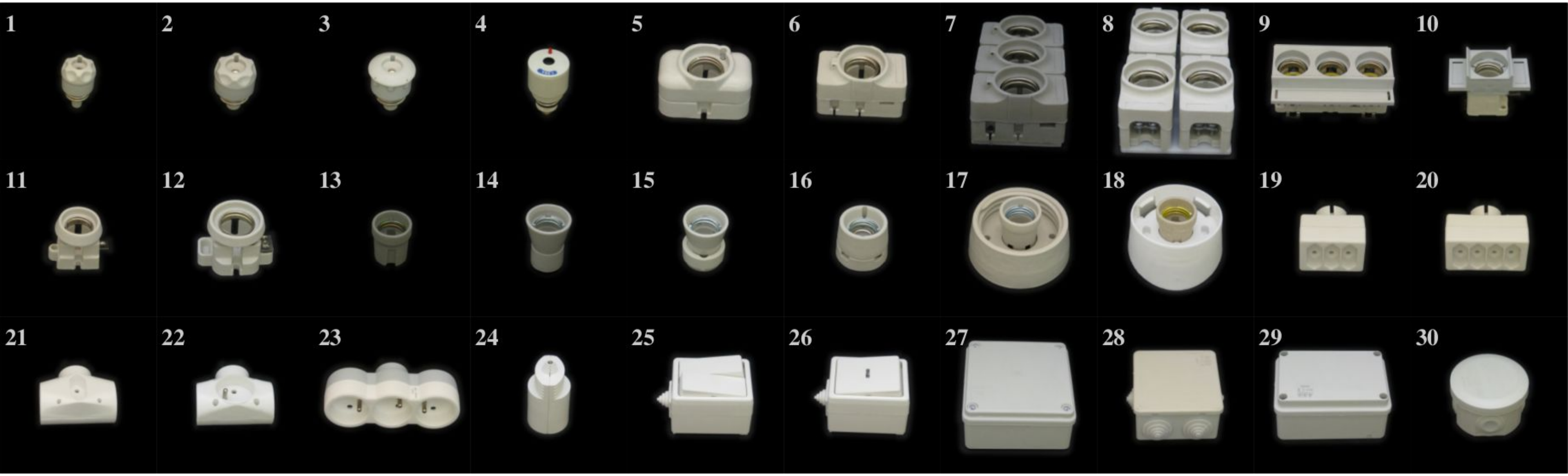


30 Industry-relevant Objects in T-LESS



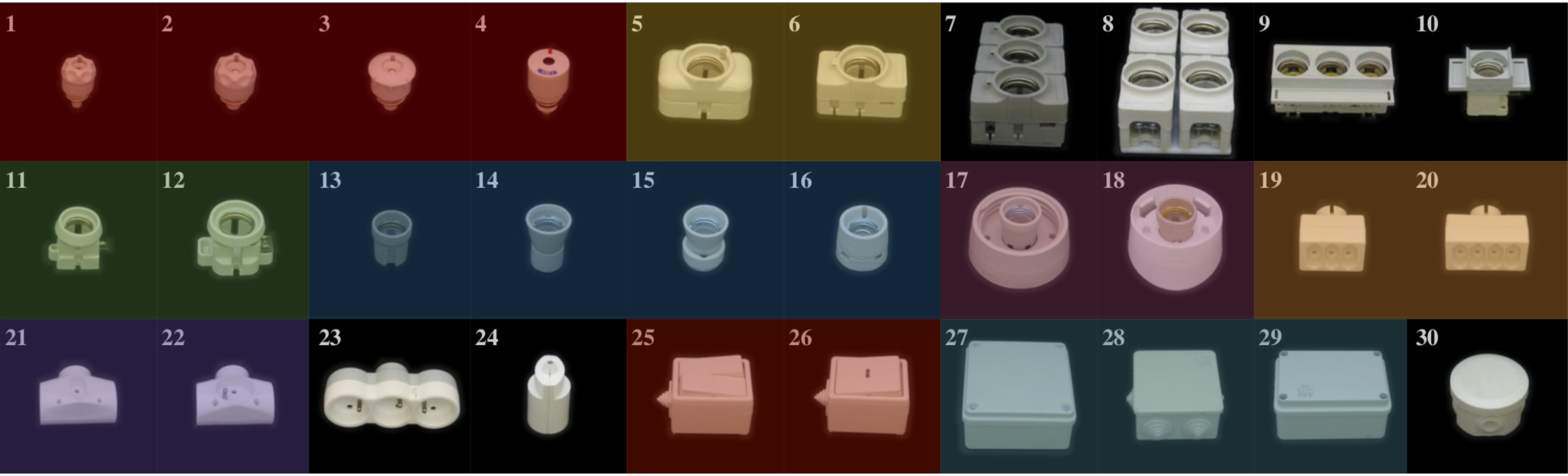
- No significant texture

30 Industry-relevant Objects in T-LESS



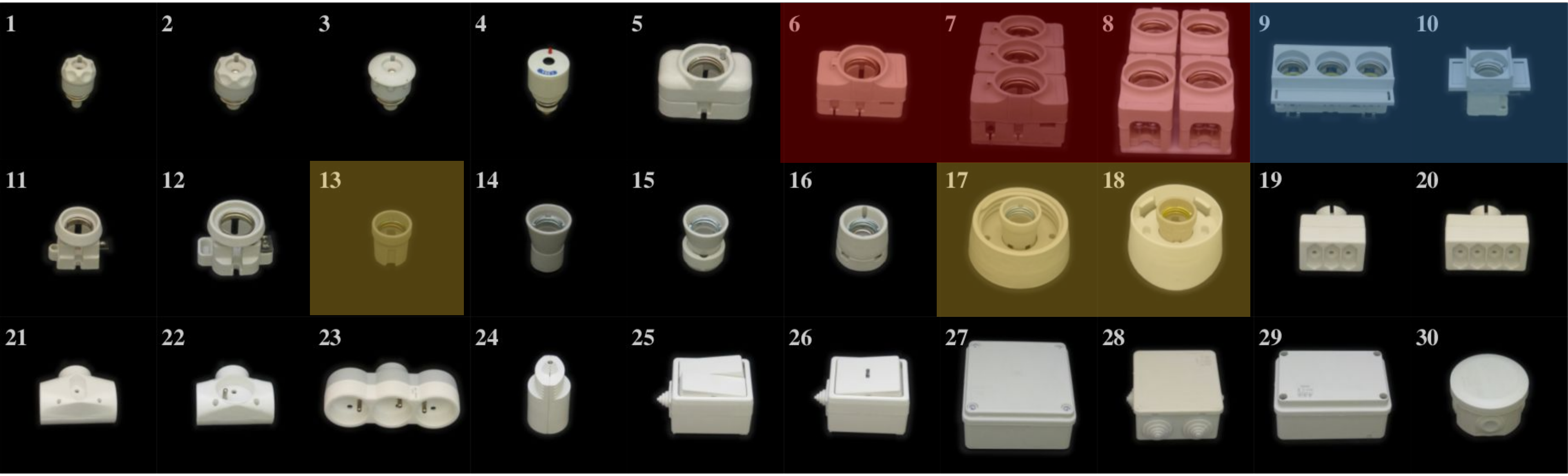
- No significant texture
- No discriminative reflectance properties

30 Industry-relevant Objects in T-LESS



- No significant texture
- No discriminative reflectance properties
- Symmetries and mutual similarities in shape or size

30 Industry-relevant Objects in T-LESS



- No significant texture
- No discriminative reflectance properties
- Symmetries and mutual similarities in shape or size
- Some objects are parts of others

Three Synchronized Sensors

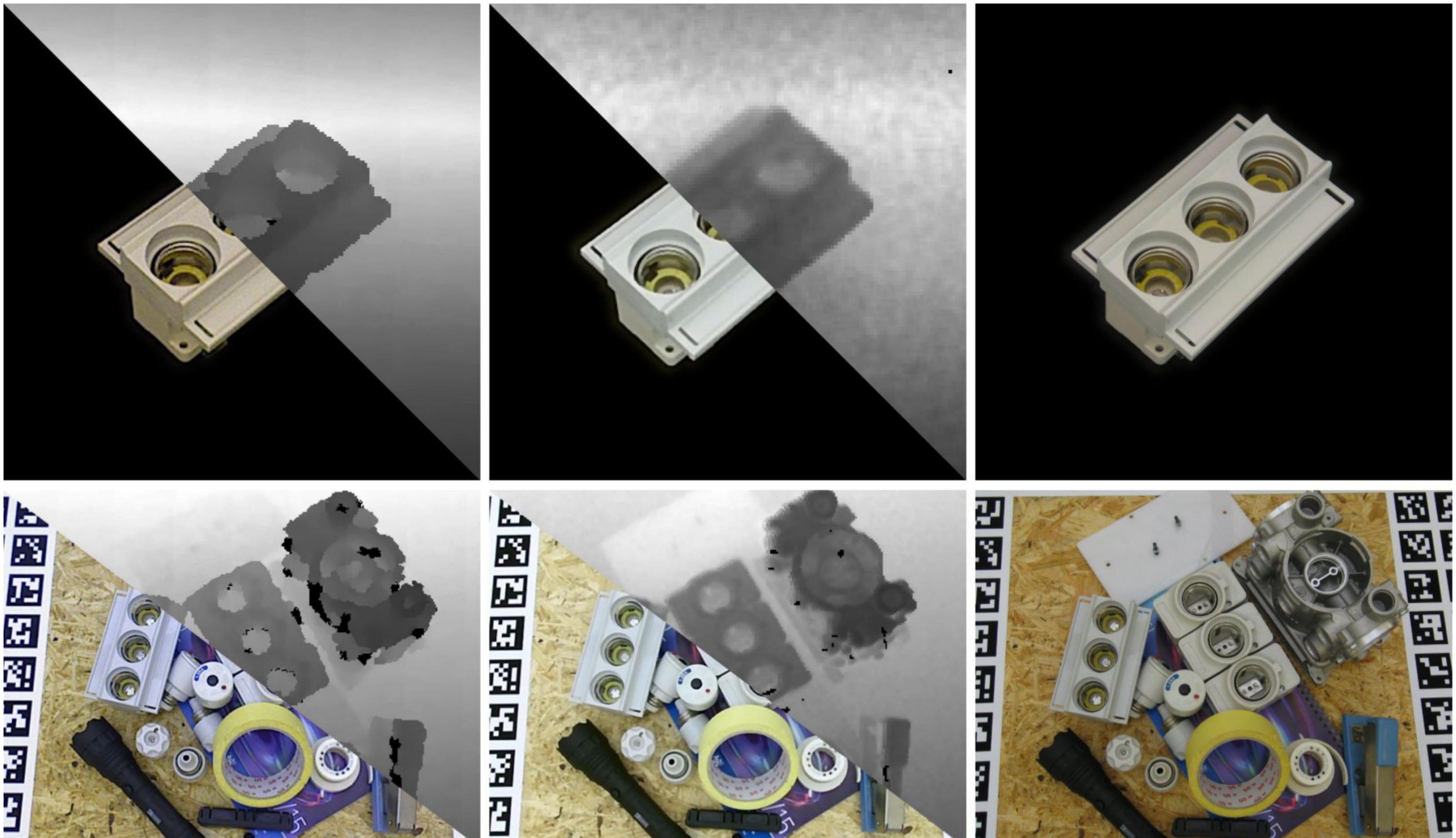

Carmine 1.09


Kinect v2


Canon IXUS 950 IS

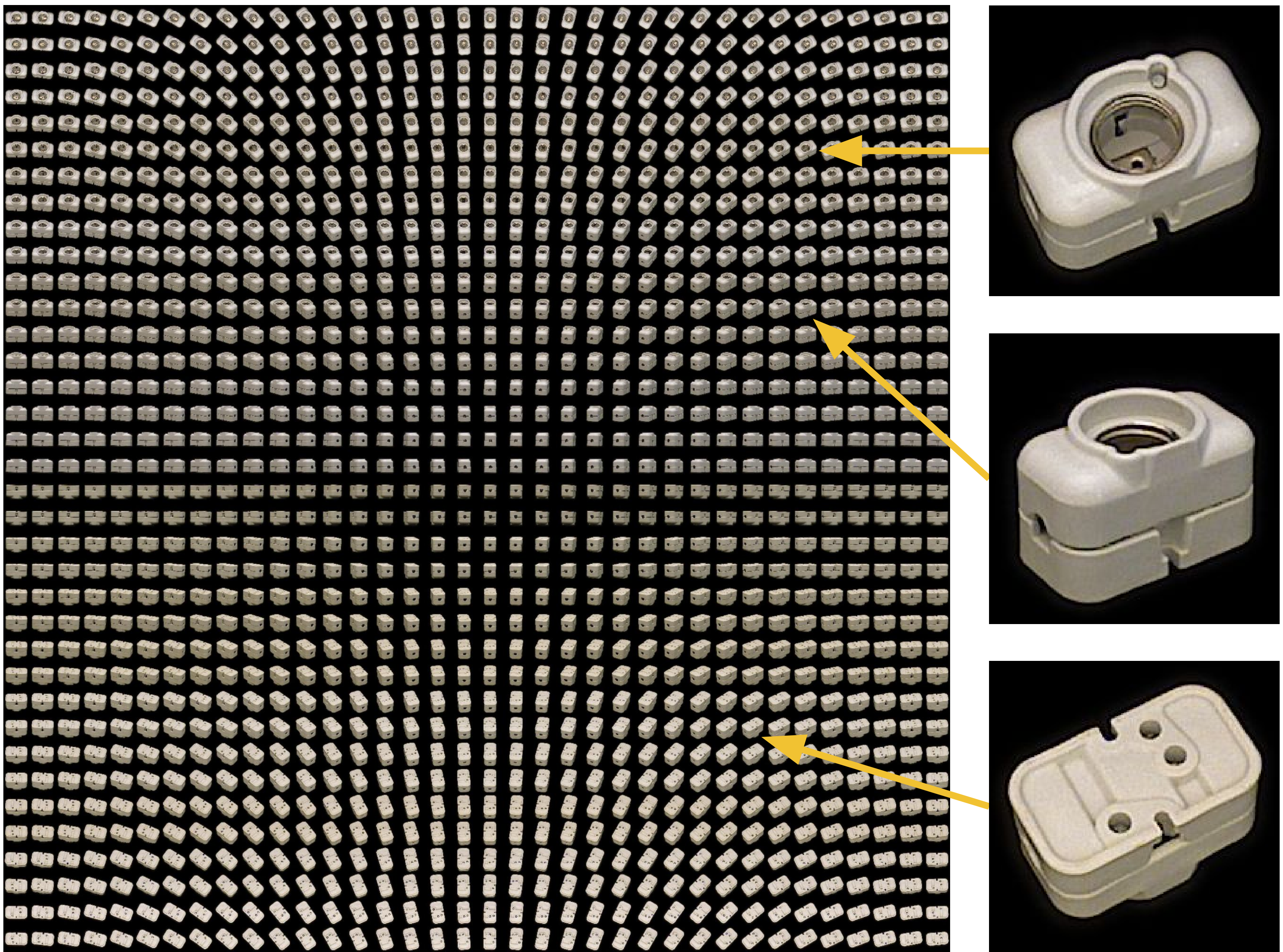
Training images

Test images



Training Images, 39K per Sensor

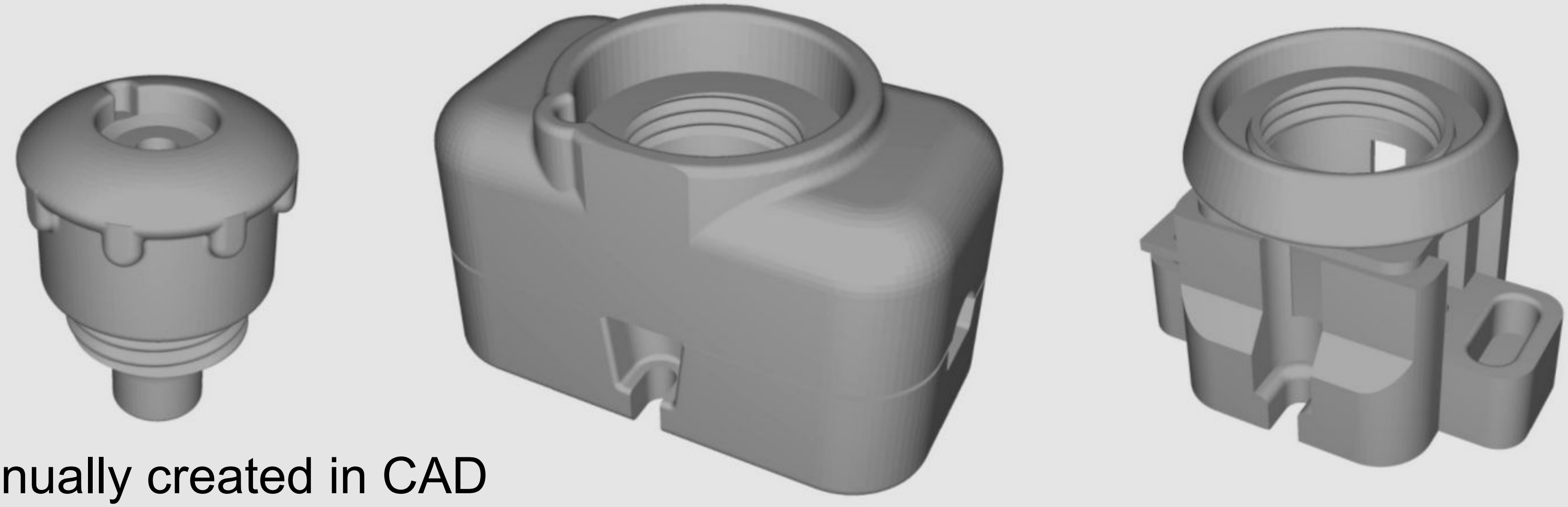
- Depict individual objects against **a black background**
- Captured from **a systematically sampled view sphere**



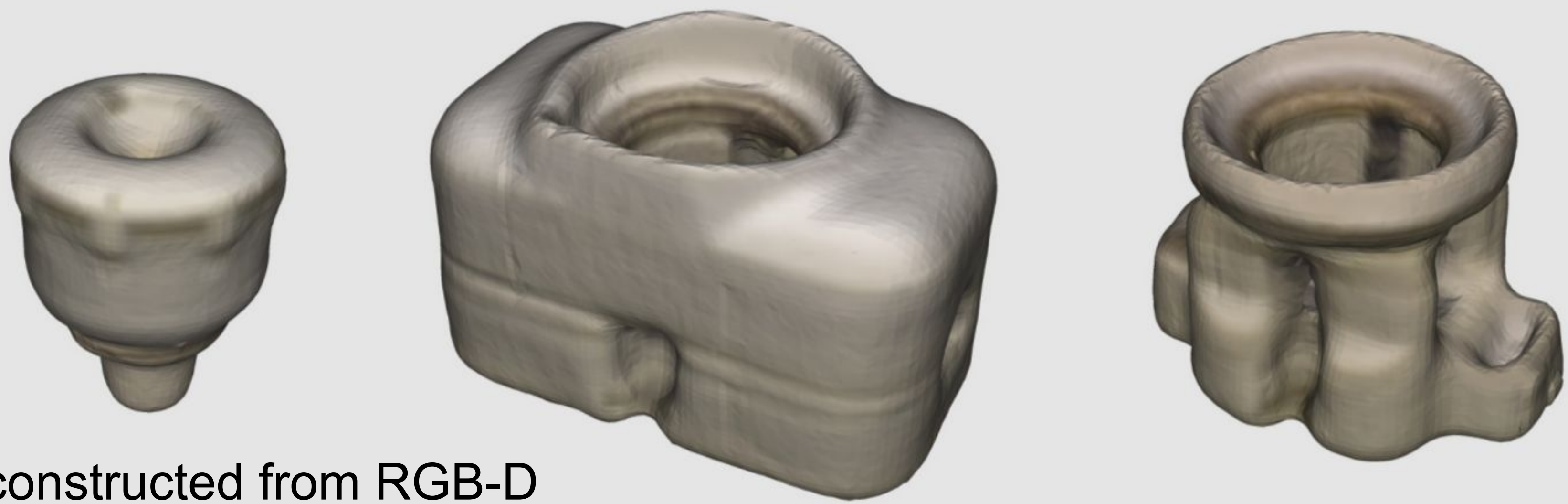
Test Images from 20 Scenes, 10K per Sensor

- From simple scenes with **several isolated objects** to very challenging ones with **multiple objects** and a high amount of **clutter and occlusion**
- Captured from **a systematically sampled upper view hemisphere**

3D Object Models



Manually created in CAD



Reconstructed from RGB-D

Accurate Ground Truth 6D Poses

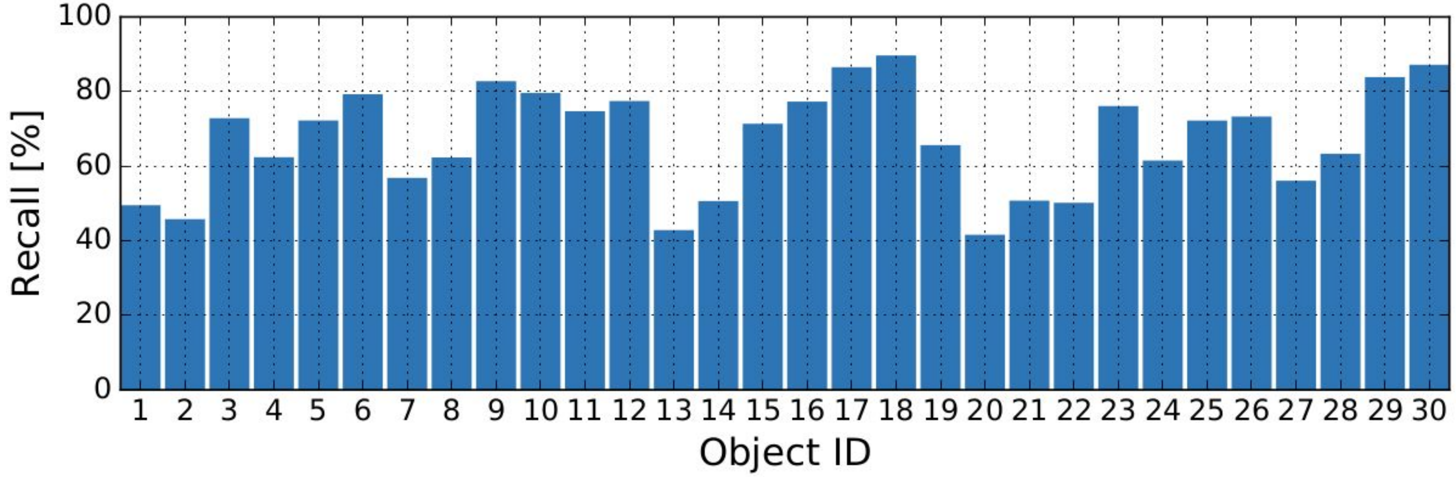
Fully annotated - GT 6D pose for each instance of the modeled objects

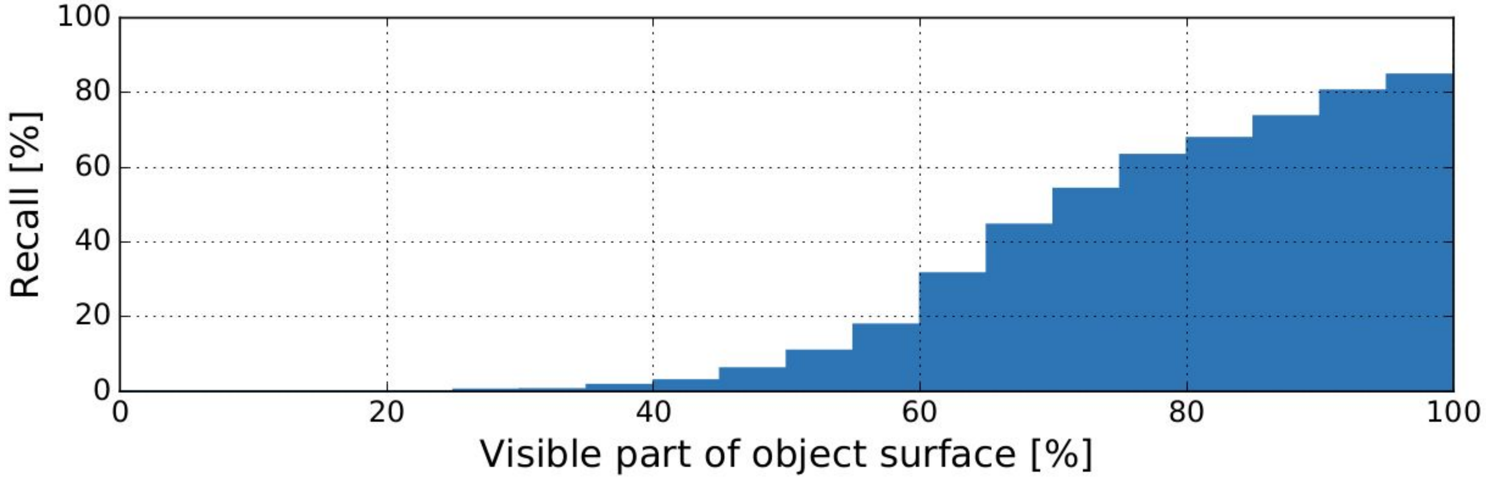
6D Localization - Hodaň et al. (IROS'15)

Input: A test image + IDs of object instances that are present in the image

Output: 6D pose estimates of the object instances

Success rate: **67.2% → There is ample room for improvement!**





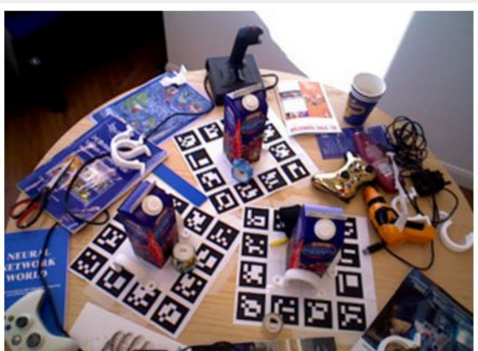
SIXD Challenge at ICCV 2017 Workshop

- At the **3rd Workshop on Recovering 6D Object Pose**
- **To establish SOTA** in 6D object pose estimation
- Will be **announced in April**
- 6 selected datasets converted to **a unified format**:

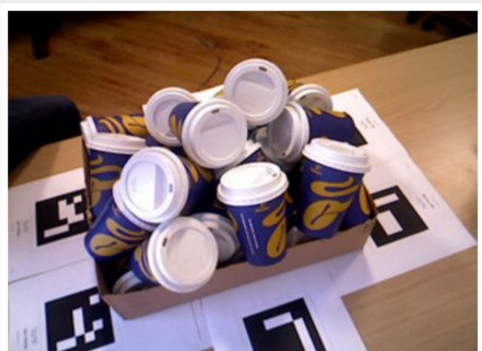
Hinterstoisser et al. [3] with extra ground truth from Brachmann et al. [4]
DOWNLOAD

T-LESS [2]
DOWNLOAD

TUD Light
DOWNLOAD



Tejani et al. [5] - reduced version
DOWNLOAD



Doumanoglou et al. [6] - scenario 2
coming soon

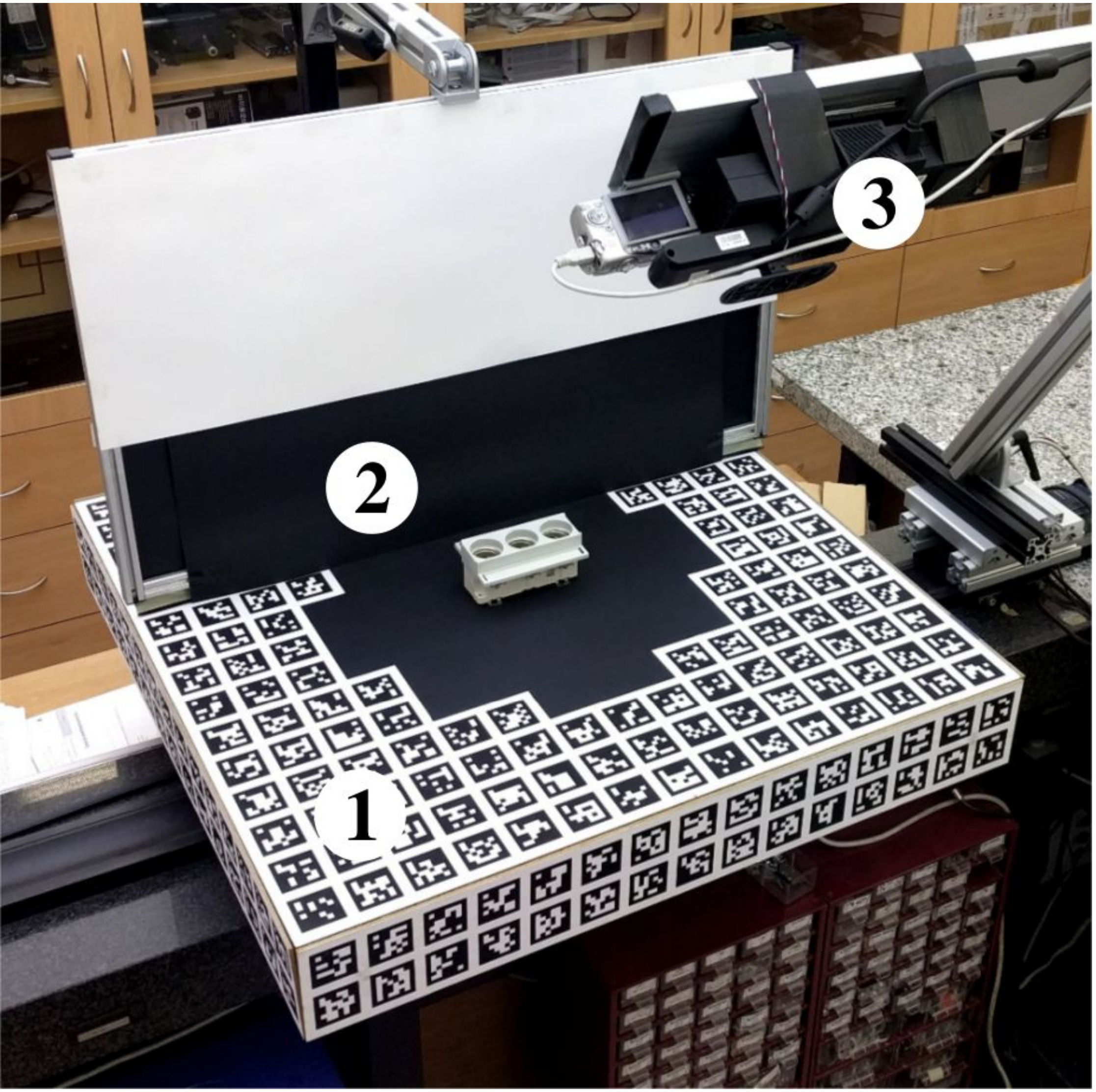
Rutgers APC [7] - reduced version
DOWNLOAD

T-LESS available online:

cmp.felk.cvut.cz/t-less

Poster 185

Acquisition Setup



1) Turntable with marker field.

2) Screen ensuring a black background for training images, removed when capturing test images.

3) Triplet of sensors attached to a jig with adjustable tilt.

Estimation of Ground Truth 6D Poses

1. Manually align the object models to the scene model to get **initial object poses**.
2. **Render the object models** at the current poses into several scene images.
3. **Identify misalignments** and **manually refine** the object poses accordingly.
4. **Go to step 2 until a satisfactory alignment** of the renderings with the images.