TransCut: Transparent Object Segmentation from a Light-Field Image

Supplementary Material

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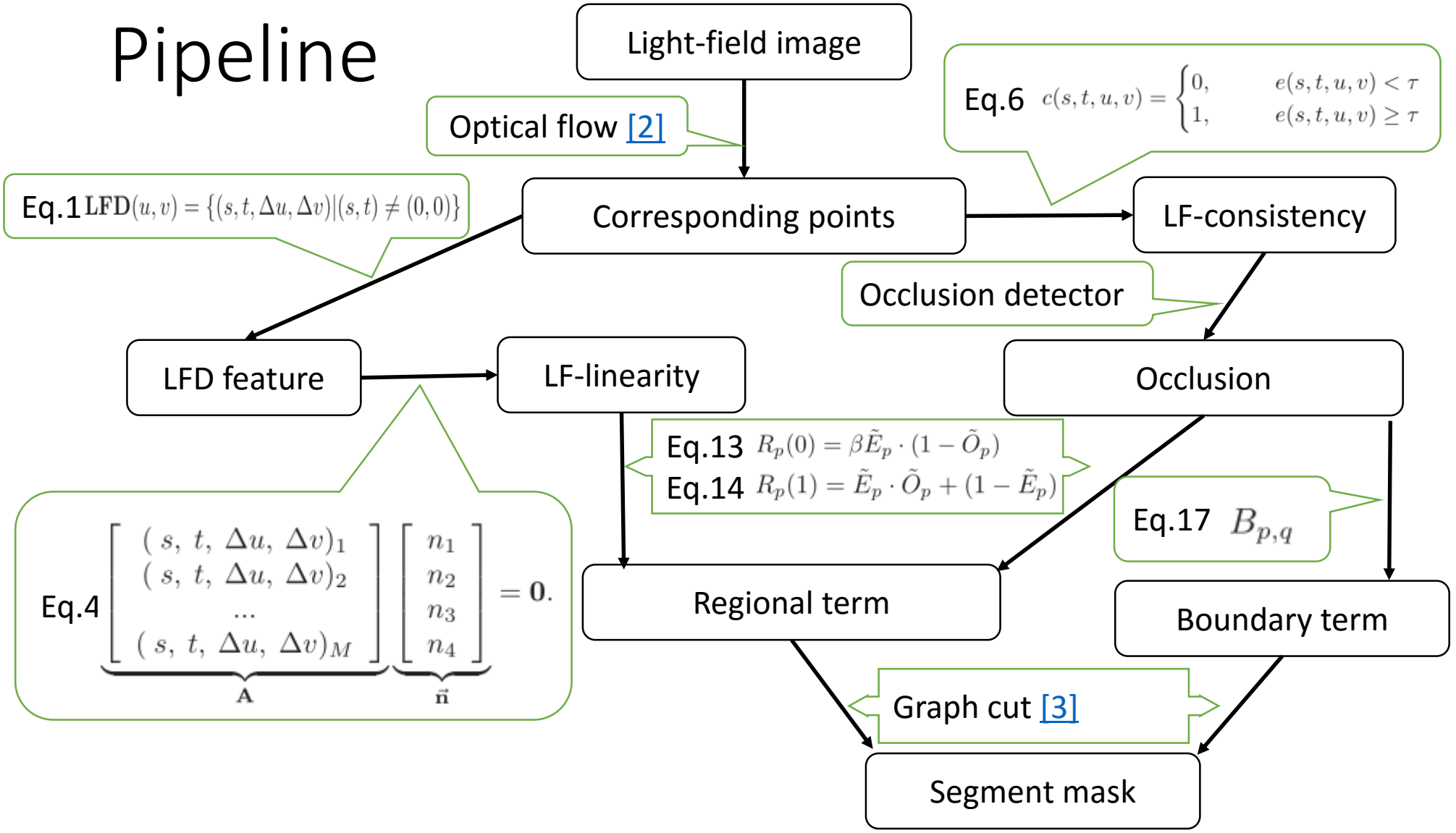
Outline

- In this supplementary material, we first show the pipeline of the proposed method. The process steps with related equations will be shown in the pipeline.
- Full relationship between the occlusion detector and boundary weight $w_{p,q}$ will be listed.
- Then we demonstrate additional experimental results, including single and multiple objects segmentation with lab setting and real scenes. The results are compared with those given by Finding glass [1] and LF-linearity thresholding method.

Pipeline

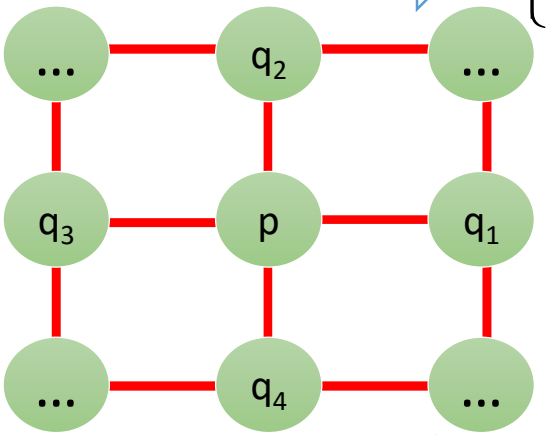

Light-field image
Optical flow [2]
Eq.6 $c(s,t,u,v) = \begin{cases} 0, & e(s,t,u,v) < \tau \\ 1, & e(s,t,u,v) \geq \tau \end{cases}$
Eq.1 $\mathrm{LFD}(u,v) = \{(s,t,\Delta u,\Delta v) | (s,t) \neq (0,0)\}$
Corresponding points
LF-consistency
Occlusion detector
LFD feature
LF-linearity
Occlusion
Eq.13 $R_p(0) = \beta \tilde{E}_p \cdot (1 - \tilde{O}_p)$
Eq.14 $R_p(1) = \tilde{E}_p \cdot \tilde{O}_p + (1 - \tilde{E}_p)$
Eq.17 $B_{p,q}$
Eq.4 $\underbrace{\begin{bmatrix} (s,\ t,\ \Delta u,\ \Delta v)_1 \\ (s,\ t,\ \Delta u,\ \Delta v)_2 \\ \dots \\ (s,\ t,\ \Delta u,\ \Delta v)_M \end{bmatrix}}_{\mathbf{A}} \underbrace{\begin{bmatrix} n_1 \\ n_2 \\ n_3 \\ n_4 \end{bmatrix}}_{\vec{\mathbf{n}}} = \mathbf{0}.$
Regional term
Boundary term
Graph cut [3]
Segment mask

Relationship between occlusion detector and $w_{p,q}$

0	0	0	0.1	0.1
0	0	0	0.1	0.1
0	0	0	0.1	0.1
0	0	0	0.1	0.1
0	0	0	0.1	0.1

If $\tilde{O}_p$ is from $\tilde{\theta} = 0$,

$$\begin{cases} w_{p,q_1} = \tilde{O}_p \\ w_{p,q_2} = w_{p,q_3} = w_{p,q_4} = 0 \end{cases}$$



0	0.1	0.1	0.1	0.1
0	0	0.1	0.1	0.1
0	0	0	0.1	0.1
0	0	0	0	0.1
0	0	0	0	0.1

If $\tilde{O}_p$ is from $\tilde{\theta} = 45$,

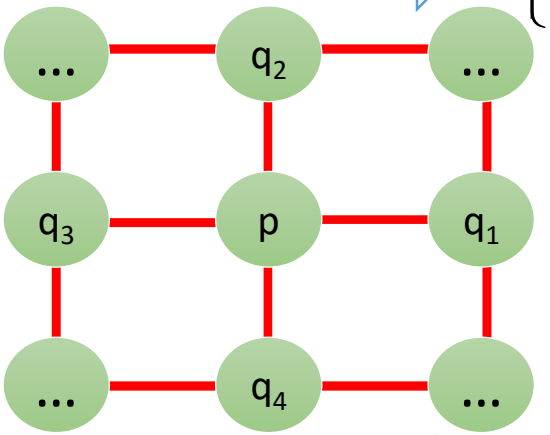
$$\begin{cases} w_{p,q_1} = w_{p,q_2} = \tilde{O}_p / \sqrt{2} \\ w_{p,q_3} = w_{p,q_4} = 0 \end{cases}$$

Relationship between occlusion detector and $w_{p,q}$

0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

If $\tilde{O}_p$ is from $\tilde{\theta} = 90$,

$$\begin{cases} w_{p,q_2} = \tilde{O}_p \\ w_{p,q_1} = w_{p,q_3} = w_{p,q_4} = 0 \end{cases}$$



0.1	0.1	0.1	0.1	0
0.1	0.1	0.1	0	0
0.1	0.1	0	0	0
0.1	0	0	0	0
0	0	0	0	0

If $\tilde{O}_p$ is from $\tilde{\theta} = 135$,

$$\begin{cases} w_{p,q_2} = w_{p,q_3} = \tilde{O}_p / \sqrt{2} \\ w_{p,q_1} = w_{p,q_4} = 0 \end{cases}$$

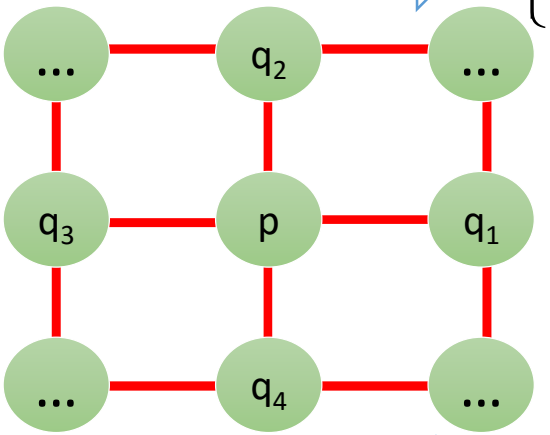
Relationship between occlusion detector and $w_{p,q}$

0.1	0.1	0	0	0
0.1	0.1	0	0	0
0.1	0.1	0	0	0
0.1	0.1	0	0	0
0.1	0.1	0	0	0

0	0	0	0	0
0.1	0	0	0	0
0.1	0.1	0	0	0
0.1	0.1	0.1	0	0
0.1	0.1	0.1	0.1	0

If $\tilde{O}_p$ is from $\tilde{\theta} = 180$,

$$\begin{cases} w_{p,q_3} = \tilde{O}_p \\ w_{p,q_1} = w_{p,q_2} = w_{p,q_4} = 0 \end{cases}$$



If $\tilde{O}_p$ is from $\tilde{\theta} = 225$,

$$\begin{cases} w_{p,q_3} = w_{p,q_4} = \tilde{O}_p / \sqrt{2} \\ w_{p,q_1} = w_{p,q_2} = 0 \end{cases}$$

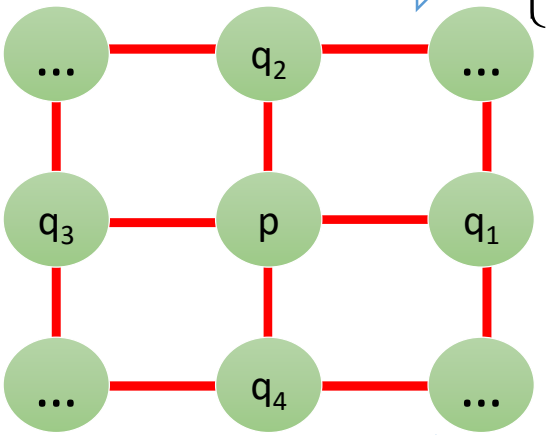
Relationship between occlusion detector and $w_{p,q}$

0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0.1	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1

0	0	0	0	0
0	0	0	0	0.1
0	0	0	0.1	0.1
0	0	0.1	0.1	0.1
0	0.1	0.1	0.1	0.1

If $\tilde{O}_p$ is from $\tilde{\theta} = 270$,

$$\begin{cases} w_{p,q_4} = \tilde{O}_p \\ w_{p,q_1} = w_{p,q_2} = w_{p,q_3} = 0 \end{cases}$$



If $\tilde{O}_p$ is from $\tilde{\theta} = 315$,

$$\begin{cases} w_{p,q_1} = w_{p,q_4} = \tilde{O}_p / \sqrt{2} \\ w_{p,q_2} = w_{p,q_3} = 0 \end{cases}$$

Experimental results

- We first show the results of single object segmentation. There are seven objects and seven scenes in the single object dataset.
- We then show the results of two objects segmentation. Seven scenes with two different combinations of two objects are used in the experiments.
- We also show the results of real scenes. Four different objects are used in the experiments.
- We tune the parameters in these experiments in order to make them suitable for specific scenes.

Single object


Object 1


Object 2


Object 3


Object 4


Object 5


Object 6


Object 7


Scene 1


Scene 2


Scene 3


Scene 4

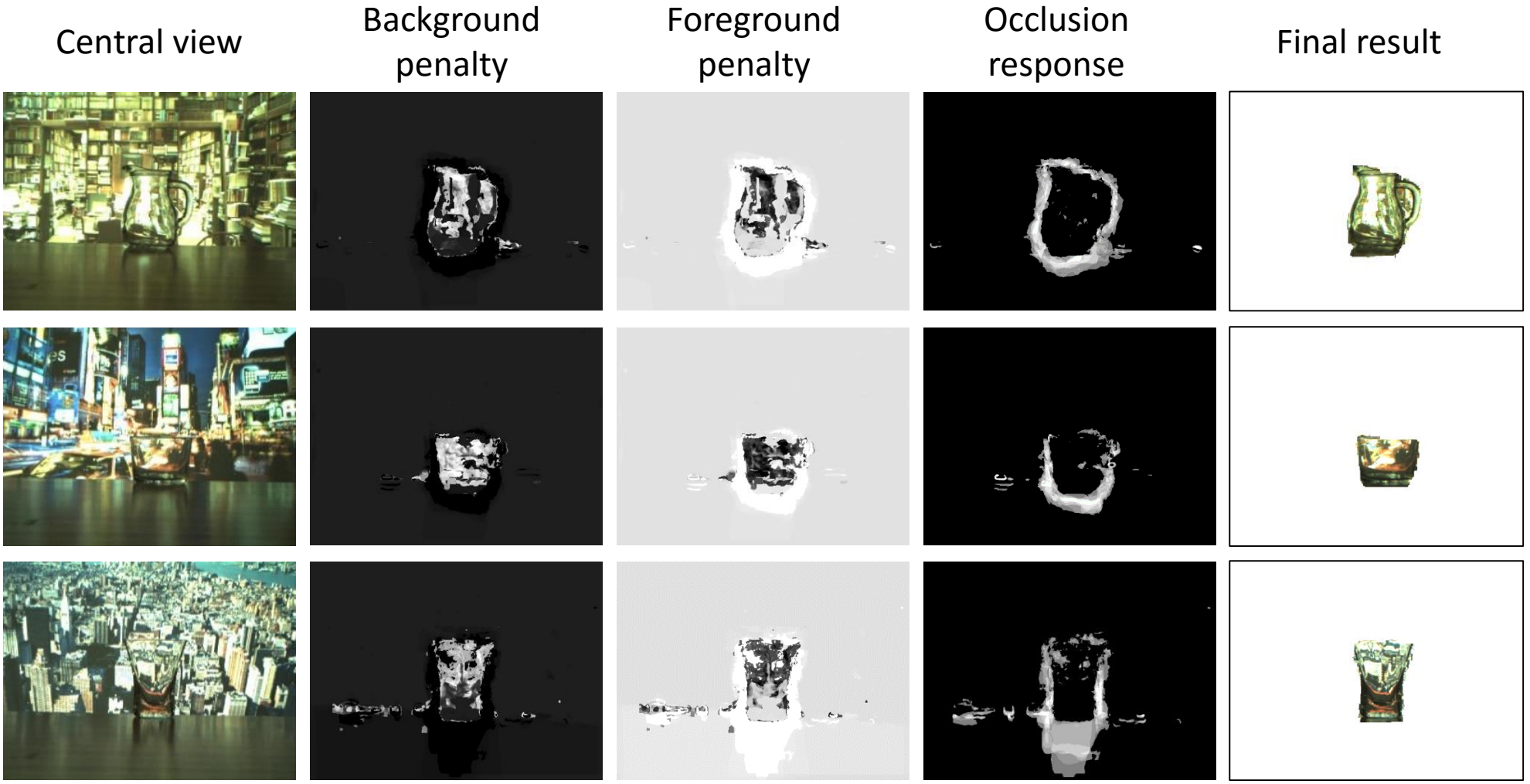

Scene 5


Scene 6


Scene 7

- All the results processed by Finding glass, LF-linearity thresholding and proposed TransCut method will be demonstrated. The ground truth will be given for comparison.
- The light-field data with ground truth will be released on our website.

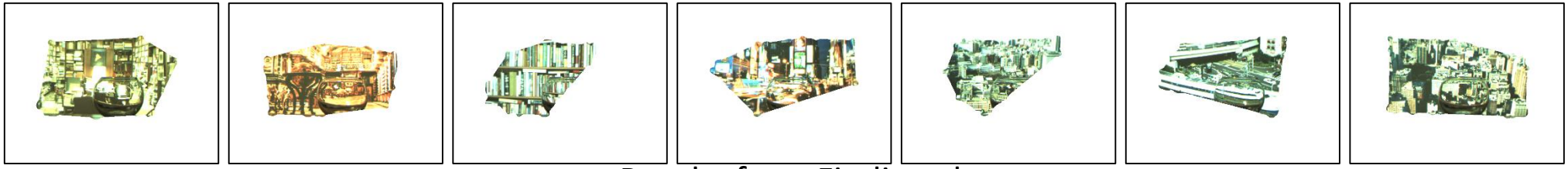
Intermediate results



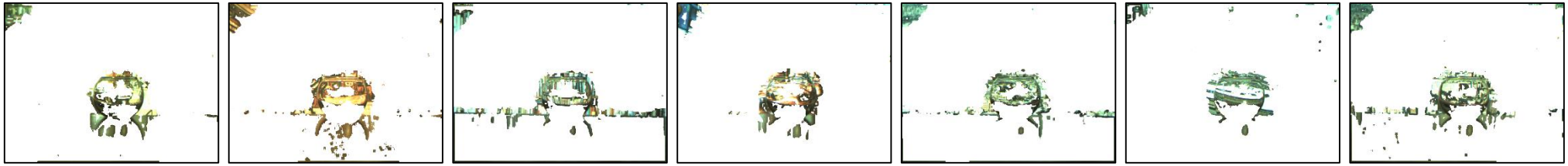
- We show several examples of the intermediate results here. The 2nd and 3rd column show the penalty for background and foreground respectively. The darker color represents lower penalty. And the 4th column shows the maximum response from the occlusion detector, brighter means higher response.

Object 1

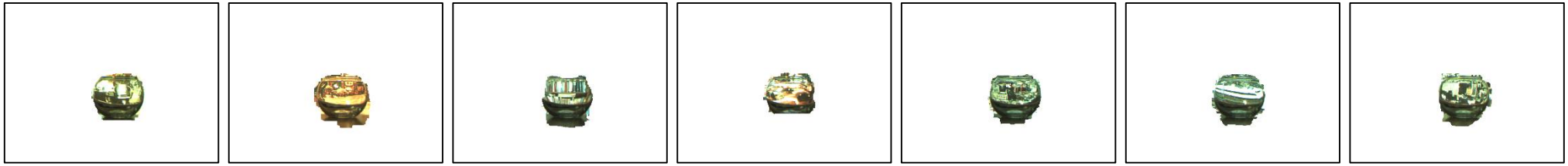
Images from the central viewpoint



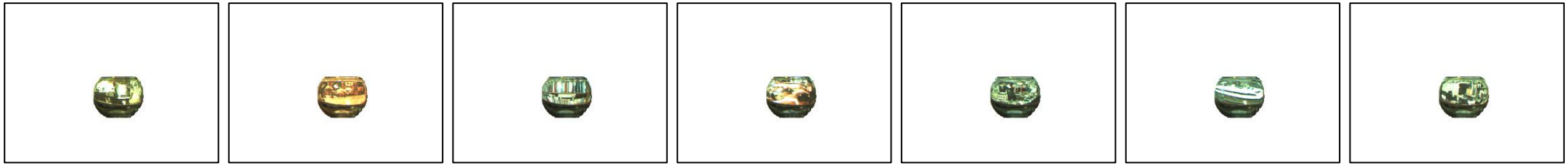
Results from Finding glass



Results from LF-linearity thresholding



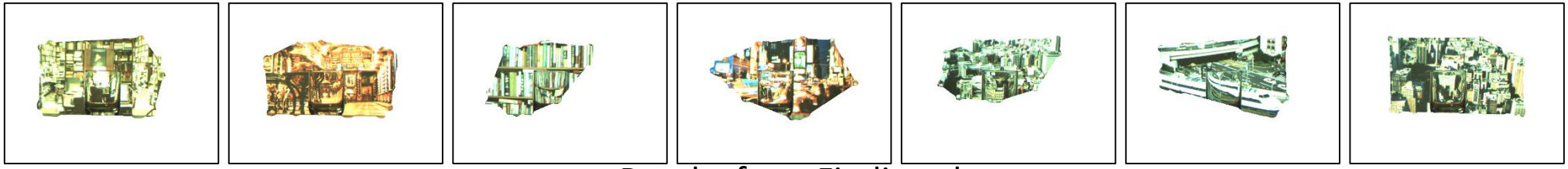
Results from TransCut



Ground Truth

Object 2

Images from the central viewpoint



Results from Finding glass

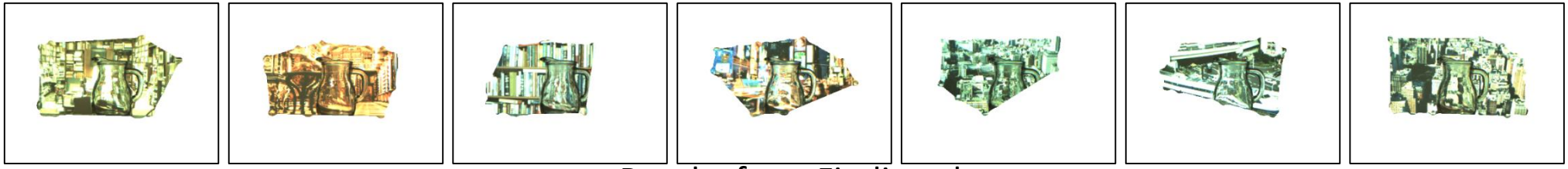
Results from LF-linearity thresholding

Results from TransCut

Ground Truth

Object 3

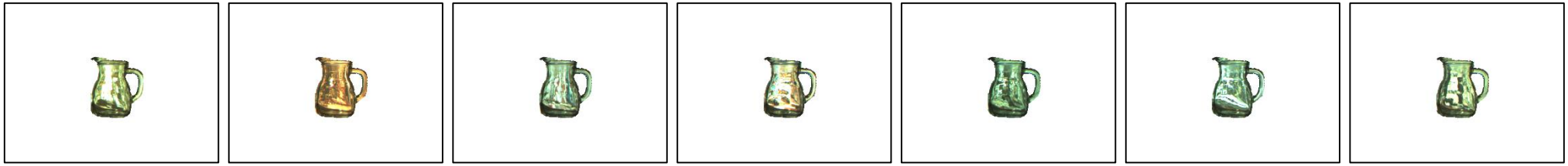
Images from the central viewpoint



Results from Finding glass

Results from LF-linearity thresholding

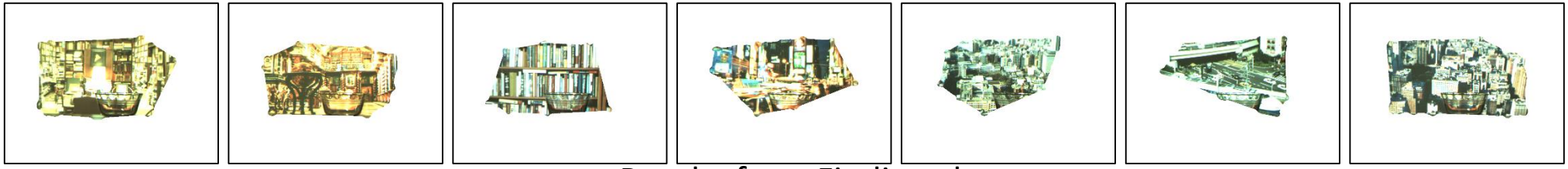
Results from TransCut



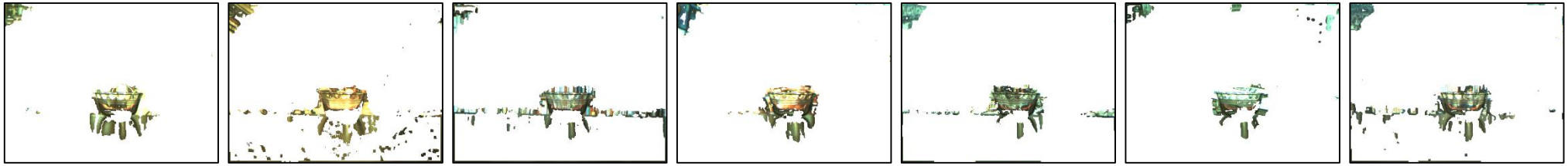
Ground Truth

Object 4

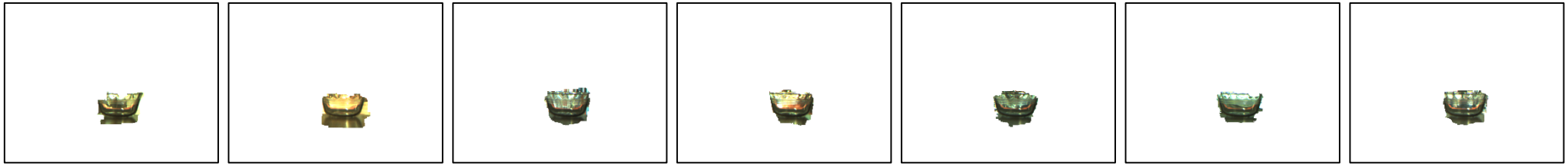
Images from the central viewpoint



Results from Finding glass



Results from LF-linearity thresholding

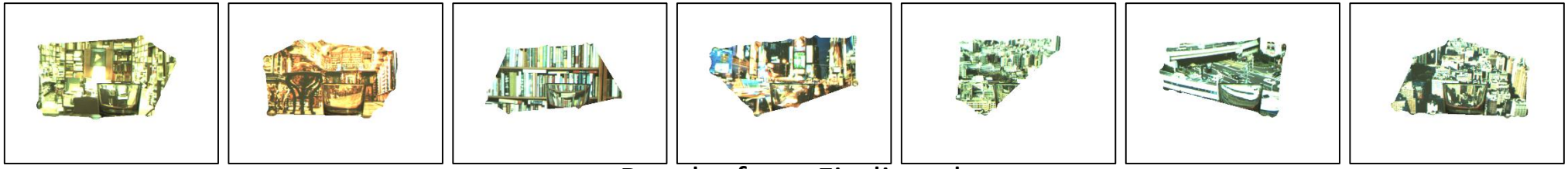


Results from TransCut

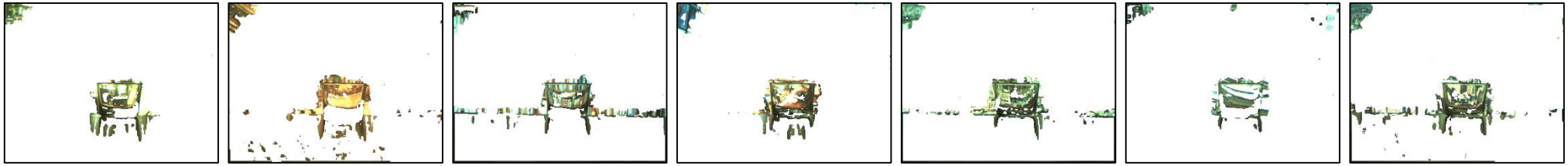
Ground Truth

Object 5

Images from the central viewpoint



Results from Finding glass



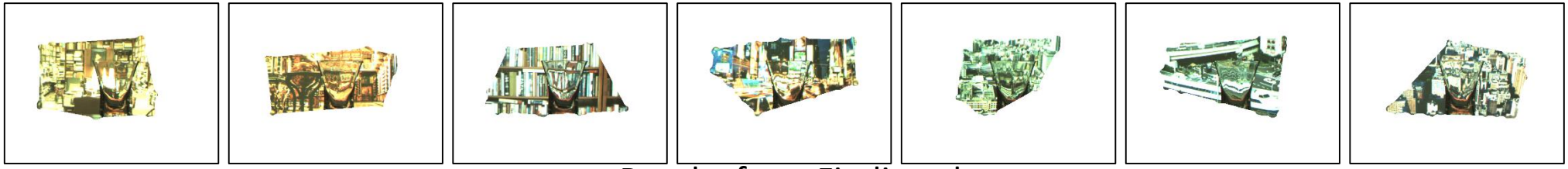
Results from LF-linearity thresholding

Results from TransCut

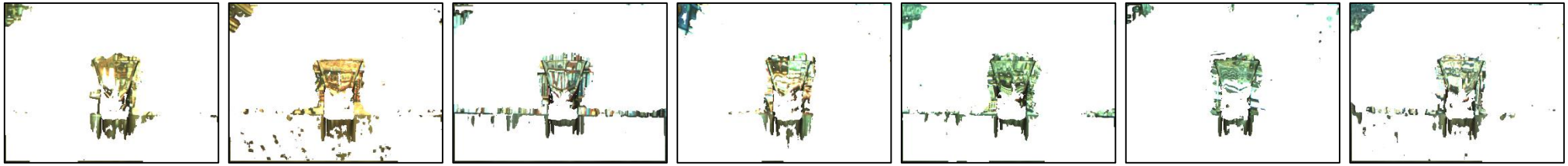
Ground Truth

Object 6

Images from the central viewpoint



Results from Finding glass



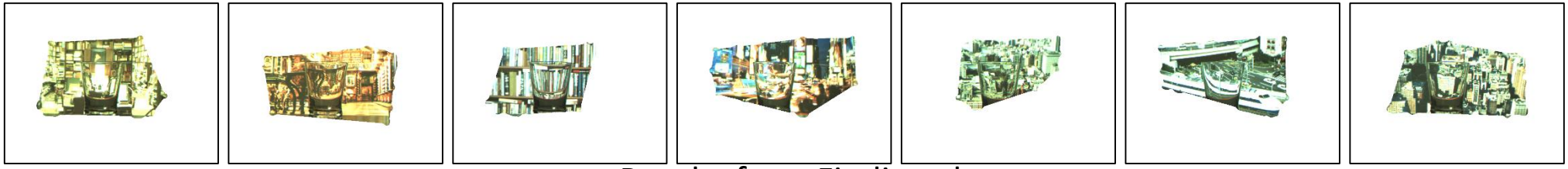
Results from LF-linearity thresholding

Results from TransCut

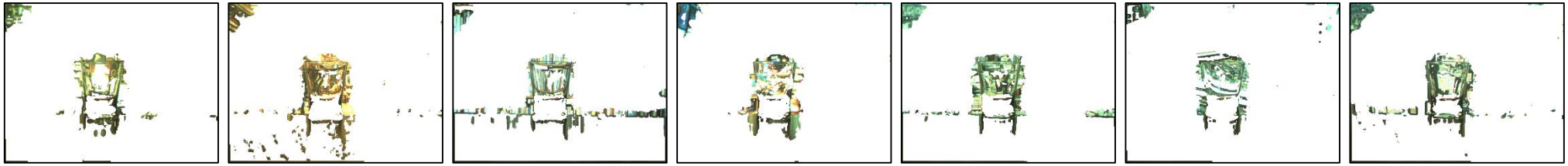
Ground Truth

Object 7

Images from the central viewpoint



Results from Finding glass

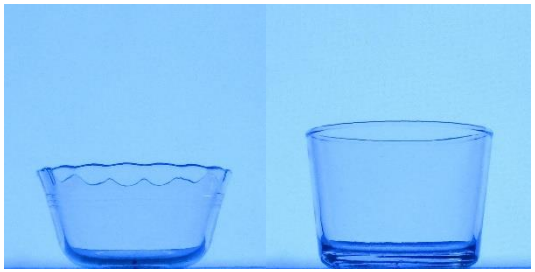


Results from LF-linearity thresholding

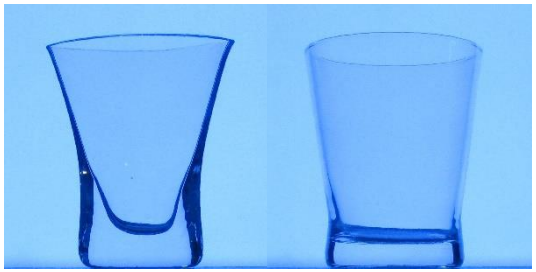
Results from TransCut

Ground Truth

Two objects



Object combination 1



Object combination 2

Scene 1

Scene 2

Scene 3

Scene 4

Scene 5

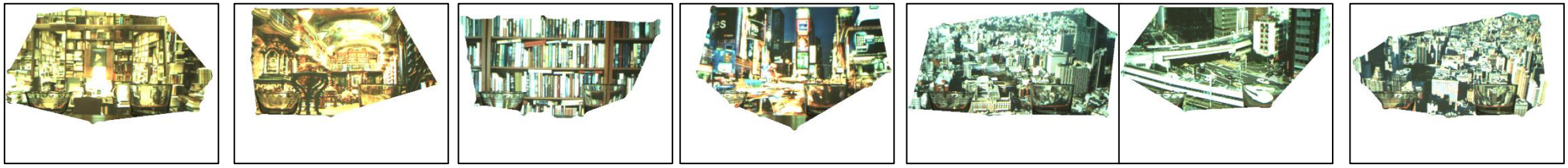
Scene 6

Scene 7

- We show all the results processed by Finding glass, LF-linearity thresholding and proposed TransCut method.

Object combination 1

Images from the central viewpoint



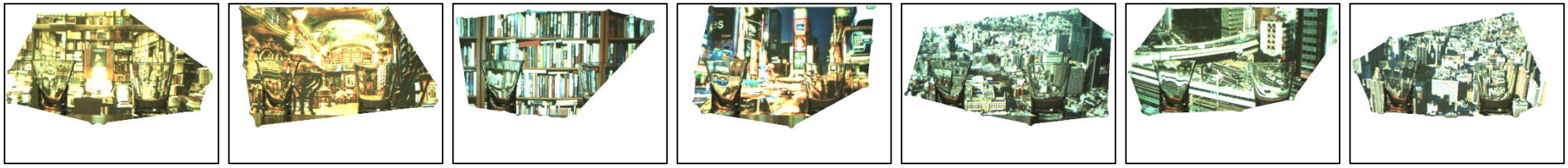
Results from Finding glass

Results from LF-linearity thresholding

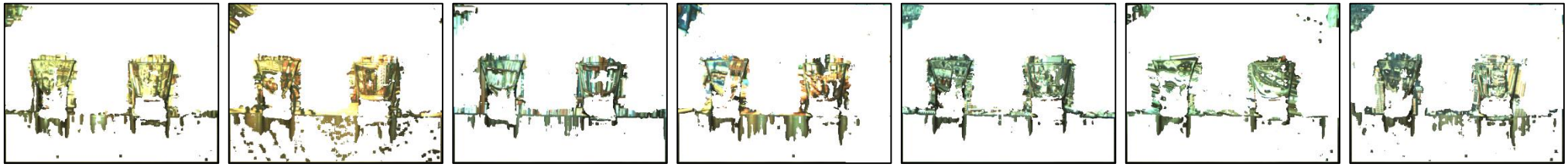
Results from TransCut

Object combination 2

Images from the central viewpoint



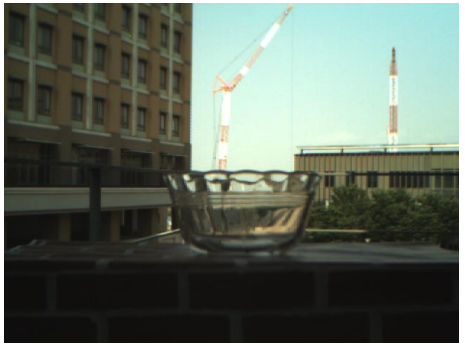
Results from Finding glass



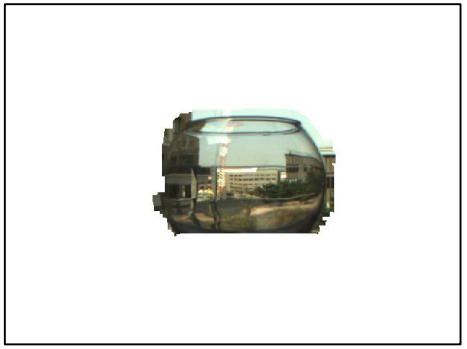
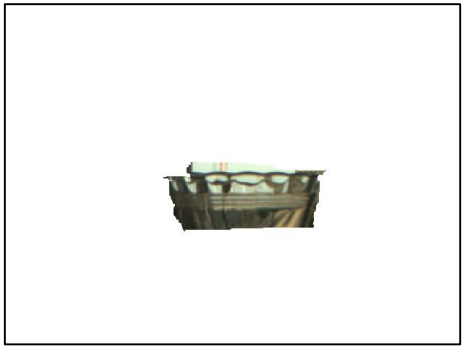
Results from LF-linearity thresholding

Results from TransCut

Real scene

Images from the central viewpoint

Results from TransCut

References

1. K. McHenry, J. Ponce, and D. Forsyth. Finding glass. In IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pages 973–979, 2005.
2. T. Brox and J. Malik. Large displacement optical flow: descriptor matching in variational motion estimation. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 33(3):500–513, 2011
3. Y. Boykov and G. Funka-Lea. Graph cuts and efficient nd image segmentation. *International Journal of Computer Vision*, 70(2):109–131, 2006