Intrinsic Color Correction for Stereo Matching

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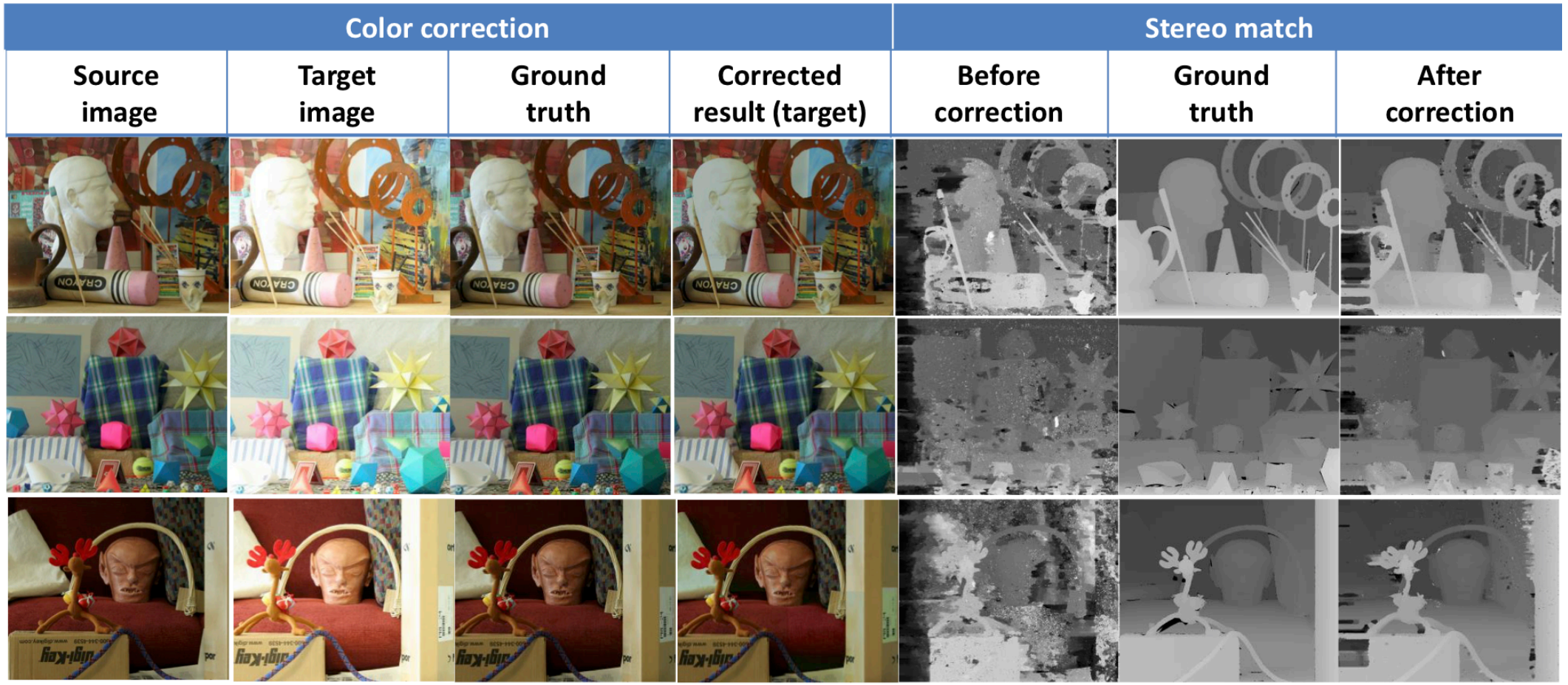
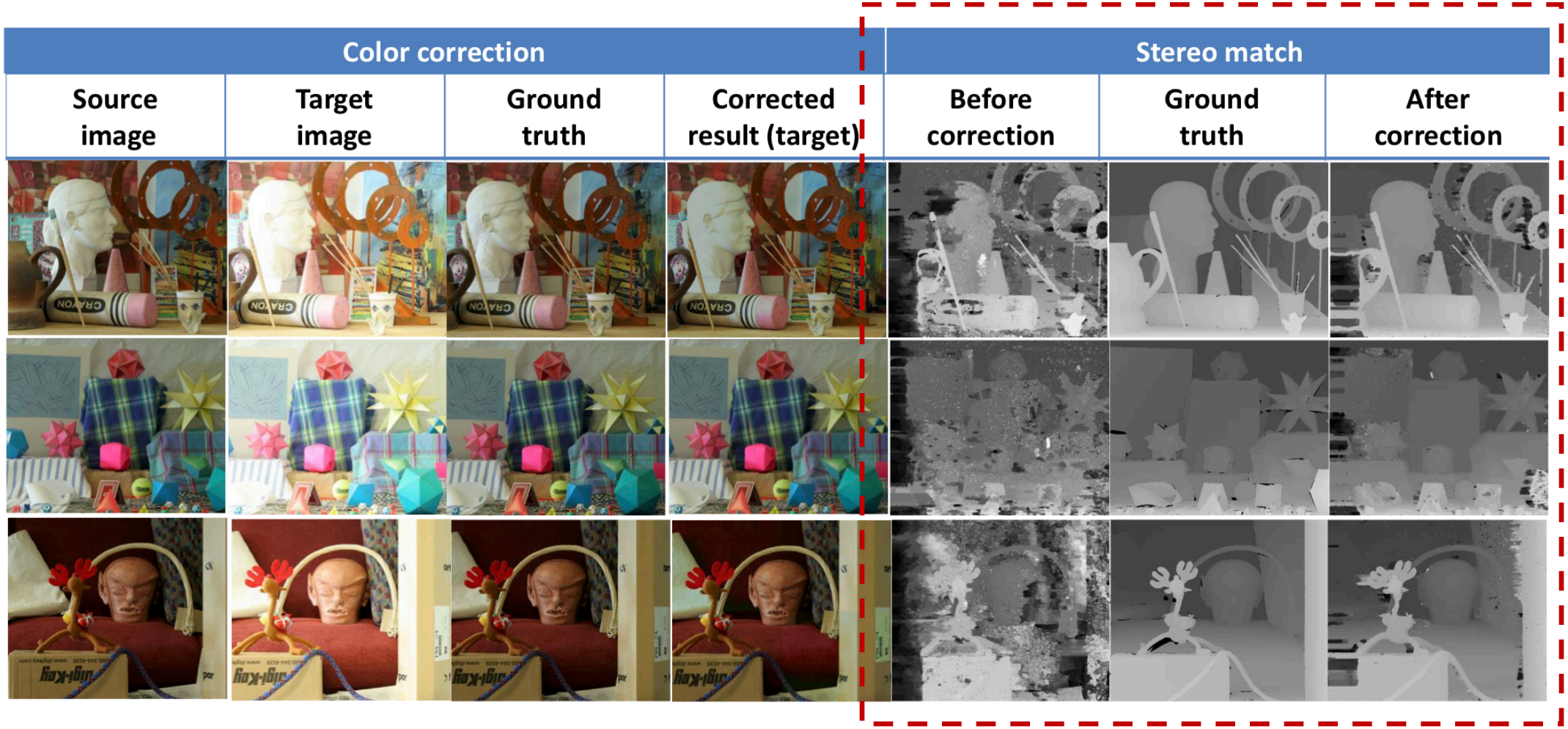
Graphics Abstract



Graphics Abstract



Outline

- Introduction
- Pipeline
- Algorithm
- Results

Introduction

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- Stereo Matching
  - the color difference has a bad influence on disparity estimation

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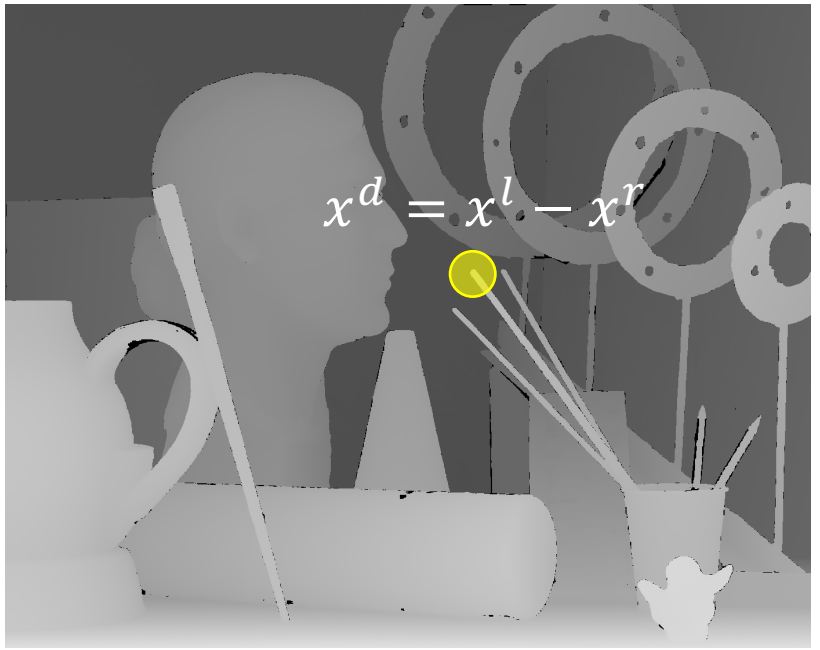
  - the color difference has a bad influence on disparity estimation
- Color Correction
  - compensate the color difference

Introduction

- Stereo Matching
  - the color difference has a bad influence on disparity estimation
- Color Correction
  - compensate the color difference
- Intrinsic Decomposition
  - distinguish and process different degrees of color discrepancies

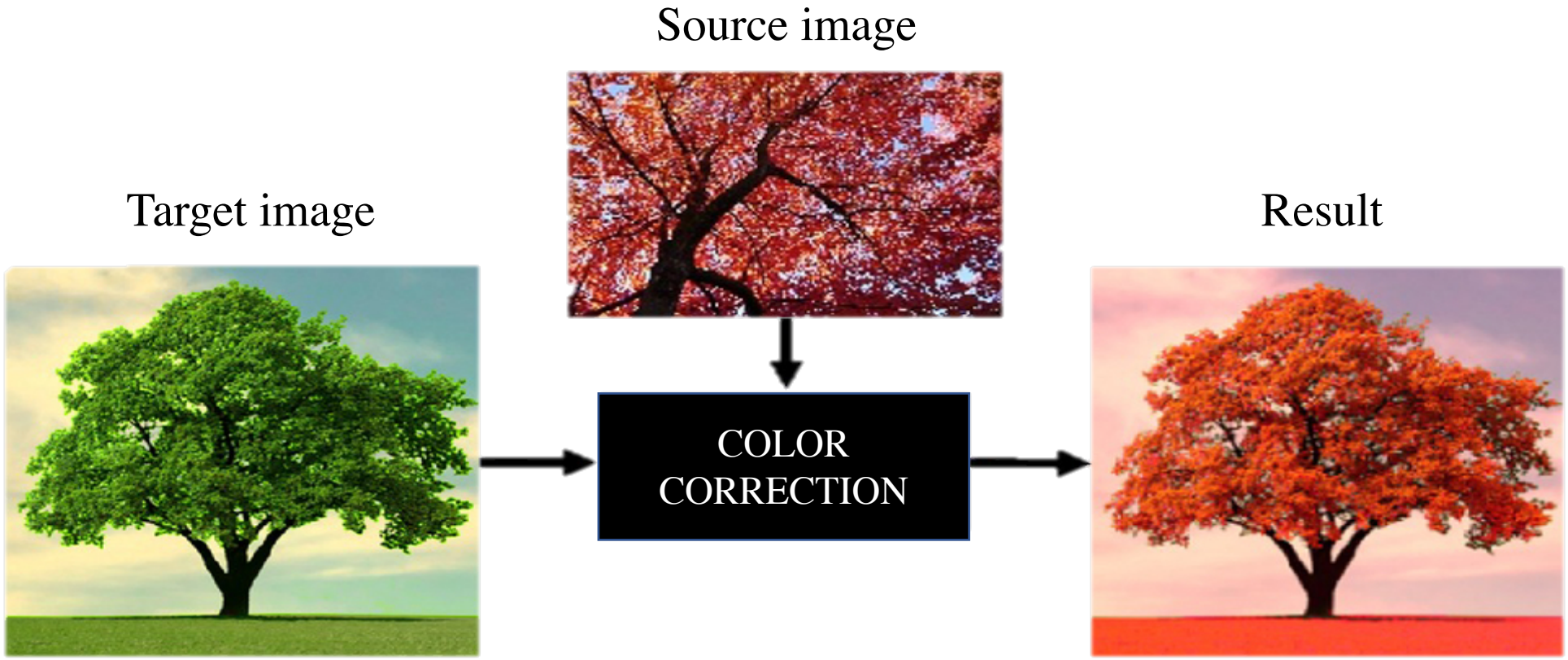
Stereo Matching

the inference of disparity maps from stereo images



Color Correction

the consistency of the color appearance between two images



Intrinsic Decomposition

the decomposition of an image into a reflectance layer and a shading layer

=

reflectance

+

shading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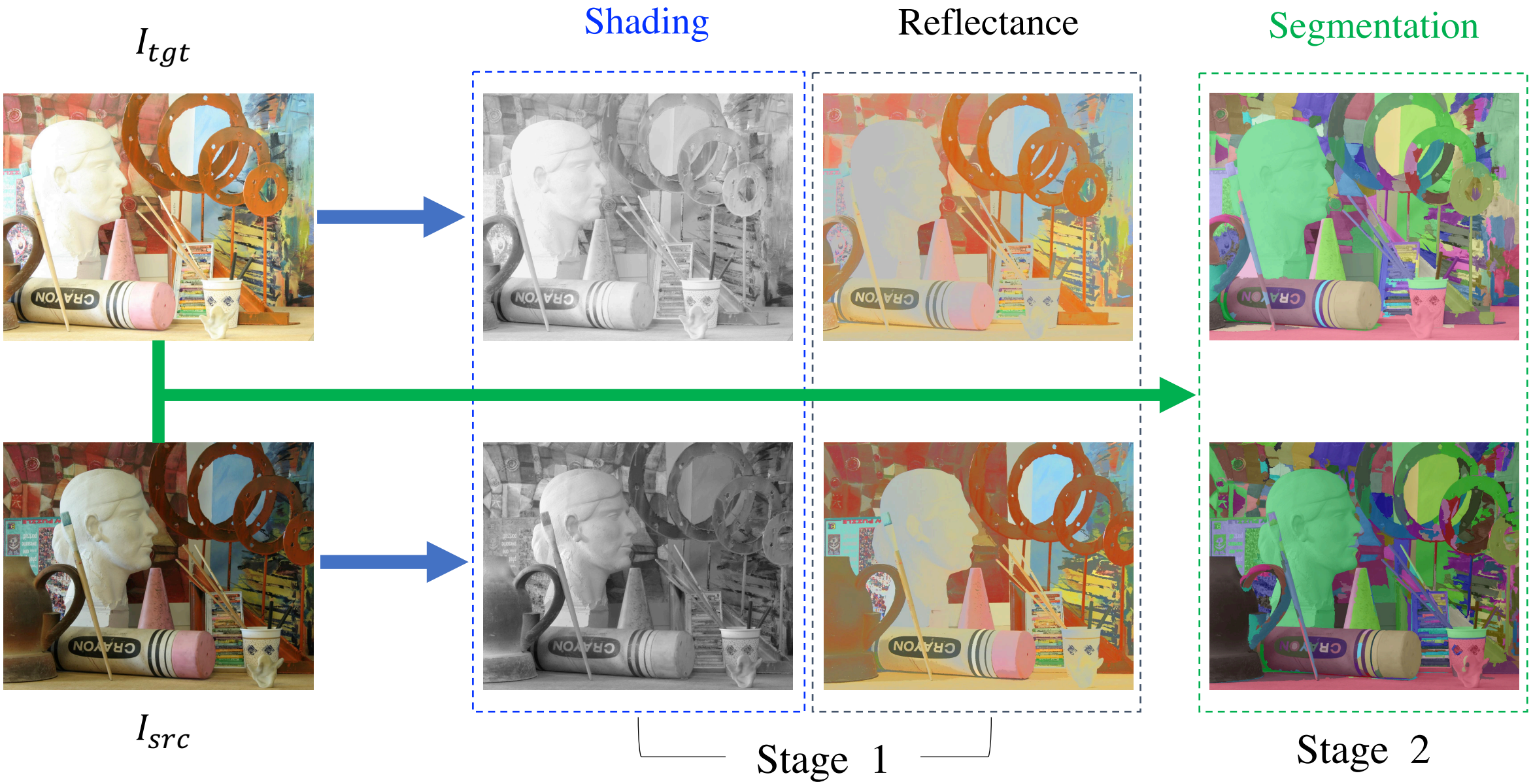
Pipeline


I_{tgt}
Shading
Reflectance
Segmentation
I_{src}
Stage 1
Stage 2

Stage 3

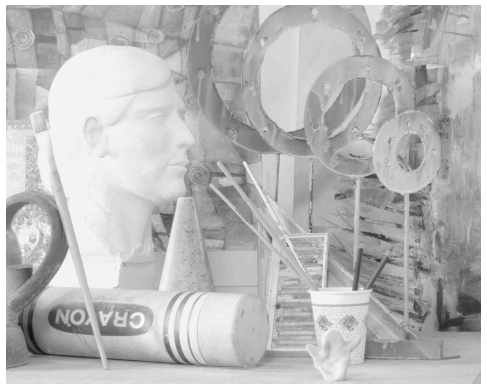
Luminance Correction

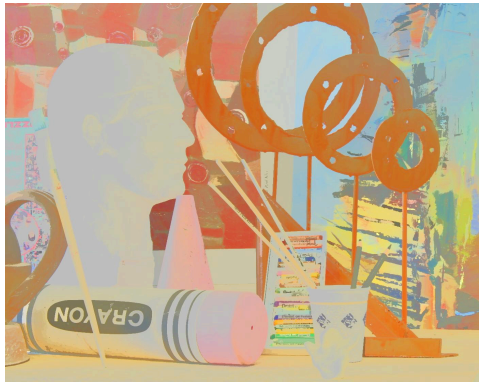
Reflectance Correction

Shading

Reflectance

Correspondence





corrected $S_{tgt}^{'}$

corrected $R_{tgt}^{'}$

Stage 4

corrected target image $I_{tgt}^{'}$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Algorithm

Intrinsic Decomposition

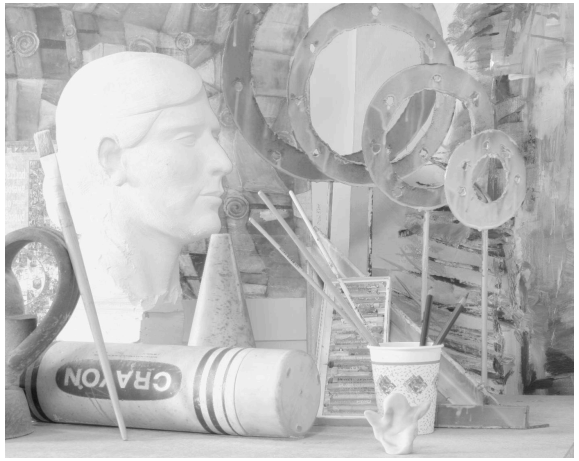
Bell et al. 2014 SIGGRAPH

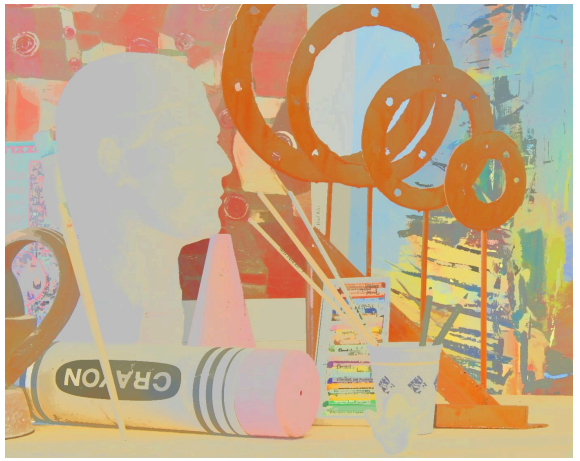
stereo images

shading layers

reflectance layers

I_{tgt} 

S_{tgt} 

R_{tgt} 

I_{src} 

S_{src} 

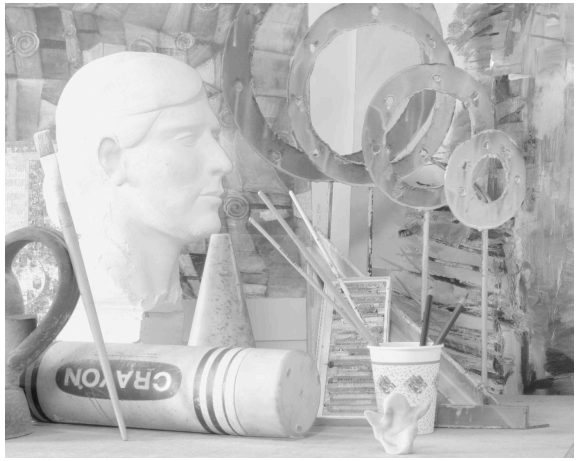
R_{tgt} 

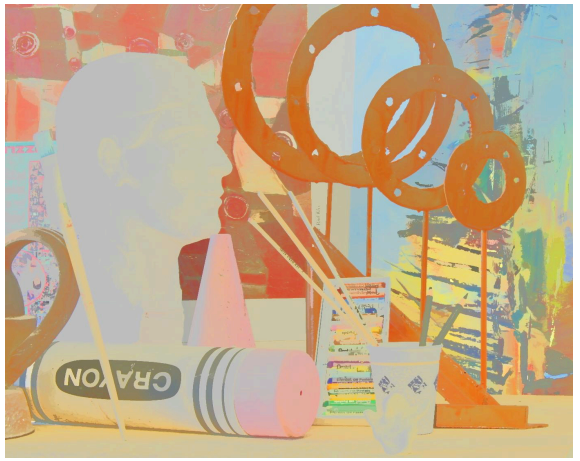
RGB

Ambient light spectral distribution

Object reflectance property

I_{tgt} 

S_{tgt} 

R_{tgt} 

I_{src} 

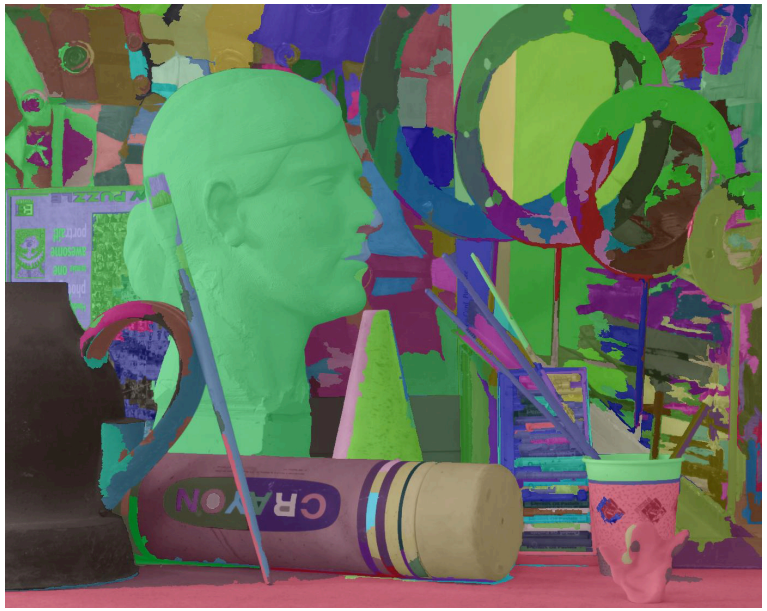
S_{src} 

R_{tgt} 

Intrinsic Decomposition Bell et al. 2014 SIGGRAPH

- A ill-posed problem $I = R \cdot S$
- $R^*, S^* = argmax_{R,S}\, p(R, S|I)$
- $E(x) = \omega_r E_r(x) + \omega_s E_s(x) + \omega_l E_l(x)$
  - $\omega_r, E_r(x)$: neighboring pixels have similar chromaticties or intensities
  - $\omega_s, E_s(x)$: shading channel tends to vary smoothly across a smooth surface
  - $\omega_l, E_l(x)$: permit to select extreme values of shading

Consistent Segmentation



Definition:

if two pixels belong to a region in the segmented source image, their corresponding pixels also belong to the corresponding region in the segmented target image.

Consistent Segmentation

1. SIFT matches extraction to obtain sparse but robust pixel correspondence

Consistent Segmentation

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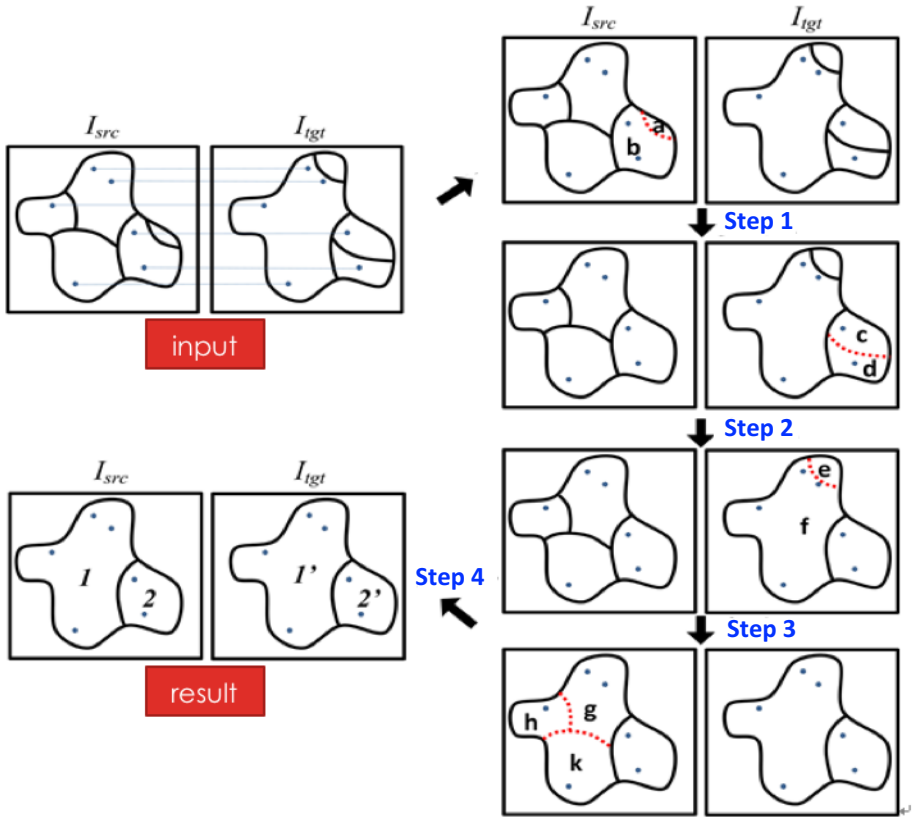
Consistent Segmentation

2. Initial segmentation via the Mean-Shift algorithm method

- Every region belongs to a single object
- Every region contains a certain number of features

Consistent Segmentation

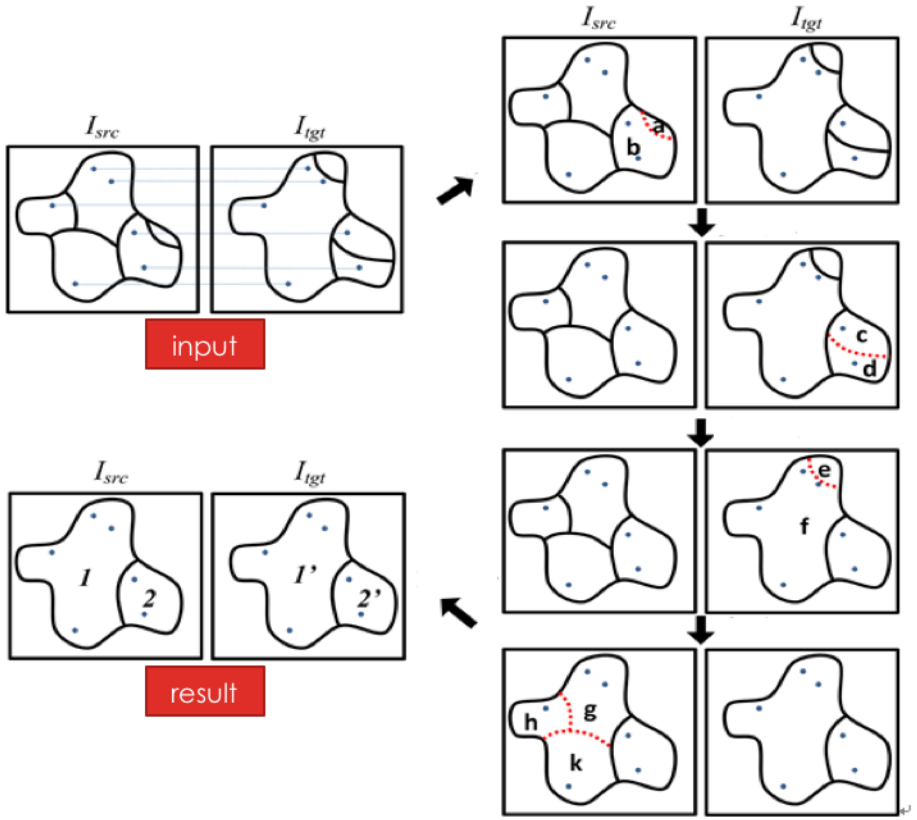
3. a merging process based on the initial segmentation and SIFT matches



Problems:

1) Regions with no feature points
2) A region in the target image is corresponding to multiple regions in the source image

Consistent Segmentation



Merging process:

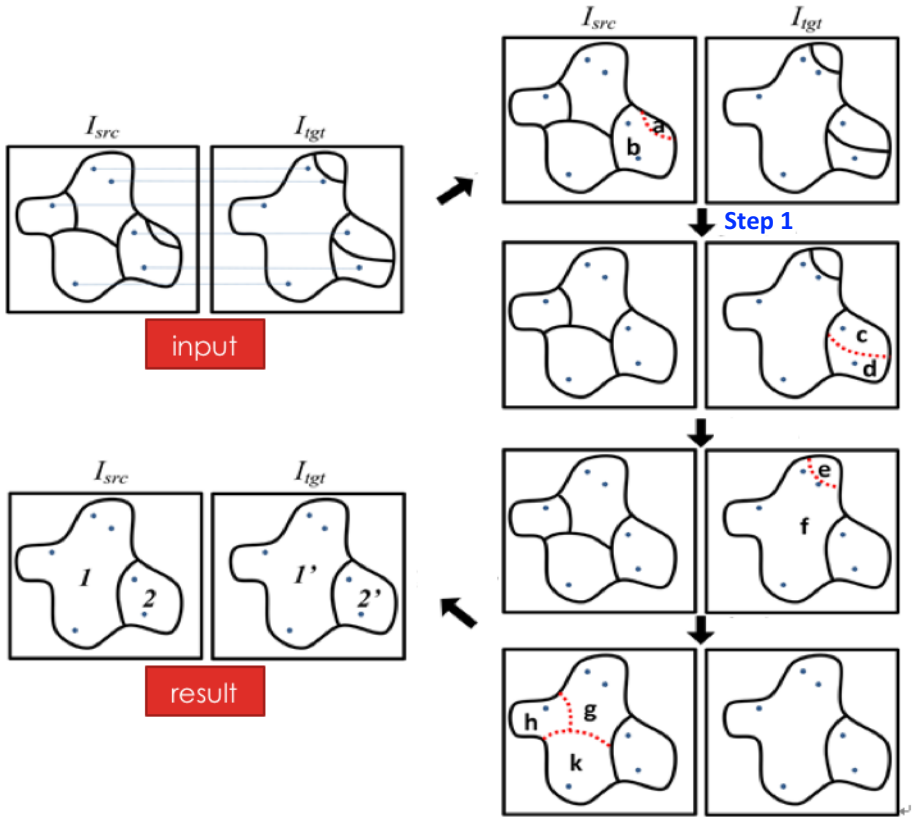
1) I_{src} : merge a non-matched region into one of nearby regions with features correspondence

2) I_{src} : merge regions which have the same corresponding regions in I_{tgt}

3) I_{tgt} : similar to step 1

4) I_{tgt} : similar to step 2

Consistent Segmentation



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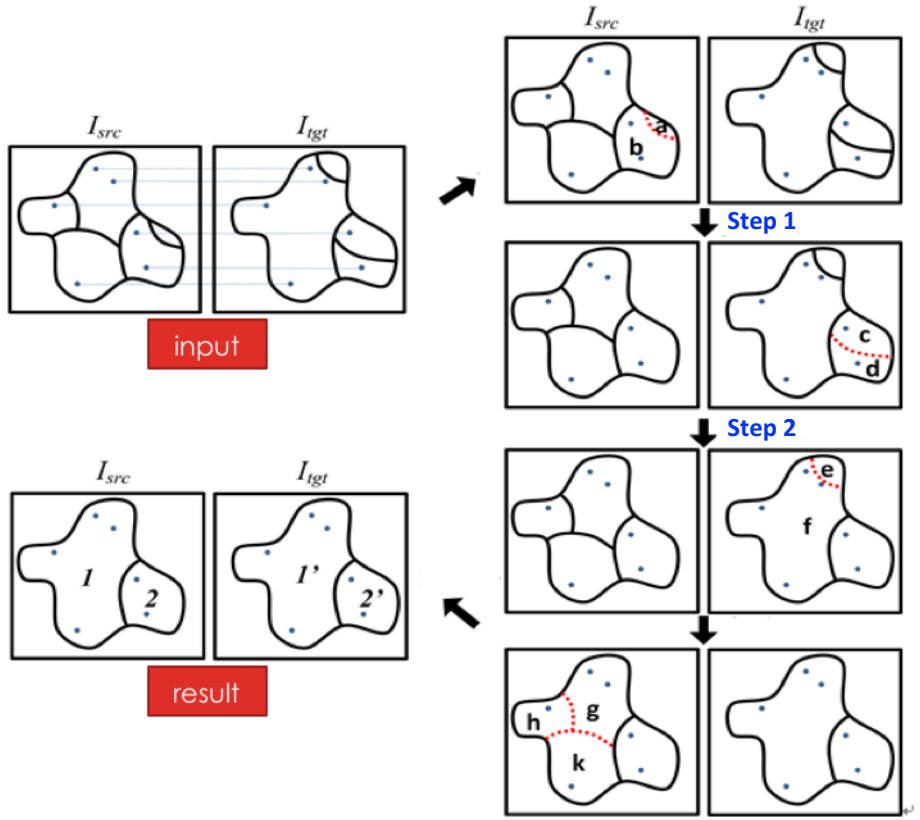

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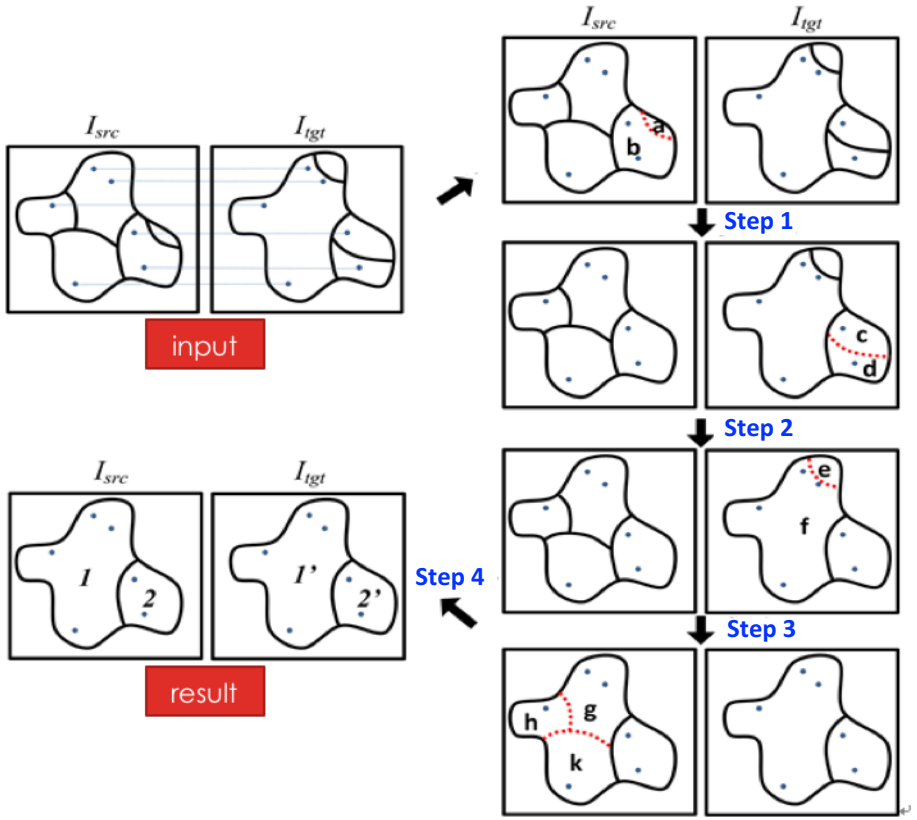

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Consistent Segmentation

Correction Functions

The shading layers:

$$C_k^{tgt'}(i,j) = \mu_k^{src} + \frac{\sigma_k^{src}}{\sigma_k^{tgt}}\left(C_k^{tgt}(i,j) - \mu_k^{tgt}\right)$$

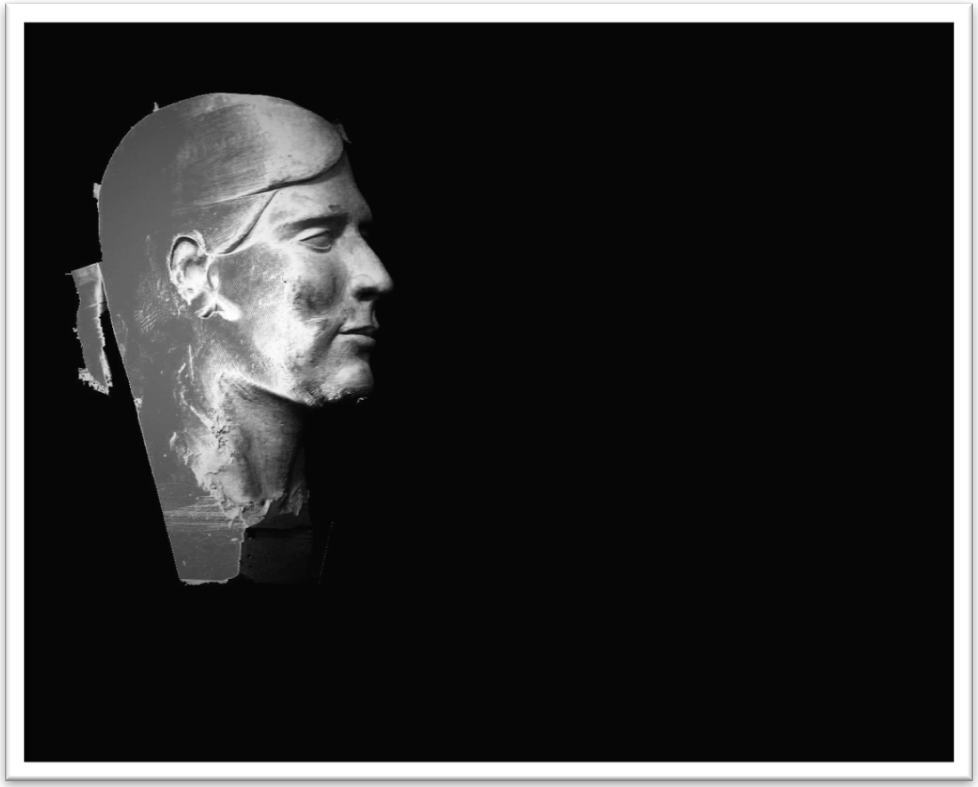
The reflectance layers:

$$R_k^{tgt'}(i,j) = Q_k^{src} \cdot Q_k^{tgt} \cdot R_k^{tgt}(i,j)$$

Weighted Frame

Problem: color discontinues caused by local method

- An influence mask : to visualize the weight of a region acting on each pixel
- The corrected color for each pixel: a weighted average of its adjective regions



Layer Combination

$$\boldsymbol{I'_{tgt} = R'_{tgt} \cdot S'_{tgt}}$$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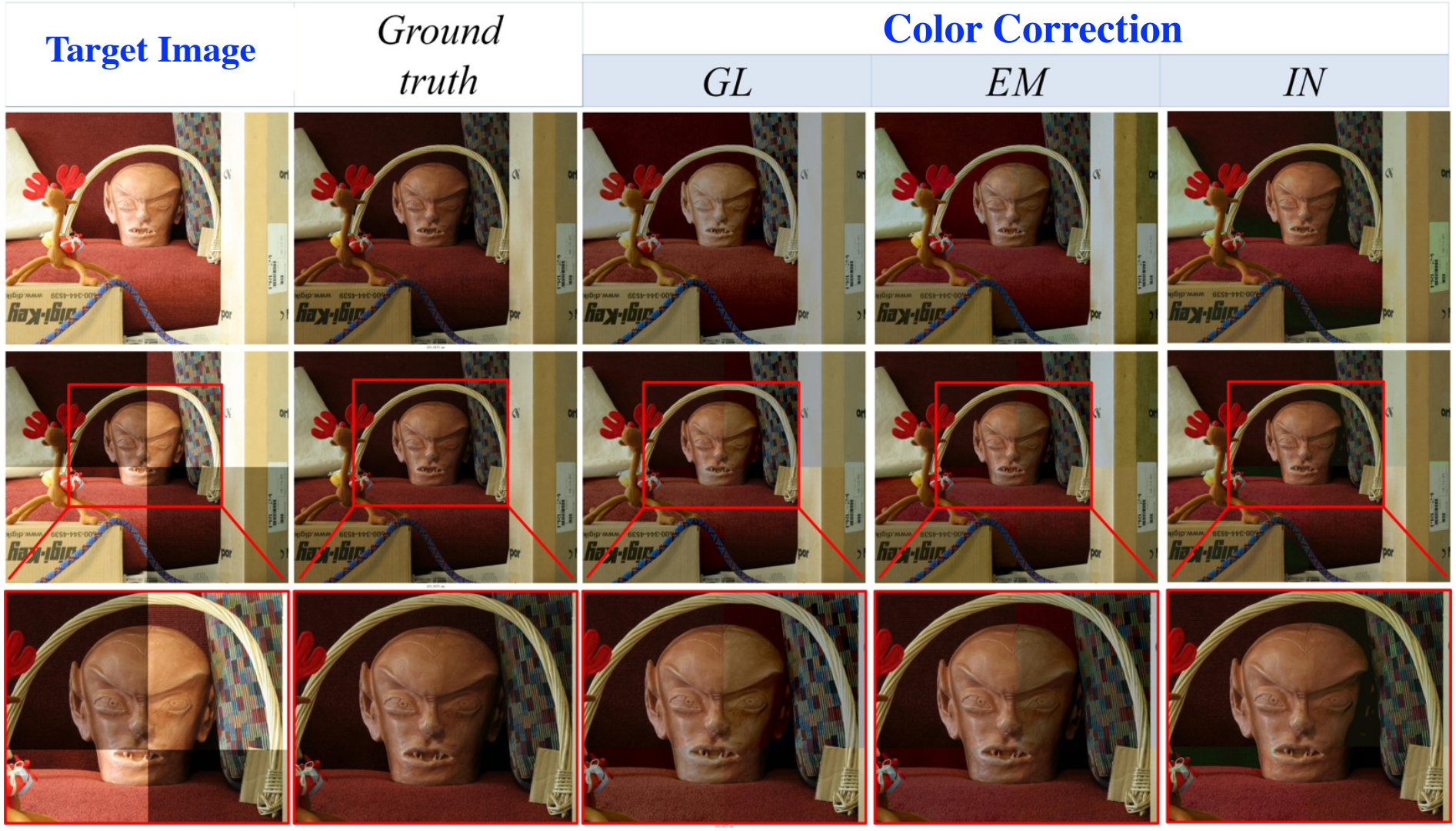
Results

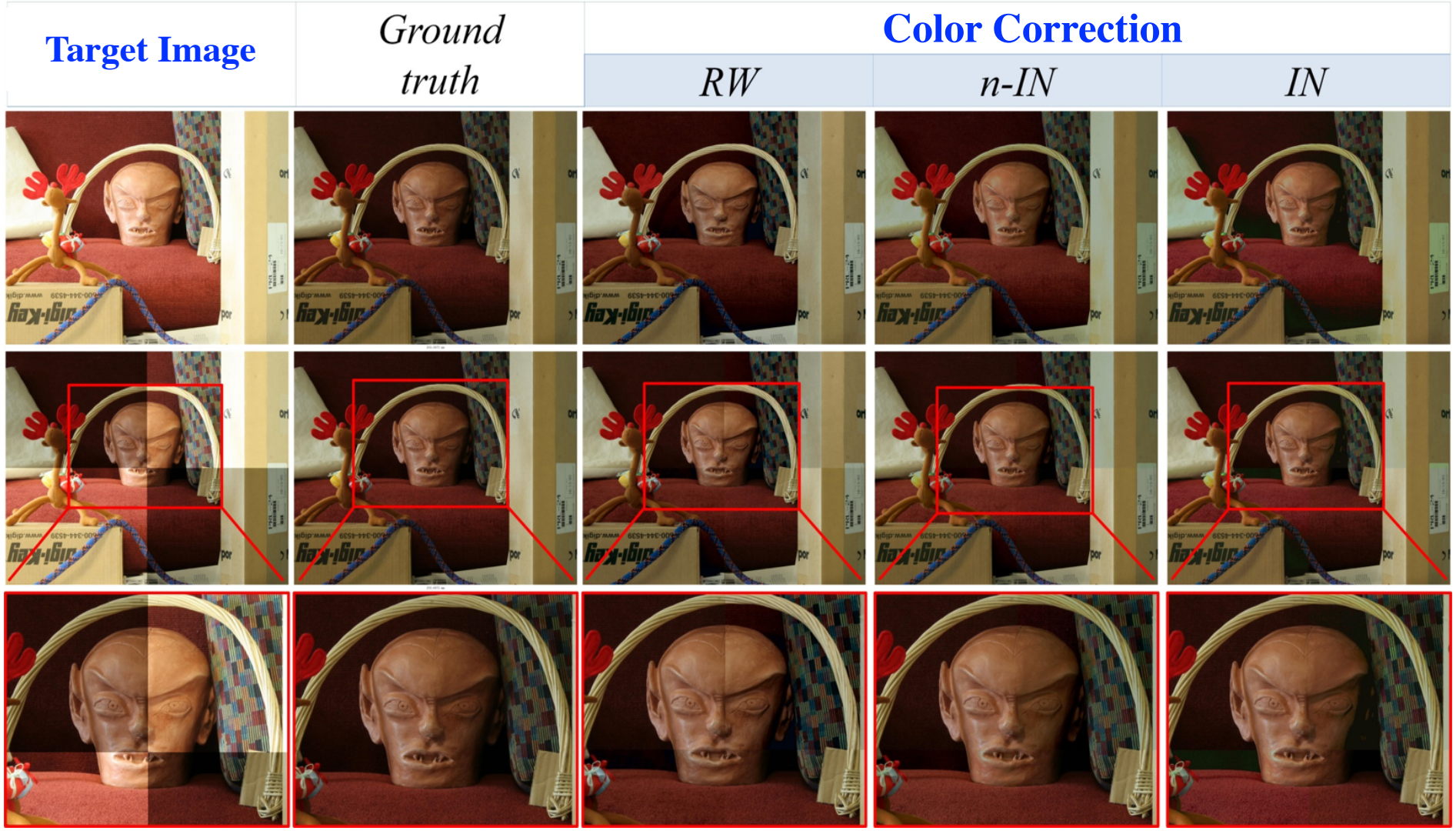
Evaluation

- Subjective evaluation
- Color similarity evaluation
- Stereo matching evaluation

Comparison

- GL: global color correction
- EM: expectation maximum color correction
- RW: region wise color correction
- n-IN: the proposed color correction without intrinsic decomposition
- IN: the proposed color correction


Target Image
Ground truth
Color Correction
GL
EM
IN


Target Image
Ground truth
Color Correction
RW
n-IN
IN

Color Similarity

$$CS_m = \sum \left\| C_{gt}(i,j) - C_m(i,j) \right\|, \quad RCS = 1 - \frac{CS_{crt}}{CS_{org}}$$

	Aloe	Art	Baby1	Baby2	Baby3	Books
GL	79.756	85.206	84.308	81.274	83.863	77.479
EM	90.688	90.4	93.458	81.494	88.273	78.914
RW	91.412	85.206	92.395	88.649	89.161	78.914
n-IN	94.365	91.989	93.906	89.479	88.843	78.255
IN	95.301	93.481	93.678	91.219	90.248	79.213

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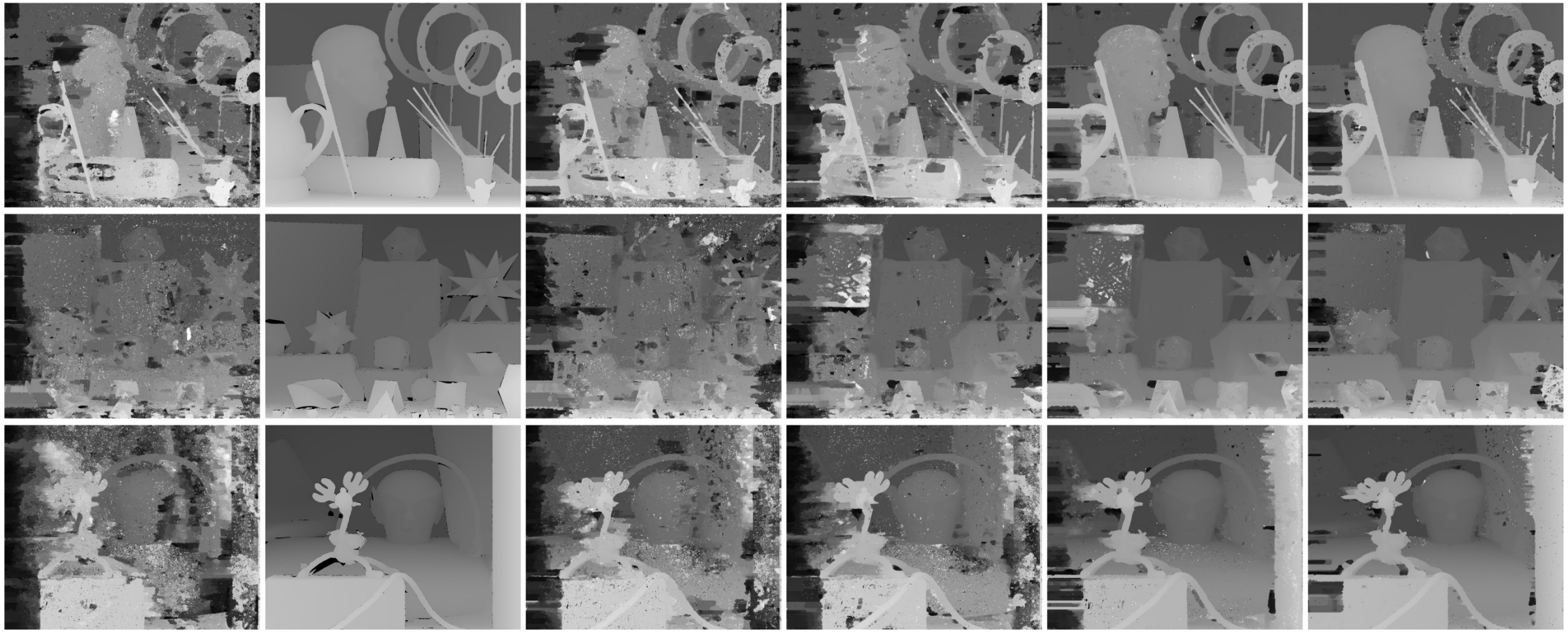
Stereo Matching

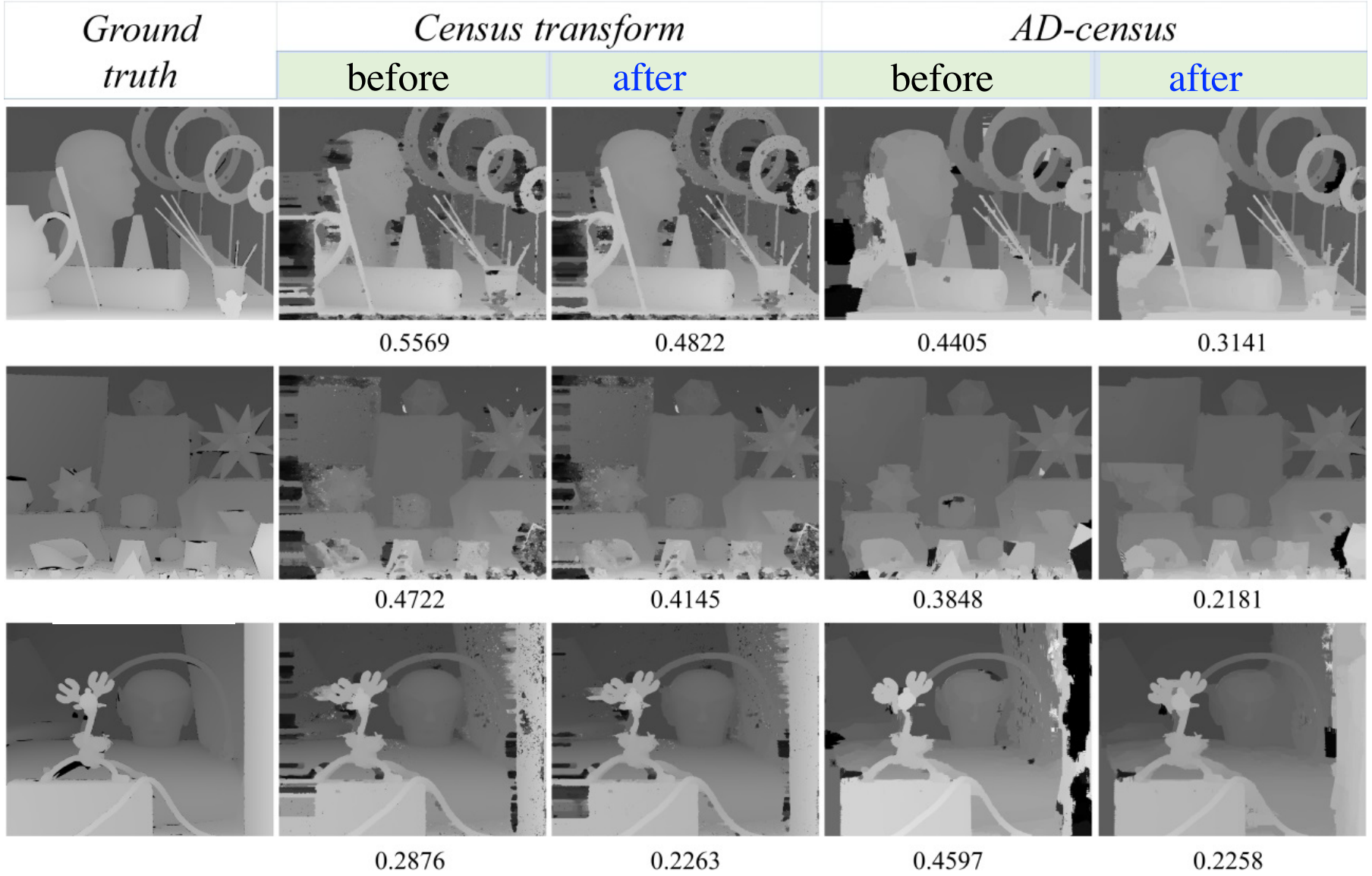
Before	*Ground truth*	**Stereo Matching Results**			
		GL	*EM*	*RW*	*IN*



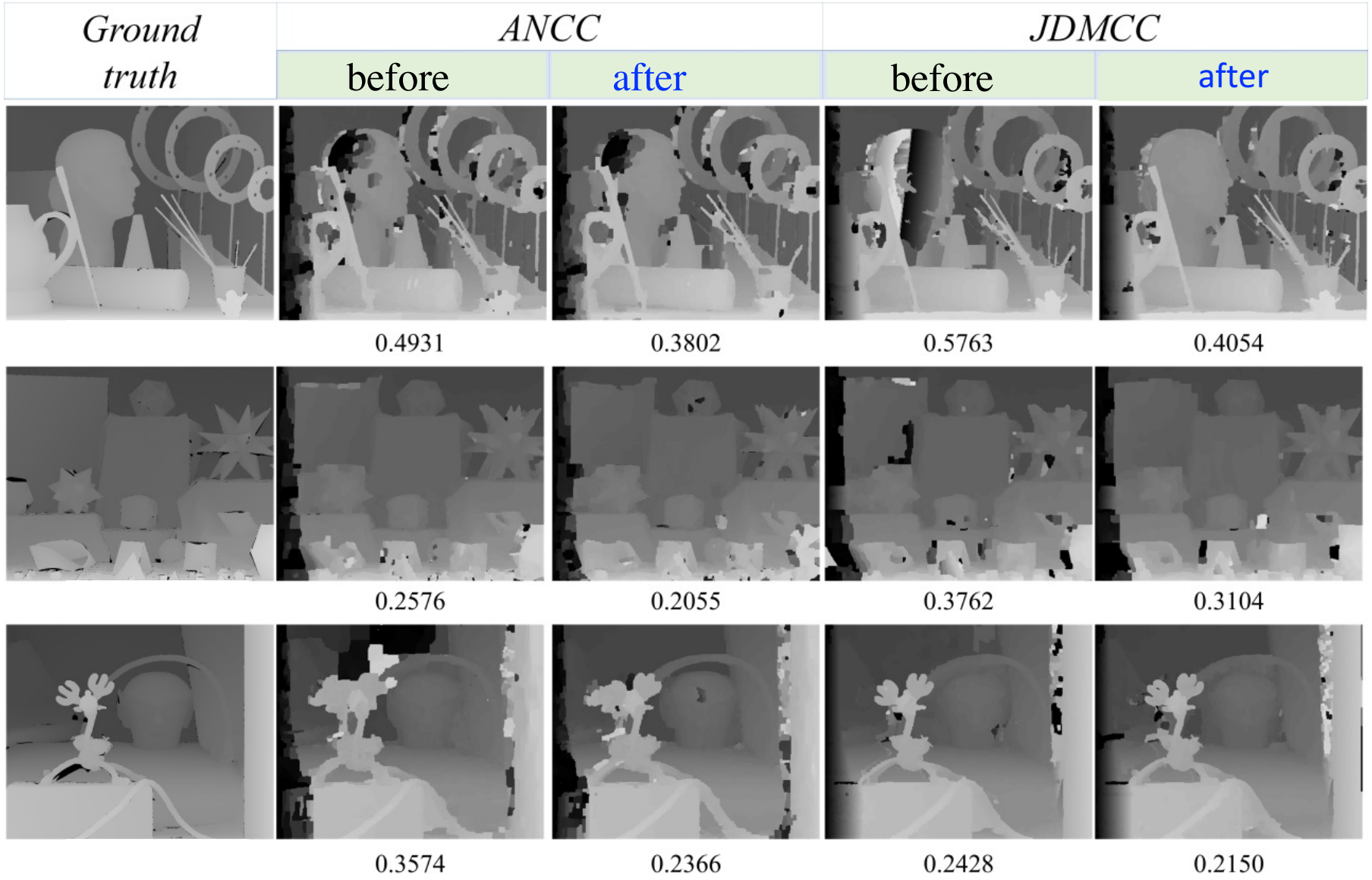
Bad Pixels Percentage $|d_m(i,j) - d_{gt}(i,j)| \geq 1$

	Aloe	Art	Baby1	Baby2	Baby3	Bowling1
Tgt	0.4676	0.4405	0.217	0.2318	0.244	0.324
GL	0.3646	0.3155	0.1526	0.2093	0.1292	0.2602
EM	0.2453	0.2599	0.0927	0.1762	0.1008	0.1858
RW	0.2152	0.2295	0.0998	0.1223	0.1084	0.1721
IN	0.1232	0.0905	0.0788	0.0955	0.0953	0.1389

Different Matching Costs



Different Stereo Matching



Q&A

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