Recovering Intrinsic Images with a Global Sparsity Prior on Reflectance

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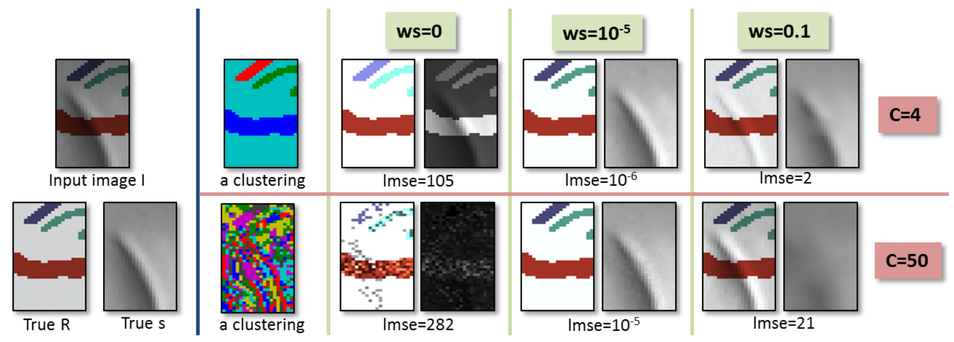
Problem

Decompose a single image $I \in [0,255]^{m\times n\times 3}$ into separate shading $S \in [0,255]^{m\times n}$ and reflectance $R \in [0,255]^{m\times n\times 3}$ layers.

$$I_i = R_i s_i, \quad I_i^c = s_i R_i^c, \quad R_i = r_i \vec{R}_i$$

Effect of E_{cl}



Intrinsic Model

MAP problem

$$\min_{r_i,\alpha_i;i=1,\ldots,n} \mathrm{w}_s E_s(\mathbf{r}) + \mathrm{w}_r E_{ret}(\mathbf{r}) + \mathrm{w}_{cl} E_{cl}(\mathbf{r},\alpha)$$

- **Shading Prior**

$$E_s(\mathbf{r}) = \sum_{i\sim j} \left(\frac{\|I_i\|}{r_i} - \frac{\|I_j\|}{r_j} \right)^2 \qquad (s_i = \|I_i\|/r_i)$$

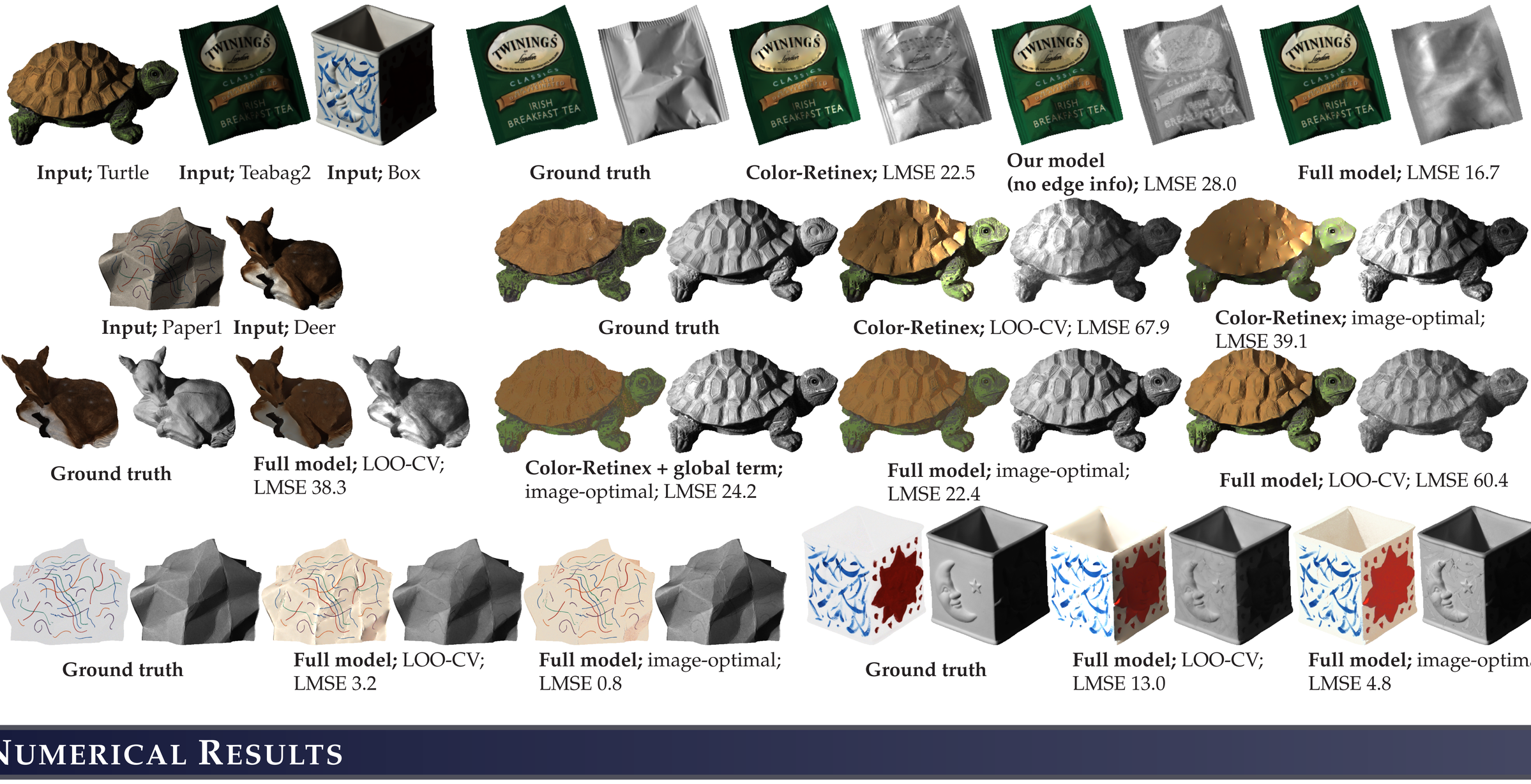
- **Gradient Consistency** (Color-Retinex)
  Edge-Classifier $g_{ij}(I)$: shading or reflectance edge?

$$E_{ret}(\mathbf{r}) = \sum_{i\sim j} (\log(r_i) - \log(r_j) - g_{ij}(I)(\log\|I_i\| - \log\|I_j\|))^2$$

- **Global Sparse Reflectance Prior**

$$E_{cl}(\mathbf{r},\alpha) = \sum_{i=1}^{n} \|r_i\vec{R}_i - \tilde{R}_{\alpha_i}\|^2, \quad \tilde{R}_c = \frac{\sum_{i:\alpha_i=c} r_i \vec{R}_i}{|\{i:\alpha_i=c\}|}$$

Results



Numerical Results

comment	E_s	E_{cl}	E_{ret}	LOO-CV	best single	image opt.
Color-Retinex	-	-	✓	29.5	29.5	25.5
no edge information	✓	✓	-	30.0	30.6	18.2
Col-Ret+ global term	-	✓	✓	27.2	24.4	18.1
full model	✓	✓	✓	27.4	24.4	16.1

Comparing the effect of including different terms.

	LOO-CV	rank	best single	im. opt.
Tappen et al., 2005, PAMI	56*	-	-	-
Tappen et al., 2006, CVPR	39*	-	-	-
Shen et al., 2008, CVPR	n/a	n/a	56.2	n/a
Shen&Yeo, 2011, ICCV [2]	n/a	n/a	(20.4)	-
Baseline: Grosse, 2011, ICCV [1]	72.6	5.1	60.3	36.6
Gray-Retinex [1]	40.7	4.9	40.7	28.9
Color-Retinex [1]	29.5	3.7	29.5	25.5
full model	27.4	3.0	24.4	16.1
Weiss, 2001, ICCV (sequences)	21.5	2.7	21.5	21.5
Weiss+Retinex, [1](sequences)	16.4	1.7	16.4	15.0

Comparison to literature.

Summary

- A new latent variable MRF model for intrinsic images
- A global sparse reflectance prior in pixel domain
- Extends of Color-Retinex
- More training data is needed for progress in this field!

References & Source Code

[1] R. Grosse, M. Johnson, E. Adelson, and W.T. Freeman. Ground truth dataset and baseline evaluations for intrinsic image algorithms In *ICCV '09*

[2] L. Shen and C. Yeo Intrinsic images decomposition using a local and global sparse representation of reflectance In *CVPR '11*

The source code is available at `http://tinyurl.com/cql2dhl`