BLOCK-BASED COLOR CONSTANCY: THE DEVIATION OF SALIENT PIXELS

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Overview

1. Introduction
2. Proposed Method
3. Experimental Results
4. Conclusion

1. Introduction

Motivation of this Study

- We recently proposed a color constancy method based on the observations *
  - The human visual system might be "*discounting*" the illuminant by using
    - Highest luminance patches
    - Space-average color

- We observed that some regions of the image decrease the performance

* Ulucan, O., Ulucan, D., & Ebner, M. (2022, October). Color Constancy Beyond Standard Illuminants. In *2022 IEEE International Conference on Image Processing (ICIP)* (pp. 2826-2830). IEEE.

1. Introduction

Aim of this Study

- We improve the performance of our algorithm with a simple approach
  - Reducing the impact of non-informative image elements

- We show that the performance of several algorithms can be improved by using our approach

1. Introduction

Color Constancy

- The perceived color remains constant regardless of the illumination
  - Performed unconsciously by the human visual system
  - Machine vision systems have difficulty to perform such tasks

Figure. Performing color constancy.

1. Introduction

Importance of Computational Color Constancy

Consumer Photography

Higher Level Computer Vision

- Object Recognition
- Image Dehazing

- Without color constancy, objects could no longer be reliably identified by their color *
- Utilized in various computer vision pipelines *
  - Robotics
  - Security Systems

* M. Ebner, *Color Constancy, 1st ed.*, Wiley Publishing, 2007.

1. Introduction

Aim of Color Constancy

- To estimate the color vector of the light source $\mathbf{L}$

$$I(x, y) = \int R(x, y, \lambda)\, E(x, y, \lambda)\, S(\lambda) d\lambda \quad (1)$$

$$L(x, y, \lambda) = \int E(x, y, \lambda)\, S(\lambda) d\lambda \quad (2)$$

- We do not know;
  - The type of the light source
  - The type of the capturing device

I: Image
x, y: Pixel positions
E: Light source
λ: Wavelength of the visible spectrum
R: Amount of reflected light
S: Sensor response characteristics of the capturing device

1. Introduction

Computational Color Constancy Methods

Traditional Methods

- Make assumptions relying on the statistical properties of images

Learning-based Methods

- Dataset dependent
- Generally require parameters , i.e, $S(\lambda)$

- Performance of learning-based algorithms tends to decrease [*]
  - Unique illumination conditions
  - Without prior information of $S(\lambda)$

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2. Proposed Method

Observations

- Human visual system might be estimating the illuminant of a scene *

✓ Space-average color ✓ Highest luminance patch

✓ Gray world ✓ maxRBG

Assumptions

1. The world is gray on average
2. There are bright pixels somewhere in the scene

Main Idea

✓ If there is a deviation from the gray value, it should be caused by the light source

* M. Ebner, *Color Constancy, 1st ed.*, Wiley Publishing, 2007.

2. Proposed Method

Initial Steps of Algorithm

Figure. Image is divided into non-overlapping patches.

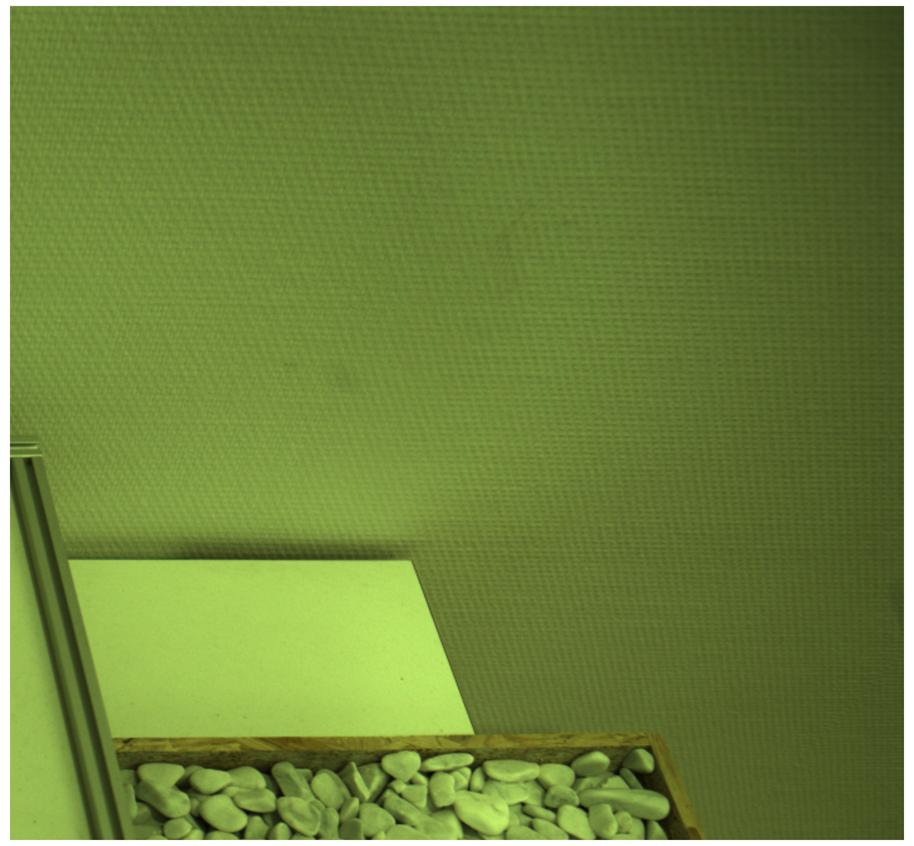
First Steps of Algorithm

- In case of an sRGB image, gamma correction is applied
- The darkest and brightest pixels in the image are not considered in the calculation to reduce possible noise
- Image is divided into non-overlapping blocks;

$$\left\{ I_p \right\}_{p=1}^{n} \qquad n:\ \textit{number of blocks}$$

2. Proposed Method

Informative Elements of the Blocks



Assumptions

1. The world is gray on average
2. There are bright pixels somewhere in the scene

- It is assumed that for each block there exist two informative elements;
    1. A unique achromatic value, i.e. gray value
        - μ_p can be computed by taking the mean of pixels over all channels within the patch
    2. A bright pixel, i.e. maximum intensity values
        - $I_{p,max} = \left[R_{p,max}, G_{p,max}, B_{p,max}\right]$ can be determined by taking the maximum response of each channel

2. Proposed Method

The Deviation from Gray World

Main Idea

✓ If there is a deviation from the gray value, it should be caused by the light source

- The deviation of $I_{p,max}$ from μ_p can be computed by using a scaling vector $\mathbf{C}_p = [c_r,\ c_g,\ c_b]$

$$R_{p,max} \cdot c_r + G_{p,max} \cdot c_g + B_{p,max} \cdot c_b = \mu_p \qquad (1)$$

$$\mathbf{C_p} = \underset{\mathbf{C_p}}{\arg\min} \left\| I_{p,max}\, \mathbf{C_p} - \mu_p \right\|_2 \quad with \quad \forall c \in \mathbf{C_p} : c \geq 0 \qquad (2)$$

- The estimate of the global illuminant can be found by $\mathbf{L}_{est} = \sum_{p=1}^{n} \frac{\mathbf{C}_p}{n}$ (3)

2. Proposed Method

Salient Pixels

- Instead of using all pixels in block, only the salient ones are used to find the deviation
  - Salient regions are obtained from the pixels, which are closest to white
- In order to find the salient pixels *
  1. Temporary color of the light source, L_{temp}, is estimated by assuming the world is gray
  2. Temporary white balanced image, I_{temp}, is obtained by dividing the image by L_{temp}
  3. The angular error between the pixels of I_{temp} and white vector, [1, 1, 1] is calculated
  4. The elements having an error less than 5 are considered as salient pixels

* Ulucan, O., Ulucan, D., & Ebner, M. (2022). BIO-CC: Biologically Inspired Color Constancy. In *2022 British Machine Vision Conference (BMVC).* BMVA press.

3. Experimental Results

Table 1: Statistical results of the methods. For each metric the best result is highlighted.

	INTEL-TAU Dataset				REC Commended ColorChecker Dataset			
	Mean	**Median**	**B-25%**	**W-25%**	**Mean**	**Median**	**B-25%**	**W-25%**
White-Patch Retinex	11.01	13.16	1.81	19.44	10.27	9.12	1.64	20.50
Gray World	4.91	3.88	0.96	10.60	4.74	3.61	0.97	10.44
Shades of Gray Edge	5.51	4.16	0.97	12.29	5.87	4.25	0.75	13.72
1^{st} order Gray Edge	6.10	4.23	0.96	14.27	6.42	3.84	0.94	15.83
2^{nd} order Gray Edge	6.41	4.50	1.04	14.73	6.94	4.41	1.07	16.53
Weighted Gray Edge	6.00	3.64	0.81	14.90	6.10	3.33	0.79	15.59
Double-Opponent Cells based Color Constancy	7.19	4.67	0.81	16.98	7.24	4.26	0.80	18.05
PCA based Color Constancy	4.47	3.03	0.69	10.64	4.11	**2.52**	0.53	10.19
Local Surface Reflectance Estimation	4.17	3.42	0.98	8.61	4.03	3.07	1.40	8.17
Mean Shifted Gray Pixels	3.57	**2.56**	0.64	8.24	3.81	2.96	0.77	8.35
White-Patch Retinex: Block-based with Salient Pixels	3.41	2.65	0.79	7.36	4.05	2.93	0.94	8.99
Gray World: Block-based with Salient Pixels	3.69	2.58	**0.63**	8.60	4.39	2.80	**0.52**	10.85
Proposed: Without Blocks and Salient Pixels	8.74	7.89	1.74	17.08	9.23	7.49	2.79	18.11
Proposed: Without Blocks and with Salient Pixels	5.92	4.11	1.04	13.72	6.44	4.73	1.55	14.06
Initial Version	4.29	3.61	1.20	8.53	3.82	3.17	1.46	7.38
Proposed	**3.37**	2.63	0.79	**7.25**	**3.48**	2.71	1.06	**7.35**

- 2 benchmarks are utilized
- 9 algorithms are compared
- Angular error is reported
- Our strategy is investigated

3. Experimental Results

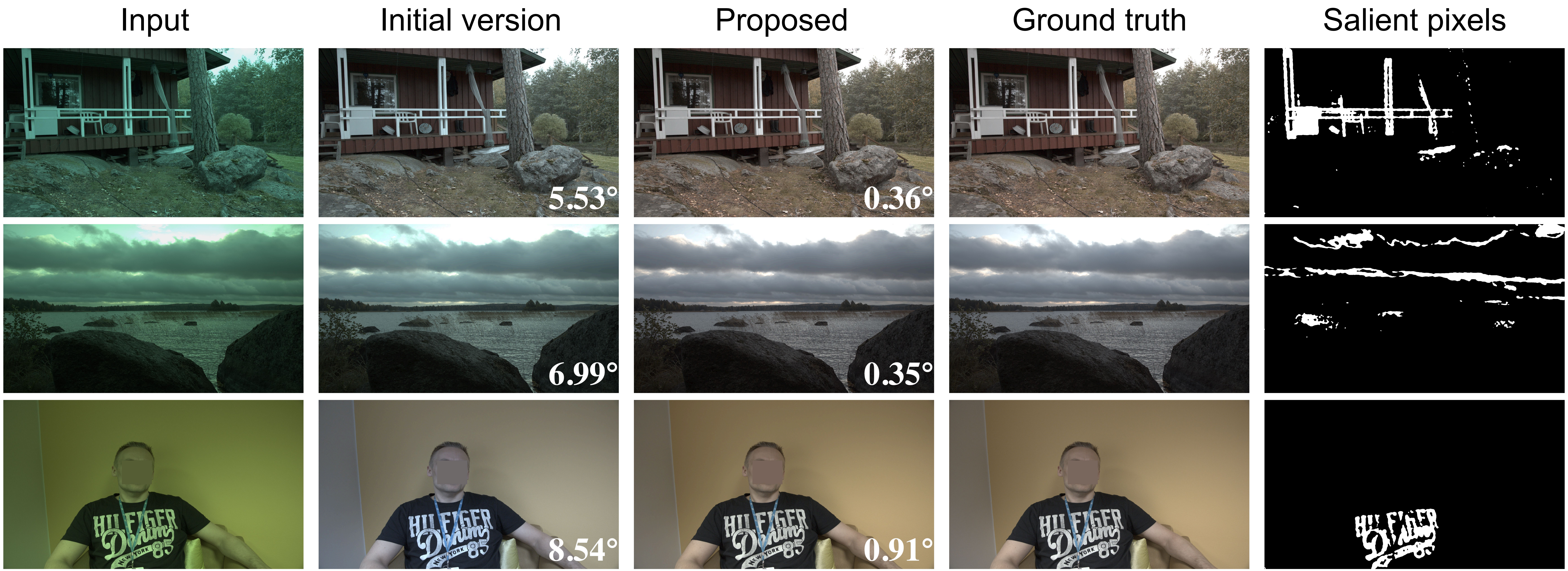


Figure. Comparison with the initial version.

3. Experimental Results

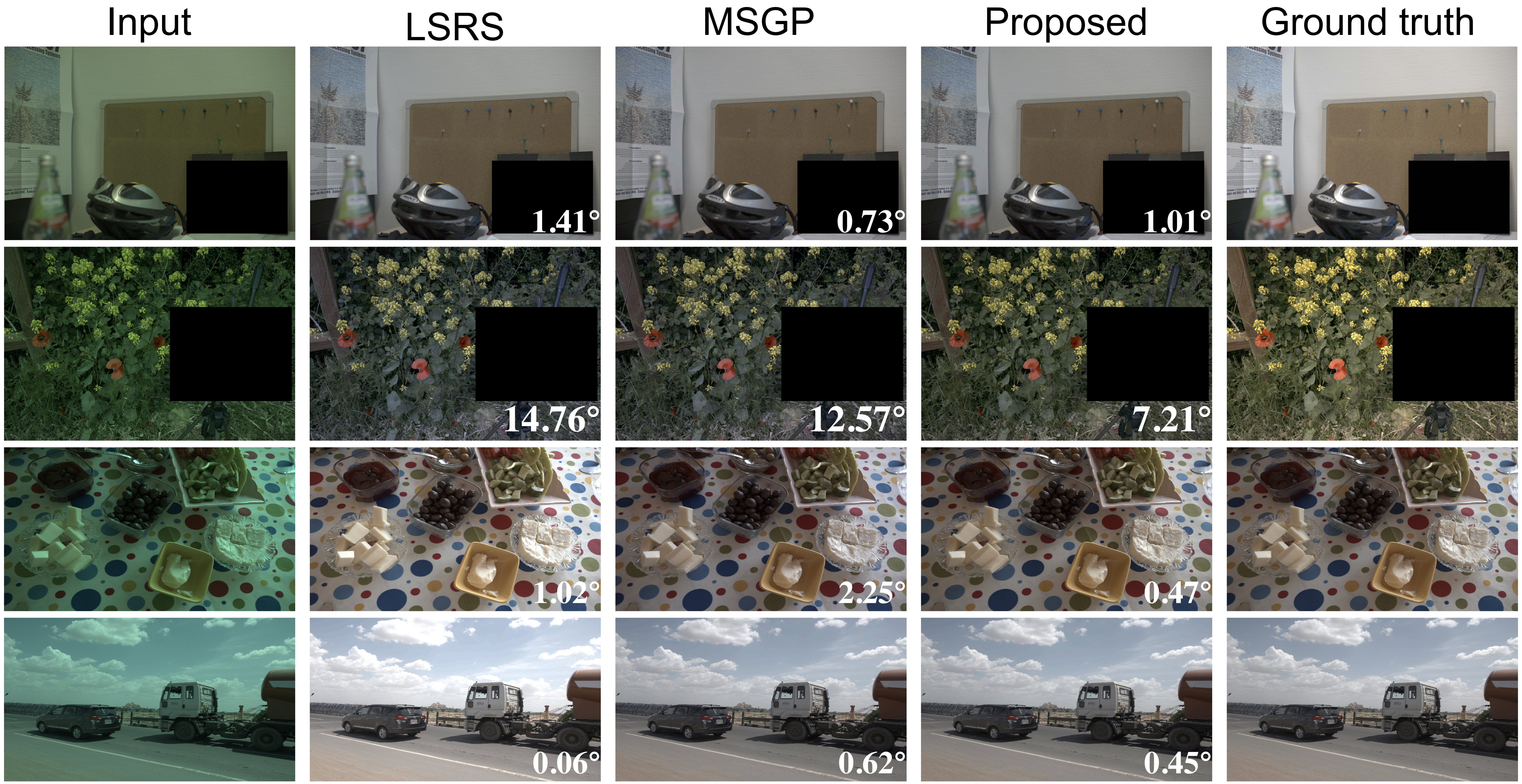


Figure. Comparison with other methods.

3. Experimental Results

Table 2. Investigation of the kernel size of the non-overlapping blocks. The kernel size having the lowest mean angular error is selected.

	INTEL-TAU Random Set							RECommended ColorChecker Random Set						
	8×8	16×16	32×32	64×64	128×128	300×300	600×600	8×8	16×16	32×32	64×64	128×128	300×300	600×600
Mean Angular Error	3.759	3.747	3.733	3.729	**3.725**	3.733	3.783	3.630	3.603	3.571	3.542	3.518	**3.492**	3.607

- The size of the non-overlapping patches is the only fixed parameter
  - Determined experimentally by investigating the relationship between the mean angular error and different kernel sizes
- Experiments are performed on a sub-set called random set

4. Conclusion

- We proposed a learning-free algorithm relying on the assumptions
  - Gray world
  - maxRBG
- We modify our algorithm by only considering the patches containing the salient pixels
  - Pixels closest to white
- We showed applying our strategy to some methods can improve their effectiveness
  - Block-based approach
  - Considering only the salient pixels

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Thank you!

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