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COLOR CONSTANCY BEYOND STANDARD ILLUMINANTS

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Color Constancy

Identifying the colors in a scene regardless of the illumination conditions [1]

"Discounting the Illuminant"

Aim of Color Constancy

Estimate the color vector of the light source $\mathbf{L}$

Obtain a canonical image from color casted scene [1]

$$I(x,y) = \int R(x,y,\lambda)\, E(x,y,\lambda)\, S(\lambda) d\lambda \qquad \mathbf{L} = [l_R\ l_G\ l_B]^T = \int E(x,y,\lambda)\, S(\lambda) d\lambda$$

I: Image $\quad x, y$: Pixel position $\quad R$: Reflectance $\quad E$: Light source

S: Sensor response characteristics of the capturing device

λ: Wavelength of the visible spectrum

Aim of the Study

! Datasets and learning based methods do not include illuminants with values outside the color temperature curve (CTC)

- First study investigating the response of color constancy methods to illuminants
  - ✓ On the edges and outside the CTC
- A novel traditional color constancy method is developed

Dataset

- *The Rendered WB Dataset* [2] is modified and *10528* images under illuminants outside and edge of the CTC are created
  - ✓ Greenish, purplish, *2000K*, *3500K*, *4800K*, *5200K*, *10000K*

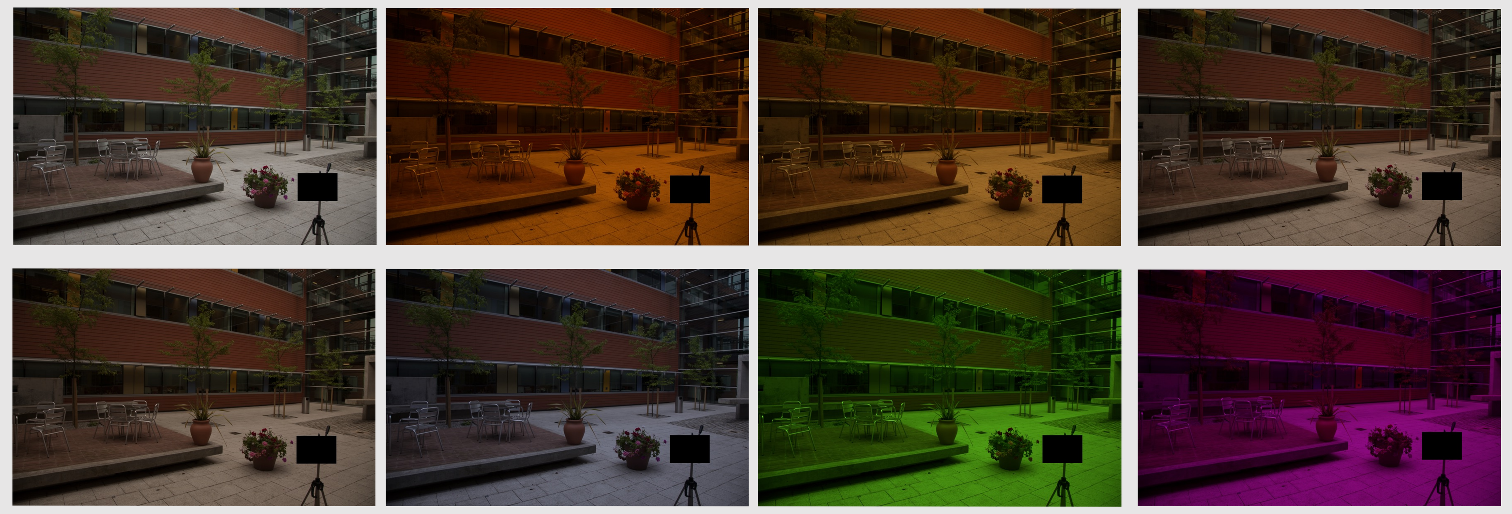

Figure. Example from the dataset.

Proposed Method

Observations

- Color constancy studies based on human visual system are effective
  - ✓ Gray World
  - ✓ max - RGB
- Human visual system might be estimating the illuminant of a scene [1]
  - ✓ Space-average color
  - ✓ Highest luminance patch

Assumptions

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

Main Idea

✓ If there is a shift from the gray world, it should be caused by the illumination condition of the scene

Steps of the Proposed Method

Figure. Image is divided into non-overlapping blocks.

- Image is linearized
- *2%* percent of the darkest and the brightest pixels are clipped to reduce possible noise
- Image is divided into blocks, $\{I_p\}_{p=1}^{n}$

n: number of blocks, $5 < n < 9$

- For each I_p there exists at least one bright pixel, $I_{p,max} = [R_{p,max}, G_{p,max}, B_{p,max}]$
- Each I_p should be gray on average
- The deviation of $I_{p,max}$ from gray world can be computed by using a scaling vector $\mathbf{C}_p = [c_r\ c_g\ c_b]$;

$$\mathbf{C}_p = \operatorname{argmin} \left\| I_{p,max}\, \mathbf{C}_p - I_{p,gray} \right\|_2 \quad s.t.\ \ \forall c \in \mathbf{C}_p \geq 0$$

- The estimate of the global illuminant can be found by;

$$\mathbf{L}_{est} = \sum_{p=1}^{n} \frac{\mathbf{C}_p}{n}$$

$I_{p,gray}$: mean over all channel values of I_p

Experimental Results

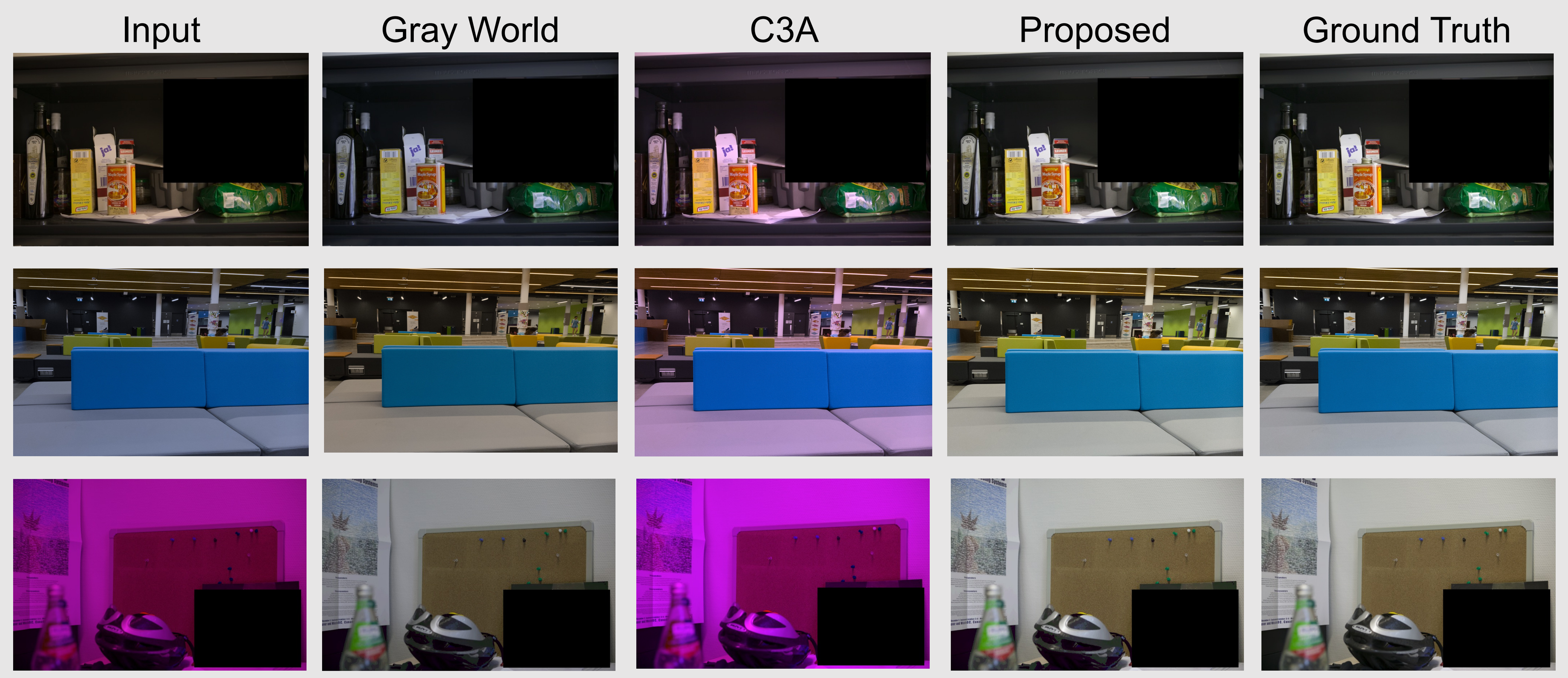

Figure. Visual comparison of the methods.

Table. Statistical analysis of the algorithms. For each metric the best result is highlighted. Average run time of the methods in seconds is reported in the last column.

	Lights on the CTC					Lights outside the CTC					
Algorithms	**ΔE**	**Mean**	**Median**	**Best-25%**	**Worst-25%**	**ΔE**	**Mean**	**Median**	**Best-25%**	**Worst-25%**	**Avg. run time**
Gray World	9.239	3.555	1.809	0.670	9.633	10.051	4.305	3.072	1.494	9.139	0.077
max-RGB	7.646	3.657	1.966	0.718	9.535	8.383	4.324	3.117	1.530	9.081	0.052
Shades-of-Gray	7.966	3.626	1.904	0.701	9.687	8.765	4.305	3.086	1.503	9.136	0.104
1^{st} order Gray Edge	7.779	3.659	1.951	0.709	9.740	8.570	4.318	3.089	1.509	9.146	0.171
2^{nd} order Gray Edge	7.765	3.664	1.966	0.709	9.749	8.552	4.316	3.103	1.510	9.139	0.180
Weighted Gray Edge	7.771	3.680	1.983	0.714	9.778	8.477	4.314	3.092	1.511	9.135	0.850
MSGP	3.889	3.436	1.679	0.618	9.483	5.042	4.342	3.151	1.518	9.132	0.307
DOCC	9.127	3.754	2.040	0.732	9.900	13.331	4.401	3.091	**1.446**	9.515	0.196
PCA-CC	3.659	3.504	1.495	**0.554**	10.127	4.585	4.345	3.091	1.481	9.270	0.097
Proposed	**2.636**	**3.214**	**1.427**	0.563	**9.127**	**3.768**	**4.221**	**3.008**	1.462	**8.993**	0.097
Deep-WB	10.845	7.803	5.315	2.388	17.241	18.337	14.485	13.603	8.006	22.500	0.985
AWB-MIS	11.720	8.393	5.168	1.970	20.313	21.771	15.809	14.586	7.714	26.183	0.826
C5	11.793	9.620	7.115	3.225	20.213	22.196	13.632	13.246	8.956	18.980	0.086
C3A	14.472	4.359	2.296	0.926	11.497	25.860	15.588	13.563	4.065	31.013	**0.037**
WB-sRGB	11.734	4.933	2.644	1.176	12.395	19.606	25.362	19.694	6.360	52.935	0.334

1. M. Ebner, *Color Constancy, 1st ed.*, Wiley Publishing, 2007.
2. M. Afifi, B. Price, S. Cohen, and M. S. Brown, "When color constancy goes wrong: Correcting improperly white-balanced images," in IEEE Conf. Comput. Vision Pattern Recognit., 2019, pp. 1535–1544.

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