BIO-CC: Biologically Inspired Color Constancy

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Motivation and Contribution of the Study

- How does the brain perform color constancy?
- How is the brain *fooled* by color illusions?
- Combination of color constancy and color illusions
  - Can reveal the mechanisms of color perception
  - Help the researchers in computer vision to design models that closely mimic the human visual system
- First study;
  - Investigating color constancy and color illusion phenomenon together
  - Taking the focal and peripheral vision, and retinotopy structure into account

Color Constancy

Identifying the colors in a scene regardless of the illumination conditions

"Discounting the illuminant"

Aim of Color Constancy

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

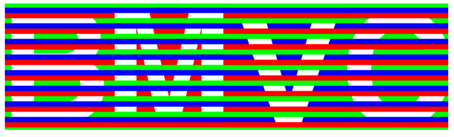
$$I(x,y) = \int R(x,y,\lambda)\, E(x,y,\lambda)\, S(\lambda) d\lambda \qquad \mathbf{L} = [l_R\, l_G\, l_B]^T = \int E(x,y,\lambda)\, S(\lambda) d\lambda$$

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

S: Sensor response characteristics of the capturing device λ: Wavelength of the visible spectrum

Color Assimilation Illusion

Color Assimilation Illusion



Target

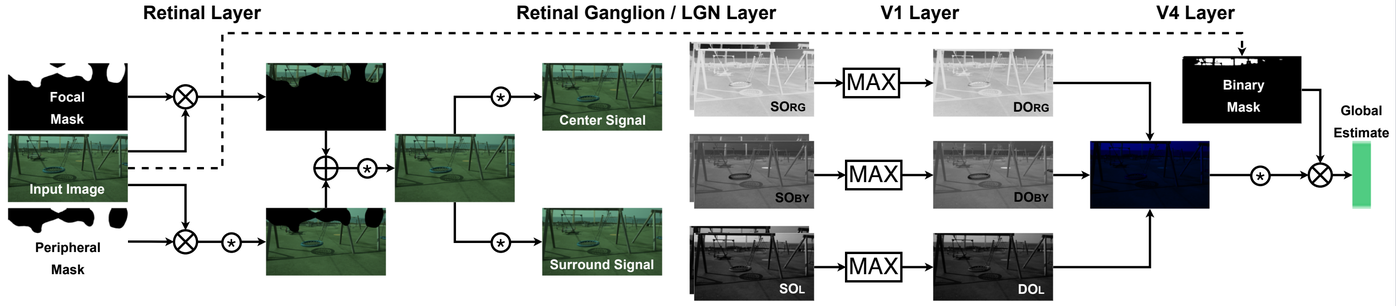
- One of the interesting aspects of color processing is the difference between the colors perceived by the human visual system and the actual physical reflectance in certain situations
- In color assimilation illusions, the perceived color of the target shifts towards that of its local neighbours

1. F. Laakom, J. Raitoharju, J. Nikkanen, A. Iosifidis, and M. Gabbouj. Intel-TAU: A color constancy dataset. *IEEE Access*, 9(-):39560–39567, 2021.

** Some of the color illusions are courtesy of Akiyoshi Kitaoka and Michael Bach.

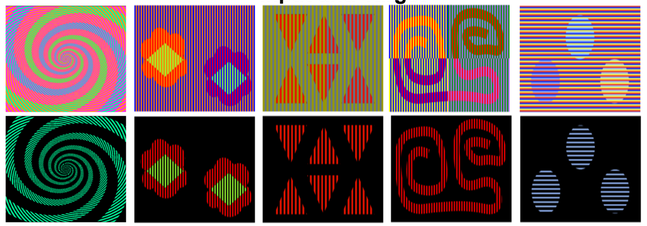
Proposed Method : Bio-CC

- Bio-CC has a hierarchical order as the human visual system

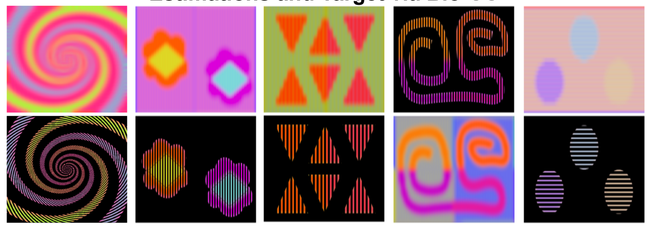


Response to Color Illusions

Input and Target



Estimations and Target via Bio-CC



Performing Color Constancy

Input Image

Salient pixels via V1

Bio-CC

Ground truth

	Camera-Invariant					Canon					Nikon					Sony					
	ΔE	Mean	Median	B-25%	W-25%	ΔE	Mean	Median	B-25%	W-25%	ΔE	Mean	Median	B-25%	W-25%	ΔE	Mean	Median	B-25%	W-25%	run time
GW	4.22	4.91	3.88	0.95	10.59	3.93	4.52	3.55	0.85	9.83	4.15	5.29	4.19	1.03	11.49	4.62	4.77	3.84	0.98	10.06	0.14
max-RGB	10.15	11.01	13.16	1.81	19.44	11.54	13.41	17.64	2.37	20.99	8.74	10.02	11.31	1.56	17.65	10.69	9.98	11.52	1.83	16.76	**0.13**
SoG	5.30	5.51	4.16	0.97	12.29	5.82	6.16	4.26	1.05	14.30	4.64	5.17	3.82	0.96	11.46	5.71	5.33	4.41	0.92	11.34	0.23
1^{st} GE	5.80	6.09	4.23	0.96	14.26	6.34	6.93	4.34	0.94	16.87	4.91	5.47	3.65	0.87	12.87	6.49	6.14	4.79	1.13	13.35	0.38
2^{nd} GE	6.09	6.41	4.49	1.04	14.73	6.70	7.33	4.76	1.04	17.29	5.20	5.79	4.02	0.93	13.38	6.69	6.34	5.01	1.20	13.71	0.42
WGE	5.64	6.00	3.64	0.81	14.90	6.18	6.86	3.55	0.79	17.81	4.72	5.29	3.19	0.72	13.16	6.36	6.13	4.41	0.98	14.12	2.63
DOCC	6.65	7.19	4.67	0.81	16.98	7.13	8.20	5.00	0.78	19.73	5.29	6.07	3.62	0.72	15.03	8.05	7.72	6.27	1.00	16.26	0.43
PCA-CC	4.14	4.47	**3.03**	**0.69**	10.64	4.45	4.81	3.11	**0.71**	11.87	3.52	**4.09**	**2.76**	**0.67**	**9.82**	4.67	4.65	**3.42**	**0.71**	10.50	0.16
LSRS	3.82	4.17	3.42	0.98	**8.61**	3.69	3.94	3.08	1.01	8.16	3.63	4.33	3.59	0.99	8.97	**4.18**	**4.17**	3.54	0.94	**8.55**	0.14
Bio-CC	**3.55**	**4.14**	3.05	0.76	9.42	**3.17**	**3.68**	**2.85**	0.75	**8.00**	**3.27**	4.22	2.92	0.77	9.88	4.32	4.49	3.45	0.73	10.00	1.61

* *INTEL-TAU Dataset* [1] * *Camera-Invariant* contains all the images in the dataset