BIO-CC: Biologically inspired color constancy (Supplementary File)

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This supplementary file provides information about the color space conversions, the calculation of the angular error, and the parameter selection in the V4 layer of Bio-CC, which are mentioned in the paper. Additionally, more visual results are demonstrated for both color assimilation illusions and color constancy.

The illusions created by the authors will be publicly available upon publication. The code of Bio-CC will be accessible after it is modified for more color illusions and multi-illuminant color constancy.

1 Color Space Conversions

Since Bio-CC uses the opponent color space, the color conversions between the opponent and RGB channels, which are explained in the work of Ebner [4] are followed. The single-opponent responses in Eqn. 5 are obtained by using a conversion matrix as follows,

$$\begin{bmatrix} SO_{RG} \\ SO_{BY} \\ SO_{L} \end{bmatrix} = \begin{pmatrix} \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 \\ \frac{1}{\sqrt{6}} & \frac{1}{\sqrt{6}} & -\frac{\sqrt{2}}{\sqrt{3}} \\ \frac{1}{\sqrt{3}} & \frac{1}{\sqrt{3}} & \frac{1}{\sqrt{3}} \end{pmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \tag{1}$$

The double-opponent channels are converted to RGB channels as follows,

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{pmatrix} \frac{1}{\sqrt{3}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{6}} \\ \frac{1}{\sqrt{3}} & -\frac{1}{\sqrt{2}} & \frac{1}{\sqrt{6}} \\ \frac{1}{\sqrt{3}} & 0 & -\frac{\sqrt{2}}{\sqrt{3}} \end{pmatrix} \begin{bmatrix} DO_{\mathcal{L}} \\ DO_{RG} \\ DO_{YB} \end{bmatrix} \tag{2}$$

2 Angular Error

The angular error (ε) is computed between the ground truth illuminant ($\mathbf{L}^{gt}$) and the estimated illuminant ($\mathbf{L}^{est}$) vectors as follows,

$$\varepsilon(\mathbf{L}^{gt},\mathbf{L}^{est}) = cos^{-1}\left(\frac{\mathbf{L}^{gt}\mathbf{L}^{est}}{\|\mathbf{L}^{gt}\|\|\mathbf{L}^{est}\|}\right). \tag{3}$$

3 Parameter Selection of the V4 Layer

The performance of Bio-CC depends on the parameters of the V4 layer, which are the kernel size and the σ value of the Gaussian kernel in Eqn. 7. In this file, the investigation of these parameters are provided in Table 1.

The tests are carried out on the subset of the dataset mentioned in the paper. In order to create this set, images containing diverse indoor and outdoor scenes with different textures and color distributions, are randomly selected.

For each parameter combination, the mean angular error between the estimate of the global illumination and the ground truth light vector is computed (Table 1). The parameters having the lowest mean angular error, which can also reproduce the behaviour of the human visual system on color assimilation illusions are selected. Note that, in Table 1 the kernel size and σ are not further reduced, since smaller values face a challenge in replicating the behaviour of the human visual system on color assimilation illusions. Also, since in the $V4$ layer the retinotopy structure degrades, the kernel size and σ of the receptive field function have to be sufficiently large to simulate this degradation.

	σ			
Kernel Size (% of the image)	***32***	***64***	***128***	***256***
8	**3.763**	3.767	3.769	3.769
16	3.766	3.784	3.793	3.795
32	3.766	3.788	3.809	3.818

Table 1: The investigation of the parameters in V4. The mean angular error between the global estimate and the ground truth is provided. Best combination is highlighted.

4 Visual Results and Comparisons

Due to the page limit, a limited number of visual results of Bio-CC and visual comparisons of the color constancy methods could be provided in the paper. Hence, in this supplementary material additional results of Bio-CC are presented for both color assimilation illusions (Fig. 1) and color constancy (Fig. 2). Also, output images of Bio-CC having an angular error below the B-25%, close to the mean and above W-25% are visually compared with the best performing algorithms (Fig. 3). Moreover, in Fig. 4, Bio-CC is compared visually with the color constancy studies mentioned in the paper; gray world (GW) [2], white patch Retinex (max-RGB) [9], shades of gray (SoG) [5], 1^{st} and 2^{nd} order gray-edge (GE) [10], weighted gray-edge (WGE) [8], double-opponent cells based color constancy (DOCC) [7], PCA based color constancy (PCA-CC) [3], and color constancy with local surface reflectance estimation (LSRS) [6].

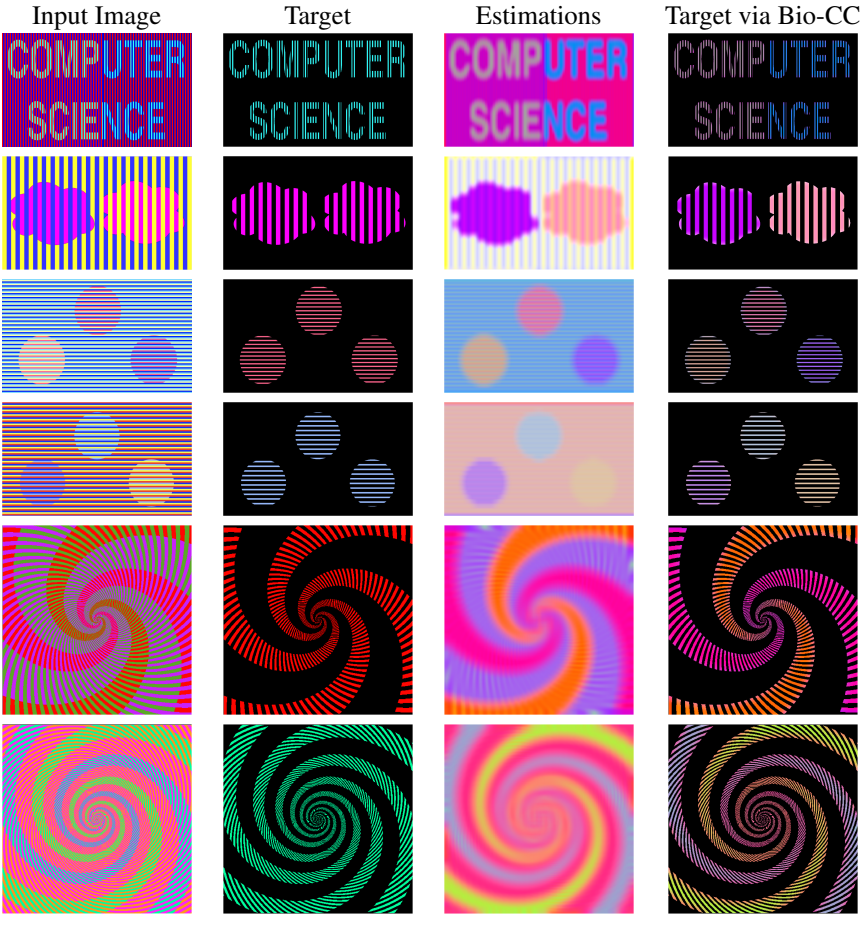

Figure 1: The results of Bio-CC for color assimilation illusions. Top two images are created by the authors, next two images are created on the website of Michael Bach [1], and images in the last two rows are courtesy of Akiyoshi Kitaoka.

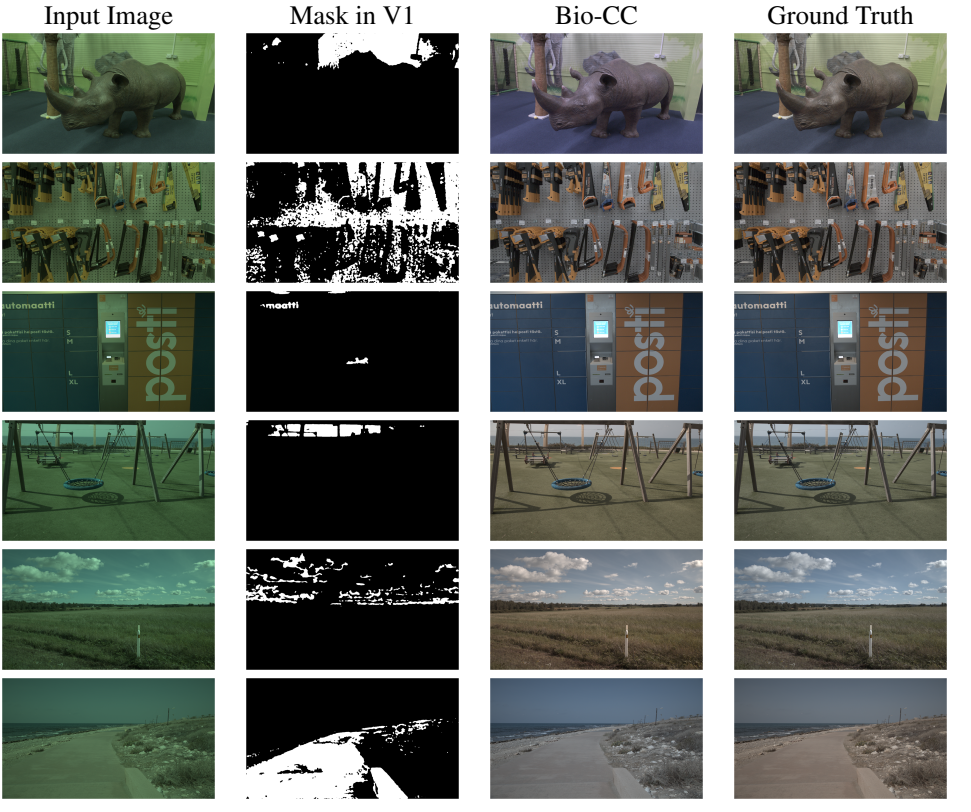

Figure 2: The results of Bio-CC for color constancy. Gamma correction is applied for better visualization.

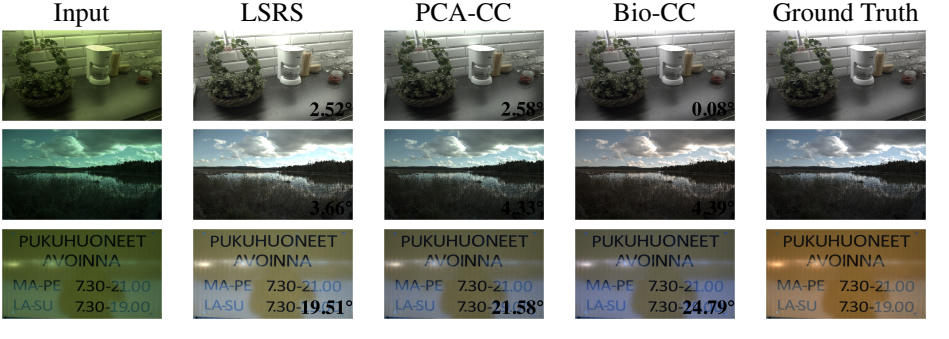

Figure 3: Comparisons for the outputs of Bio-CC having an angular error below the B-25%, close to the mean angular error and above W-25%.

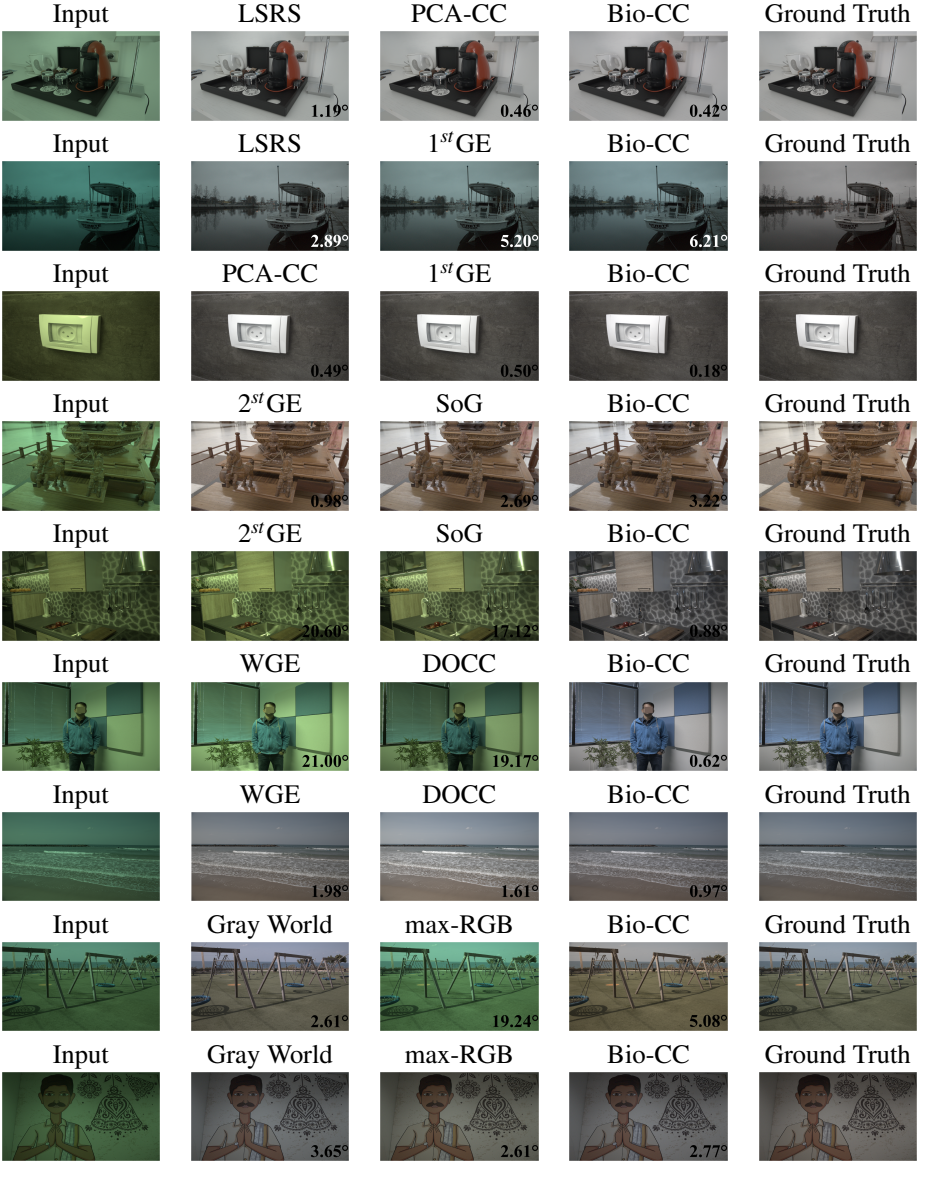

Figure 4: Comparison of algorithms. The angular error of each method is provided on the bottom-right side of the image. Gamma correction is applied for better visualization.

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