Chromatic Adaptation and White-Balance Problem

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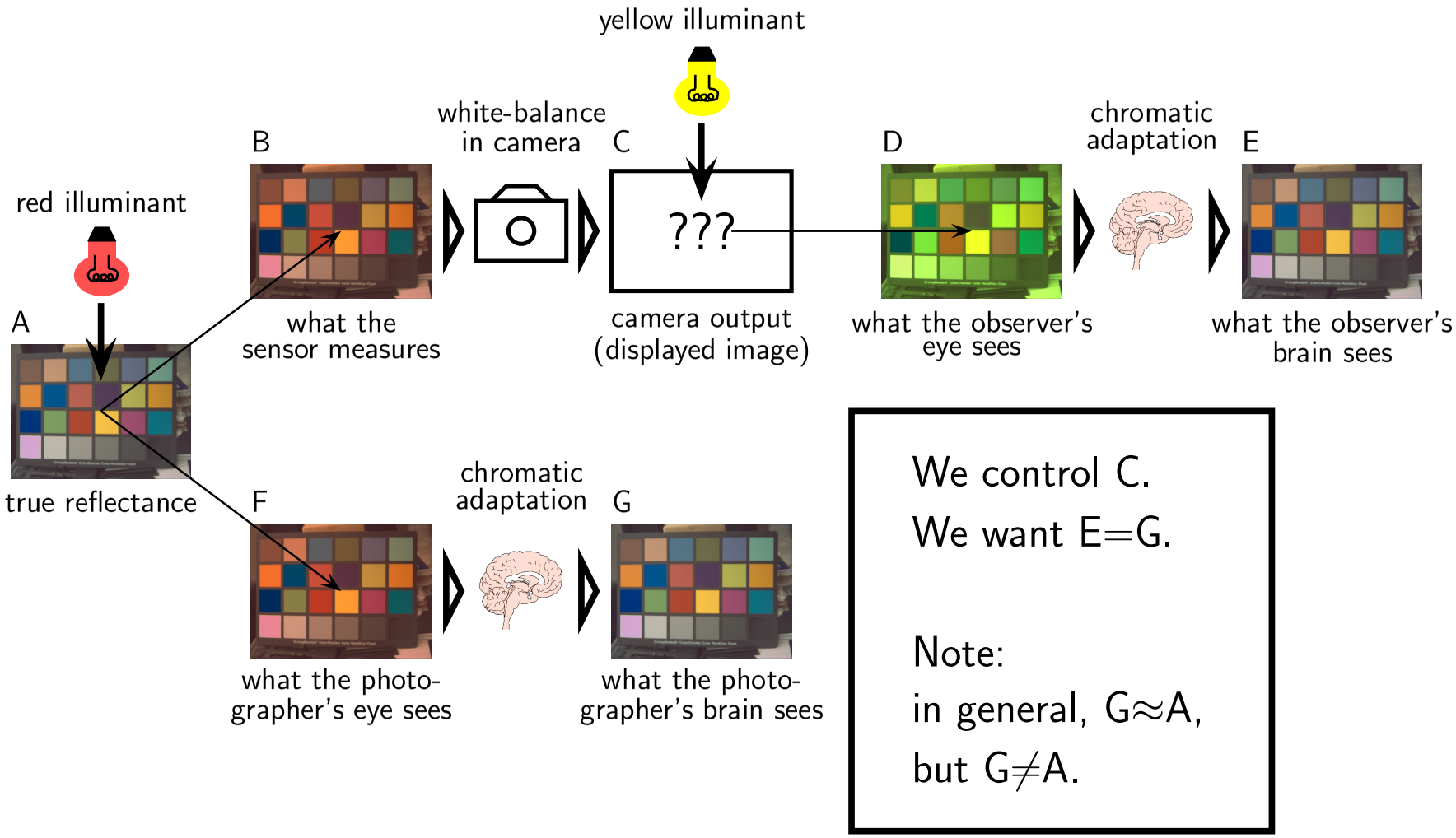
What is Chromatic Adaptation?

- *Chromatic adaptation* is the process of a change in the photoreceptive sensitivity of the human visual system (HVS) under various viewing conditions.
- The chromatic adaptation mechanism has the effect of discounting the illuminant, and thus metameric colors under one illuminant often appear metameric (i.e. same) under another illuminant.

White-Balance Problem Overview

- Image sensors in digital cameras measure intensity of light. Their sensitivities are spectrally shifted to capture the color data.
- We would like the output image from a digital camera, viewed under a standard condition, to match the scene that photographer saw.
- The process of adjusting the image appearance to a different viewing condition is commonly known as the white-balance problem.



We control C.
We want E=G.

Note:
in general, G≈A,
but G≠A.

Human Visual Model

- To solve for C, we need a model for chromatic adaptation.

$$\Psi([p_1, p_2, p_3]w, y) = \Psi(u, r)$$

- Two competing theories for chromatic adaptation:
  - von Kries “Coefficient Law” (popular but inacurate!)
  - Jameson and Hurvich “Induced Opponent Response”

Induced Opponent Response Theory

$$\Psi(u,s) = M^{-1}\Big((Mu)^n - k(Ms)^n\Big)$$

$$\Psi(u,s) = M^{-1}\left(Mu - k\frac{m_1 u}{m_1 s}(M_0 s)\right)$$

Solution

$$w = [p_1, p_2, p_3]^{-1} L(y)^{-1} L(r) u$$

where

$$L(s) = \left(I - \frac{k}{m_1 s} M^{-1} M_0 s m_1 \right)$$

note: this matrix multiplication is computationally free.

Results: No White-Balance



Solid colors represent the illuminant colors detected by the gray-world method (left) and method in [1] (right).

[1] G. Finlayson *et al.* "Convex and non-convex illuminant constraints for dichromatic colour constancy," Proc. IEEE Conf. Computer Vision and Pattern Recognition, Kauai, USA.

Results: With White-Balance

gray world + von Kries gray world + proposed



[1] + von Kries [1] + proposed

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Results: With White-Balance

CIELAB Δ_{ab} distance between the *white* panel and a neutral white.

illuminant estimation	chromatic adaptation	Δ_{ab} left	middle	right
gray-world	von Kries	1.2353	1.2526	3.5937
method in [1]	von Kries	3.0351	0.8294	5.2194
gray-world	proposed	0.8454	0.7062	0.8456
method in [1]	proposed	0.8143	0.7062	0.8456

Conclusion

- Used viewing model to define white-balance problem.
- Solution using induced opponent response.
- Color using proposed solution appears more natural than the traditional method.
- Computational cost is virtually zero.

Announcement...

- Please also see our other ICIP 2005 paper, “Joint Demosaicing and Denoising.”
- Hirakawa is looking for a tenure-track university position in the US. Any suggestions would be appreciated.