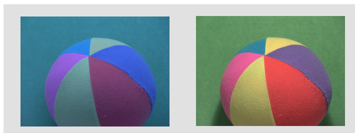
Diagonal Model for Color

(Same scene, but different illuminant)

Light color (R_{L1}, G_{L1}, B_{L1})

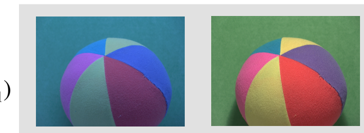


Light color (R_{L2}, G_{L2}, B_{L2})

Diagonal Model for Color

(Same scene, but different illuminant)

Light color (R_{L1}, G_{L1}, B_{L1})



Light color (R_{L2}, G_{L2}, B_{L2})

Diagonal model assumes that all the (R,G,B) in the left image change by the ratio of the lights

$$R_2 = \frac{R_{L2}}{R_{L1}} * R_1 \qquad G_2 = \frac{G_{L2}}{G_{L1}} * G_1 \qquad B_2 = \frac{B_{L2}}{B_{L1}} * B_1$$

Diagonal Model for Color

- In matrix form $$\begin{pmatrix} R_2 \\ G_2 \\ B_2 \end{pmatrix} = \begin{vmatrix} \frac{R_{L2}}{R_{L1}} & & \\ & \frac{G_{L2}}{G_{L1}} & \\ & & \frac{B_{L2}}{B_{L1}} \end{vmatrix} \begin{pmatrix} R_1 \\ G_1 \\ B_1 \end{pmatrix}$$

- Note that this says $\frac{R_2}{R_{L2}} = \frac{R_1}{R_{L1}}$ (etc, for G, B)

Diagonal Model for Color

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- This would mean $\frac{\int E_2(\lambda)S(\lambda)R^{(k)}(\lambda)d\lambda}{\int E_2(\lambda)R^{(k)}(\lambda)d\lambda} = \frac{\int E_1(\lambda)S(\lambda)R^{(k)}(\lambda)d\lambda}{\int E_1(\lambda)R^{(k)}(\lambda)d\lambda}$!

- But this is not generally true!

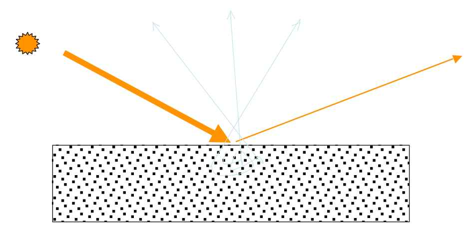
Diagonal Model for Color

In general, $$\frac{\int E_2(\lambda)S(\lambda)R^{(k)}(\lambda)d\lambda}{\int E_2(\lambda)R^{(k)}(\lambda)d\lambda} \neq \frac{\int E_1(\lambda)S(\lambda)R^{(k)}(\lambda)d\lambda}{\int E_1(\lambda)R^{(k)}(\lambda)d\lambda}$$

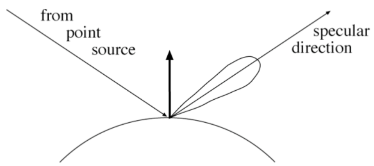
- But expression holds when
  - Surface reflectance is uniform
  - Sensors are delta functions
- Naïve approximation is relatively good when the camera sensors are “sharp” with minimal overlap.

Color and specularities

- Dielectric surfaces are well approximated by a specular part and a Lambertian body part.

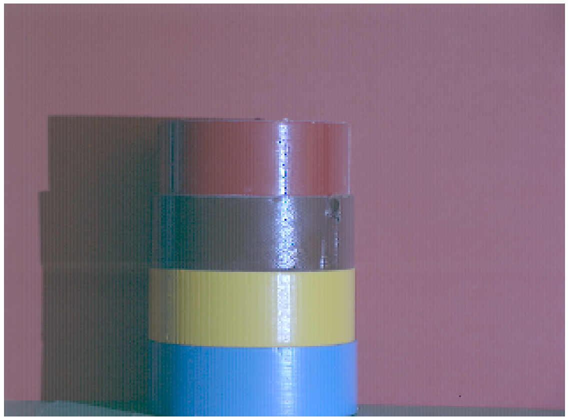


Specular surfaces

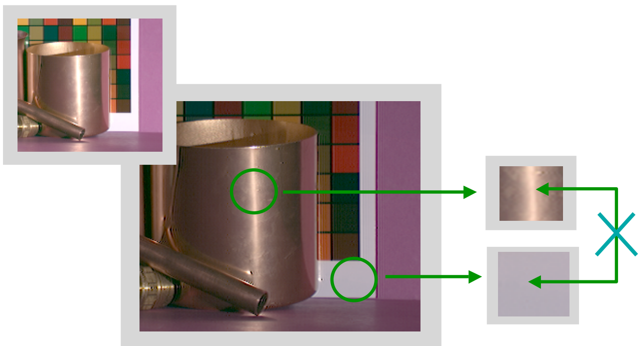


- Important point: The specular part of the reflected light usually carries the color of the **light**
- Technically, this is the case for dielectrics--plastics, paints, glass.
- Important exception is metals (e.g. gold, copper)

Dielectric Specularities



Metallic Specularities

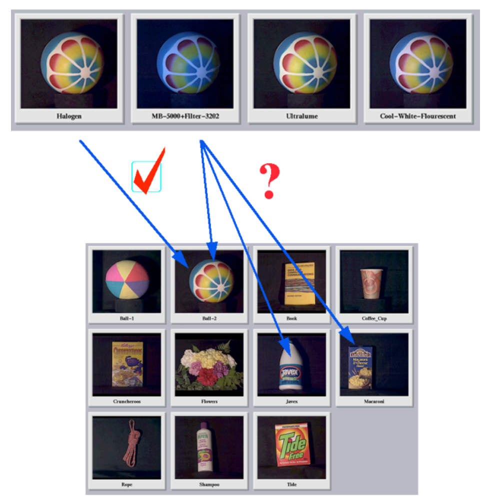


Color for recognition

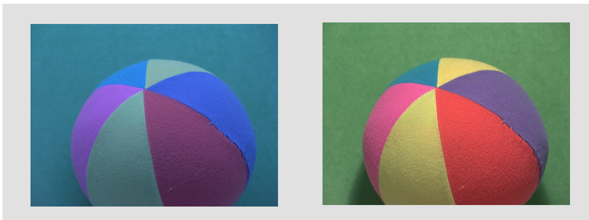
- It seems natural to use color (as opposed to grays in a B&W image) to recognize things--why?

Color for recognition

- It seems natural to use color (as opposed to grays in a B&W image) to recognize things--why?
  - Color has more information than grays
  - Grays in a B&W image are subject to shading
  - Light varies greatly in intensity--less so in chromaticity
  - Chromaticity is color without magnitude. For example
    - $r=R/(R+G+B)$ and $g=G/(R+G+B)$
  - BUT the ambiguity between what part of the signal is due to light and what part is due to the world **remains**.



The Computational Colour Constancy Problem



(Same scene, but different illuminant)

unknown light standard light

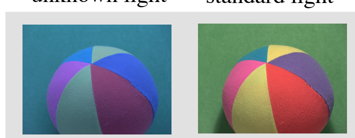
Color constancy

Color constancy algorithms strive to map image pixels to useful illuminant invariant values. One example is the image as if it was taken under the known standard light.

Often done by estimating the illuminant, followed by color correction (but there are other ways).

unknown light standard light

Color Correction



Suppose that the image on the right was how the scene on the left would look under a known, “standard” light.

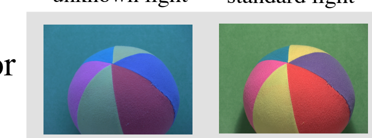
Under that light a uniform reflective surface (white) is $\left(R_W^S, G_W^S, B_W^S\right)$

So, to correct the image on the left, we can estimate the color of white, under the unknown light. Suppose it is: $\left(R_W^U, G_W^U, B_W^U\right)$

Then we can correct the image using the diagonal matrix from a few slides back.

unknown light standard light

Estimating the color of the light



The hard part is to estimate the color of the light (i.e., $\left(R_W^U, G_W^U, B_W^U\right)$)

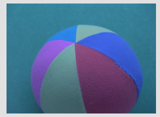
Many interesting algorithms have been developed. Two simple ones:

Max RGB: $R_W^U = \max_{pix}(R)$ (Similarly for G and B)

Gray world: $\left(\frac{1}{2}\right) R_W^U = \underset{pix}{ave}(R)$ (Similarly for G and B)

Estimating the color of the light

unknown light



standard light

The two simple methods mentioned previously focus on the global statistics of the image.

More formally, one can set up an inference problem focused on estimating the probability that the light is a certain color, **given** the image data.

Another approach is find specularities (recall why this works!).