CS 217 - Light & Geometry in Computer Vision (Prof. Deva Ramanan)

Lecture 14 - Friday ,May 1, 2009 (Scribe :Uddipan Mukherjee)

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1 Color

1.1 Radiance (L) $= \partial Q/\partial t cos\theta \partial A \partial \omega$

where ∂Q is the energy of photons

Each photon can be thought to be travelling with a particular wavelength λ,typically measured in nanometers (10^{-9}m)

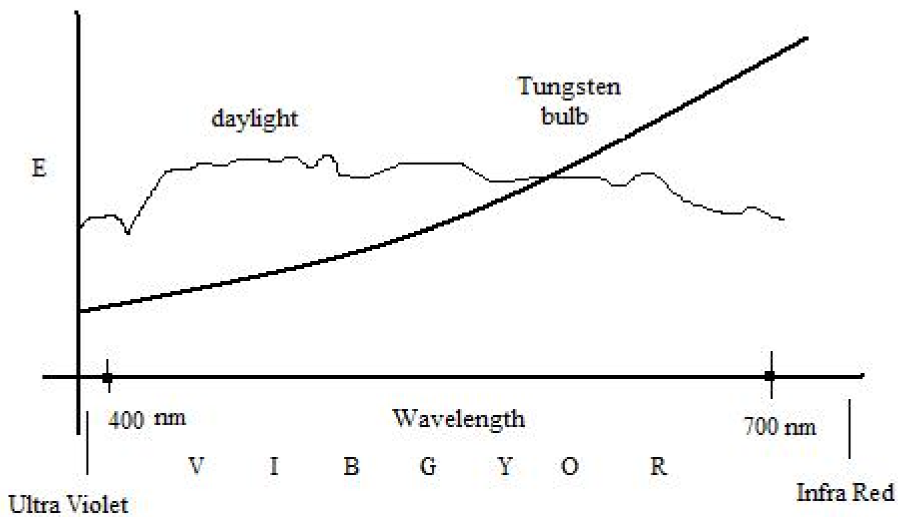
1.2 Spectral Radiance (E) $= \partial Q/\partial t cos\theta \partial A \partial \omega \partial \lambda$

therefore, Q = E$\Delta t\ cos\theta \Delta A \Delta \omega \Delta \lambda$

The spectral radiance E(x,θ, ϕ, λ)is usually written as L$^{\lambda}(x, \theta, \phi)$.It has units ,watts per cubic meter per sterdian.

1.3 Spectral BRDF (f) $= L_o^\lambda(x,\theta,\phi)/L_i^\lambda(x,\theta,\phi)cos\theta\partial A$

1.4 Physical Description of the color of Light



1.5 Light Source

e.g Black Body Object which absorbs all photons

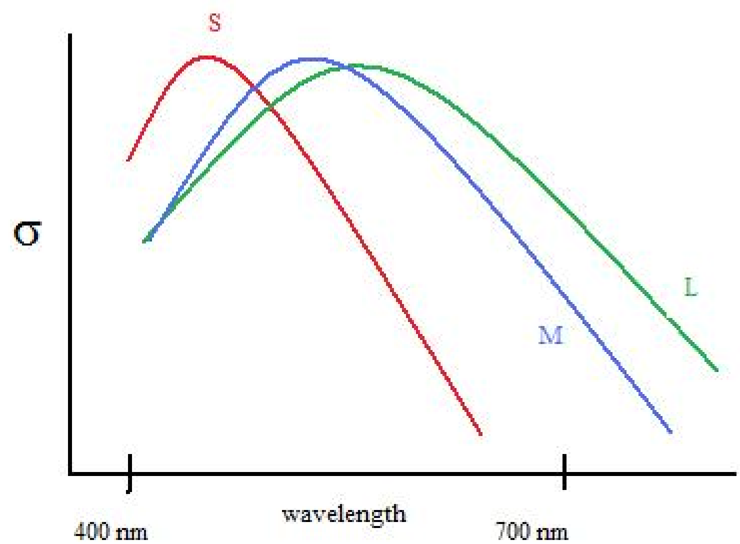
If T is the absolute temperature of the body , h is Planck's constant , k is Boltzmann's constant , c is the speed of Light and λ

is the wavelength , the spectral radiance of the Black body can be written as.

$E(\lambda) = 1/\lambda^5(exp(hc/k\lambda T) - 1)$.

2 Color Perception

Most Cameras (including human eye) has 3 color receptors. They are usually called the long (L) , medium (M) and the short (S) wavelength receptors The response of a receptor to incoming light can be obtained by summing the product of the sensitivity and the spectral radiance of the light over all wavelengths.



More formally , the response of the kthreceptor can be written as

$p_k = \int_\Lambda \sigma_k(\lambda)E(\lambda)\partial\lambda$,

where $\sigma_k(\lambda)$is the sensitivity , E(λ)is radiance arriving at the receptor and $\Lambda$is the range of the visible wavelengths

It is possible for $E_1(\lambda)$ and $E_2(\lambda)$ to generate the same responses $[p_s, p_L, p_M]$

e.g Metamers are the surfaces that appear to have the same color but different $E_1(\lambda)$and $E_2(\lambda)$

3 Measuring color

E(λ) is inconvenient in measuring color . We want a small set of numbers for color measurement.

3.1 Color Matching Experiment

In a typical experiment, a subject sees a colored test light in one half of a split field. The subject can then adjust the mixture of lights in the other half to get it to match. The adjustment involves changing the intensity of some fixed number of primaries in the mixture.

$T(\lambda)$= $w_1P_1(\lambda)$ + $w_2P_2(\lambda)$ + $w_3P_3(\lambda)$

where T is the test Light , w$_i$'s are the weights , P$'_i s$ are the primaries.

Grassman's Laws

The Matching coefficients behave linearly .If 2 test lights can be matched with the same set of weights then they

will match each other. i.e if

T_a=$w_1P_1 + w_2P_2 + w_3P_3$, and
$T_b = w_1P_1 + w_2P_2 + w_3P_3$
then $T_a = T_b$
also, $kT_a = kw_1P_1 + kw_2P_2 + kw_3P_3$

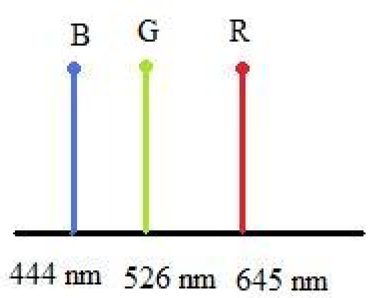
3.2 Color Subtracting Matching

Negative Coeffient csn appear when we do color matching
i.e w_1P_1+$T = w_2P_2 + w_3P_3$
$T = -w_1P_1 + w_2P_2 + w_3P_3$

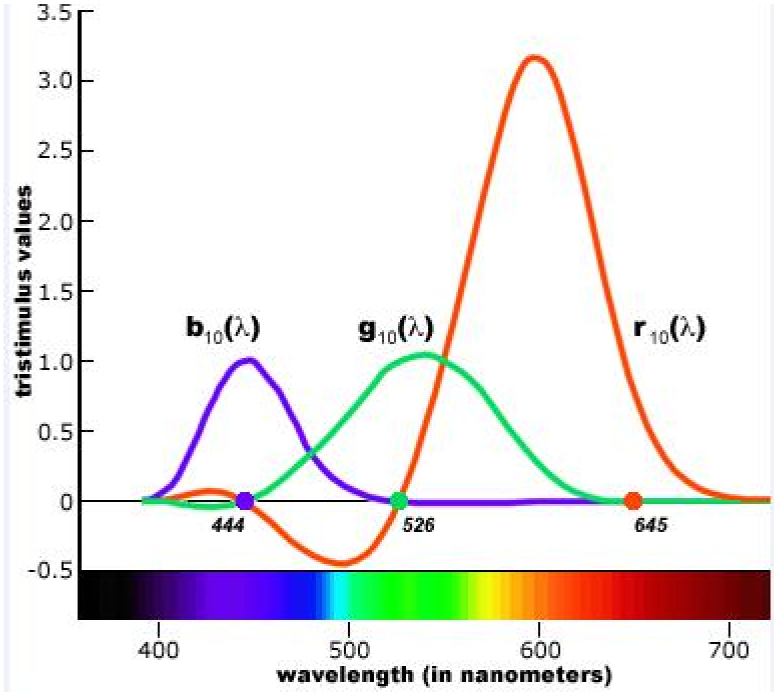
3.3 Color Matching Functions

Let Test Lights be single wavelength sources (lasers)
For each λ, record $[w_1w_2w_3]^T$
$U(\lambda)$=$f_1(\lambda)P_1$+$f_2(\lambda)P_2 + f_3(\lambda)P_3$
i.e at each wavelength λ , $f_1(\lambda)$ $f_2(\lambda)$ and $f_3(\lambda)$give the weigths required to match a unit radiance source at that wavelength
we can write any $T(\lambda)$as a combination of unit impulses, $U(\lambda)$, i.e
$T(\lambda) = [S_t f_1(t)T(t)\partial t]P_1 + [...f_2(t)...]P_2 + [...f_3(t)...]P_3$
These functions are called color Matching Functions

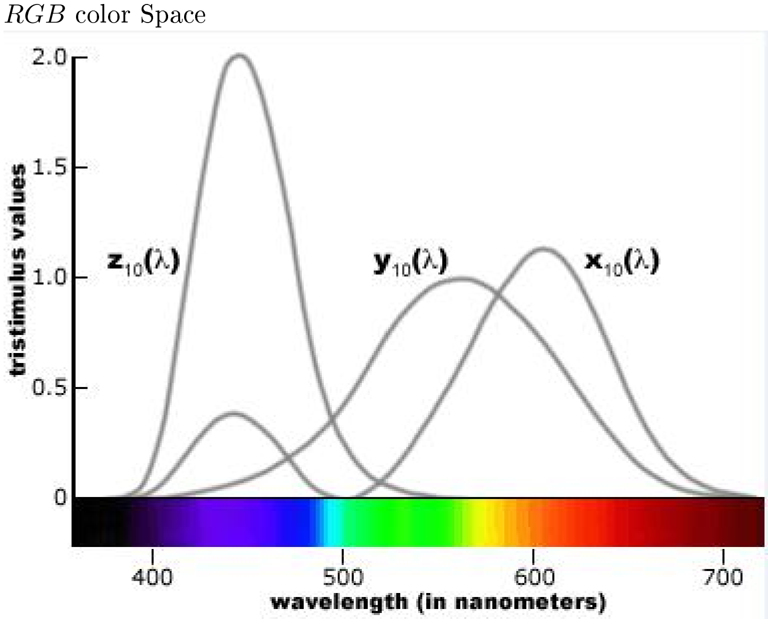
4 Color Spaces



Primaries $P_i(\lambda)$
Color Matching Function for the Primaries



RGB color Space



CIE XYZ Color Space