Photometric Image Manipulation

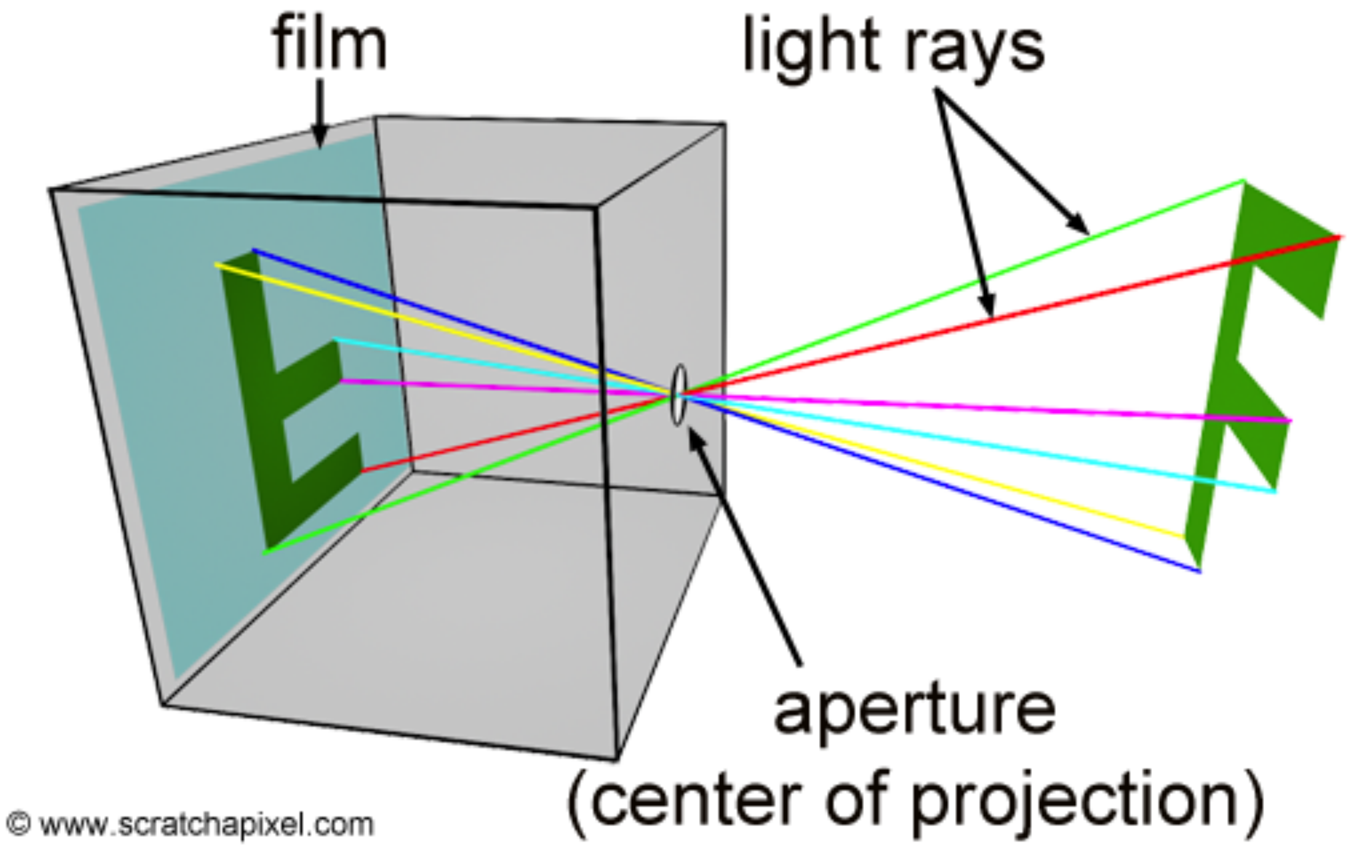
Lecture #2

January 30, 2013

Colorado State University

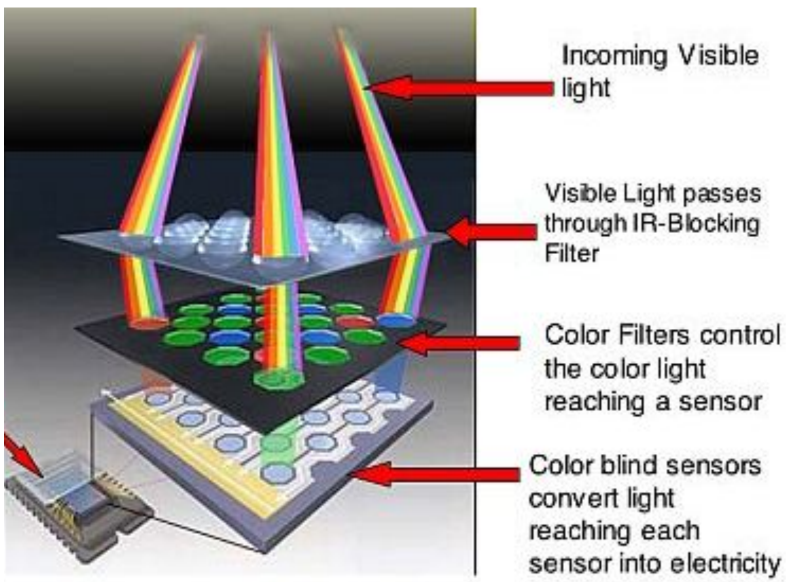
Pinhole Camera Model

Review from CS410

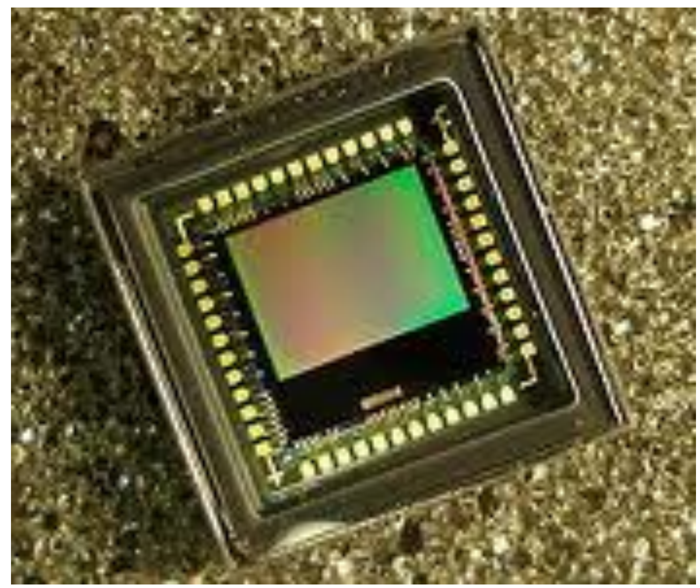


Photometric Values

- What determines the value of a pixel?
  - Energy, obviously. The more the higher.
  - But how much energy is 0?
  - How much more energy is 1? Or 255?



http://www.tikodata.com/uncategorized/cross-talk-in-small-pixel-image-sensors/

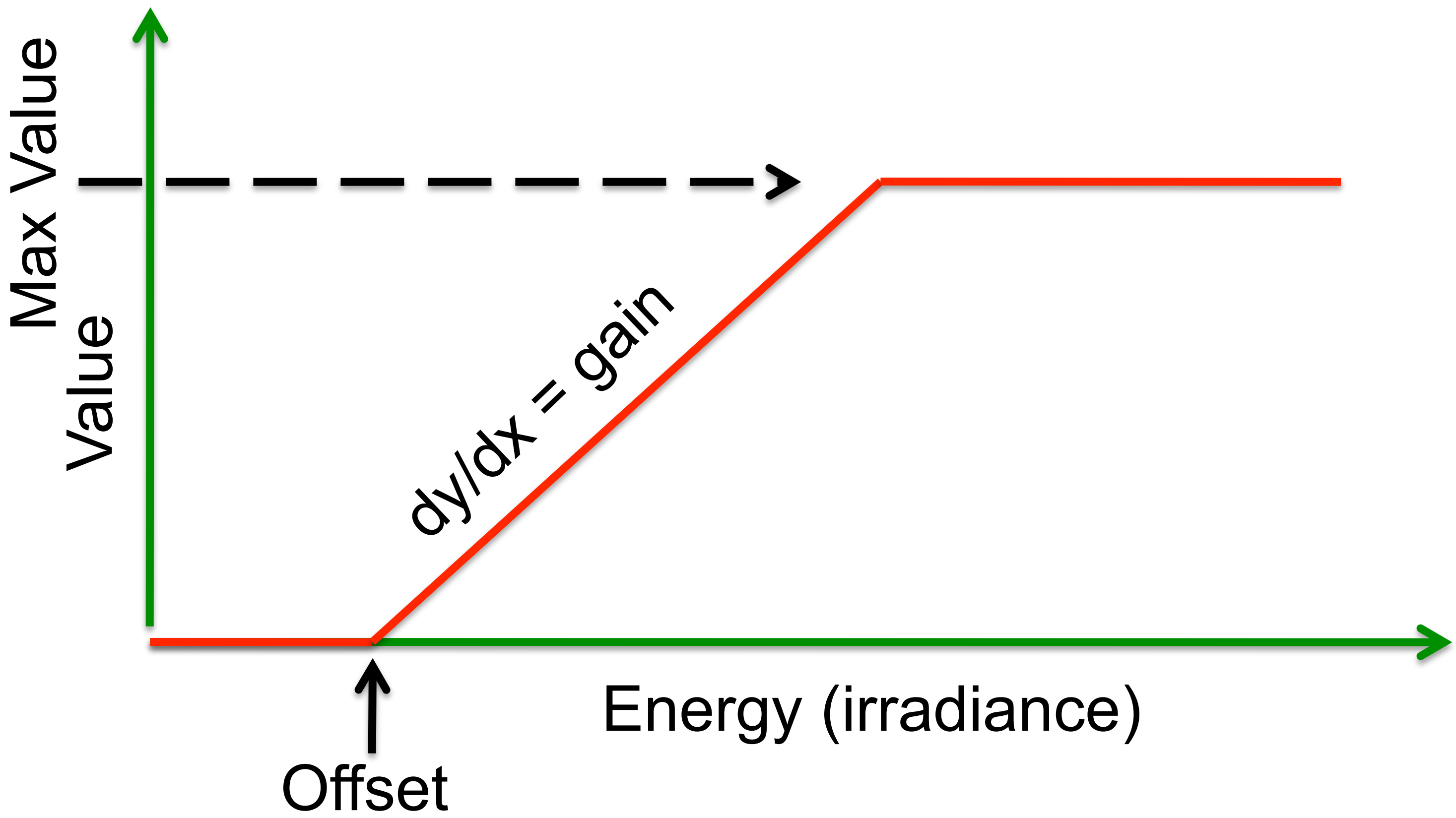


http://en.wikipedia.org/wiki/Active_pixel_sensor

Photometric Values (II)

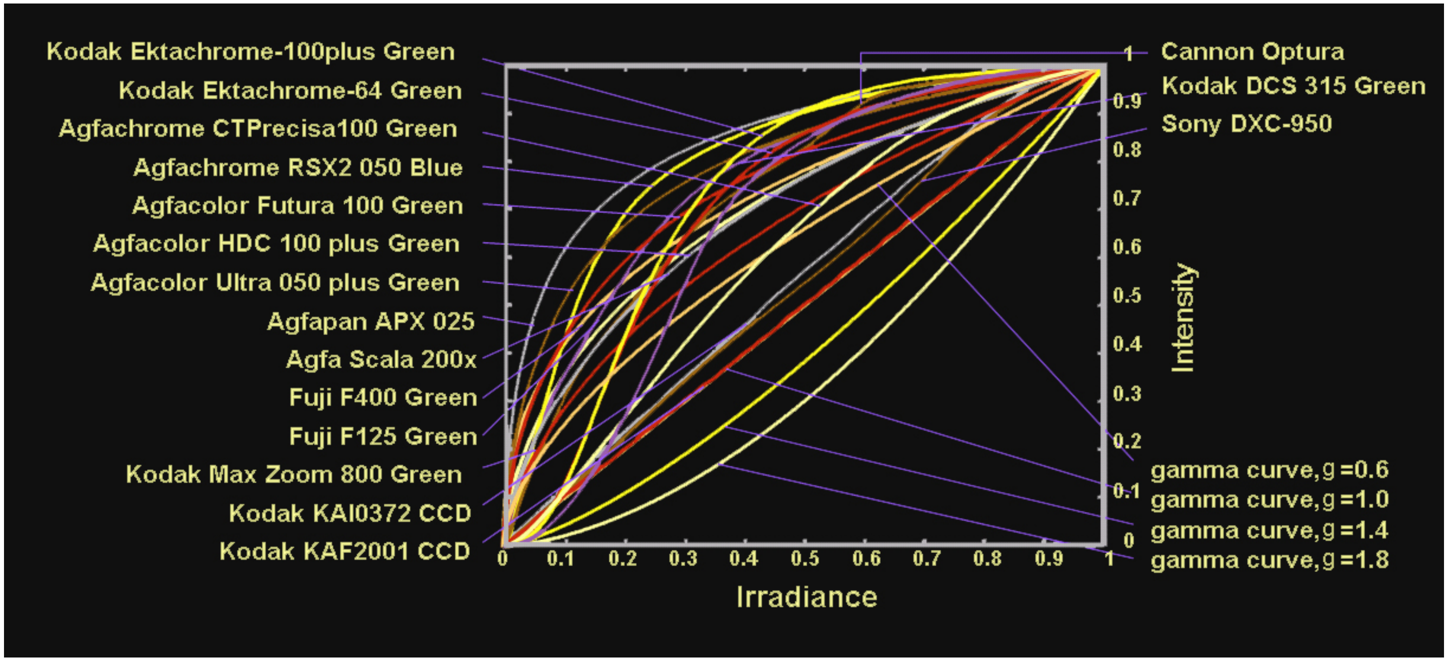
- Amount of light
- Two physical camera factors
  - Aperture
  - Shutter speed
- Three electronic camera factors
  - Offset ('0' level; a.k.a. brightness)
  - Gain (energy per increment; a.k.a. contrast)
  - Max Value (typically 255)

Model of Photometric Responses



Actual Photometric Responses

Responses for real cameras (from http://www.cs.columbia.edu/CAVE/projects/rad_cal/)



Range Equalization

- Linearly rescale every image to 0 – 255
  - Source_min is smallest observed value
  - Source_max is largest observed value
  - Max value is largest possible value (e.g. 255)
- Compensates for differences in gain only

$$value = \max\_value \cdot \frac{(source - source\_\min)}{(souce\_\max - source\_\min)}$$

Histogram Equalization

- The most common and effective photometric equalization technique
  - You will need this for the first homework
- Compensates (imperfectly) for differences in gain, offset and max value
- General idea: flatten the cumulative distribution
  - Bottom 10% of range should have 10% of pixels
  - Bottom 20% of range should have 20% of pixels
  - Etc.

http://gavtrain.blogspot.com/2010/06/quick-guide-to-reading-histogram.html

Histogram Equalization : Step 1

- Histogram the intensity values of the image
  - If source image is color, I = (R+G)/2

Histogram Equalization : Step 2

- Convert histogram into a cumulative density function (cdf)

$$cdf(I) = \frac{1}{N}\sum_{i=0}^{i=\max\_value} H(i) = cdf(i-1) + \frac{1}{N}h(i)$$

Standard Definition — Incremental Definition

Histogram Equalization : Step 3

- Reassign values based on cdf

$$I(x,y) = \max\_value \cdot cdf\left(I'(x,y)\right)$$

(In the equation above, I' is the image prior to histogram equalization, and I is the image post equalization)

Histogram Equalization Discussion

- How well does histogram equalization compensate for differences in offset?
- How well does it compensate for differences in gain?
- How about differences in max value?
- How about non-linear responses?
  - Think about the data from Columbia earlier…