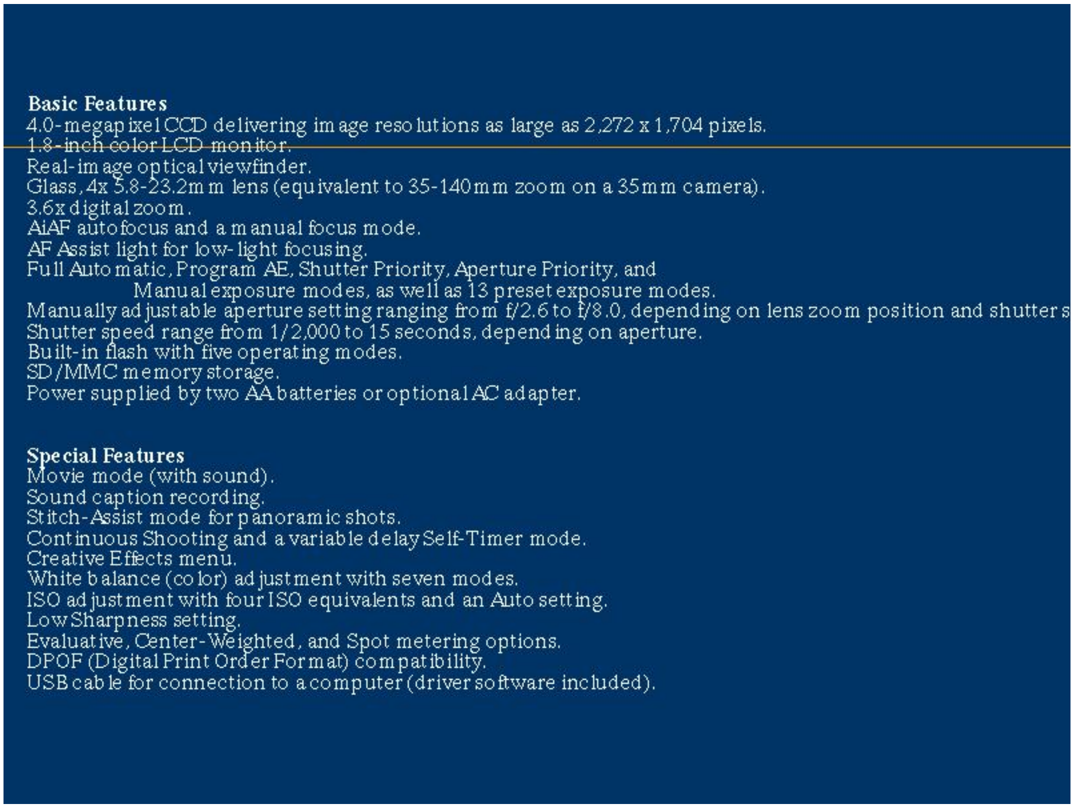
Dynamic Range and color.

There is a Canon powerShot on reserve. To automate complicated multiple exposures with different settings, you should download the SDK from "powershot.com". The SDK allows you fine grained control over cameras.

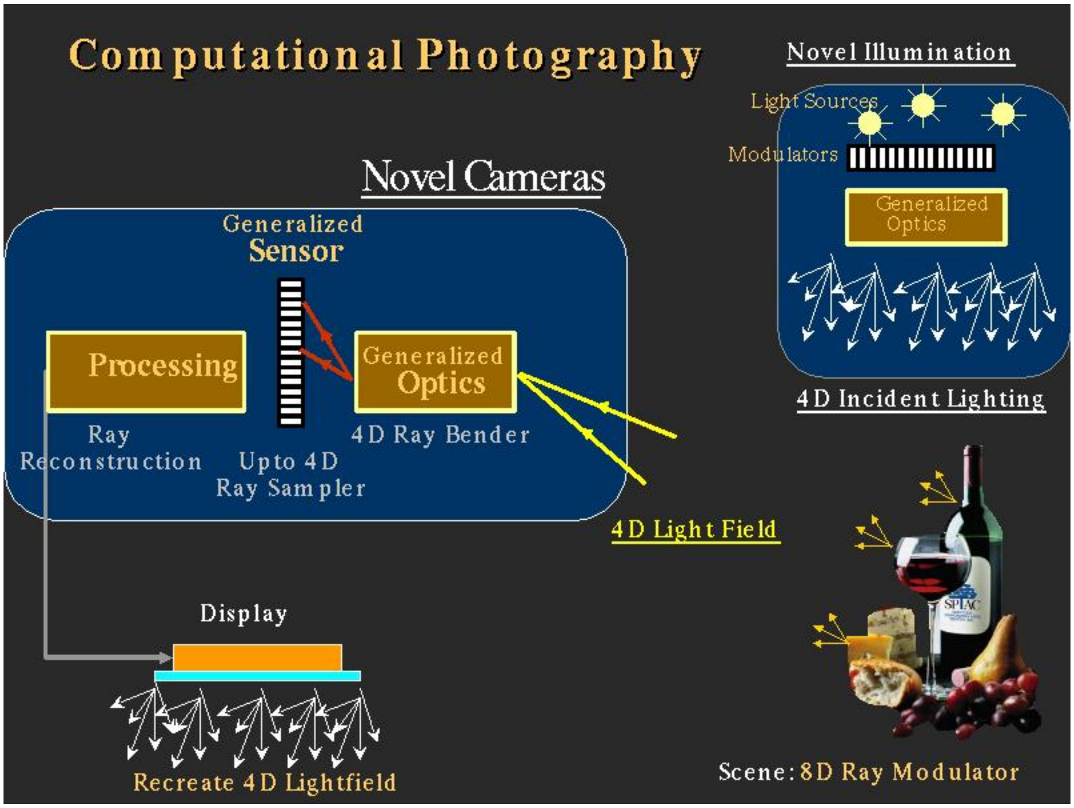


Digital cameras have all sorts of 'features' that can be compared. Point-and-Shoots have both Digital and Optical zoom. On-camera digital zoom can do more work since it has more information to deal with. Perhaps not with RAW. Focus zones and shutter speed are important to know. CCD sensitivity is important because long shutter speeds leads to noise. For short shutter speed, noise will accumulate because you need to use gain.

As an aside, video cameras are much brighter because individual pixels in video cameras are much much bigger.

AF assist light is used in dark areas to help camera focus. Using a diffraction grid af can do a much better job with focus. This would send out a grid patter that is in focus at points - the AF system would only have to focus on the grid, not on the subject.

Digital cameras also incorporate semi-intelligent flashes. The flash's intesity is based on the subject's intensity and brightness.

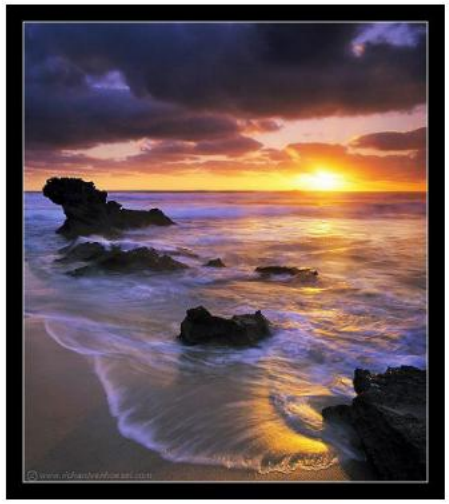


In traditional Photography there is an optical lens - a ray comes through lens, falls on a pixel.

Computational photography, from last lecture, includes mart illumination generalized optics sensors and processing.

By 4d ray sensors and benders we mean: Two parameters to capture source location, and two parameters to capture direction. Generalized lighting - multiple flashes, can control all parameters. The goal is to capture the 8d modulator - the object.

Capturing Light… in man and machine



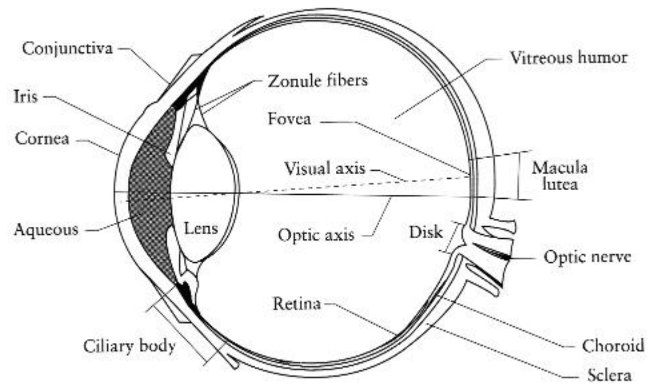
Some figures from Steve Seitz, Steve Palmer, Paul Debevec, and Gonzalez et al.

15-463: Computational Photography
Alexei Efros, CMU, Fall 2005

Image Formation happens is done by Descretization. The scene is is continuous, but the image plane is desretized. Cameras are inspired by human eye. The two prevalent type of sensors are CCD and CMOS. Go to howstuffworks.com for more detail.

CMOS behaves like a photo-diode - collects photon. CCD behaves differently. CMOS is very noisy, but very cheap, and has been catching up. Advantage of cmos is that you can have more transistors. Current large-format cameras use CMOS because it is easier to build to large scale.

The Eye

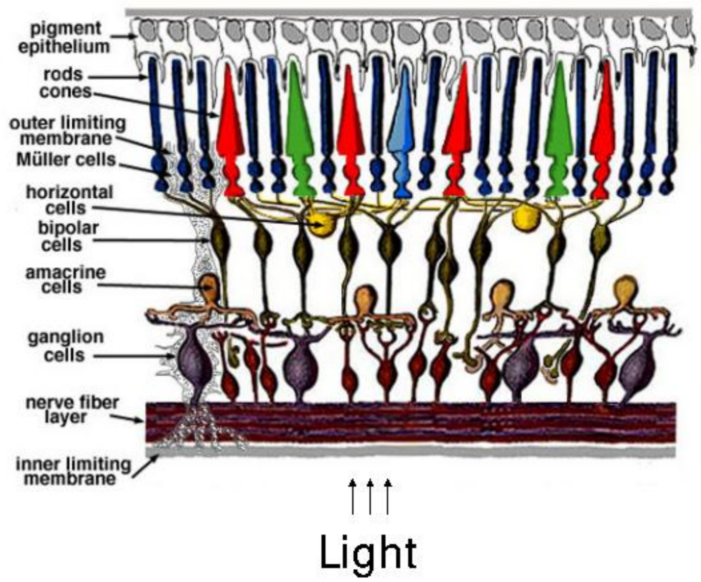


The human eye is a camera!

- **Iris** - colored annulus with radial muscles
- **Pupil** - the hole (aperture) whose size is controlled by the iris
- What's the "film"?
  - photoreceptor cells (rods and cones) in the **retina**

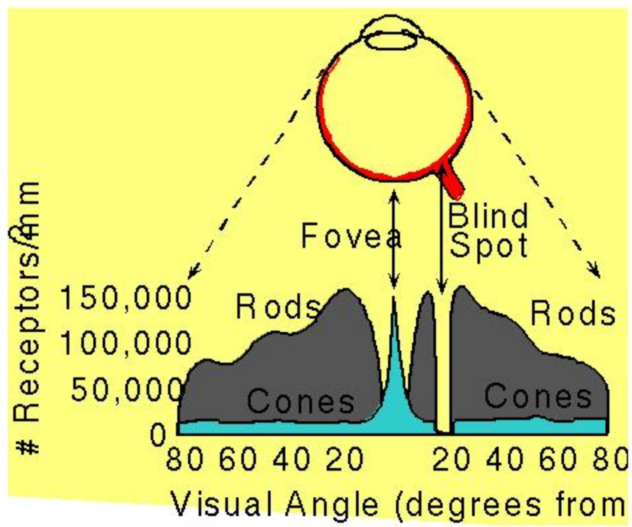
In the human Human eye, the iris supports front part of the eye. The Pupil is aperture. Retina is imaging part. The brain sees a continuous stream of images. human eyes don't disrete-ize (or it is much more fine-grained).

Retina up-close



This is the Retina up close. It is made of rods and cones. Cones are stimulated by red/green blue. The retina is designed poorly - the light goes through all the wiring.

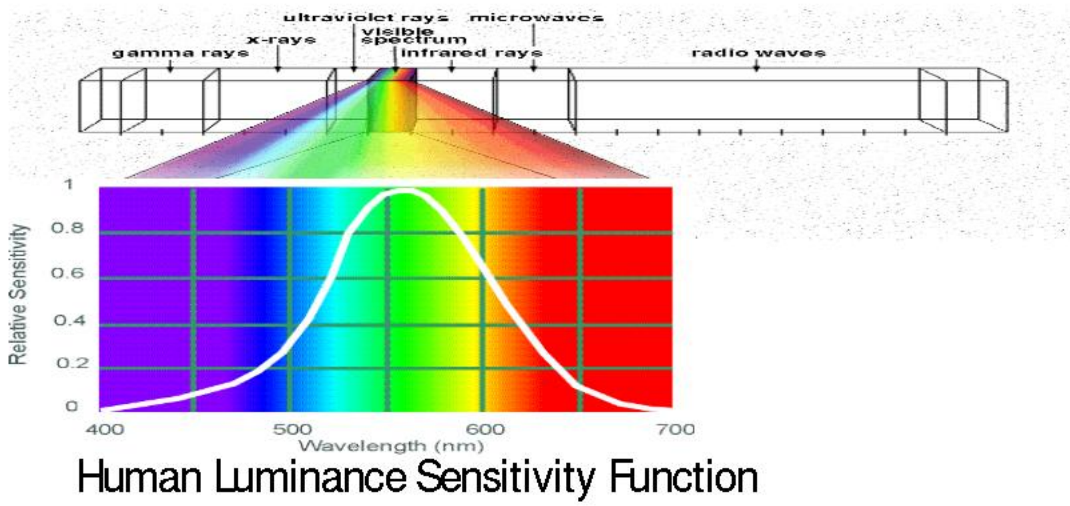
Distribution of Rods and Cones



Night Sky: why are there more stars off-center?

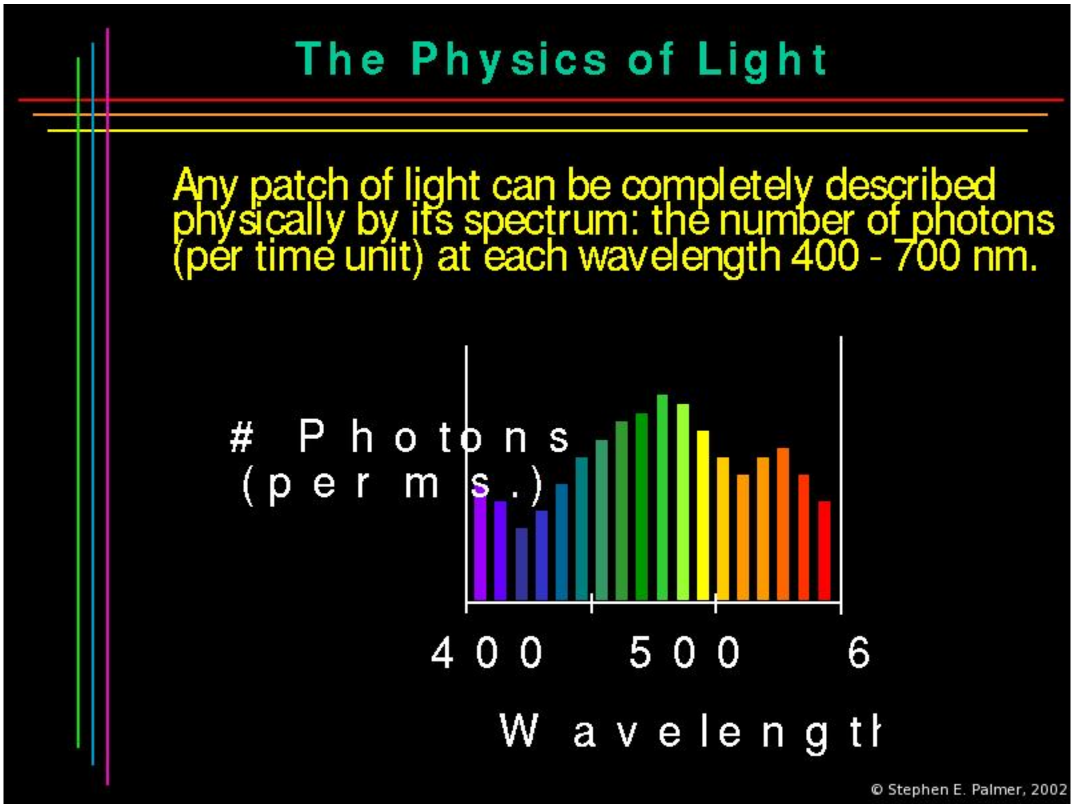
At night, we don't process colors. We have more sensing of color at center, and dark at periphery. If trying to look at something at night, it is better to look away from where the object actually is.

Electromagnetic Spectrum



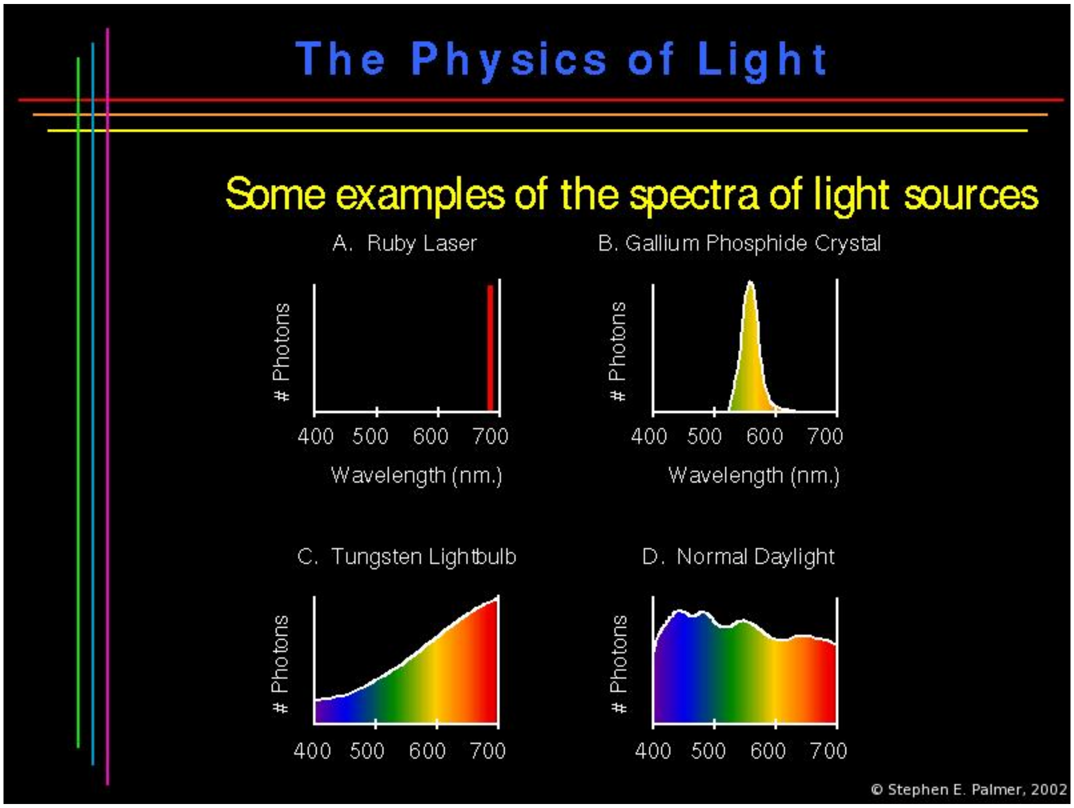
http://www.yorku.ca/eye/photopi

Light is electromagnetic radiation. The human eye captures a very small spectrum. 400-700nm. Sensitivity peaks in green 560nm



Ultraviolet light is easily convertible to visible spectrum, while infra-red is very difficult to convert. For example, shirts can be washed with detergents that cause them glow whiter in UV lights in disco clubs.

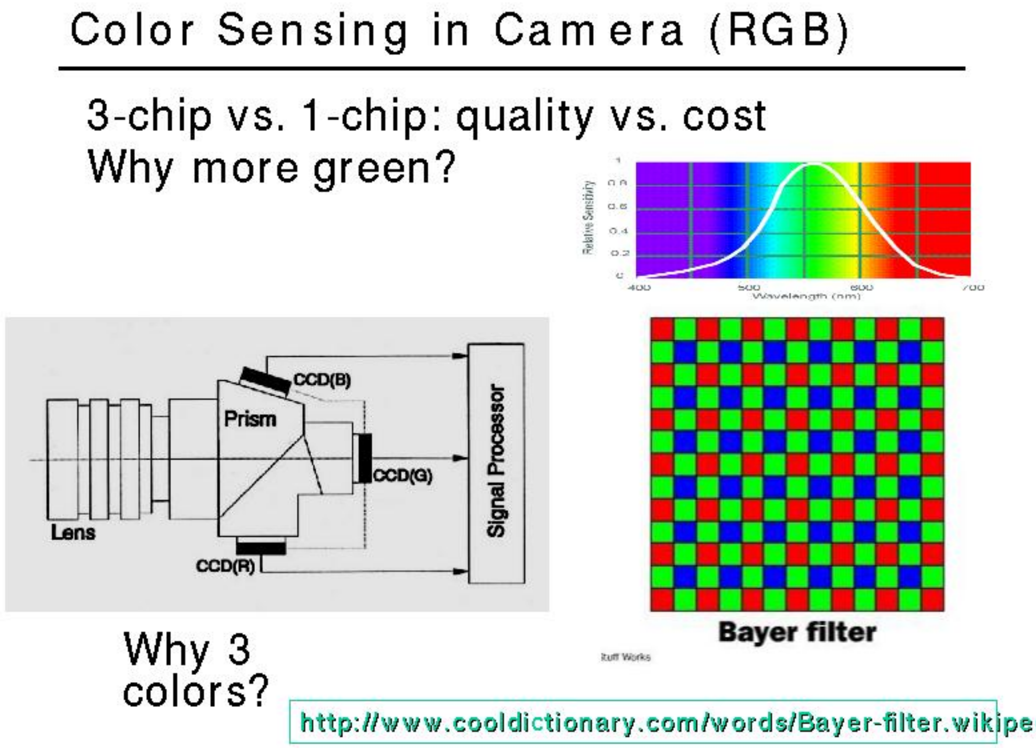
On the other hand, some substances don't absorb IR radiation at all - coke is one of them. One could use IR to look through bottles for the hidden message on coke bottle caps.



The sun emits a wide range of em radiation. Human made-sources produce varying wavelengths. Coherent light sources such as lasers produce a single wavelength.

Ir devices, wavelength is out of visible spectrum. The sun produces very low amounts of ir, and so devices use it.

CCD's and CMOS are sensitive to IR, so digital cameras block infra-red ration, which makes skin look older.



If you want color, you must trade off some parameters. There is more green because humans are more sensitive to green. It is a software problem to reconstruct the image.

Current cameras use Bayer interpolation. Green rendition is good, since half of the pixels are green, but blue and red rendition is pretty bad.

3 ccd cameras solve this problem but are more sophisticated and more expensive. A cute idea would be to use a single-ccd camera and shift the ccd.

Image Formation

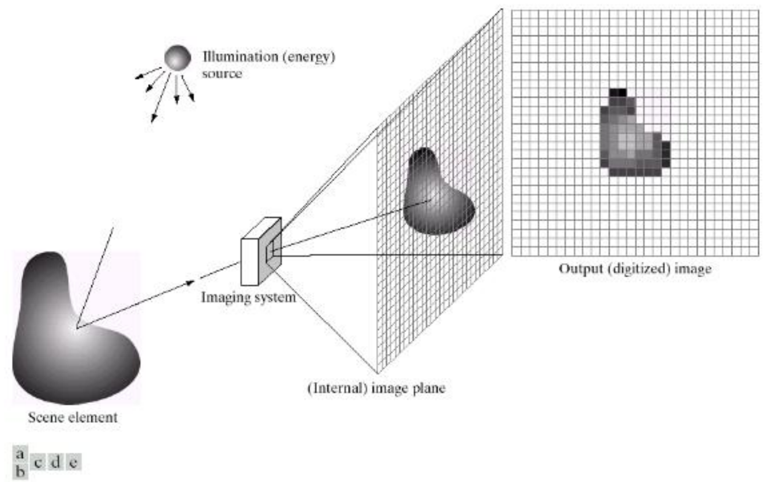
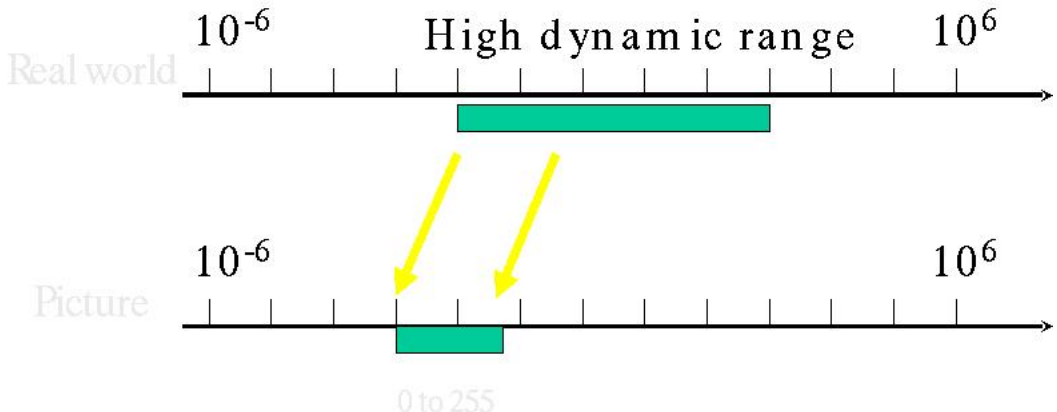


FIGURE 2.15 An example of the digital image acquisition process. (a) Energy ("illumination") source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.

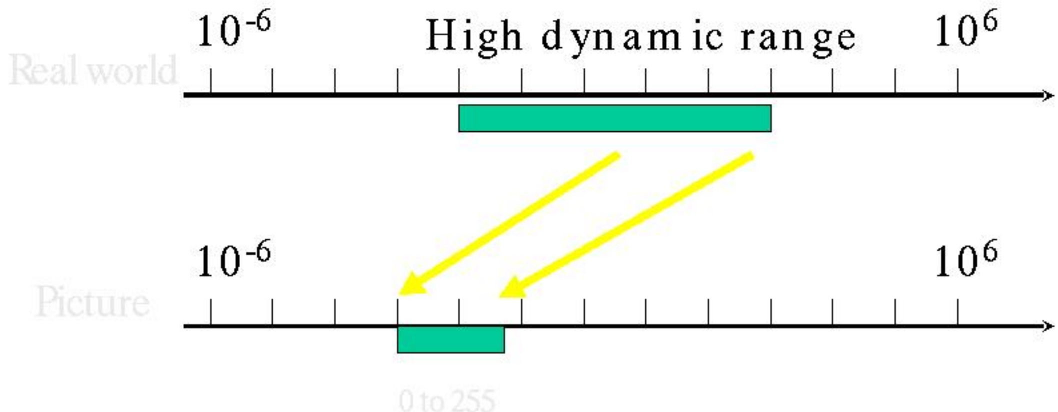
*f(x,y) = reflectance(x,y) * illumination(x,y)*
Reflectance in [0,1], illumination in [0,inf]

A common mistake is to think that reflectance varies a lot. In fact, it is illumination that can have many degrees of magnitude. We are more interested in capturing reflectance vs. illumination. Humans mostly ignore illumination, and focus on reflectance.

Long Exposure



Short Exposure



Scenes often have high dynamic range. Camera has small dynamic range. With long exposure can capture lower range. If short exposure, can capture light range. We then want to blend the two images.

Whe we look at HDR scenes with our eyes, we are rarely blinded by brightness or unable to see because of the dark. This is because the human eye locally adapts to whatever part of the scene it is looking at. This is also why almost everything appears in focus when we look at it.

Varying Exposure

One way to deal with this is to take several exposures and intelligently combine them. This is hard in reality for many real–life applications. Cameras shake, scenes move. However, we can still produce interesting results given the right conditions.

Eye is not a photometer!

"Every light is a shade, compared to the higher lights, till you come to the sun; and every shade is a light, compared to the deeper shades, till you come to the night."

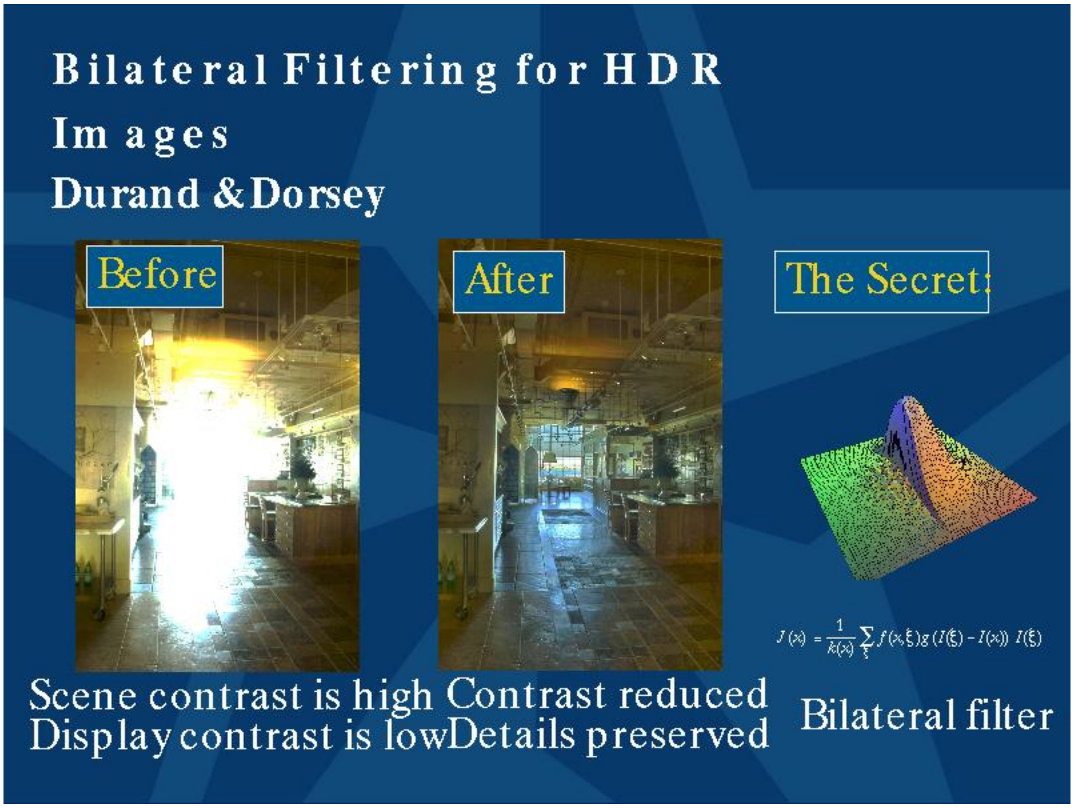
— John Ruskin, 1879

Cornsweet Illusion

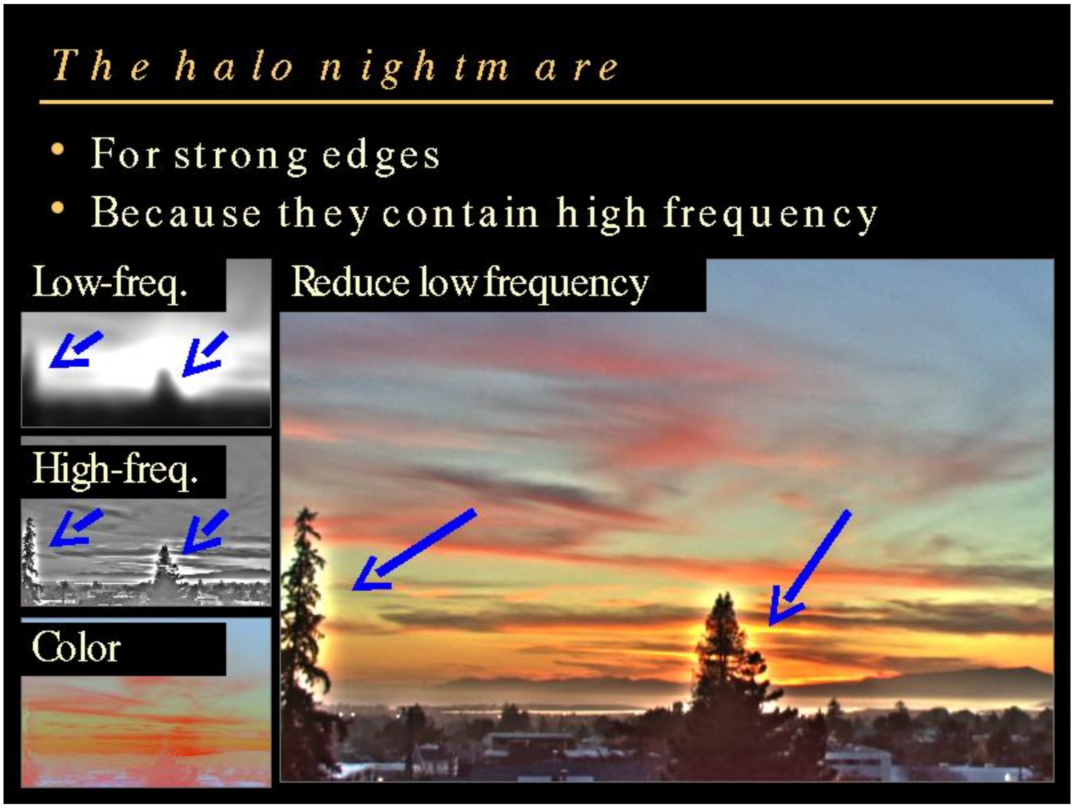
The eye is not a photometer. We should try to design cameras that sence relative light. Value we see for a for gray patch is dependent on light around it.

If next to light, it will look dimmer. Make dimmer to make the rest seem darker. The center patch patch is uniform color.

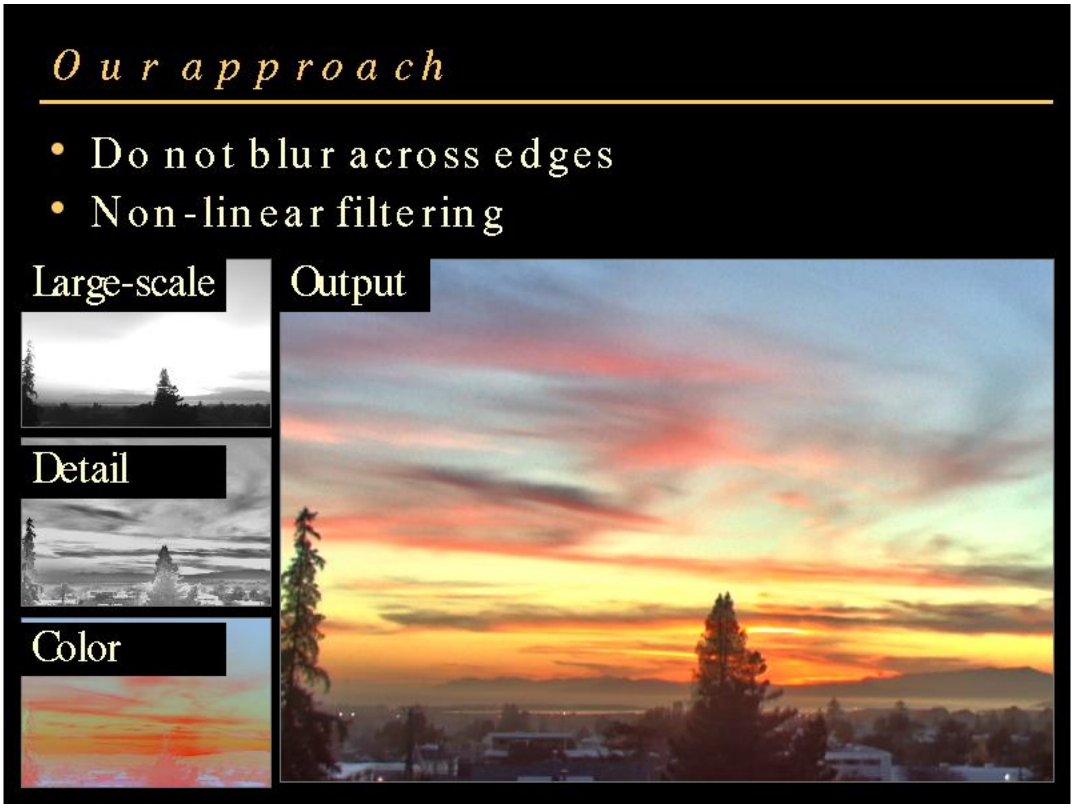
Differene of intensity creates illusion of mottion.



Assuming we can capture an HDR image we would like to convert it images to low dynamic range. We need to do this because current display devices have very low dynamic range.



Apply signification gassian filter. Then divide. Reduce brightness, multiply into high frequenccy. While mostly good, you loose detail in halos.



We need to preserve edge detail. Use an edge preserving moothing filter. Blur image, but not across eldge. Images no longer have halos. Redue the range of large scale, creating a very nice image.