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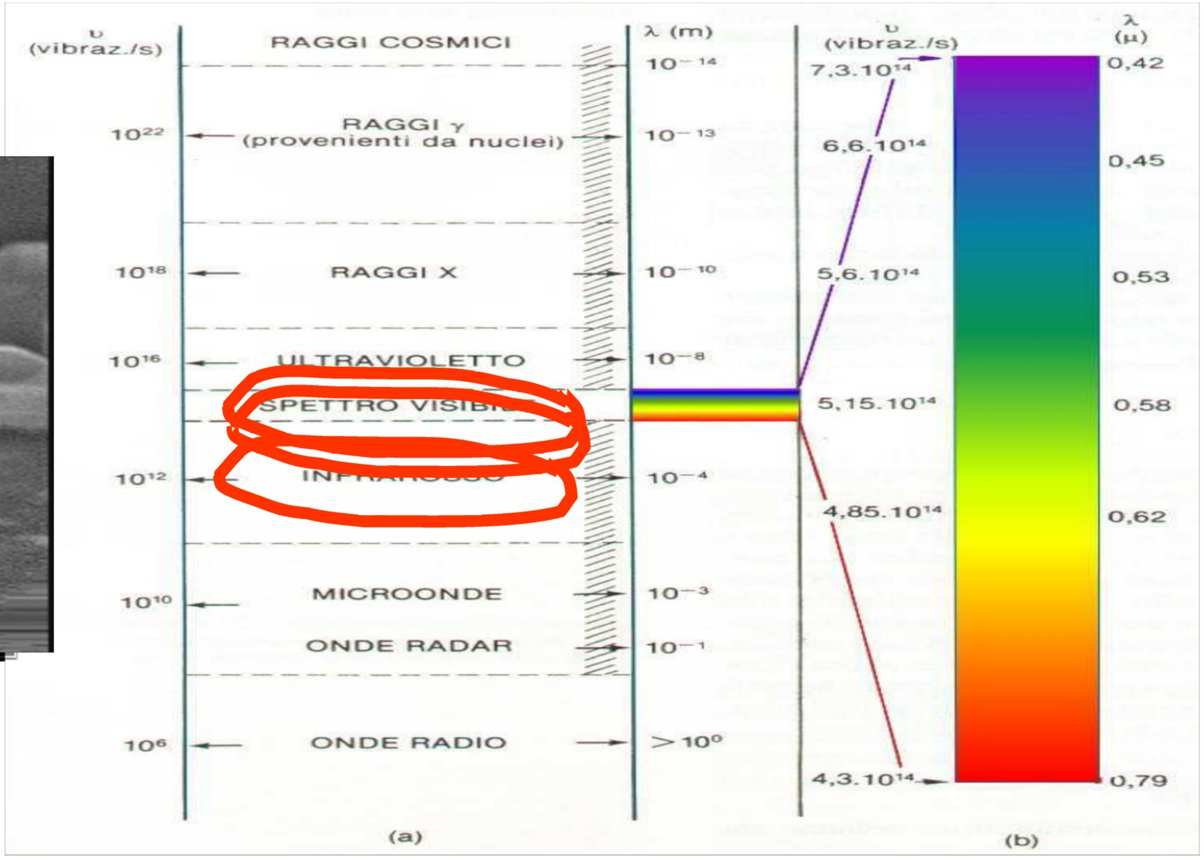
Video & Acquisition Systems

Content

- Light
- Acquisition pipeline
- CCD vs CMOS
- Color extraction techniques

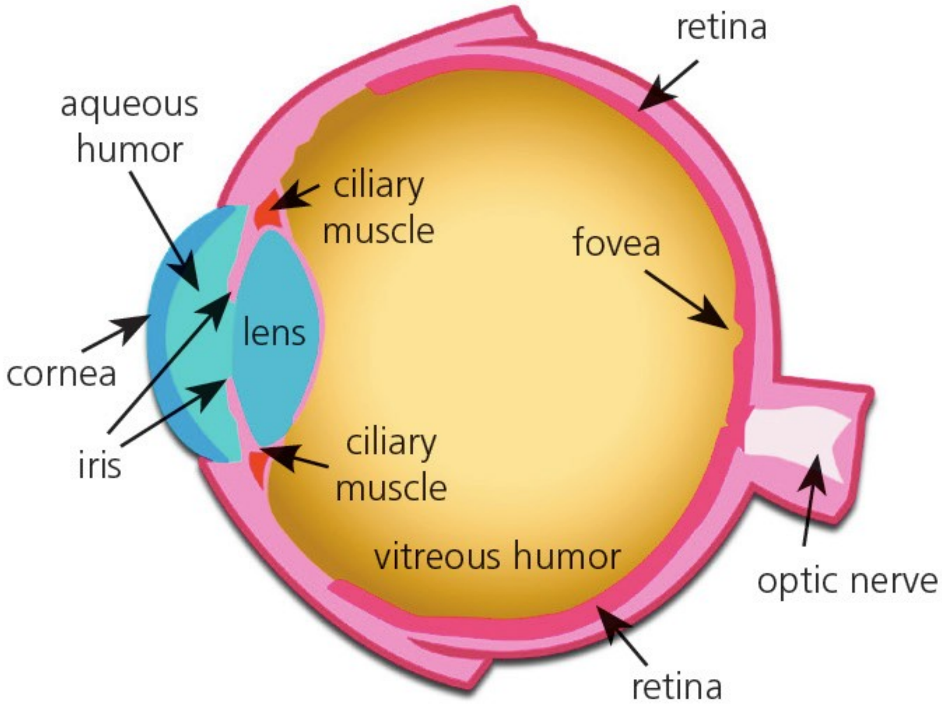
Light Spectrum

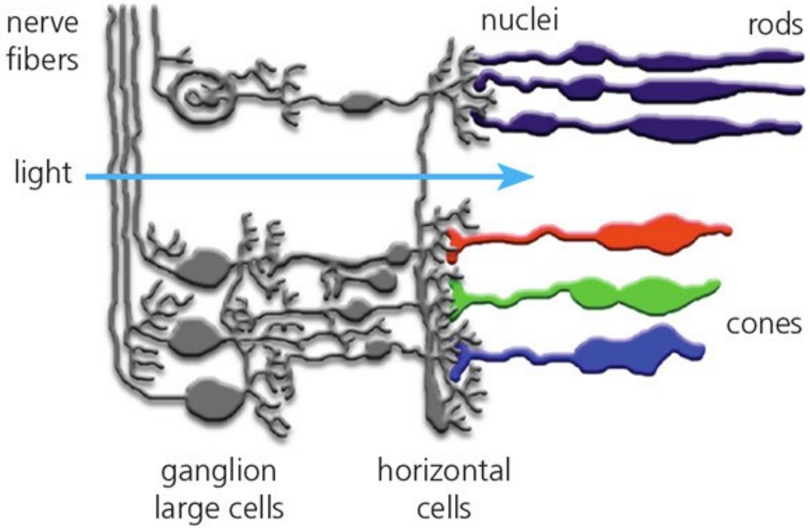


How do we sense light?

How do we sense light?

Human Vision





Human Vision

- “Two” sensors
- Rods (~100M)
  - More sensitive
  - Mostly distributed on peripheral part of retina
- Cones (~4-7M)
  - “Band pass filters”
  - Different types (typically 3)
  - Mostly around fovea

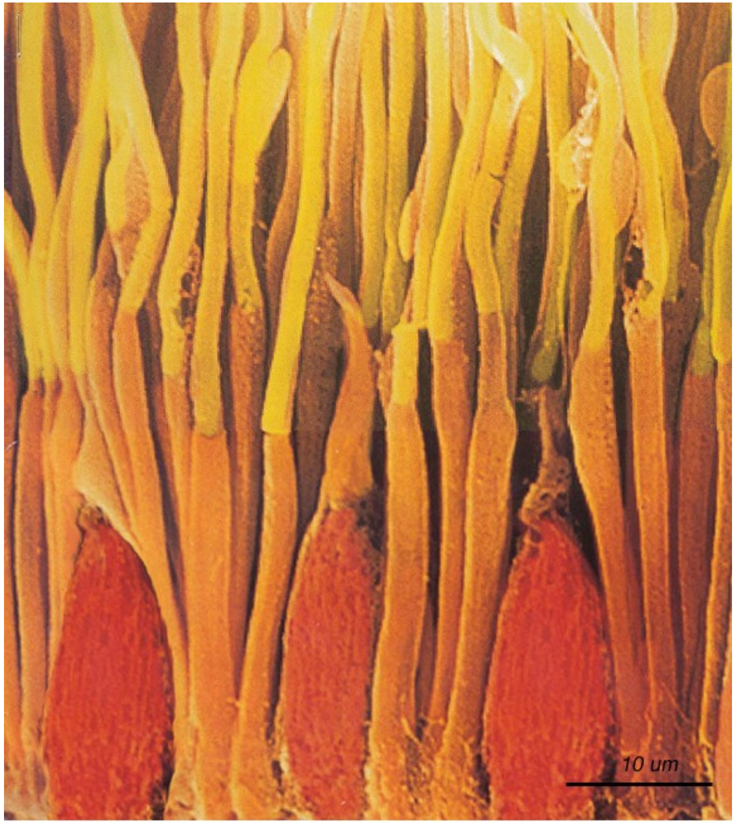


Fig1b. Scanning electron micrograph of the rods and cones of the primate retina. Image adapted from one by Ralph C. Eagle/Photo Researchers, Inc.

Human Vision

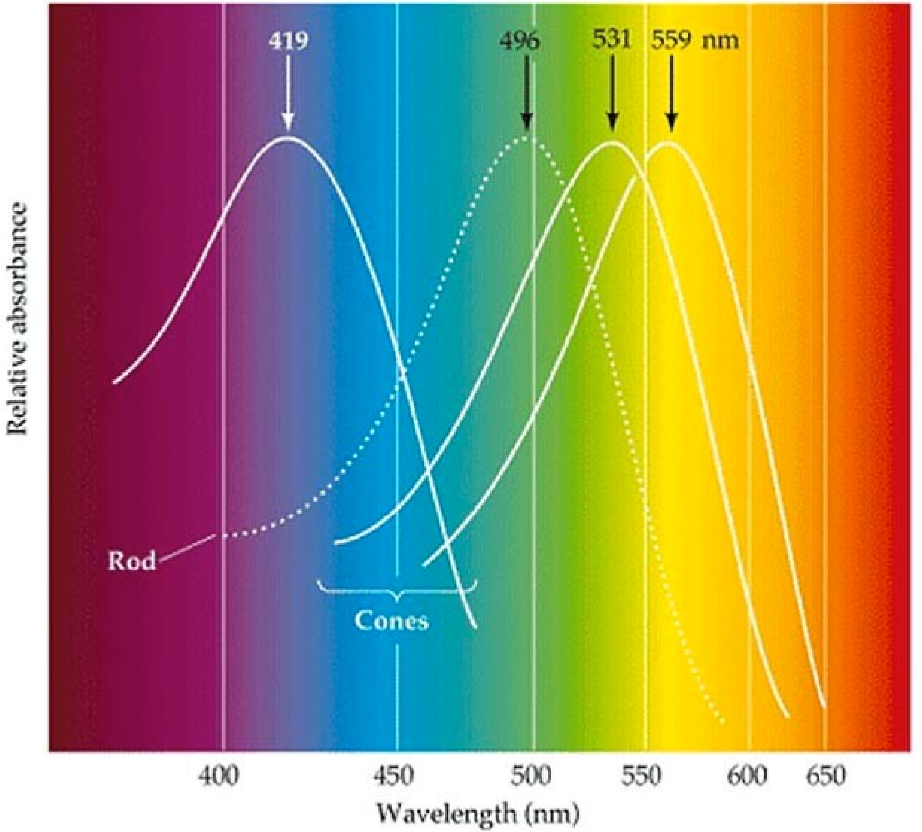
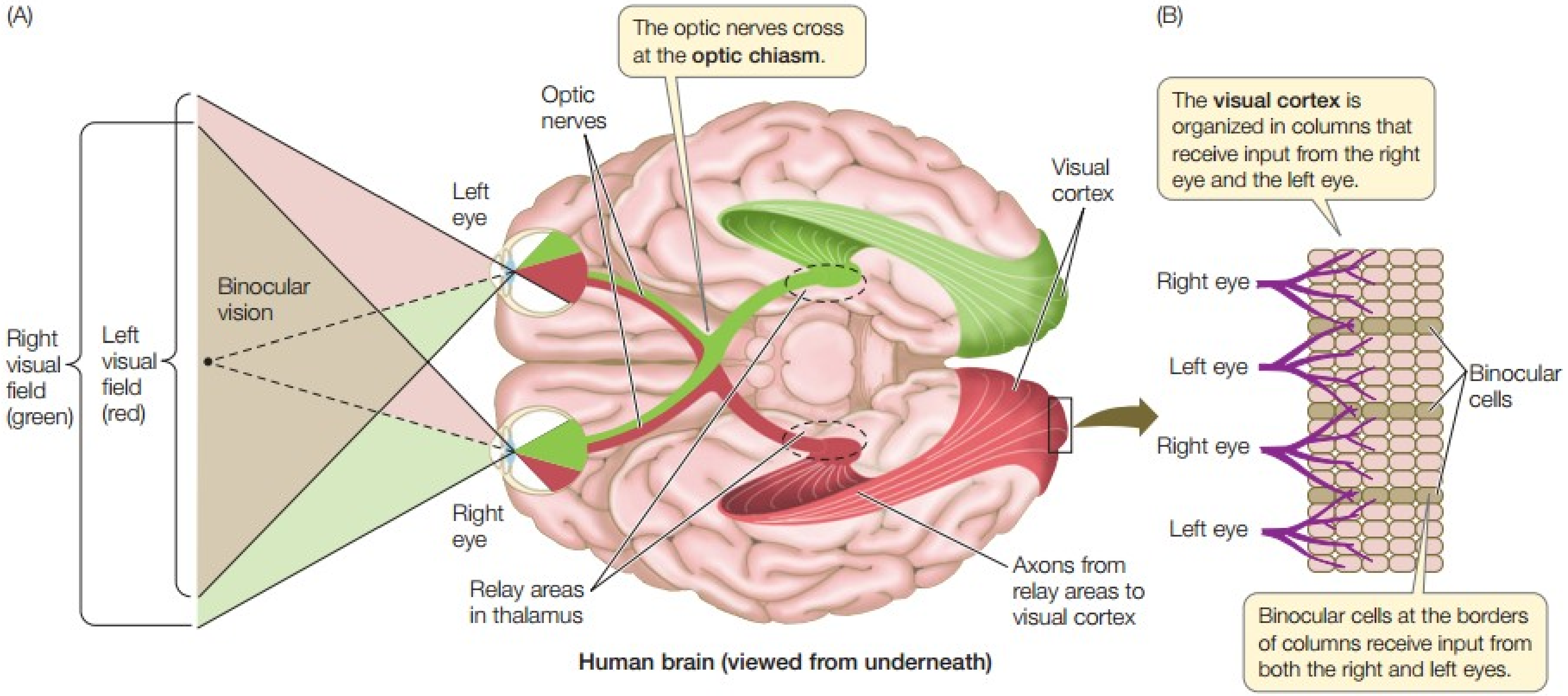


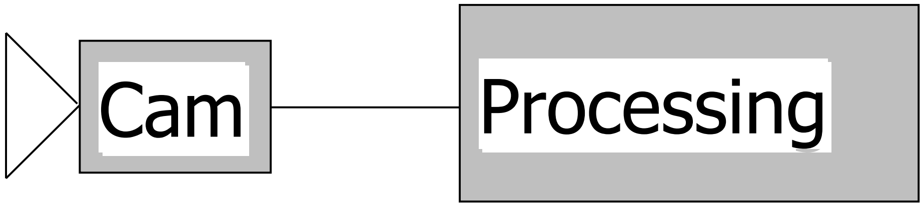
Figure 14a. The peak wavelength absorbance of the rods (dotted line 496 nm) and blue (419 nm), green (531 nm) and red (559 nm) cones in the human retina.

Human Vision

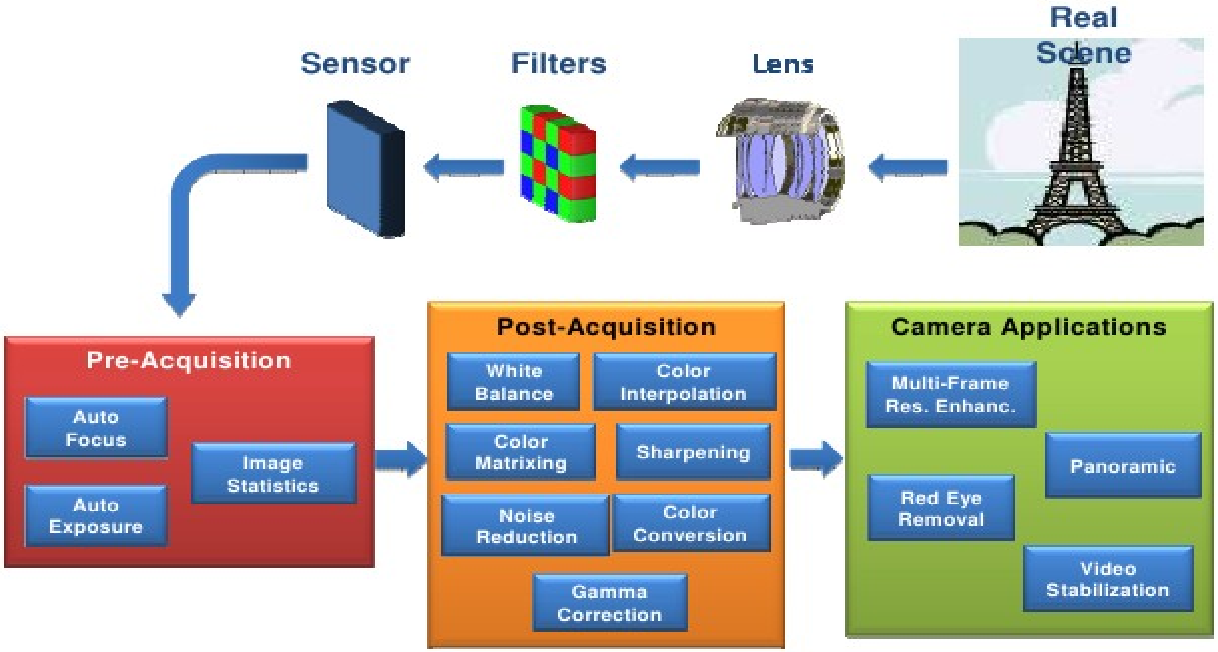


Acquisition System

- We need
  - Sensor
  - Transmission
  - Processing
- But this is unfortunately too optimistic!

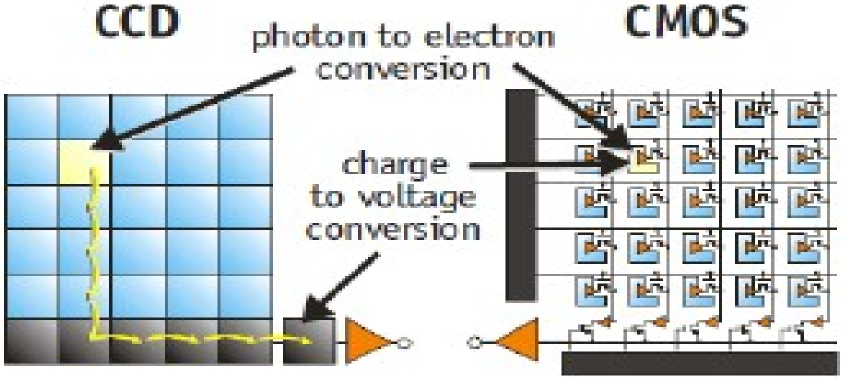


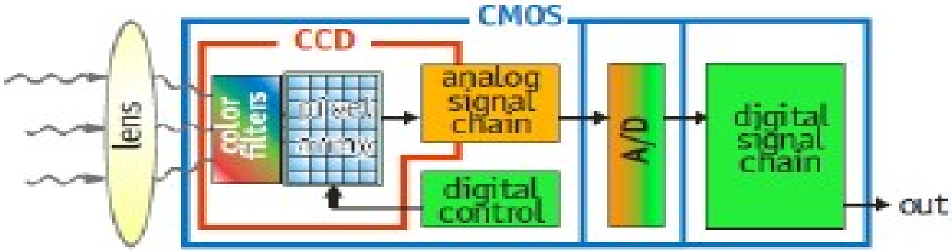
Actual Acquisition Pipeline



http://www.dmi.unict.it/~battiato/CVision1011/CVision1011.htm

CCD vs CMOS





- Charge-Coupled Device:
  - Charge is actually transported across the chip and read at one corner of the array and converted (**analog sensor**!)
  - Usage of a special manufacturing process to create the ability to transport charge across the chip without distortion.
  - Higher Fill Factor

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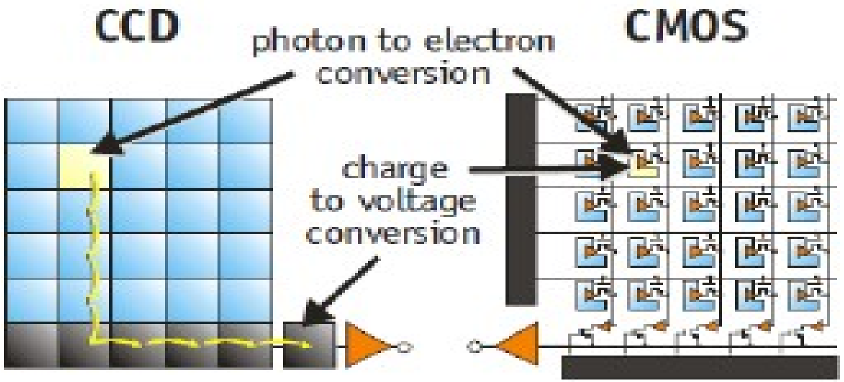
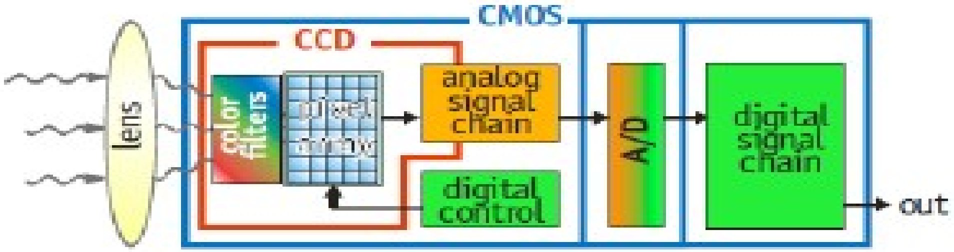
CCD vs CMOS





- Complimentary Metal-Oxide Semiconductor:
  - Several transistors at each pixel amplify and move the charge using more traditional wires
  - It is more flexible because each pixel can be read individually
  - Usage of the same traditional manufacturing processes to make most microprocessors.
  - Easy integration
  - Lower Fill Factor

CMOS microlenses

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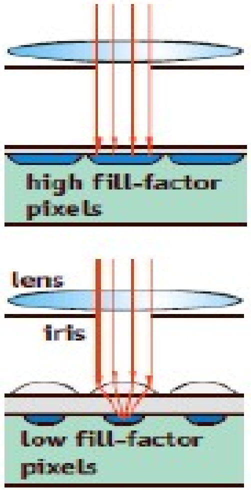
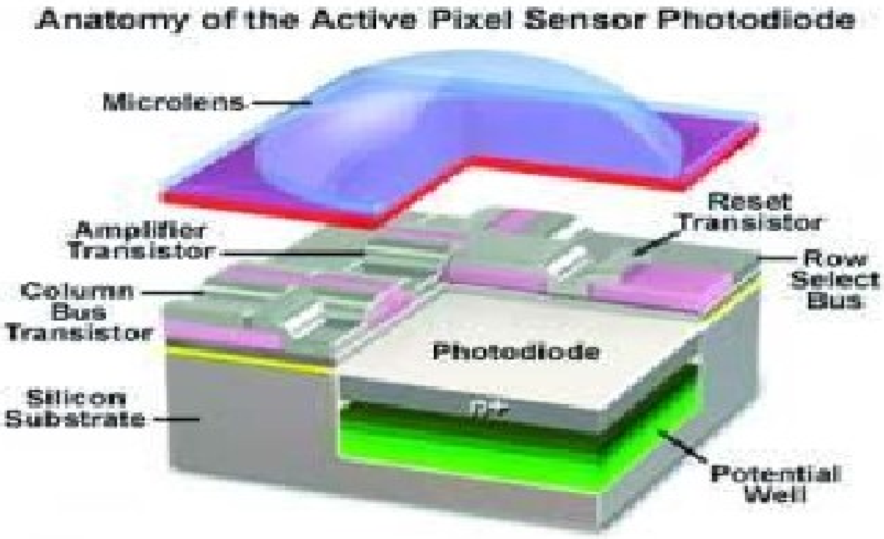


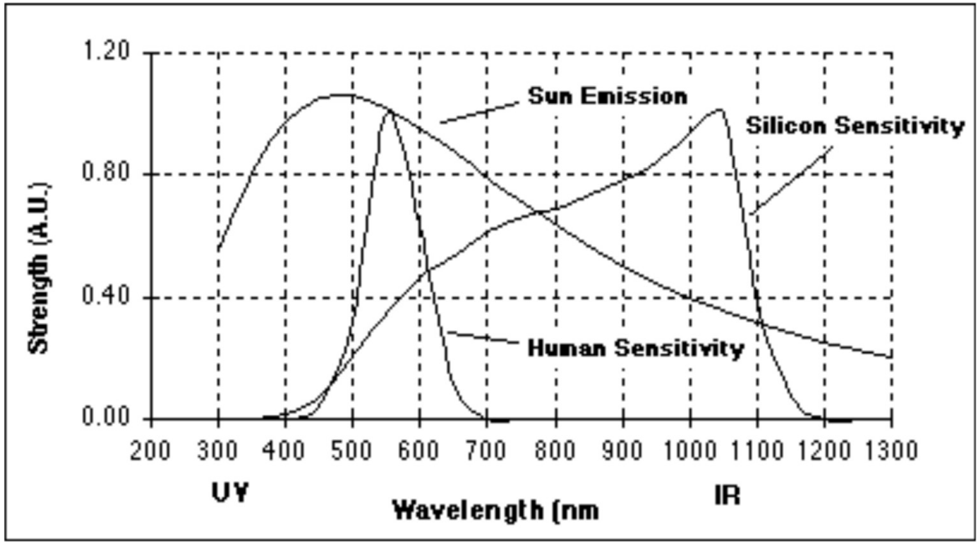


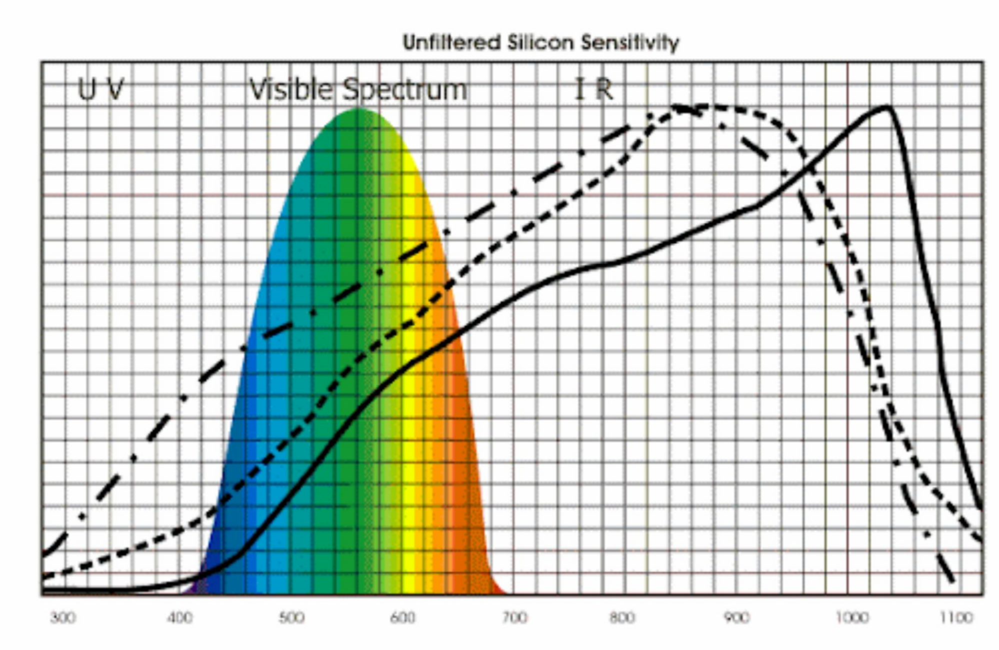
To compensate for lower fill factor (typically 30-50%), most CMOS sensors use microlenses, individual lenses deposited on the surface of each pixel to focus light on the photosensitive area. Microlenses can boost effective fill factor to approximately 70%, improving sensitivity (but not charge capacity) considerably.

http://www.dmi.unict.it/~battiato/CVision1011/CVision1011.htm

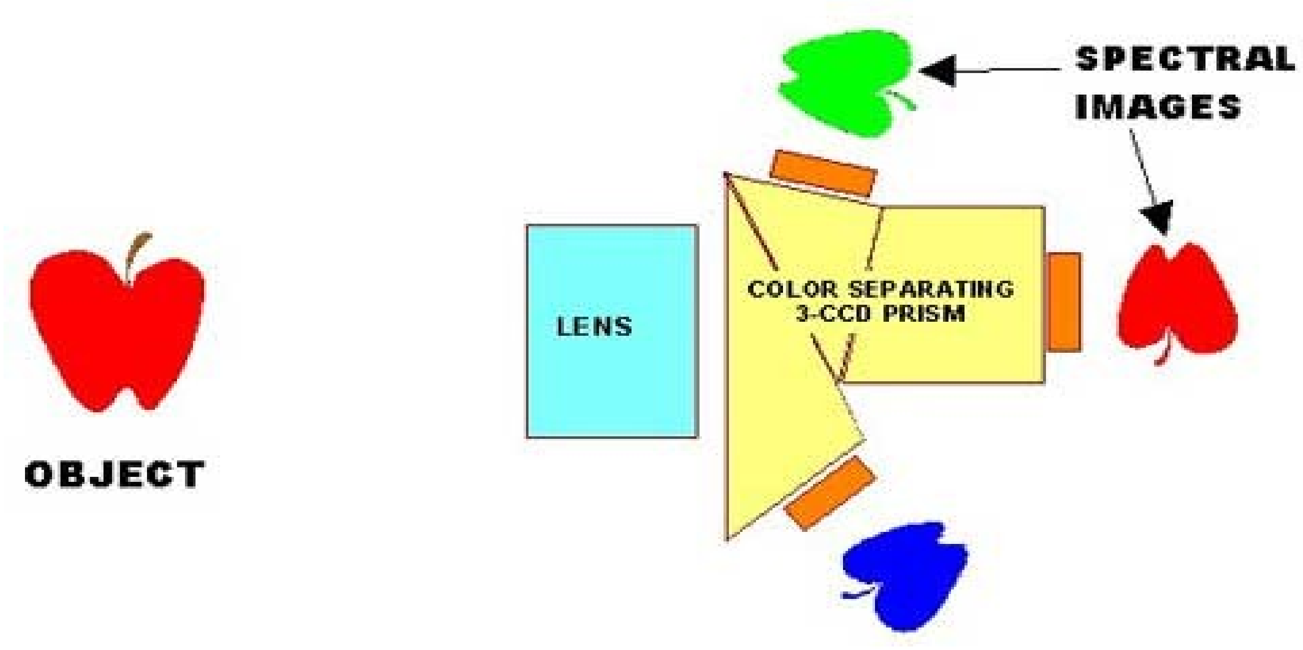
CMOS sensitivity

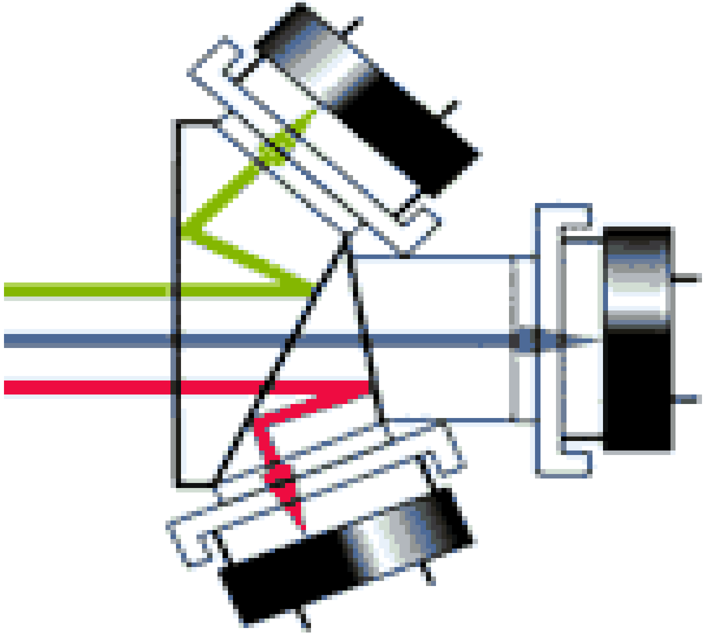
- Also valid for CCD





Color by separating spectrum

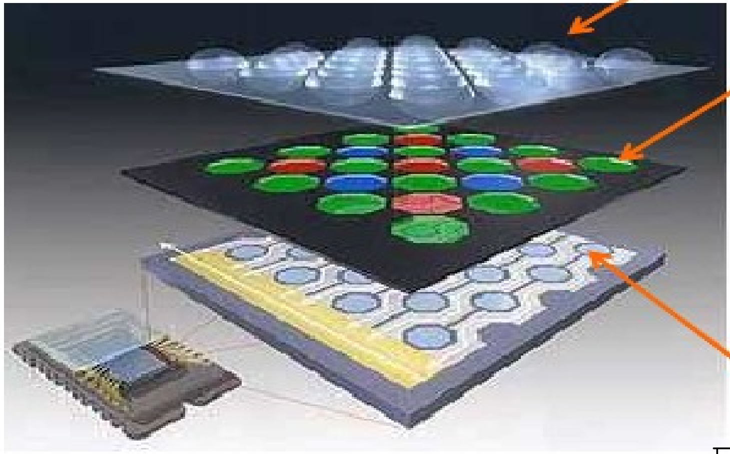




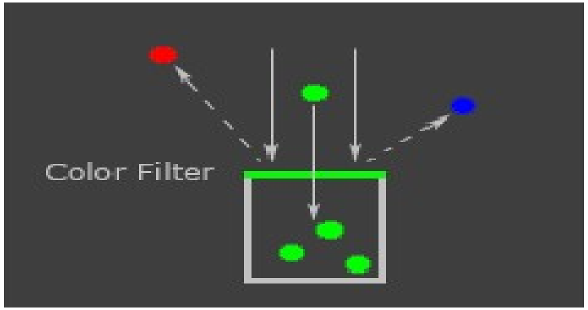
First solution: separate spectrum

Color Field Array

Microlenses to focus spectrum as seen before



Color Field Array is a filter array



Each photoreceptors get a specific color energy

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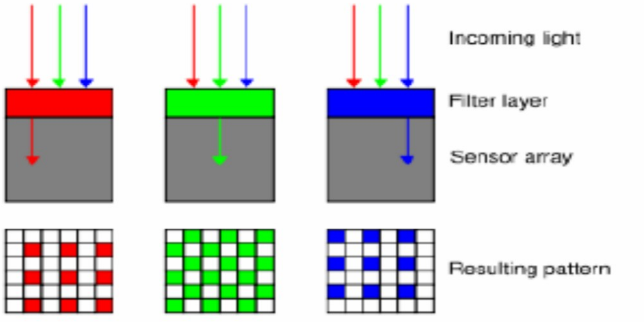
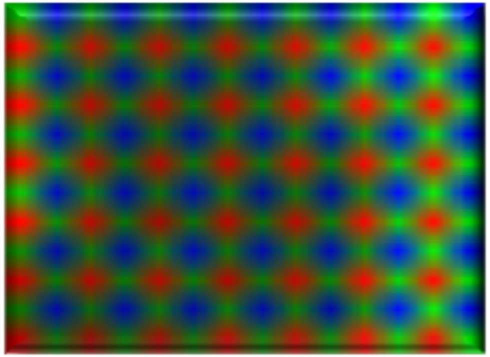
Color Field Array

CFA image sensor





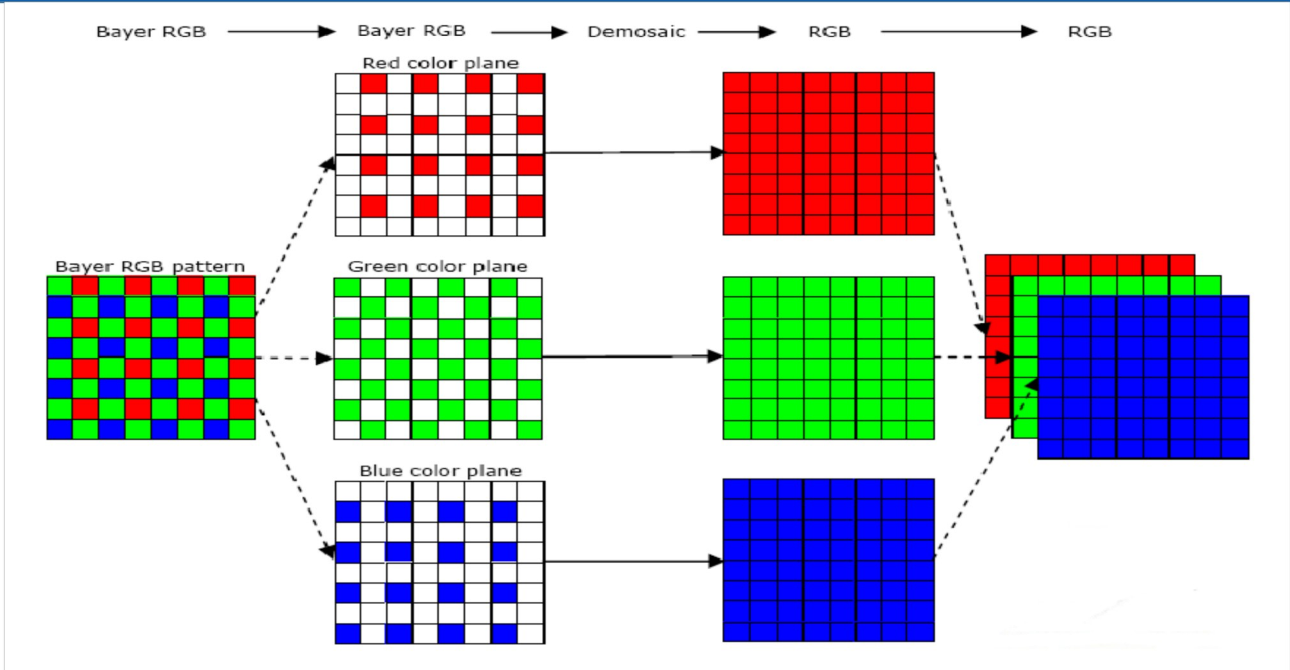
Real Scene... **...as seen by the sensor.**

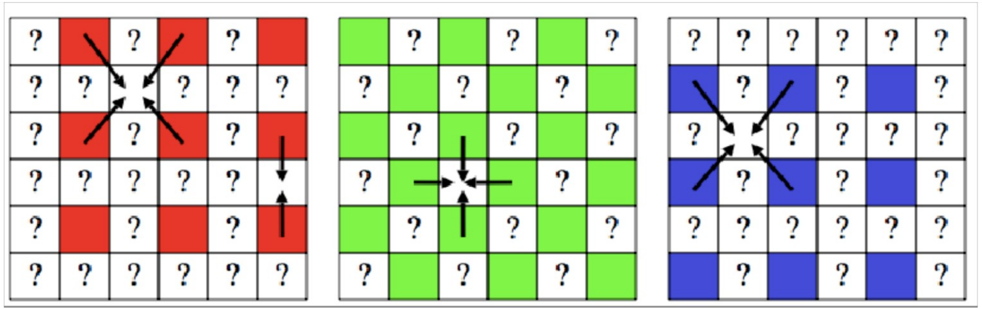
http://www.dmi.unict.it/~battiato/CVision1011/CVision1011.htm

Demosaicing Algorithms

- Simple $\longrightarrow$ interpolation is used for averaging color values
- Downsample $\longrightarrow$ use a 2x2 block to obtain a RGB pixel
- Edge Sensing $\longrightarrow$ “color” edges are used to improve average

Simple Demosaicing





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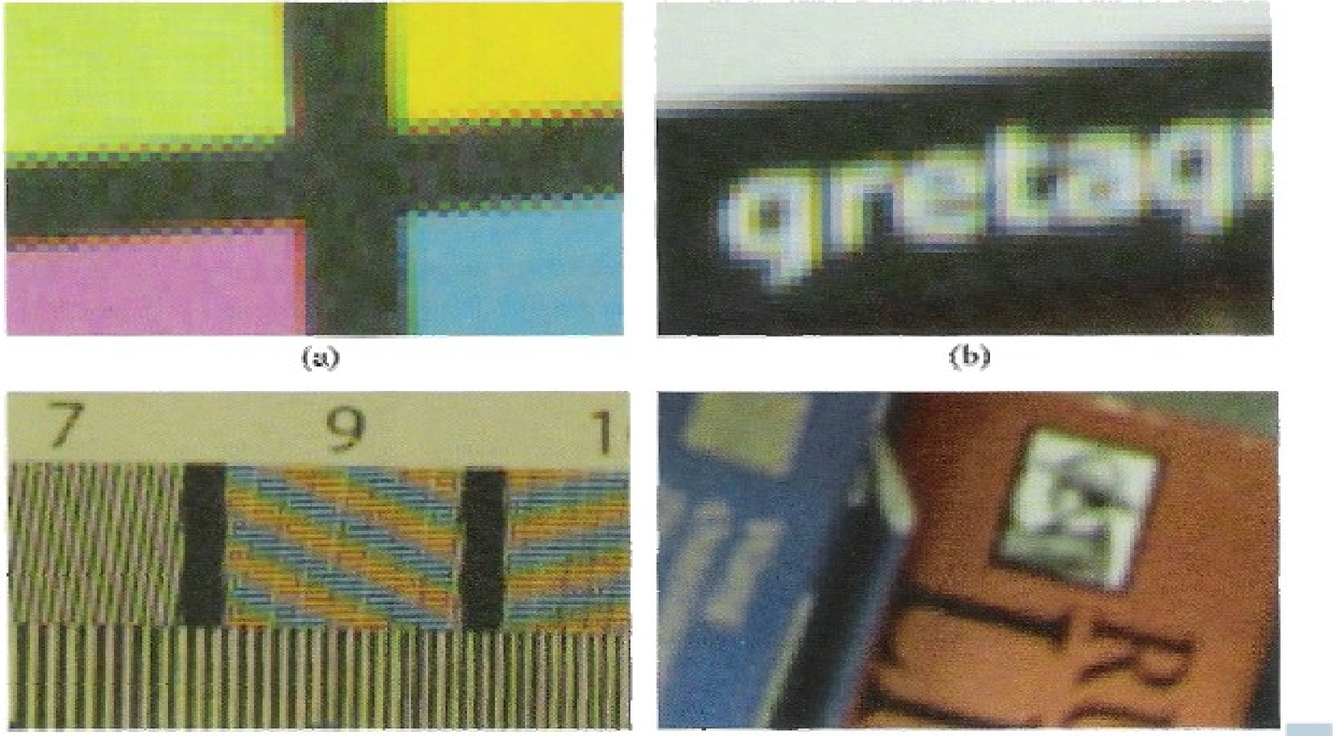
Demosaicing artifacts



(a) zipper effects, (b) color shift, (c) aliasing artifacts and (d) blur effects.

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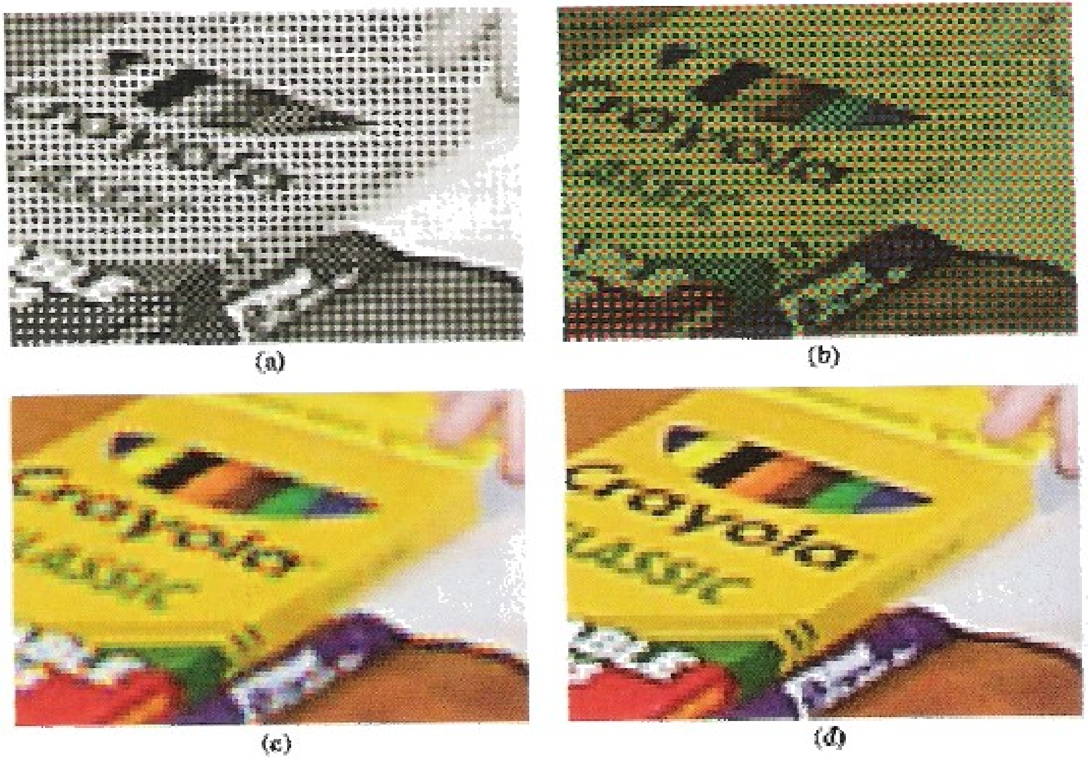
Demosaicing

a) "Grey" levels after color filter array
b) We can assign a "color" level
c) Demosaicing
d) Post Processing



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CFA Patterns

- Bayer (RGGB, BGGR, GRBG, GBRG)
- RGB+W (RGB + luminance)
- CYGM
  - Also CMY or CMYW
- RCCC (1 red filter, 3 luminance)
- RCCB
- RGB+NIR