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Video & Acquisition Systems

Content

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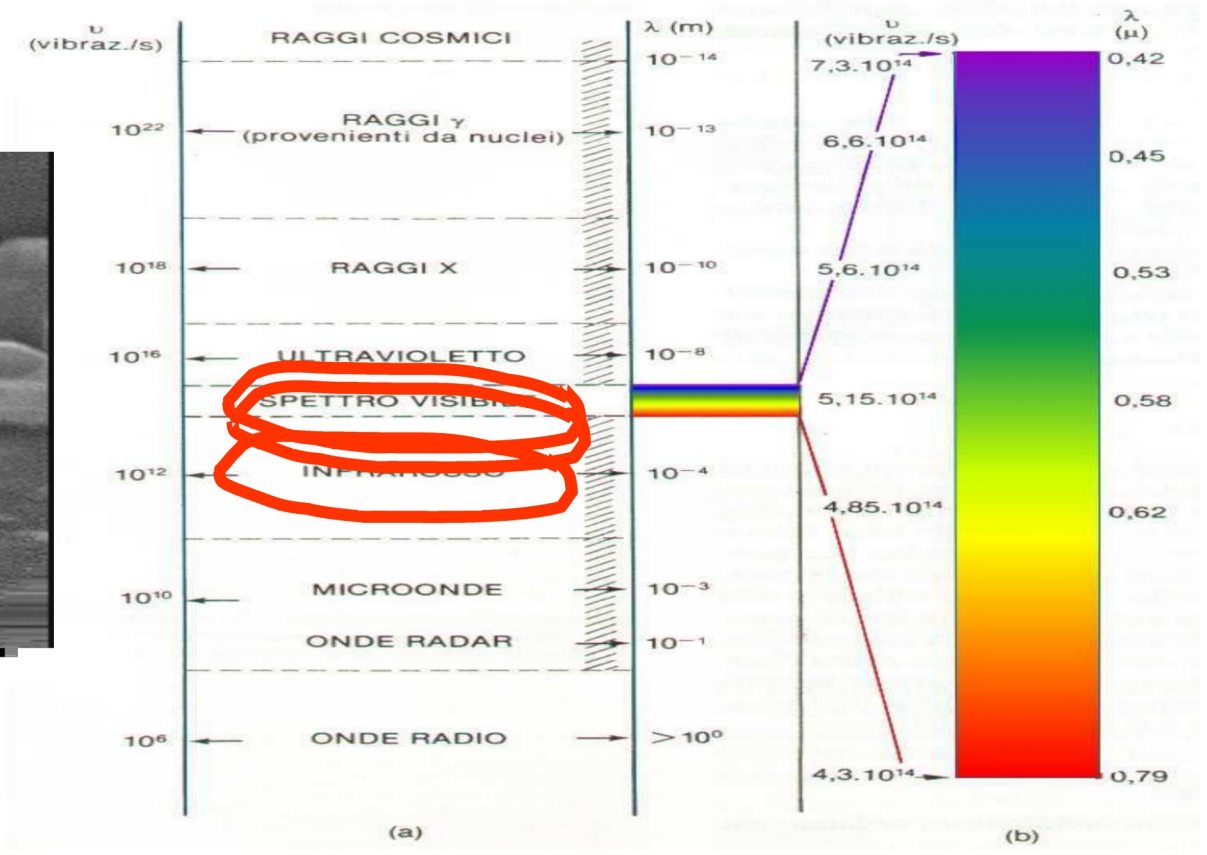
- Light
- Acquisition pipeline
- CCD vs CMOS
- Color extraction techniques

Light Spectrum



How do we sense light?

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How do we sense light?

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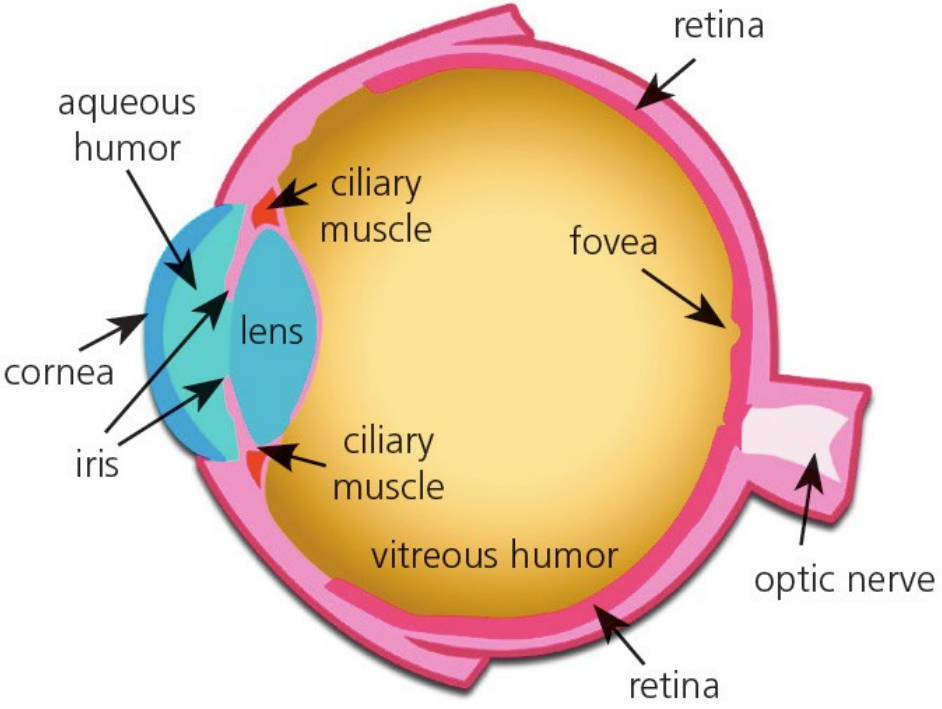
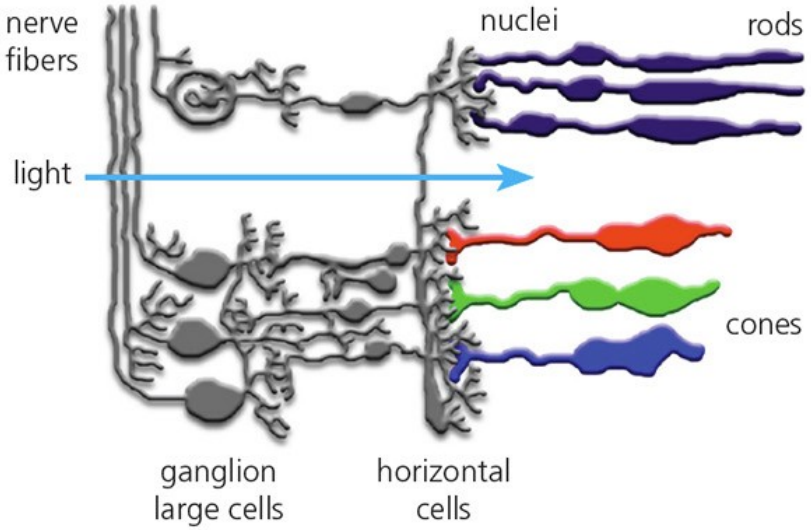
Human Vision





Human Vision

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- "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

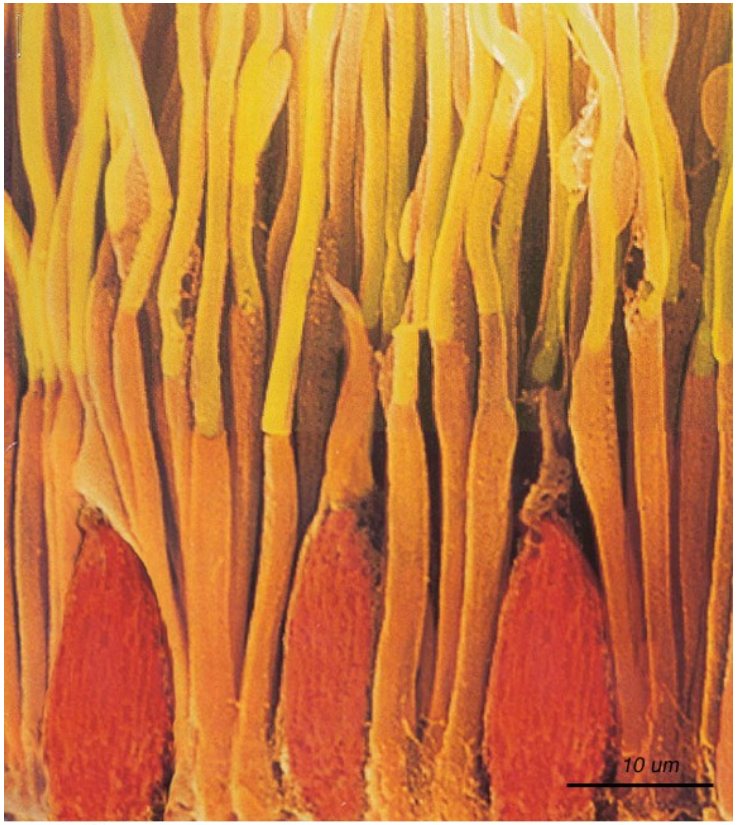
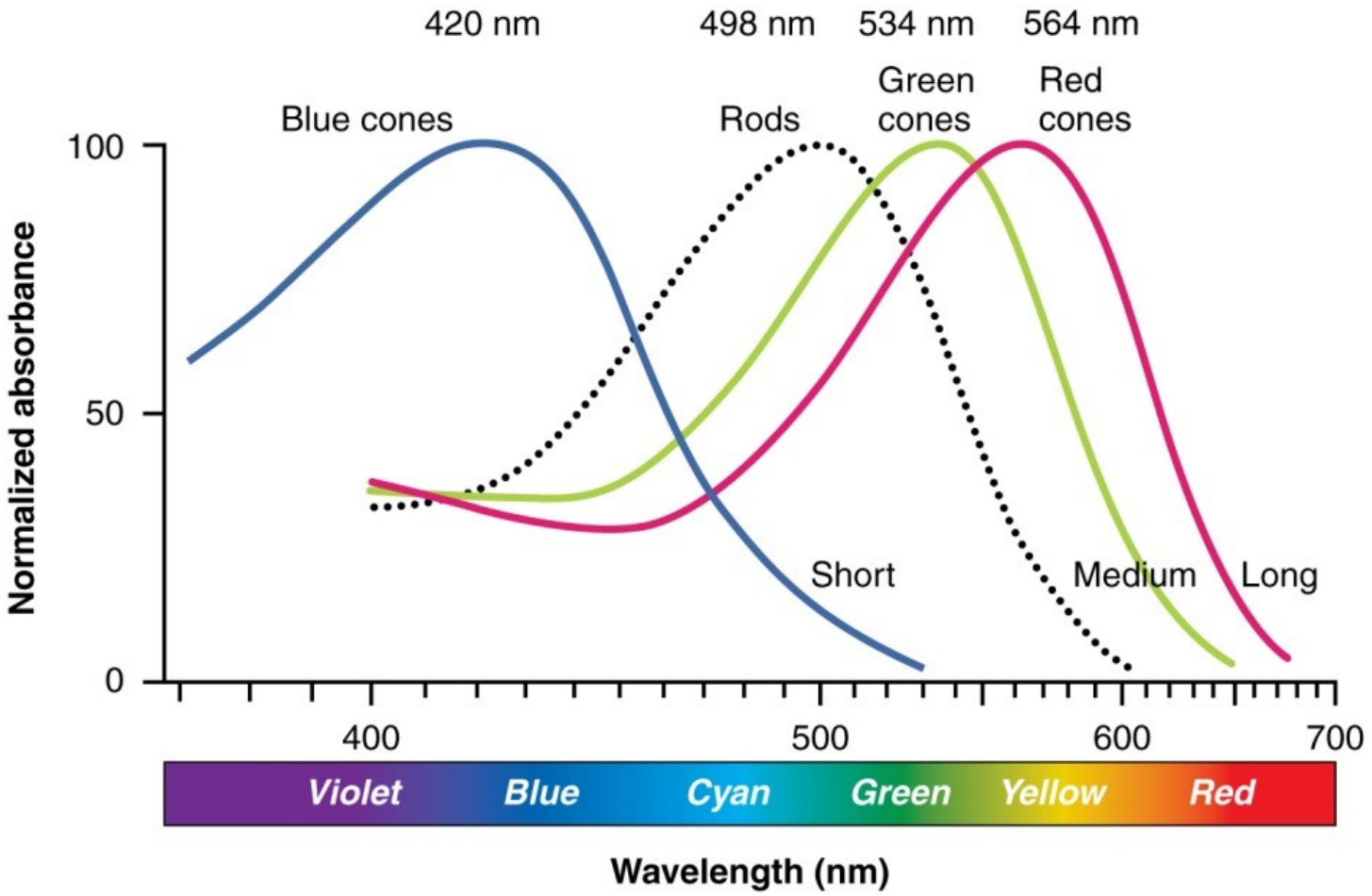
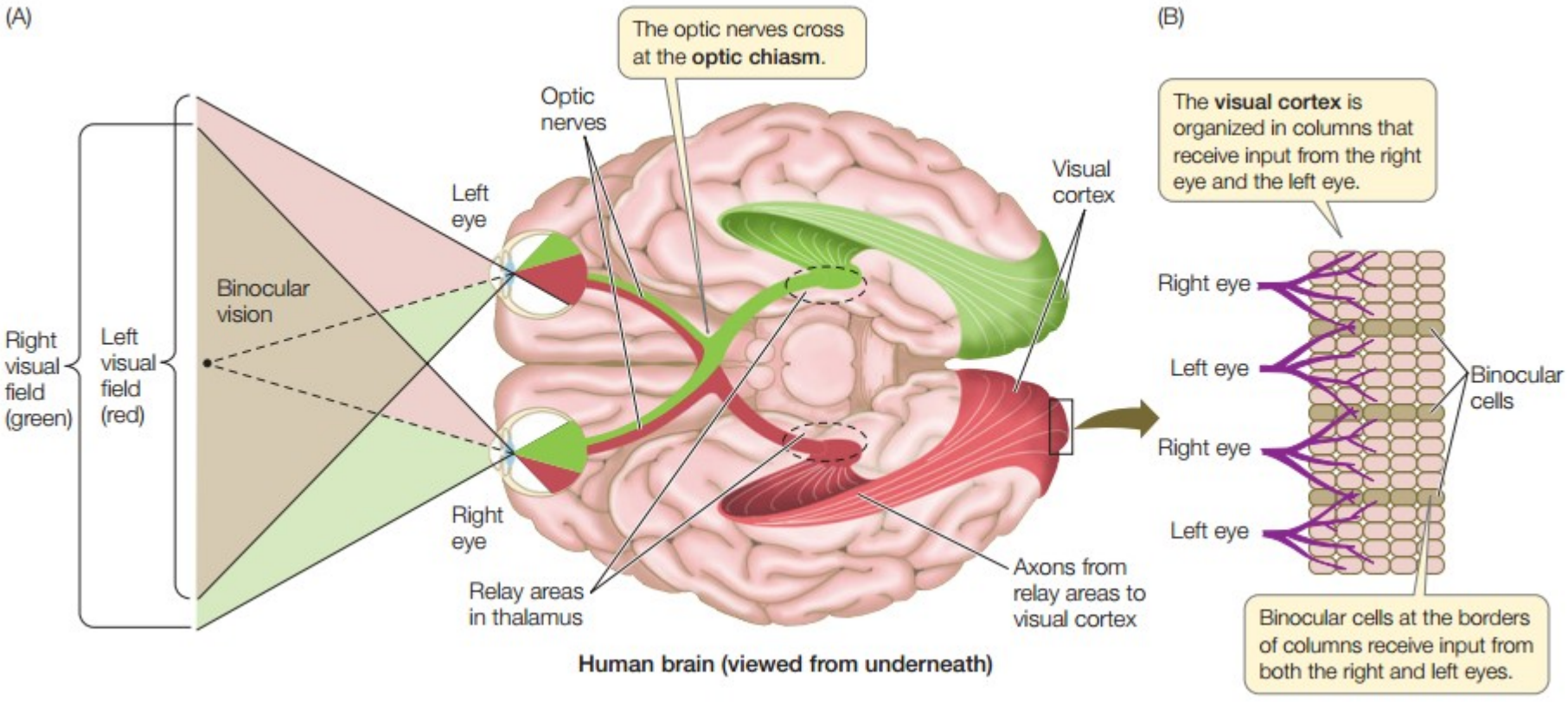


Fig1b. Scanning electron micrograph of the rods and cones of the primate retina. Image adapted from one by Ralph C. Eagle/Photo Researchers, Inc.

Human Vision



Human Vision



Acquisition System

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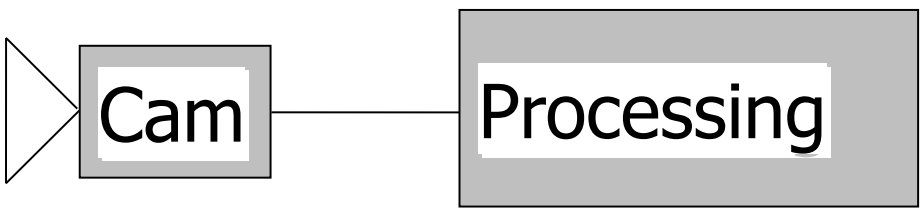
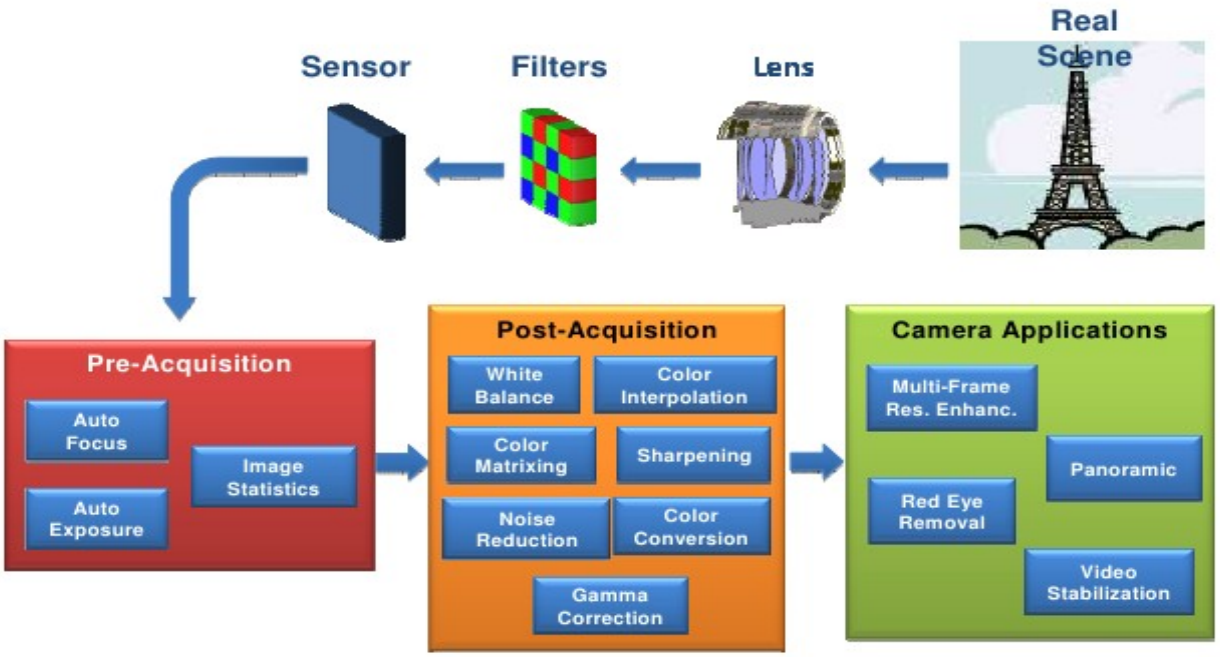
- We need
  - Sensor
  - Transmission
  - Processing
- But this is unfortunately too optimistic!

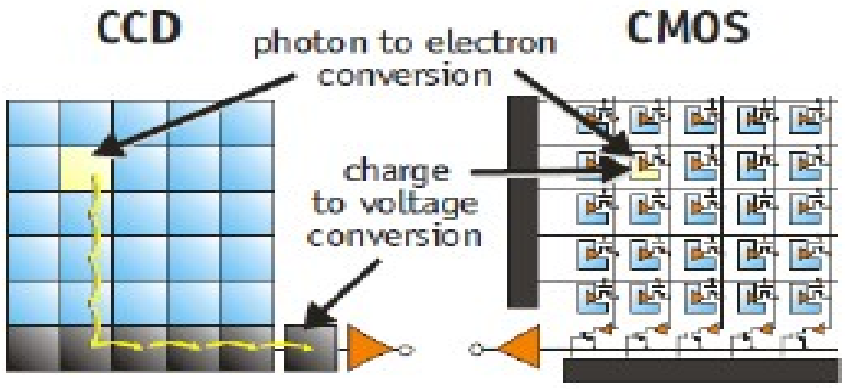


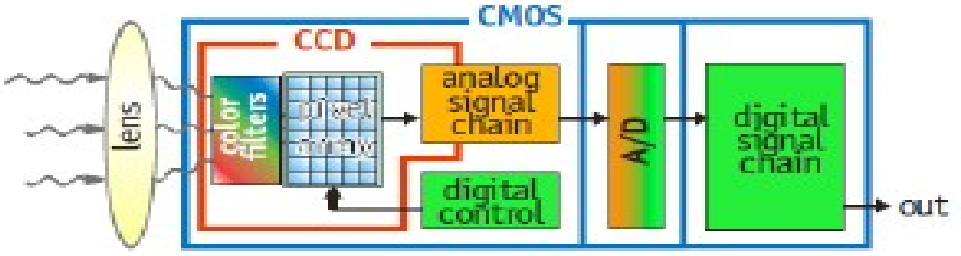
Actual Acquisition Pipeline



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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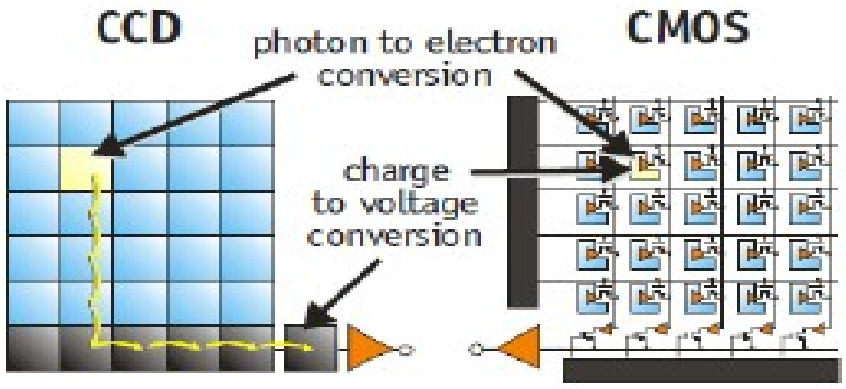
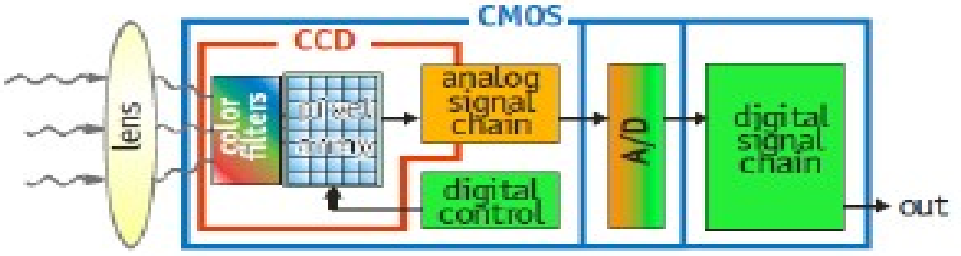
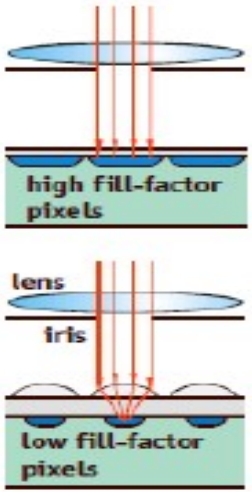
CCD vs CMOS

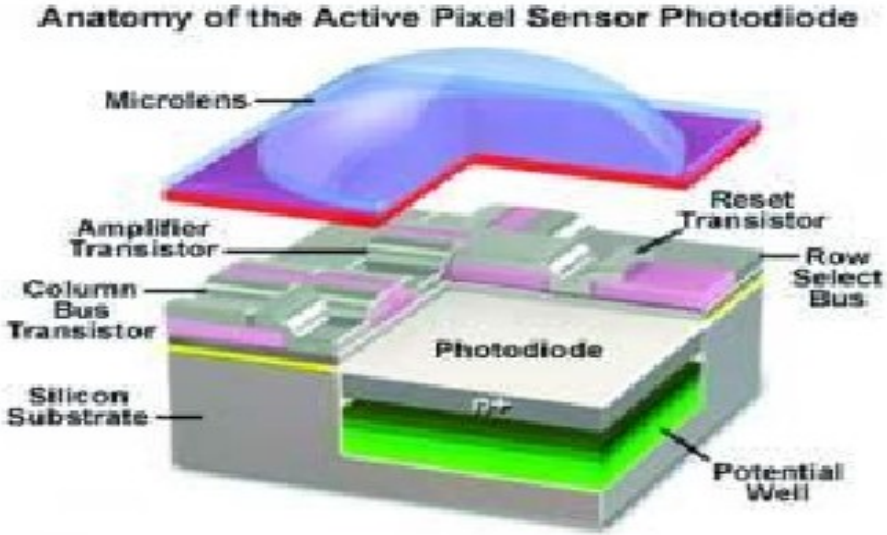




- Complimentary Metal-Oxide Semiconductor:
  - Several transistors at each pixel amplify and move the charge using more traditional wires
  - It is more flexible because each pixel can be read individually
  - Usage of the same traditional manufacturing processes to make most microprocessors.
  - Easy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

CMOS microlenses





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

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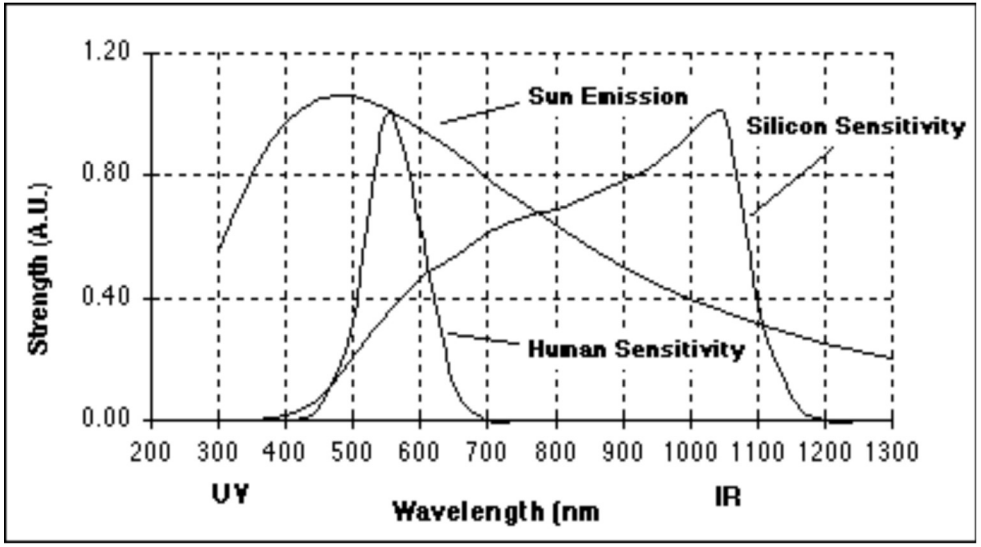
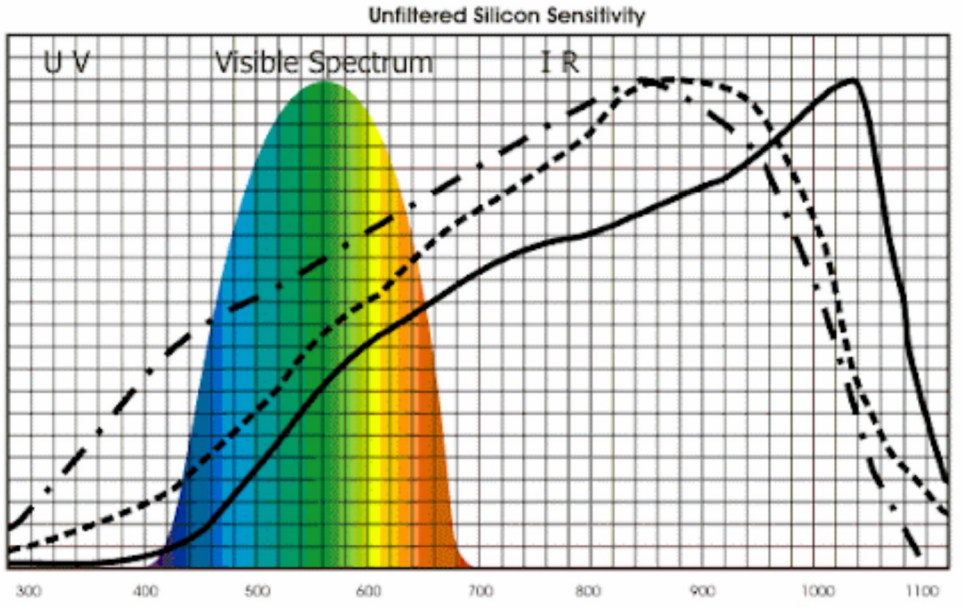
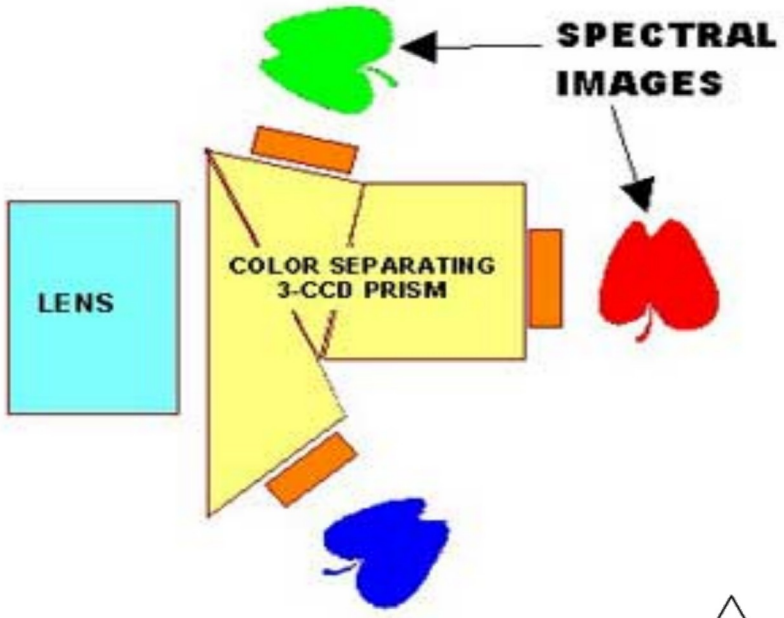
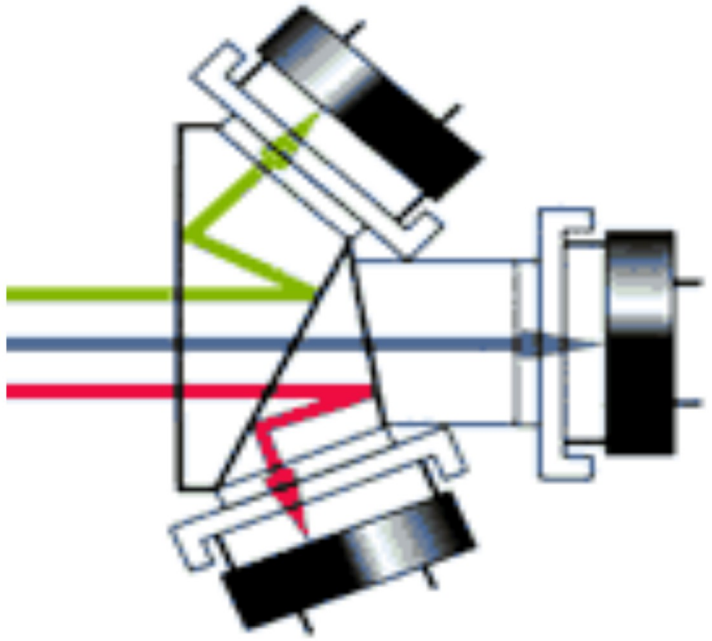
- Also valid for CCD



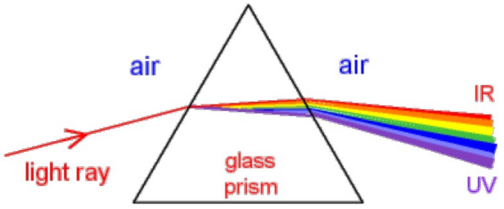


Color by separating spectrum



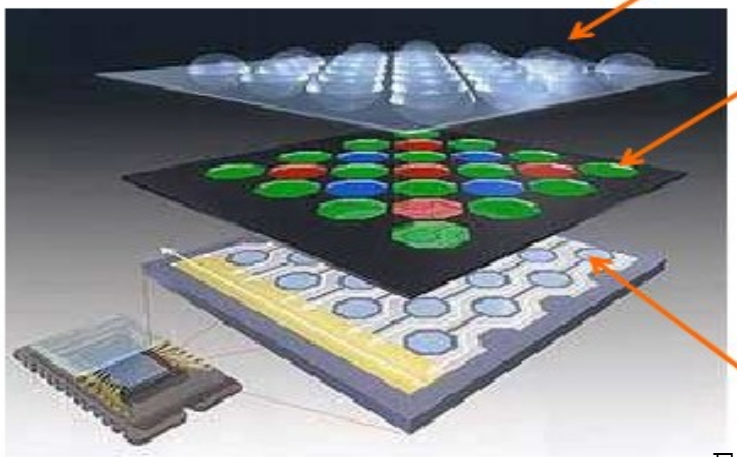


First solution: separate spectrum

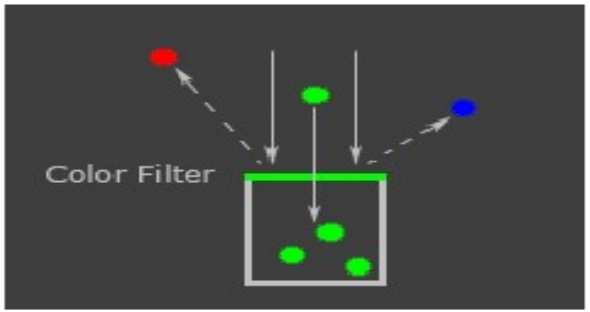


Color Field Array

Microlenses to focus spectrum as seen before



Color Field Array is a filter array



Each photoreceptors get a specific color energy

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

CFA Patterns

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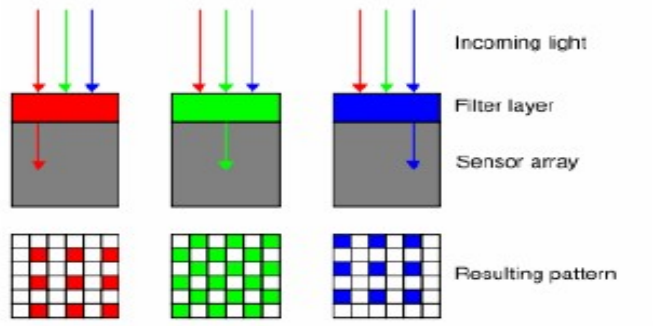
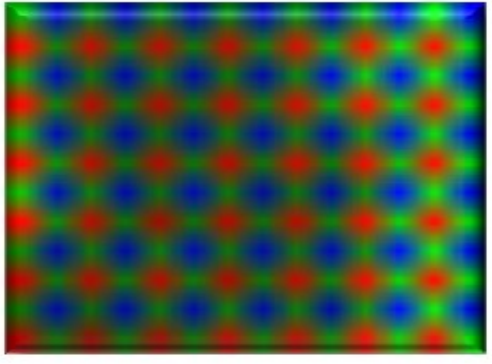
- Bayer (RGGB, BGGR, GRBG, GBRG)
- RGB+W (RGB + luminance)
- CYGM
  - Also CMY or CMYW
- RCCC (1 red filter, 3 luminance)
- RCCB
- RGB+NIR

Color Field Array





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

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

Demosaicing Algorithms

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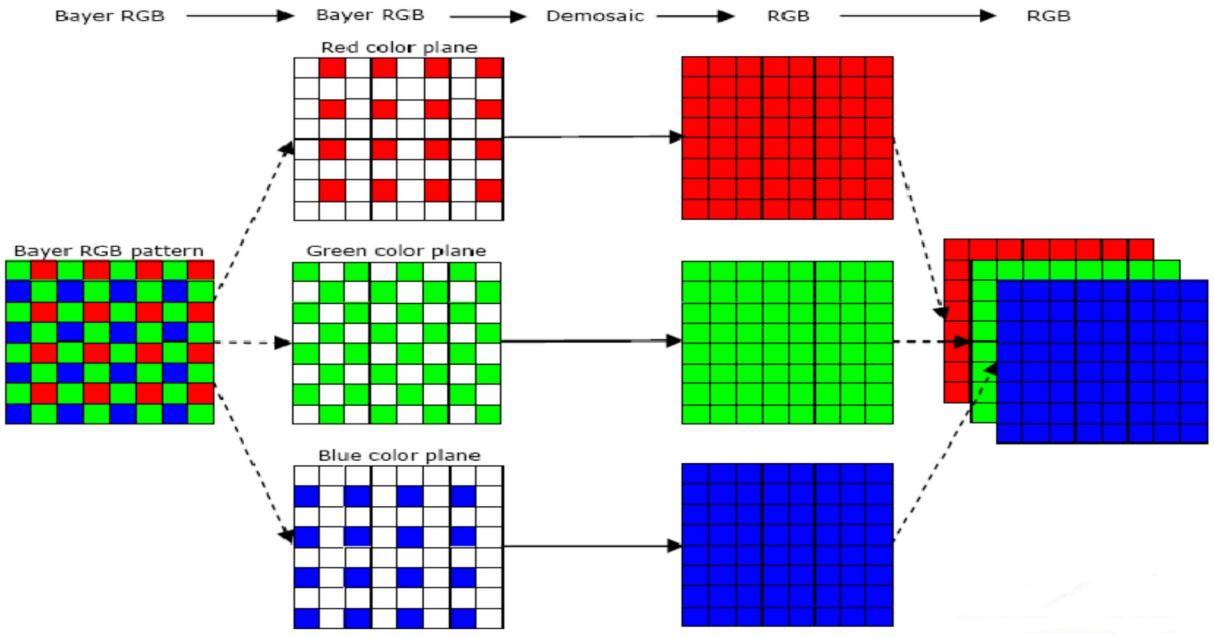
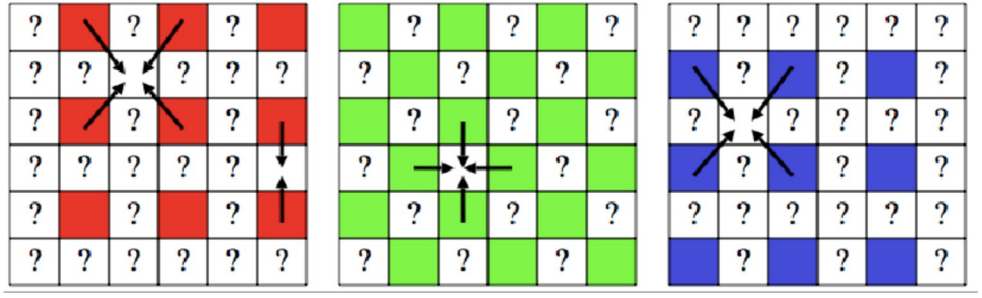
- Simple → interpolation is used for averaging color values
- Downsample → use a 2x2 block to obtain a RGB pixel
- Edge Sensing → “color” edges are used to improve average

Simple Demosaicing





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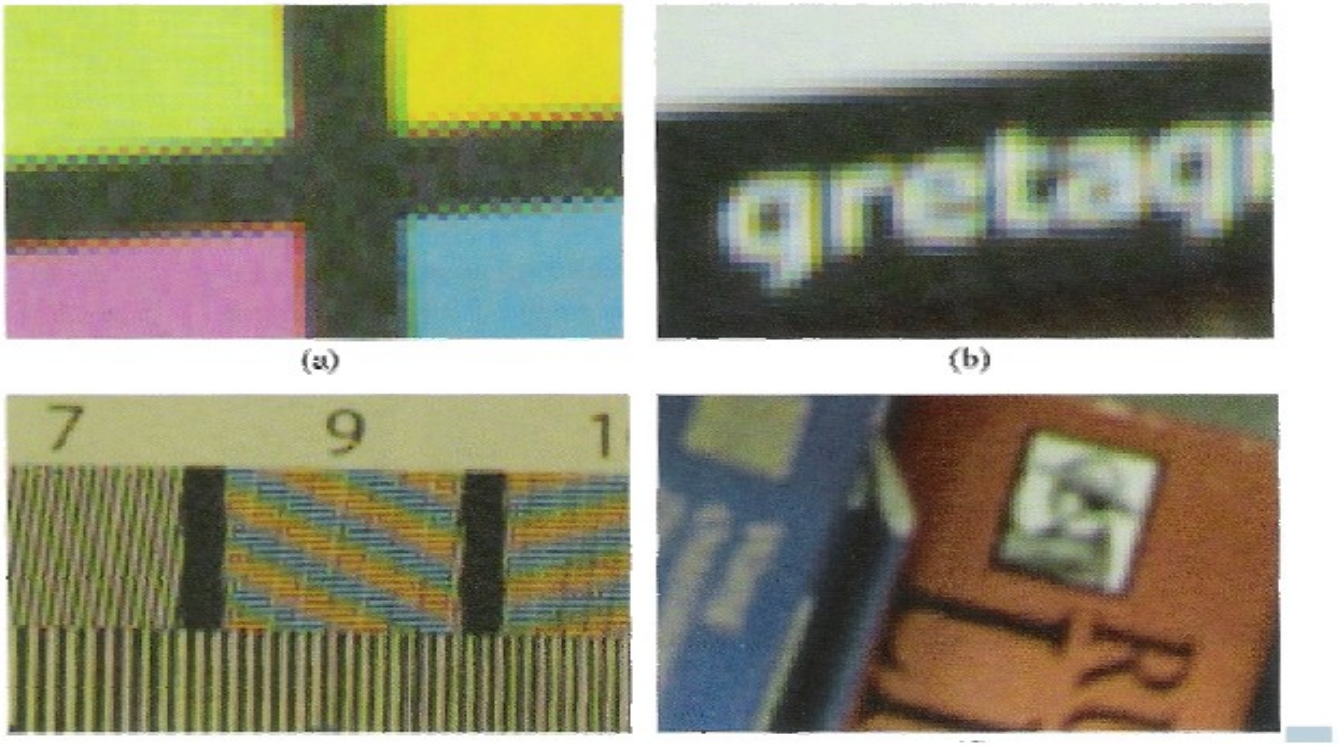
Demosaicing artifacts



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

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

Demosaicing

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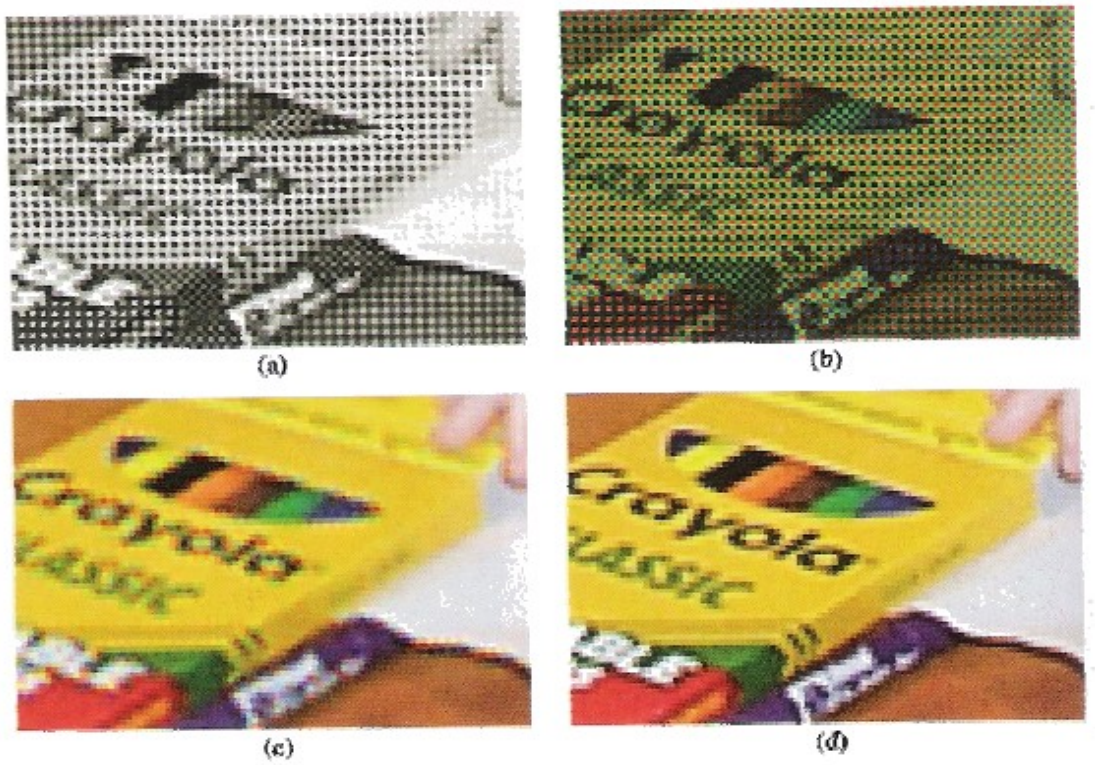
a) “Grey” levels after color filter array
b) We can assign a “color” level
c) Demosaicing
d) Post Processing



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