Sensors Simplified

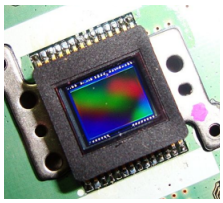
- Cameras' Sensors (and Film) where Rays of Light become Pixels

Objectives

- Photographic Processes for Digital Capture
- The Five Simplified layers of a CCD
- Two benefits of using the Camera Raw

Reading: https://en.wikipedia.org/wiki/Charge-coupled_device

Digital: Converting Light to Data



- CCD: Charge-Coupled Device, a device for converting electrical charge, into a digital value
- **Pixels** are represented by capacitors, which convert and store (accumulates) incoming photons as electron charges
- Willard Boyle and George E. Smith, 1969 (Won a Noble Prize in Physics in 2009).

https://en.wikipedia.org/wiki/Charge-coupled_device

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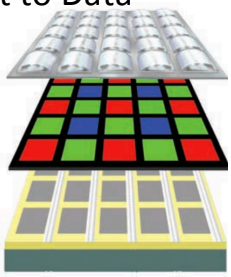
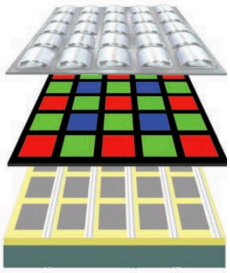
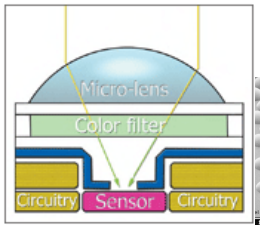


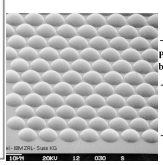
- **Micro lenses**: Capture Light and direct it to the light sensitive areas of the sensor.
  - Added Lens layer
- **Hot Mirror**: Simple Filtering. Lets visible light pass, but reflects lights in the invisible part of the spectrum (depends on kind of light to capture –e.g., **infrared**, ultraviolet- UV camera). Also provides Anti-aliasing.
- **Color Filter:** Bayer Array separate light into RGB.
- **Photo Diodes:** Color Blind. But measure intensities, and energy converted to electrons
- **Depletion Layer**: Where Electron Are collected (part of photo diodes layer)

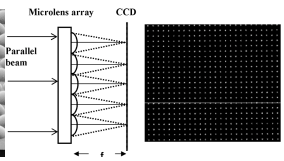
Digital: Converting Light to Data

- **Microlens Array**: Capture Light and direct it to the light sensitive areas of the sensor.
  - Added Lens layer

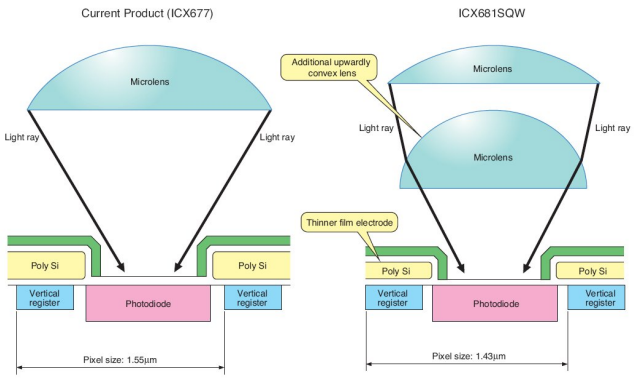






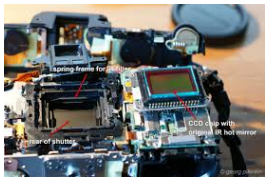


Dual Microlens Designs Shrinks Pixel Size Sony CCD

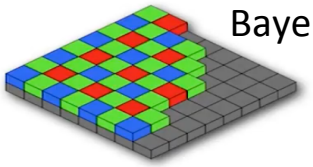


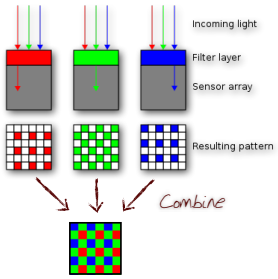
Hot Mirror

- Cuts IR light.
- Hot filter, that Filters out infrared light to mitigate sensors that are sensitive to the infrareds (750nm 1250), and contaminated colors.
  - E.g., Fires
- Cold Filter – Cold Mirror filters IR into the pahtway (more common infront of lens.



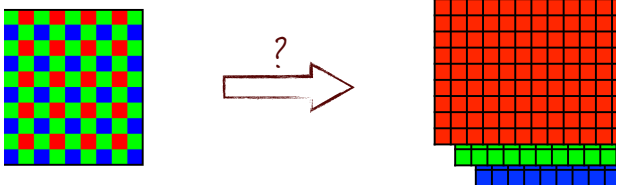
Bayer Filter



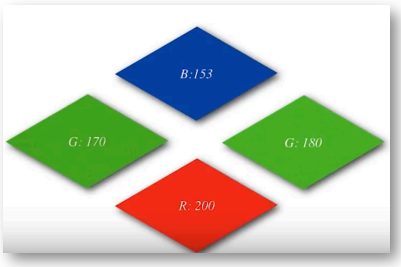


- Bayer Filter on a sensor
- Pixel :
  - square of 4 color squares.
- Lets only 1 color light through.
  - 3 Patterns one for each color
  - Combination gives us the final image

Convert Light to Data

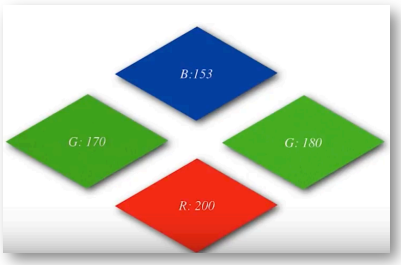


Convert Bayer to RGB



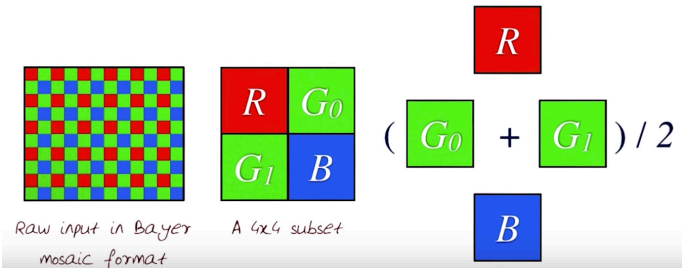
- R = 200
- G = 170, 180
- B = 153

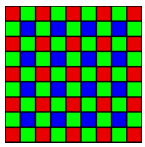
Convert Bayer to RGB



- R = 200
- G = AVG(170, 180)=175
- B = 153

Bayer Filter



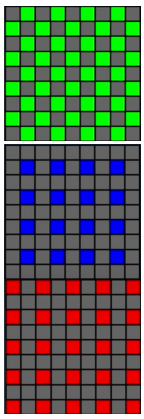


With this method sensor only captures Raw color data for 1/3 of the image.
Use Demosaic in order to estimate the remaining 2/3 of the image.

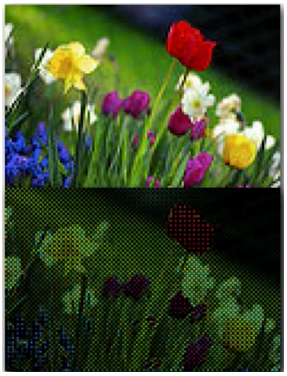
½ Green

1/4 Blue

1/4 Red



Demosaic

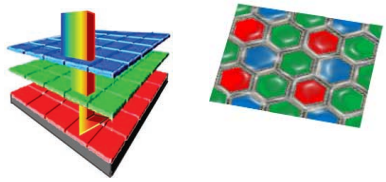


- Combine Bayer Filter & **Interpolation** to estimate other colors from the incomplete sample by Bayer Filter Mechansism
- Bayer Filter

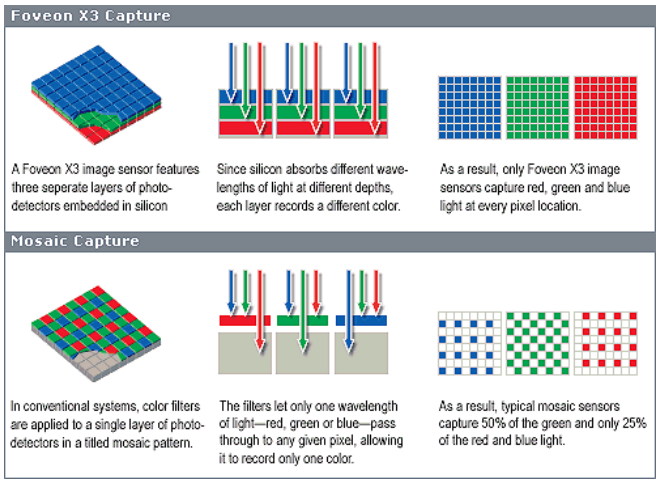
https://en.wikipedia.org/wiki/Demosaicing

http://www.csee.wvu.edu/~xinl/papers/demosaicing_survey.pdf

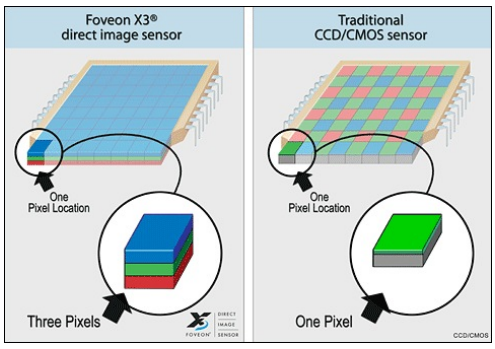
Other Filters



- Foveon: stacks photodiodes to capture all light at a **single** location.
- Fujifilm Super CCD (more neighbors) → Claims more data to work with for interpolation



http://www.vividlight.com/articles/2514.htm



Camera RAW File Format

- Contains minimally processed data from the sensor
- Image encoded in a device-dependent colorspace
- Captures radiometric characteristics of the scene
- Viewable image from the camera's sensor data
- Like a photographic negative
  - Has a wider dynamic range or color; preserves most of the information of the captured image