

Contents

1. What is an Image sensor
2. CCD Image Sensors
3. CMOS Image Sensors
4. Main Advantages/Disadvantages between CMOS and CCD
5. Matlab Image processing toolbox

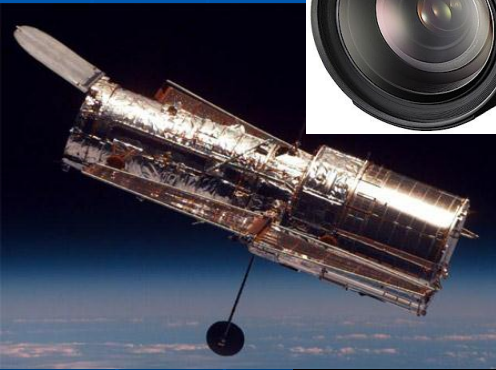
What is an Image Sensor?

- An Image Sensor is a photosensitive device that converts light signals into digital signals (colours/RGB data).
- Typically, the two main types in common use are CCD and CMOS sensors and are mainly used in digital cameras and other imaging devices.
- CCD stands for Charged-Coupled Device and CMOS stands for Complementary Metal–Oxide–Semiconductor

Uses: imaging-spectroscopy

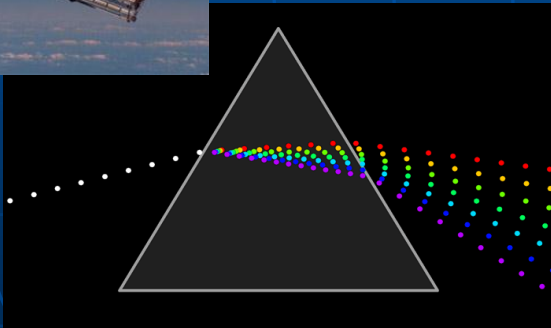


- Image sensors are not only limited to digital cameras.

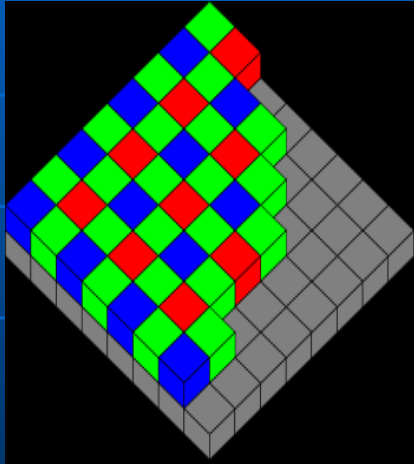


- Image sensors are used in other fields such as:

- Machine vision/sensing
- UV Spectroscopy
- Etc.

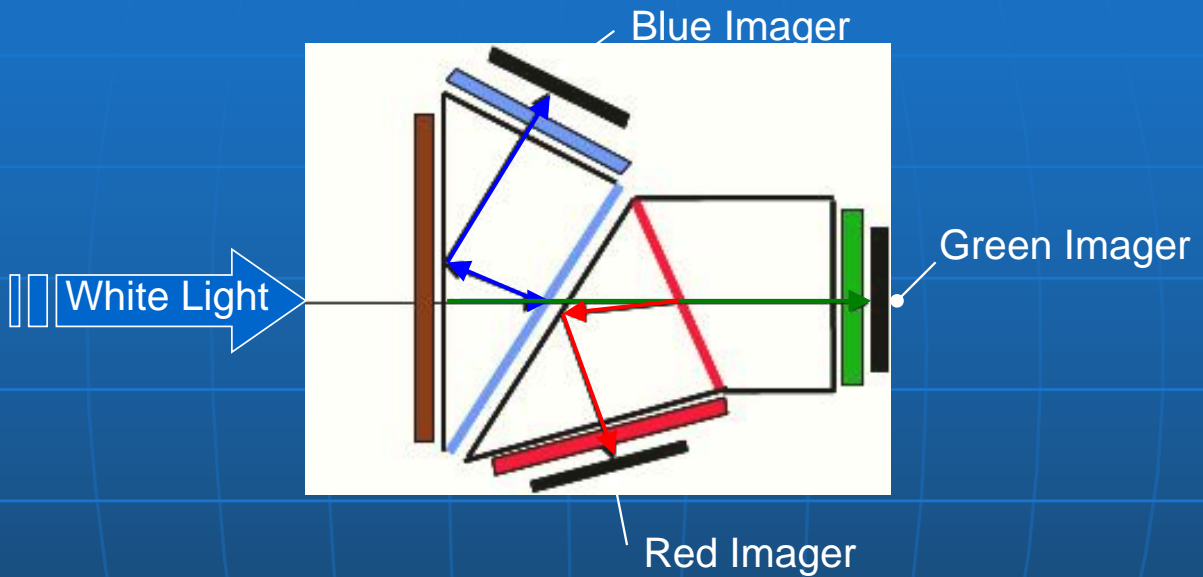


How CCDs Record Colour



- Each CCD cell in the CCD array produces a single value independent of colour.
- To make colour images, CCD cells are organized in groups of four cells (making one pixel) and a Bayer Filter is placed on top of the group to allow only red light to hit one of the four cells, blue light to hit another and green light to hit the remaining two.
- The reasoning behind the two green cells is because the human eye is more sensitive to green light and it is more convenient to use a 4 pixel filter than a 3 pixel filter (harder to implement) and can be compensated after a image capture with something called white balance.
- Ex. A Bayer filter applied to the underlying CCD pixel

Dichroic Prism

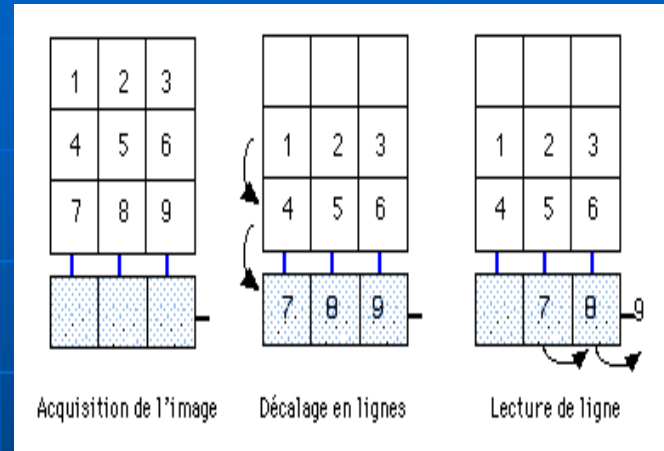
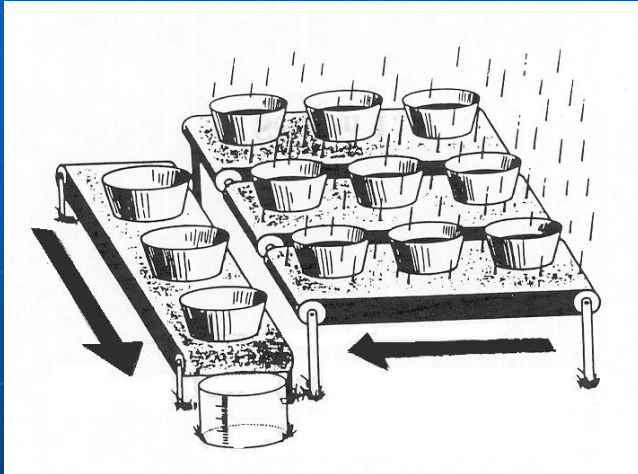


Filter wheel (microscopy astronomy)

CCD

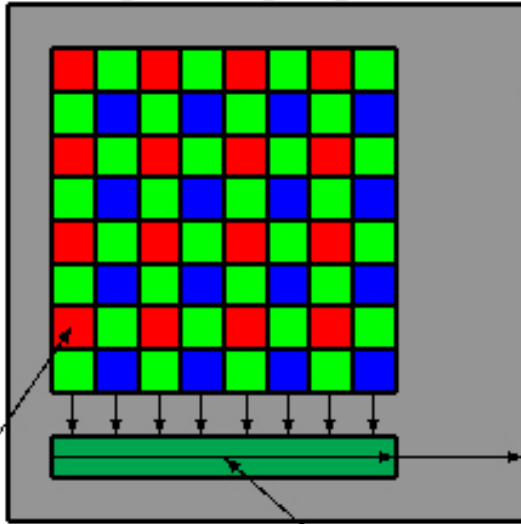
- A CCD, or a Charged-Coupled Device, is a photosensitive analog device that records light as a small electrical charge in each of its pixels or cells. In essence a CCD is an collection of CCD cells.
- The signal captured by the CCD requires additional circuitry to convert the analog light data into a readable digital signal.
- This is mainly layers of capacitors called Stages which act as a way to transport the analog signal to an array of flip-flops which store the data all controlled by a clock signal.
- This is the definition of an Analog Shift Register.

CCDs

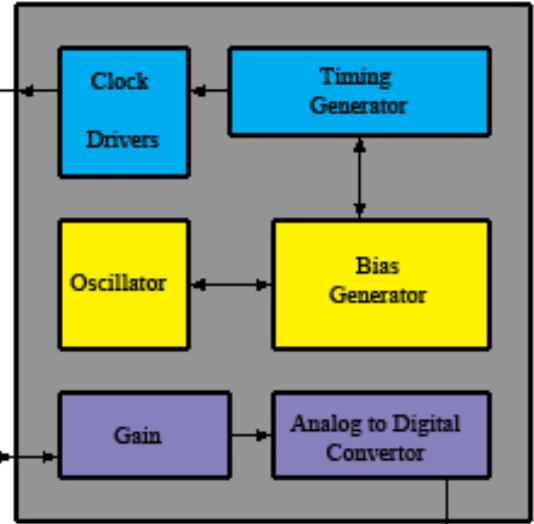


- Digital Oscilloscopes use CCDs

Charged Coupling Device



Camera Circuit Board



proton to electron conversion

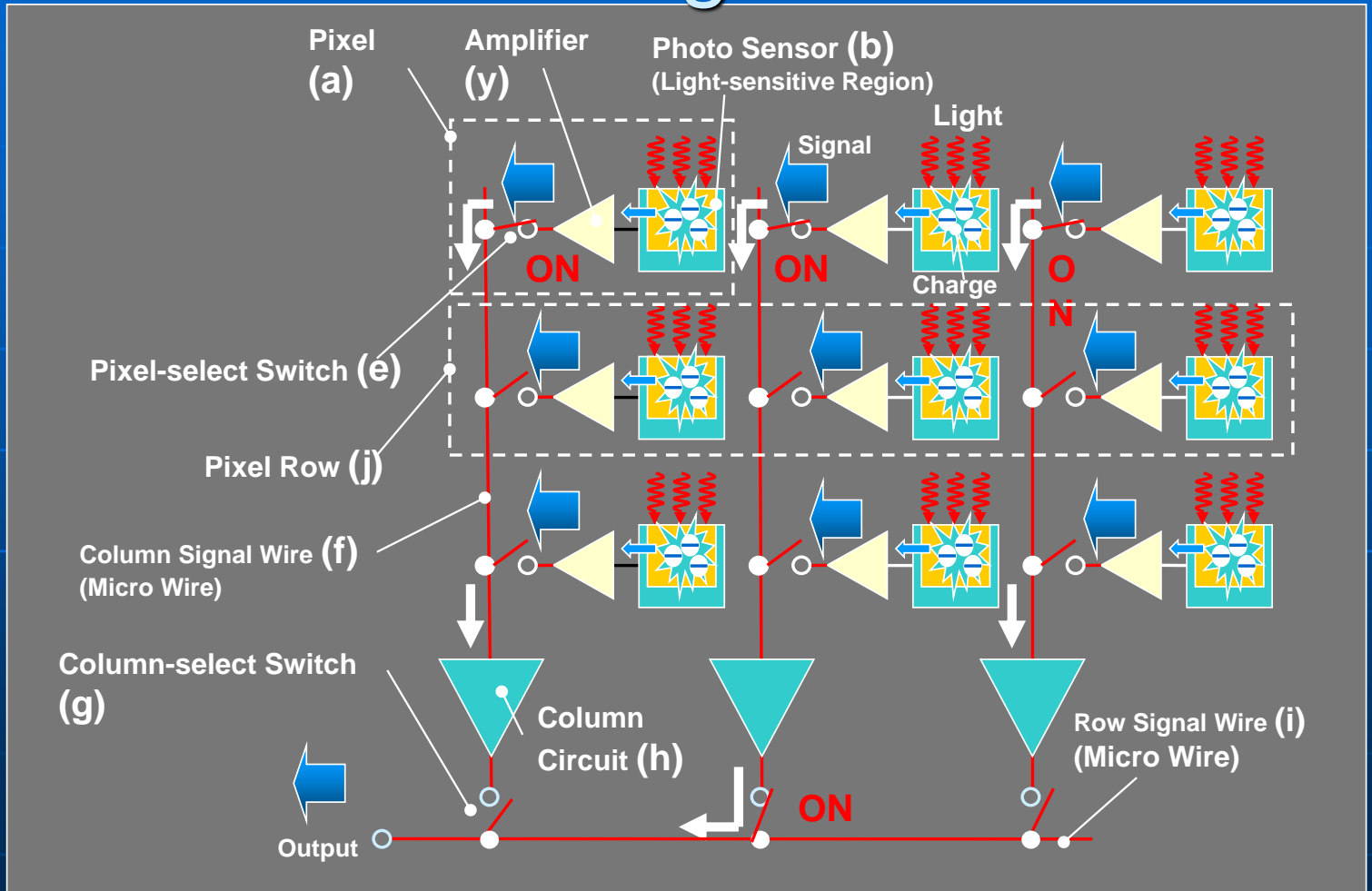
electron to voltage conversion



CMOS

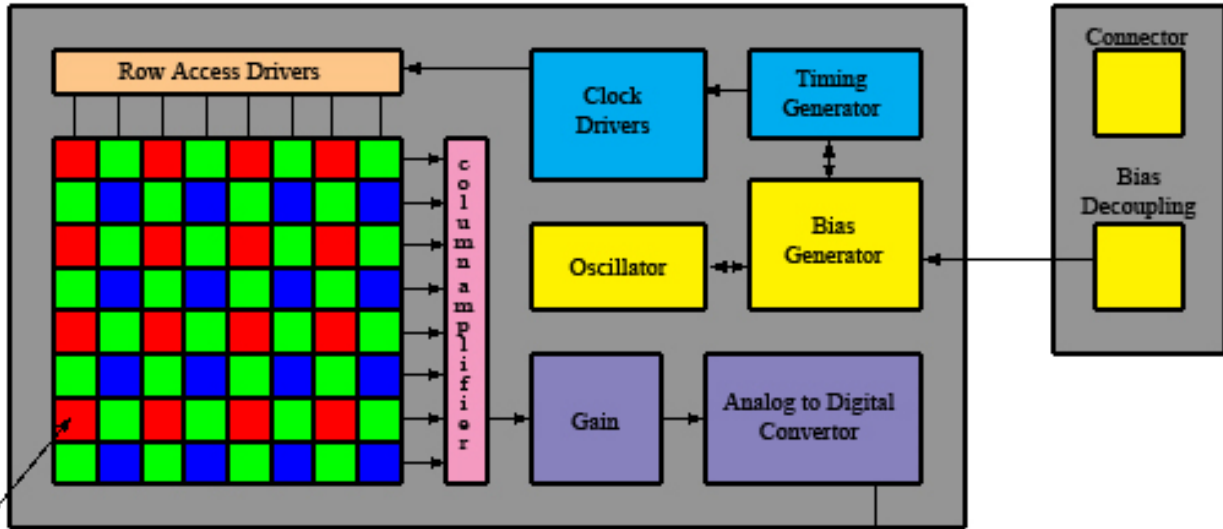
- A CMOS, or Complementary Metal Oxide Semiconductor, each pixel has neighboring transistors which locally perform the analog to digital conversion.
- This difference in readout has many implications in the overall organization and capability of the camera.
- Each one of these pixel sensors are called an Active Pixel Sensor (APS).

CMOS Image Sensor



Complementary Metal Oxide Semiconductor

Camera Circuit Board



proton to electron conversion (photosite)

electron to voltage conversion (transistors)



CMOS

- The imaging logic is integrated on a CMOS chip, where a CCD is a modular imager that can be replaced.
- Because of this, design of a new CMOS chip is more expensive.
- However, APSs are transistor-based, which means that CMOS chips can be cheaply manufactured on any standard silicon production line.

Pros and Cons

- CCD
 - Capacitor->charge
 - High sensitivity dynamic range of lighting
 - Less noise due to less on-chip circuitry
 - Uniform
 - Needs extra circuitry to convert to digital signal
- CMOS
 - Transistor->voltage
 - Active pixel (independent)
 - Lower complexity on the sensor leading to faster image capture
 - Antiblooming (pixel can saturate->multi exposure)
 - On-chip analog-to-digital conversion
 - Reduced power consumption

What is the Image Processing Toolbox?

- The Image Processing Toolbox is a collection of functions that extend the capabilities of the MATLAB's numeric computing environment. The toolbox supports a wide range of image processing operations, including:
 - Geometric operations
 - Neighborhood and block operations
 - Linear filtering and filter design
 - Transforms
 - Image analysis and enhancement
 - Binary image operations
 - Region of interest operations