Fundamentos de Processamento Imagens

Aula 03

Anatomia de Câmeras Digitais

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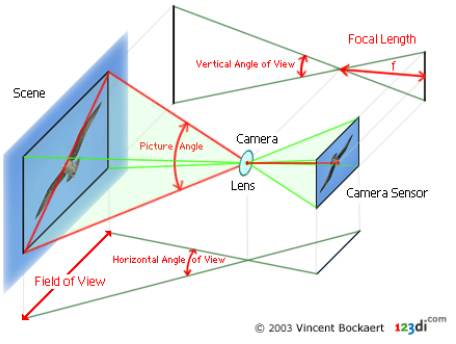
The Anatomy of Digital Cameras

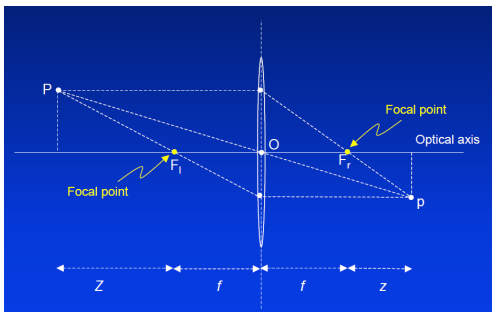
Formação da imagem - Modelo simples



Optical Systems

- In practice, optical systems can be very complex
- The fundamental ideas can be understood studying the simplest optical system: the thin lens
- Thin lens attributes
  - An optical axis passing through the lens center
  - Two focal points, placed on opposite sides of the optical axis and equidistant from the lens center

Geometric Optics of a Thin Lens

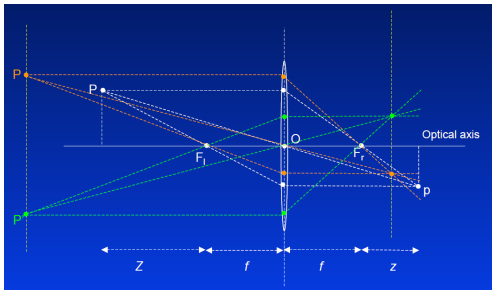


- Focal Length
  - distance (in mm) from the lens to its focal point

Thin Lens Properties

- Any ray entering the lens parallel to the optical axis on one side goes through the focus on the other side
- Any ray entering the lens from the focus on one side emerges parallel to the axis on the other side

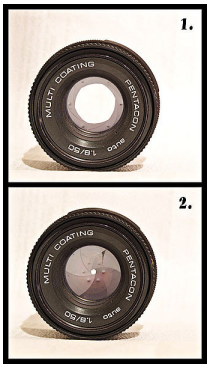
Geometric Optics of a Thin Lens



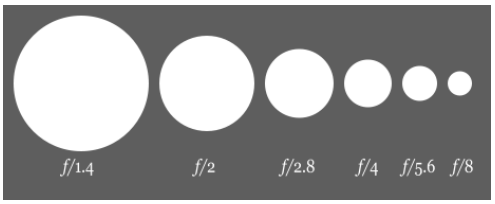
Some Definitions

- Aperture
  - adjustable diaphragm of over overlapping blades which can be thought of as the iris of the eye
  - The aperture value represents a ratio of the equivalent focal length of a lens to the diameter of its entrance pupil
  - Different notations: f/8, F8, 1:8 (all the same)
  - The larger the f-number the smaller the aperture

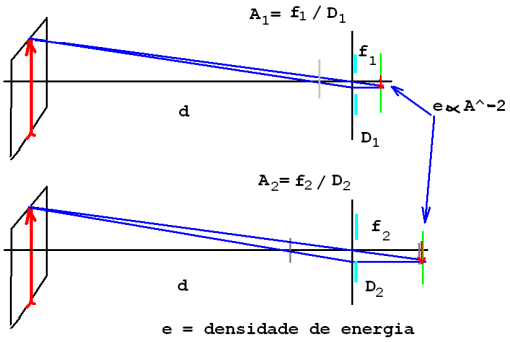
Aperture, f-stops



Aperture, f-stops

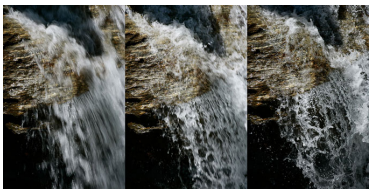


Aperture, f-stops



Shutter Speed

- Length of time the "shutter" allows light onto the CCD
- To "freeze" the action use a shutter speed of 1/250s plus



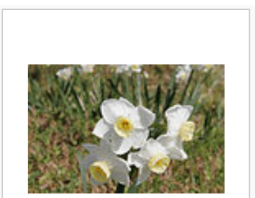
Some Definitions

- ISO value
  - in traditional film photography the ISO (ASA) value of a film represents the film's sensitivity
  - a film with lower ISO value requires more light to create the same image than a film with a higher ISO value
  - in a digital camera the sensitivity depends on the sensor
  - a CCD is an analogue device which outputs a certain voltage for a certain amount of light that reaches it
  - when you increase the sensitivity you are really just turning up the amplification of this signal (and of the "dark current" noise)

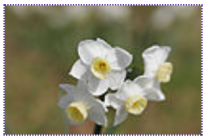
Depth of Field (DOF)

- Region in front (1/3 of the DOF) and behind (2/3 of the DOF) the main focus point which remain sharp
- Affected by aperture, subject distance and focal length
- The bigger the F number, the larger the DOF

Depth of Field (DOF)

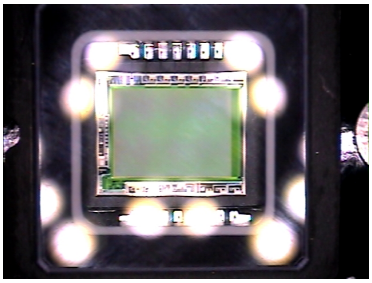


f/32 - narrow aperture and slow shutter speed

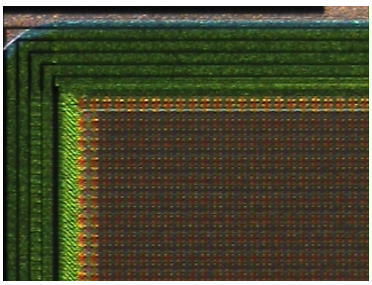


f/5.6 - wide aperture and fast shutter speed

CCD Arrays

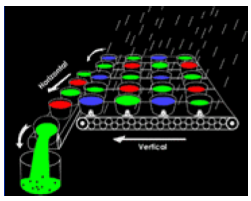


CCD Arrays



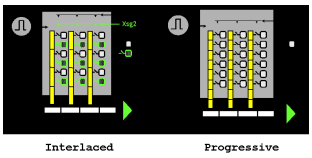
CCD Arrays

- Bucket Analogy
- Collect photons and outputs a voltage reading
- Major types of sensor
  - Interline Transfer sensors
  - Full Frame sensors



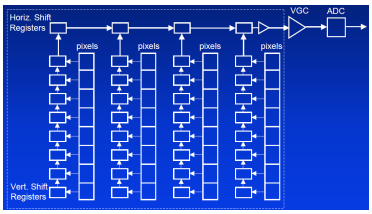
Interline Transfer Sensors

- Used in typical consumer-grade digital cameras
- Transfer values from photodiodes into shift registers
- Can produce video feed output
- Extra electronics required around each pixel
  - Fill factor 30
  - Use of microlenses to capture and focus more light into the smaller photodiode area
    - Improves fill factor to about 70

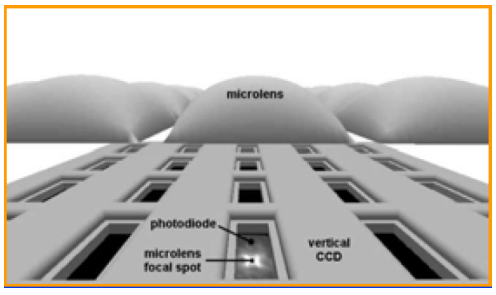


Interline Transfer Sensors (Cont.)

- CCD Sensor Architecture

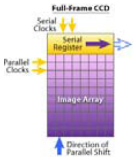


CCD Arrays - microlenses

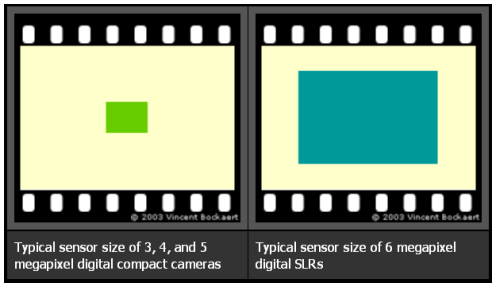


Full Frame Sensors

- Used in professional cameras (high image quality)
- Do not use shift registers, requires mechanical shutter
- Fill factor: 70
- High sensitivity
- High dynamic range
- No need for microlenses
- Disadvantages
  - Cannot get video feed out
  - Top shutter speed constrained by mechanical shutter



Sensor sizes



Sensor sizes

Common Image Sensor Sizes

In the table below "Type" refers to the commonly used type designation for sensors, "Aspect Ratio" refers to the ratio of width to height, "Dia." refers to the diameter of the tube size (this is simply the Type converted to millimeters), "Diagonal / Width / Height" are the dimensions of the sensors image producing area.

			Sensor (mm)		
Type	Aspect Ratio	Dia. (mm)	Diagonal	Width	Height
1/3.6"	4:3	7.056	5.000	4.000	3.000
1/3.2"	4:3	7.938	5.680	4.536	3.416
1/3"	4:3	8.467	6.000	4.800	3.600
1/2.7"	4:3	9.407	6.721	5.371	4.035
1/2.5"	4:3	10.160	7.182	5.760	4.290
1/2.3"	4:3	11.044	7.70	6.16	4.62
1/2"	4:3	12.700	8.000	6.400	4.800
1/1.8"	4:3	14.111	8.933	7.176	5.319
1/1.7"	4:3	14.941	9.500	7.600	5.700
2/3"	4:3	16.933	11.000	8.800	6.600
1"	4:3	25.400	16.000	12.800	9.600
4/3"	4:3	33.867	22.500	18.000	13.500
1.8" (*)	3:2	45.720	28.400	23.700	15.700
35 mm film	3:2	n/a	43.300	36.000	24.000

Sensor sizes

Implementation Examples

Below is a list of a few digital cameras (as examples) and their sensor size.

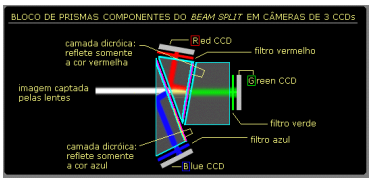
Camera	Sensor Type	Pixel count	Sensor size
Konika Minolta DiMAGE Xg	1/2.7" CCD	3.3 million	5.3 x 4.0 mm
PowerShot S500	1/1.8" CCD	5.0 million	7.2 x 5.3 mm
Nikon Coolpix 8800	2/3" CCD	8.0 million	8.8 x 6.6 mm
Olympus C-8080 Wide Zoom	2/3" CCD	8.0 million	8.8 x 6.6 mm
Sony DSC-828	2/3" CCD	8.0 million	8.8 x 6.6 mm
Konica Minolta Dimage A2	2/3" CCD	8.0 million	8.8 x 6.6 mm
Nikon D70s	CCD	6.1 million	23.7 x 15.7 mm
Nikon D2X	CMOS	12.2 million	23.7 x 15.7 mm
Kodak DSC-14n	CMOS	13.8 million	36 x 24 mm
Canon EOS-1Ds Mark II	CMOS	16.6 million	36 x 24 mm

Color CCD Cameras

- Photodiodes are monochrome devices
- In order to capture color, we need to use color filters
- Approaches
  - Use three CCDs (one for each of the RGB channels)
  - Use one CCD with a color filter array (CFA)

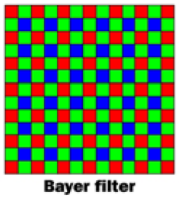
Three-CCD Camera

- A beam splitter is used to project the incident light onto three CCD arrays (RGB)
- Higher quality, but more expensive and bigger cameras



Color Filter Array (CFA)

- Bayer filter Pattern
- Human visual system more sensitive to green
  - Luminance: Y = 0.299*R + 0.587*G + 0.114*B



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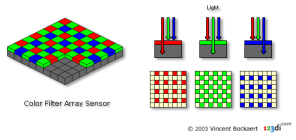
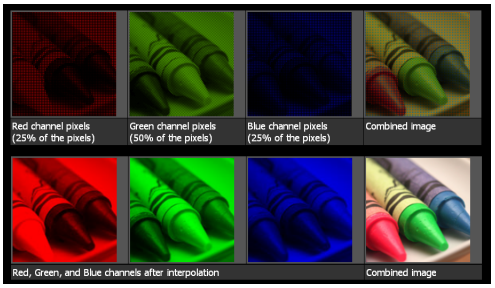
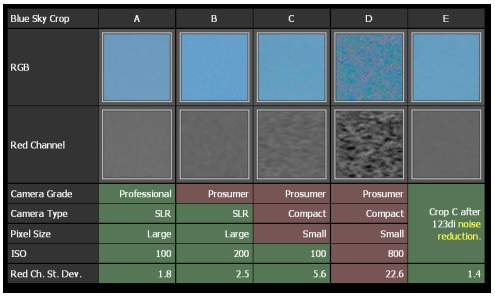


Producing the Final Image



Digital Image Noise



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