02.08.2018

Digital Image Processing (CSE/ECE 478)
Lecture-2: Digital Imaging Fundamentals

Ravi Kiran

Rajvi Shah

Center for Visual Information Technology (CVIT), IIIT Hyderabad

Announcements

- Revised grading policy …
- Assessment
  - 2 mid semester exams (10x2% = 20%) + 1 Final Exam (20%)
  - Assignments (**5** x 6% = 30%) + 1 Final project (30%)
  - Last Assignment due : Oct 18 (2 weeks after MID-2)

Announcements

- Project
  - Proposal due : Oct 8 (a week before MID-2)
  - Final presentation + submission due:
    - Nov 23 (4 days after final DIP exam)
    - Nov 29 (10 days after final DIP exam)
    - Inform choice of date before final exam
    - These dates may move slightly +/- 2 days

Announcements

- Lecture-1 slides up on moodle
- Teaching Assistants
  - Abhijeet (abhijeet@research.iiit.ac.in)
  - Anil Kumar (anil.kumar@research.iiit.ac.in)
  - Ashwin (ashwin.pathak@students.iiit.ac.in)
  - Siddhartha (siddhartha.gairola@research.iiit.ac.in)

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  - Ashwin (ashwin.pathak@students.iiit.ac.in)
  - Siddhartha (siddhartha.gairola@research.iiit.ac.in)
- Tutorial hours : 3.30p – 4.30p, Saturdays, H-203

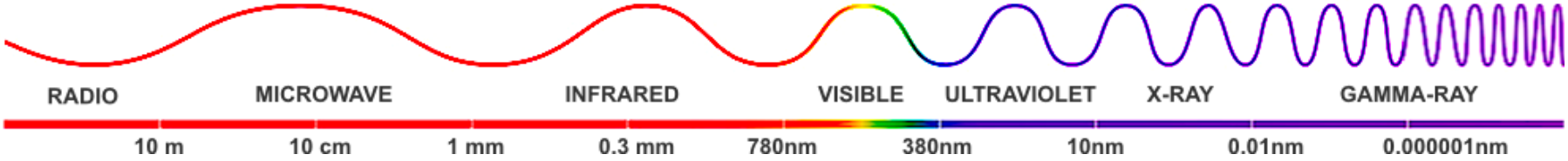
Today's Lecture

- **Digital Image Acquisition**
- Image Sampling and Quantization
- Fundamental Steps in Image Processing

How images are acquired

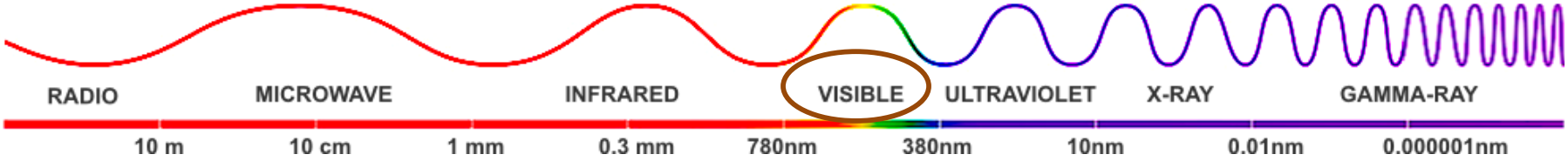
How images end up in digital form

EM spectrum



- EM radiation
  - Energy travelling as a wave
  - Produced by oscillating charge or energy source

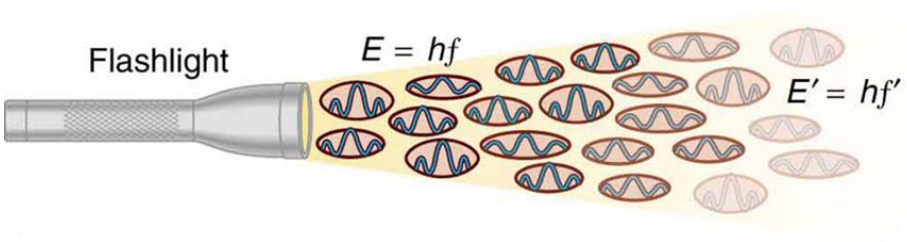
EM spectrum



- EM radiation
  - Energy travelling as a wave
  - Produced by oscillating charge or energy source
- Visible light
  - Band of EM radiation sensed by human eye

Light as a particle stream

- Energy carried by light
  - Not wave-like
  - Discrete (Quantized) particles = Photons



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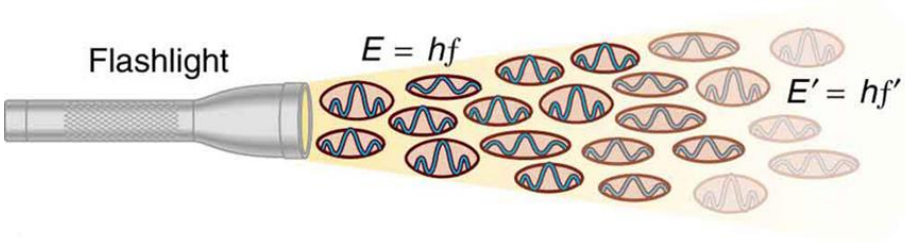


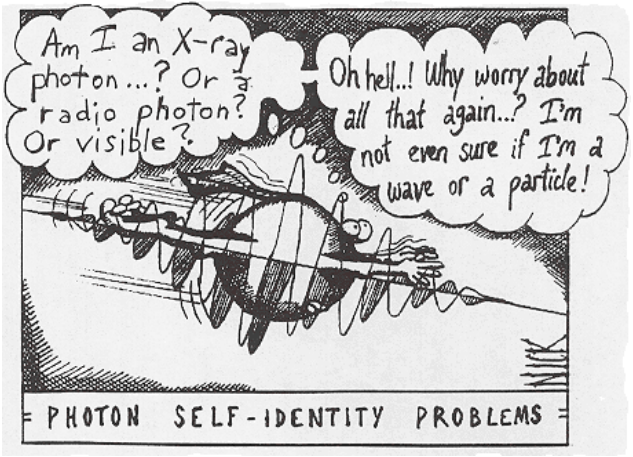
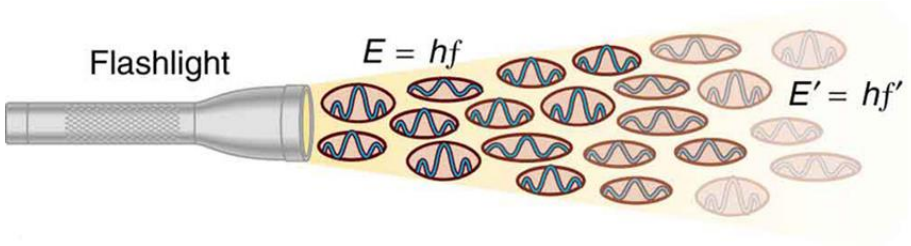
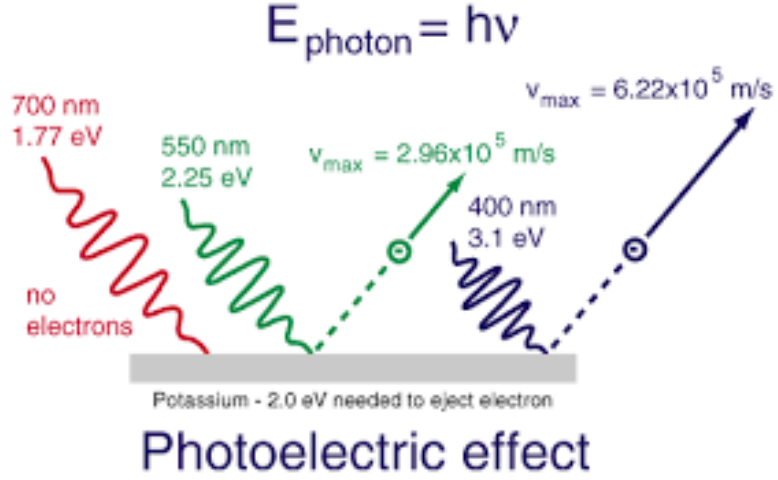


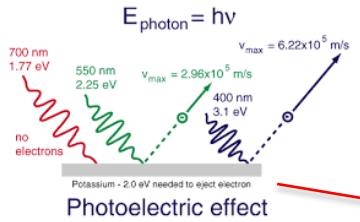
Photo-electric effect

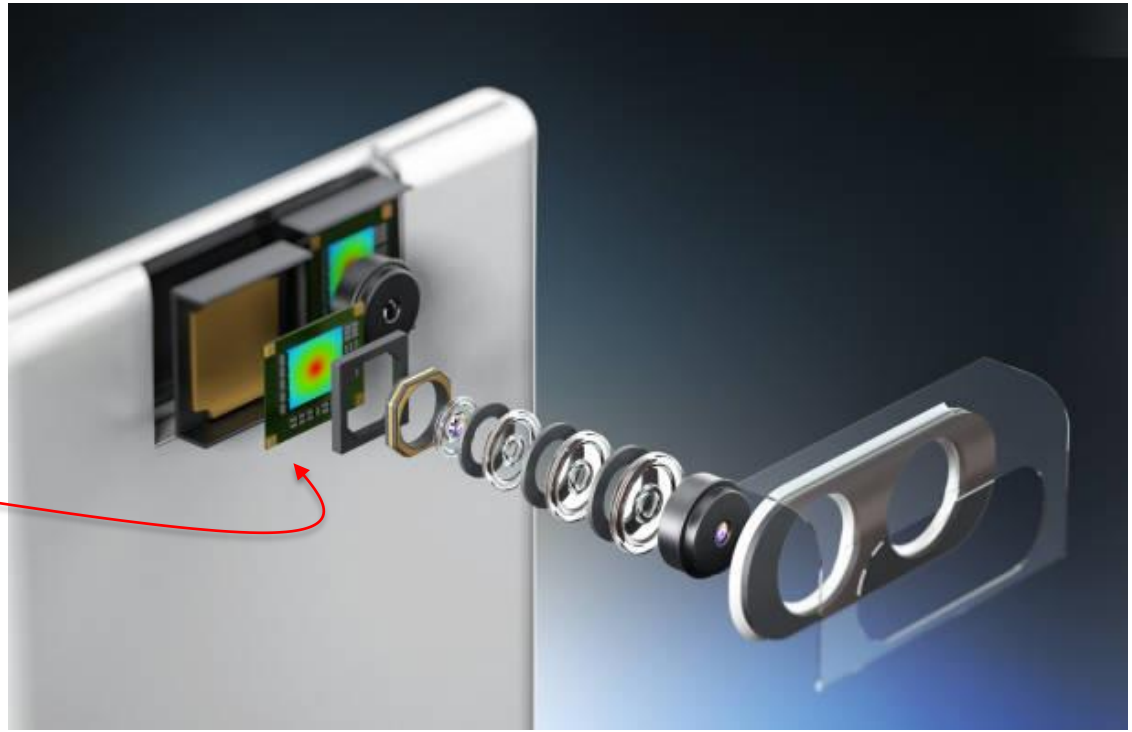




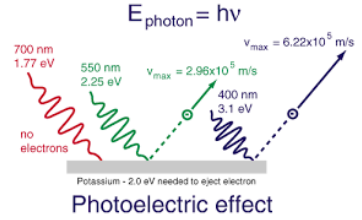
Cross-section of typical smartphone camera

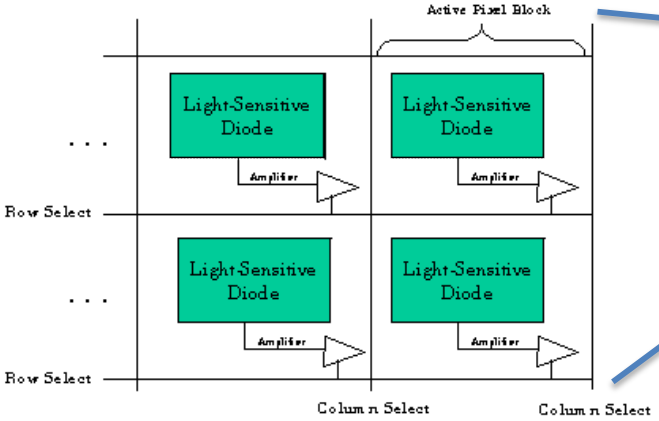
Photo-electric effect in cameras

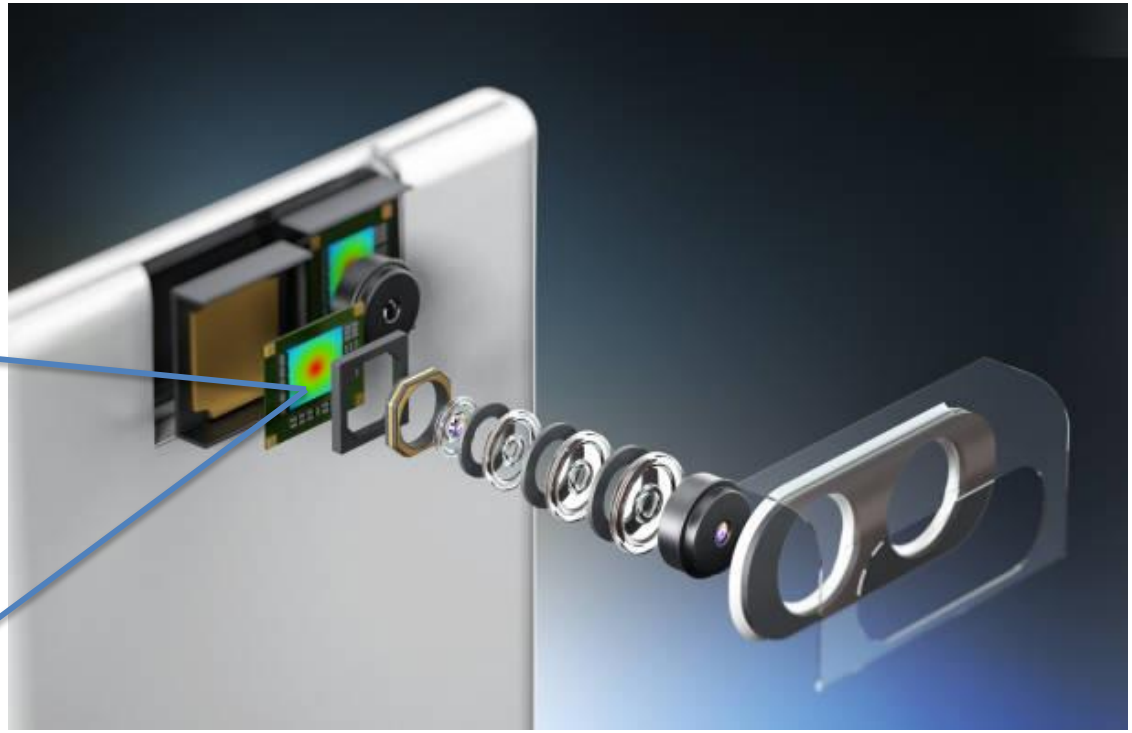




CMOS photo-electric sensor



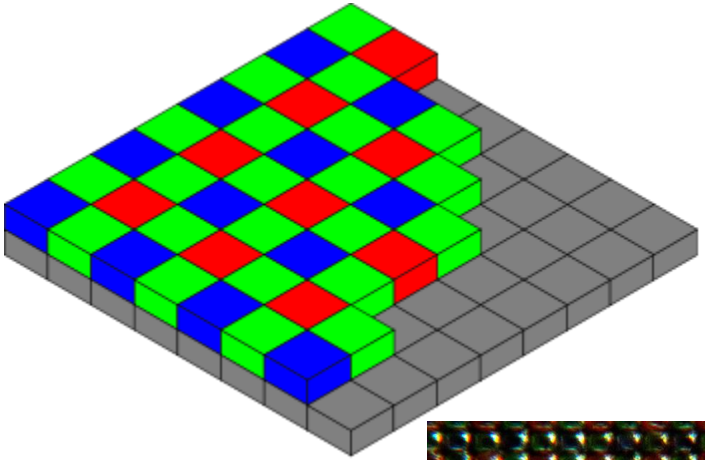


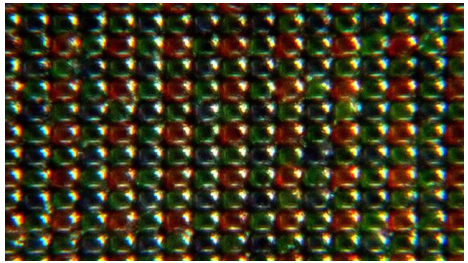


Light → Color

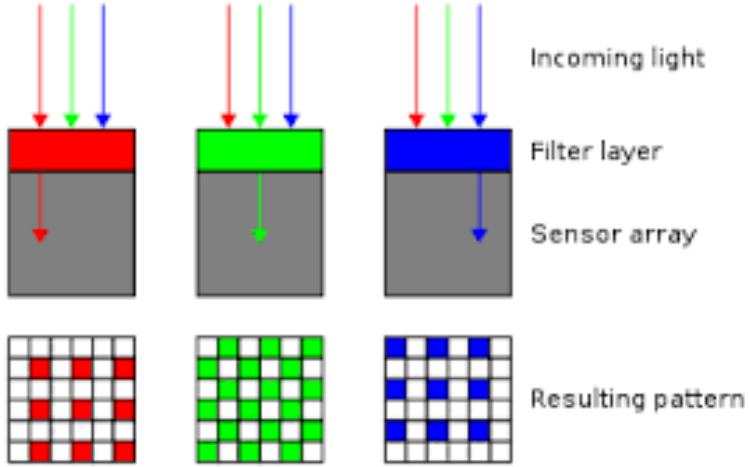
- CMOS sensitive to “light”, not “color”

Bayer Filter





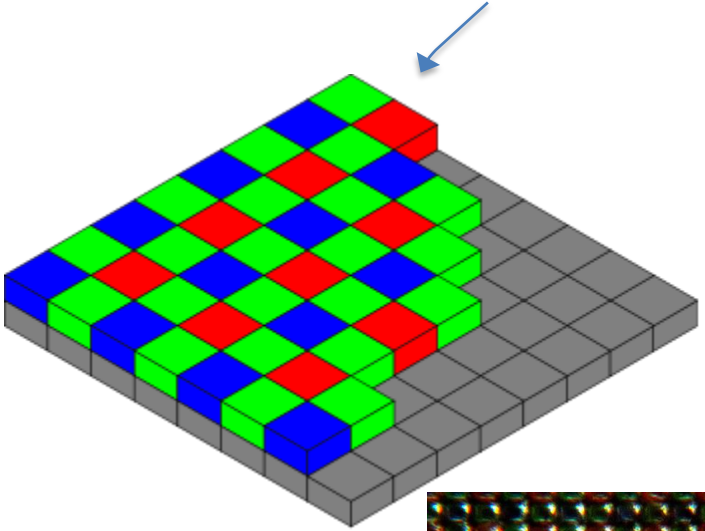
600x

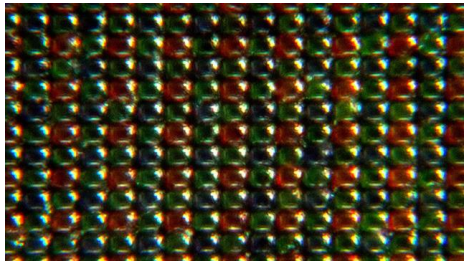


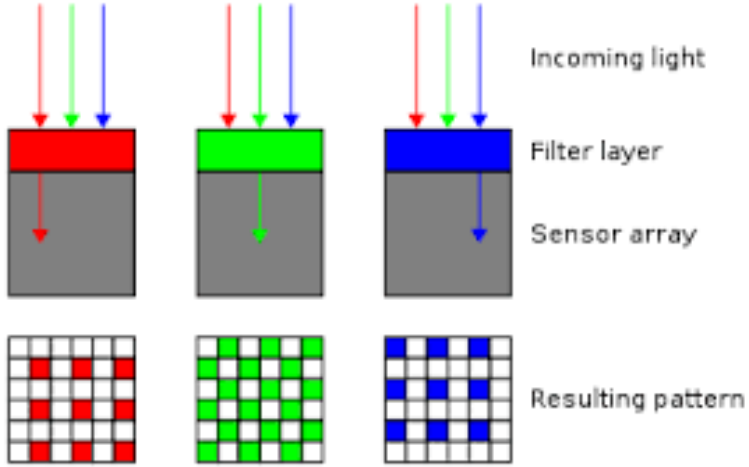
https://en.wikipedia.org/wiki/Bayer_filter

Bayer Filter

Relatively more green filters. Why ?







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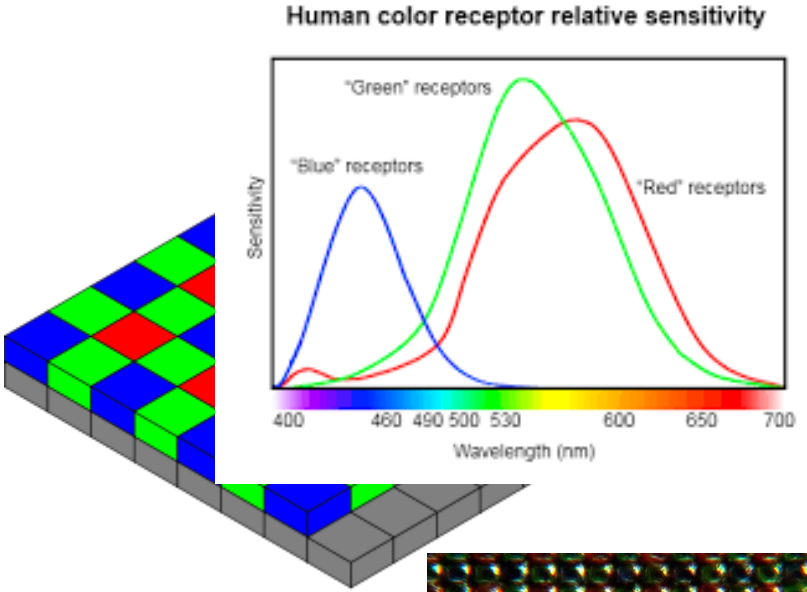
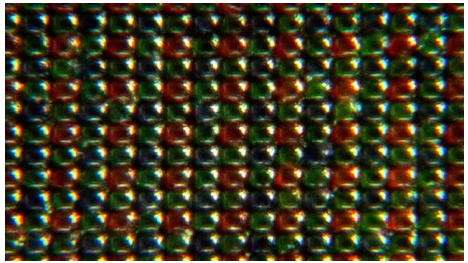
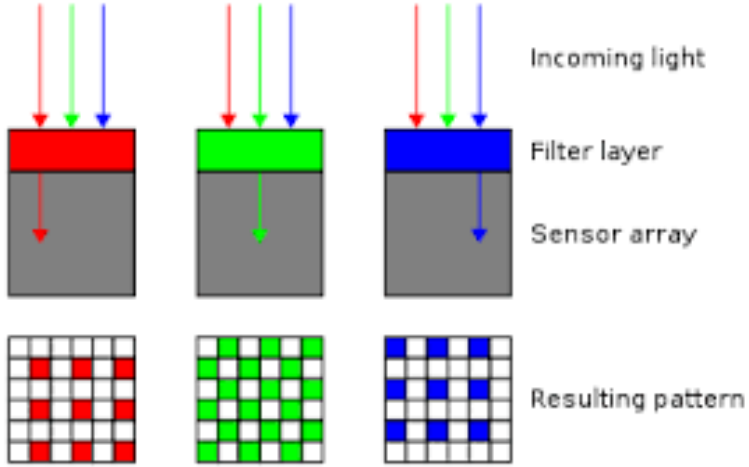
Bayer Filter





https://petapixel.com/2016/03/30/people-can-see-100-times-colors/



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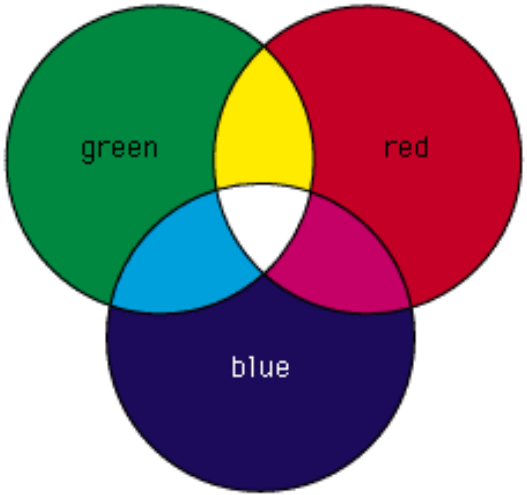
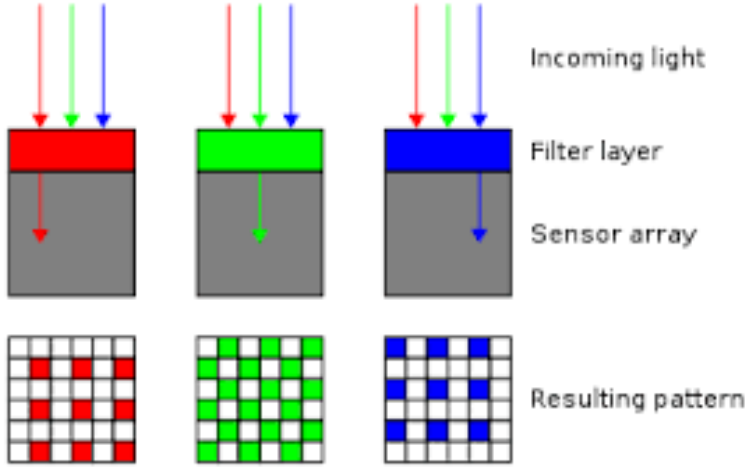
Bayer Filter

- How do we get color now ?





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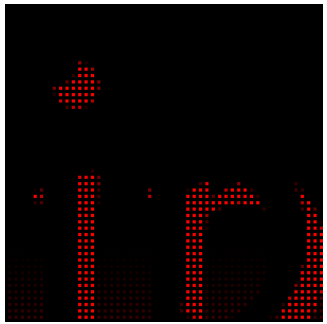
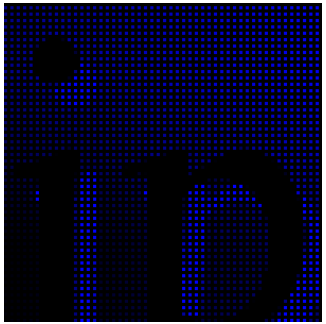
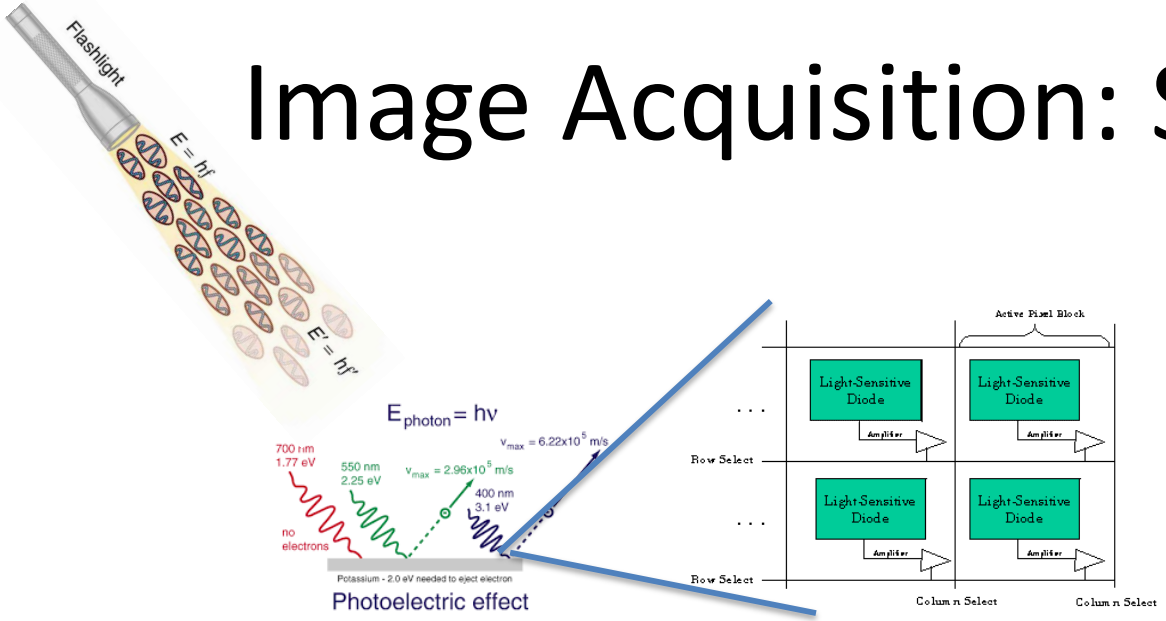
Demosaicing

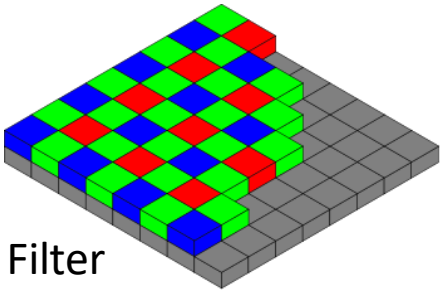




https://en.wikipedia.org/wiki/Demosaicing

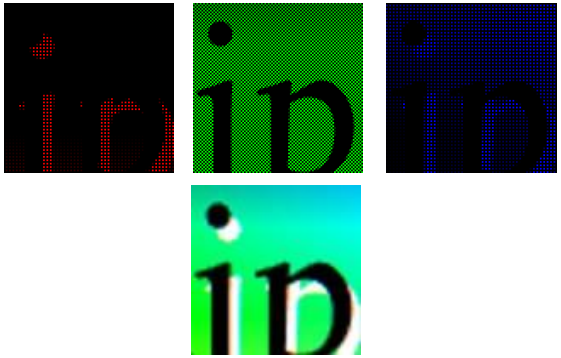
Image Acquisition: Summary





Bayer Filter

Demosaicing

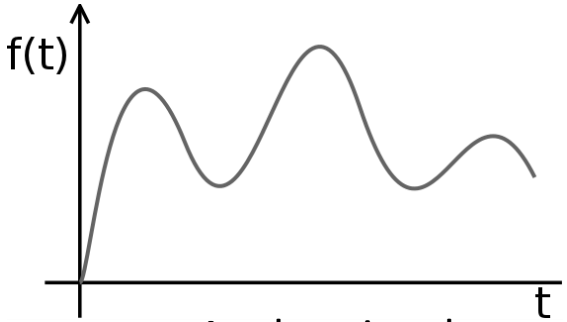


Today’s Lecture

- Digital Image Acquisition
- **Image Sampling and Quantization**
- Fundamental Steps in Image Processing

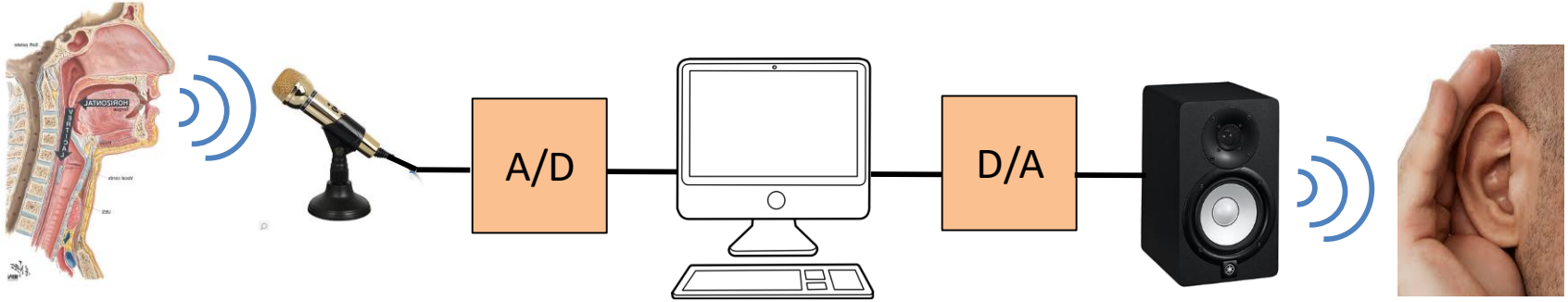
Signal

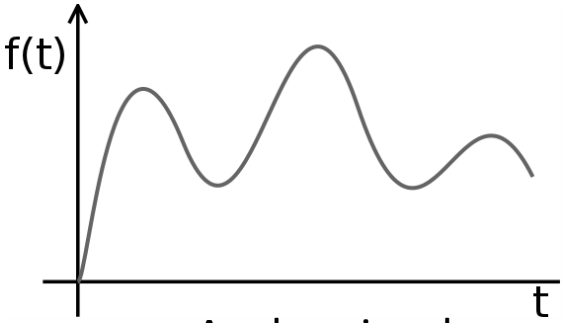
"Function that conveys information about the behavior or attributes of some phenomenon" (wikipedia)



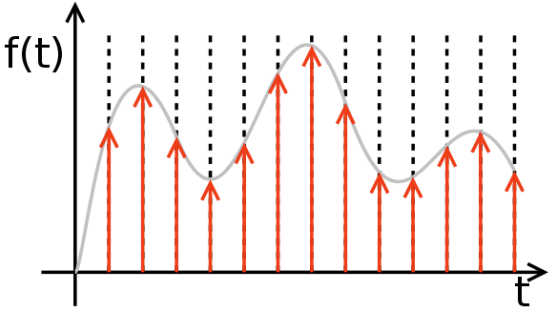
Analog signal

Analog vs. Digital signal (1-D)

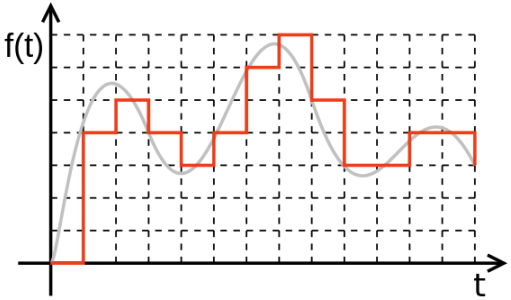




Analog signal



Sampling



Sampling + Quantization

Image courtesy: wikipedia

Analog vs. Digital signal (2-D signal)

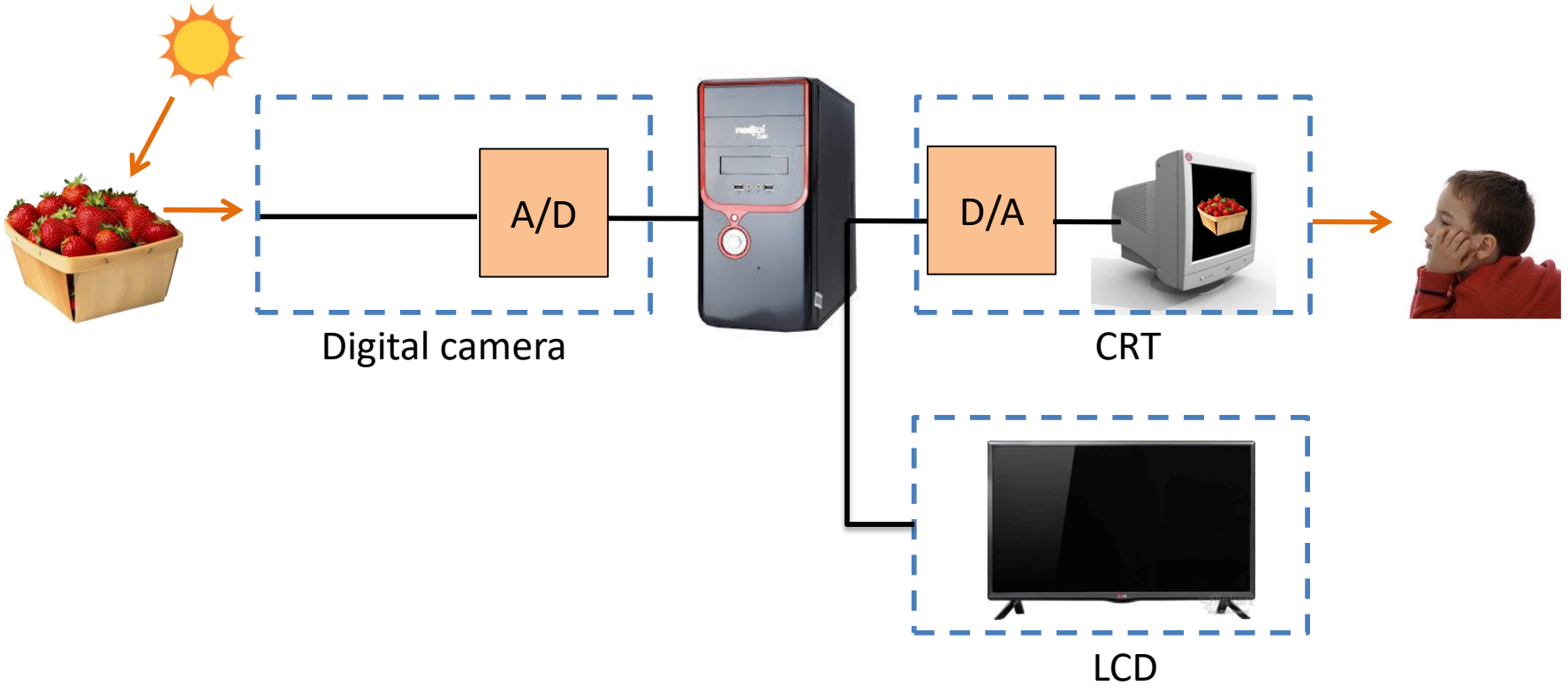
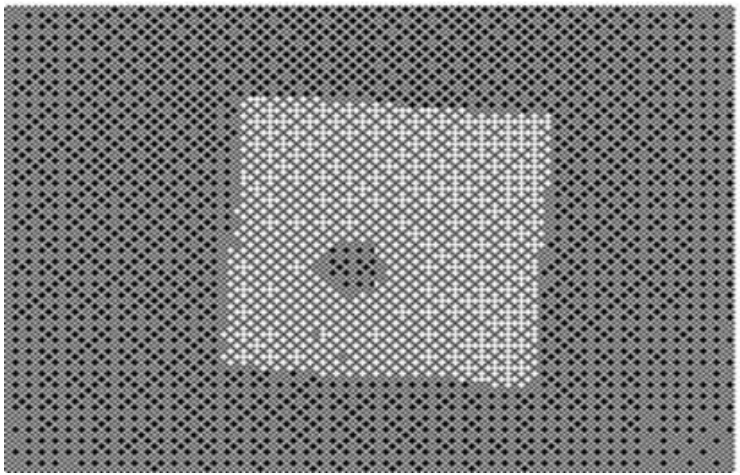


Image as a 3D surface



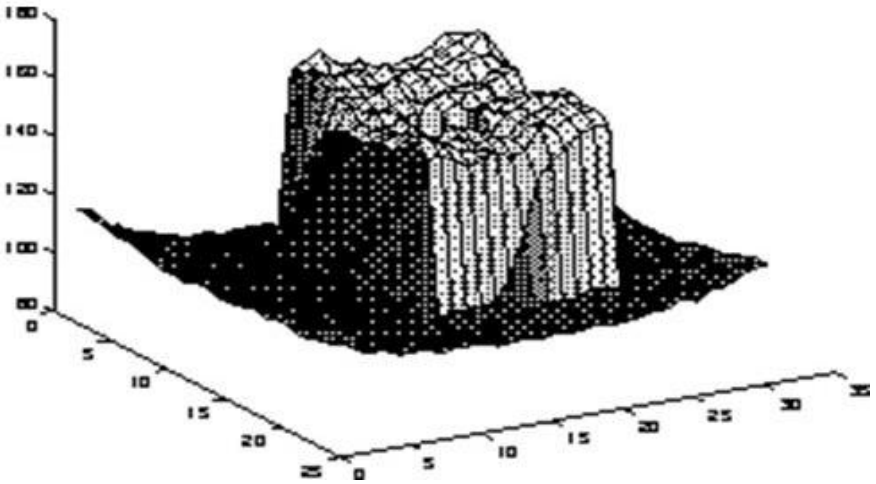


Image acquisition process

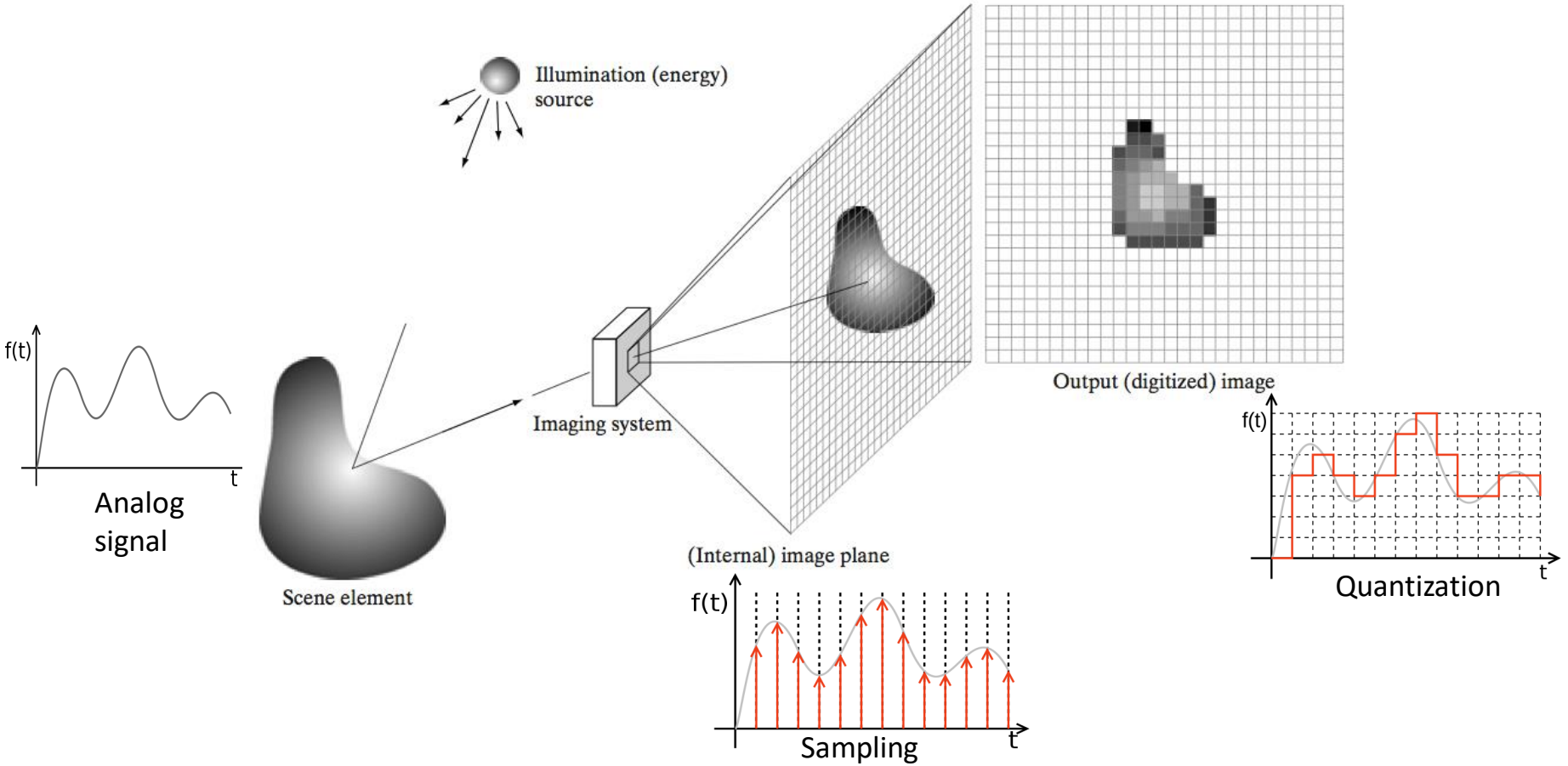
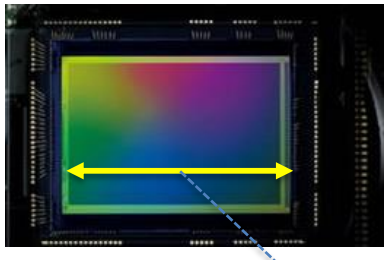


Image courtesy: Gonzalez and Woods

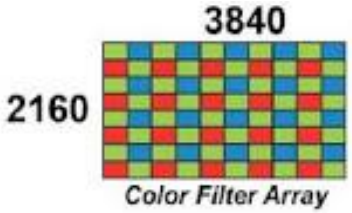
Cross-section of typical smartphone camera

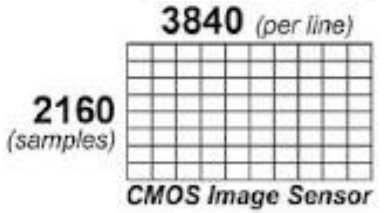
Physical Characteristics	
Active image area size	24.6 (H) x 13.8 (V) mm
Total number photosites	4206 (H) x 2340 (V)
Number photosites for active image	3840 (H) x 2160 (V)
Color filter array (with microlens)	RGB Bayer
Size of photosite (microns)	6.4 (H) x 6.4 µm
Pixel pitch	6.4 µm
Power supply	3.3v / 1.8v
Power consumption	950mW

Resolution (of the sensor)

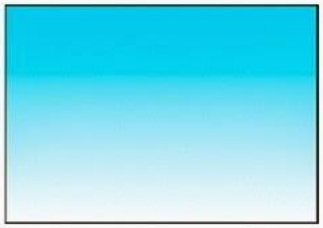


24.6 mm





Digital Camera Sensor Sizes



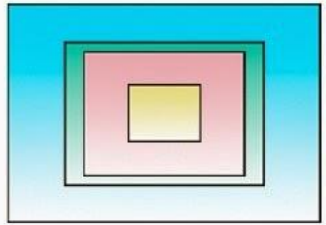
Full Frame Sensor

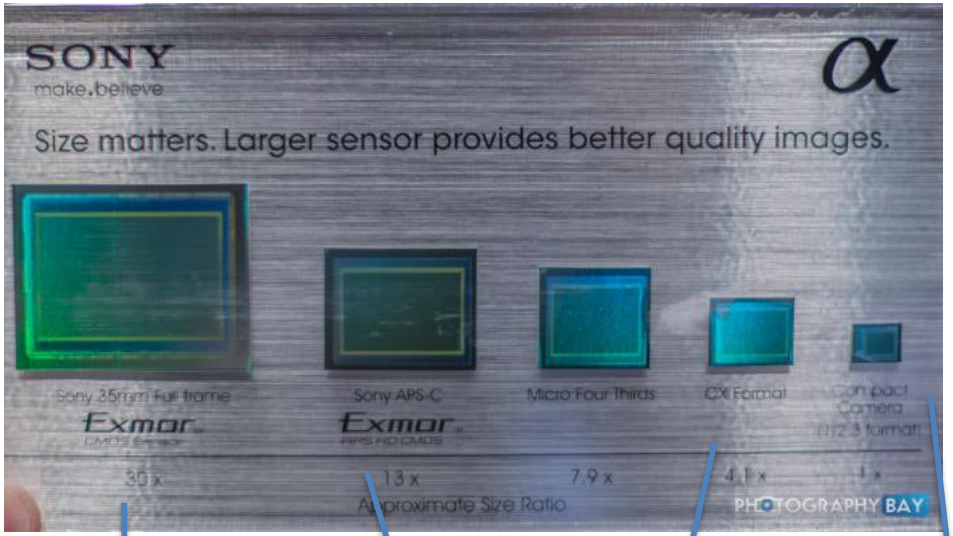
APS Size Sensor

Micro Four Thirds Sensor

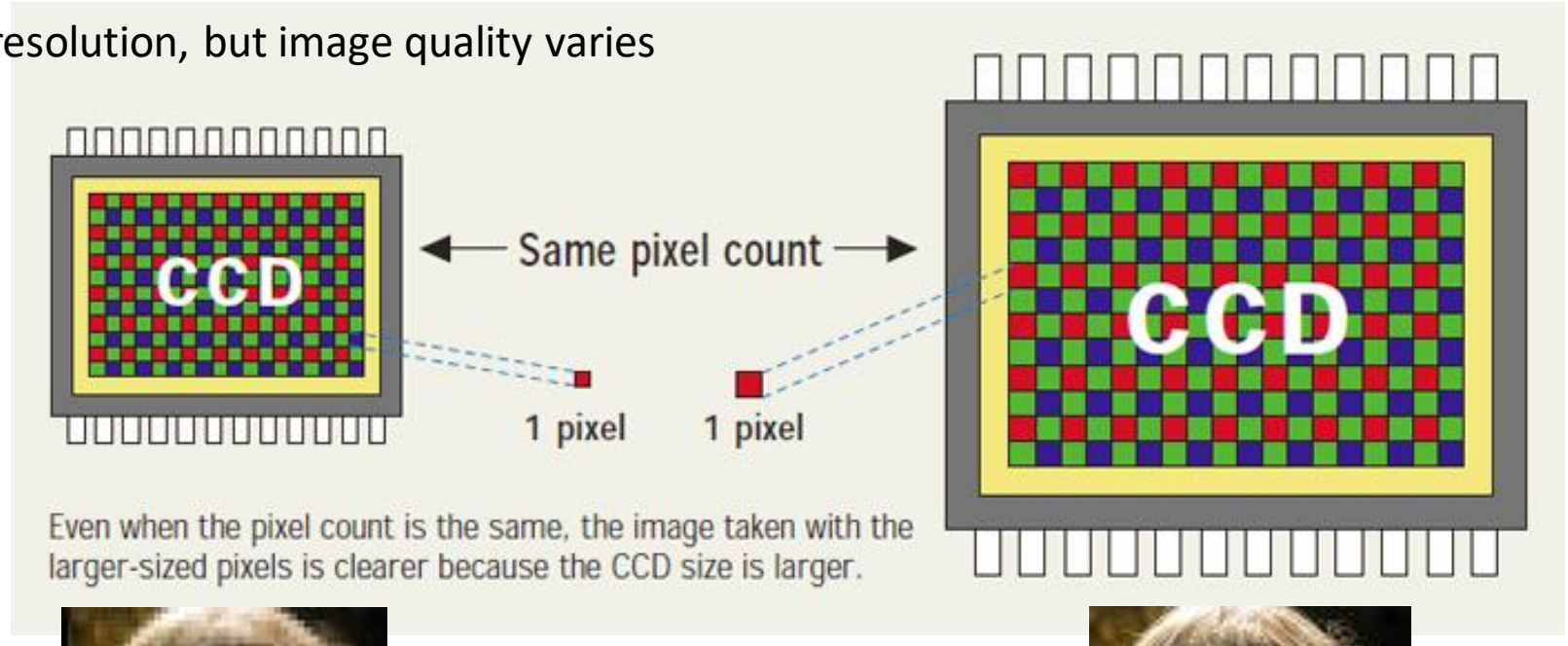
Point and Shoot Sensor

Sensor Size Comparison

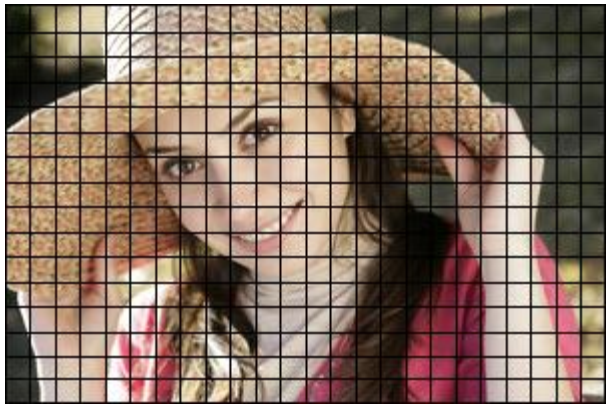



SONY
make.believe
α
Size matters. Larger sensor provides better quality images.
Sony 35mm Full frame
Exmor
Sony APS-C
Exmor
Micro Four Thirds
CX Format
Compact Camera
1/2.3 format
30 x
13 x
7.9 x
4.1 x
1 x
Approximate Size Ratio
PHOTOGRAPHY BAY

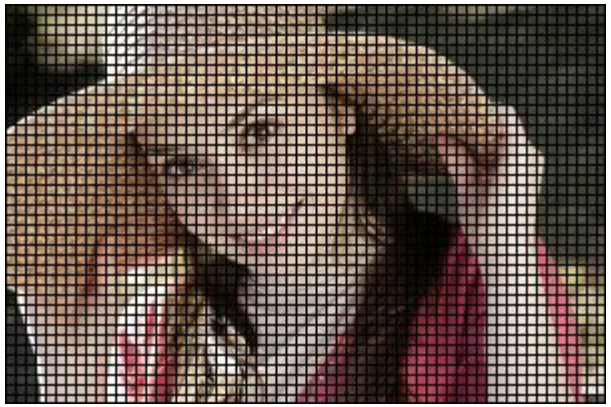
Same resolution, but image quality varies



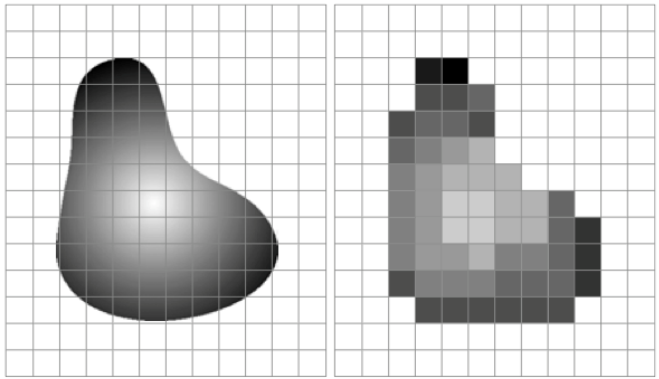
Same sensor size, but # of sensor pixels/mm varies



Small number of CCD pixels

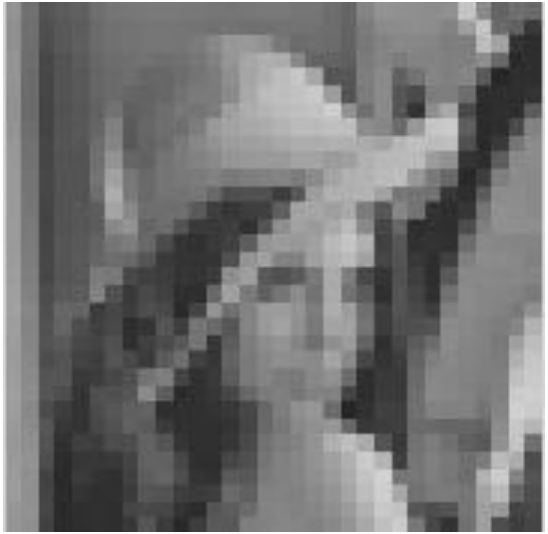


Large number of CCD pixels

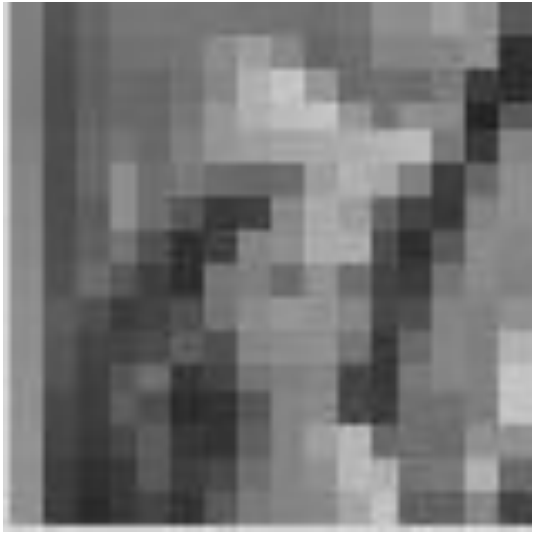


Sampling

256 × 256



32 × 32



16 × 16

Image acquisition process

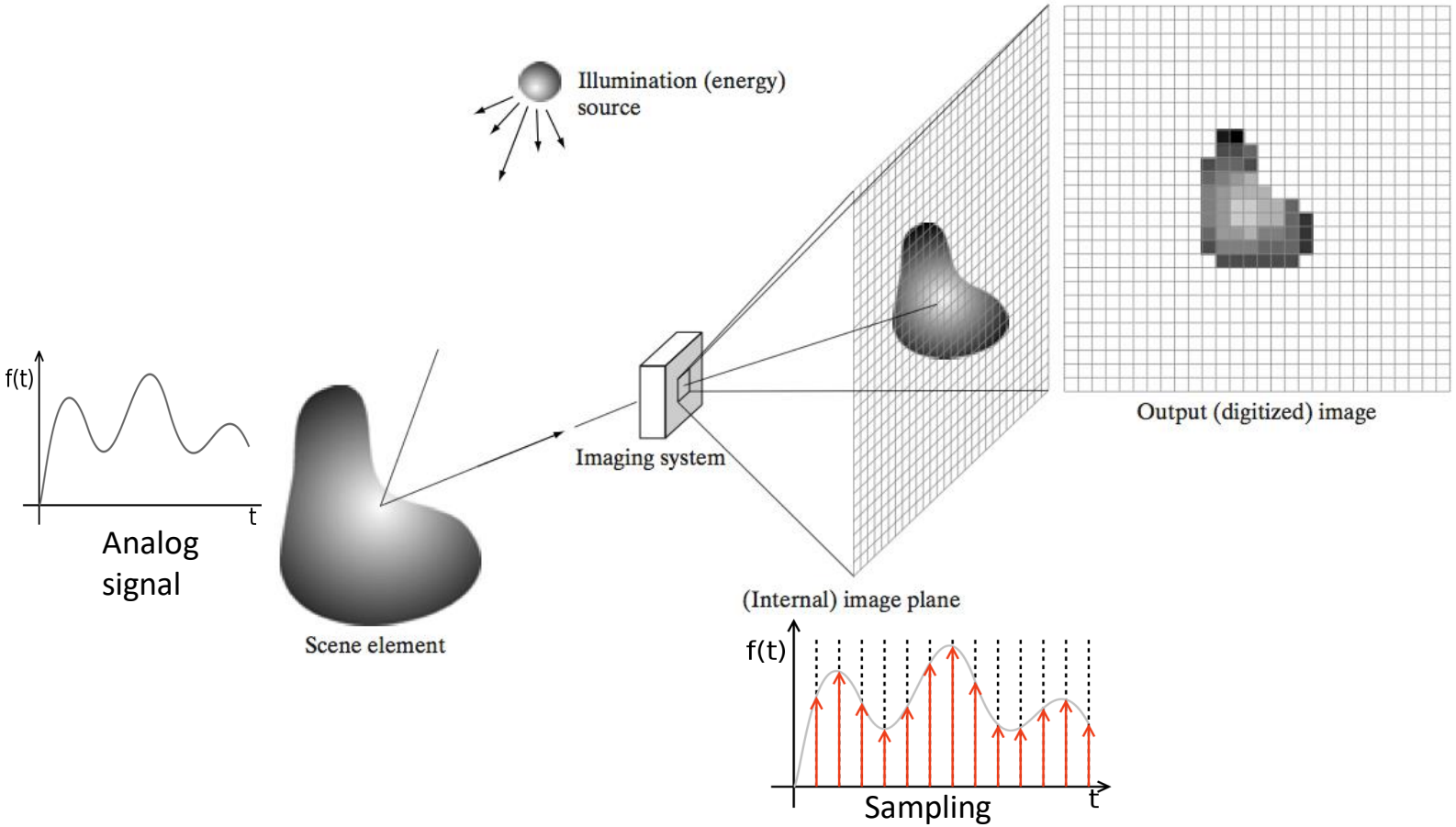


Image courtesy: Gonzalez and Woods

Image acquisition process

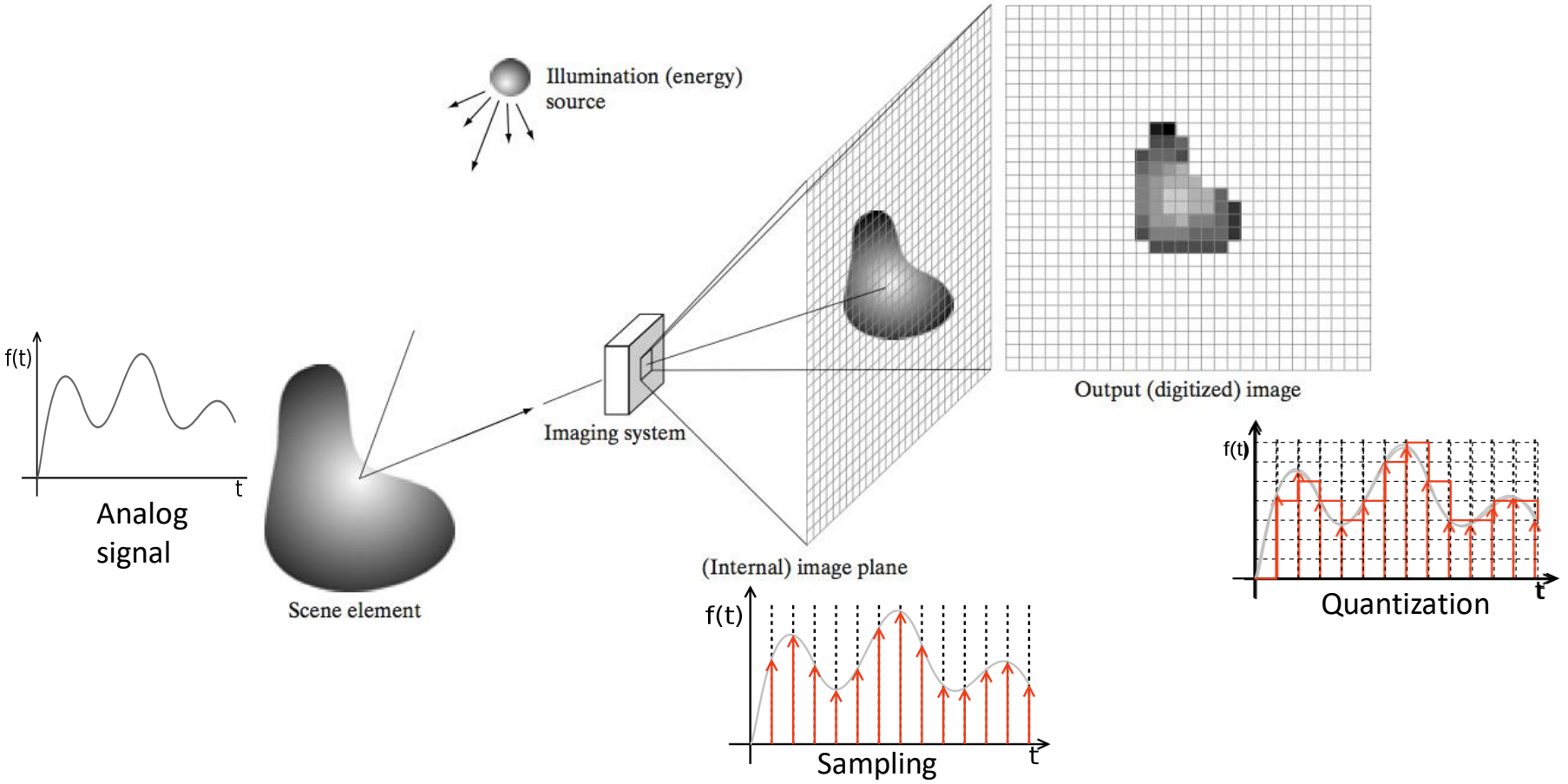


Image courtesy: Gonzalez and Woods

Quantization

8 bits per pixel

4 bits per pixel

2 bits per pixel

1 bit per pixel

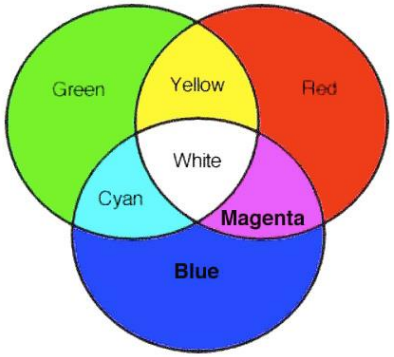
Quantization

1 bit per pixel

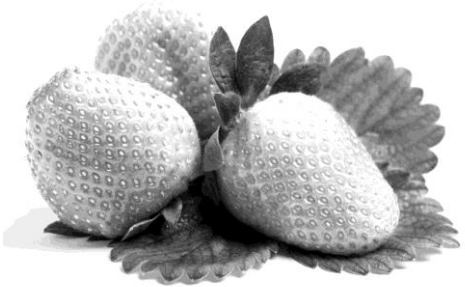
8 bit per pixel

24 bit per pixel

Color Images



R

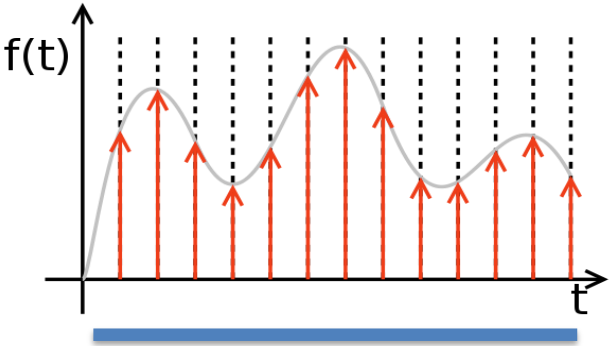


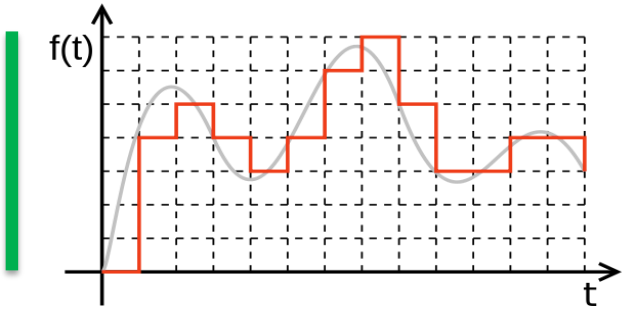
G

B

8 bits per pixel + 8 bits per pixel + 8 bits per pixel

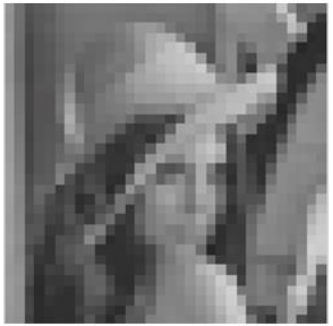
Summary





Sampling

256 × 256



32 × 32

16 × 16

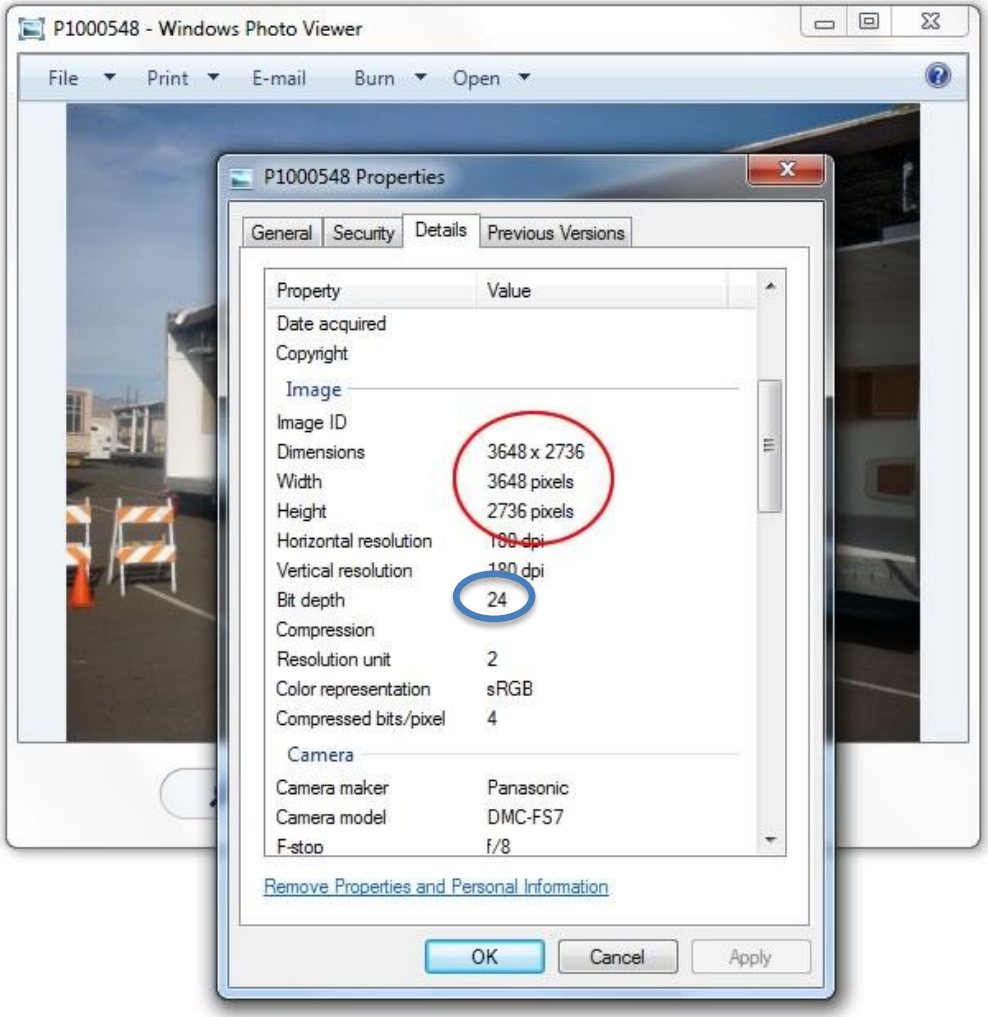
Quantization

8 bits per pixel

4 bits per pixel

2 bits per pixel

1 bit per pixel


P1000548 - Windows Photo Viewer
File
Print
E-mail
Burn
Open
P1000548 Properties
General
Security
Details
Previous Versions
Property
Value
Date acquired
Copyright
Image
Image ID
Dimensions
3648 x 2736
Width
3648 pixels
Height
2736 pixels
Horizontal resolution
180 dpi
Vertical resolution
180 dpi
Bit depth
24
Compression
Resolution unit
2
Color representation
sRGB
Compressed bits/pixel
4
Camera
Camera maker
Panasonic
Camera model
DMC-FS7
F-stop
f/8
Remove Properties and Personal Information
OK
Cancel
Apply

Additional Notes on Sampling and Quantization

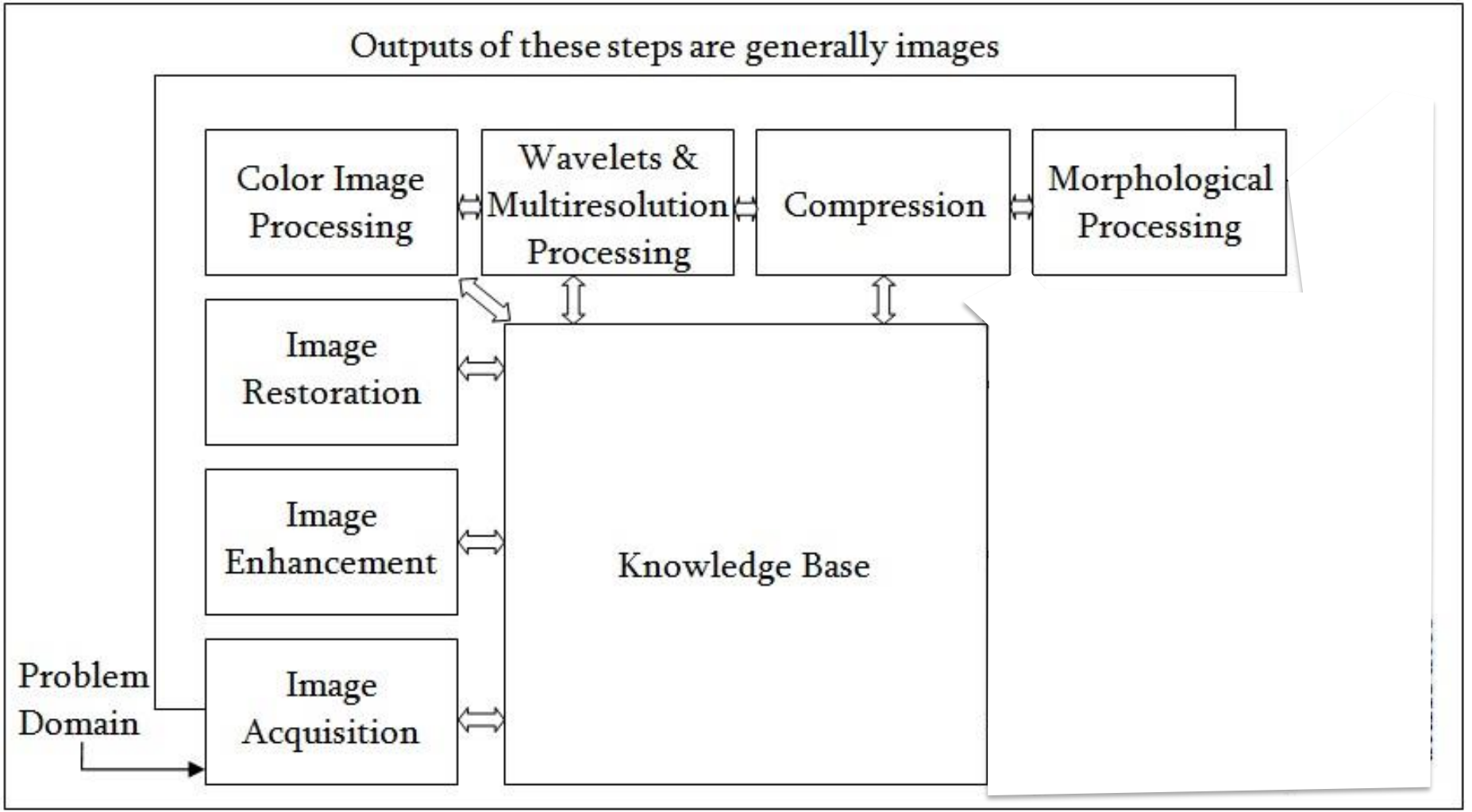
- Temporal sampling → exposure time

Quantization

- Hardware (# of voltage levels, # of bits)
- Software (raw → JPEG)

Today's Lecture

- Digital Image Acquisition
- Image Sampling and Quantization
- **Fundamental Steps in Image Processing**


Outputs of these steps are generally images
Color Image Processing
Wavelets & Multiresolution Processing
Compression
Morphological Processing
Image Restoration
Image Enhancement
Image Acquisition
Knowledge Base
Problem Domain

Outputs of these steps are generally images

Color Image Processing

Image Restoration

Image Enhancement

Image Acquisition

Problem Domain

Outputs of these steps are generally images

Color Image Processing

Wavelets & Multiresolution Processing

Compression

Morphological Processing

Image Restoration

Image Enhancement

Problem Domain

Image Acquisition

Outputs of these steps are generally images

Color Image Processing

Wavelets & Multiresolution Processing

Compression

Morphological Processing

Image Restoration

Image Enhancement

Image Acquisition

Problem Domain

Uncorrected Image

With .Look Applied

Outputs of these steps are generally images

Color Image Processing

Wavelets & Multiresolution Processing

Compression

Morphological Processing

Image Restoration

Image Enhancement

Image Acquisition

Problem Domain

Size-270 KB

Size-22 KB

"Without Compression a CD store only 200 Pictures or 8 Seconds Movie"

Outputs of these steps are generally images

Color Image Processing

Wavelets & Multiresolution Processing

Compression

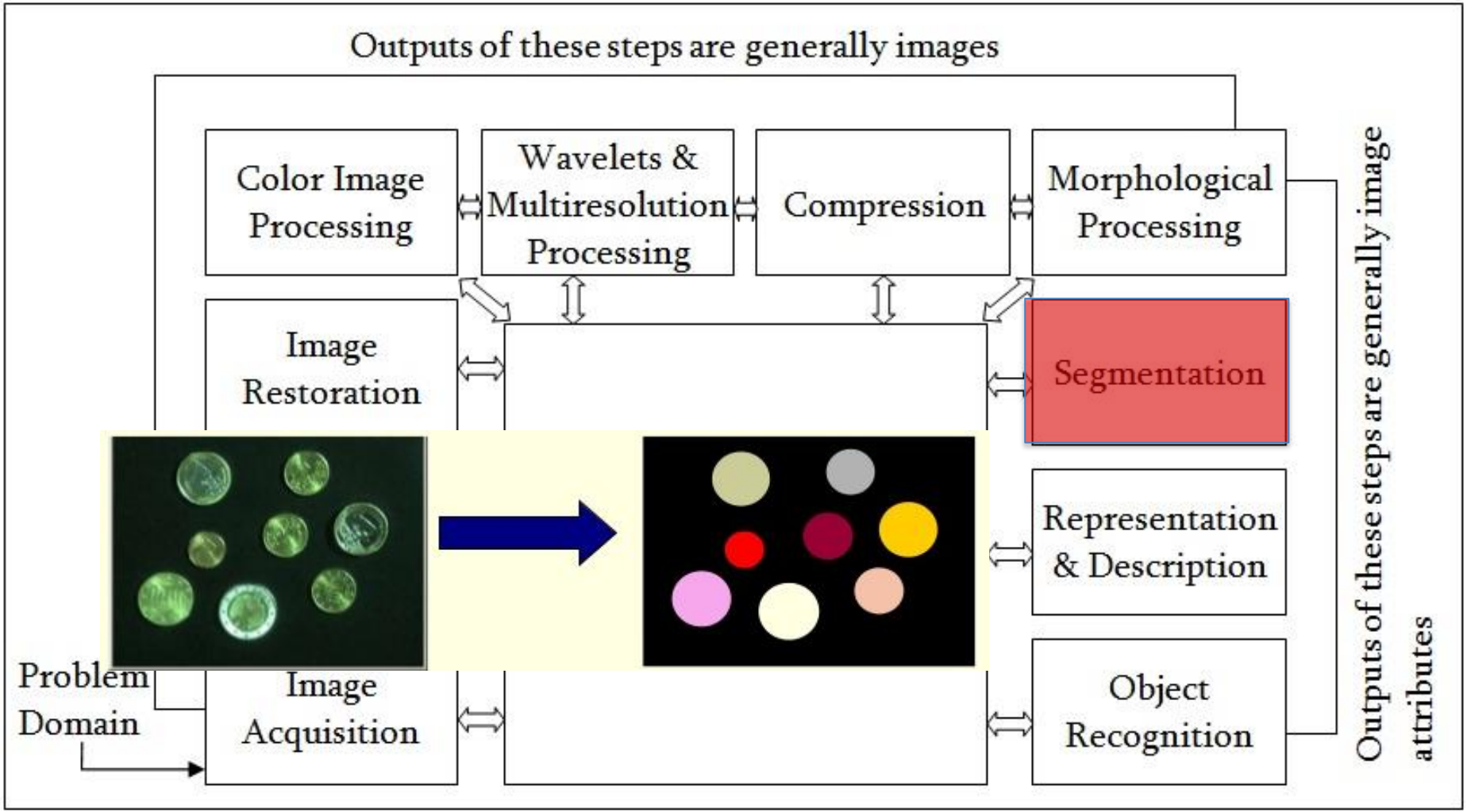
Morphological Processing

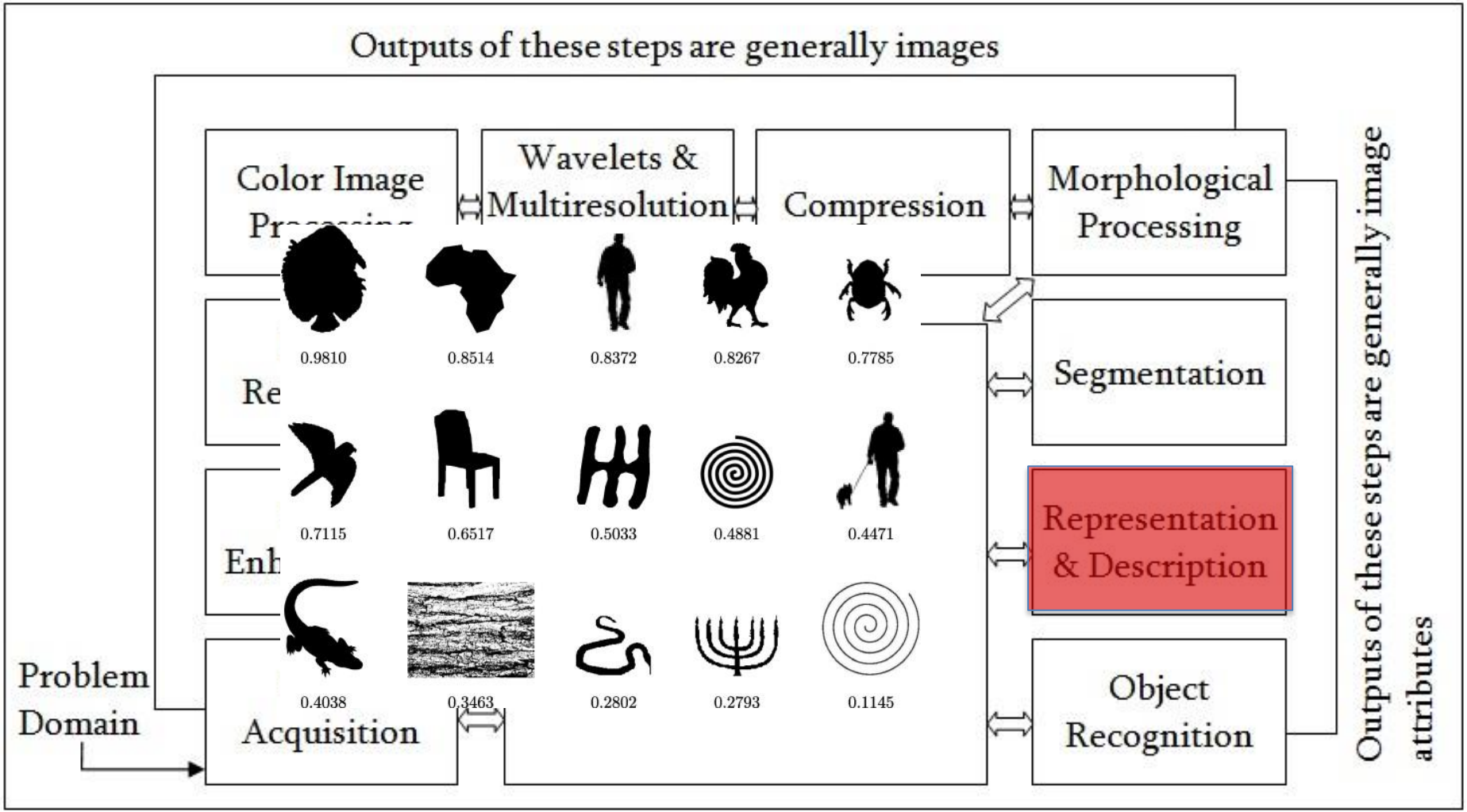
Image Restoratic

Image Enhancem

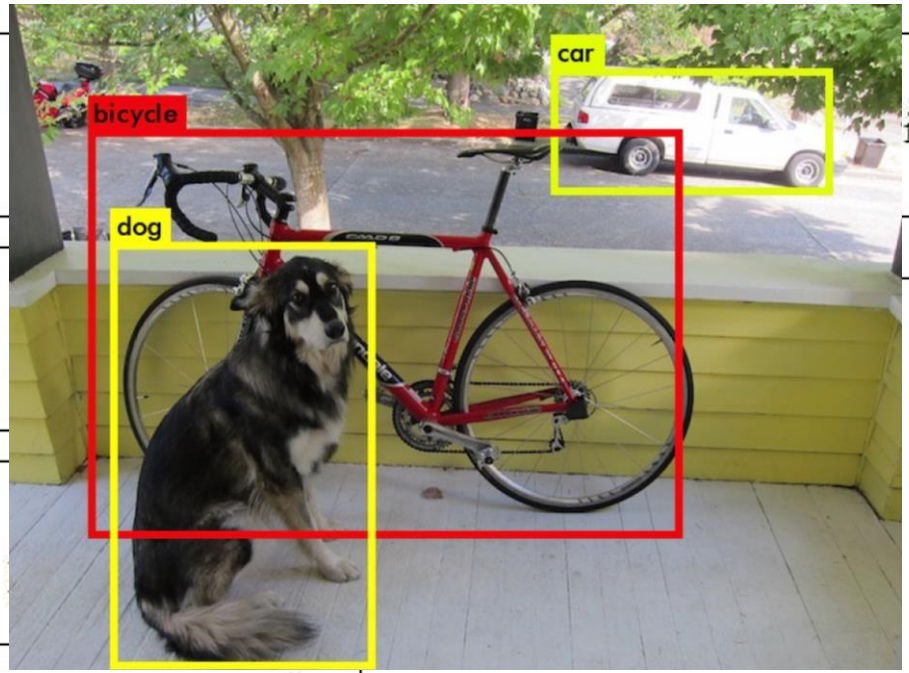
Image Acquisitic

Problem Domain


Outputs of these steps are generally images
Color Image Processing
Wavelets & Multiresolution Processing
Compression
Morphological Processing
Image Restoration
Segmentation
Representation & Description
Problem Domain
Image Acquisition
Object Recognition
Outputs of these steps are generally image attributes


Outputs of these steps are generally images
Color Image Processing
Wavelets & Multiresolution
Compression
Morphological Processing
Segmentation
Representation & Description
Object Recognition
Acquisition
Problem Domain
Outputs of these steps are generally image attributes
0.9810
0.8514
0.8372
0.8267
0.7785
0.7115
0.6517
0.5033
0.4881
0.4471
0.4038
0.3463
0.2802
0.2793
0.1145

Outputs of these steps are generally images



Problem Domain

Image Acquisition

ion

Morphological Processing

Segmentation

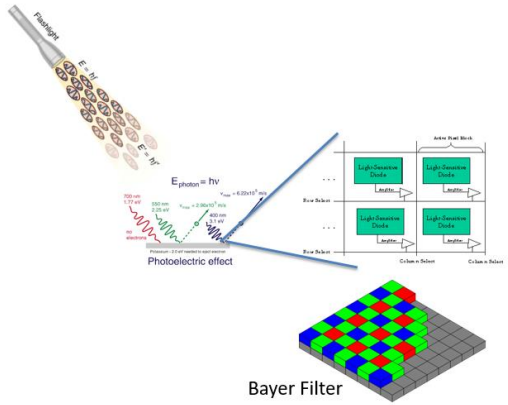
Representation & Description

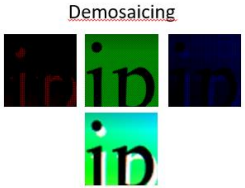
Object Recognition

Outputs of these steps are generally image attributes

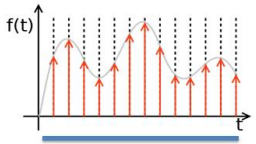
What we saw today

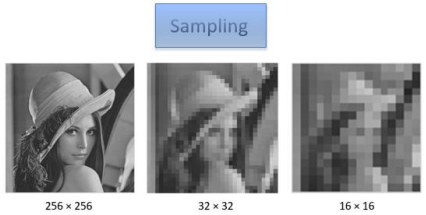
Digital Image Acquisition

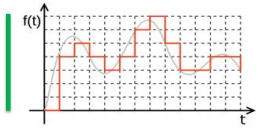


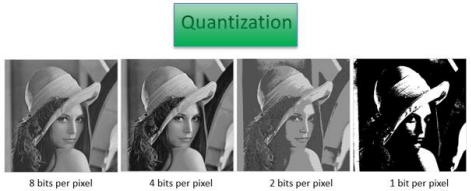


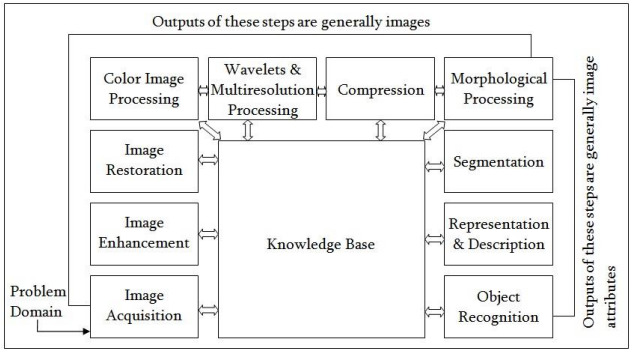
Sampling and Quantization











Fundamental Steps in Image Processing

Coming up …

- Intensity Transformations
- Histograms and Histogram Processing
- NOTE: No class on Monday (Bonalu)