BREADTH Scholars Curriculum

School of Engineering
BROWN UNIVERSITY

AI Monitoring Through Computer Vision:

Image Acquisition and Image Processing Basics

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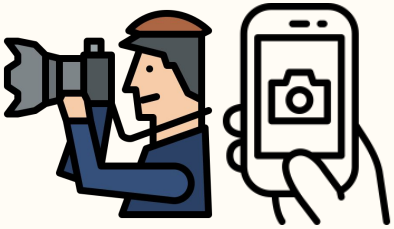
What is Computer Vision?

Computer vision is an analysis of digital images by a computer for various applications.



Stages of Computer Vision

Low-Level

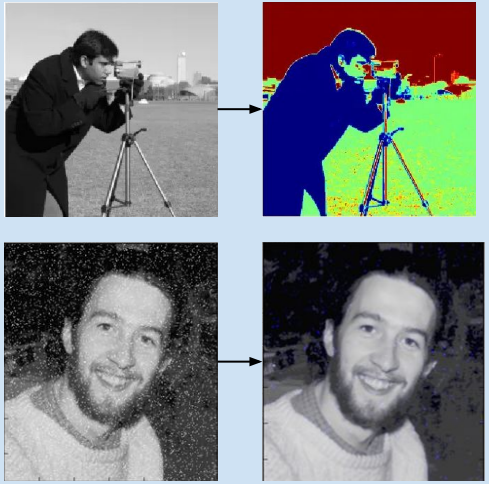


Image → Image
(image processing)

Mid-Level

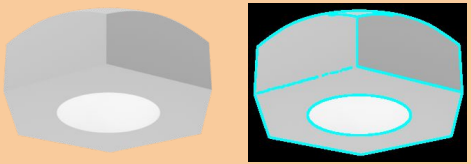
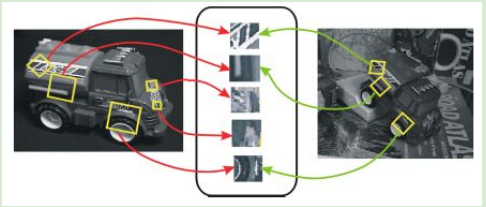


Image source: https://phototour.cs.washington.edu/

Image → features
(feature extraction)

High-Level



features → recognition
(object tracking,
reconstruction, etc)

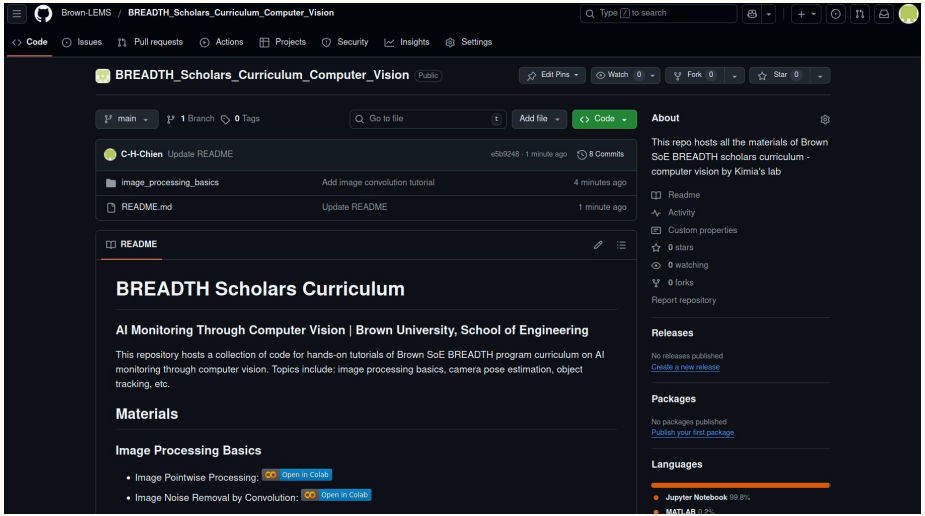
Knowledge + Practical Implementation

PART I: Image Formation & Acquisition

- Practical Implementation: Image Pointwise Processing

Part II: Image Convolution

- Practical Implementation: Image Noise Removal

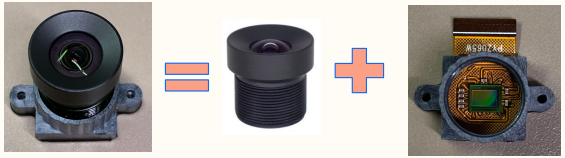


https://github.com/Brown-LEMS/BREADTH_Scholars_Curriculum_Computer_Vision

PART I: Image Formation & Acquisition

What is an image?

Where do images come from?



Optical camera

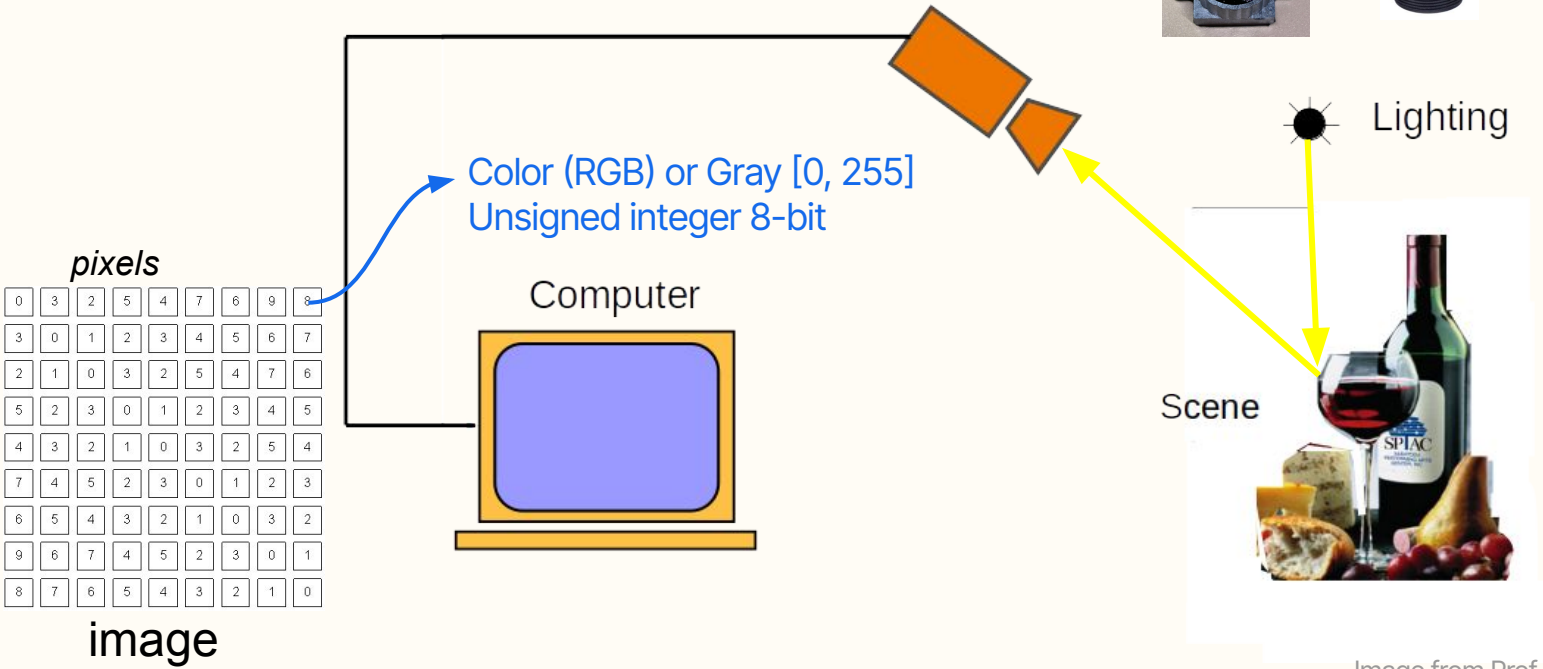
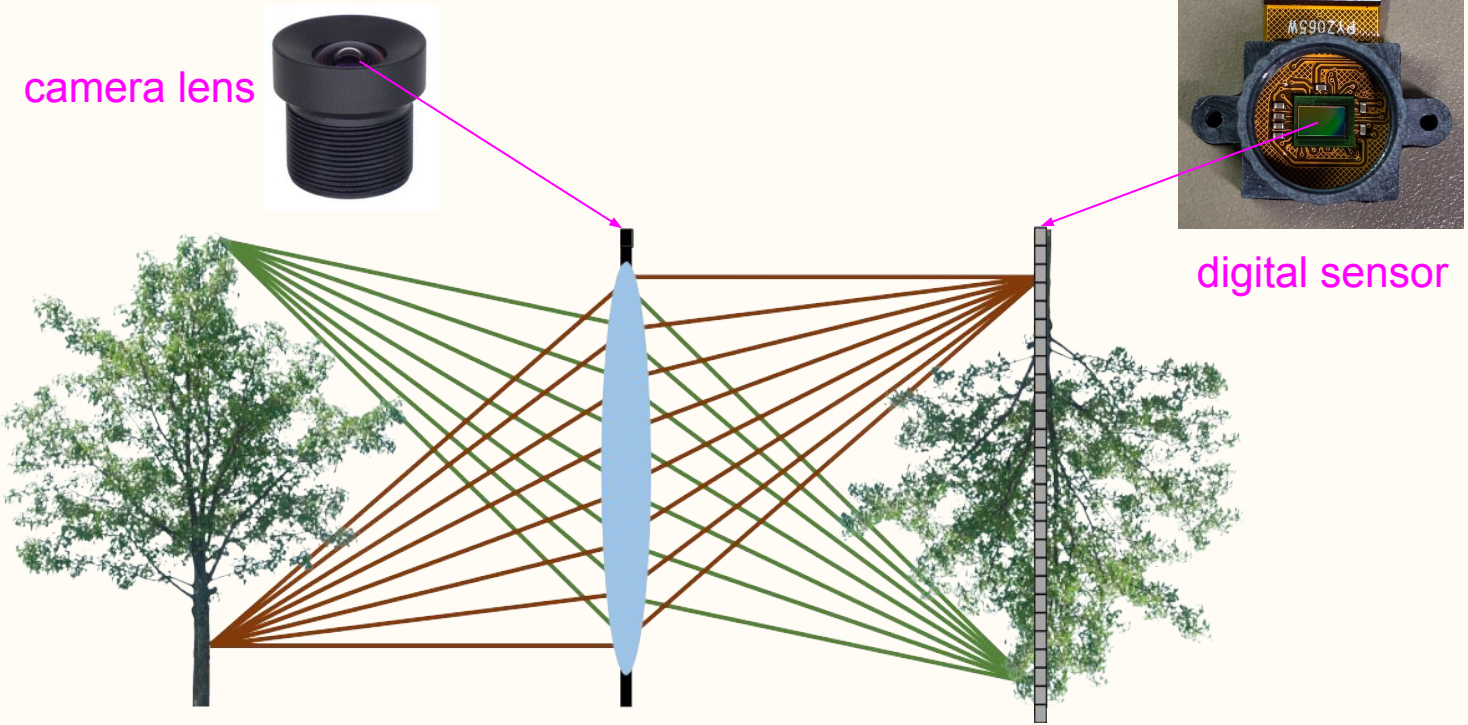


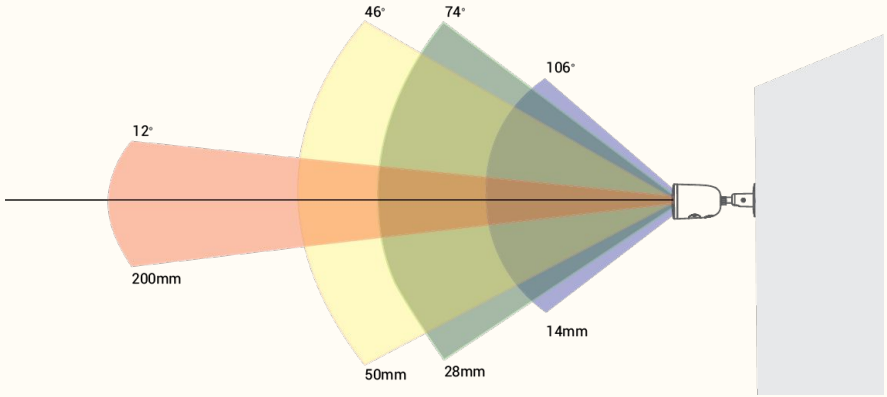
Image from Prof. Srinivasa Narasimhan's slide

PART I: Image Formation & Acquisition



PART I: Image Formation & Acquisition

Field of View (FOV)



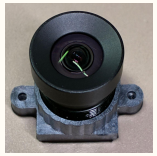
Arducam Camera Lens
M40180H13L

(D/H/V): 122°/110°/94.5°

Field of view depends on the chosen lens, field of view, and sensor size

Frames Per Second (FPS)

Frequency at which consecutive images (frames) are displayed



Arducam OV9281 camera runs
- 45 FPS for 1280 x 800 images
- 140 FPS for 640 x 400 images

Exposure Rate

The amount of light used to expose a photograph

Higher exposure
@ 1 FPS

Normal exposure
@ 45 FPS

PART I: Image Formation & Acquisition

Let's look at the code: Image Pointwise Processing

- Reading and viewing the image
- Understanding how images are interpreted in computers
- Image intensity histogram
- Increasing image intensity contrast
- Image thresholding

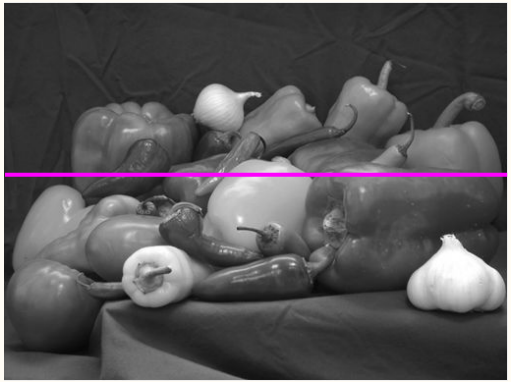
https://github.com/Brown-LEMS/BREADTH_Scholars_Curriculum_Computer_Vision

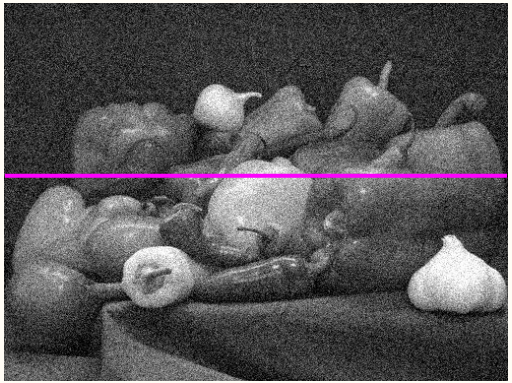
PART II: Image Convolution

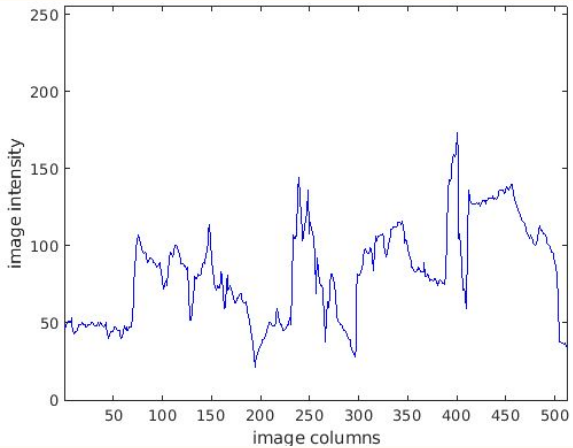
Image signals are often corrupted with *noise*

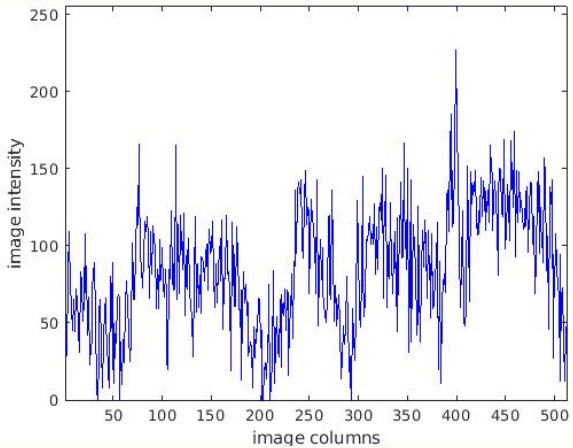
- Irregularity: lacks continuity and appears as rapid, random fluctuations without correlation across neighboring points, exhibiting a wide spectrum of *frequencies*

PART II: Image Convolution

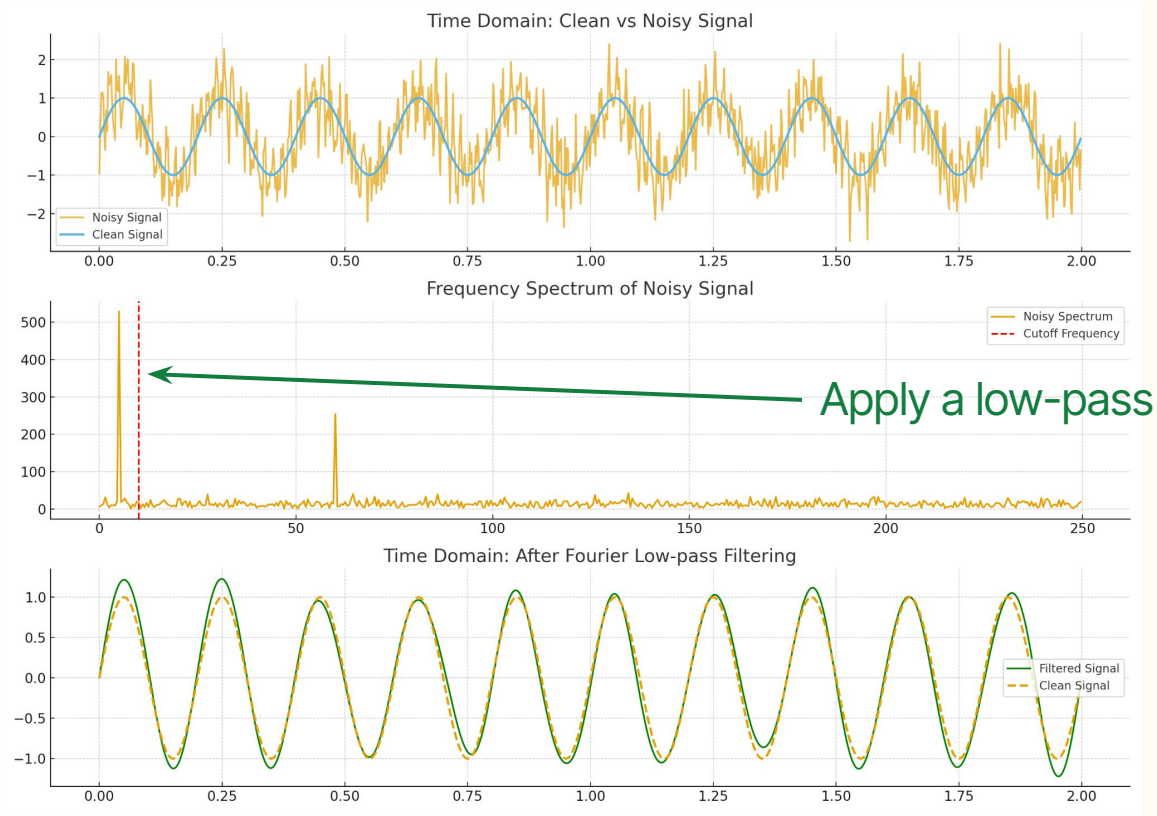




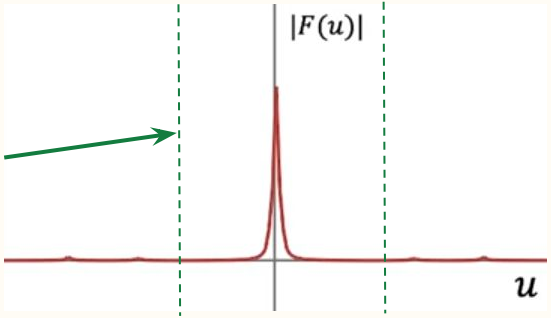




PART II: Image Convolution



Apply a low-pass filter



PART II: Image Convolution

The change between time and frequency domains is captured by Fourier transform

$$F(\omega) = \int_{-\infty}^{\infty} f(x) e^{-i\omega x}\, dx$$

signal in frequency domain — signal in time domain

Let's say we have a low-pass filter *H(w)* so that

$$G(\omega) = F(\omega)H(\omega)$$

which in time domain

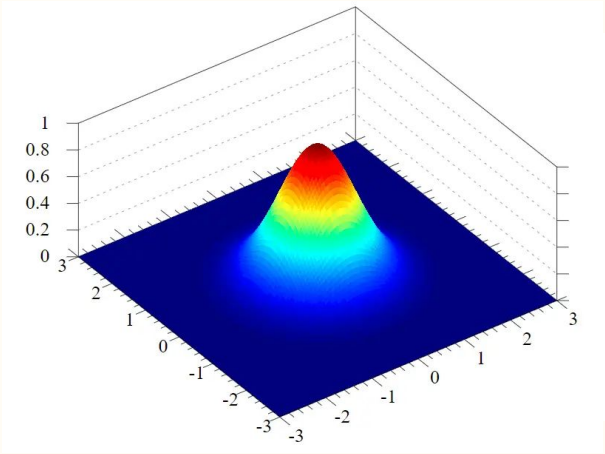
$$g(t) = f(t) * h(t)$$

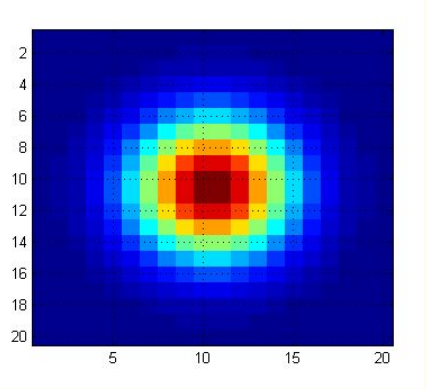
convolution!

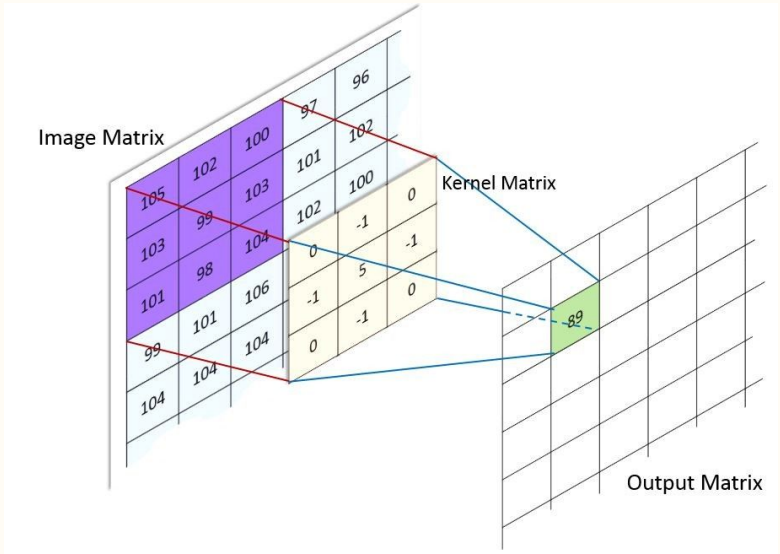
A good low-pass filter is a Gaussian function

PART II: Image Convolution

On an image, we need a 2D discrete Gaussian kernel







- Other types of kernels extract features on an image
  - Convolutional Neural Network (CNN) learns the kernel to extract image features for various applications

PART II: Image Convolution

Let's look at the code: Image Noise Removal by Convolution

- Removing noise from the image
- Evaluate the effectiveness of Gaussian convolved images with an edge detector
- Explore convolution through separable 1D Gaussian kernels

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