

# CS4243

# Computer Vision & Pattern Recognition

AY 2023/24

## Lab Session 1



**NUS**  
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School of  
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# Teaching Assistants



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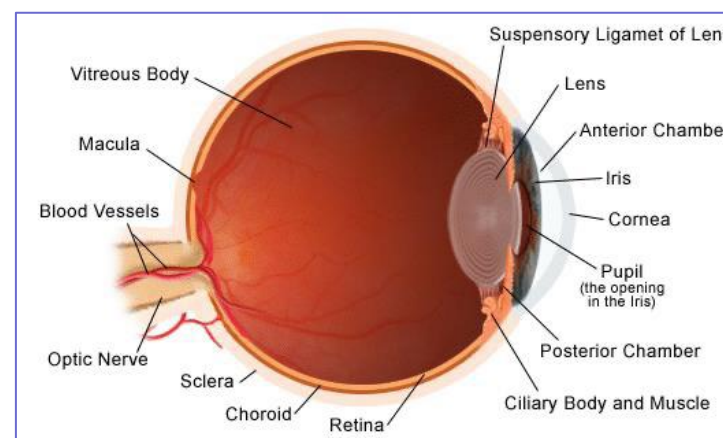
[xiaocao@u.nus.edu](mailto:xiaocao@u.nus.edu)



# Lesson 1

## Introduction and Fundamentals

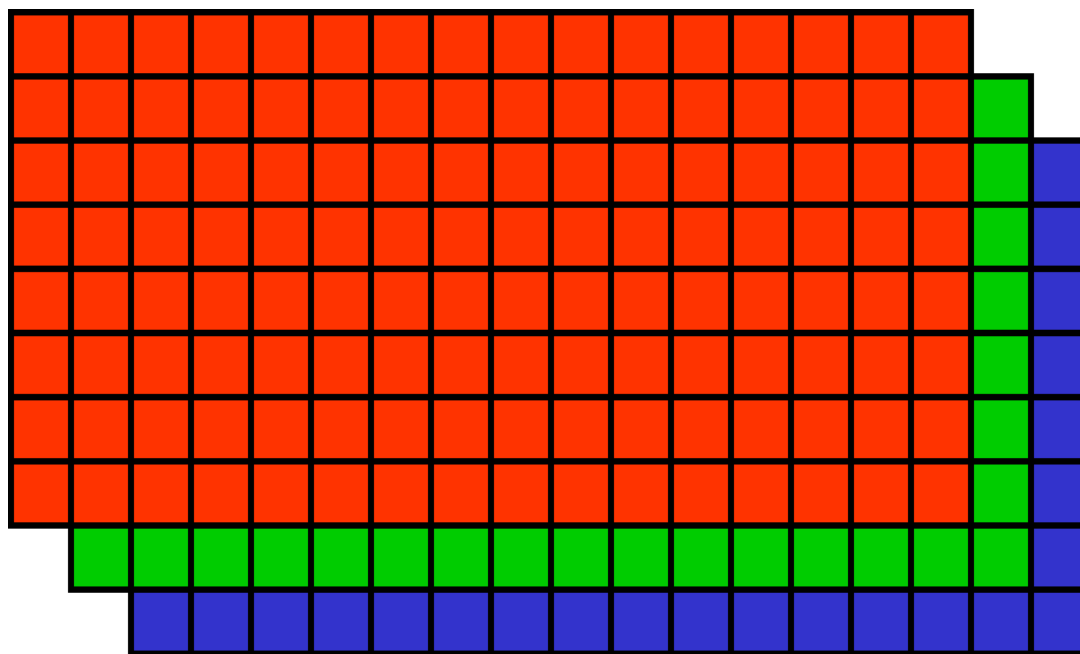
What is this?



# A Color Image

- An  $M \times N \times 3$  matrix
- Each pixel is an 8-bit number between 0 and 255
- RED, GREEN, BLUE
- $M \times N$   
 = resolution  
 = number of pixels in  
 columns / rows

Caution: OpenCV uses BGR format



# Operations

Anything Can be applied on your  
Digital Image or Video

Logical  
Operations

Transforms

Statistical  
Operations

Geometrical  
Operations

Mathematical  
Operations

Morphology,  
Coding,

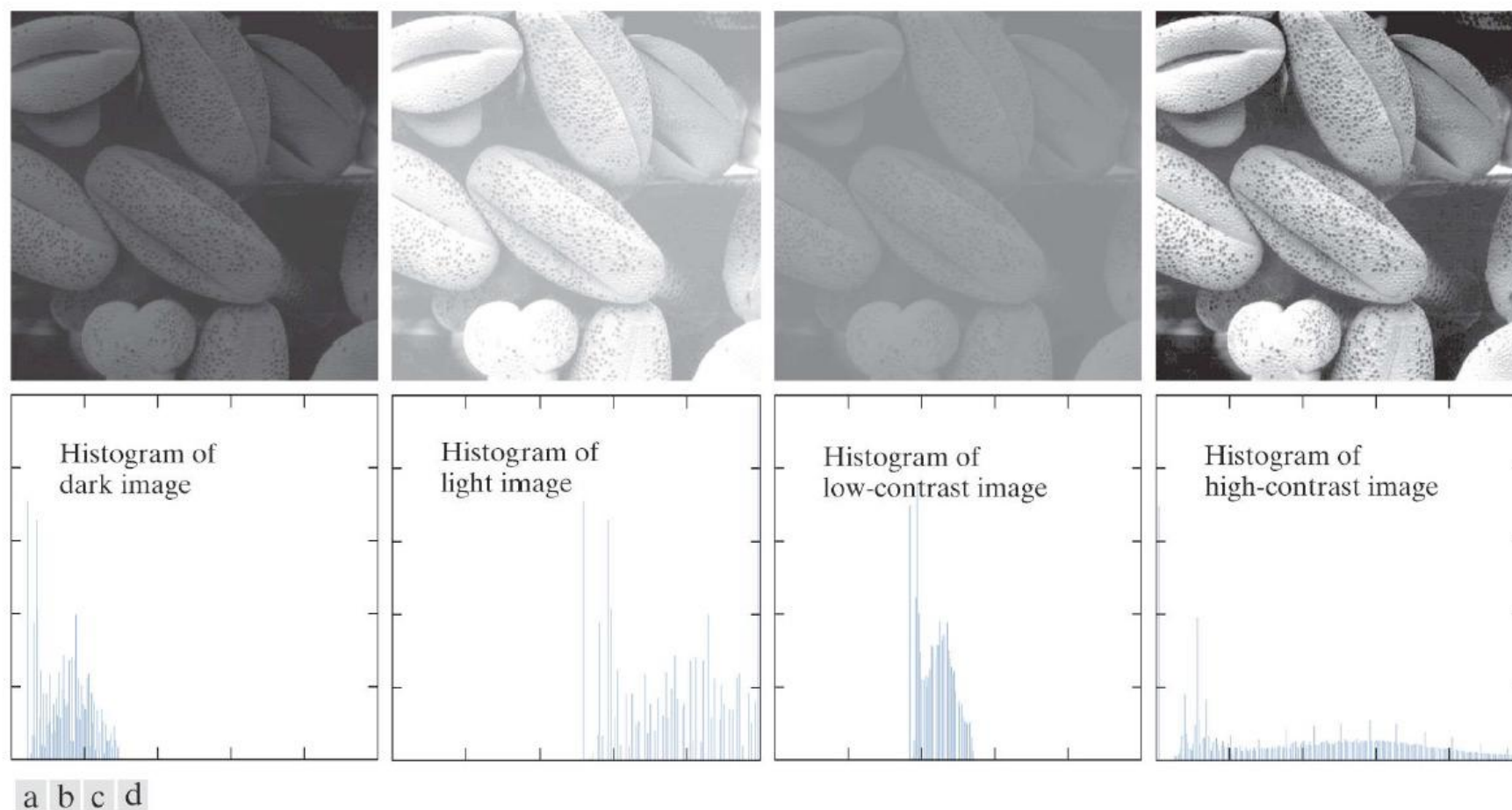
Fourier,  
Walsh, PCA

Histograms,  
Correlation,  
Max/Min

Affine  
Transforms

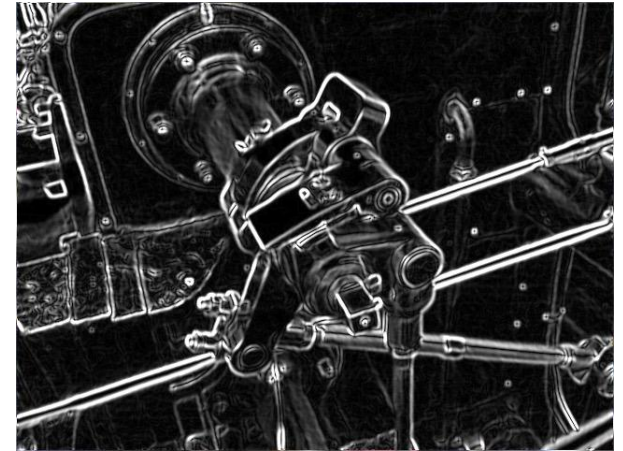
Filtering,  $^{**}$

# Histogram



**FIGURE 3.16**

Four image types and their corresponding histograms. (a) dark; (b) light; (c) low contrast; (d) high contrast. The horizontal axis of the histograms are values of  $r_k$  and the vertical axis are values of  $p(r_k)$ .



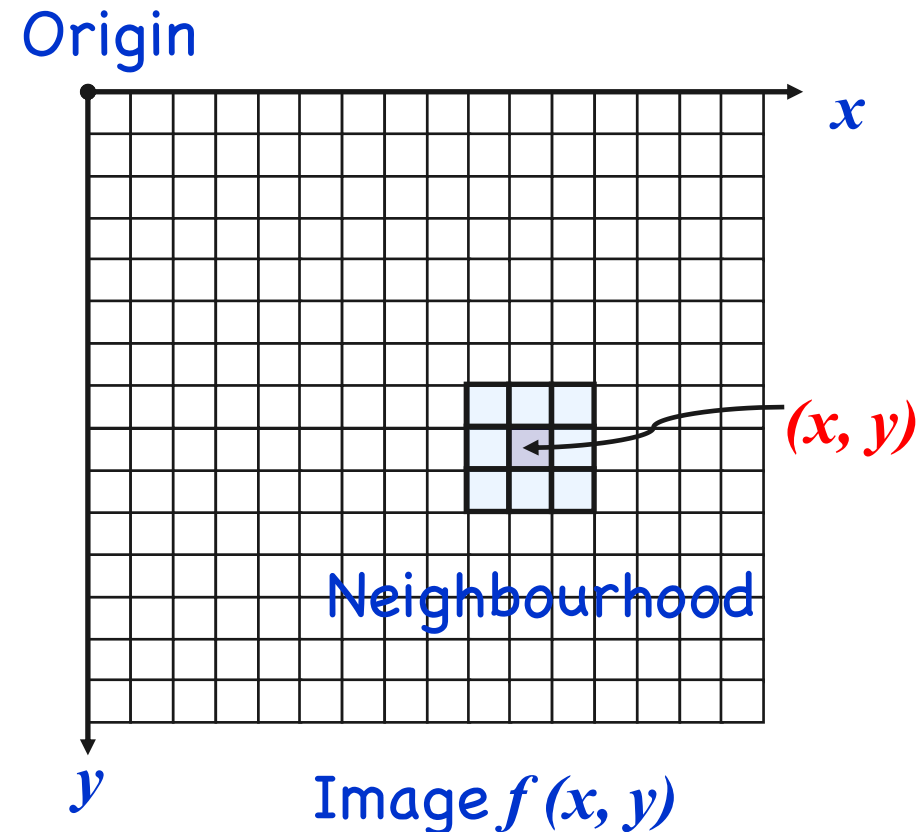
# Lesson 2

## Local Operations, Filtering, and Convolution

- Where we see how we can filter an image
- Every system in this big universe is a filter

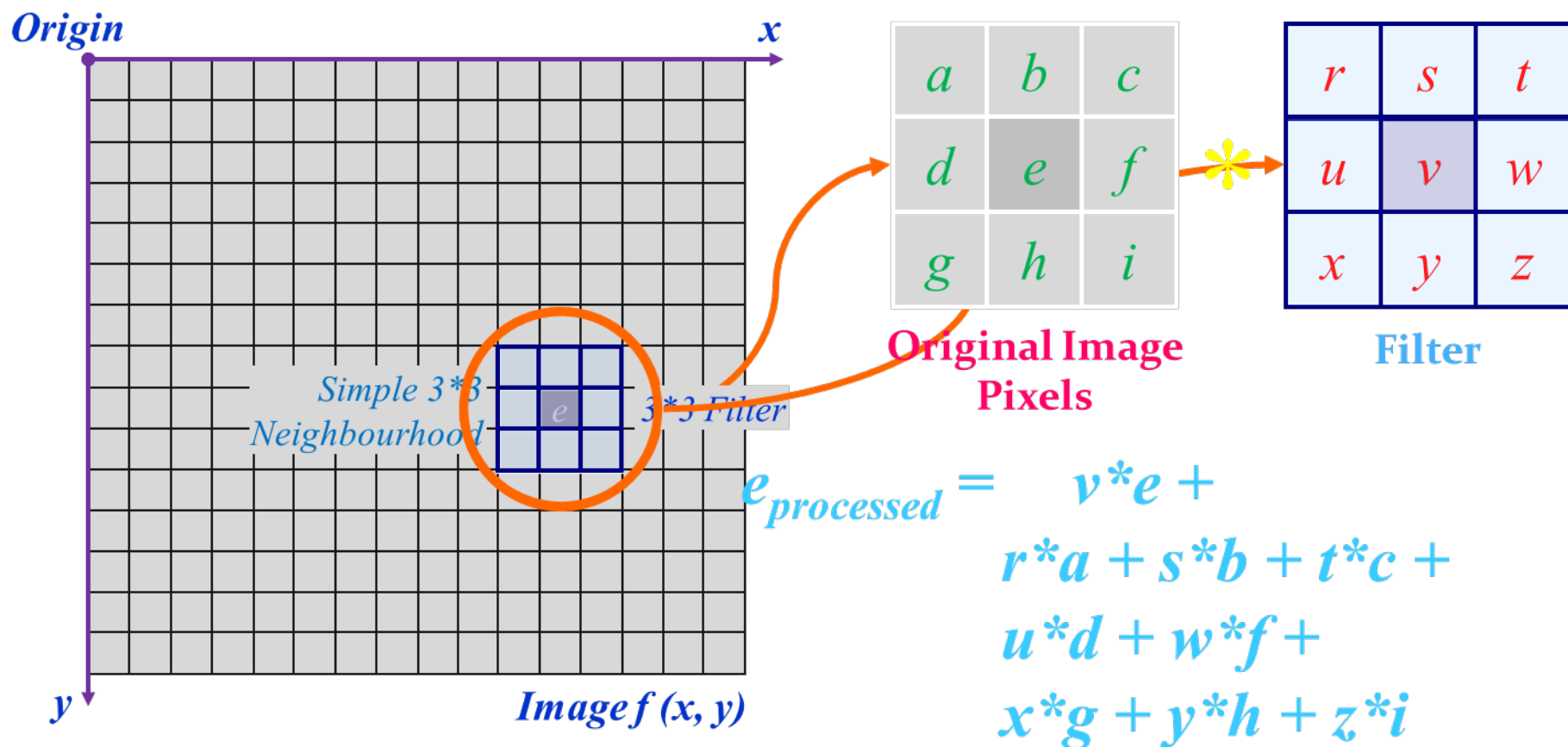
# Local Operations

- An image in the spatial domain
- A local operator uses the pixel and its neighbours to compute the new value of that pixel.
- E.g., replace each pixel  $f(x,y)$ , with the average of that and its 8 neighbours.
- $g(x,y) = T[ f(x \pm \Delta x, y \pm \Delta y) ]$



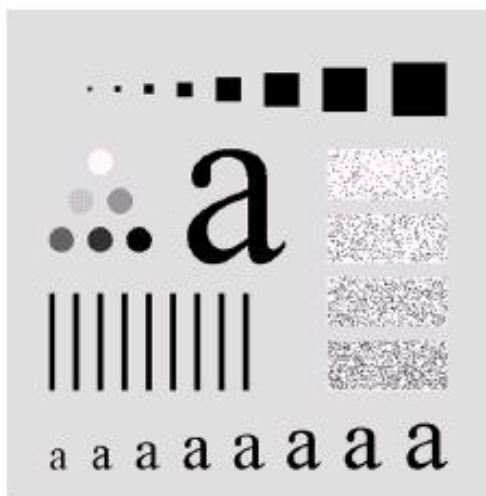


# Local Operations

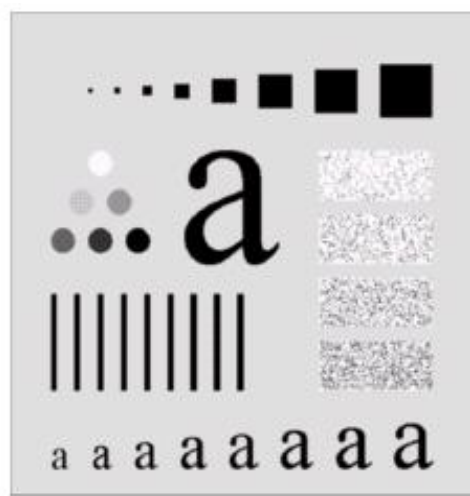


The **filter** would slide over the image, shift or stride is 1 column and then 1 row

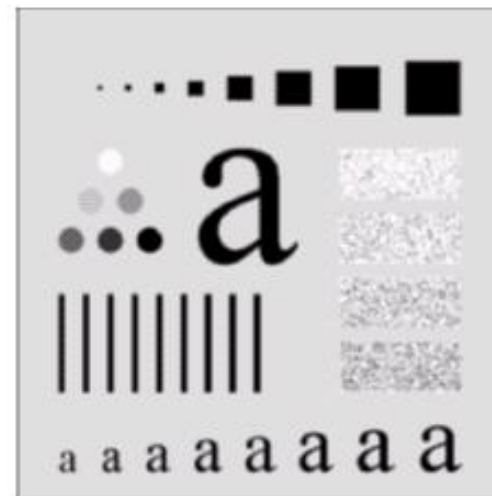
# Low-Pass Filters



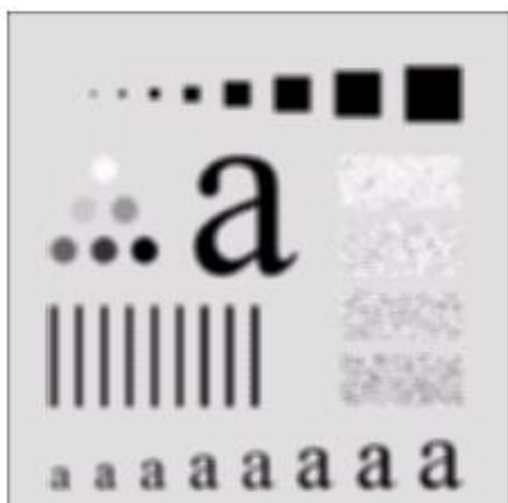
Original image



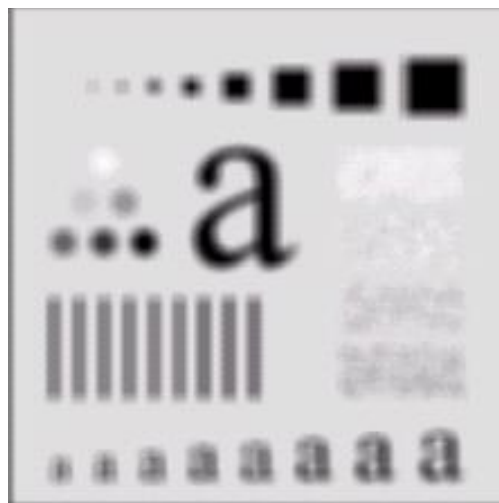
Filtered with 3x3



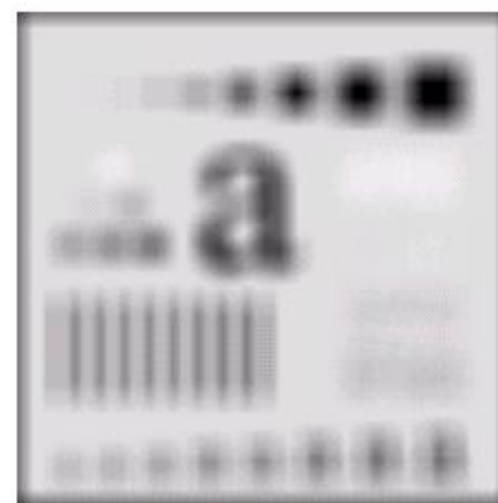
Filtered with 5x5



Filtered with 9x9

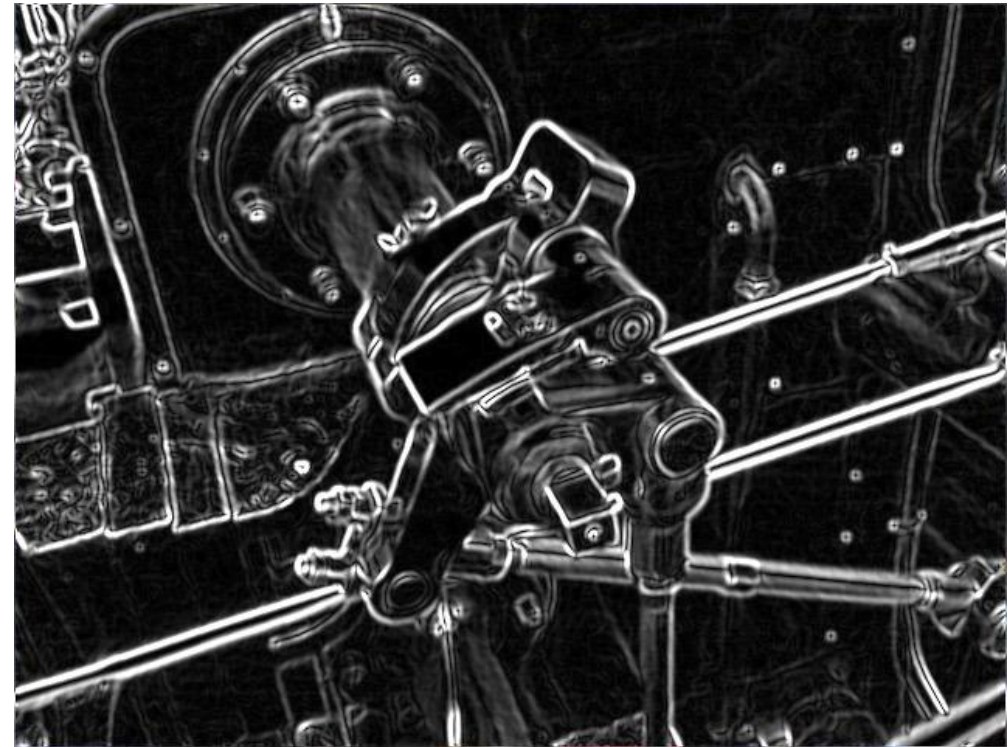
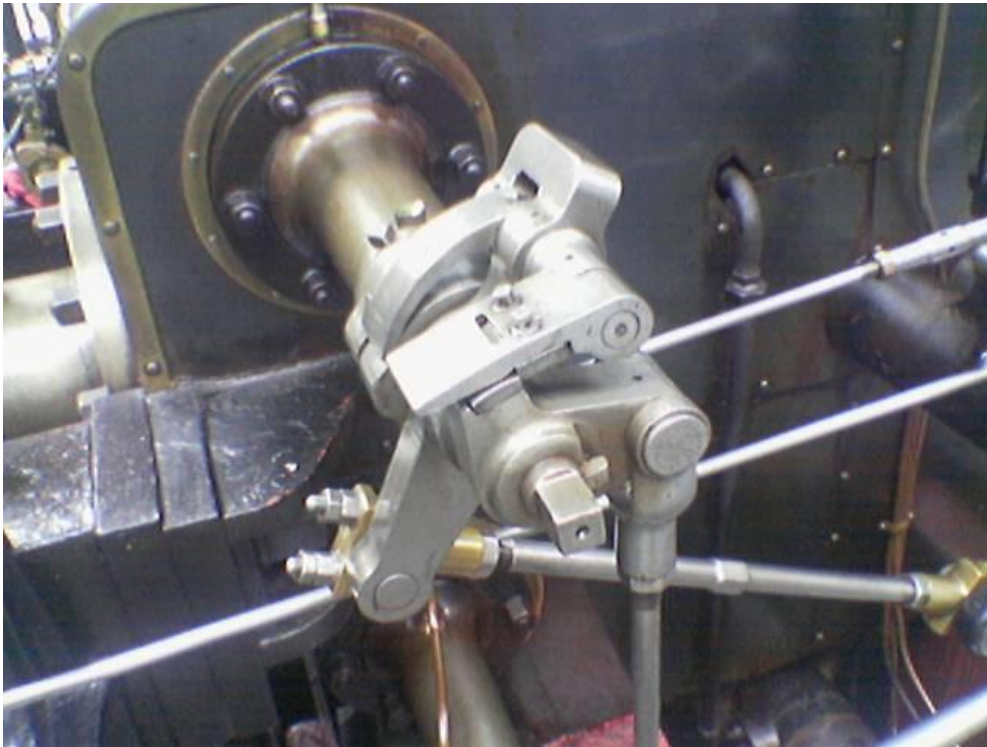


Filtered with 15x15



Filtered with 35x35

# High-Pass Filters

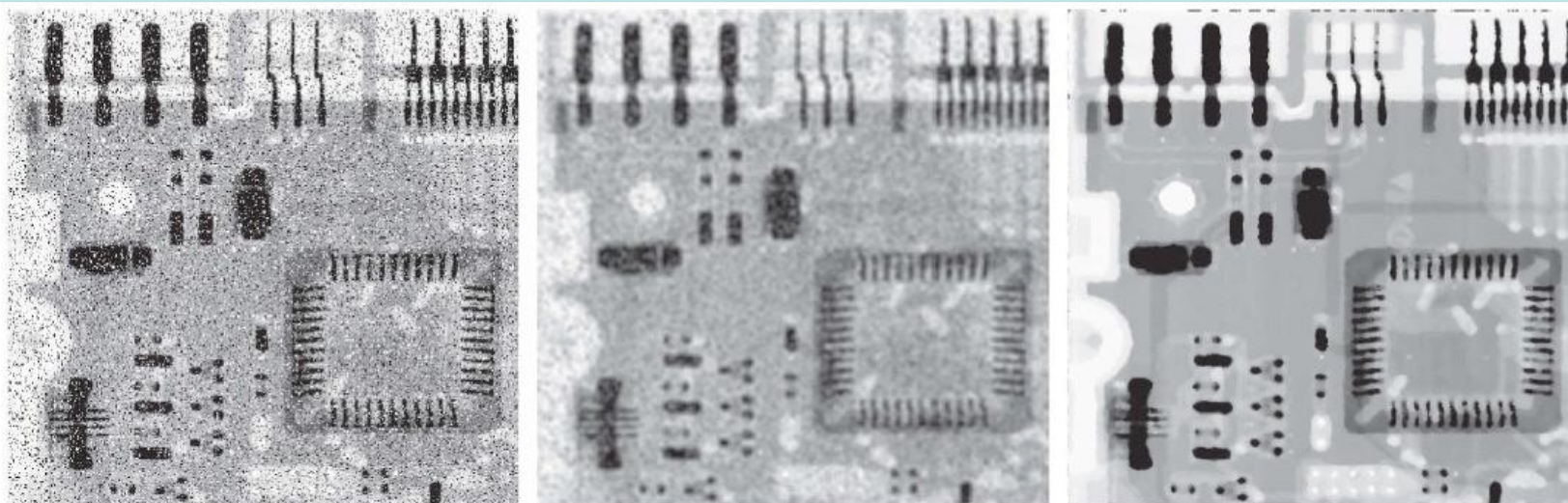


Discrete 1st derivative or **gradient** of an image.

An image and result of **edge detection** using the Sobel algorithm.

# Median Filters

- In a small  $n \times n$  patch/neighborhood
- Sort the pixels and find the median,  $M$
- Replace the central pixel of your patch with  $M$
- Slide one pixel to the next neighborhood



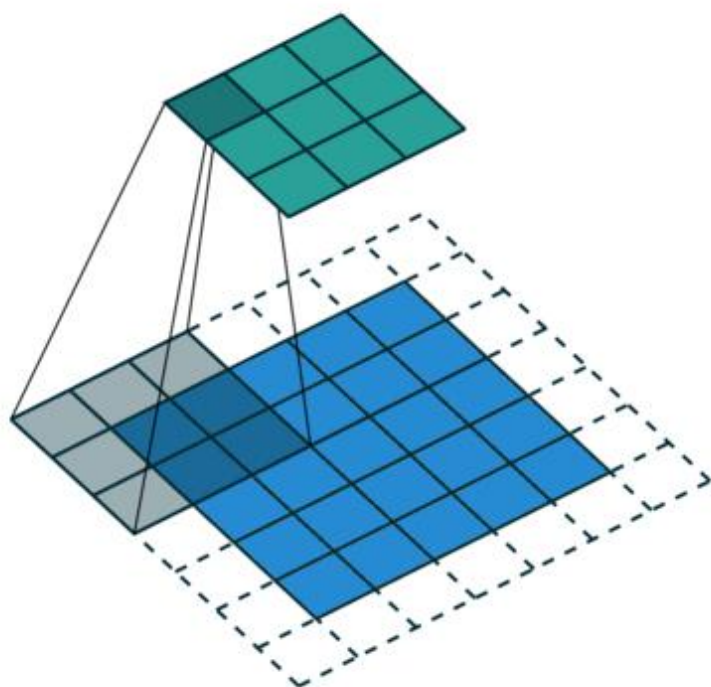
a b c

**FIGURE 3.49**

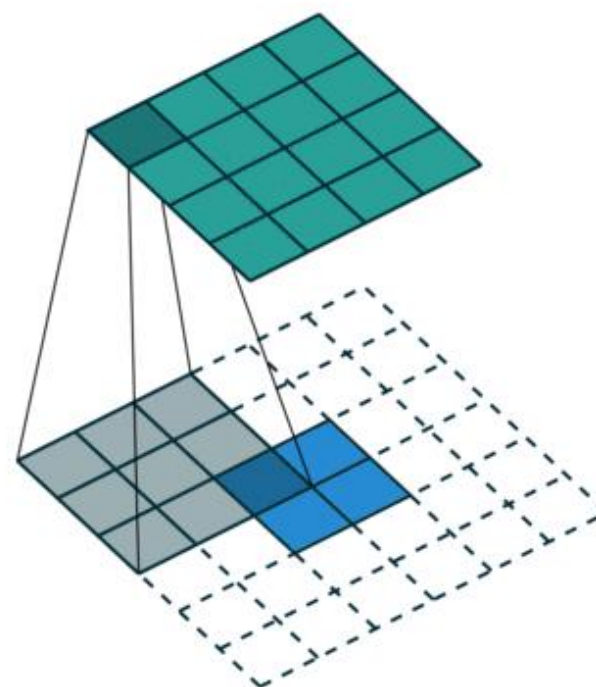
(a) X-ray image of a circuit board, corrupted by salt-and-pepper noise. (b) Noise reduction using a  $19 \times 19$  Gaussian lowpass filter kernel with  $\sigma = 3$ . (c) Noise reduction using a  $7 \times 7$  median filter. (Original image courtesy of Mr. Joseph E. Pascente, Lixi, Inc.)



# Convolution, 2D

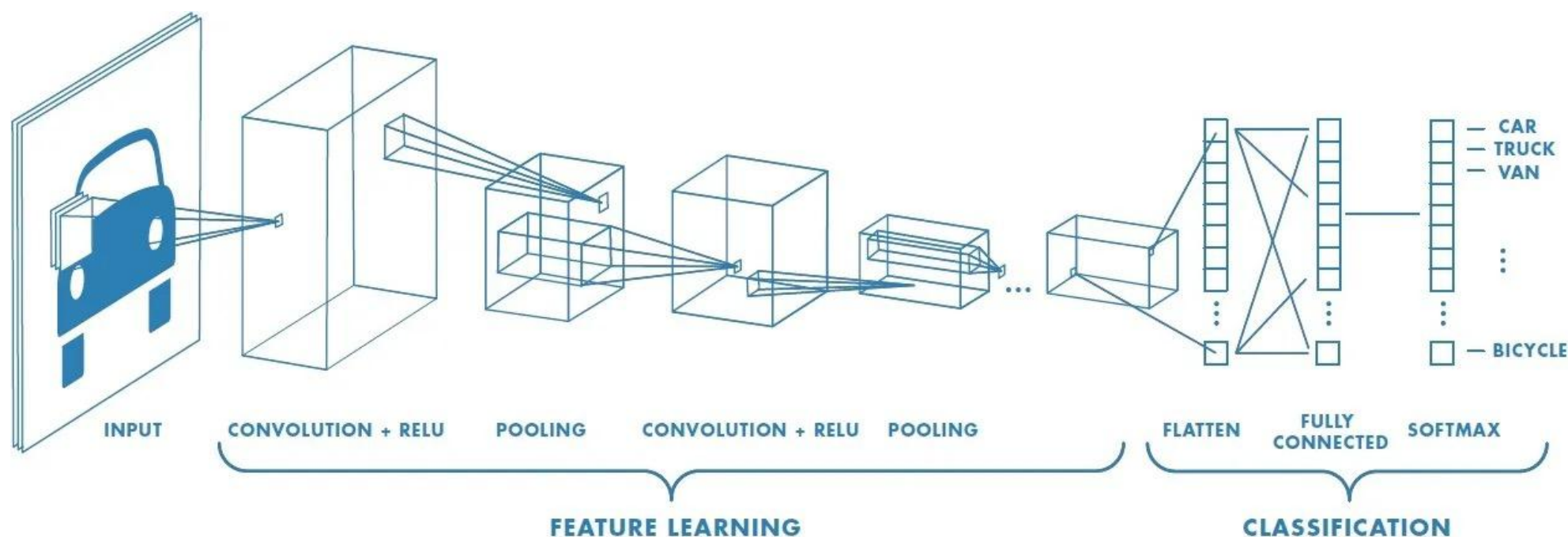


convolution with stride = 1



convolution with stride = 2

# Convolutional Neural Nets (CNNs)



# Lab Session 1

## Background & Global Operations



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