



MSc in Digital Humanities
Image Processing/Analysis

Processing, Classification, Segmentation

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Introduction to Image Processing/Analysis

Definition: Process of examining and processing images to extract useful information

Applications: Medical imaging, object detection, facial recognition, etc.

Steps in Image Analysis:

- Image Acquisition
- Preprocessing
- Feature Extraction
- Classification

Image Acquisition and Preprocessing

Image Acquisition: Methods include cameras, sensors, medical imaging devices

Preprocessing Techniques:

- Image enhancement (contrast adjustment, histogram equalization)
- Noise reduction (Gaussian filter, median filter)
- Edge detection (Canny, Sobel)
- Normalization & Resizing

→ [Image Basic Analysis Code.ipynb](#)

→ [Supplementary Materials](#)

Preprocessing Techniques: Image Basic Analysis

Output	Description	What it Tells You
Size	The width and height of the image in pixels.	Overall resolution and aspect ratio.
Mode	The color space (e.g., ' RGB ' for color, ' L ' for grayscale).	How color information is stored.
Shape	Height, Width, Channels of the image (The dimensions of the NumPy array)	Essential for matrix operations.
Mean Intensity	The average pixel value (0-255) for a channel.	A measure of overall brightness (higher mean = brighter).
Std Dev	Standard Deviation of the pixel values.	A measure of image contrast (higher std dev = higher contrast/more detail).
Histogram	A graph showing how many pixels have each intensity value.	Distribution of tones: A balanced spread means good exposure; peaks near 0 mean dark shadows; peaks near 255 mean bright highlights.

→ [Image Basic Analysis Code.ipynb](#)

Features Extraction Techniques

Transform raw image data into meaningful representations

Types of Features

- Low-Level Features (color, texture, shape)
- High-Level Features (edges, corners, blobs, keypoints)

Feature Extraction Methods

- Histogram-based features
- Edge detection techniques
- Texture descriptors

Challenges in Feature Extraction

- Sensitivity to noise
- Computational complexity
- Variability in lighting and viewpoint

What is Edge Detection?

Edges are defined as sets of connected pixels where the intensity of an image function changes **sharply**.

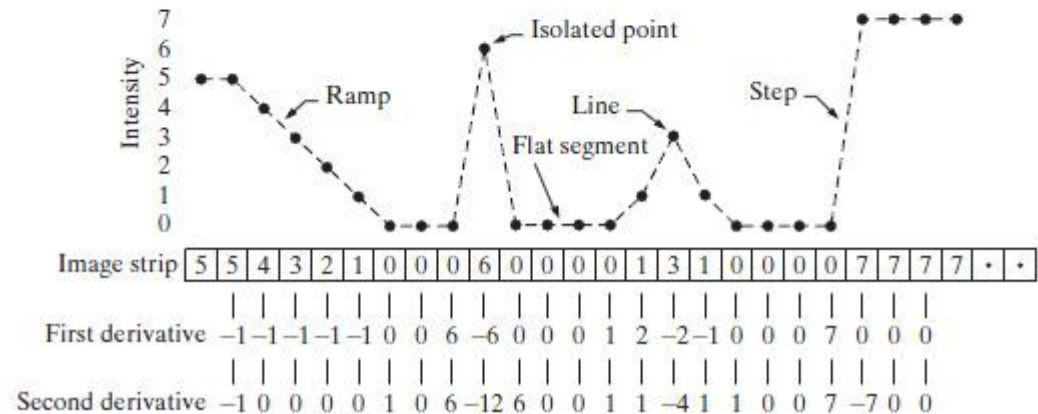
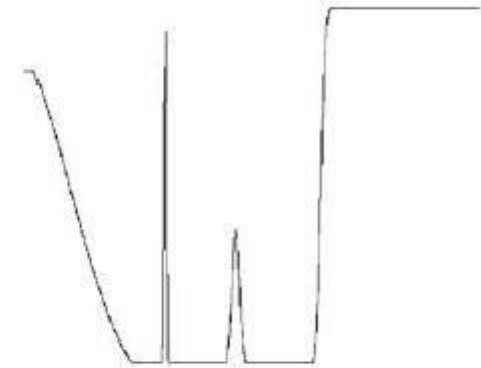
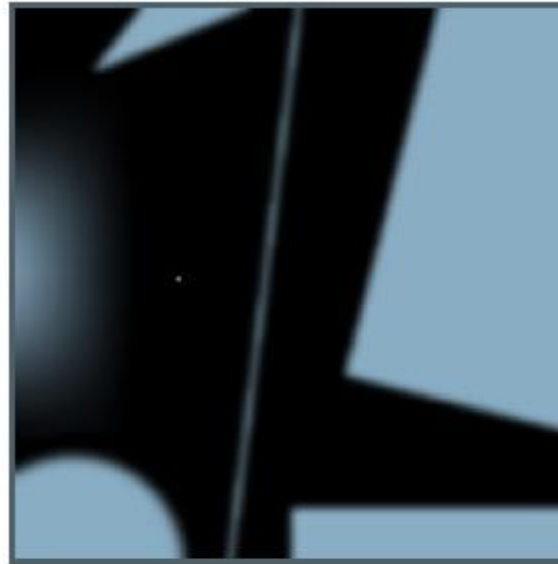
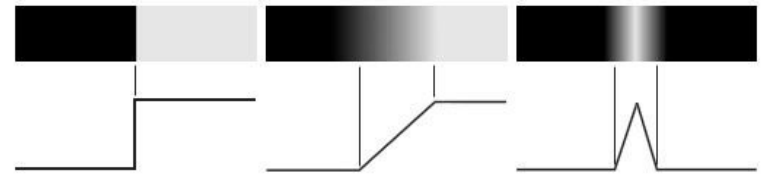
Edge detectors are local image processing methods designed to detect edge pixels.

A **line** can be considered an edge segment, where on either side of it there is a strong variation in brightness.

The derivatives of a digital function are defined using differences.

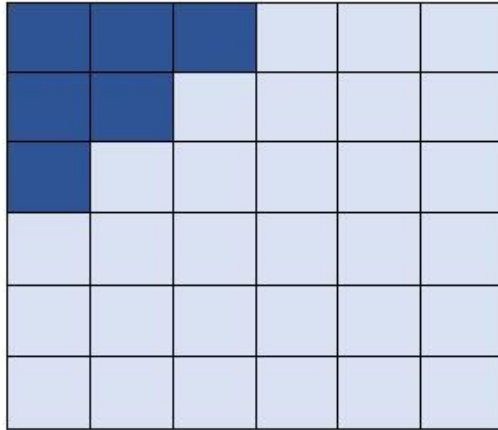
From any such approach for calculating the **1st derivative**, we require it:

1. to have a **zero value** in regions of constant intensity,
2. to be **non-zero** at the start of an intensity change described as a step function or as a ramp function,
3. to be **non-zero** at points belonging to an intensity ramp.



Features Extraction Techniques: Convolution !!!

Original Color Image



Input Image in Grayscale (let us call this Matrix A)

150	150	150	255	255	255
150	150	255	255	255	255
150	255	255	255	255	255
255	255	255	255	255	255
255	255	255	255	255	255
255	255	255	255	255	255

Kernel (let us call this Matrix B)

-1	-2	-1
0	0	0
1	2	1

Convolution

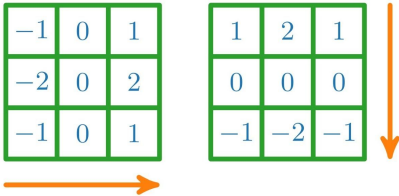
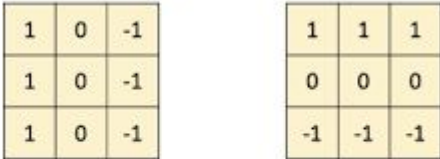
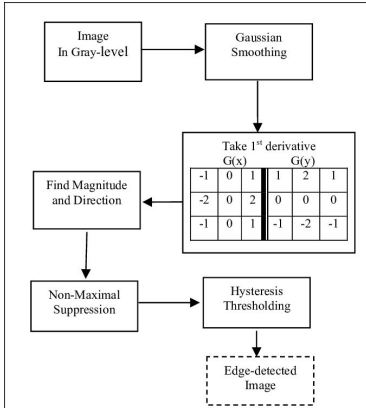
$150 * -1$	$150 * -2$	$150 * -1$	255	255	255
$150 * 0$	$150 * 0$	$255 * 0$	255	255	255
$150 * 1$	$255 * 2$	$255 * 1$	255	255	255
255	255	255	255	255	255
255	255	255	255	255	255
255	255	255	255	255	255

Output Image

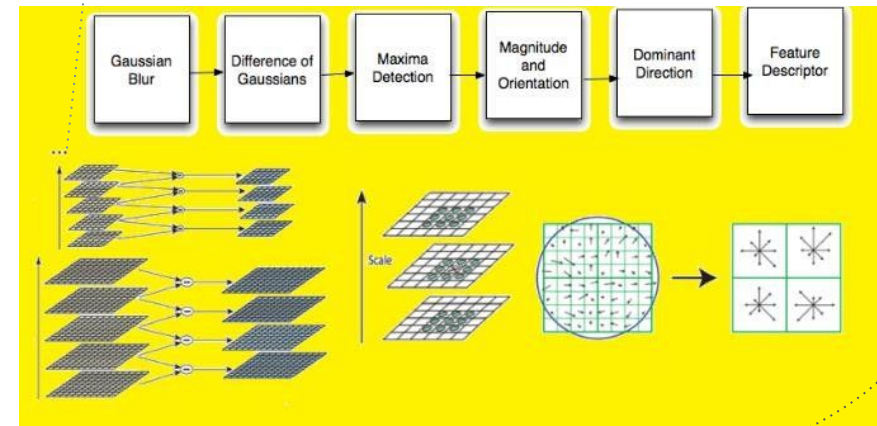
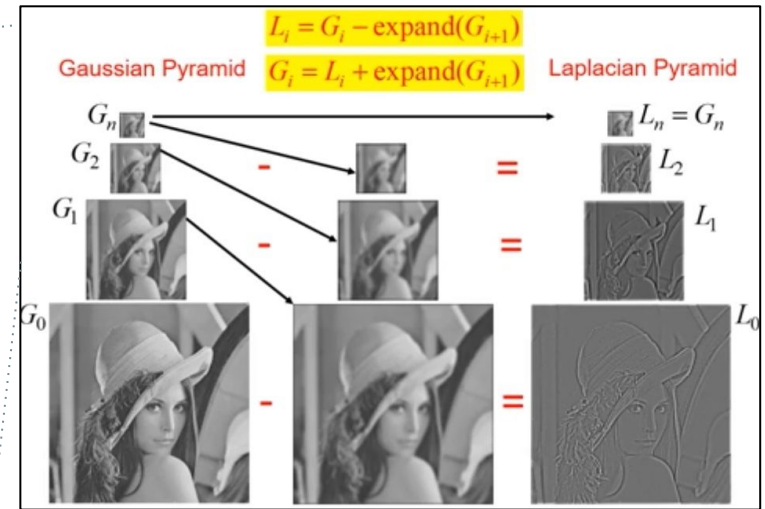
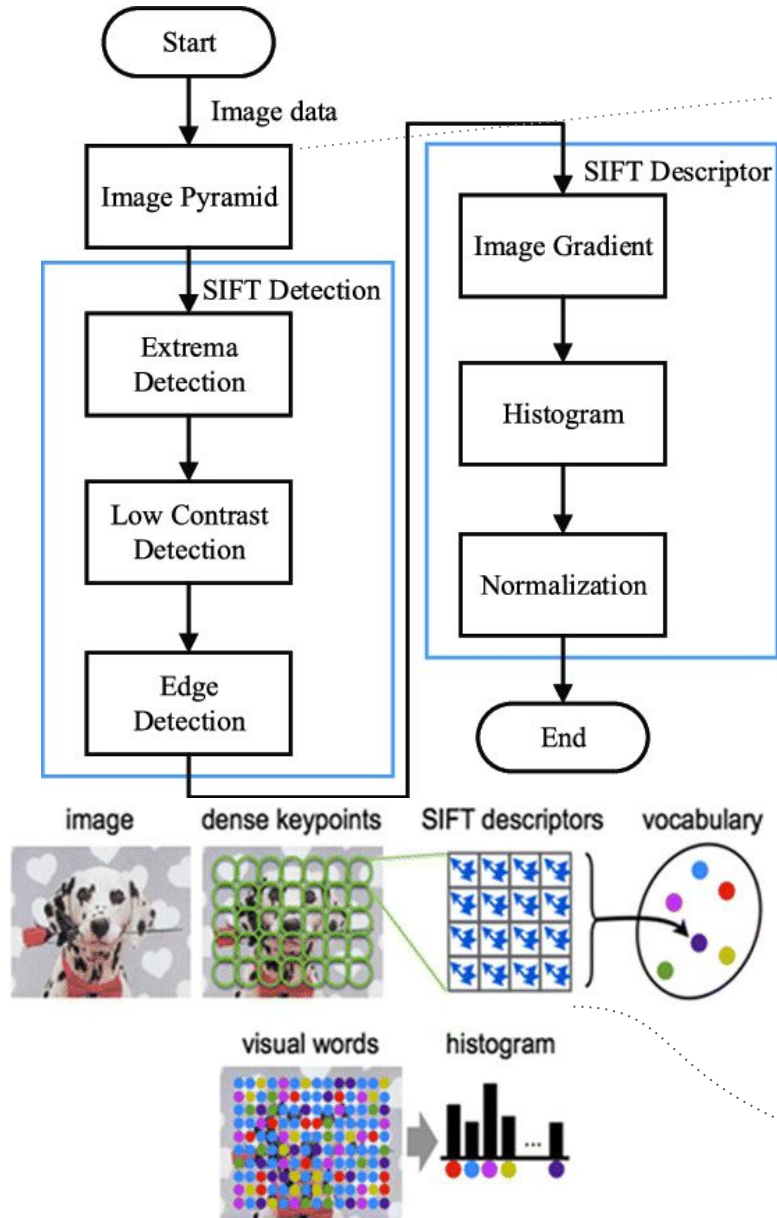
315			

$$-150 + -300 + -150 + 0 + 0 + 0 + 150 + 510 + 255 = 315$$

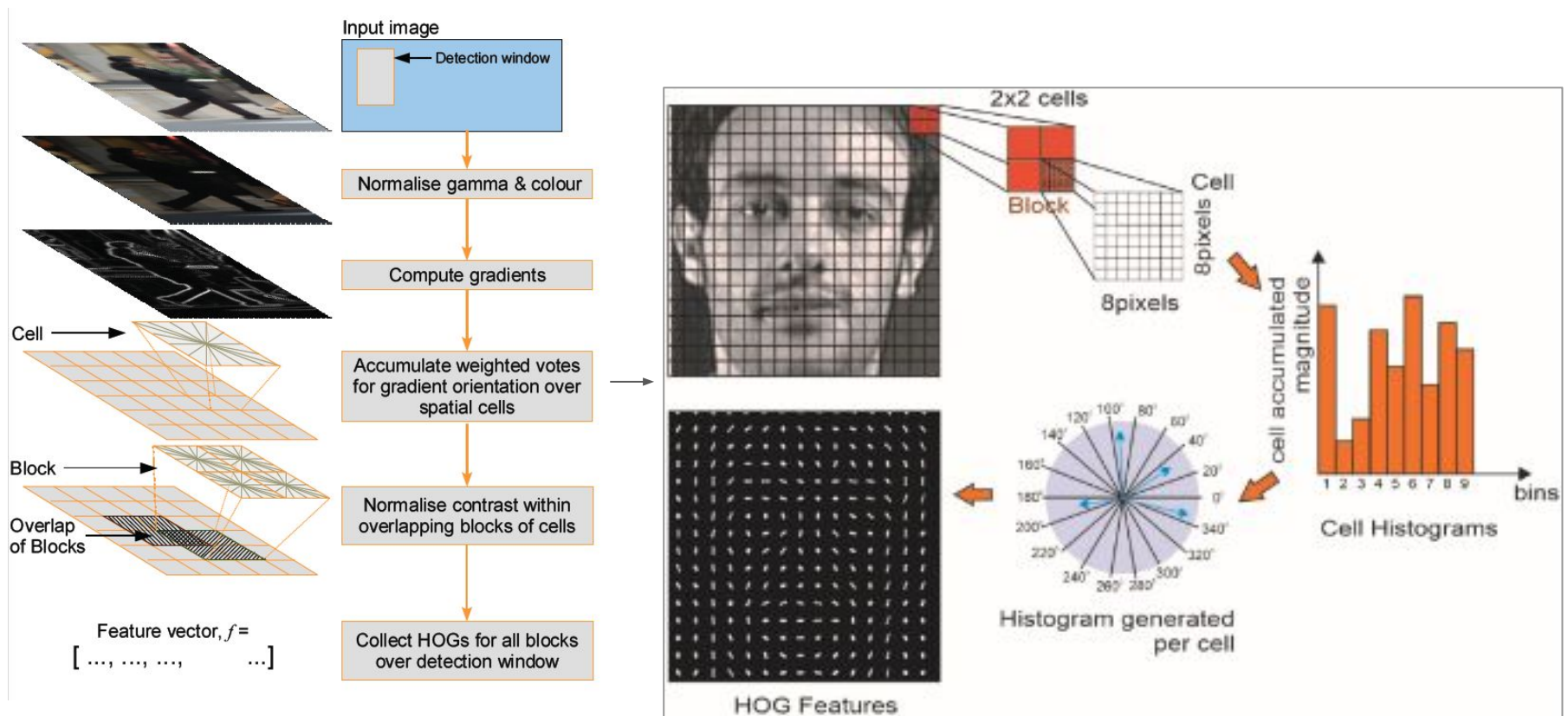
Features Extraction Techniques: Popular Edge Detectors

Detector	Category/Core Principle	Kernel	Disadvantages
Sobel (1968)	1st Derivative (Approximation of Gradient)		• Produces relatively thick edges. • Highly sensitive to noise compared to Canny. • Only approximations of the derivatives.
Prewitt (1970)	1st Derivative (Approximation of Gradient)		• No built-in smoothing: More sensitive to noise than Sobel. • Produces relatively thick edges.
Canny (1986)	Multi-Step (Optimized for localization and response)		• Best balance between noise suppression and edge localization. • Computationally intensive: Requires multiple steps (Gaussian blur, gradient, NMS, Hysteresis). • More parameters to tune (e.g., two thresholds for hysteresis).

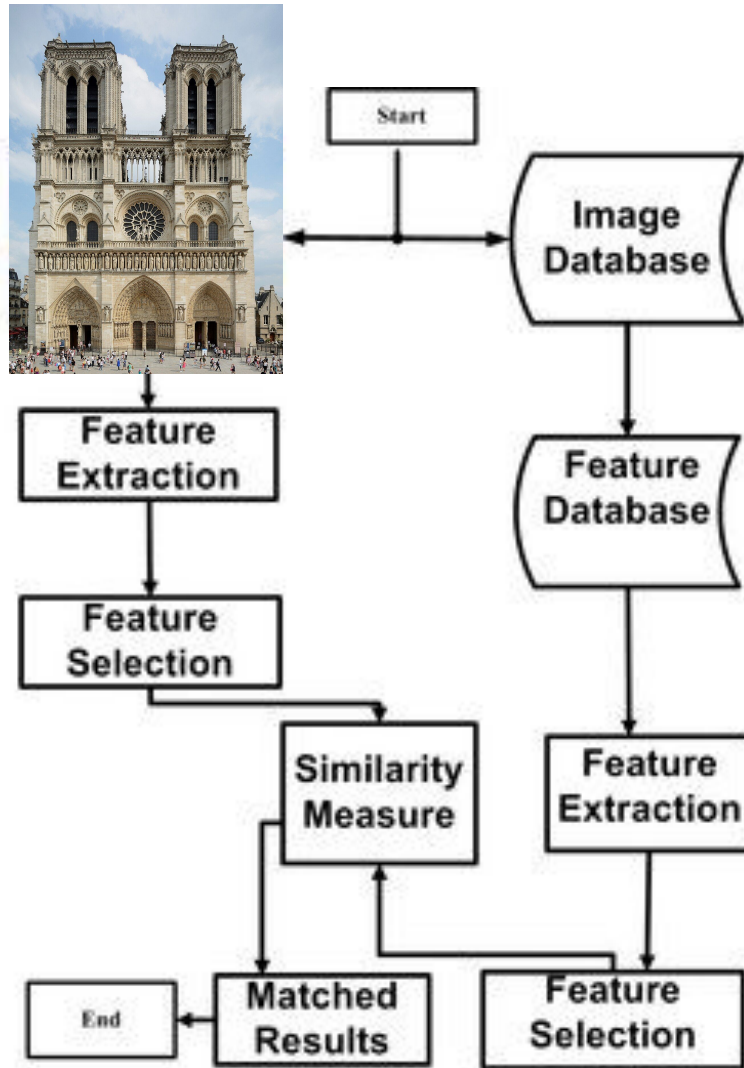
SIFT (Scale Invariant Features Transform) Descriptor



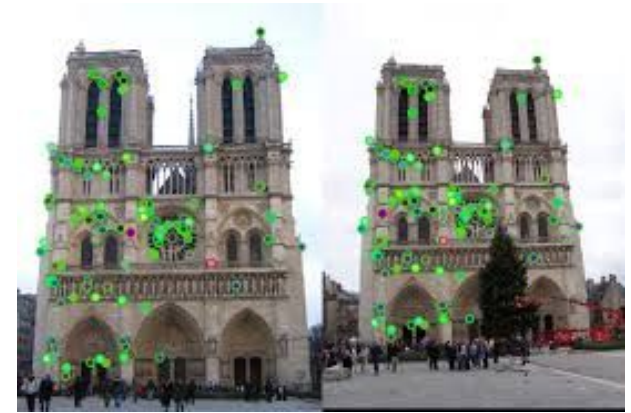
HOG (Histogram of Oriented Gradients) Descriptor



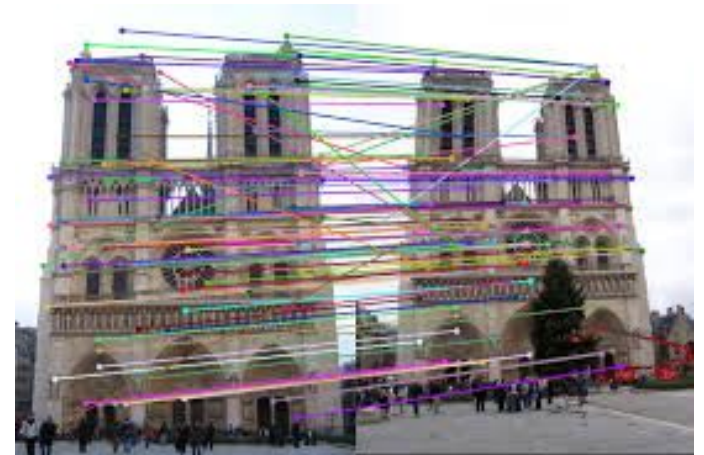
Features Matching



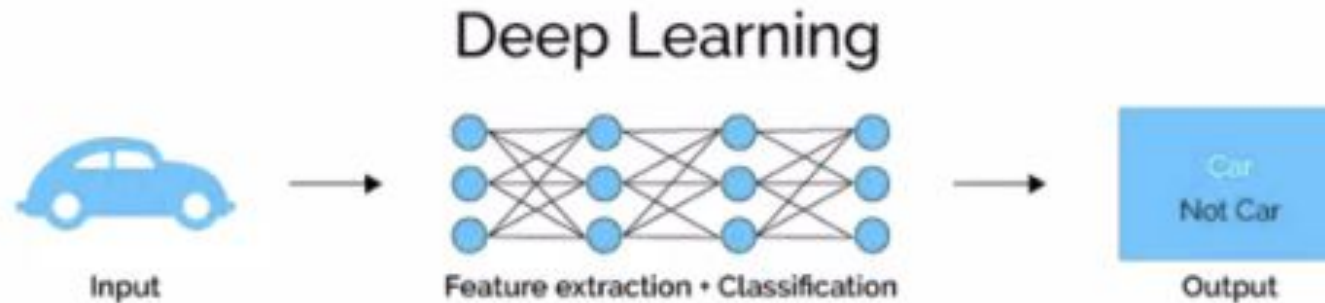
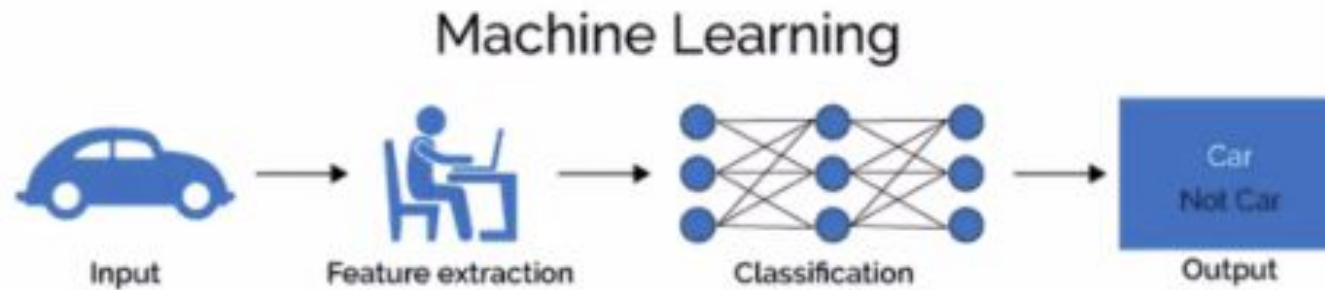
Features Extraction



Features Matching



Machine Learning vs Deep Learning



Features Extraction Techniques over the time

