Computer Vision

Lab 01 - Introduction

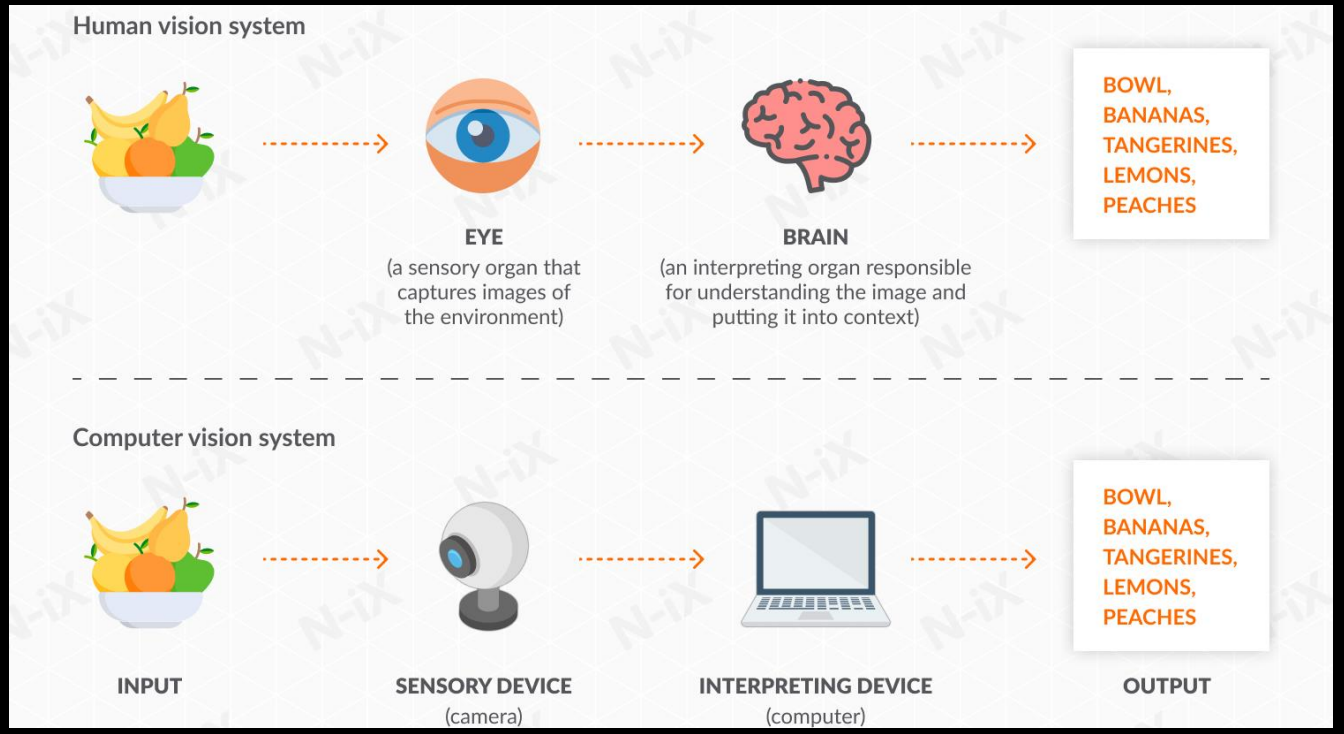
Content

Introduction to Computer vision
What is Computer Vision
Image (pre-) Processing
Feature Detection
Segmentation
Object Recognition
Computer Vision Applications

These slides is a reproduction of the Introduction To Computer Vision by Emma Beauxis-Aussalet, Digital Society School.
https://digitalsocietyschool.org/wp/wp-content/uploads/2020/09/1807_ESIEA_ComputerVision-1.pdf

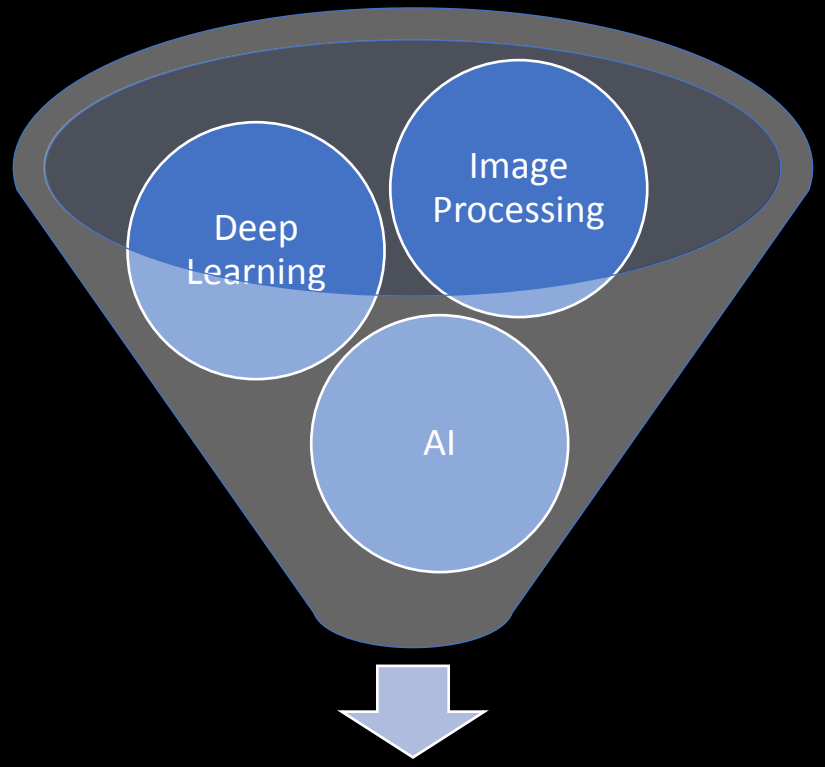
What is Computer Vision

- Computer vision involves **extracting, analysing and understanding images**.
  - Develop a theoretical and algorithmic basis to achieve automatic visual understanding.

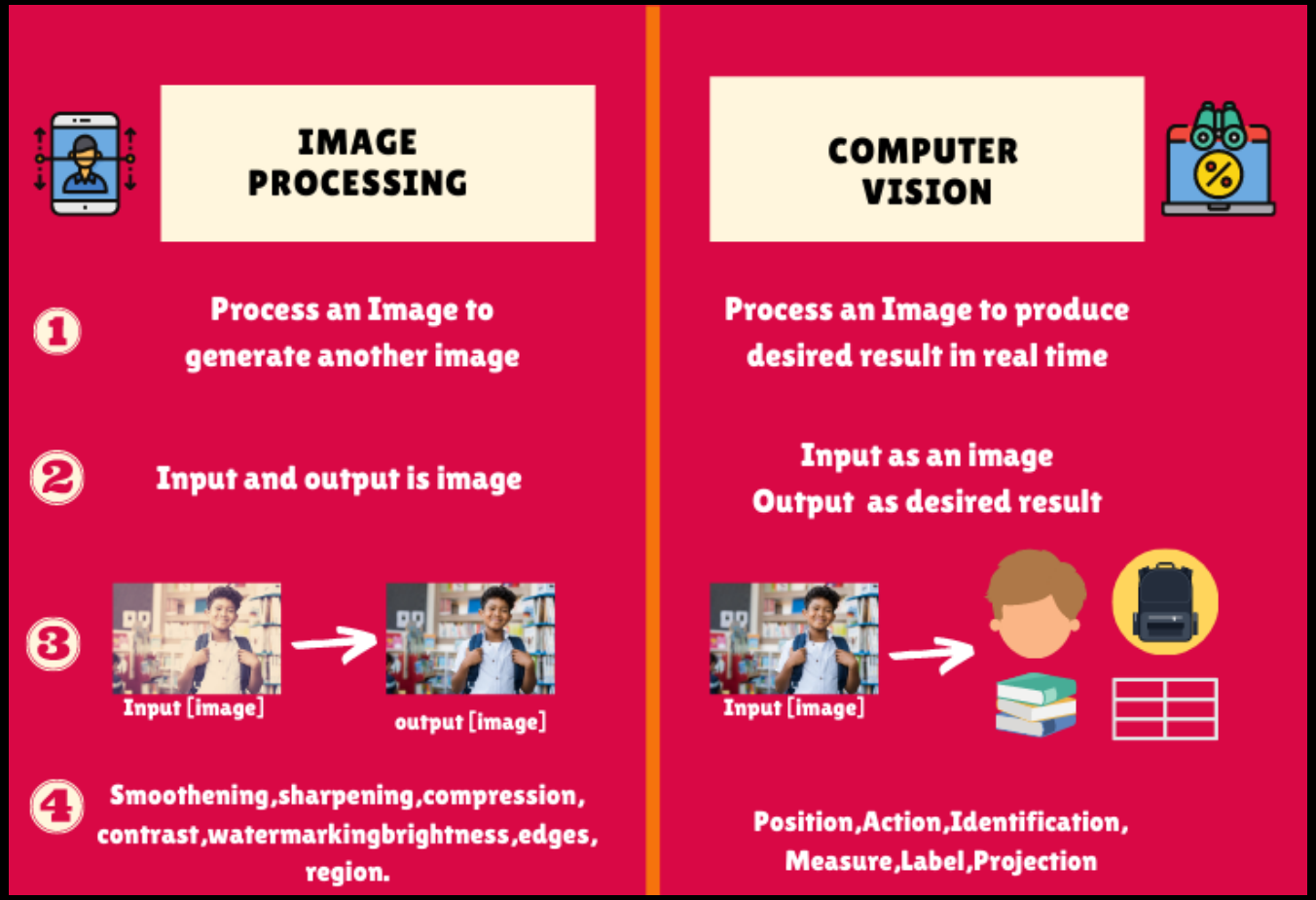


https://src.n-ix.com/uploads/2022/02/07/2d7ce0da-6472-4e3c-827a-7783fdcd3876.png

What is Computer Vision

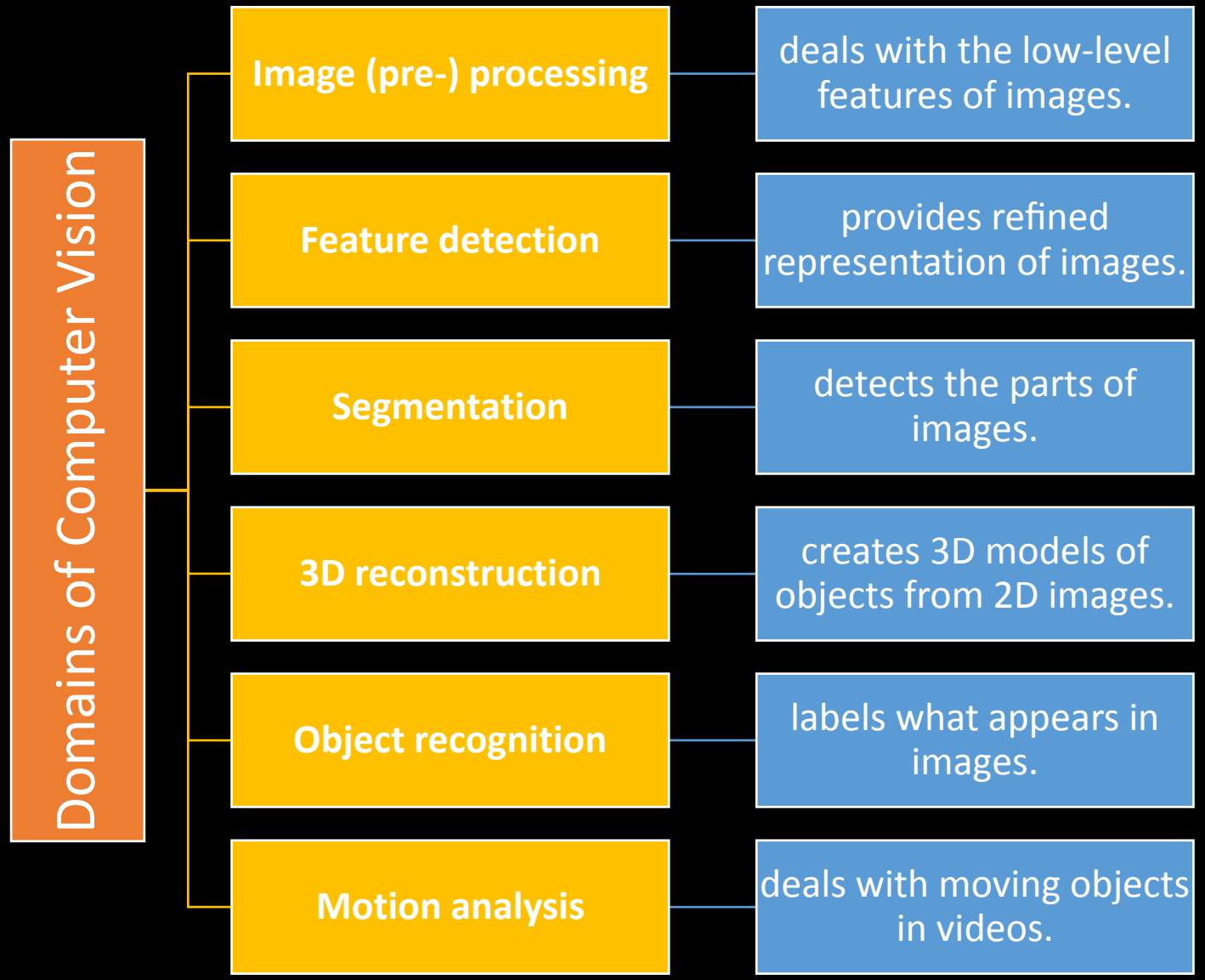


What is Computer Vision



https://matlabsimulation.com/wp-content/uploads/2020/11/Image_Processing_And_Computer_Vision_Projects.png

What is Computer Vision



Content

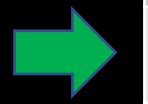


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Image (pre-) Processing

- Images consist of **pixels**

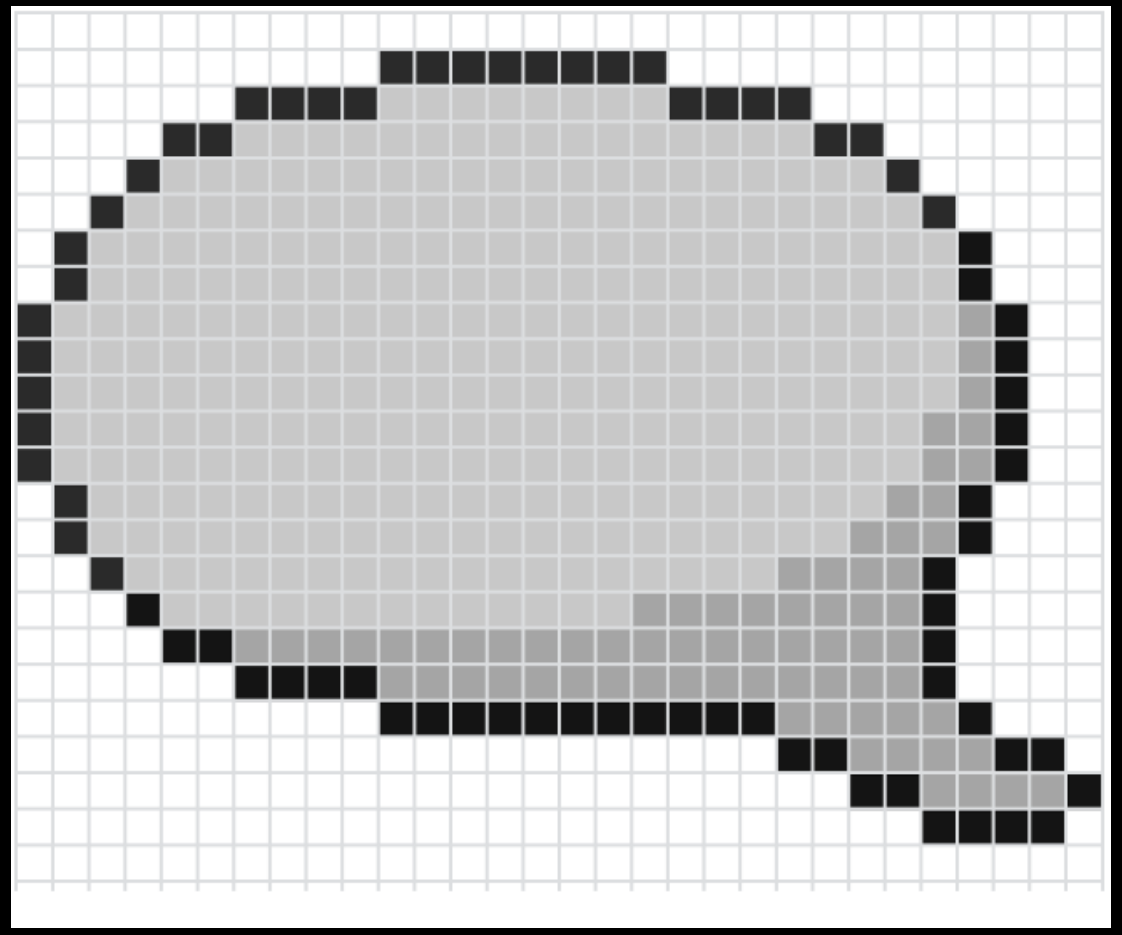


Image (pre-) Processing

- Images consist of **pixels**

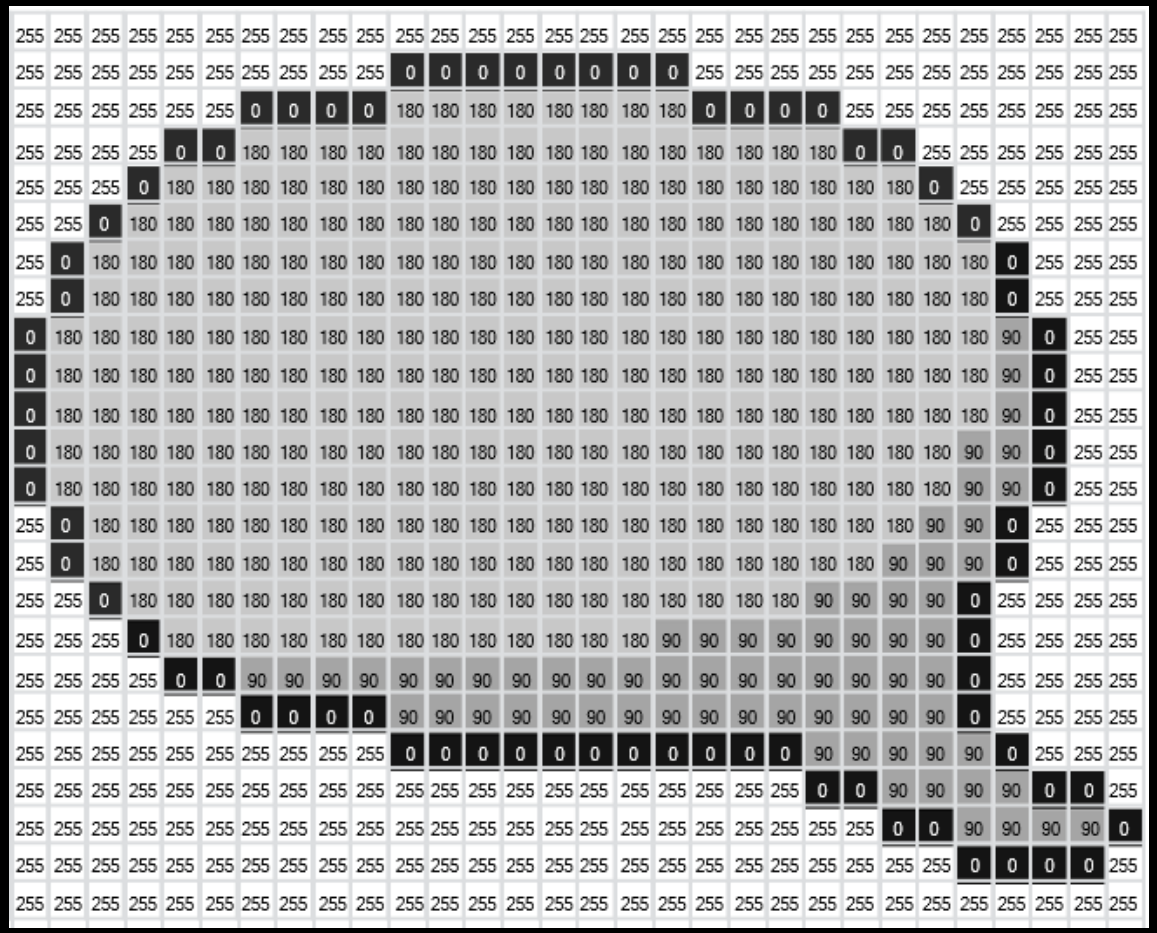


Image (pre-) Processing

- Images consist of **pixels**

This an image matrix, with single color channel (grayscale)

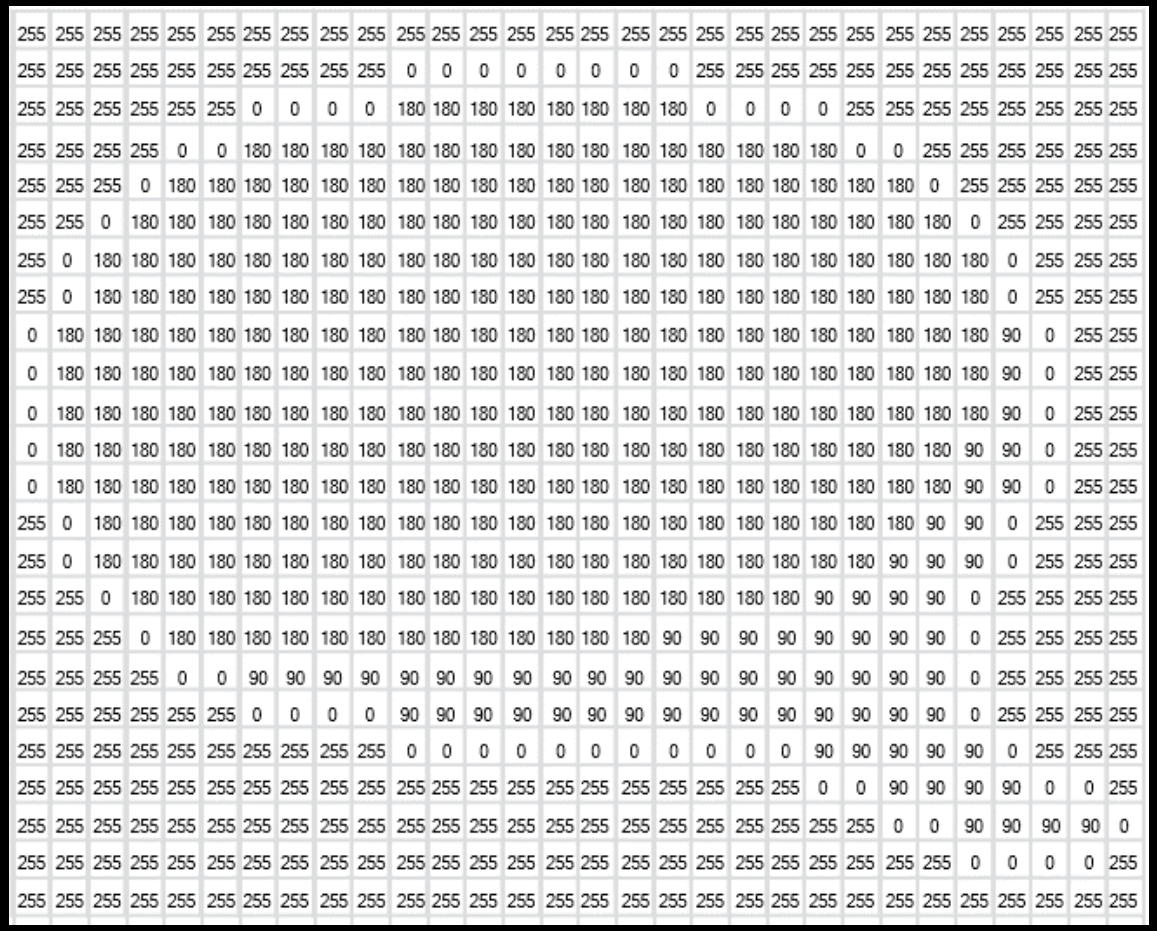


Image (pre-) Processing

- A colored image consists of 3 color channels: RGB

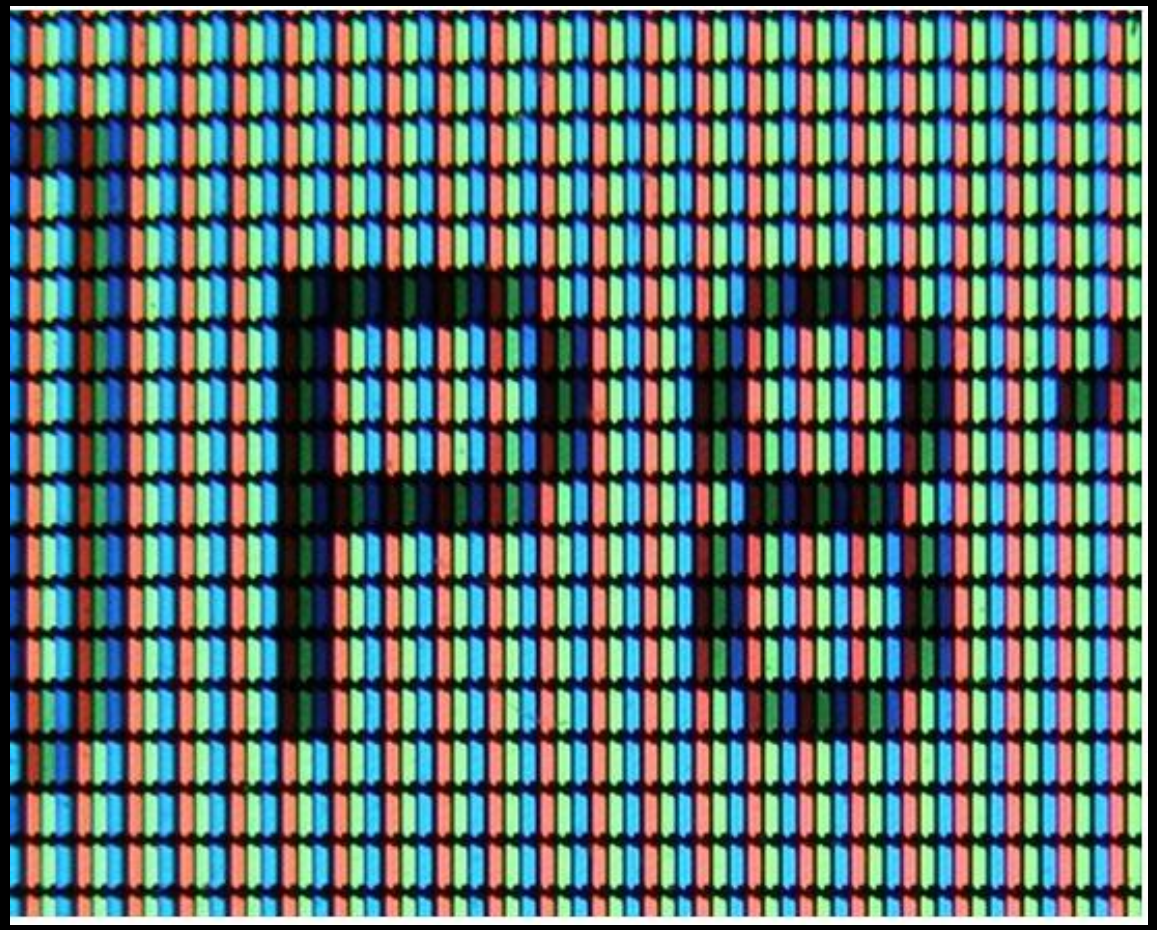


Image (pre-) Processing

- A colored image consists of 3 color channels: RGB

Fig. 1.4 Original RGB colour image `Fountain` (*upper left*), showing a square in Guanajuato, and its decomposition into the three contributing channels: *Red* (*upper right*), *Green* (*lower left*), and *Blue* (*lower right*). For example, *red* is shown with high intensity in the *red channel*, but in low intensity in the *green* and *blue channel*

Image (pre-) Processing

- Image pre-processing is the direct manipulation of pixel values.
  - Brightness, Contrast
  - Histogram Equalisation
  - Color Normalization
  - Filtering

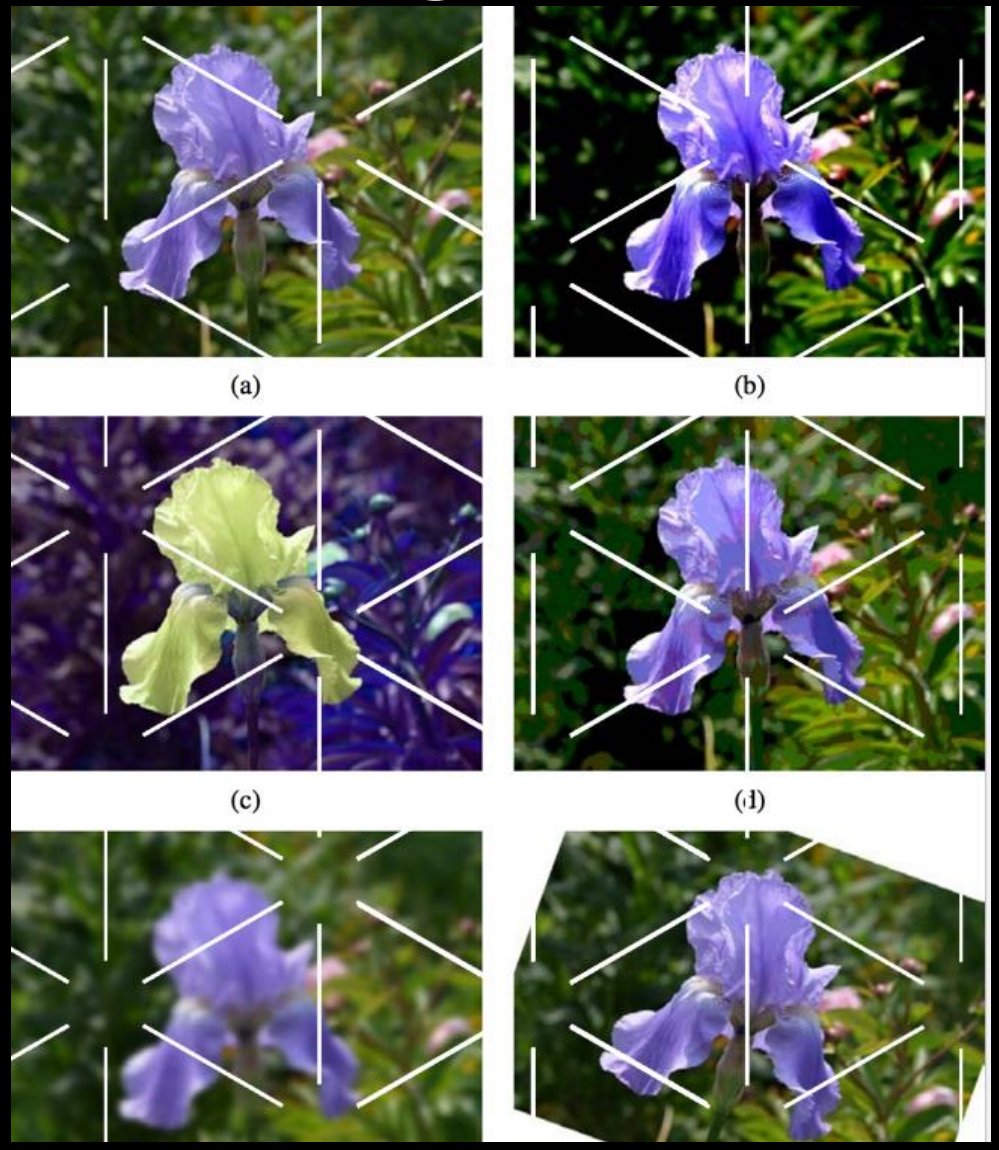
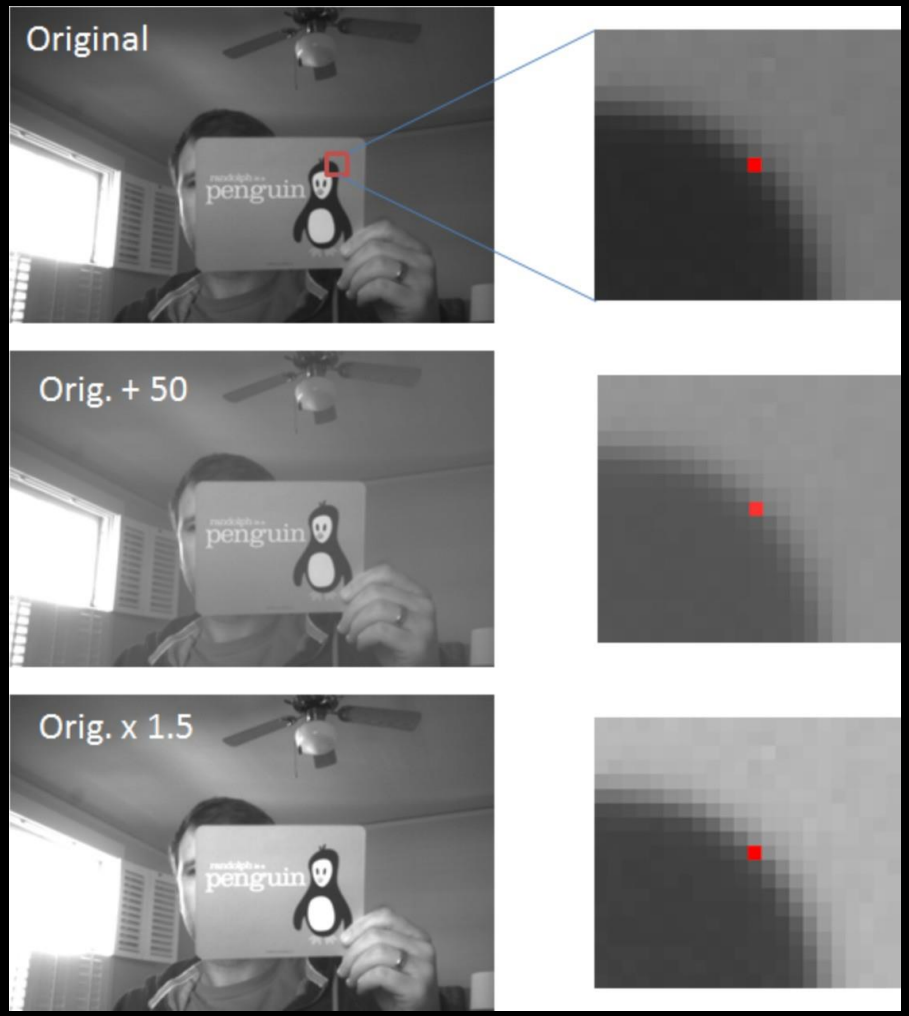


Image (pre-) Processing

- Brightness and contrast

Add X to
all pixel values…

Multiply X with
all pixel values…

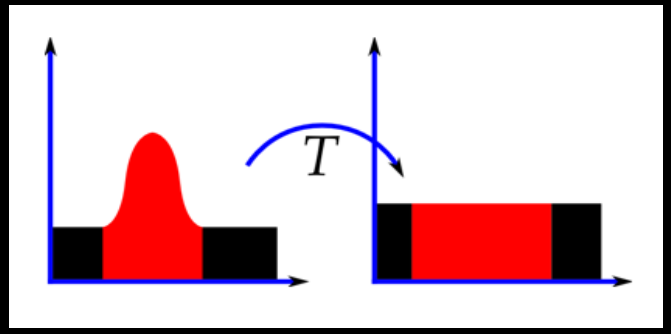


…to increase brightness.

…to increase contrast.

Image (pre-) Processing

- Histogram Equalization



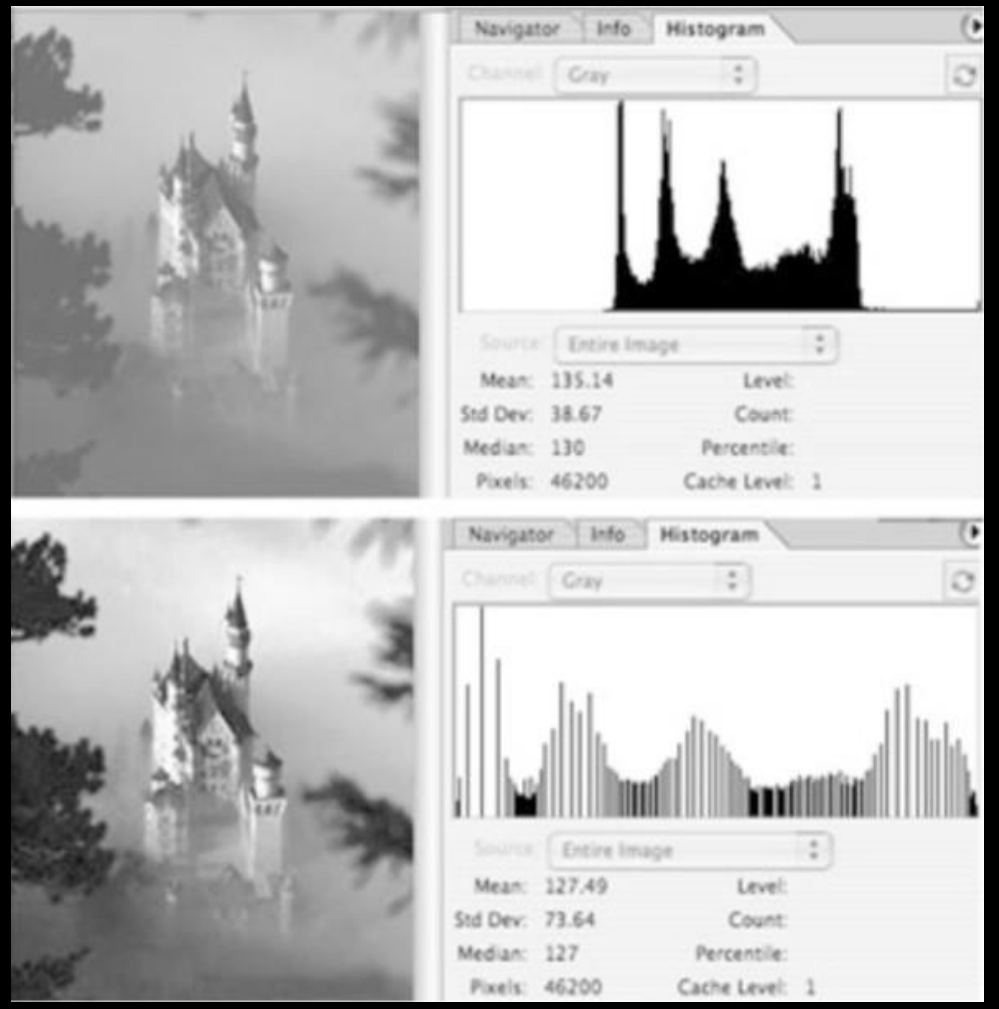


Image (pre-) Processing

- Histogram Equalization

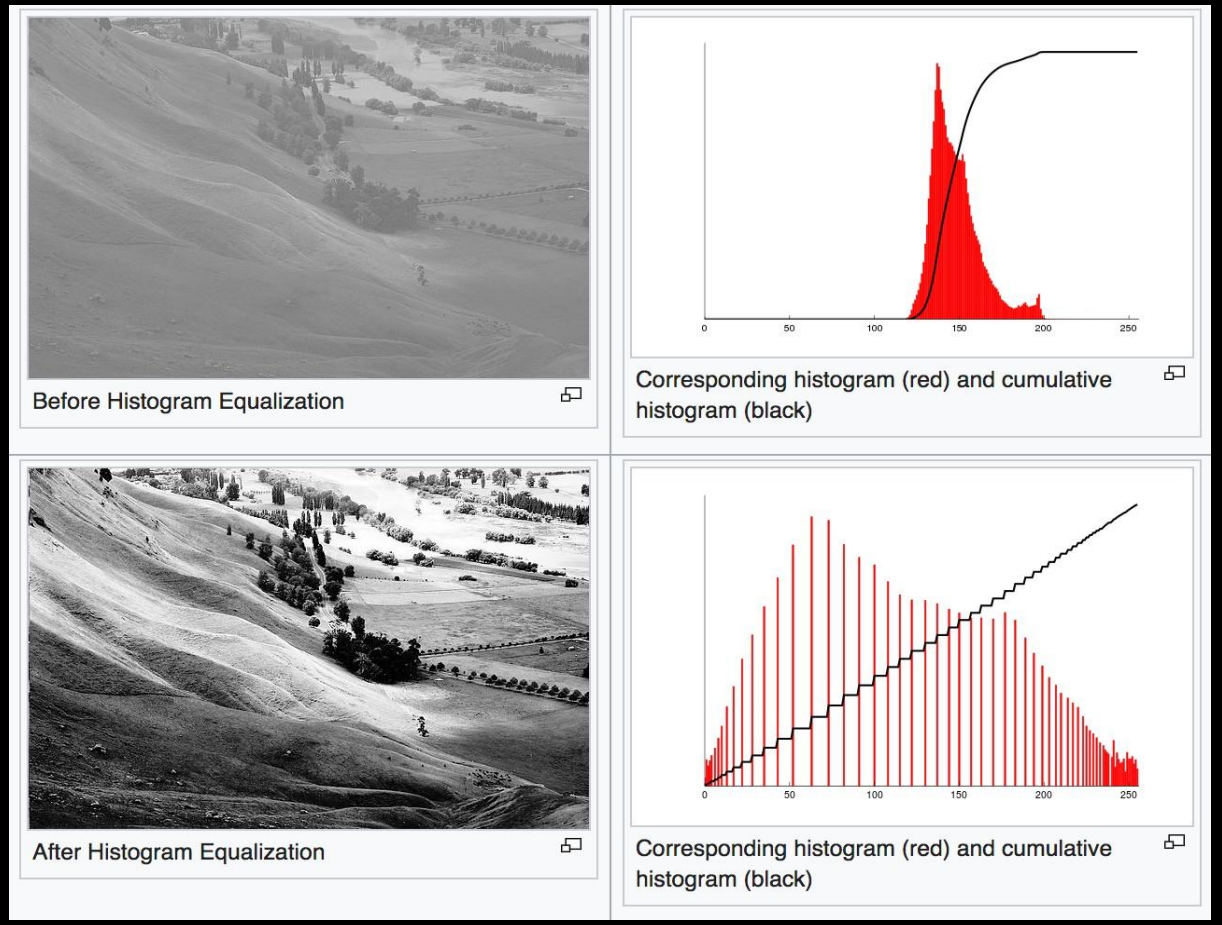
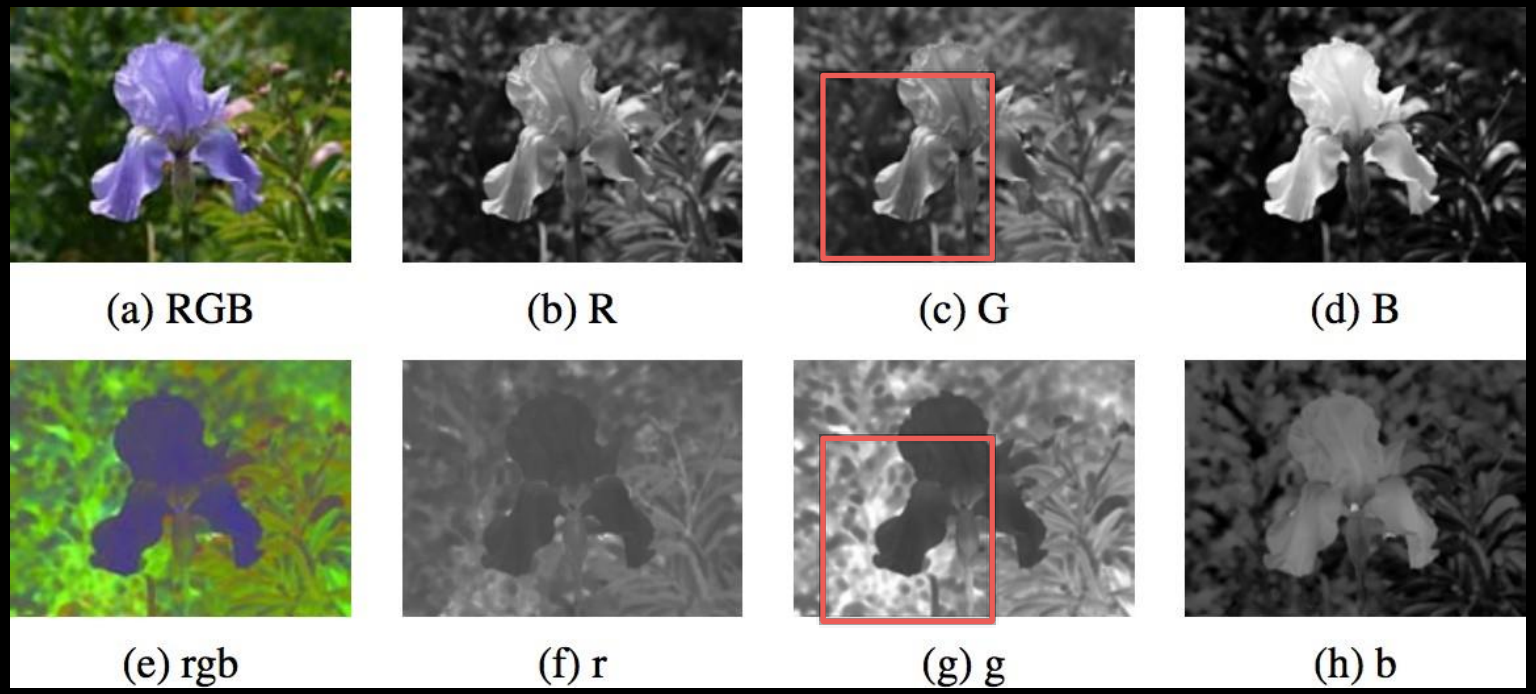


Image (pre-) Processing

- Color normalization: manipulating colors and the illumination of the image



$$r = \frac{R}{R+G+B}, \quad g = \frac{G}{R+G+B}, \quad b = \frac{B}{R+G+B}$$

Image (pre-) Processing

- Filtering: applying a moving kernel to the pixels of the image

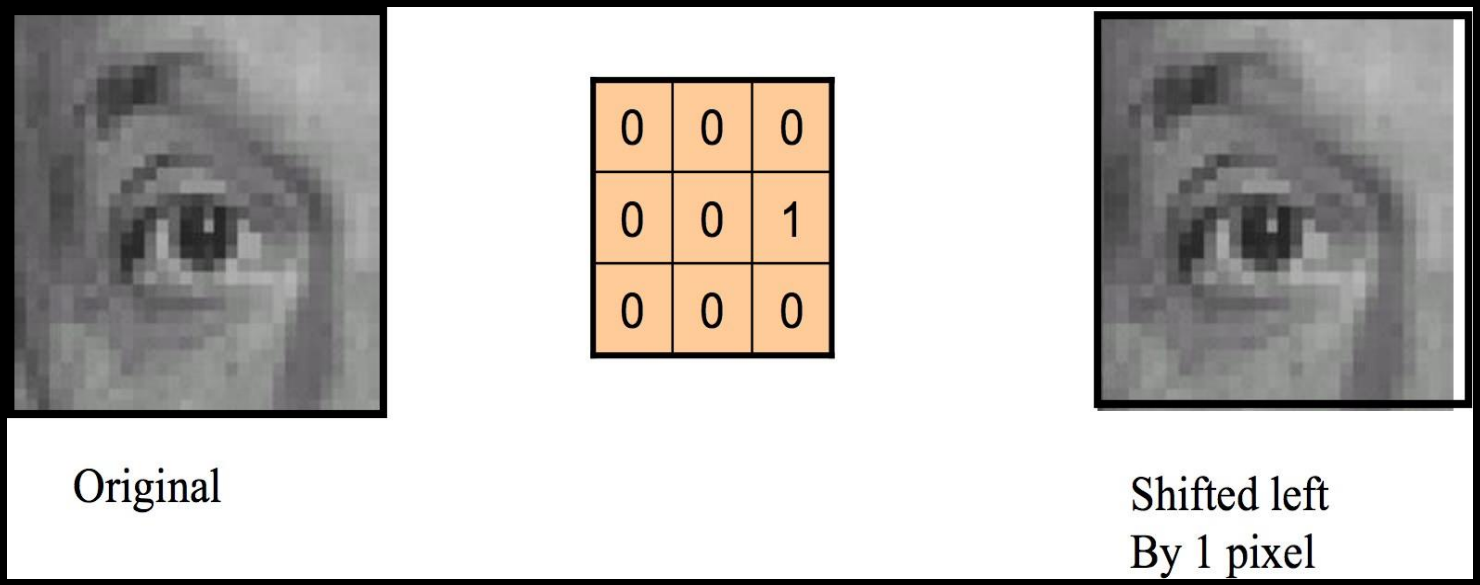


Image (pre-) Processing

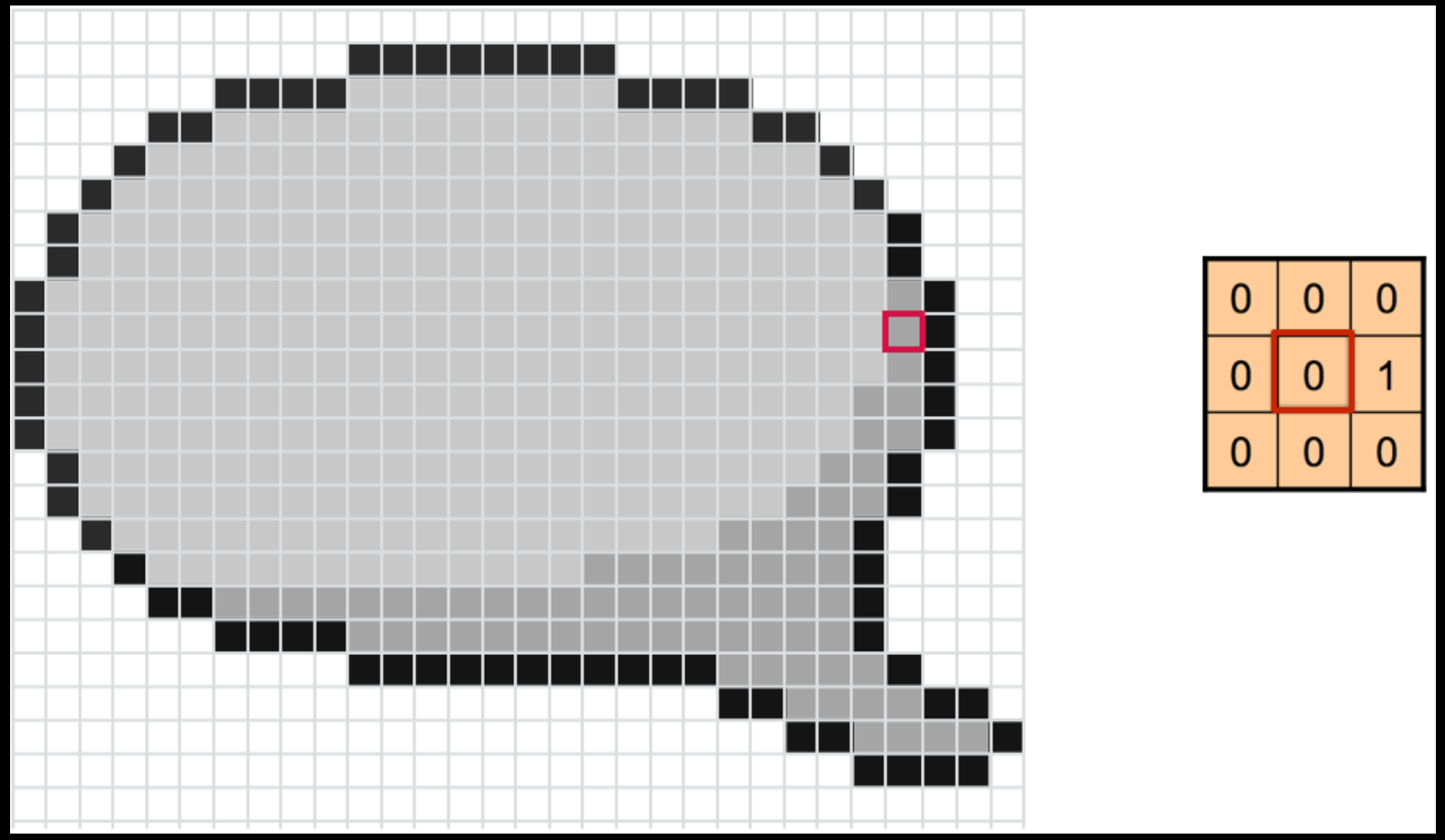


Image (pre-) Processing

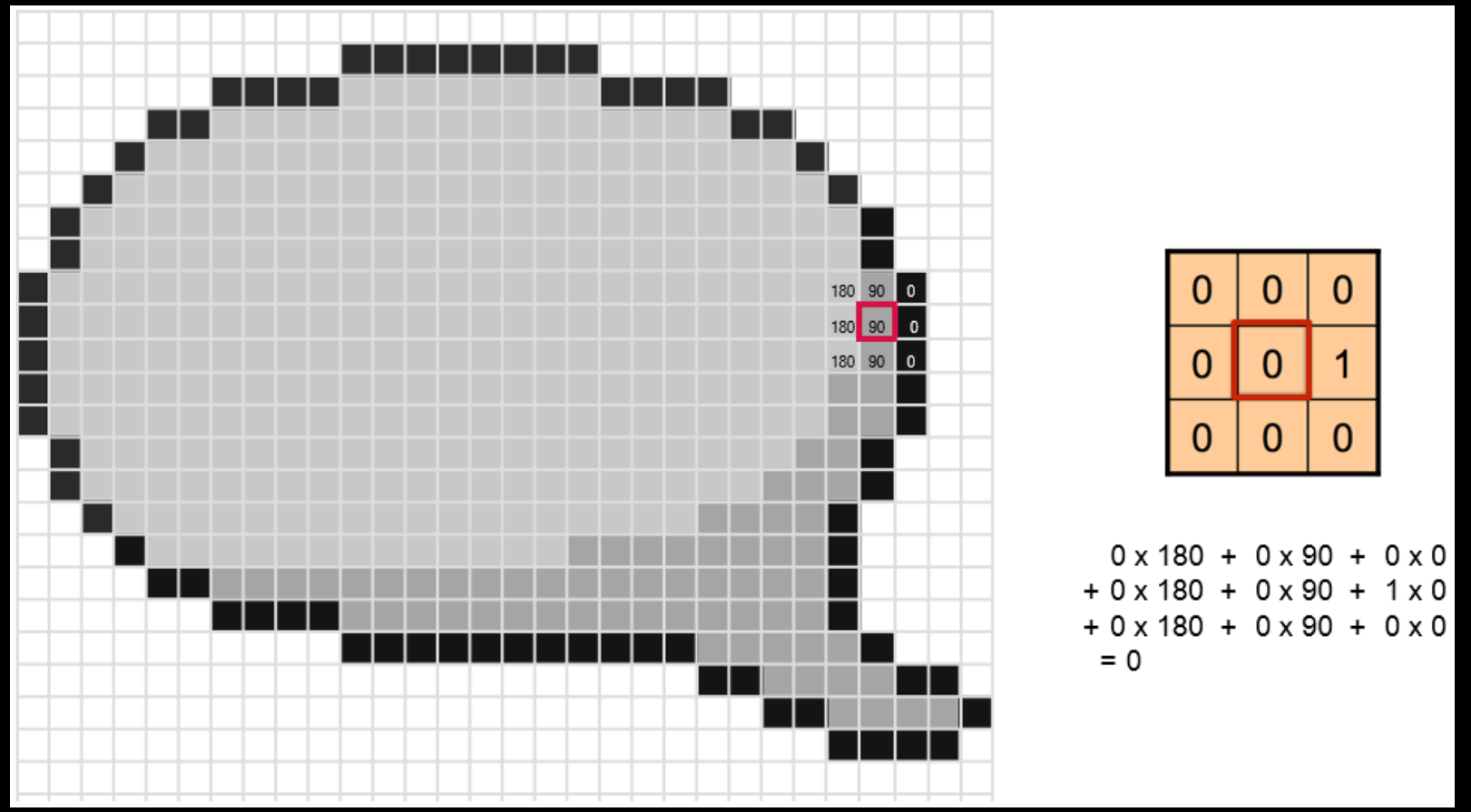


Image (pre-) Processing

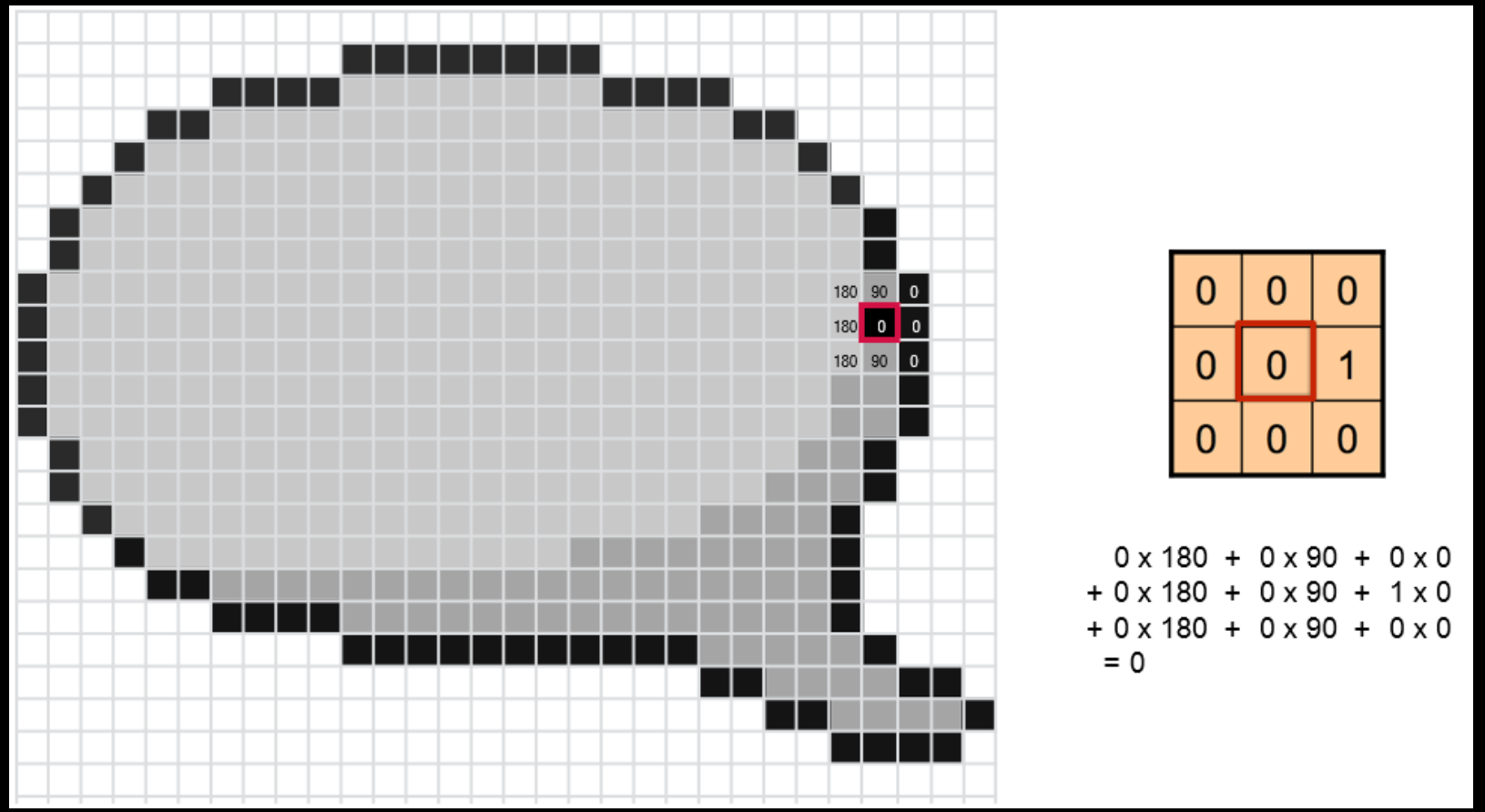


Image (pre-) Processing

- Filtering: applying a moving kernel to the pixels of the image

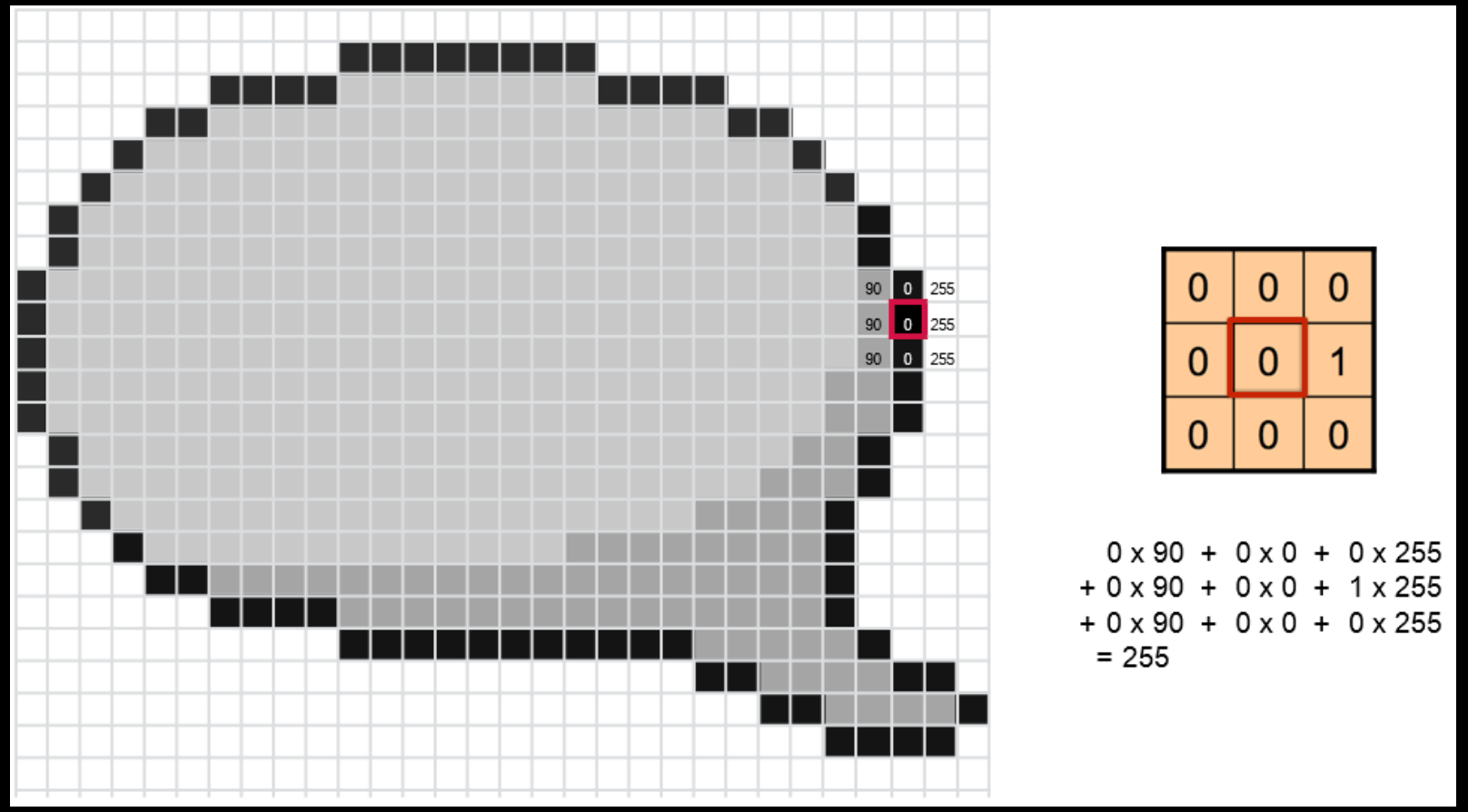


Image (pre-) Processing

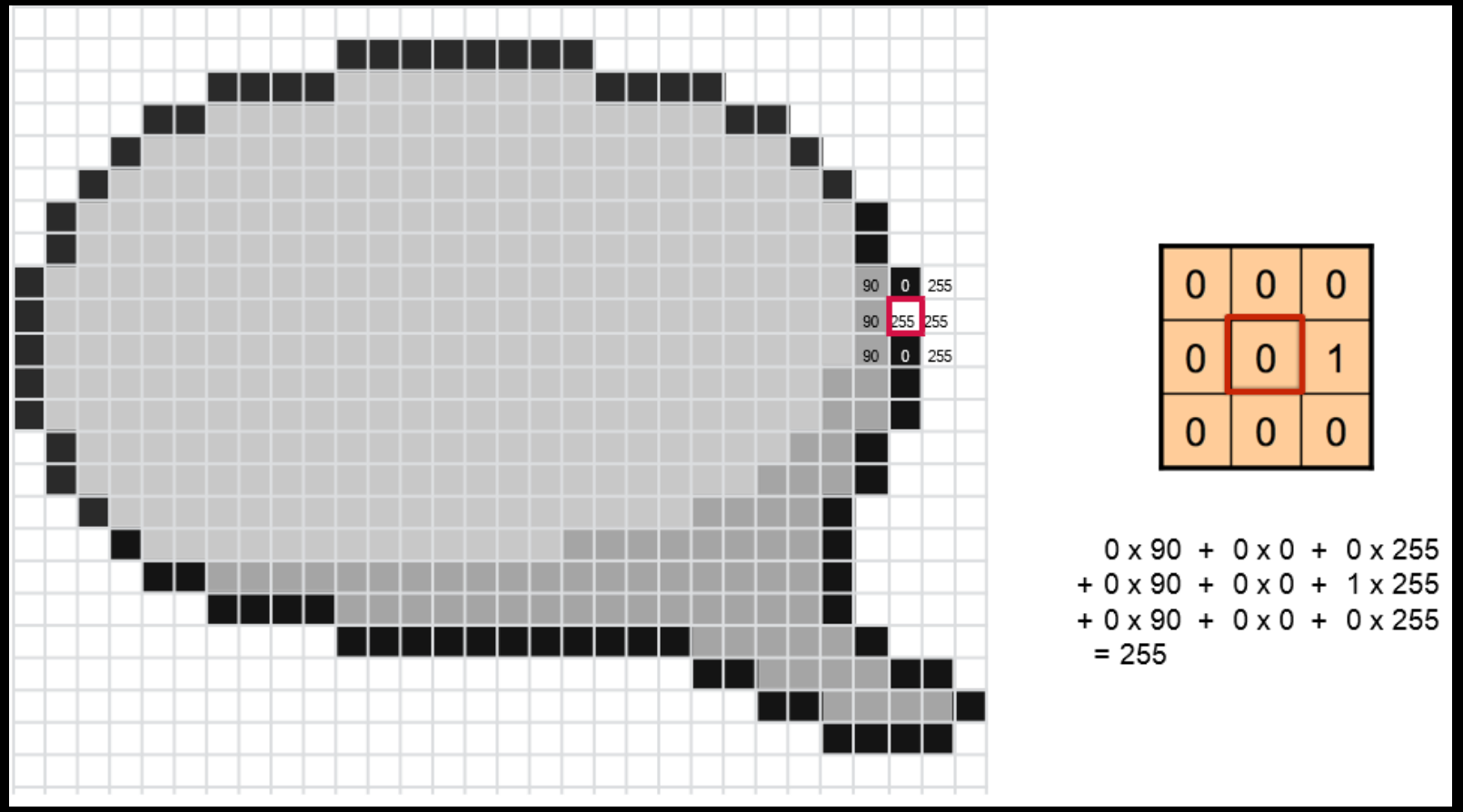


Image (pre-) Processing

- This filter leaves the image unchanged

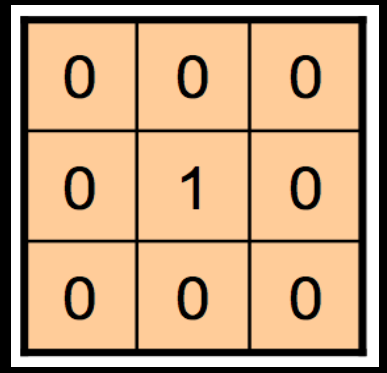
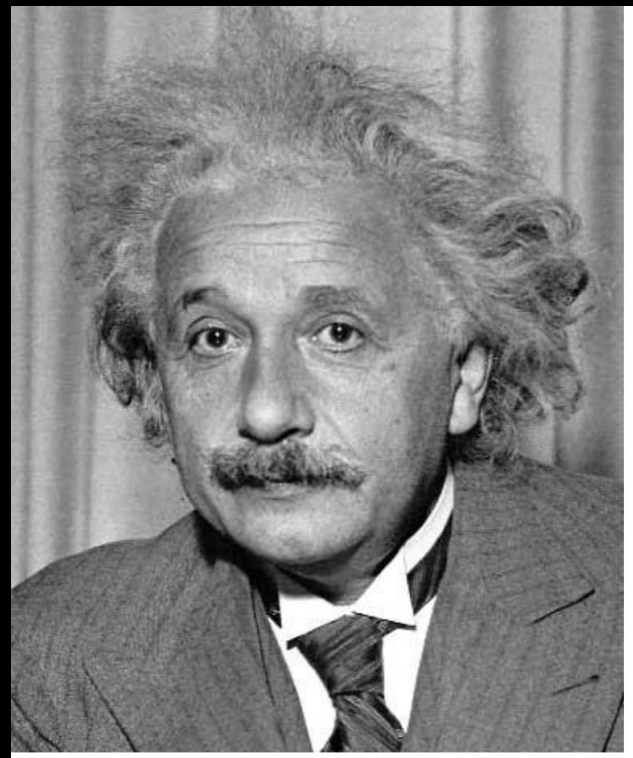
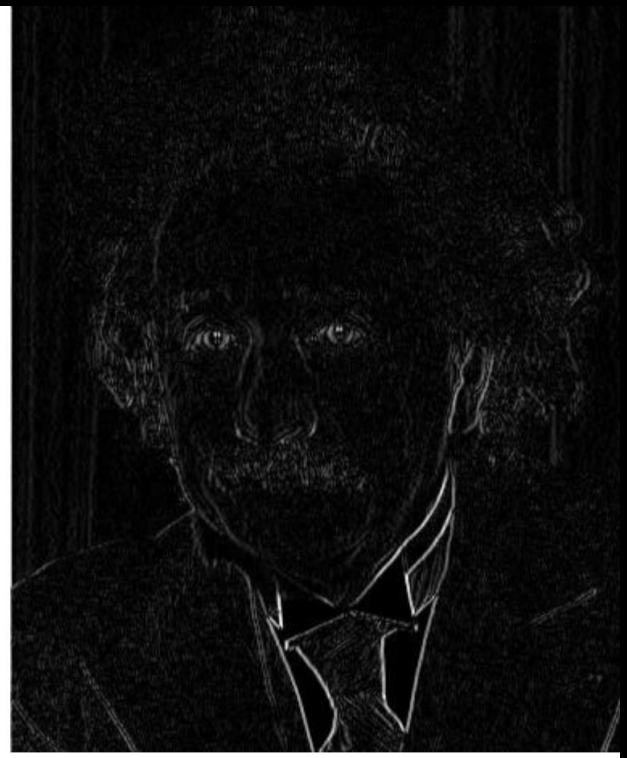


Image (pre-) Processing

- Vertical edge



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



Vertical Edge

Image (pre-) Processing

- Horizontal edge

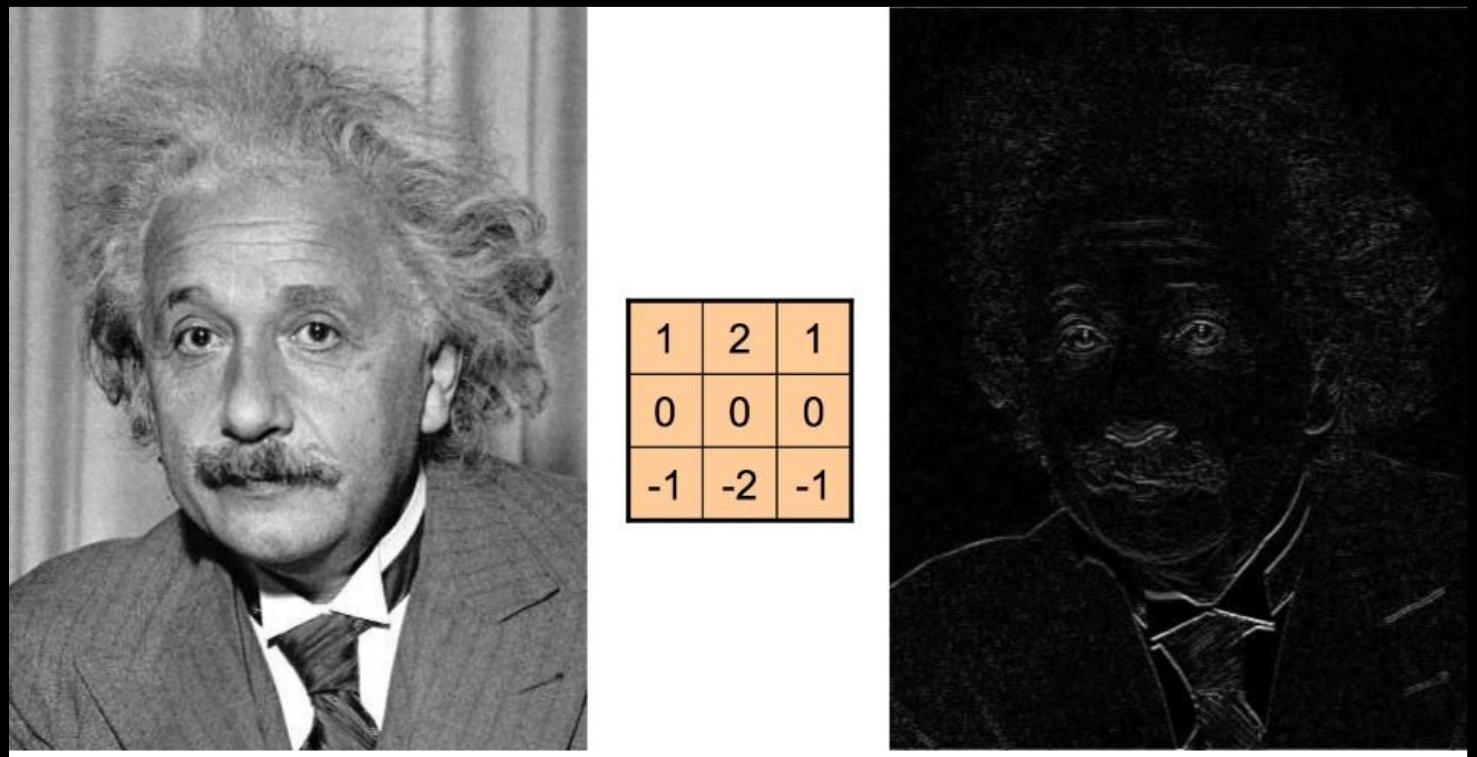
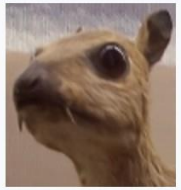
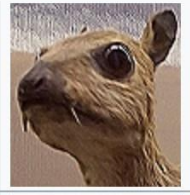
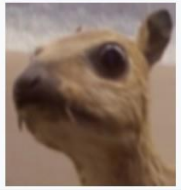
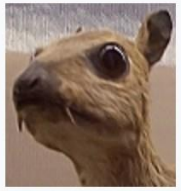


Image (pre-) Processing

- Other filters

Operation	Kernel ω	Image result g(x,y)
Identity	$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$	
Edge detection	$\begin{bmatrix} 1 & 0 & -1 \\ 0 & 0 & 0 \\ -1 & 0 & 1 \end{bmatrix}$	
	$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$	
	$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$	

Operation	Kernel ω	Image result g(x,y)
Sharpen	$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$	
Box blur (normalized)	$\frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$	
Gaussian blur 3 × 3 (approximation)	$\frac{1}{16}\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$	
Gaussian blur 5 × 5 (approximation)	$\frac{1}{256}\begin{bmatrix} 1 & 4 & 6 & 4 & 1 \\ 4 & 16 & 24 & 16 & 4 \\ 6 & 24 & 36 & 24 & 6 \\ 4 & 16 & 24 & 16 & 4 \\ 1 & 4 & 6 & 4 & 1 \end{bmatrix}$	
Unsharp masking 5 × 5 Based on Gaussian blur with amount as 1 and threshold as 0 (with no image mask)	$\frac{-1}{256}\begin{bmatrix} 1 & 4 & 6 & 4 & 1 \\ 4 & 16 & 24 & 16 & 4 \\ 6 & 24 & -476 & 24 & 6 \\ 4 & 16 & 24 & 16 & 4 \\ 1 & 4 & 6 & 4 & 1 \end{bmatrix}$	

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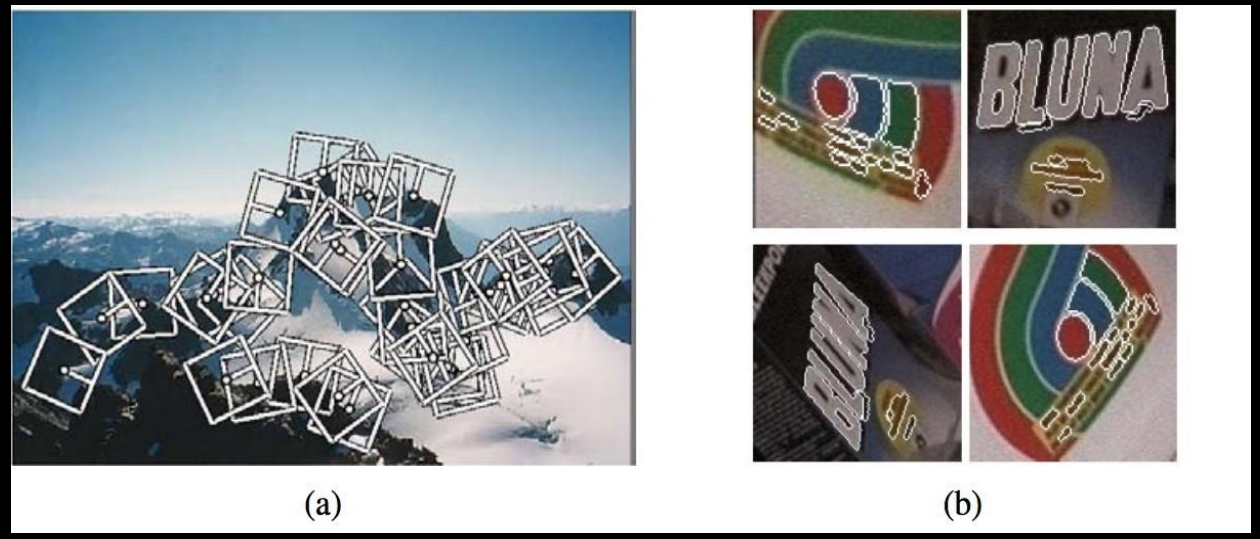
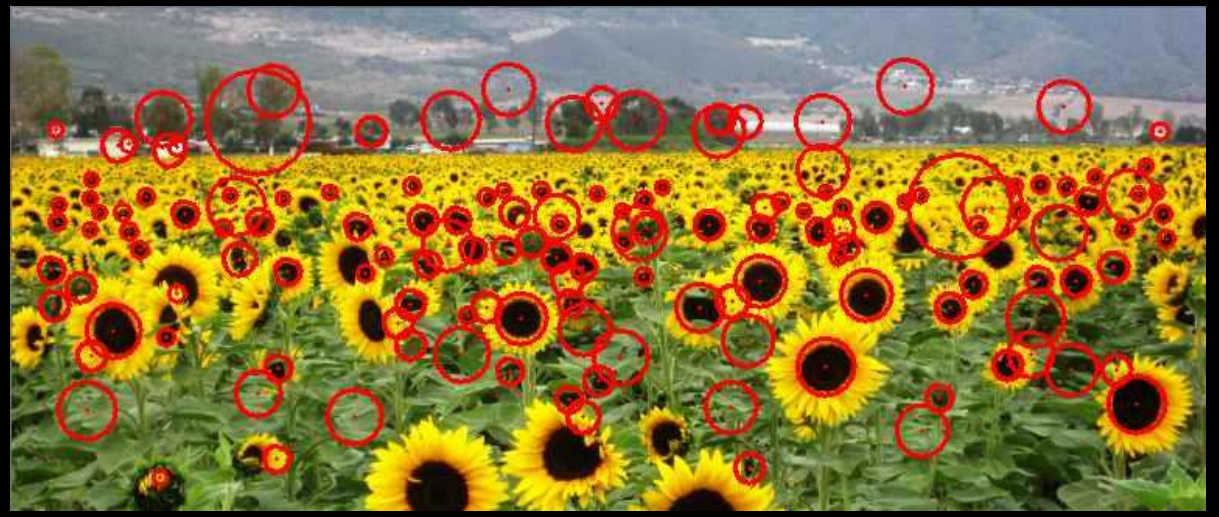
Feature Detection

- **Interest points:** refers to points in the image that can detected and are relevant for higher level processing.
  - Edges, corners, blobs, patches, ridges, textures
  - Used for matching images.
  - Track how the image changes from frame to frame in motion applications.





https://boofcv.org/images/1/1b/Example_interestpoint_detected.jpg

Feature Detection

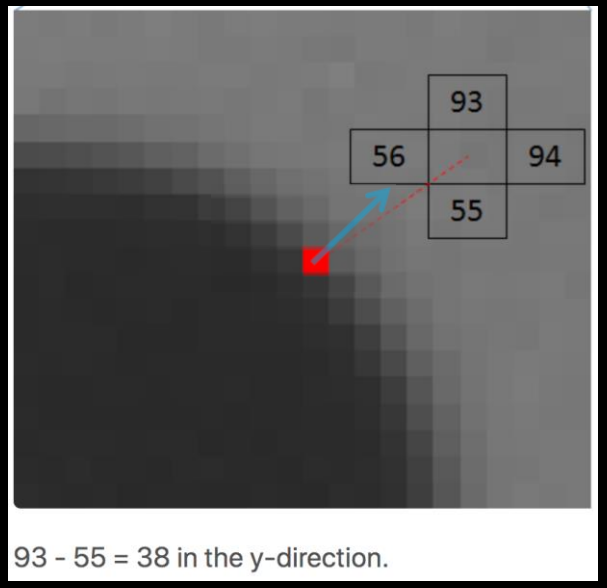
- **Edge detection** identify points where brightness changes sharply.

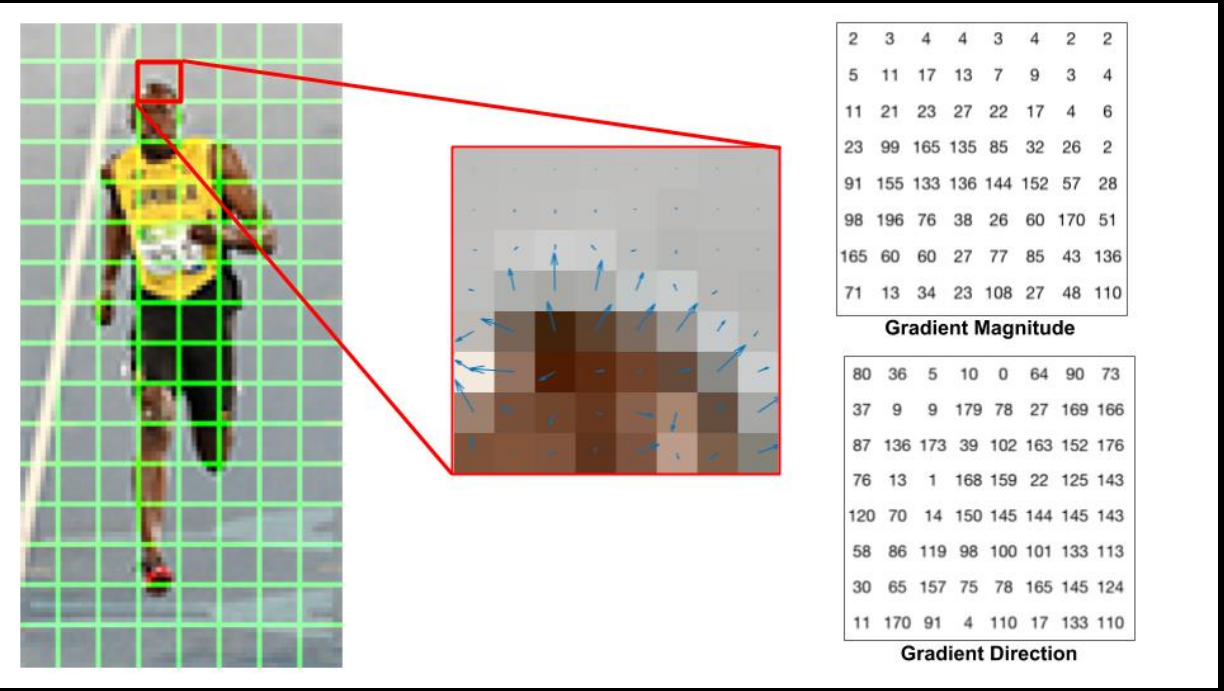
Feature Detection

- **Difference of Gaussian (DoG):** a feature enhancement algorithm that involves the subtraction of one Gaussian blurred version of an original image from another, less blurred version of the original.

Feature Detection

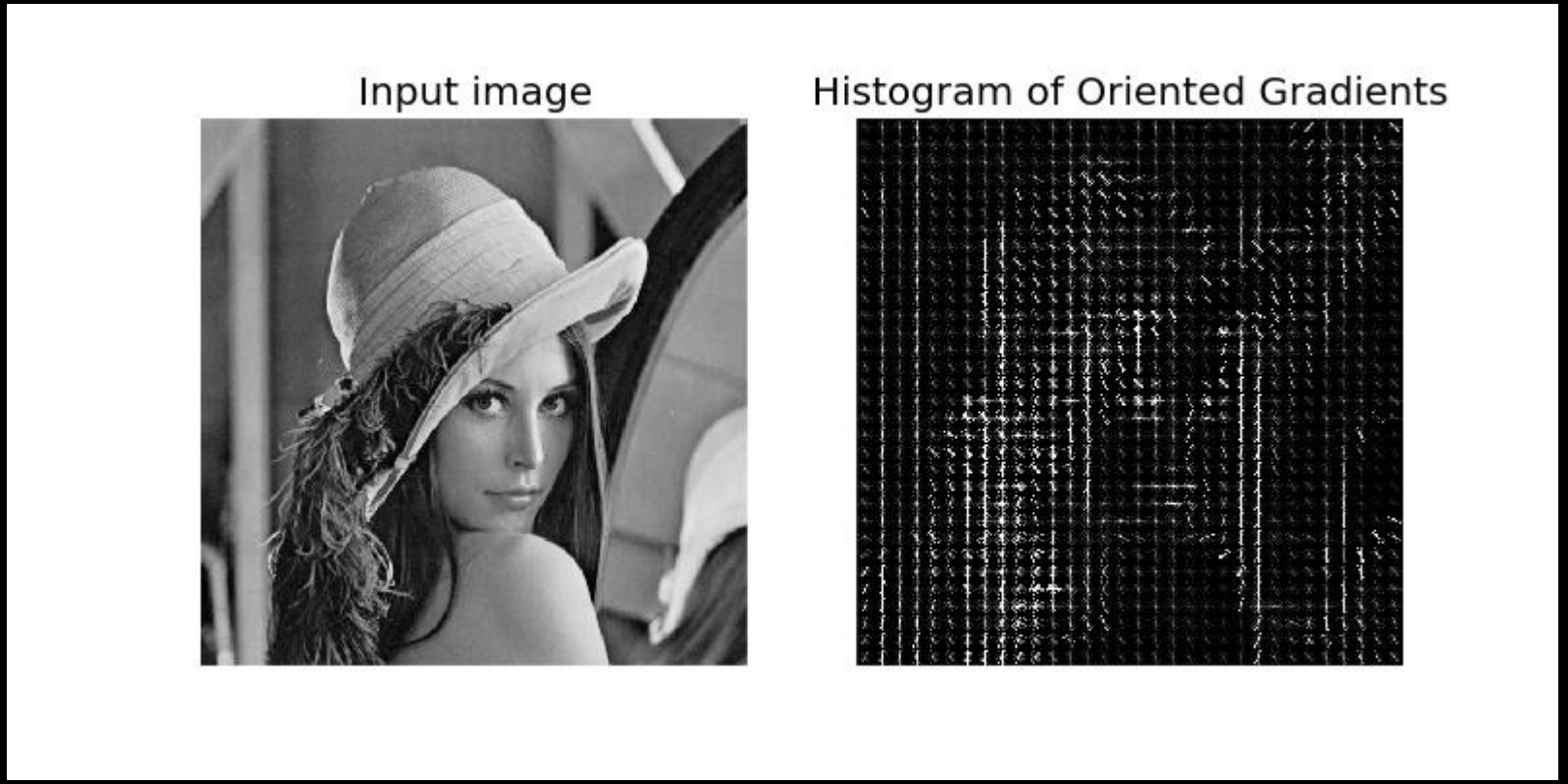
- **Histogram of Oriented Gradients (HOG):** a feature descriptor for object detection.
  - Computes the gradient vector of each pixel, i.e., the change direction and the change magnitude of each pixel.





Feature Detection

- **Histogram of Oriented Gradients (HOG)**



http://sharky93.github.io/docs/gallery/_images/plot_hog_1.png

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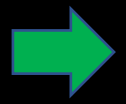
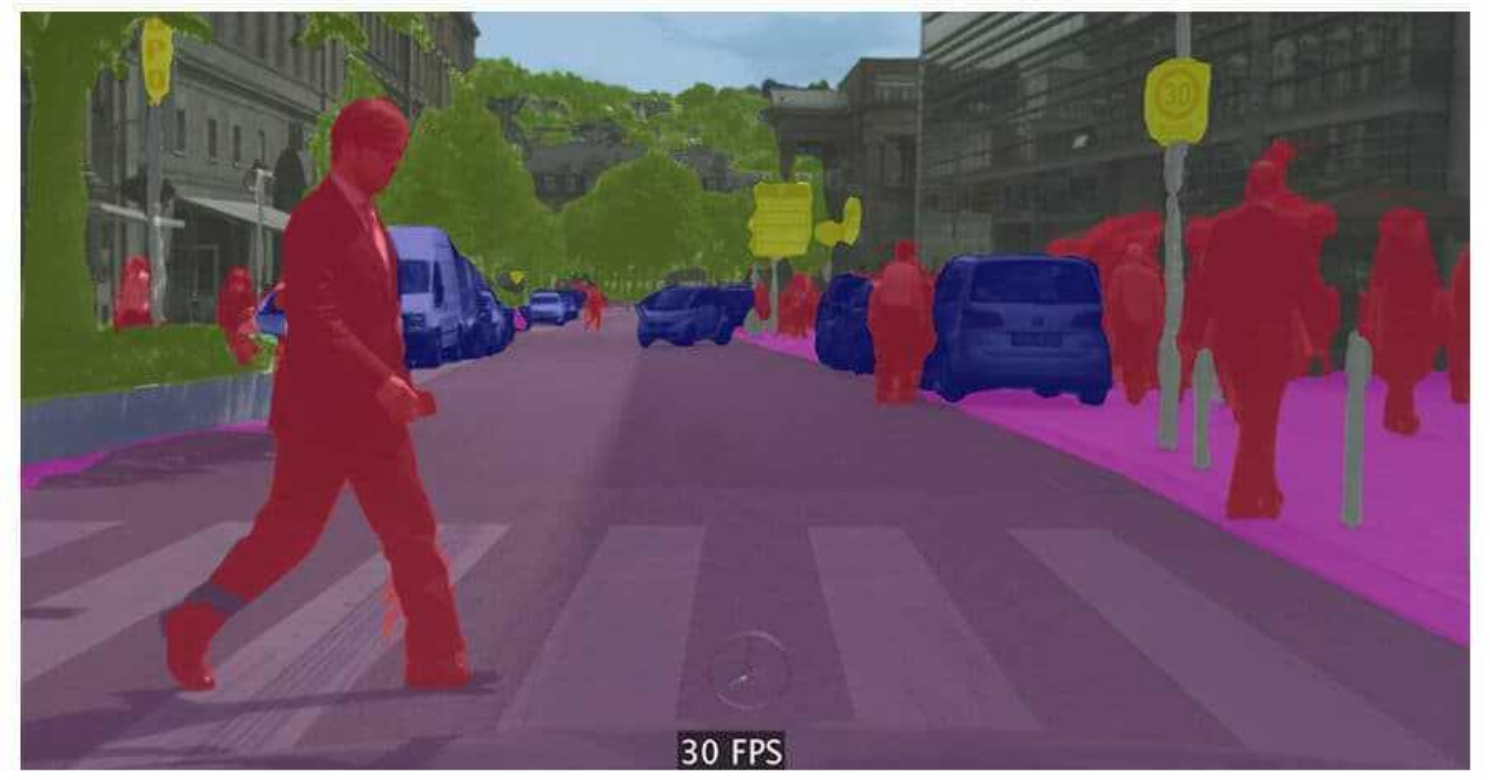


Segmentation

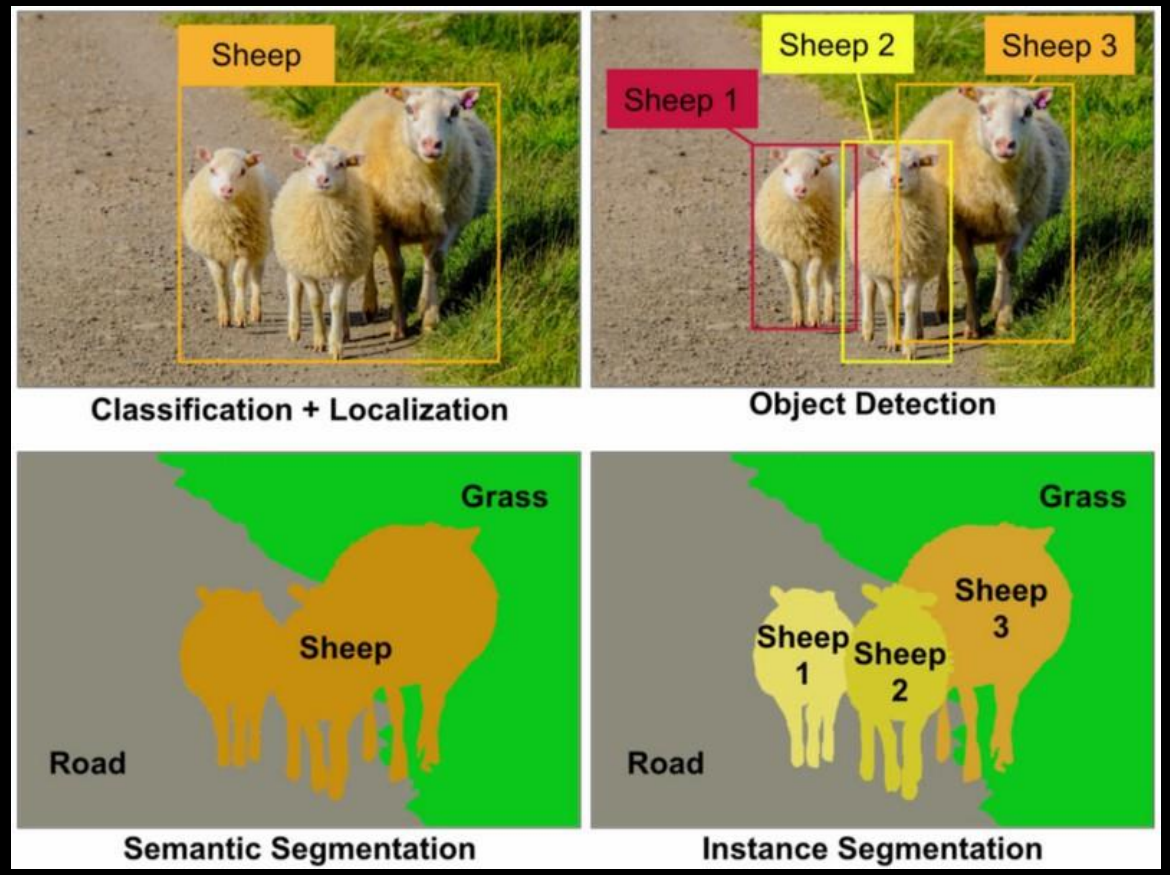
- **Segmentation:** is finding consistent regions in an image.



https://theaisummer.com/static/8b58a02198e13d2e29a41b40e7c6a035/8e1fc/semseg.jpg

Segmentation

- **Segmentation:** is finding consistent regions in an image.



https://miro.medium.com/max/800/1*SNvD04dEFIDwNAqSXLQC_g.jpeg

Segmentation

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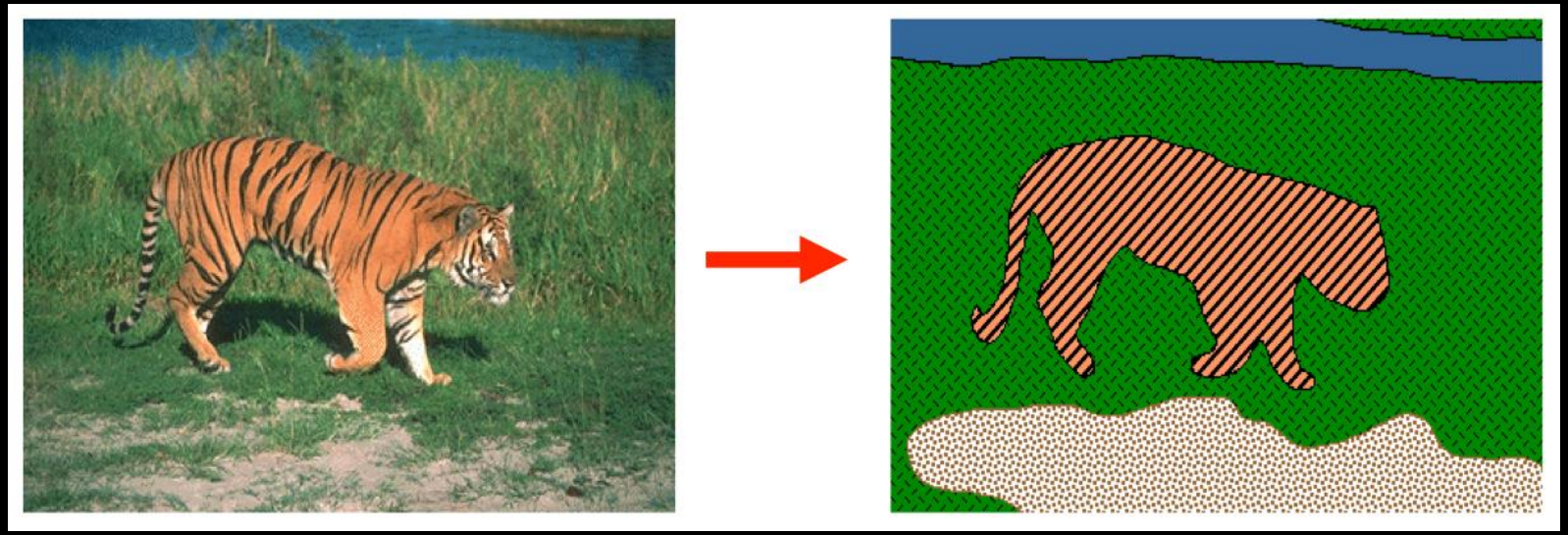

https://ai.stanford.edu/~syyeung/cvweb/Pictures3/segmentation.png

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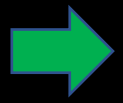
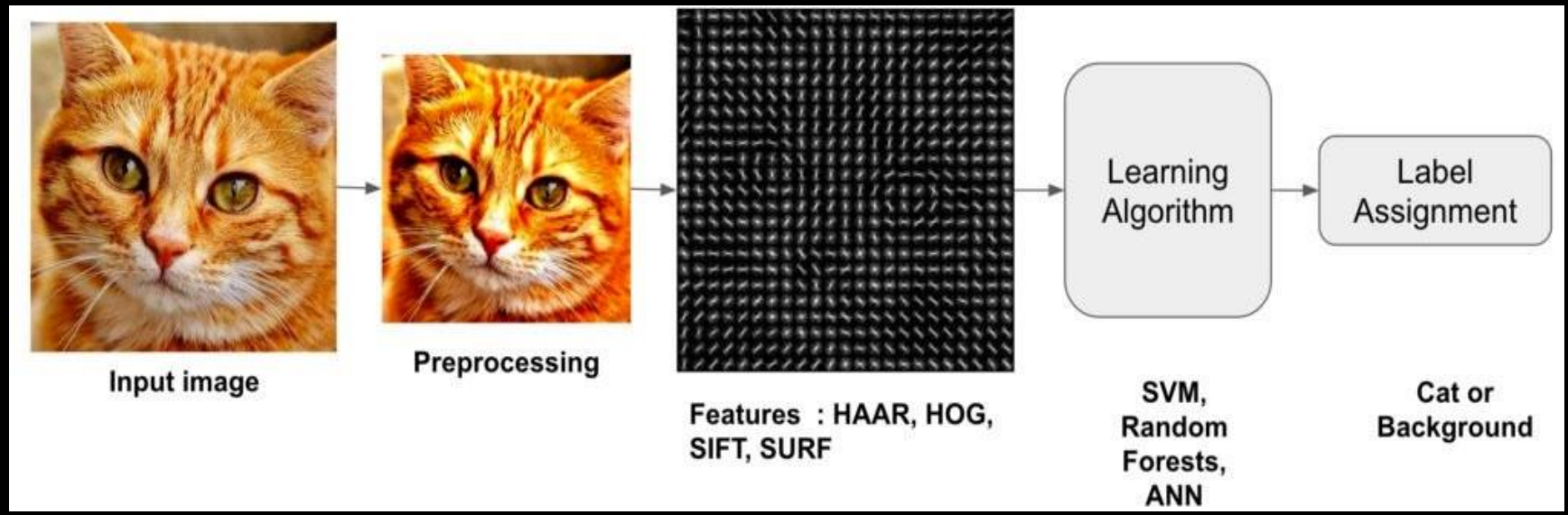


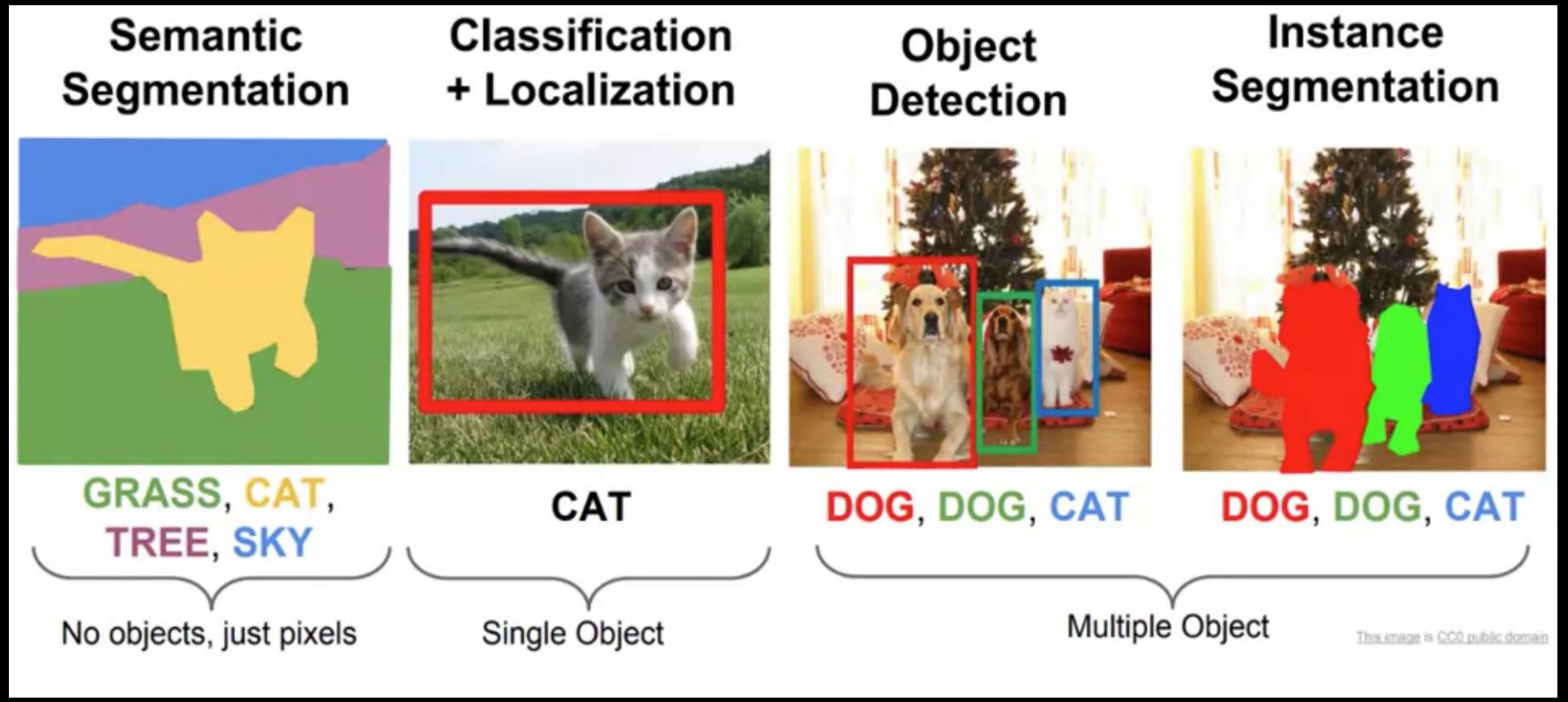
Object Recognition

- **Object recognition:** involves detecting objects in an image
- A typical pipeline



Object Recognition

- **Object recognition**



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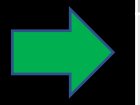


Computer Vision Applications

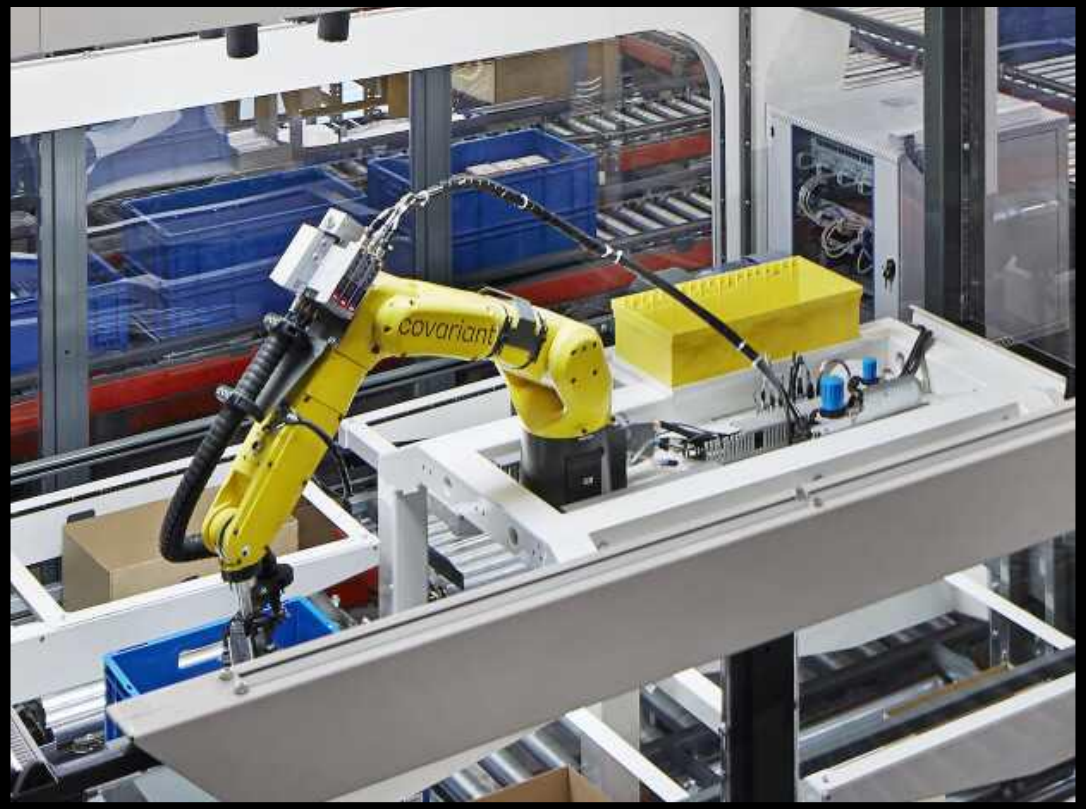
- **Optical character recognition (OCR):** reading handwritten postal codes on letters and automatic number plate recognition (ANPR);

Computer Vision Applications

- **Machine inspection:** rapid parts inspection for quality assurance using stereo vision.
  - Finding defects in airplane wing.

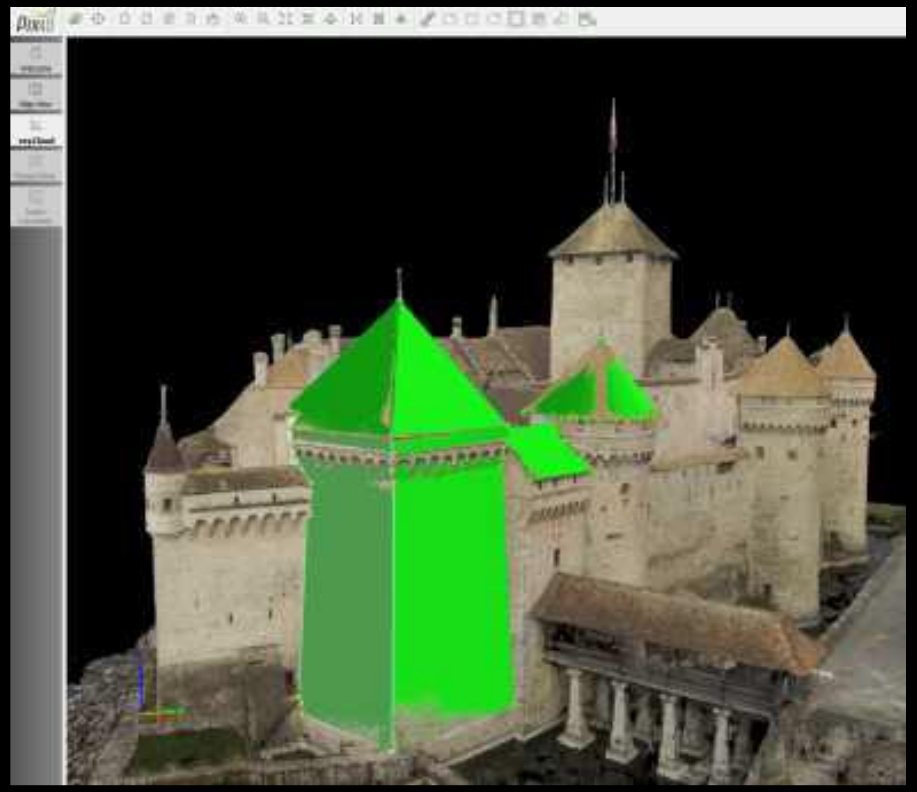
Computer Vision Applications

- **Retail**: object recognition for automated checkout lanes and fully automated stores.



Computer Vision Applications

- **3D model building:** fully automated construction of 3D models from aerial and drone photographs.



Computer Vision Applications

- **Medical imaging**