

Topic III

COMPUTER VISION AND IMAGE PROCESSING

Topic Description

This topic is designed to give students all the fundamentals in 2- D digital image processing with emphasis in image processing techniques, image filtering design and applications.

The topic emphasis in:

- I. Processing techniques,
- II. Image filtering,
- III. Image segmentation,
- IV. Image enhancement,
- V. Morphological processing of image and
- VI. Recognition of objects in an image.



Lecture 1:

Introduction to Image and Vision

Every picture tells a story

- ❑ Image carries vast amount of information.
- ❑ We, humans, are selective of what we consume through visual sense.
- ❑ The goal of computer vision is to *write computer programs that can interpret images*
- ❑ Can computers match human perception?
 - Yes and No (but mostly no!)

Humans are much better at “hard” things
Computers can be better at “easy” things



What is Digital Image Processing?

- ❑ Digital image processing helps us enhance images to make them visually pleasing, or emphasize regions or features of an image to better represent the content.
 - **Region-Of-Interest is vital in image processing**
- ❑ For example, we may wish to enhance the brightness and contrast to make a better print of a photograph, similar to popular photo-processing software.
- ❑ In a magnetic resonance image (MRI) of the brain, we may want to highlight a certain region (only interesting part) of image intensities to see certain parts of the brain.

Computer Vision!

❖ Reconstruction

Receive from the real world and reconstruct it internally---Digitally

How do humans perform this task?

Recover 3D information from data

- Angle and lighting

❖ Recognition

Feature extraction

Segmentation of image parts

Detect and identify objects

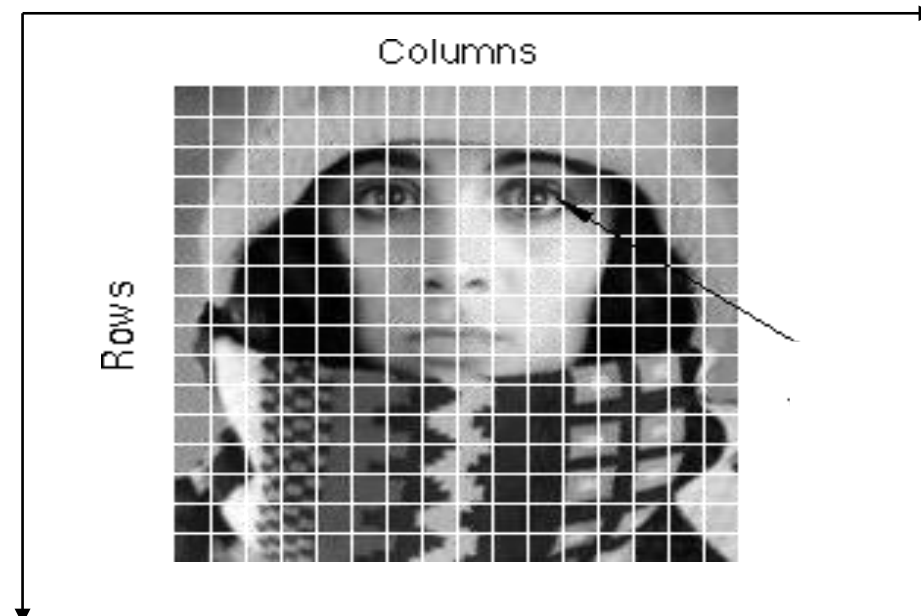
❖ Understanding

Giving context to image parts

Knowing what is happening in the scene?

What is an image?

- The pattern is defined is a coordinate system whose origin is conventionally defined as the upper-left corner of the image .
- We can describe the pattern by a function $f(x,y)$.



Closer Look at elements of image

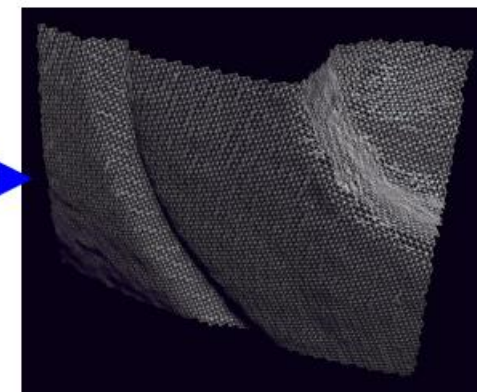
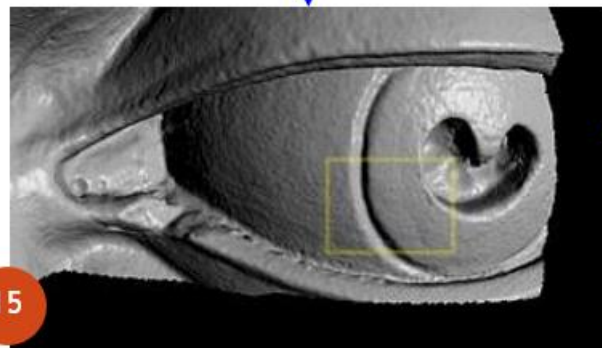
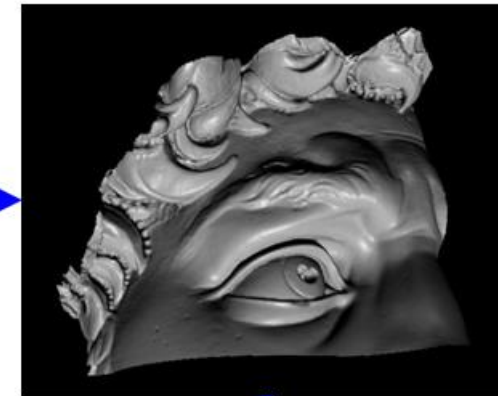


Image Processing and Related Fields

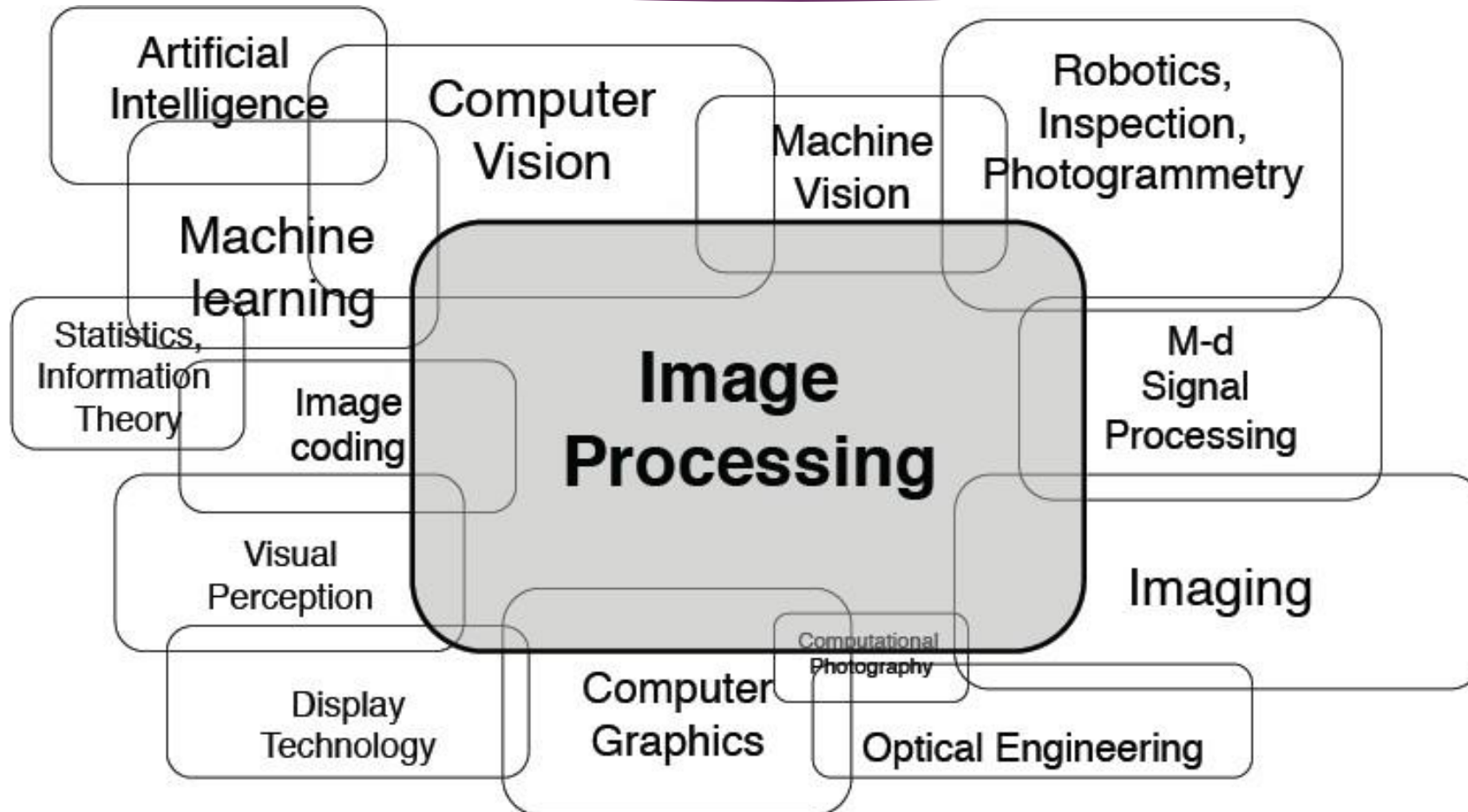
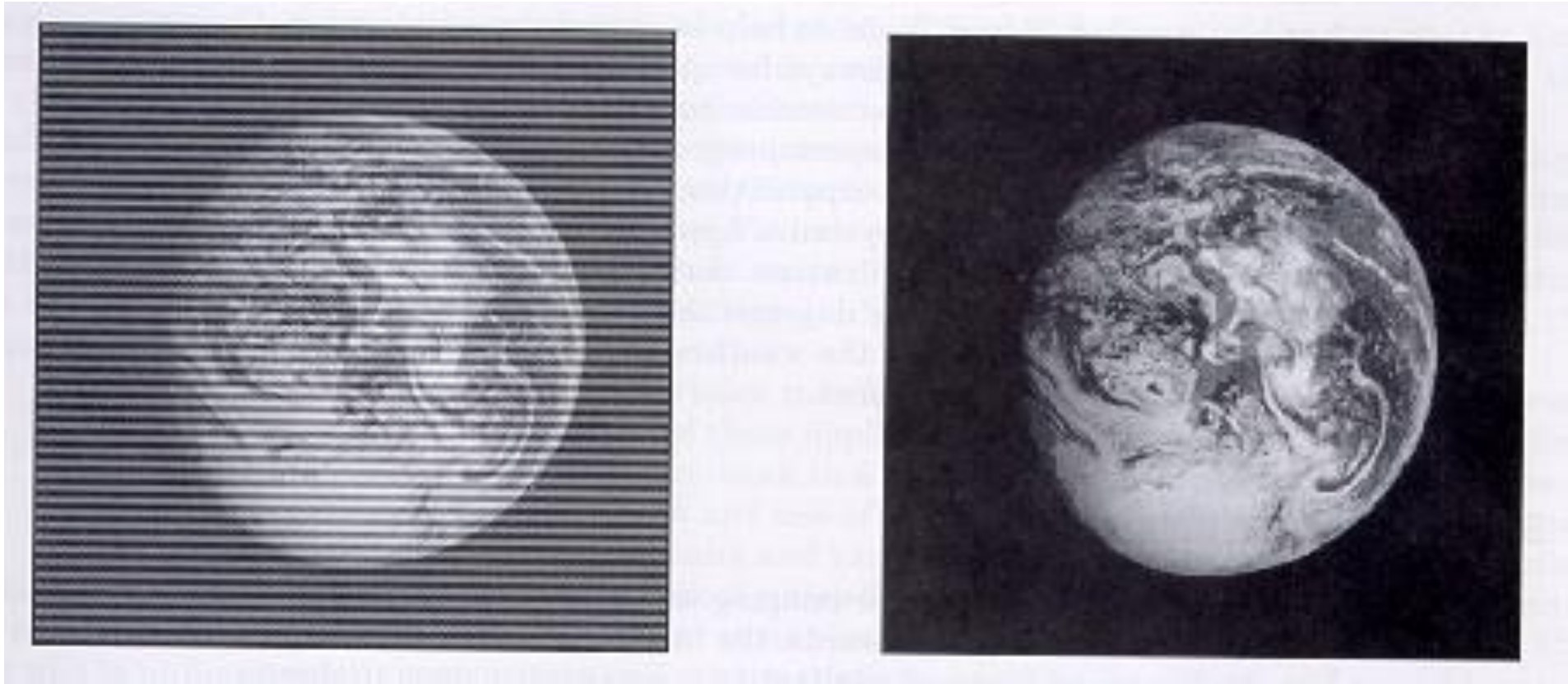
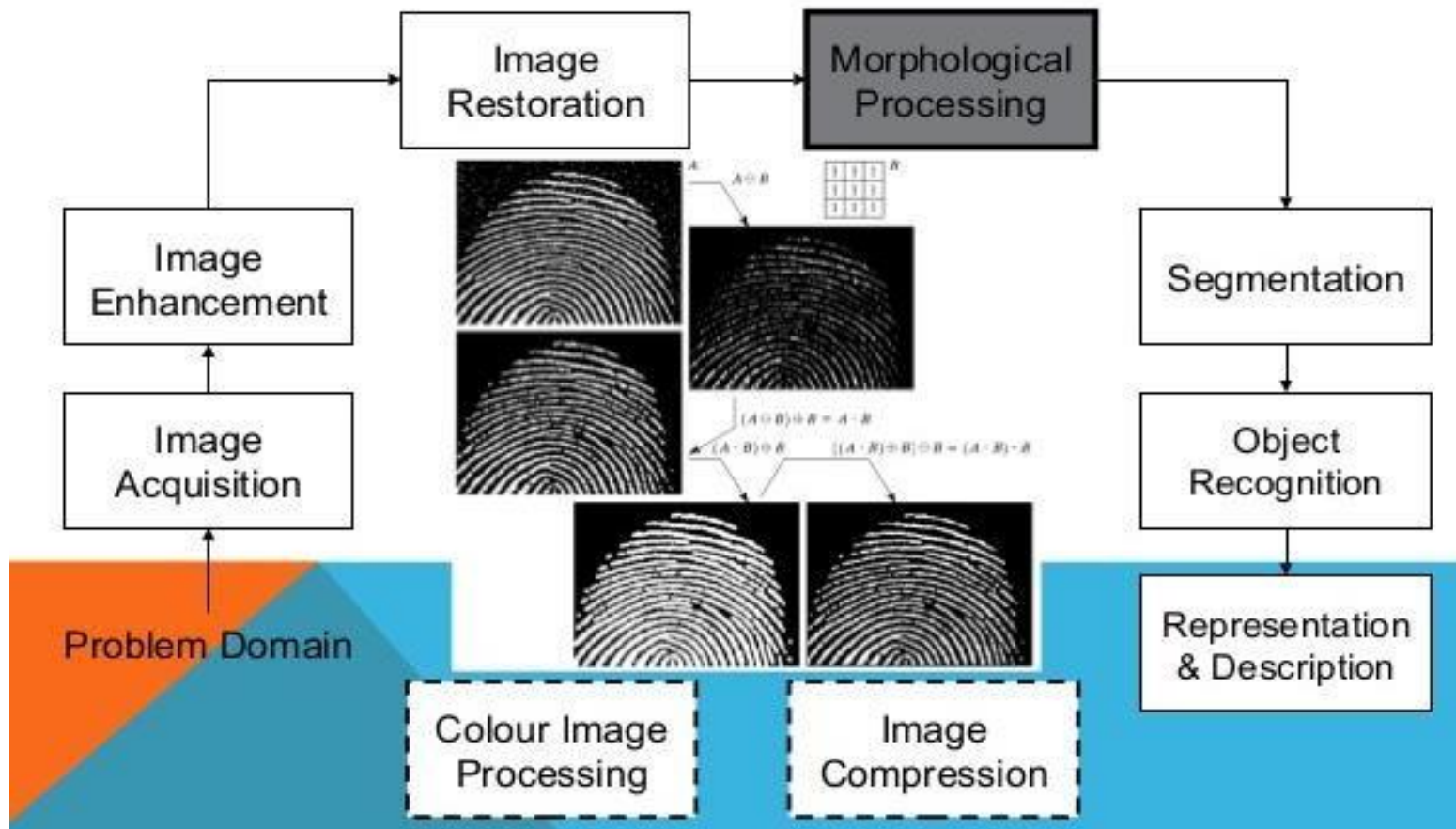


Image Restoration(e.g., correcting out-focus images)



Computer Vision



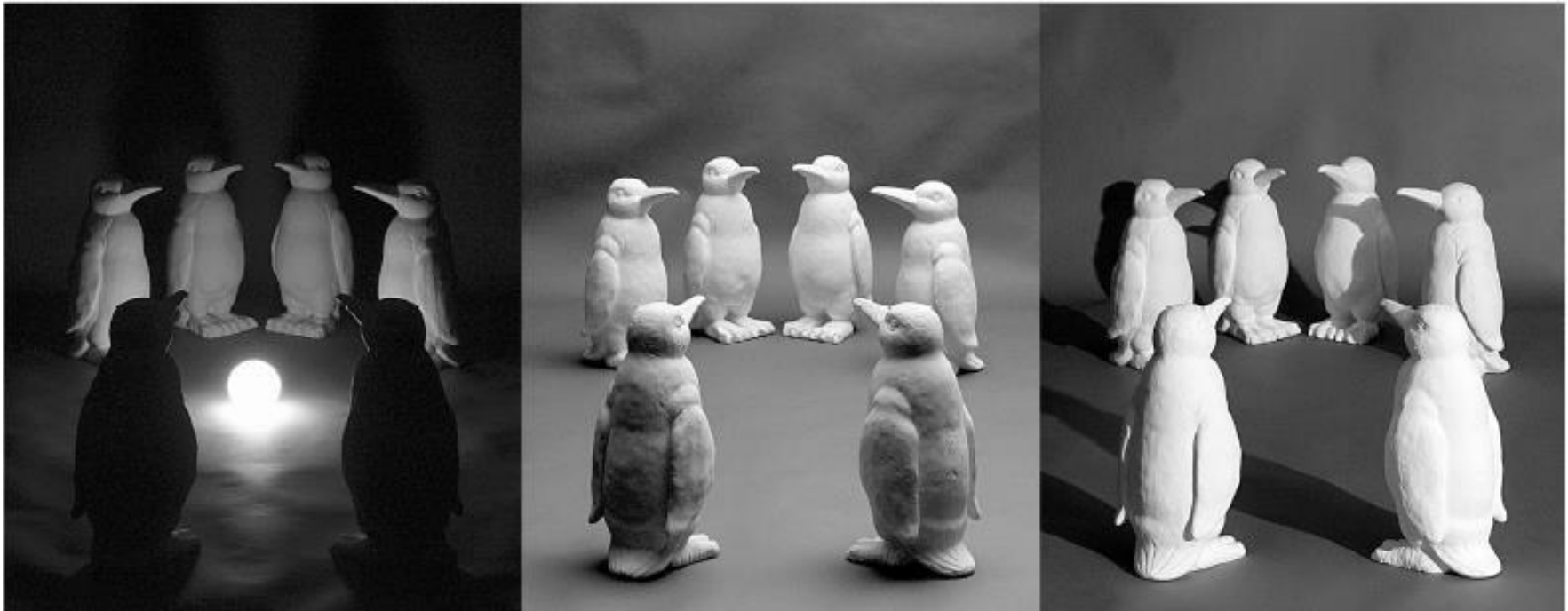
Issue of Contrast

- Objects appear to the eye to become darker as the background gets lighter.
- The example below is a piece of paper that seems white when lying on a desk, but can appear totally black in a lighter background



Issue of Illumination

- Same objects and arrangement
- Different angle of light



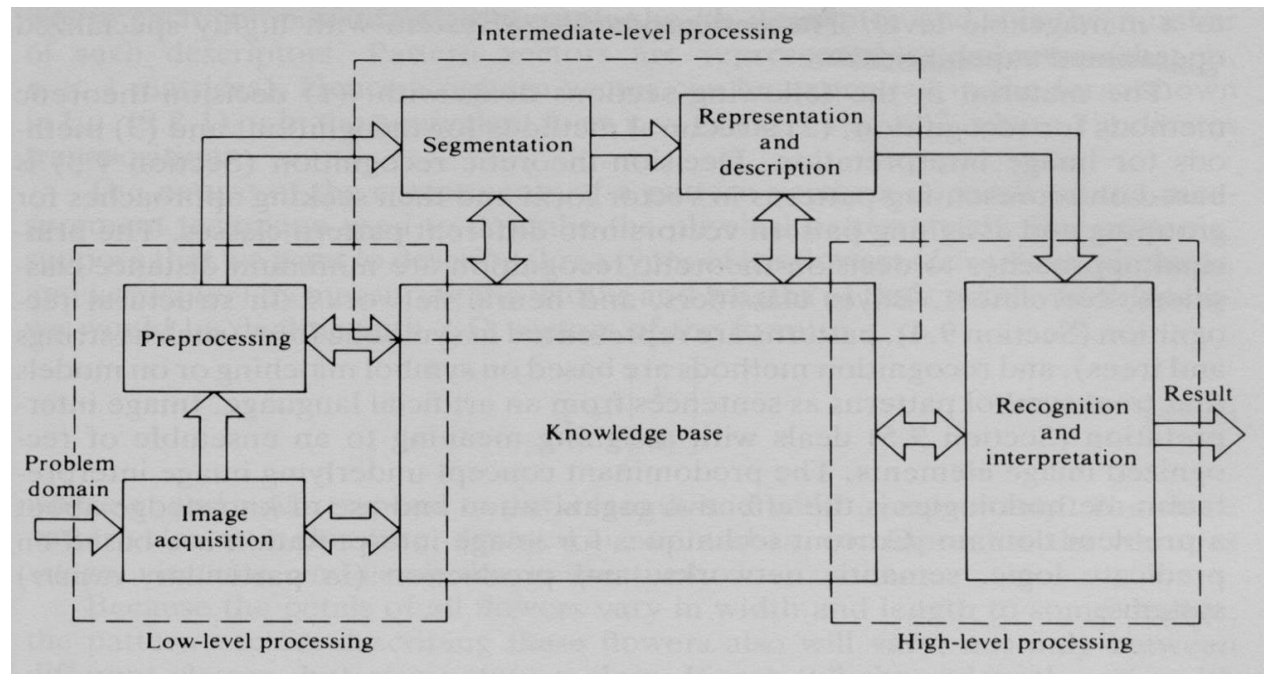
What is Computer Vision?

- ❑ Deals with the development of the theoretical and algorithmic basis by which useful information about the 3D world can be automatically extracted and analyzed from a single or multiple 2D images of the world.

The Three Image Processing Levels

1. Low-level processing

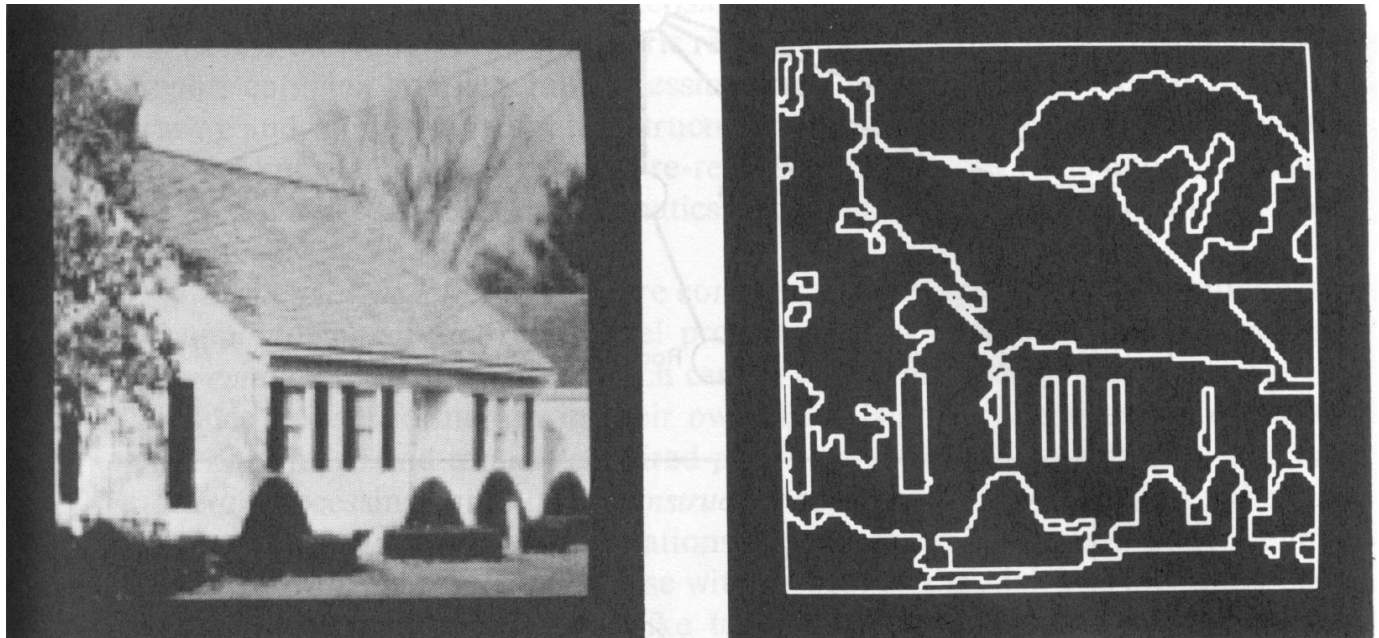
Standard procedures are applied to improve image quality.
Procedures are required to have no intelligent capabilities.



The Three Image Processing Levels (2)

2. Intermediate-level processing

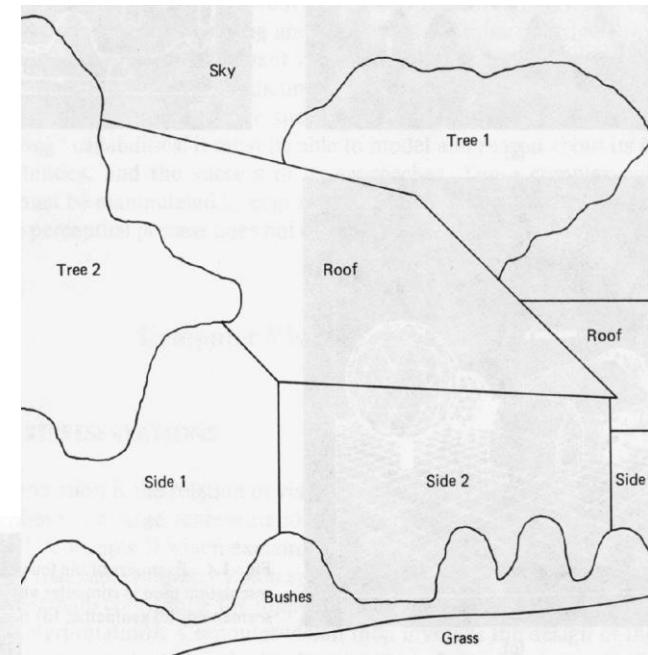
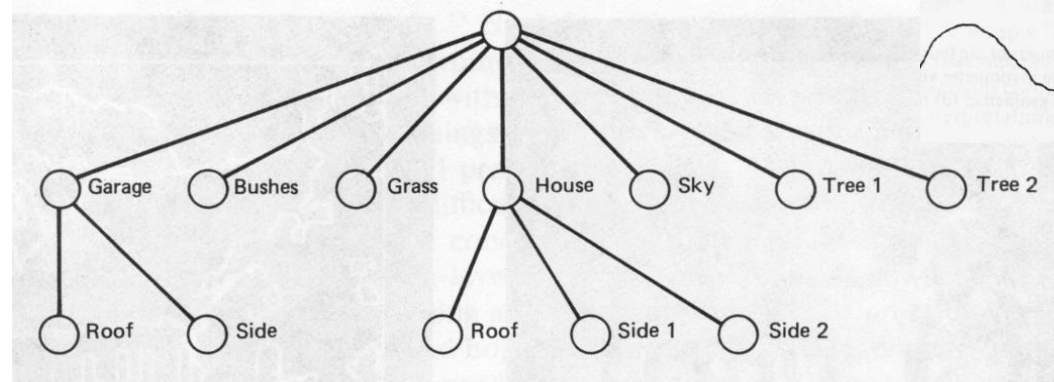
- Extract and characterize components in the image
- Some intelligent capabilities are required.



The Three Image Processing Levels (3)

3. High-level processing

- Recognition and interpretation of segments of the image
- Procedures require high intelligent capabilities.



Mathematics in Computer Vision

- ❑ In the early days of computer vision, vision systems employed simple heuristic methods.
- ❑ Today, the domain is heavily inclined towards theoretically, well-founded methods involving non-trivial mathematics.
 - Calculus
 - Linear Algebra
 - Probabilities and Statistics
 - Signal Processing
 - Projective & Computational Geometry
 - Optimization Theory
 - Control Theory

Computer Vision Applications

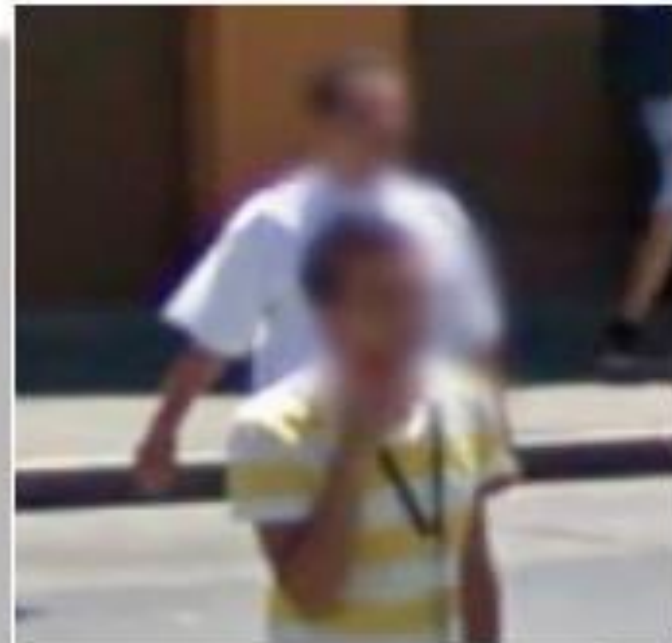
- ❑ Industrial inspection/quality control
- ❑ Surveillance and security/ biometrics
- ❑ Face recognition
- ❑ Space Science applications
- ❑ Medical image analysis
- ❑ Autonomous vehicles (self-driving car like Tesla)
- ❑ Virtual reality and much more

Face Detection Vs Face Blurring

On Facebook



on NEWS



Passport photo

[Select photo](#)



✗ The photo you want to upload does not meet our criteria because:

- Subject eyes are closed

Please refer to the technical requirements.
You have 9 attempts left.

Check the photo [requirements](#).

Read more about [common photo problems and how to resolve them](#).

After your tenth attempt you will need to start again and re-enter the CAPTCHA security check.

Reference number: 20161206-81

Filename: Untitled.jpg

If you wish to [contact us](#) about the photo, you must provide us with the reference number given above.

Please print this information for your records.

[Print](#)



Passport photo

[Select photo](#)



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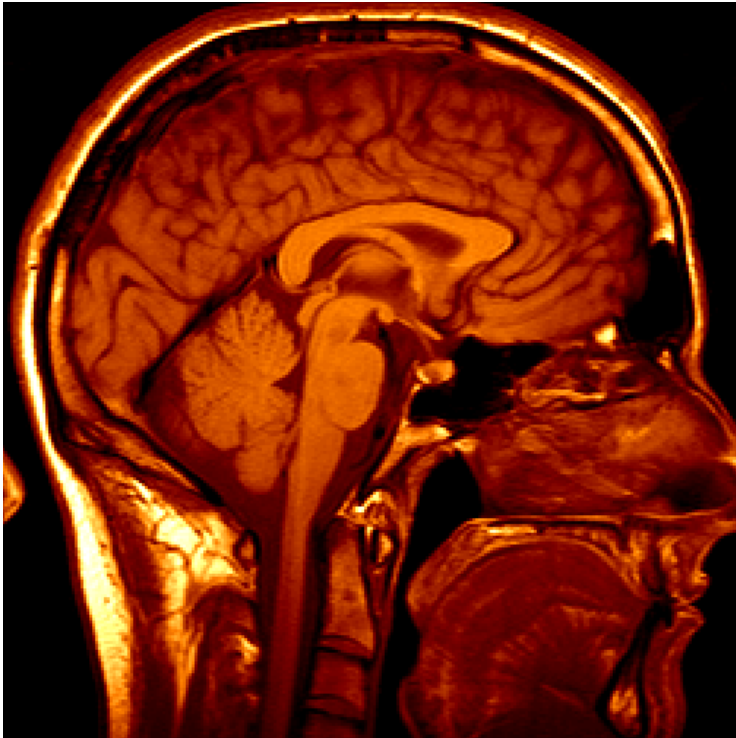
If you wish to [contact us](#) about the photo, you must provide us with the reference number given above.

Please print this information for your records.

[Print](#)



Medical image analysis

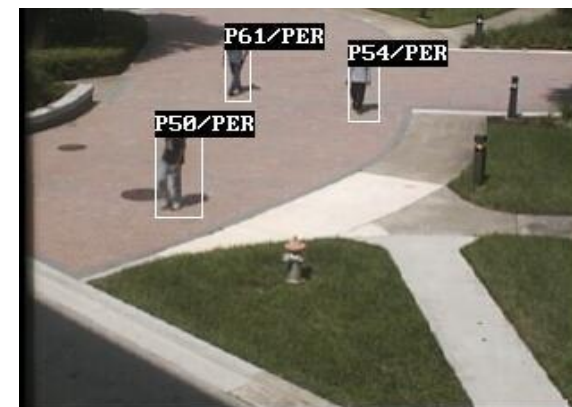
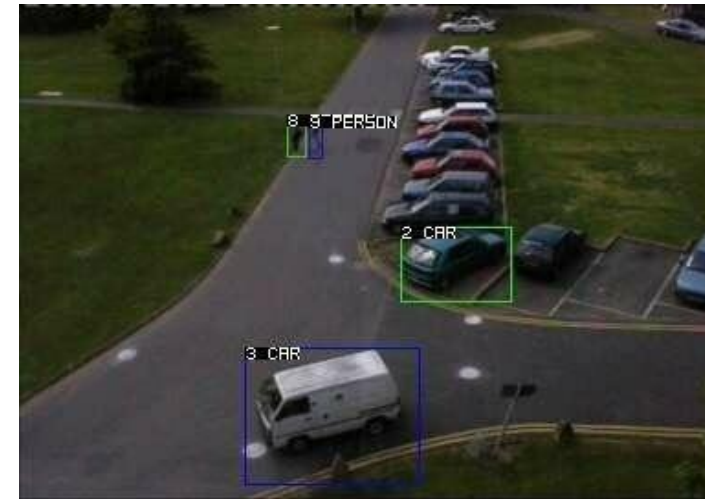
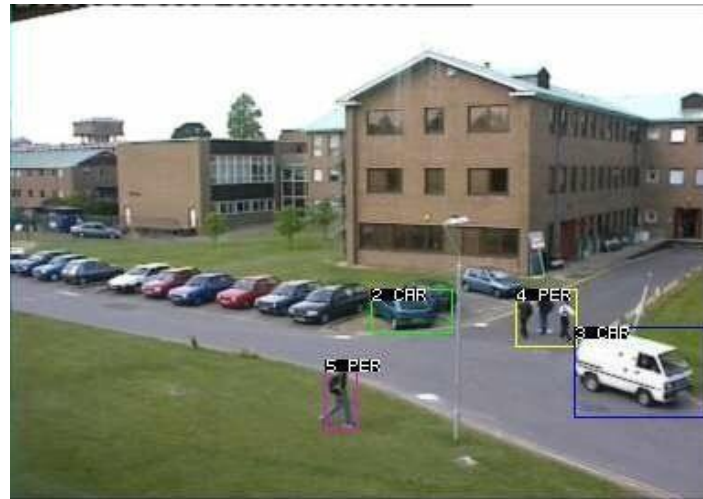


3D imaging: MRI, CT



Image guided surgery
Grimson et al., MIT

Surveillance and tracking



Surveillance and tracking



Vehicle protection



Lane departure warning, collision warning, traffic sign recognition, pedestrian recognition, blind spot warning

Smart cars

[▶▶ manufacturer products](#)[consumer products ◀◀](#)

Our Vision. Your Safety.

rear looking camera

forward looking camera

side looking camera

EyeQ Vision on a Chip



> read more

Vision Applications



Road, Vehicle, Pedestrian Protection and more

> read more

AWS Advance Warning System



> read more

News

- > [Mobileye Advanced Technologies Power Volvo Cars World First Collision Warning With Auto Brake System](#)
- > [Volvo: New Collision Warning with Auto Brake Helps Prevent Rear-end](#)

> all news

Events

- > [Mobileye at Equip Auto, Paris, France](#)
- > [Mobileye at SEMA, Las Vegas, NV](#)

> read more

<https://www.theguardian.com/technology/2018/mar/31/tesla-car-crash-autopilot-mountain-view>

Self-driving cars



Self-driving cars

Under the bonnet

How a self-driving car works

Signals from **GPS (global positioning system)** satellites are combined with readings from tachometers, altimeters and gyroscopes to provide more accurate positioning than is possible with GPS alone

Lidar (light detection and ranging) sensors bounce pulses of light off the surroundings. These are analysed to identify lane markings and the edges of roads

Video cameras detect traffic lights, read road signs, keep track of the position of other vehicles and look out for pedestrians and obstacles on the road

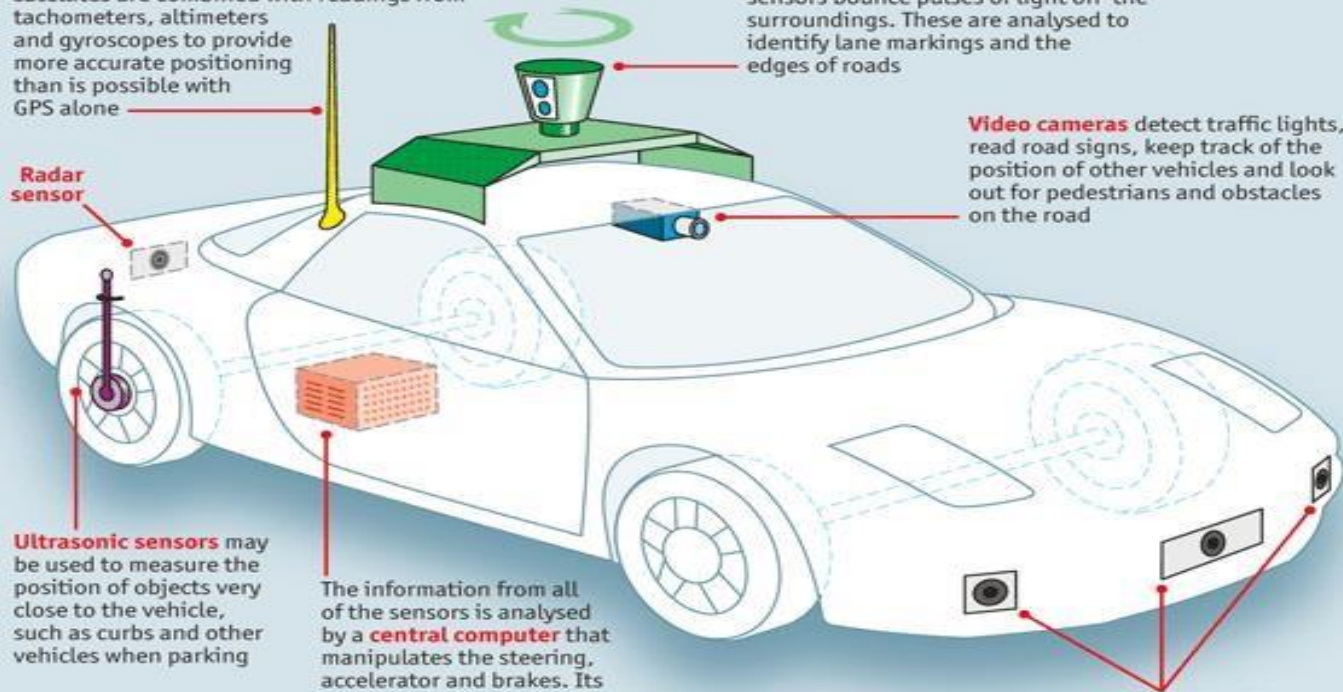
Radar sensor

Ultrasonic sensors may be used to measure the position of objects very close to the vehicle, such as curbs and other vehicles when parking

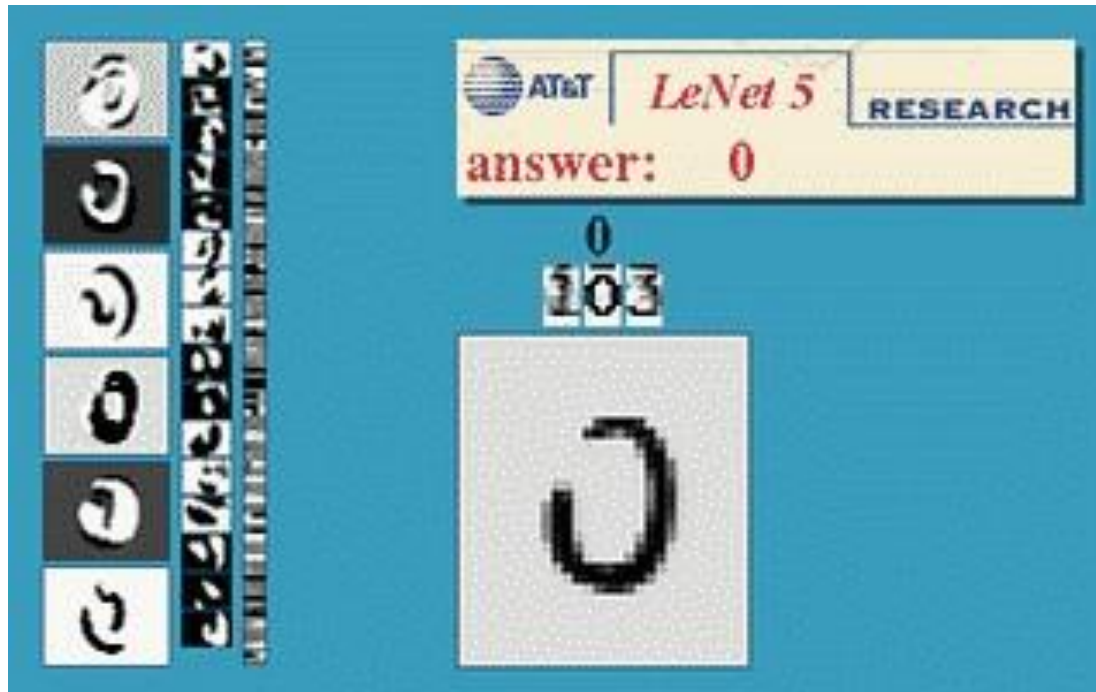
The information from all of the sensors is analysed by a **central computer** that manipulates the steering, accelerator and brakes. Its software must understand the rules of the road, both formal and informal

Radar sensors monitor the position of other vehicles nearby. Such sensors are already used in adaptive cruise-control systems

Source: *The Economist*



Optical character recognition

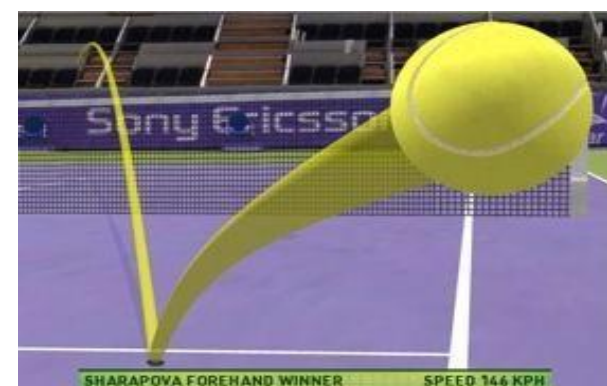
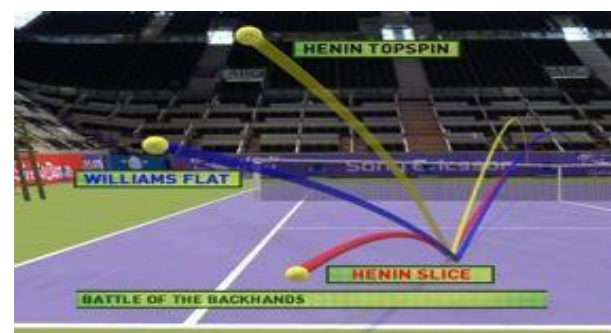
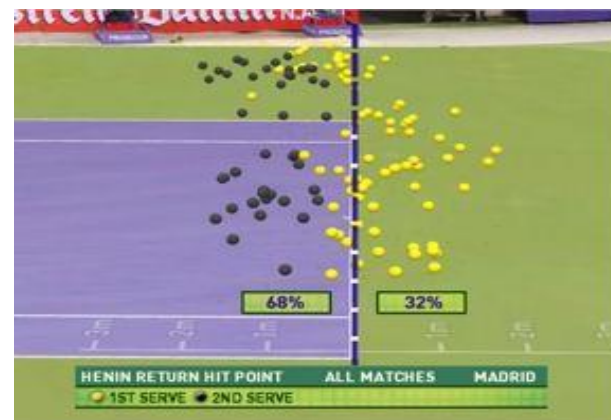


Digit recognition, AT&T labs
<http://www.research.att.com/~yann>



License plate recognition

Sports video analysis



Tennis review system

Virtual Reality



Image Sensing and Acquisition

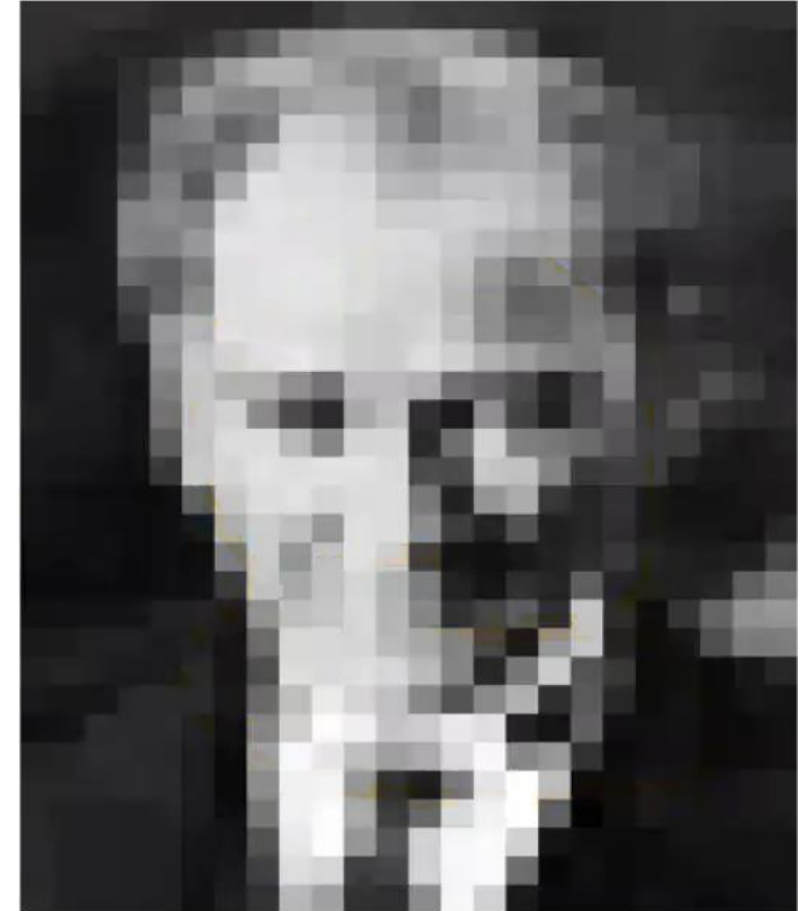
- The types of images in which we are interested are generated by the combination of an “*illumination*” source and the *reflection* or *absorption* of energy from that source by the elements of the “scene” being imaged.

What do computers see?

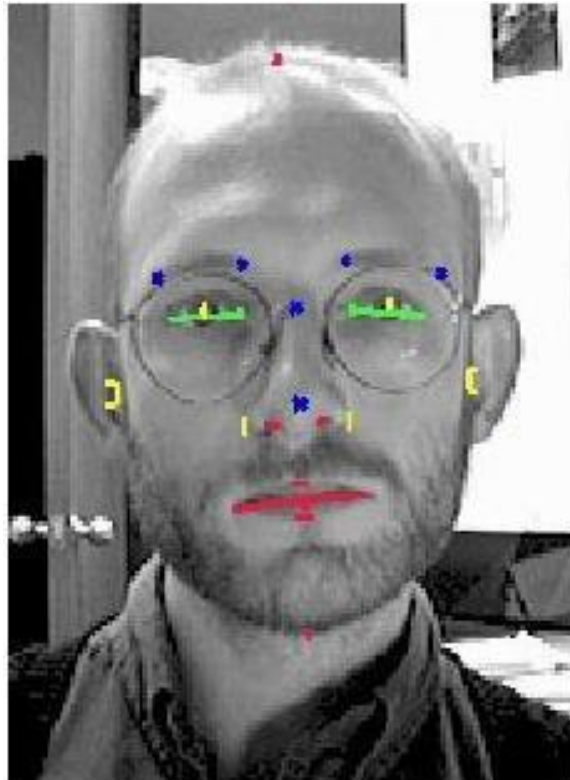
Number.....

What do these
numbers represent?

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Parts and relations



Patch Model

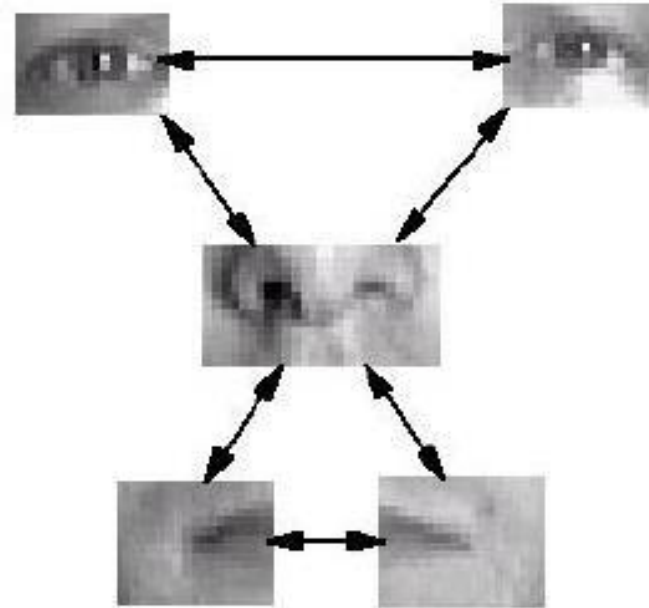


Image Sampling and Quantization

Objective of imaging is to generate digital images (representation) from sensed data (observation)

- ❑ In creating digital image, there is a need to convert the continuous sensed data into digital form.
- ❑ This involves two processes: *sampling* and *quantization*.
- ❑ An image may be continuous with respect to the x- and y- coordinates, and also in amplitude.
- ❑ To convert it to digital form, *we have to sample* the function in both coordinates and in amplitude.
 1. Digitizing the coordinate values is called *sampling*.
 2. Digitizing the amplitude(color intensity) values is called *quantization*.

Image Representation

1. Image capture
2. Image quality measurements
3. Image resolution
4. Colour representation
5. Camera calibration
6. Parallels with human visual system



The End