Introduction and Goals of Computer Vision

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Definitions of Computer Vision

Definition

Computer vision is a field of computer science, and it aims at enabling computers to process and identify images and videos in the same way that human vision does.

Objectives:

- To mimic the human visual system (modeling biological perception).
- To build artificial systems which can extract information (colour characteristics, shape information, texture characteristics, scene illumination) from images and videos as humans do.

Its input is digital images and videos.

Computer Vision System vs Human Visual System

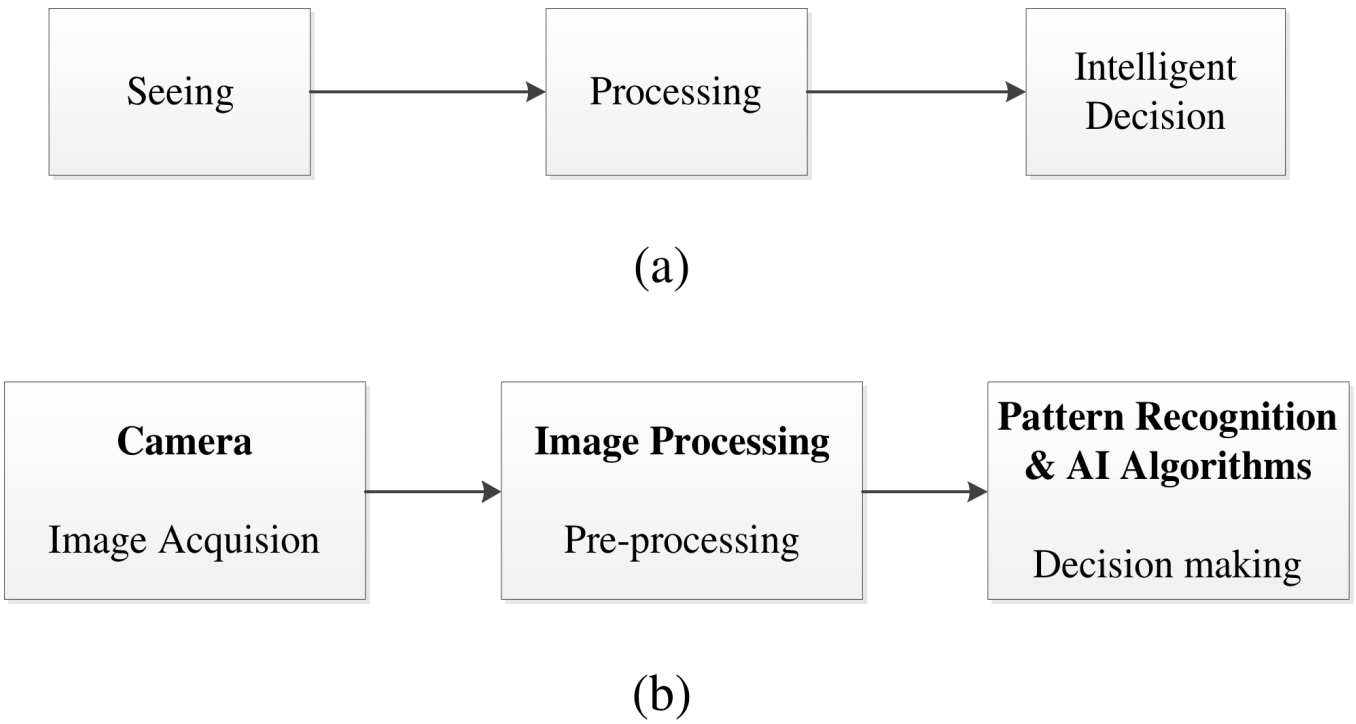

Figure 1 : Human visual system(a) vs. Computer vision(b)

- The structures of human and computer vision are somewhat similar :both have light sensors which convert photons into a signal (image), a processing step, and finally a mechanism to interpret the signal (object recognition).

- In **Computer Vision** (image analysis, image interpretation, scene understanding), the input is an image and the output is interpretation of a scene.

- In **Image Processing** (image recovery, reconstruction, filtering, compression, visualization), the input is an image and the output is also an image.

- Finally, in **Computer Graphics**, the input is any scene of a real world and the output is an image.

NB: Image analysis is concerned with making quantitative measurements from an image to give a description of the image.

Computer vision vs Computer graphics

- Computer vision makes a model from images (analysis), whereas computer graphics takes a model as an input and converts it to an image (synthesis).

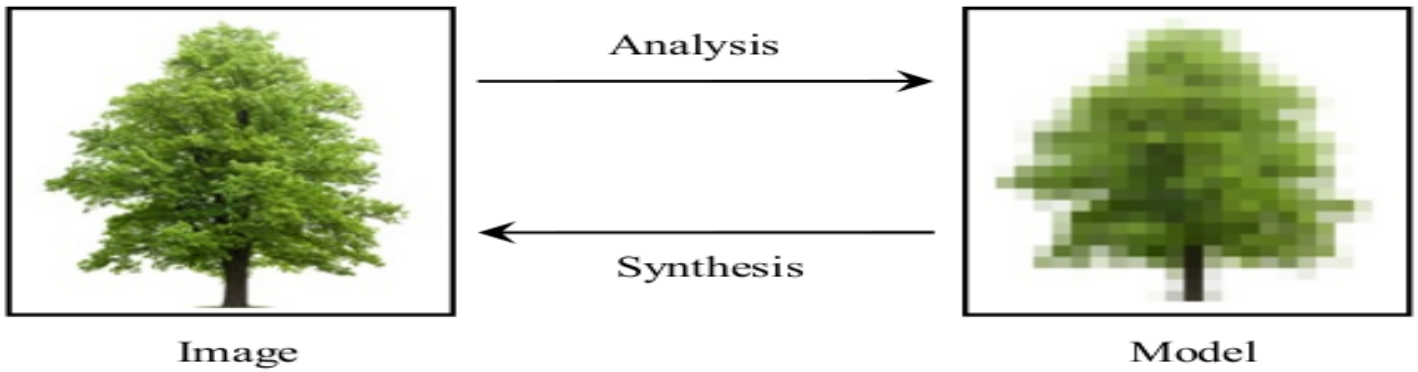

Figure 2 : Computer vision vs. Computer graphics

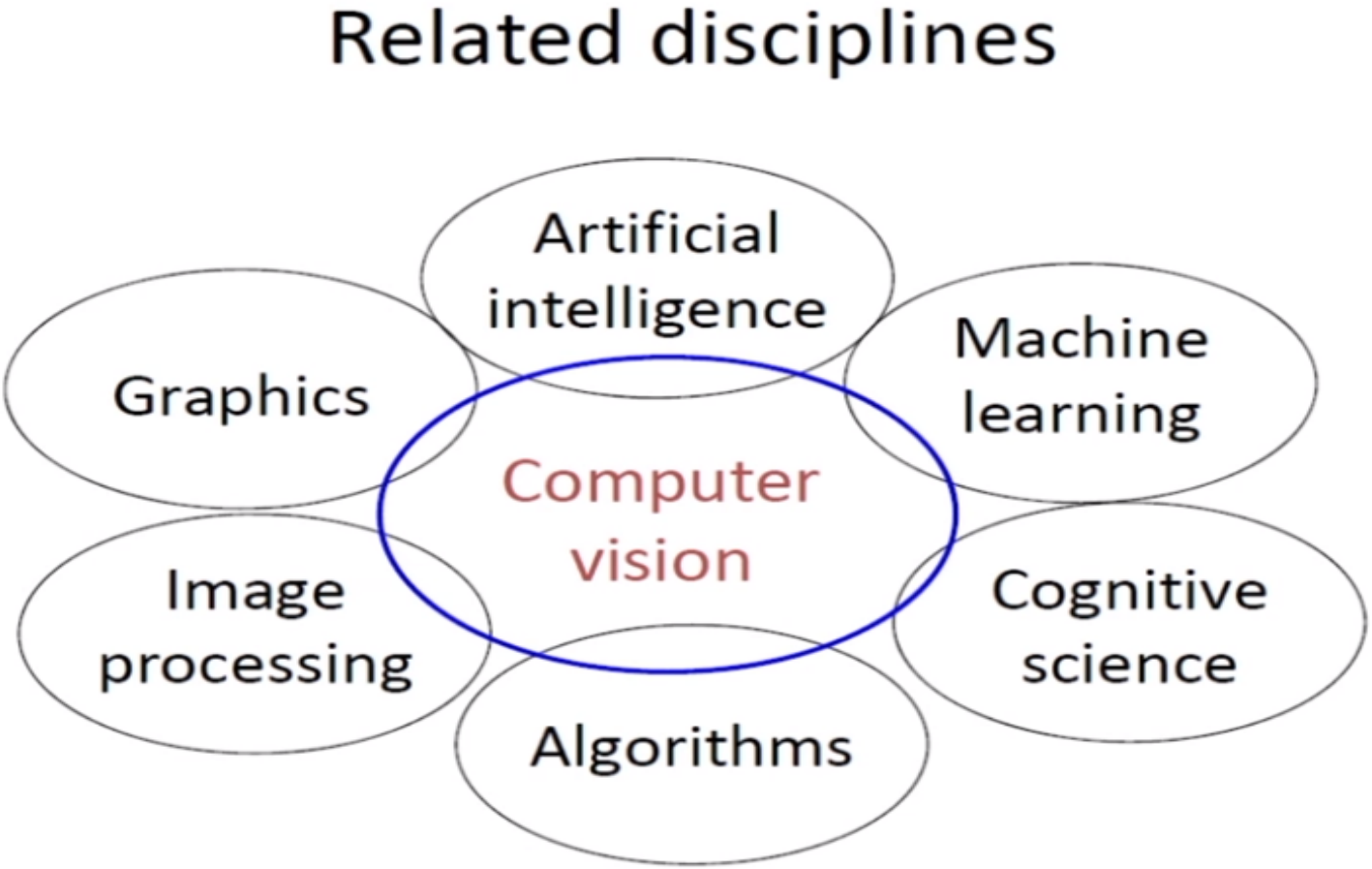

Figure 3 : Computer vision and related disciplines.

Image Analysis (Computer Vision)

- Fundamental Steps
  - Preprocessing (Image enhancement and Image reconstruction)
  - Segmentation (Isolating objects)
  - Feature Extraction (Representation and description)
  - Classification (Object recognition)

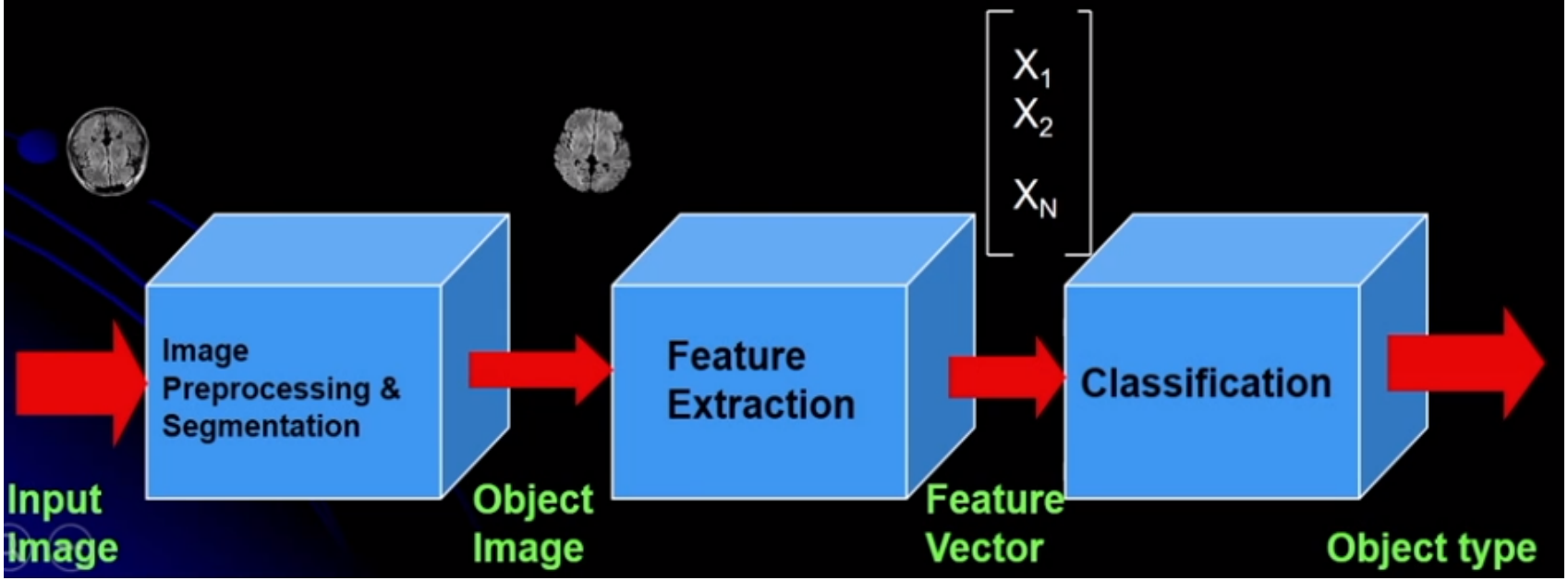

Image Formation and Radiometry

- The digital image $f(x, y)$ is the response of an image sensor at a series of fixed spatial positions $(x = 1, 2, \cdots, M;\ y = 1, 2, \cdots, N)$ in 2D Cartesian co-ordinates.
- It can be obtained from a 2D continuous tone or an analog image by the process of spatial **sampling and quantization of intensity values**.
- The indices x and y represent rows and columns of an image, respectively. So, pixels of an image are referred by their 2D spatial indices x and y (x,y).

Image Formation

- The image formation process can be mathematically represented as:

$$Image = PSF * Object\ function + Noise \tag{1}$$

  where:
  The **object function** is an object or a scene that is being imaged.
- The light from a source is incident on the scene or the object surface, and it is reflected back to the camera or the imaging system.
- In the above expression, "*" is the convolution operator, and noise in the imaging system is also considered.

- The point spread function (PSF) is the impulse response when the inputs and outputs are the intensity of light in an imaging system,
- It represents the response of the system to a point source. PSF indicates the spreading of the object function, and it is a characteristic of the imaging instrument or the camera.
- A good or sharp imaging system generally has a narrow PSF, whereas a poor imaging system has a broad PSF. For a broad PSF, blurred images are formed by the imaging system.

Image Formation

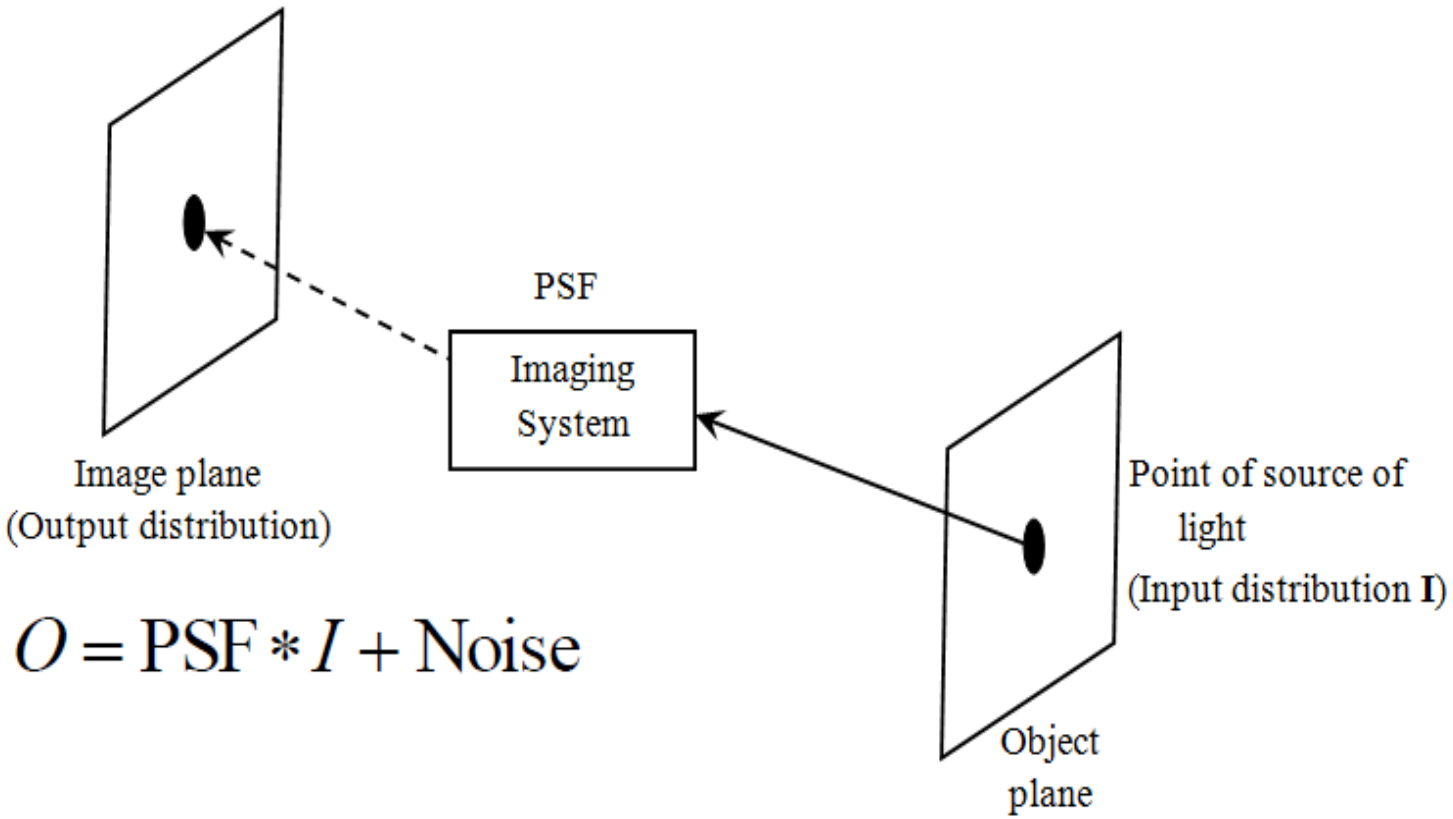

Figure 4 : Image formation process

Radiometry

- It is important to know the location of a point of a real world scene in the image plane. This can be determined by geometry of image formation process.
- The physics of light can determine the brightness of a point(pixel) in the image plane as a function of surface illumination and surface reflectance properties.
- The visual perception of scenes depends on illumination to visualize objects. The concept of image formation can be clearly understood from the principles of radiometry.

Image Formation: Radiometry

- Radiometry is the measurement of electromagnetic radiation, primarily optical, whereas photometry quantifies camera(eye) sensitivity.