INTRODUCTION

Taxonomy

Input \ Output	Image	Description
Image	Image processing	Image Analysis Image Understanding Computer Vision
Description	Computer Graphics	Data Analysis Pattern Recognition

Image processing

scope:	to form a digital image (from 3-dimensional scene to 2-dimensional image), to transform one 2D image into another.
aims:	digitisation, enhancement (for human viewing and also for subsequent computer processing), simple object extraction
examples:	remove warps or distortions, remove blur, smooth speckle or noise, improve contrast or other visual properties

Image analysis and image understanding

scope:	to obtain information from 2-dimensional image and about 2-dimensional image (rather than about 3-dimensional scene that it represents)
aim:	derive descriptions of the image contents
examples:	finding properties of the image or its parts (e.g. size, shape of image objects), finding key structures in the image (e.g. edges or regions of similar brightness),

Computer vision

scope:	to obtain information from an image (or a set of images) about 3-dimensional scene that the image(s) represents
aim:	derive meaningful and usable descriptions of the scene depicted in the image(s)
examples:	object sorting and picking by robots, object tracking, vehicle guidance, obtaining diagnostic information from medical images, face recognition, inferring object distance, inferring spatial relationships between objects, event description

Human visual perception

Knowledge about a human visual system can be very useful to the designer of 'engineering' type of applications and understanding tasks.

It is crucial in the modelling approach.

When pictures are intended for viewing by humans, to carry out image processing appropriately we need to understand:

- how to assess subjective quality of an image
- how to ensure the required fidelity of a picture to an original scene
- the nature of the “weak spots” of the human visual system

When image is to be analysed for purposes of image description, we need the knowledge of the human perception so that:

- parts extracted through image analysis correspond to those seen by humans
- parts can be described in terms used by humans

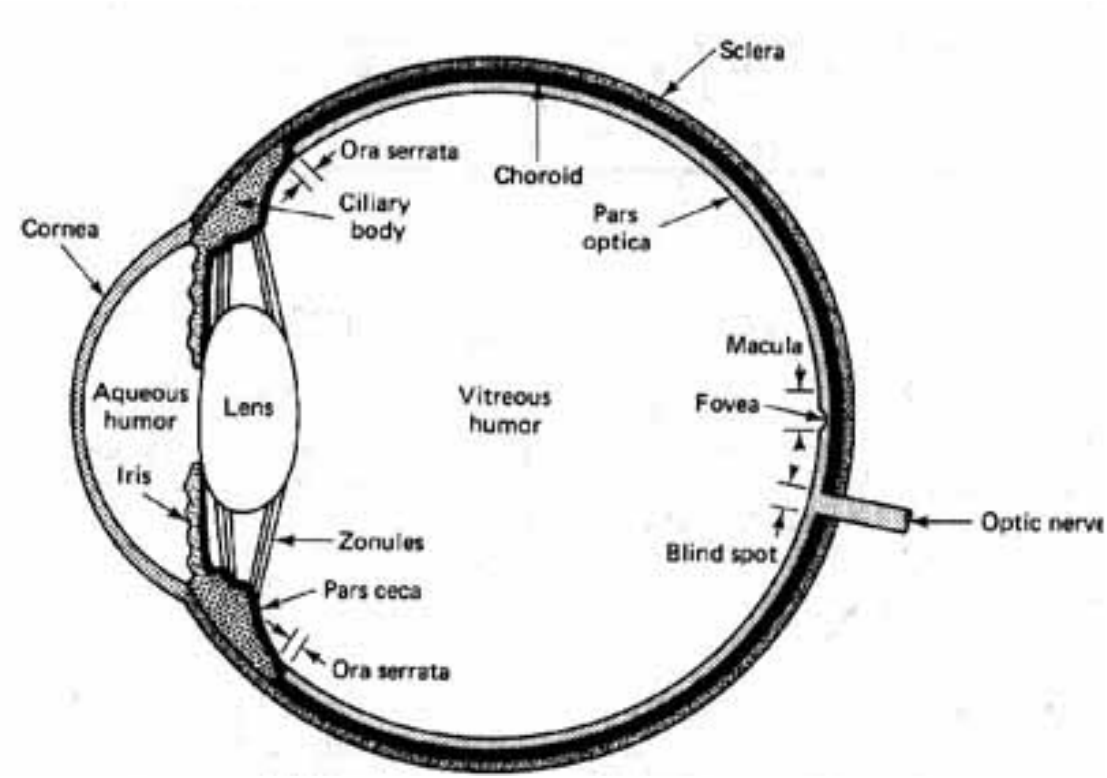
When developing computer vision systems for a particular purpose:

- the human visual system is a good model

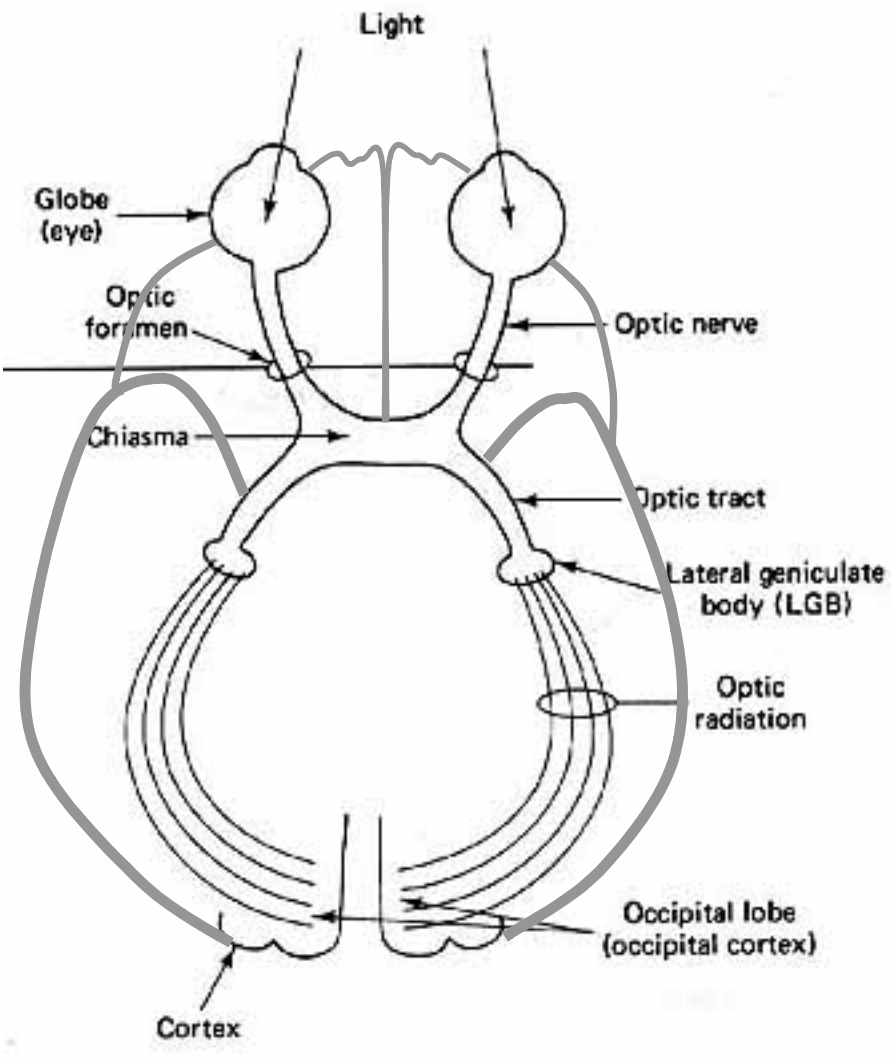
it works!

Human visual system

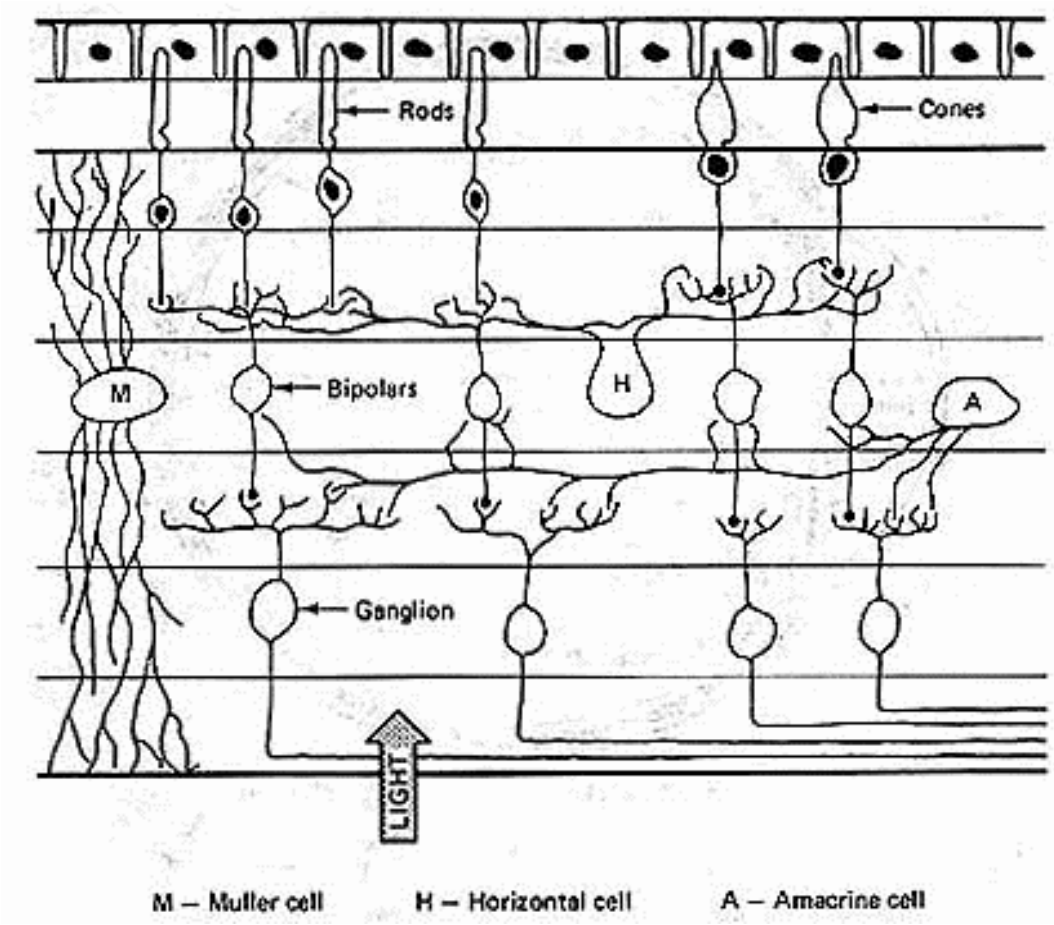
The eye



The brain


Light
Globe (eye)
Optic foramen
Optic nerve
Chiasma
Optic tract
Lateral geniculate body (LGB)
Optic radiation
Occipital lobe (occipital cortex)
Cortex

Retina - receptors and optic nerve



Retina - receptors and optic nerve

- rods sensitive to light and motion, off centre, 120 million
- cones detect detail and colour, central, 6 million
- fovea is packed with cones, uniform resolution, 2000

Stereo

- Two eyes look at the scene with angular separation of about 5 degrees.
- Convergence of two eyes changes with distance.
- Two eyes move together: they search for the target in saccades and converge together to focus.
- Each eye receives a slightly different view of the scene; this is called disparity and enables to perceive depth in the scene.

Vision

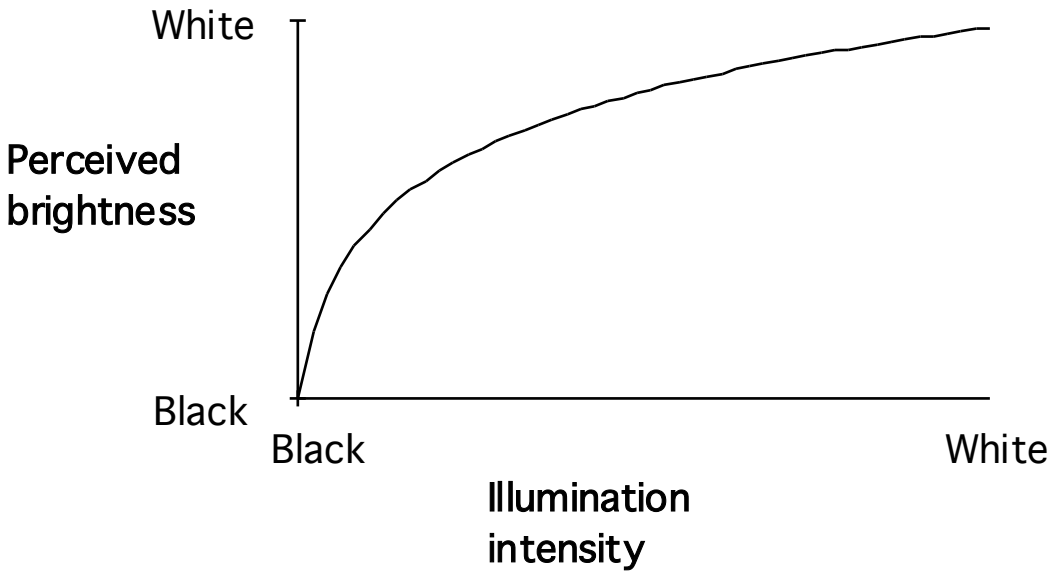
Vision is an “intelligent” process, it is

- active
- purposeful
- creative

Perceptual phenomena

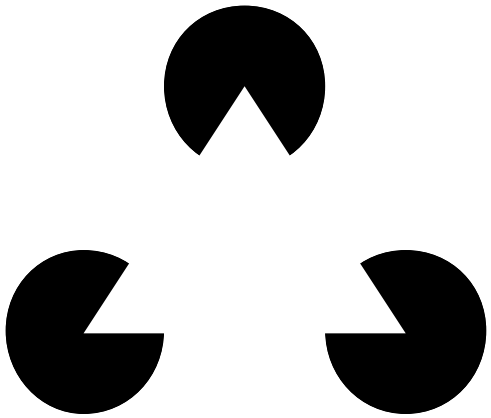
Luminance and perceived brightness

Mach bands

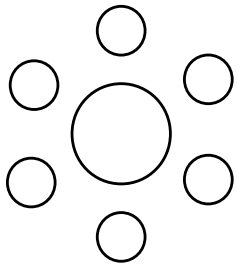

White
Perceived brightness
Black
Black
White
Illumination intensity

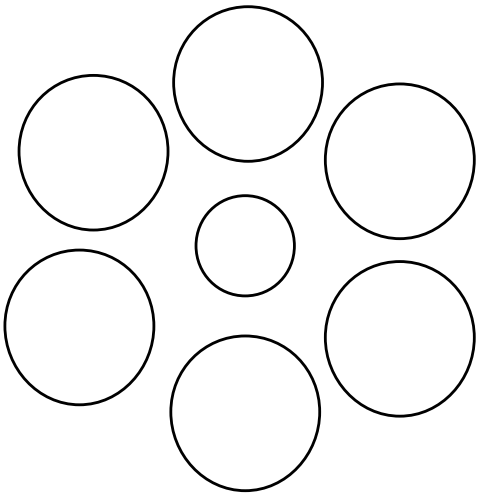
Simultaneous contrast

Kanizsa triangle



Relative size

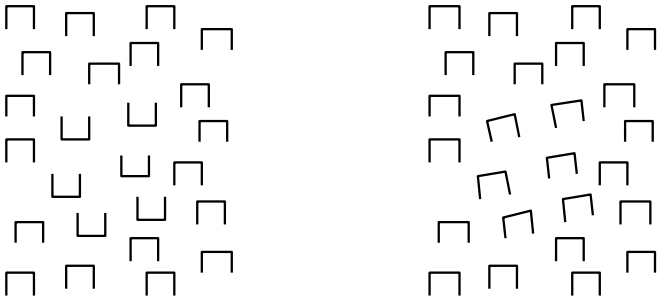




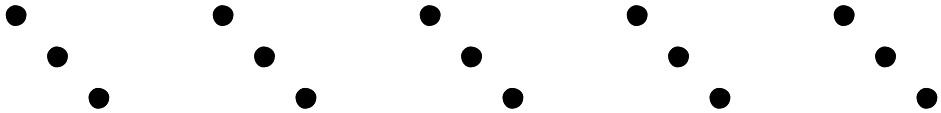
Perceptual grouping

Gestalt laws of organisation

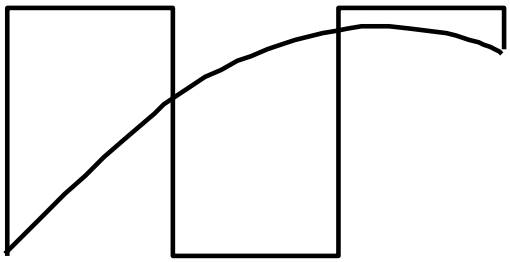
similarity



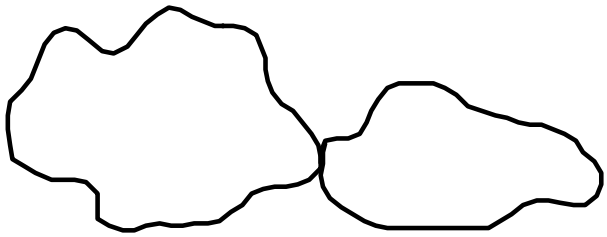
proximity



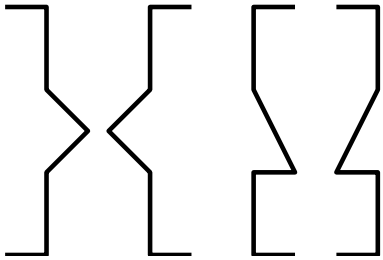
good continuation



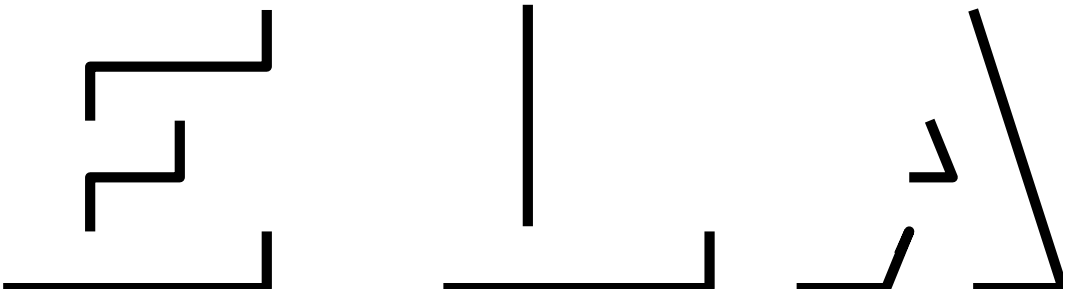
Closure



Symmetry



Recognition



Digital image

Source:

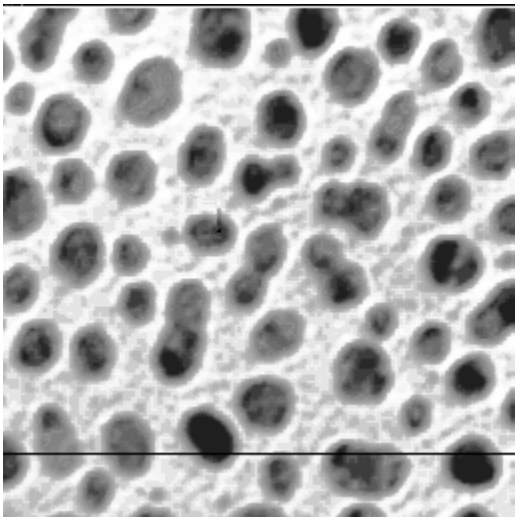
cameras, range scanners, directly from instruments

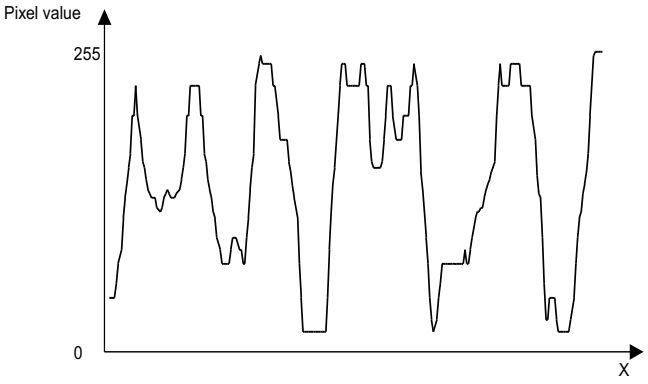
Physical signal:

light intensity, range, X-rays, ultrasound, infrared, microwave . . .

Simple tools for examining digital images

- Pixel value
- Line profile
- Histogram
- Thresholding




Pixel value
255
0
X

Thresholding

$$I'(x,y) = 0 \quad \text{if } I(x,y) < T$$

$$I'(x,y) = 1 \quad \text{otherwise}$$