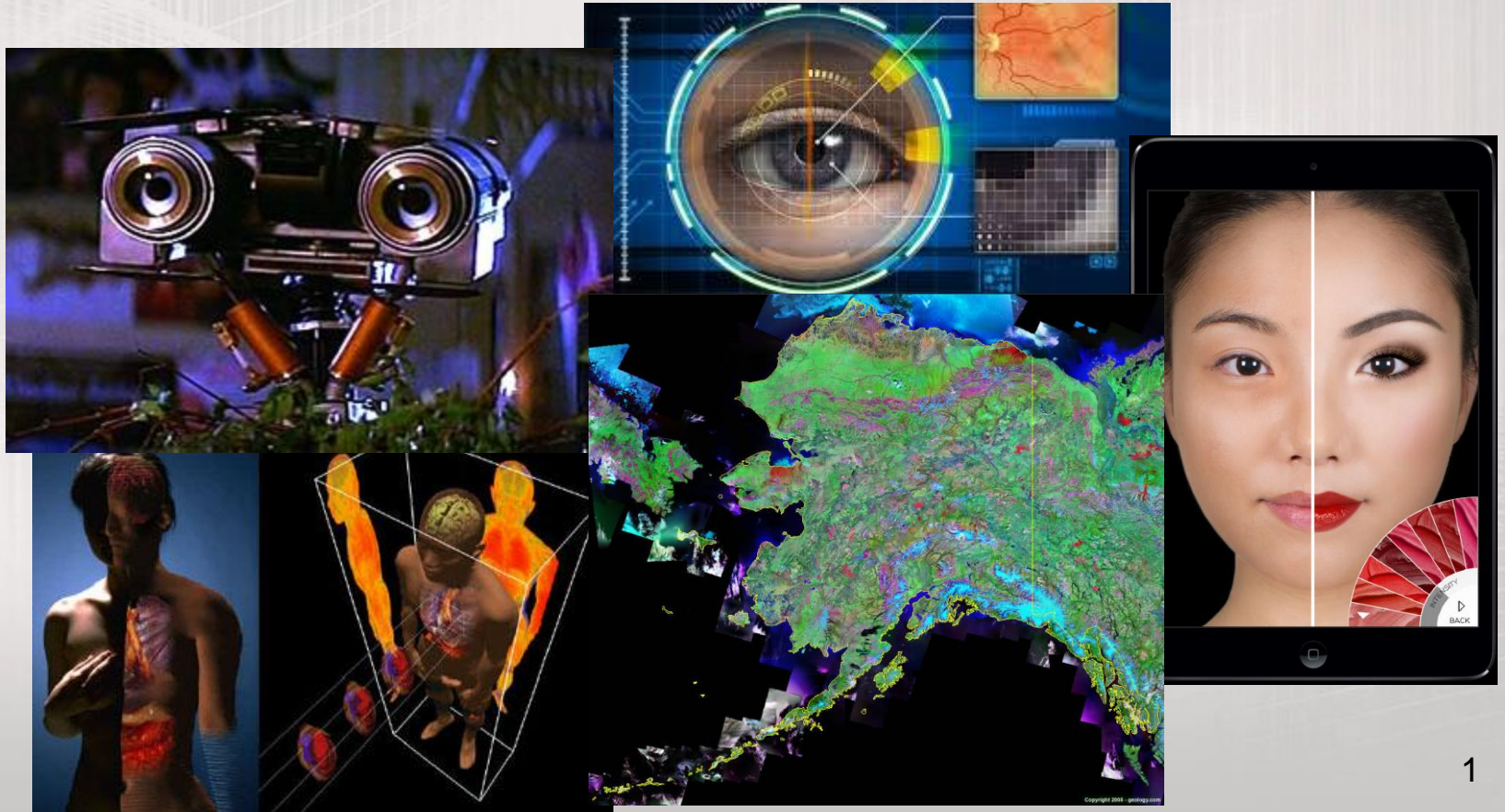# EE4704
IMAGE PROCESSING AND ANALYSIS
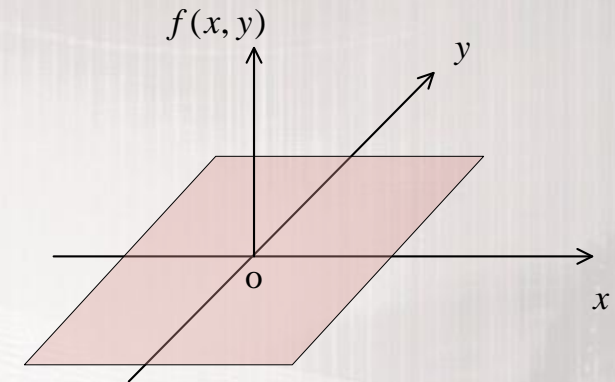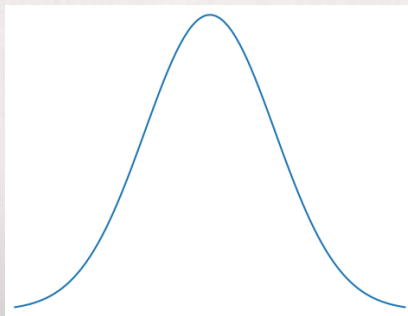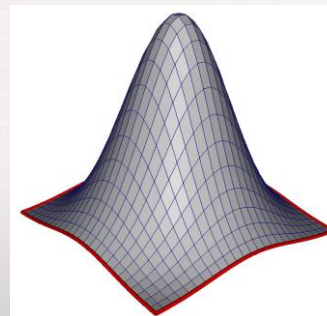
I - INTRODUCTION

What is an image?

An image is a two-dimensional function $f(x,y)$, where
- x and y are spatial coordinates
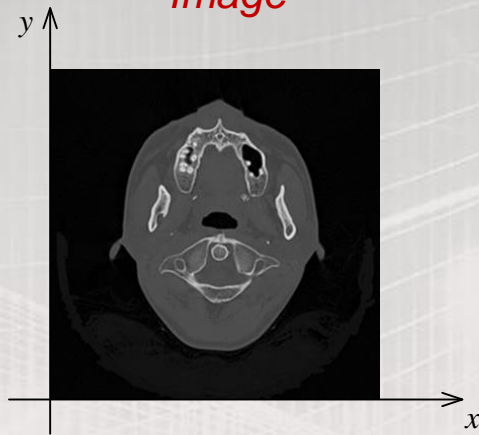- the amplitude of f at a point (x,y) gives the intensity or gray level of the image at that point.
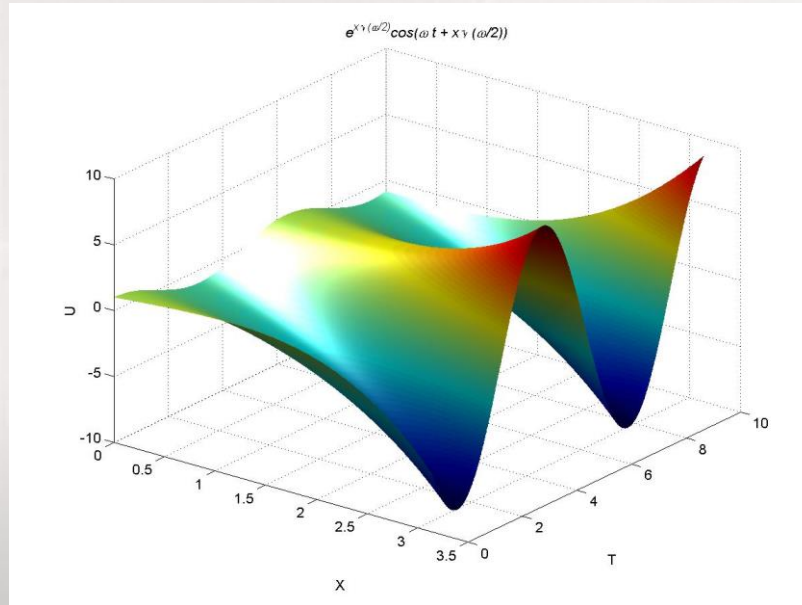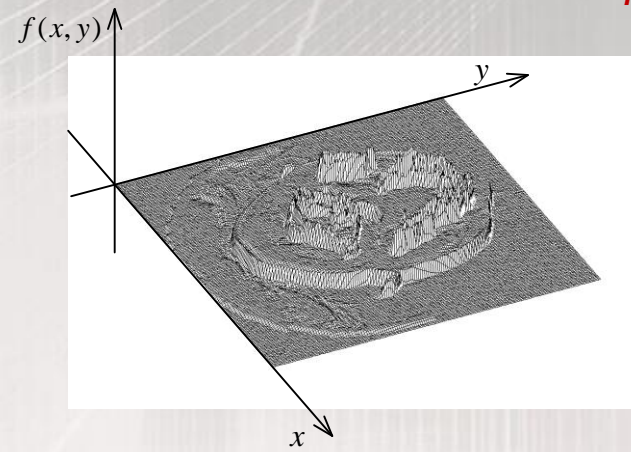
$f(x, y)$

y

x

o

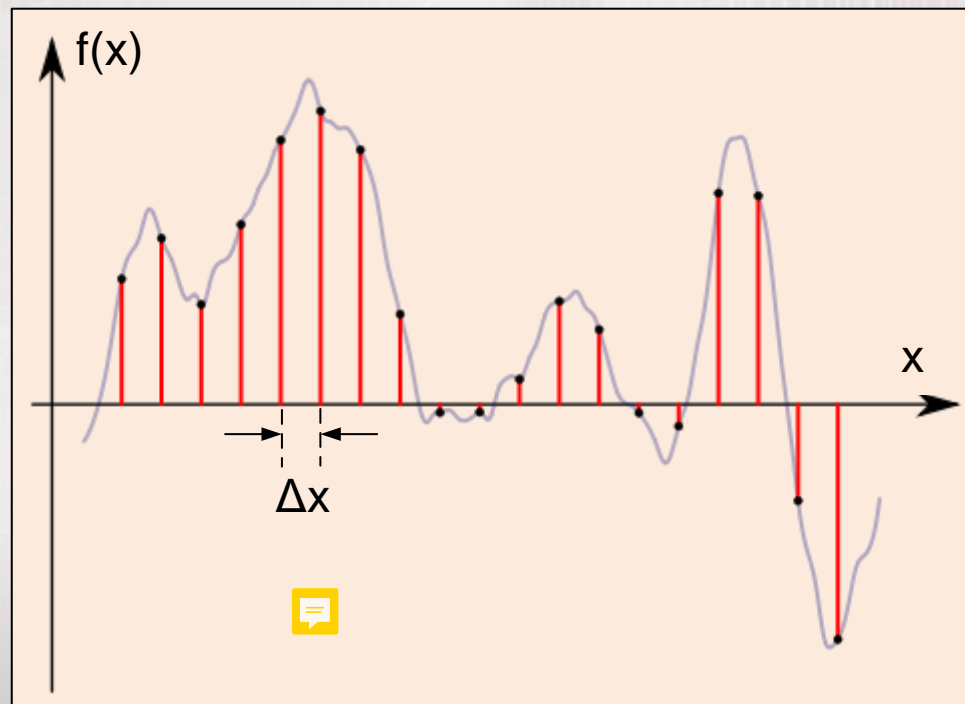$\exp(-x^2)$

$\exp(-x^2 - y^2)$

2

Image

Mesh plot

Surface plot
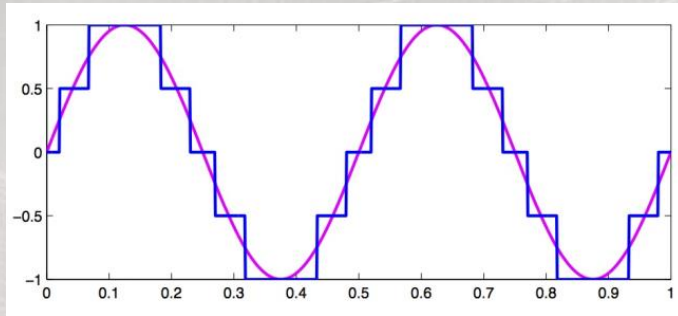
$e^{x\sqrt{(\omega/2)}}cos(\omega t + x\sqrt{(\omega/2)})$

3

- When *x*, *y*, and the amplitude values of *f* are finite, discrete quantities, *f(x,y)* is called a digital image.

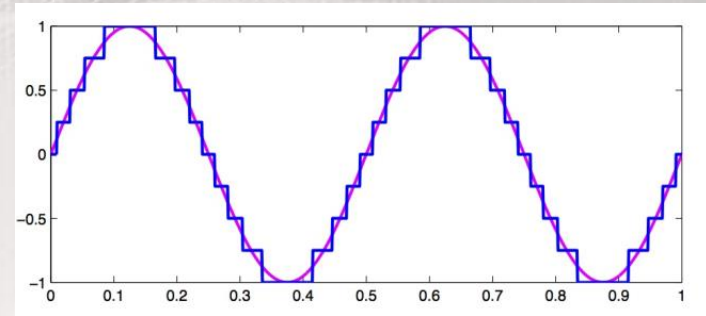- A digital image is often obtained by digitizing the original analogue signal ⟹ sampling and quantization

Sampling (1D)

Quantization (1D)
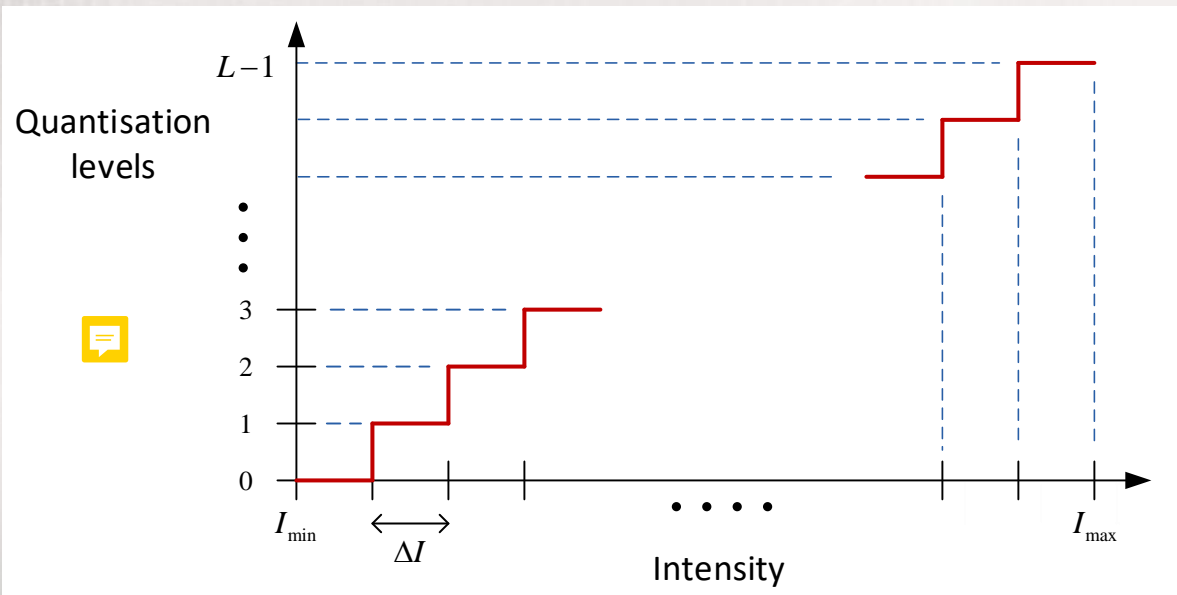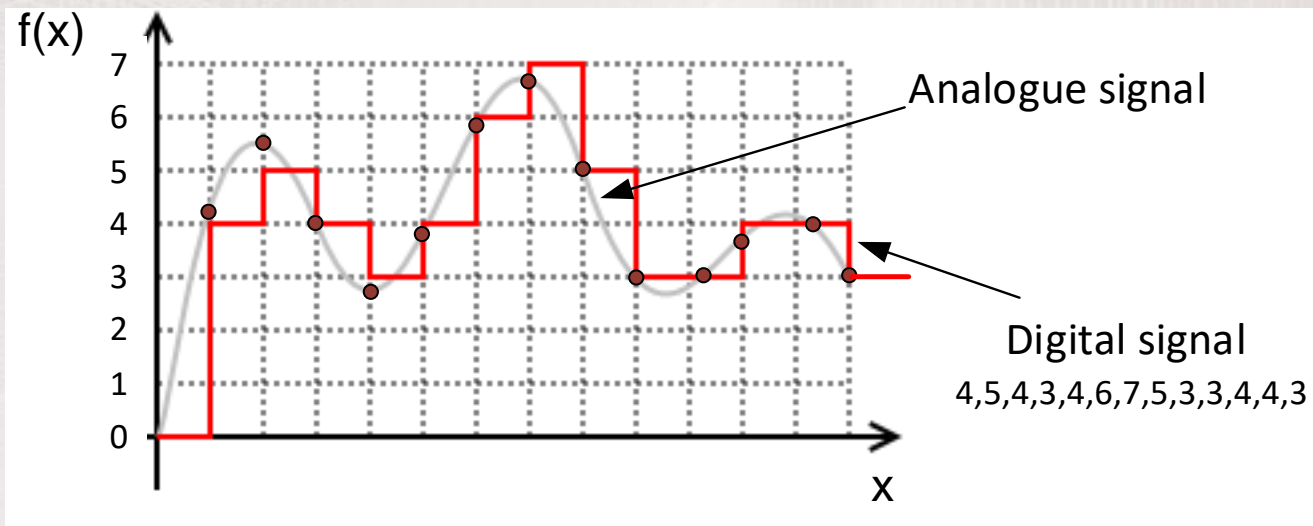

Coarse quantization
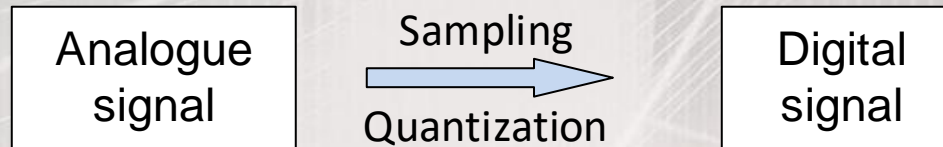

Fine quantization

ΔI = quantization interval

Quantization function

Digital signal (1D)

Analogue signal	$\xrightarrow{\text{Sampling / Quantization}}$	Digital signal

f(x)

Analogue signal

Digital signal

4,5,4,3,4,6,7,5,3,3,4,4,3

A *digital image* is just a 2D array.

y →

	0	1	2	3	4	5	6	7
0	0	0	0	0	0	0	0	0
1	0	0	16	15	56	3	53	6
2	0	0	26	48	55	66	54	23
3	0	0	36	33	8	54	68	56
4	0	0	28	42	23	56	65	84
5	0	0	27	44	33	31	53	8
6	0	0	53	23	34	43	44	8
7	0	0	76	34	34	33	43	4

x ↓

$f(4,2) = 28$

For example:

Spatial indices
$x = 0,1,2,3,..... ,511$
$y = 0,1,2,3,..... ,511$

Amplitude
$z = f(x,y) = 0,1,2,3,.....,255$

7
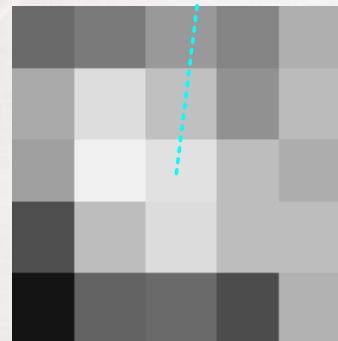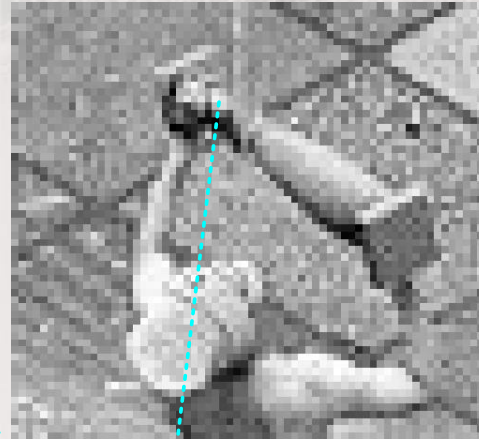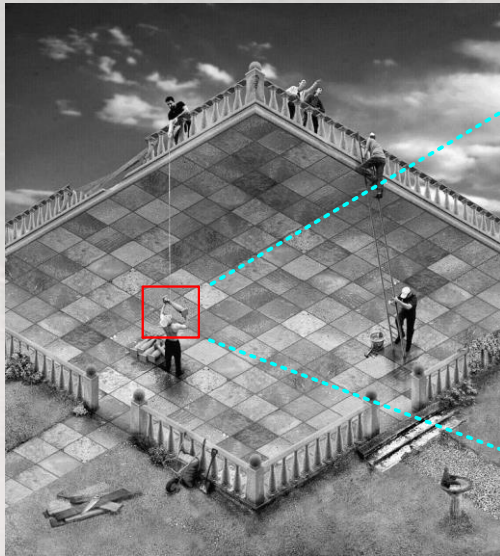
106	122	153	132	175
170	221	192	145	187
160	240	225	189	173
78	189	220	76	189
20	99	106	76	177

Images typically represent optical information, but can also represent other types of information.
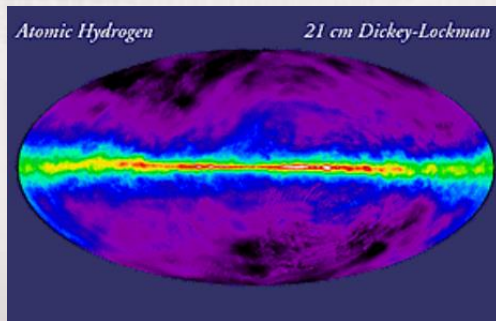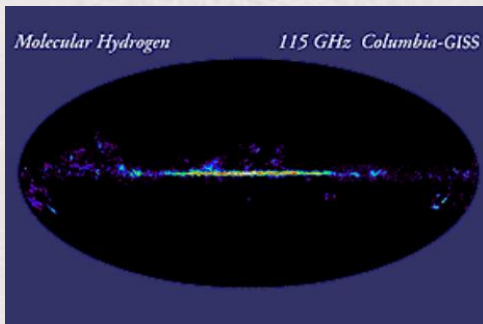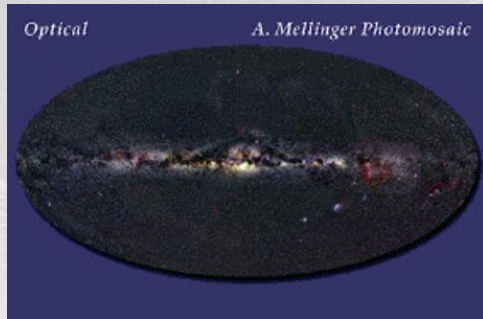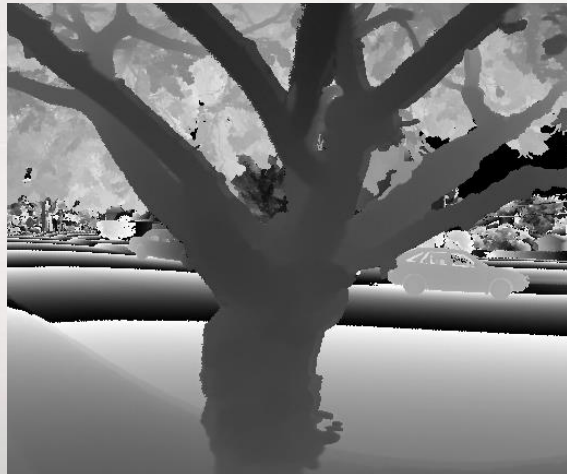

Astronomical images

Ultrasound image

Range image

Magnetic resonance image

Image processing and analysis are sub-fields of computer vision, which deals with how computers can be used to obtain high-level understanding of digital images/videos.

Image processing is concerned with operations for the manipulation of image data, e.g., image enhancement, noise reduction and image compression.
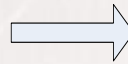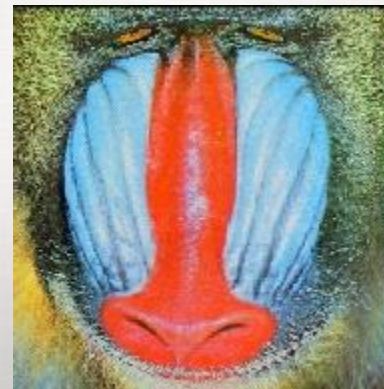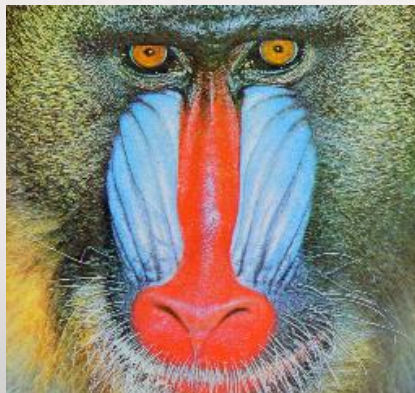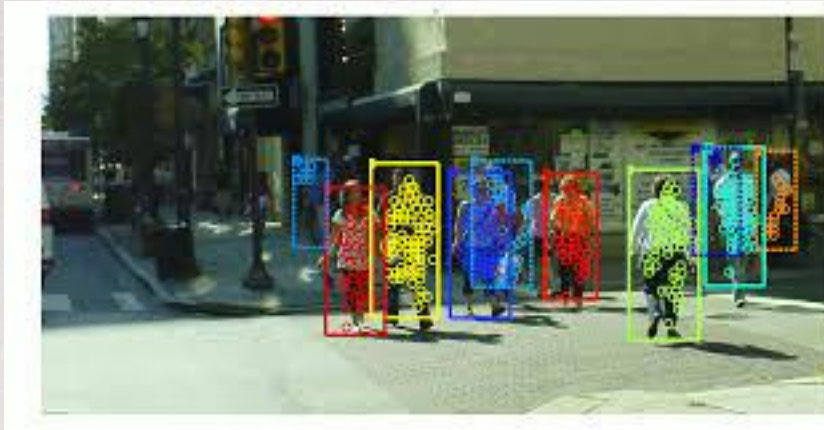
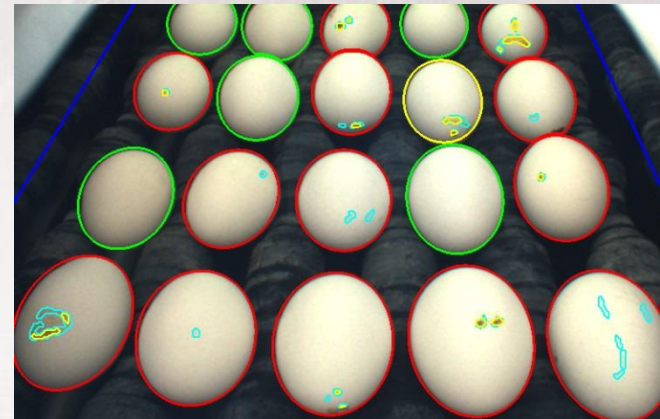Improving visual quality

Image warping

Image analysis is the process of extracting information from images of a 2-D or 3-D scene, e.g., tracking people/vehicles, face recognition and product inspection.


People tracking

Product inspection

Machine vision refers to industrial applications in which a combination of hardware and software provides operational guidance to devices in the execution of their functions based on the capture and processing of images.
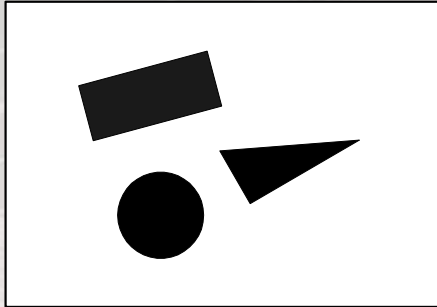
Requirements:
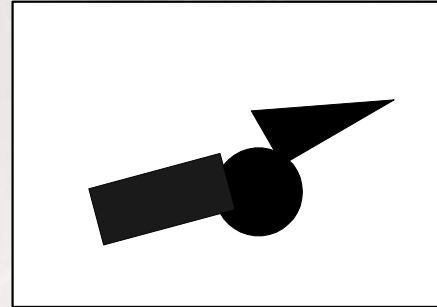low cost, acceptable accuracy, high robustness, high reliability, and high mechanical, and temperature stability
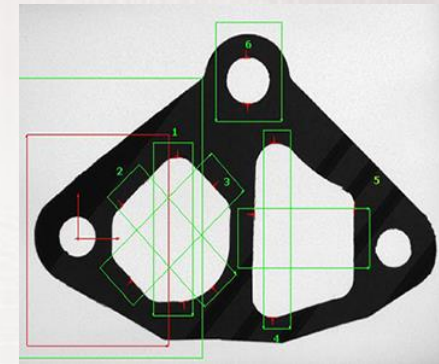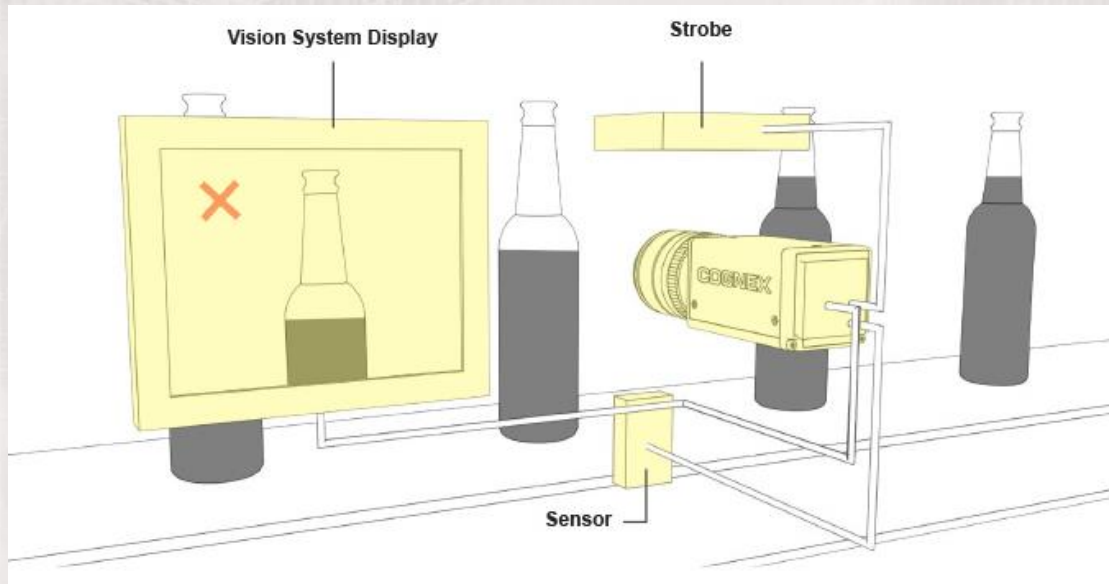
An example of a "simple" problem in computer vision is to recognise the objects in a scene:
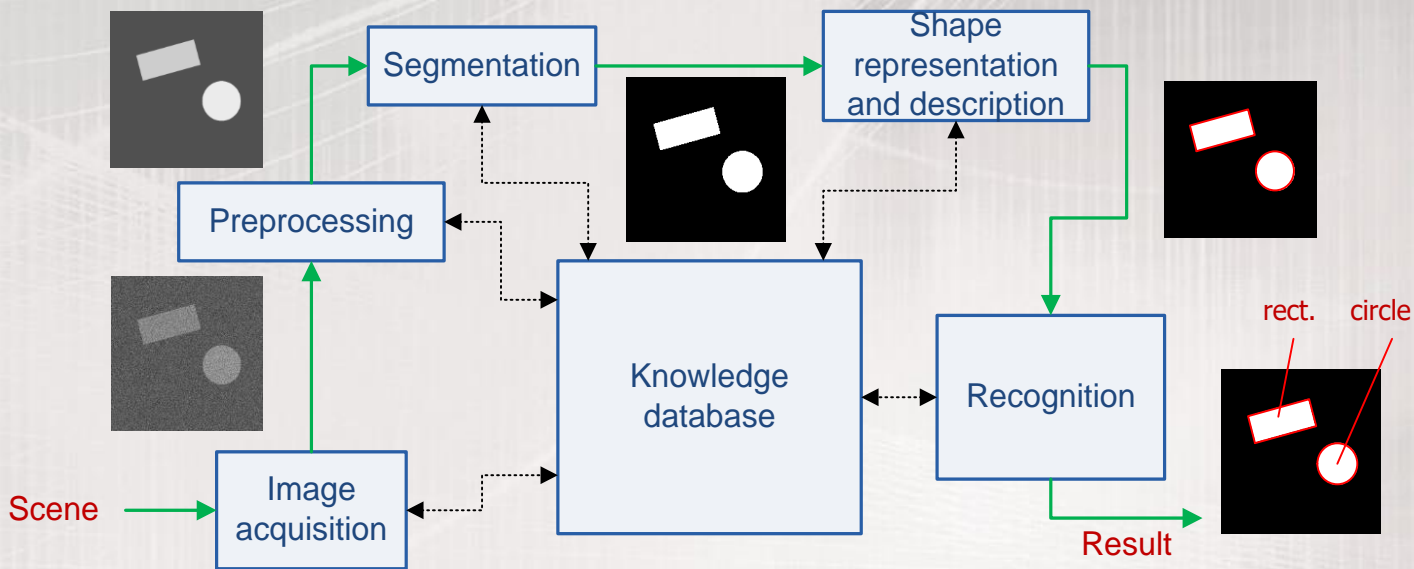
Distinct objects

Overlapping objects

Complex scene

Consider a vision system that aims to identify the objects in a scene. The components of the system are shown in the figure below. The knowledge database contains information about the problem domain. It guides the operation of each processing module and controls the interaction between modules.

Image acquisition: obtaining a digital image with an image sensor.

Preprocessing: improving the image quality, e.g., removing image noise.

Segmentation: partitioning of the image into regions of interest.

*Representation*: representing the regions by boundary or internal characteristics.

Description: extracting/measuring features that quantitatively describe classes of objects.

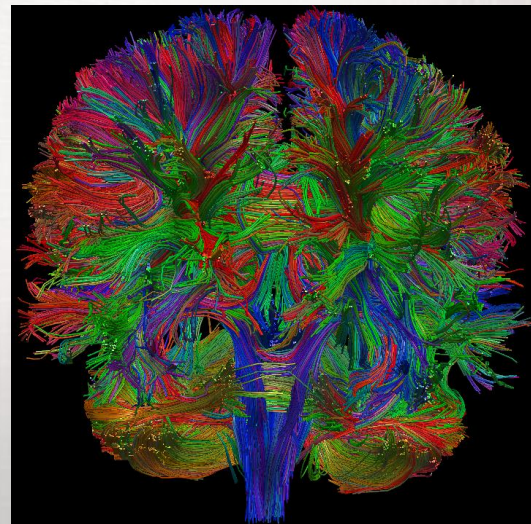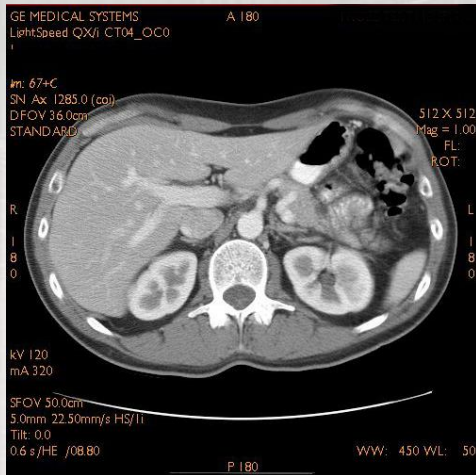*Recognition*: assigning a label to an object based on the information provided by the descriptors.

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EXAMPLES OF APPLICATIONS

Character recognition: Mail sorting, label reading, bank-cheque processing, document processing, car number plate recognition
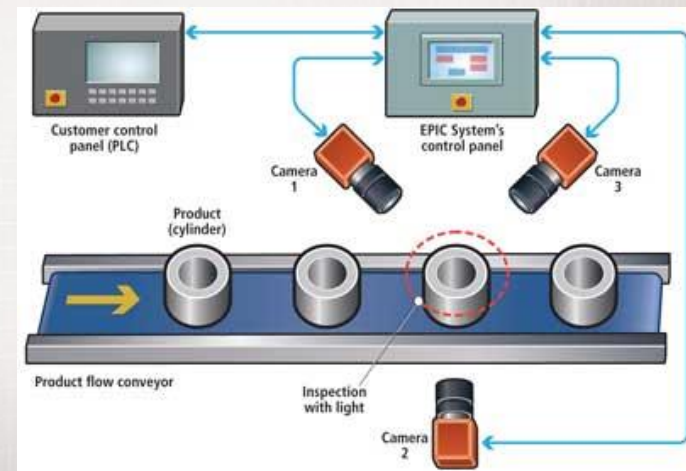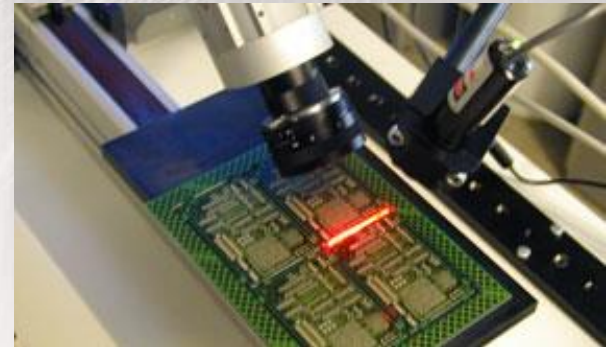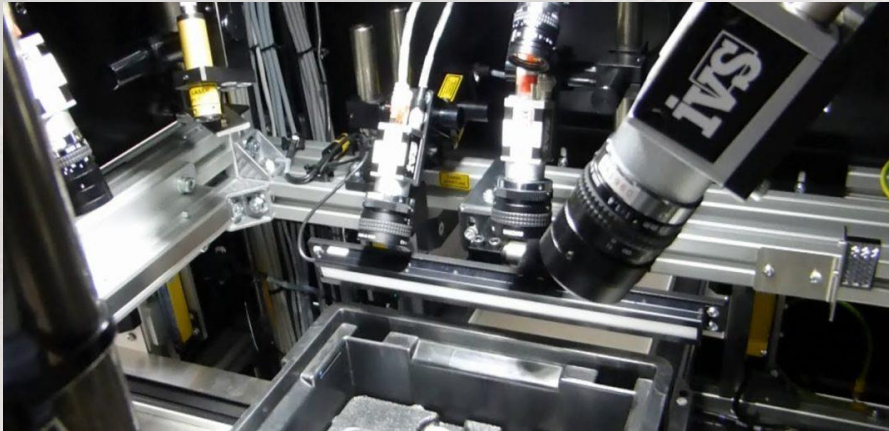
15
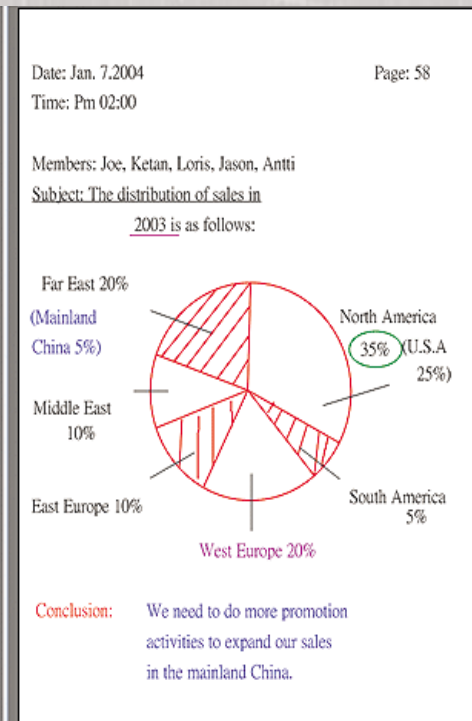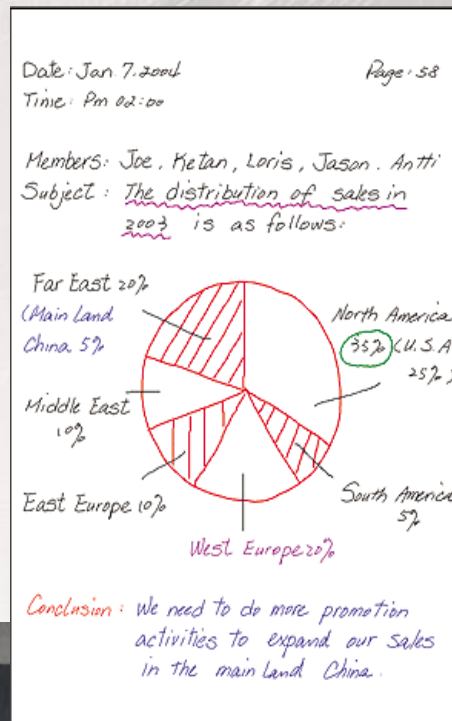
Medical imaging: Computed tomography CT) imaging, virtual surgery, tumour detection from X-rays.

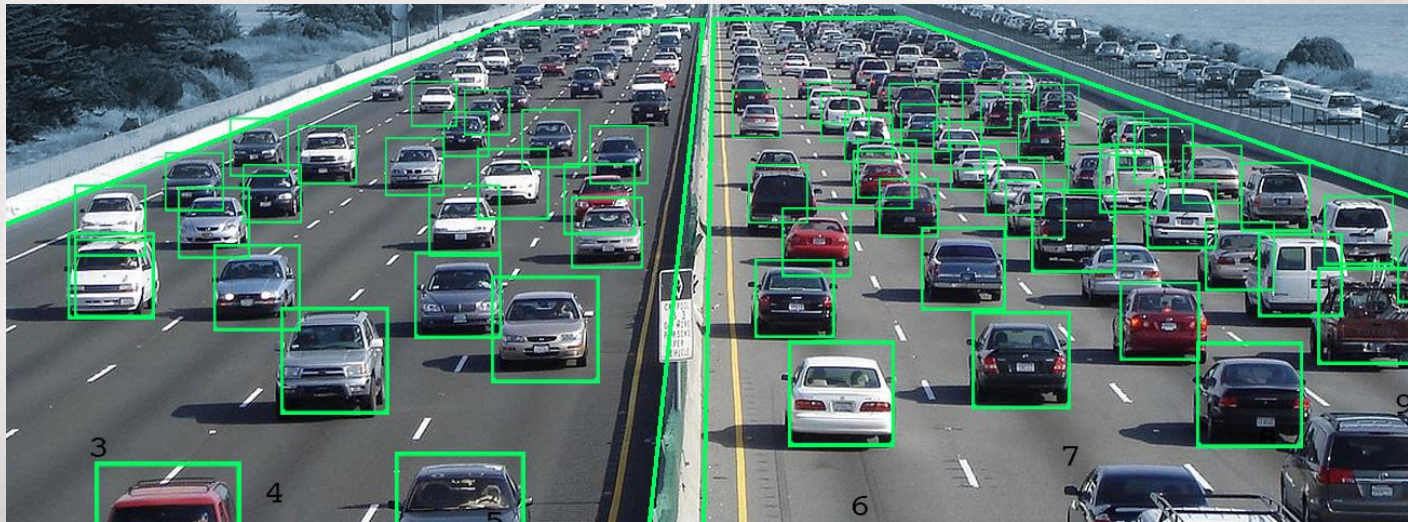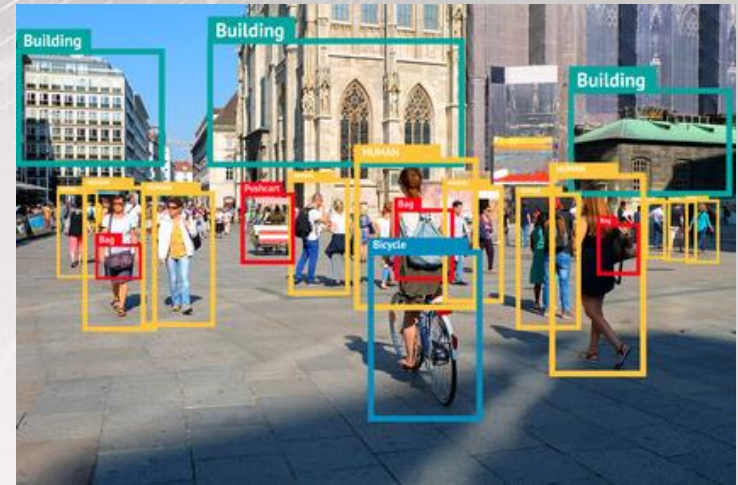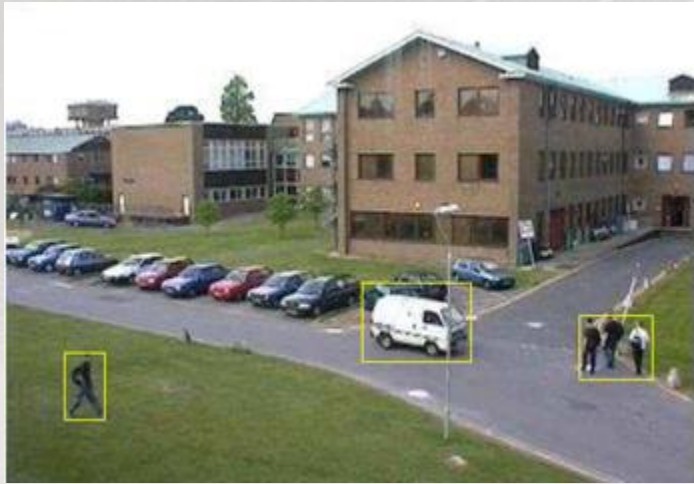*Industrial automation:* Parts identification on assembly lines, inspection for defects.

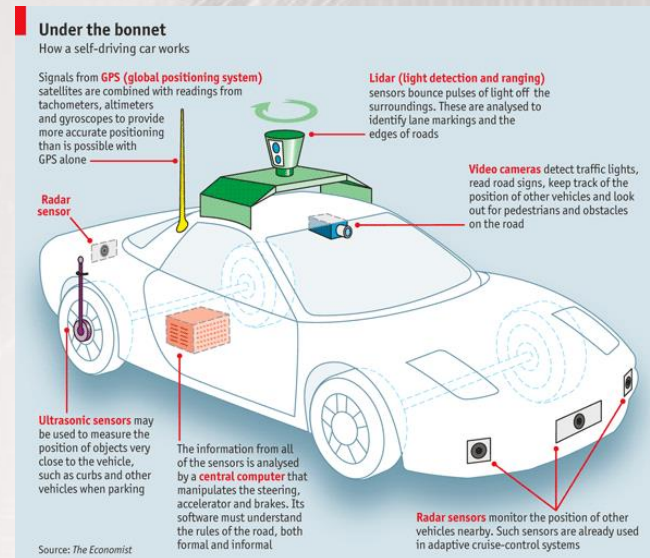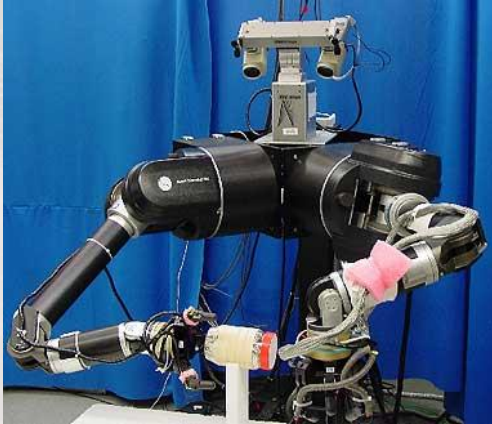*Biometrics:* Human identification, finger-print matching, face recognition.

Surveillance:

Robotics: Recognition and interpretation of objects in a scene, motion control and execution through visual feedback, picking objects in a bin, autonomous guided vehicle
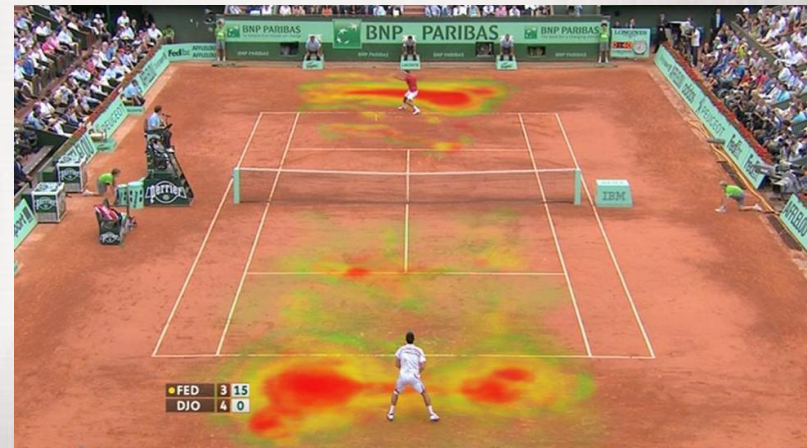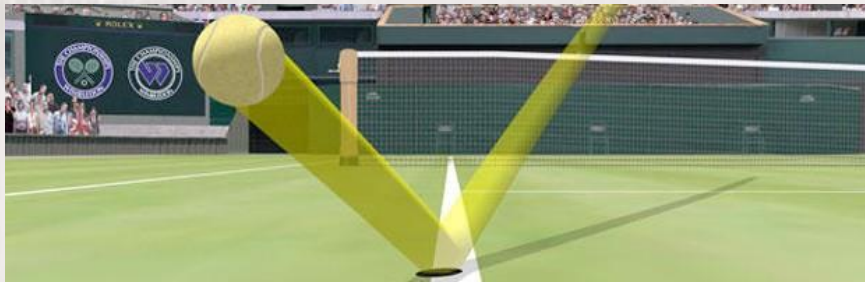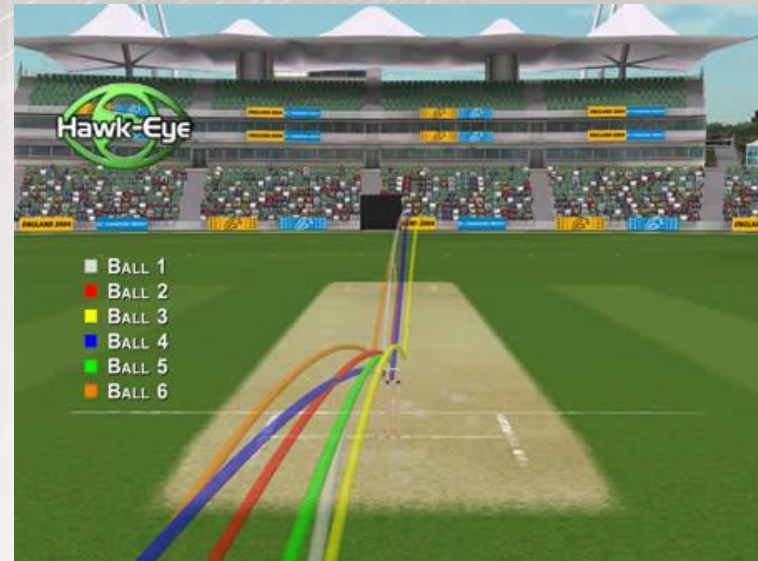

20

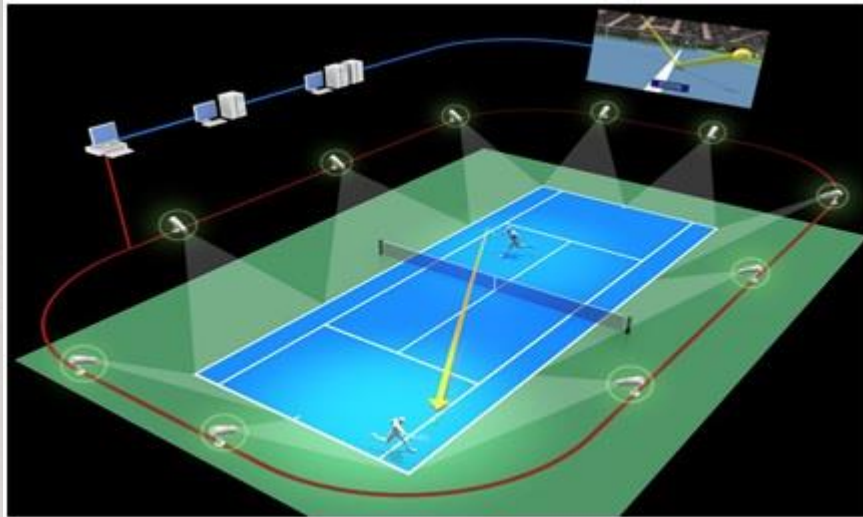*Photography:* High dynamic range (HDR) imaging

Photography: Panoramic imaging + HDR imaging
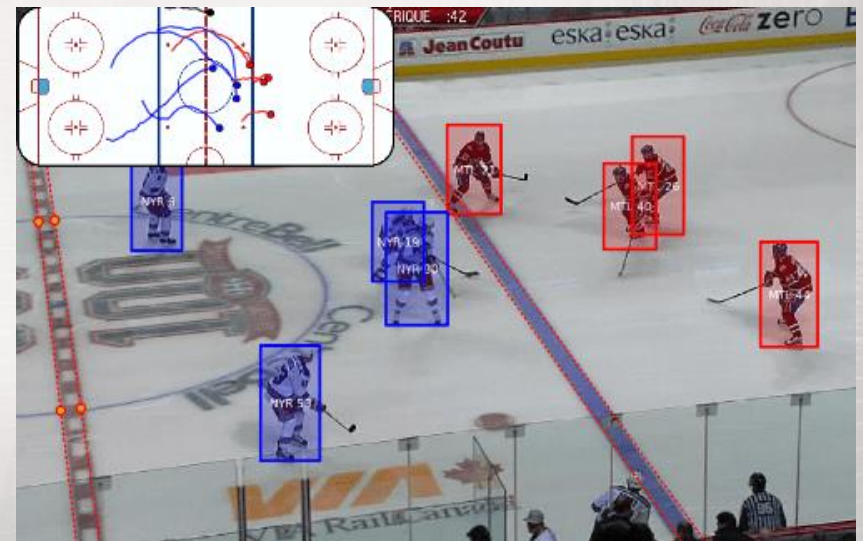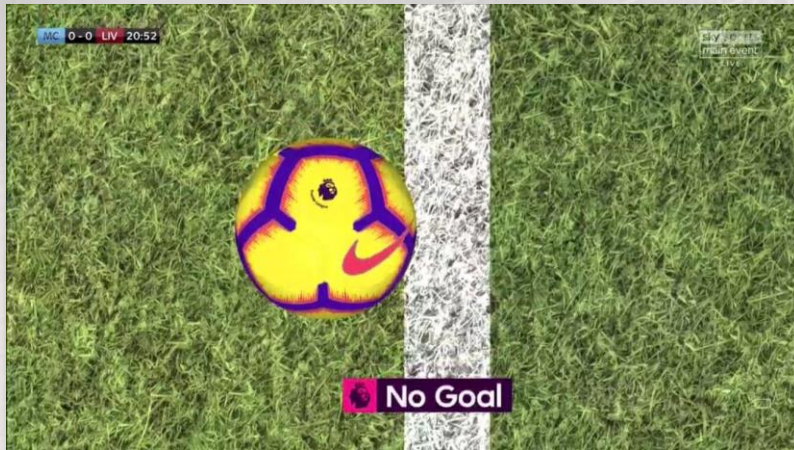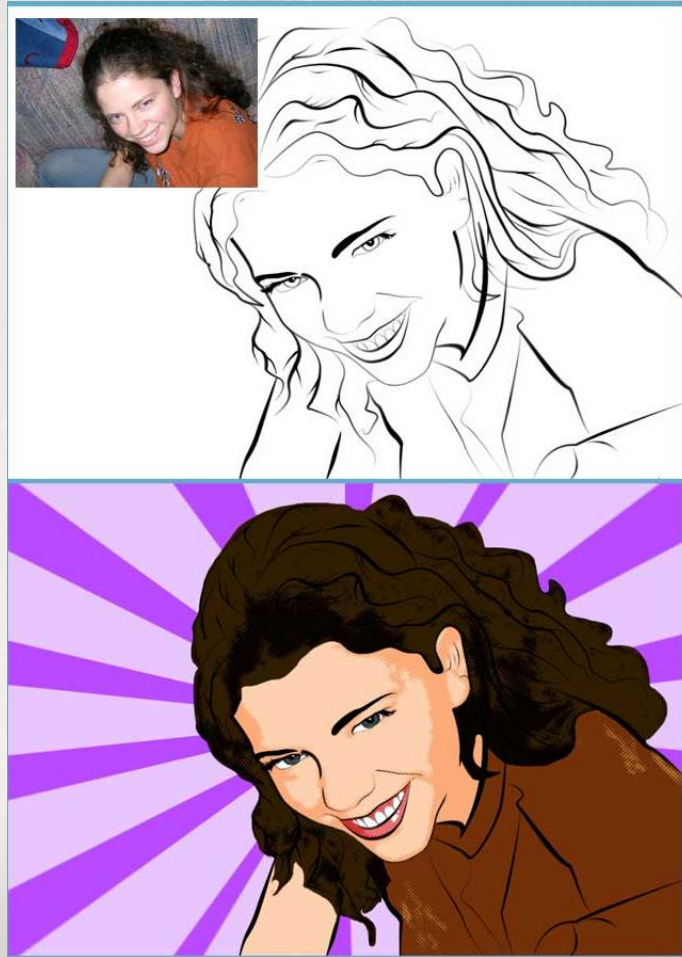
Sports

Hawk-Eye

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Sports

Graphics: Special effects

Multimedia: Video conferencing, image and video compression
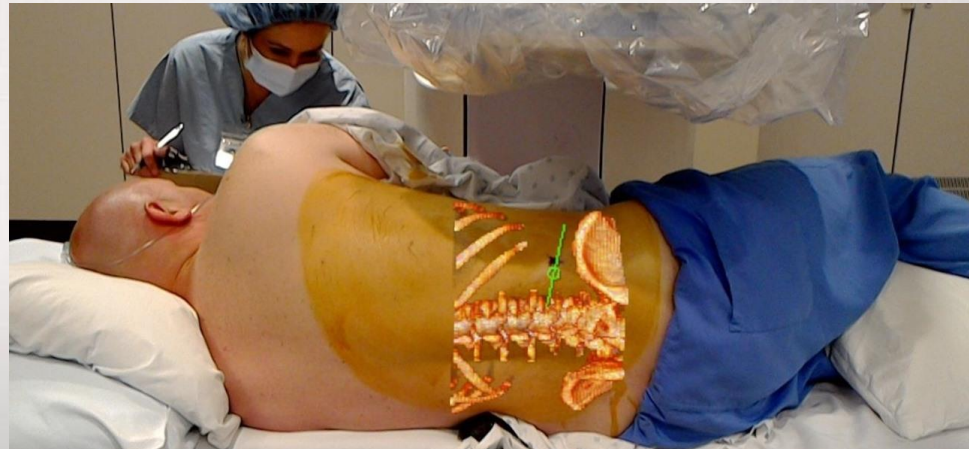

Video conferencing

HDTV

1.5 MB

30 KB

Image compression

Multimedia: Augmented reality

Multimedia: Entertainment