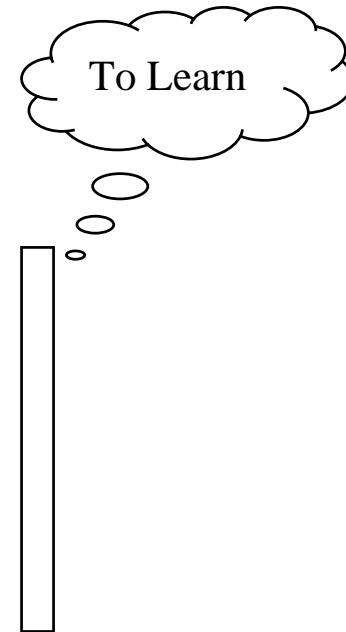


CONTENT



Chapter 2: Hardware of Machine Vision

2.1 Lens

2.2 Image Sensor

2.3 Image Formation

2.4 Modeling of Image Formation

2.5 Computing Systems of Machine Vision

2.5.1 Host processor system

2.5.2 Pipeline system

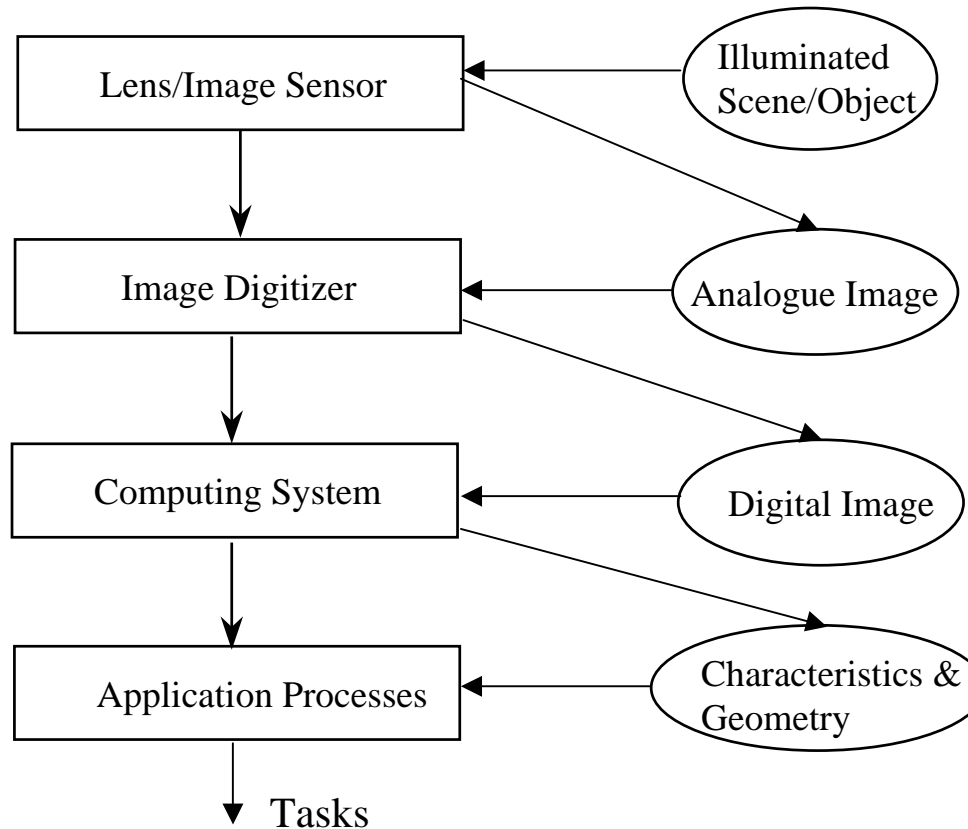
2.5.3 DSP system

2.5.4 MIMD parallel system



What is a machine vision system ? (A Review)

ANSWER:



Question:

How is an image created and how is it related to an object ?



How is an image created ?

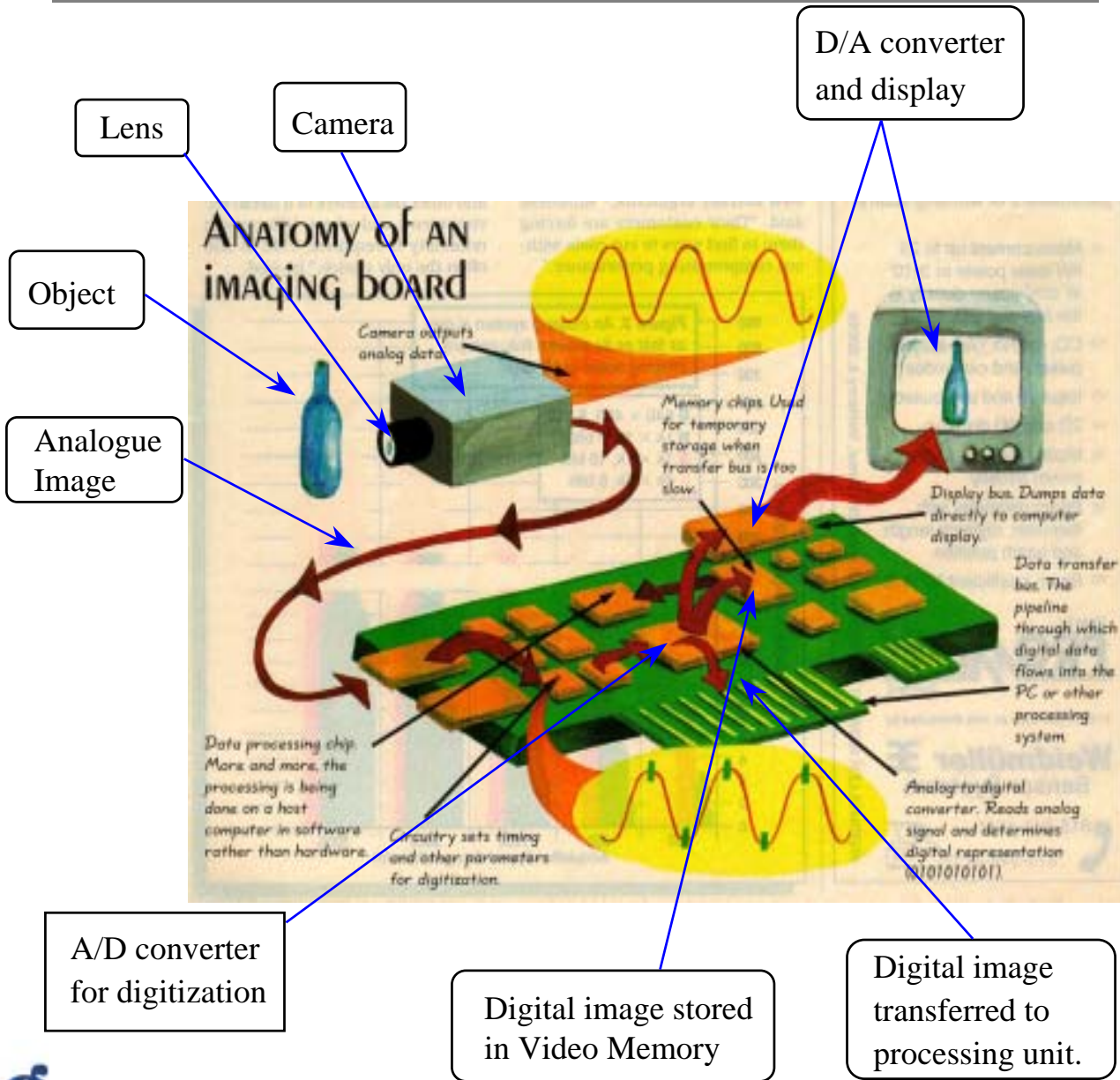
ANSWER:

To use imaging system.

How is an imaging system composed of ?

ANSWER:



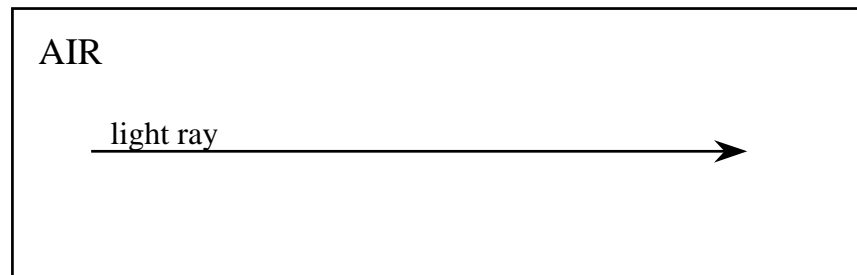


How to capture “light rays” and focus them onto an image plane ?

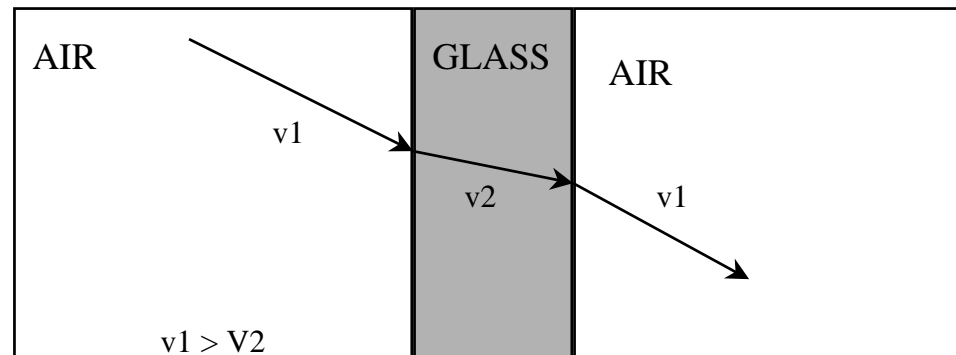
ANSWER: To use “lens system”.

1. Properties of “light ray”:

- * Can go through “air”, “glass”, “water”, or other “optical material”.
- * Follow straight path inside a same optical material.

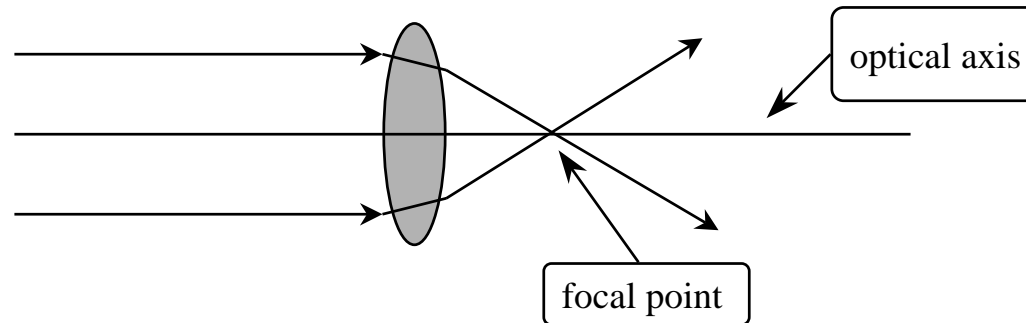


- * Light ray changes direction when going through the junction of two different materials: If going through Air-Glass junction, light bends toward surface normal; If going through Glass-Air Junction, light refracts away from the surface normal.

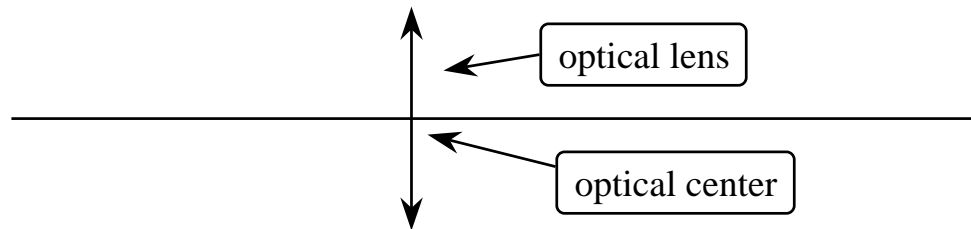


2. Properties of “convex thin lens”:

- a) A simple lens is a refracting device made of two refracting surfaces.
- b) Parallel light rays entering the lens will converge at a point called “focal point”.



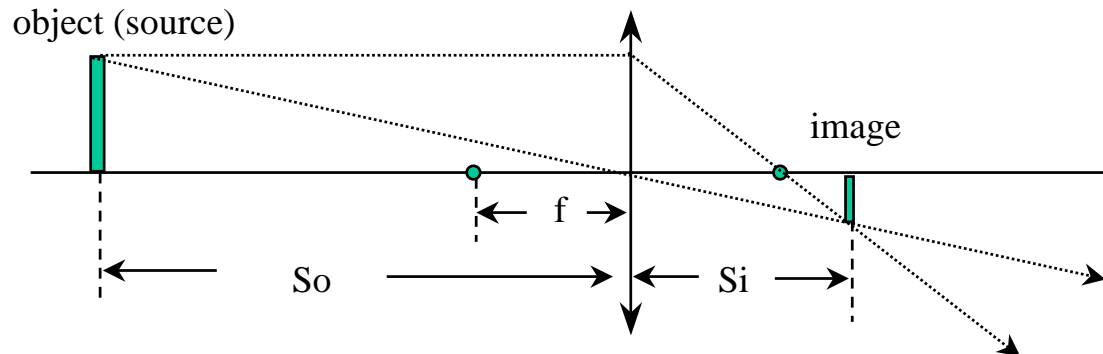
- c) For a thin lens, the thickness of the lens is negligible



d) The famous “Gaussian Lens Formula” is as follows:

$$\frac{1}{f} = \frac{1}{S_o} + \frac{1}{S_i}$$

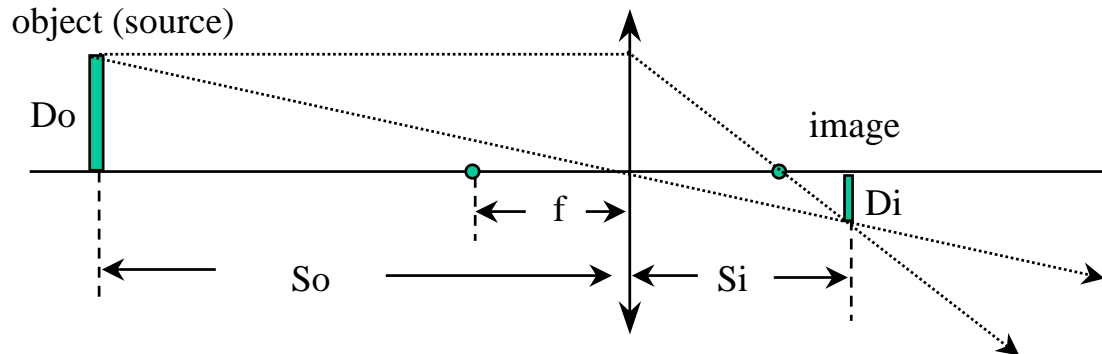
- f: the focal length
- S_o : the distance from object to lens
- S_i : the distance from image to lens



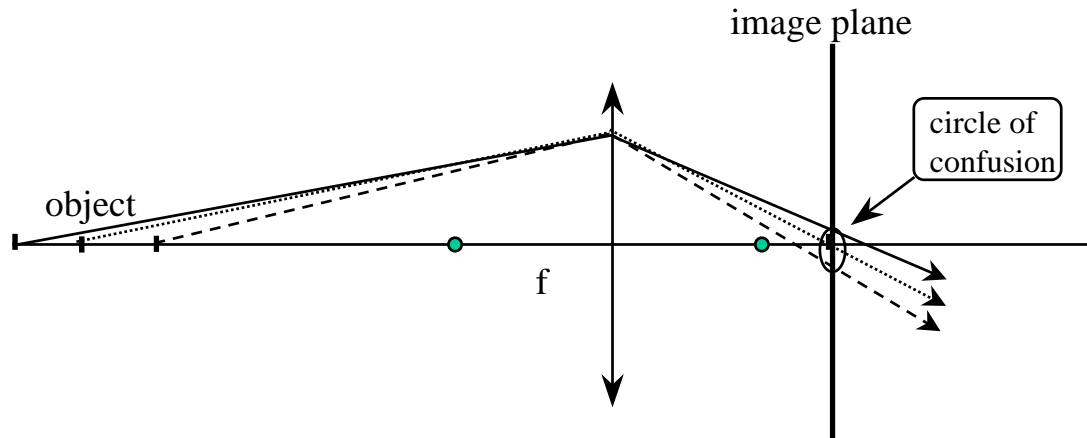
3. Properties of “lens system”:

a) The magnification: $m = (\text{image size “Di”})/(\text{object size “Do”})$

b) Focal length “f” and Image plane.



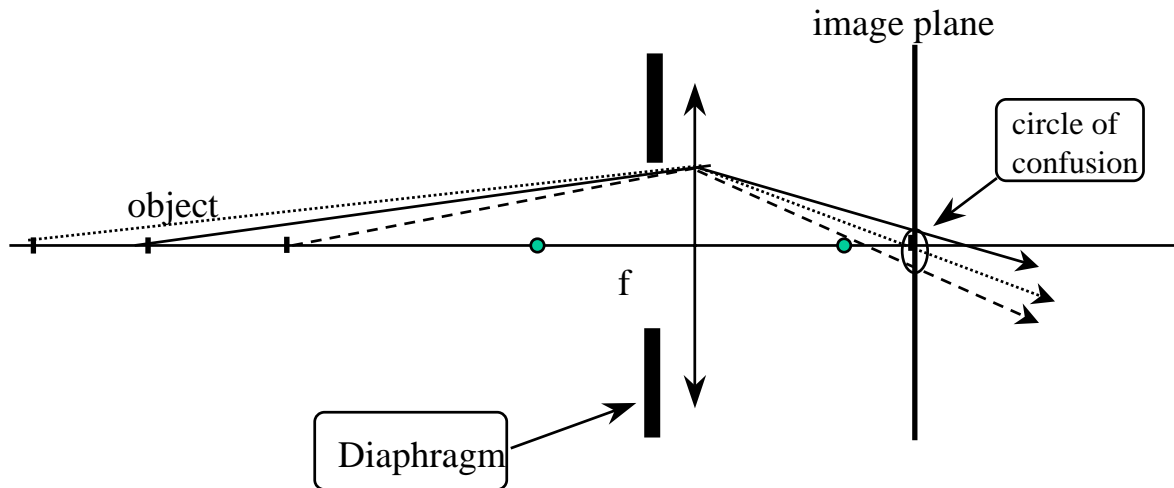
c) Depth of field (because image plane is 2D):



Depth of field is the variation range of object within which its image is still within the circle of confusion (focus) (all images within the circle of confusion is considered to be the image of a single point).



b) Smaller the opening of diaphragm, bigger the depth of field.

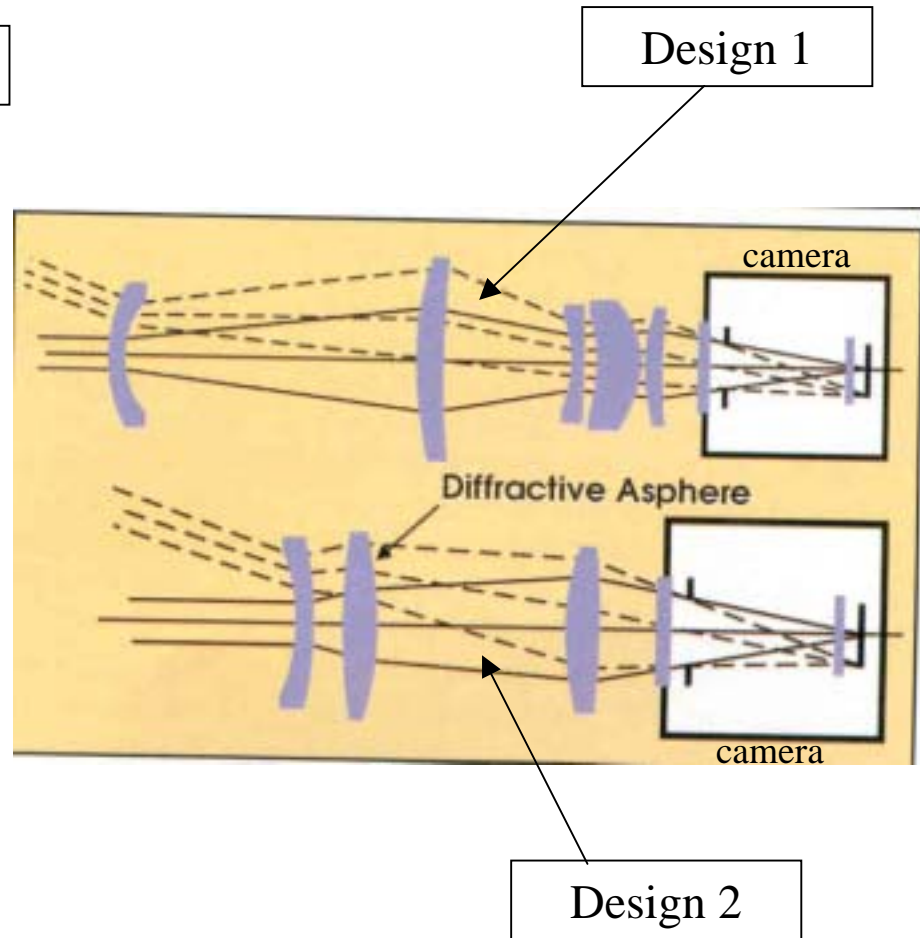
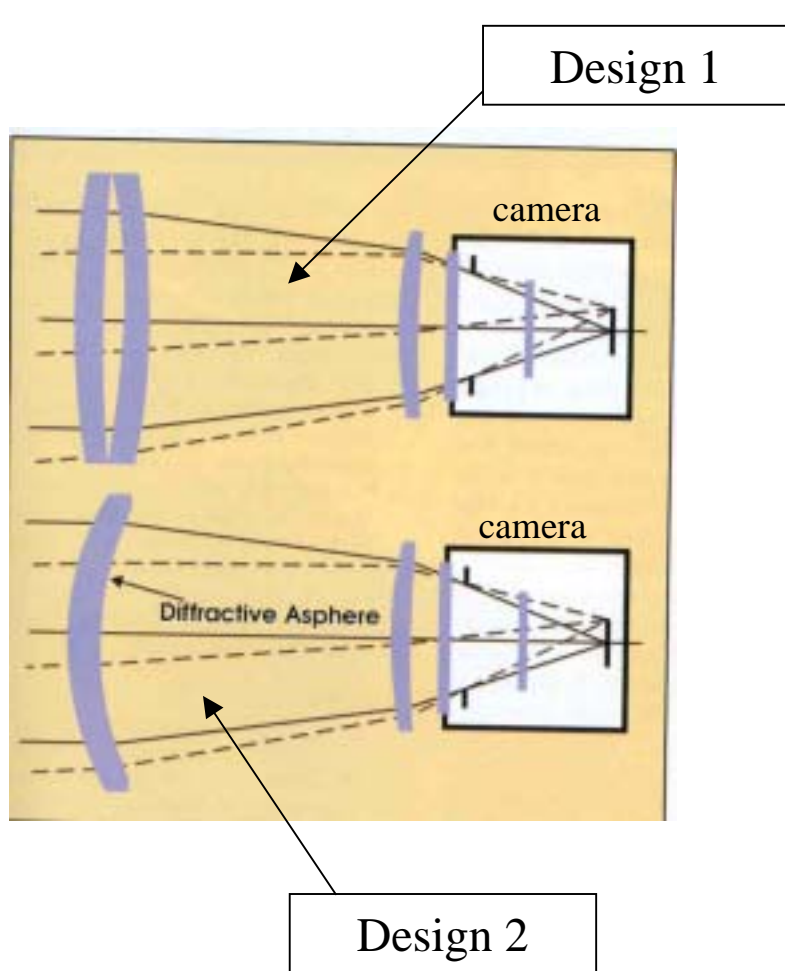


Two effects of smaller diaphragm:

- increased depth of field
- reduced amount of lights going through the lens.



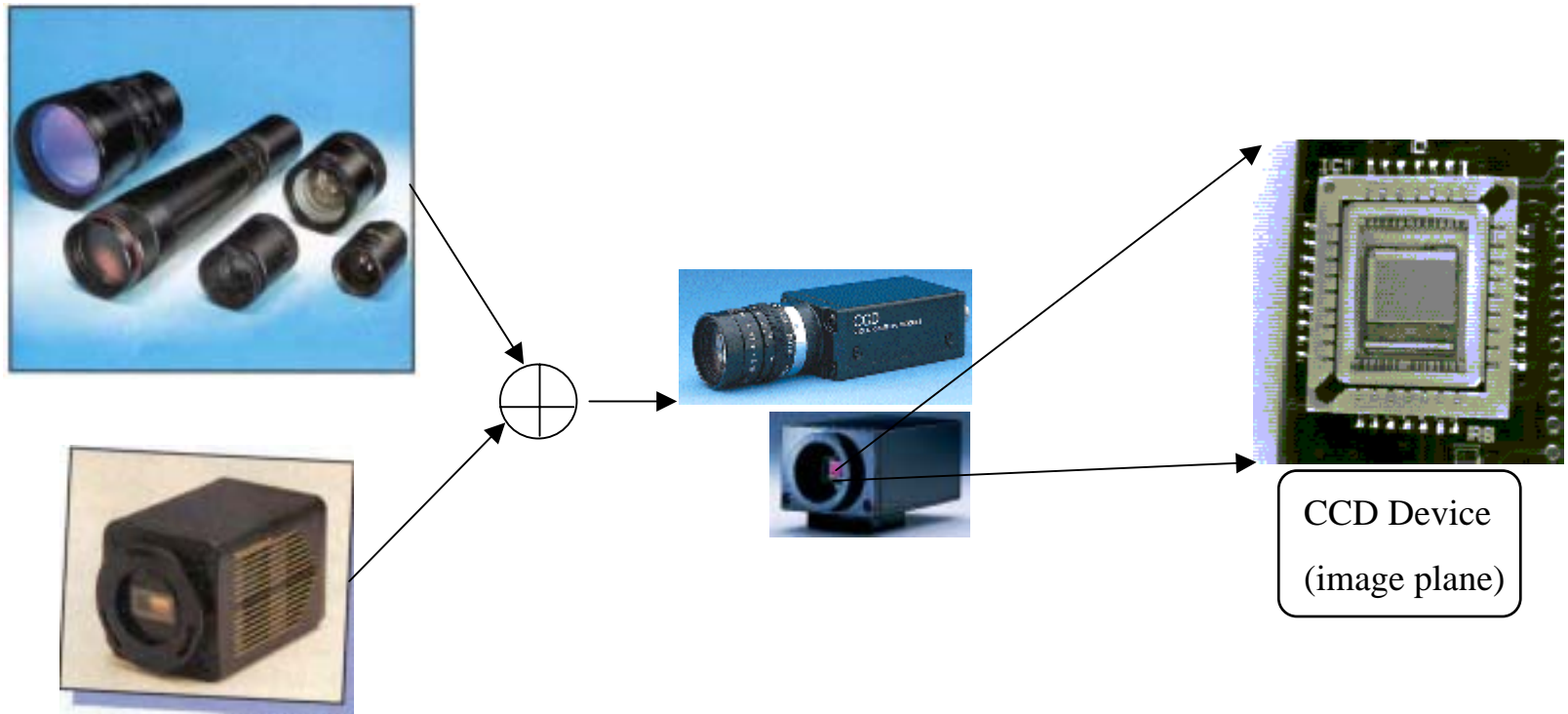
4. Design of "lens system":



How is an analogue image created ?

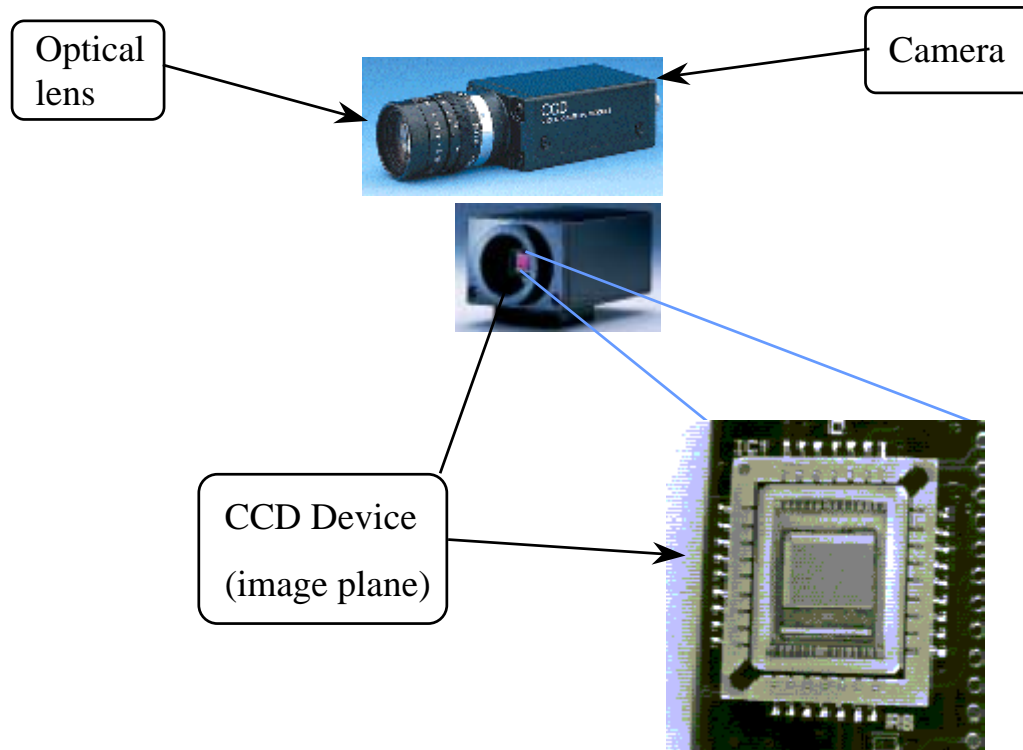
ANSWER:

It is created by using sensor following a specific principle.

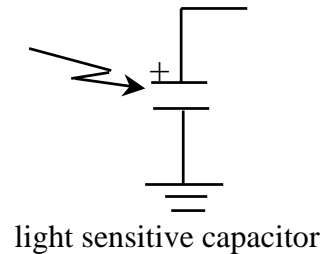


Sensor:

The commonly used sensor for capturing analogue image is CCD (charge coupled device) camera that is composed of:

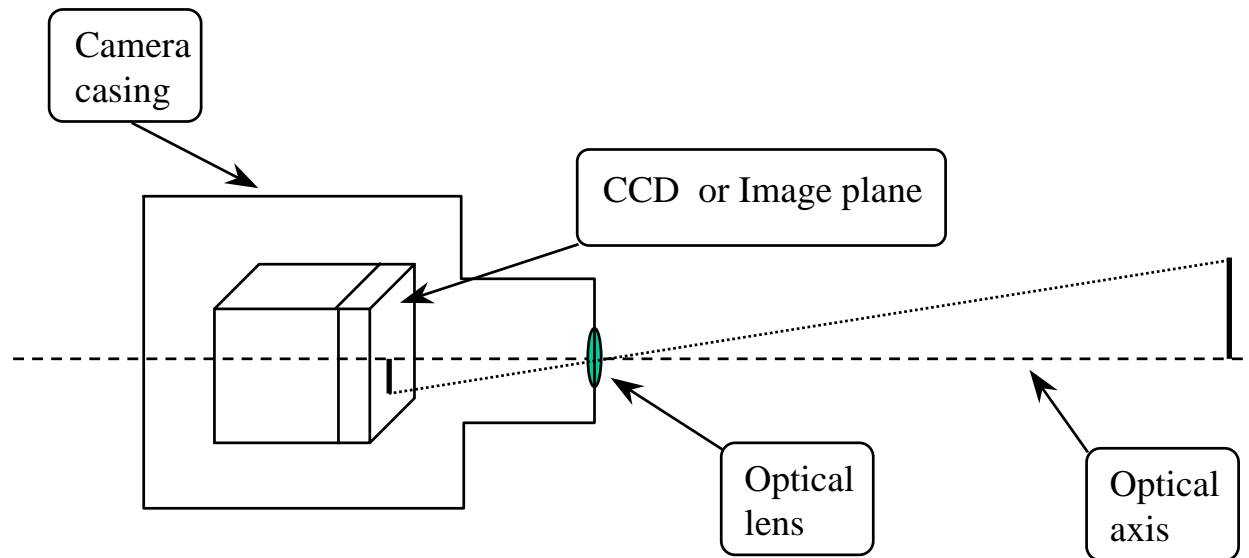


A CCD is a array of light sensitive capacitors. A capacitor converts light intensity into the corresponding electric voltage. The electronic circuit inside the camera reads out the electric charges line by line and converts them into video signal RS-170 (PAL or NTSC).



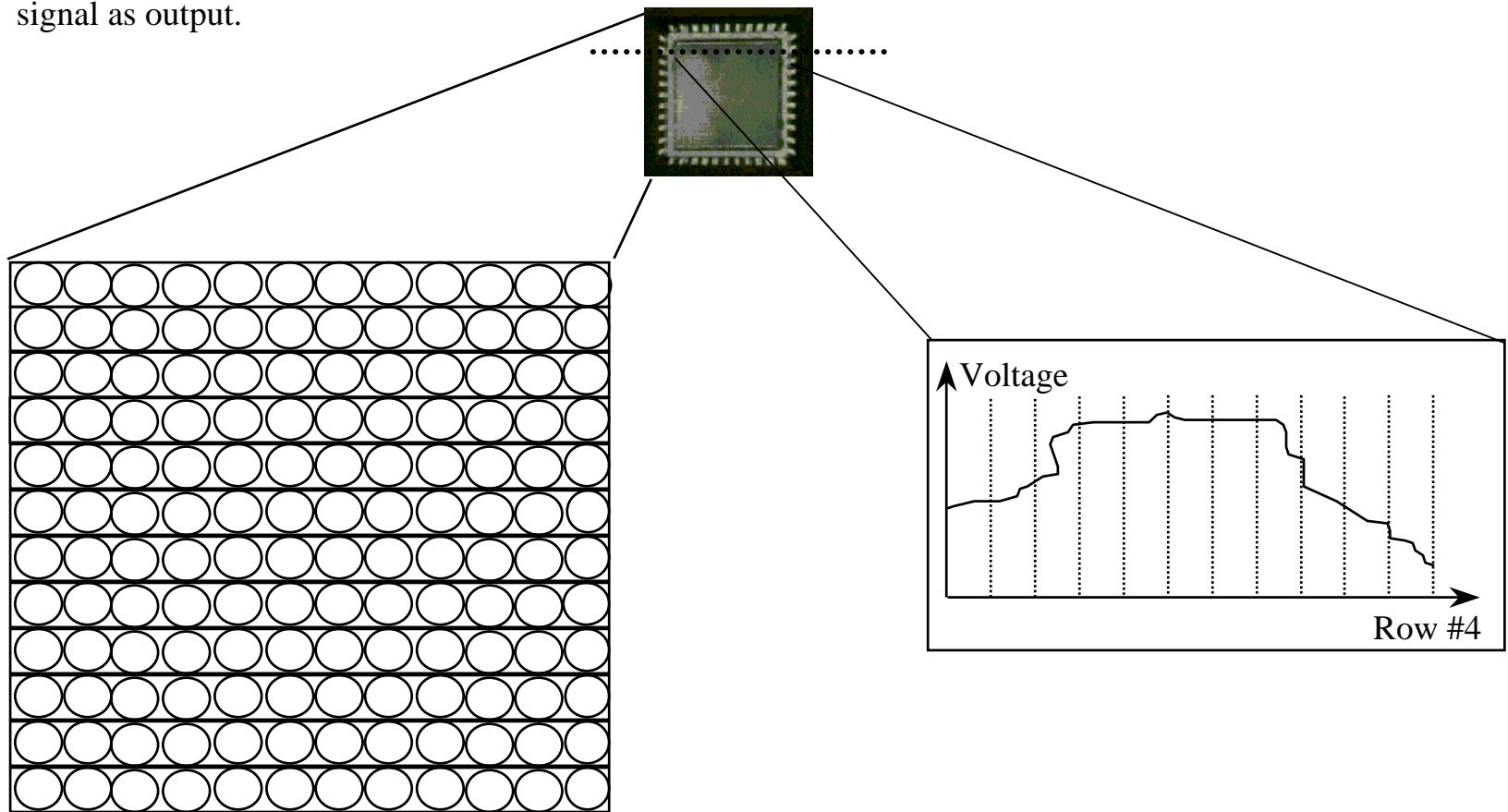
Principle of Forming Analogue Image

1. The optical lens is used to form “image” of an object in a 2D plane called “image plane”:

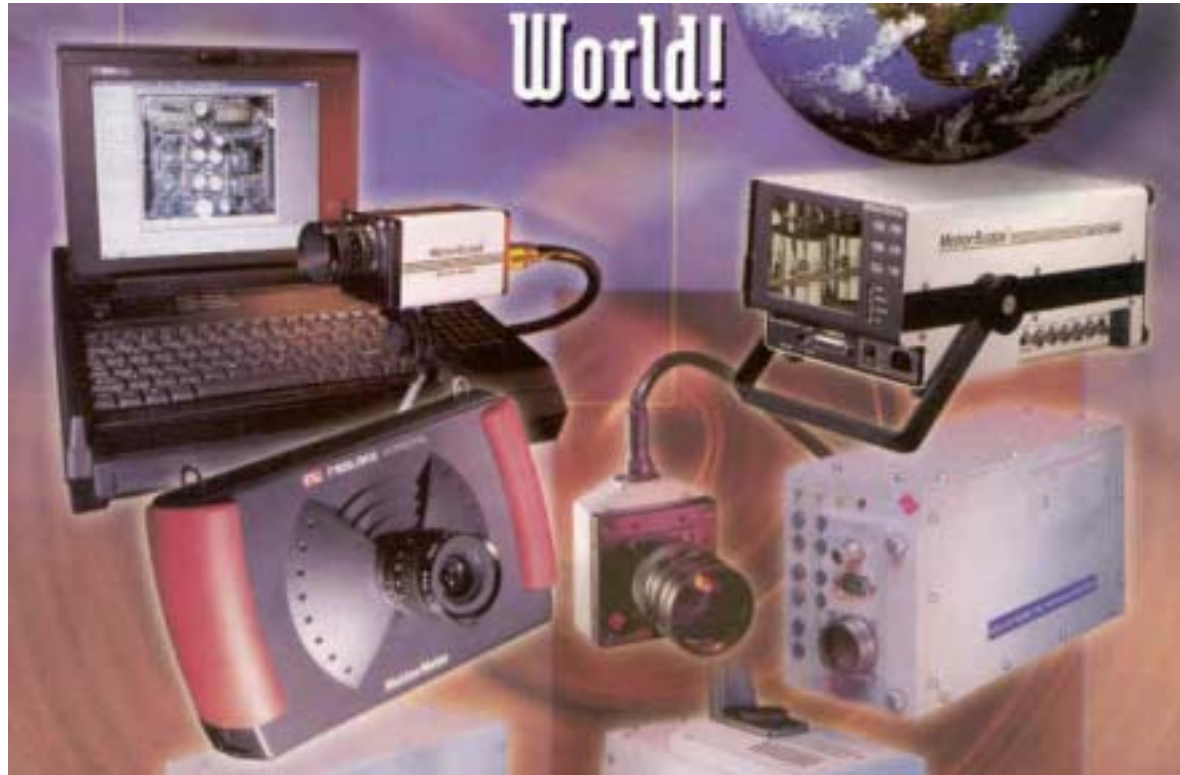


Principle of Forming Analogue Image

2. The array of light sensitive capacitors (CCD) forms the “image plane” and converts light intensities into electric charges. Finally, the circuit inside the camera converts the electric charges into analogue video signal as output.

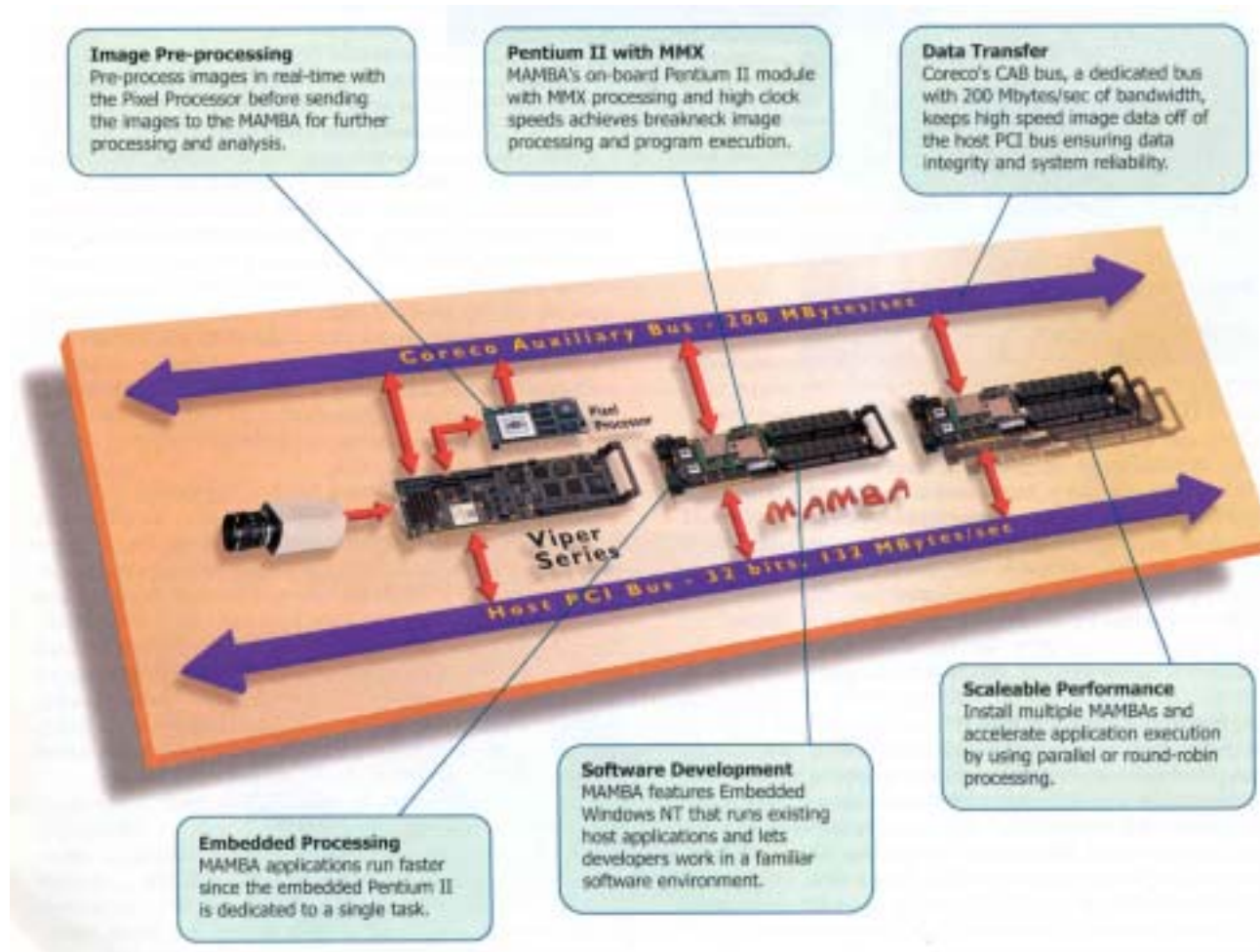


Images are normally processed by computer. Therefore, we need to have digital images.
How is a digital image created ?



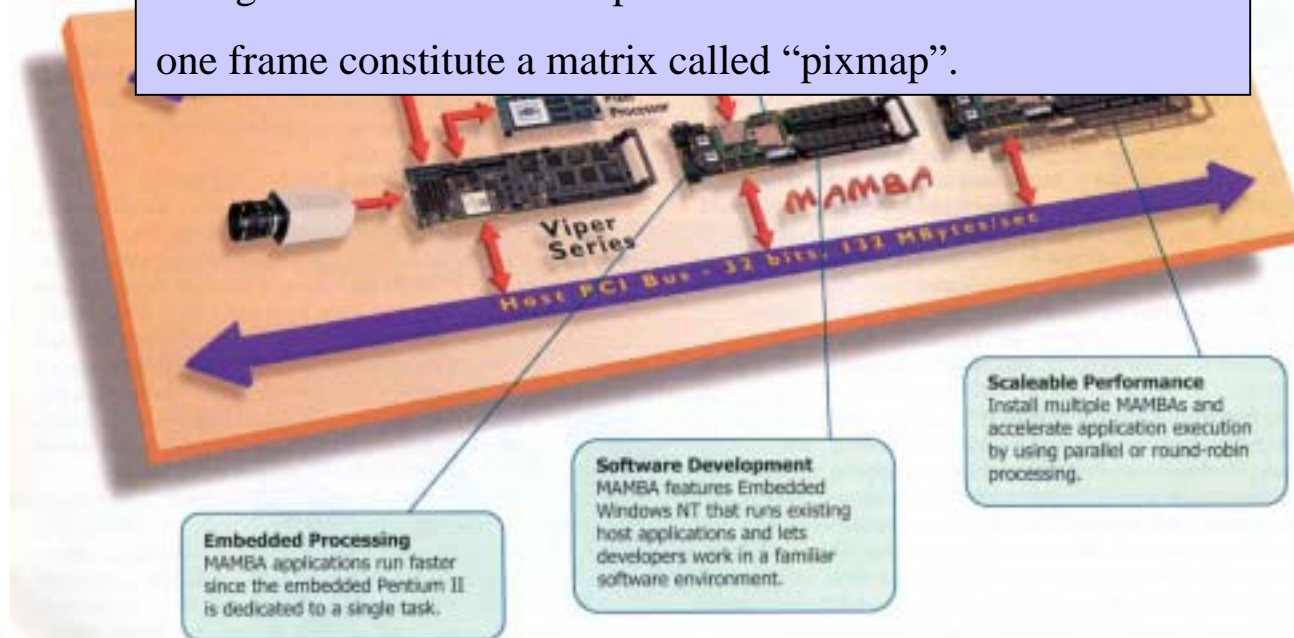
Answer:

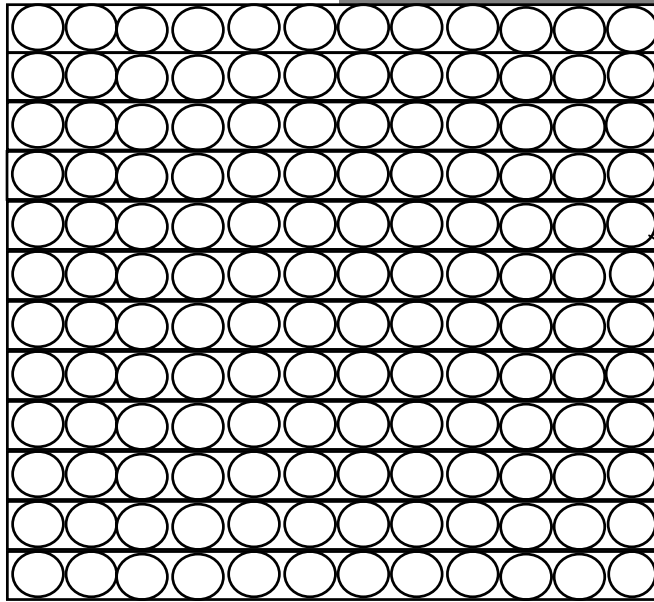
To use A/D converter that is called here “image digitizer” or “frame grabber”.



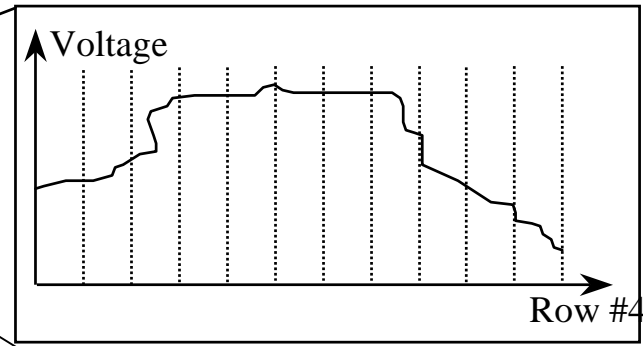
Principle of Forming Digital Image

Video signal is composed of video frames. Each frame has two fields (even and odd fields). Each field is composed of image lines. The frame grabber detects the fields and lines. Then, it converts electric voltages of each line into a vector of digital numbers called “pixel values”. The vectors of one frame constitute a matrix called “pixmap”.

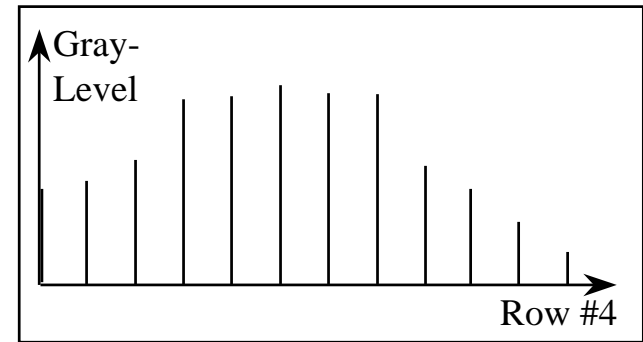




Array of CCD elements



Analogue



vector

Column	0	1	2	3	4	5	6	7	8	9	10	11
0												
1												
2												
3												
4	97	103	110	140	141	150	145	143	110	90	55	30
5												
6												
7												
8												
9												

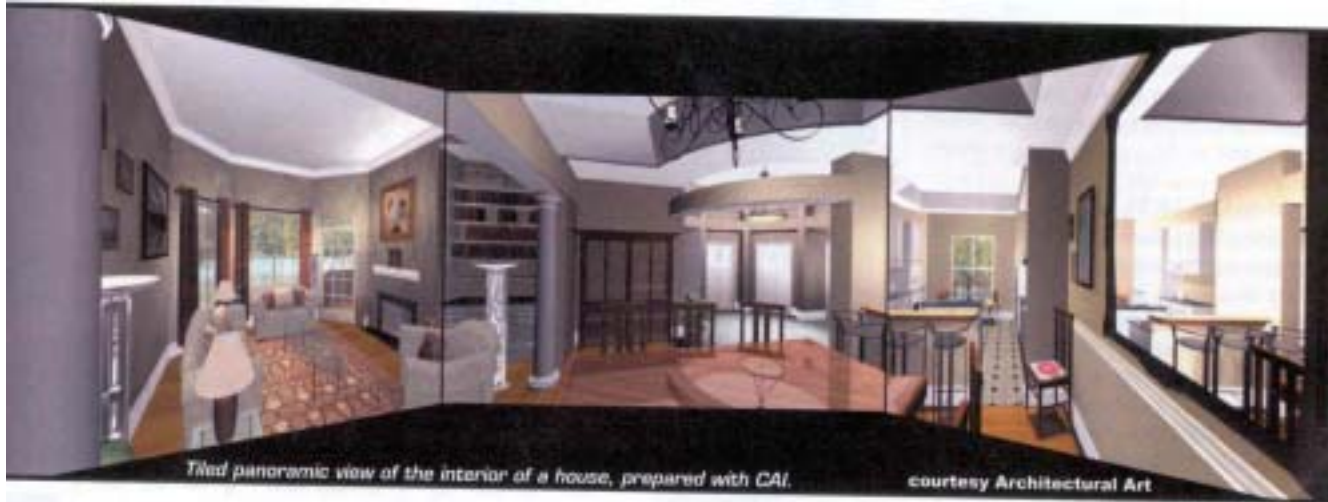
Digital Image or Pixmap



SUMMARY

1. A lens system is employed to capture light rays and focus them onto a plane called “image plane”.
2. The important lens parameters are: magnification and focal length.
3. The diaphragm of a lens is employed to control: a) the depth of field and b) the amount of lights entering the lens.
4. An analogue image is created by using CCD (array of light sensitive capacitors).
5. A digital image is created by using a A/D converter (called “image digitizer” or “frame grabber”). A digital image is a matrix of rows and columns. Its elements are called “pixels”. The digital number at a pixel is called “pixel value”.





	0	1	2	3	4	5	6	7	8	9	10	11
0												
1												
2												
3												
4												
5												
6												
7												
8												
9												

