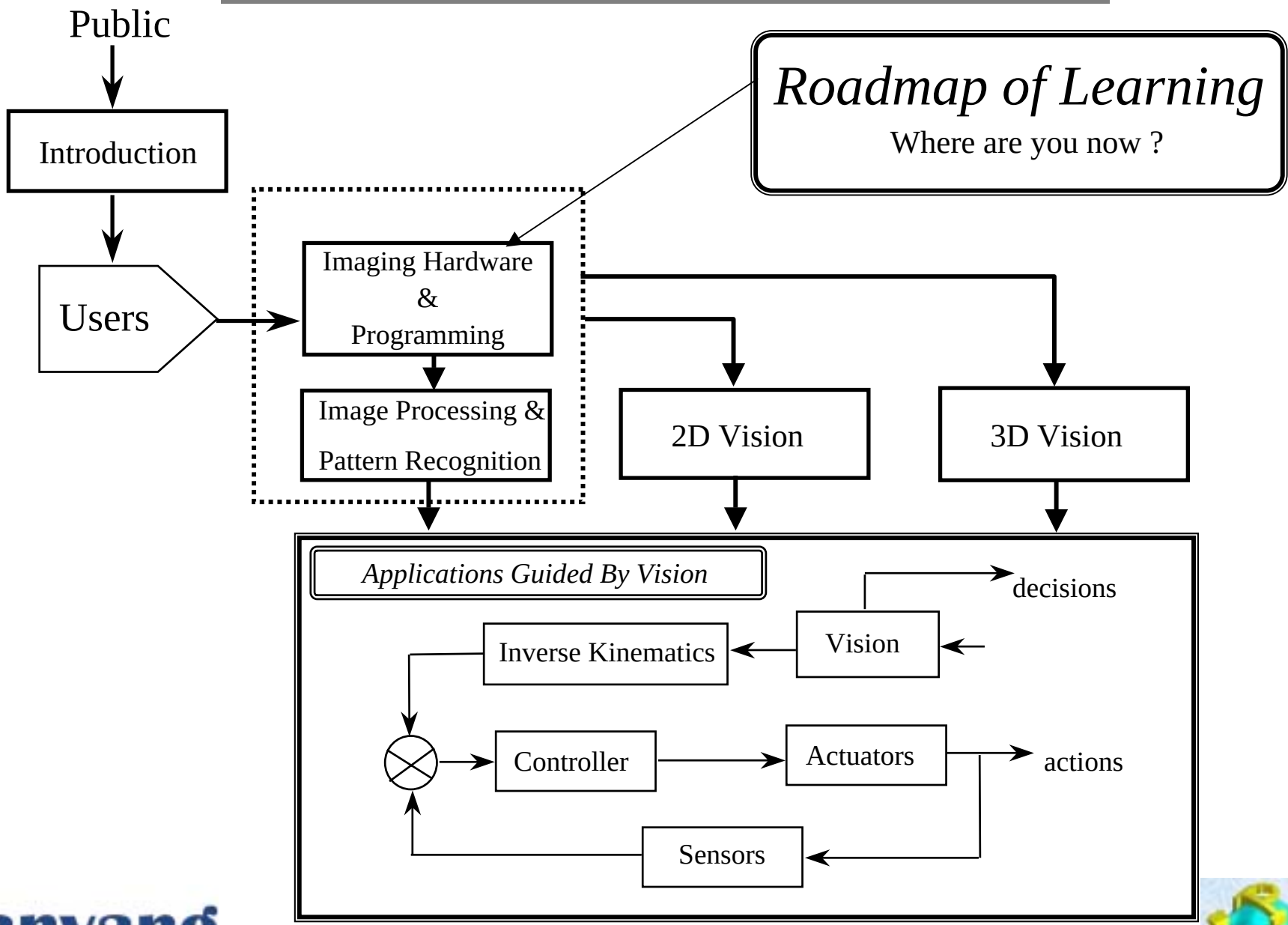
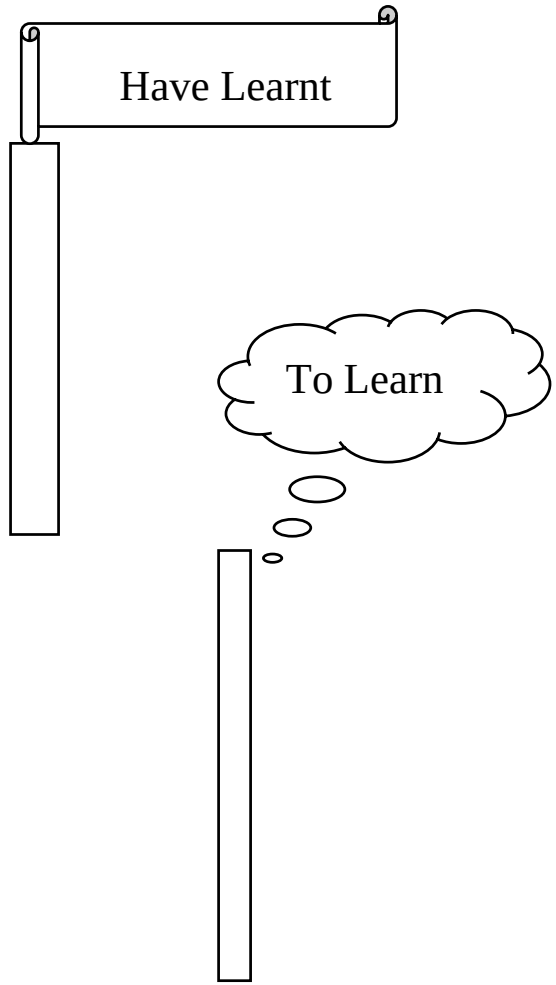


CONTENT

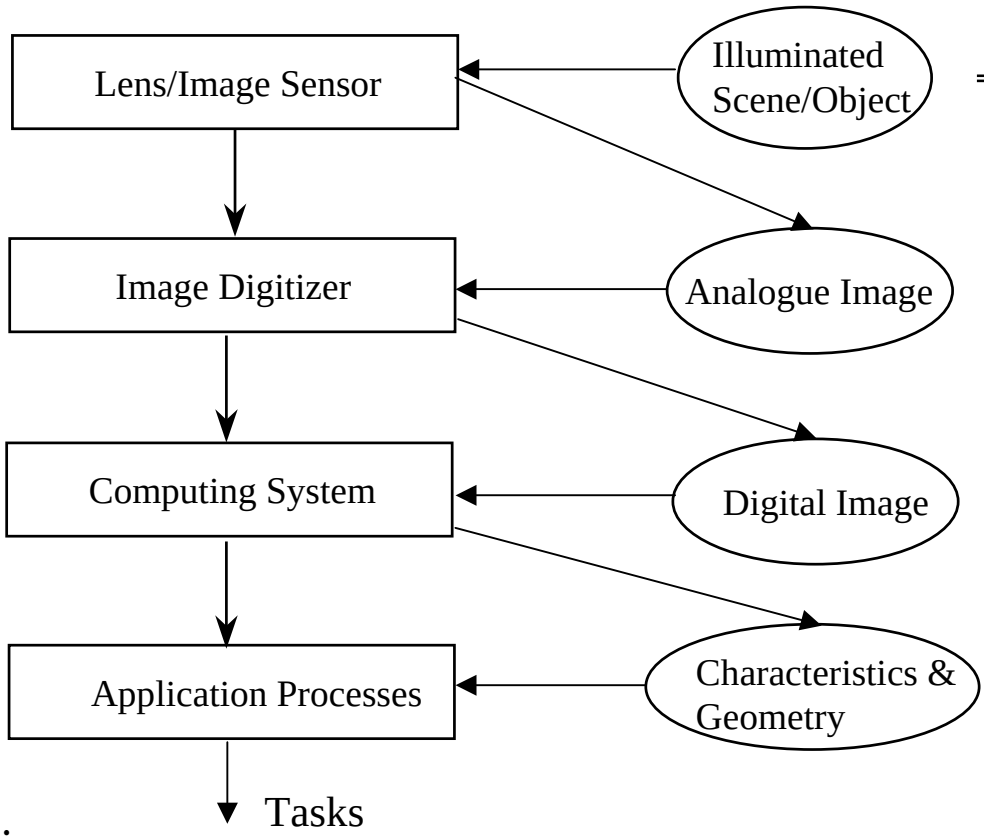


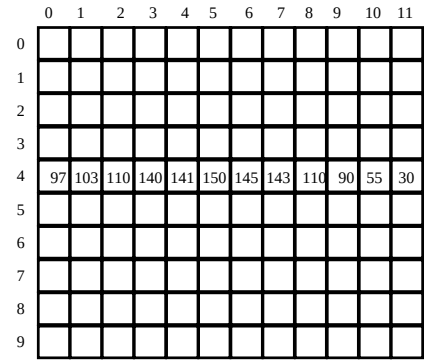
Chapter 2: Hardware of Machine Vision

- 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:

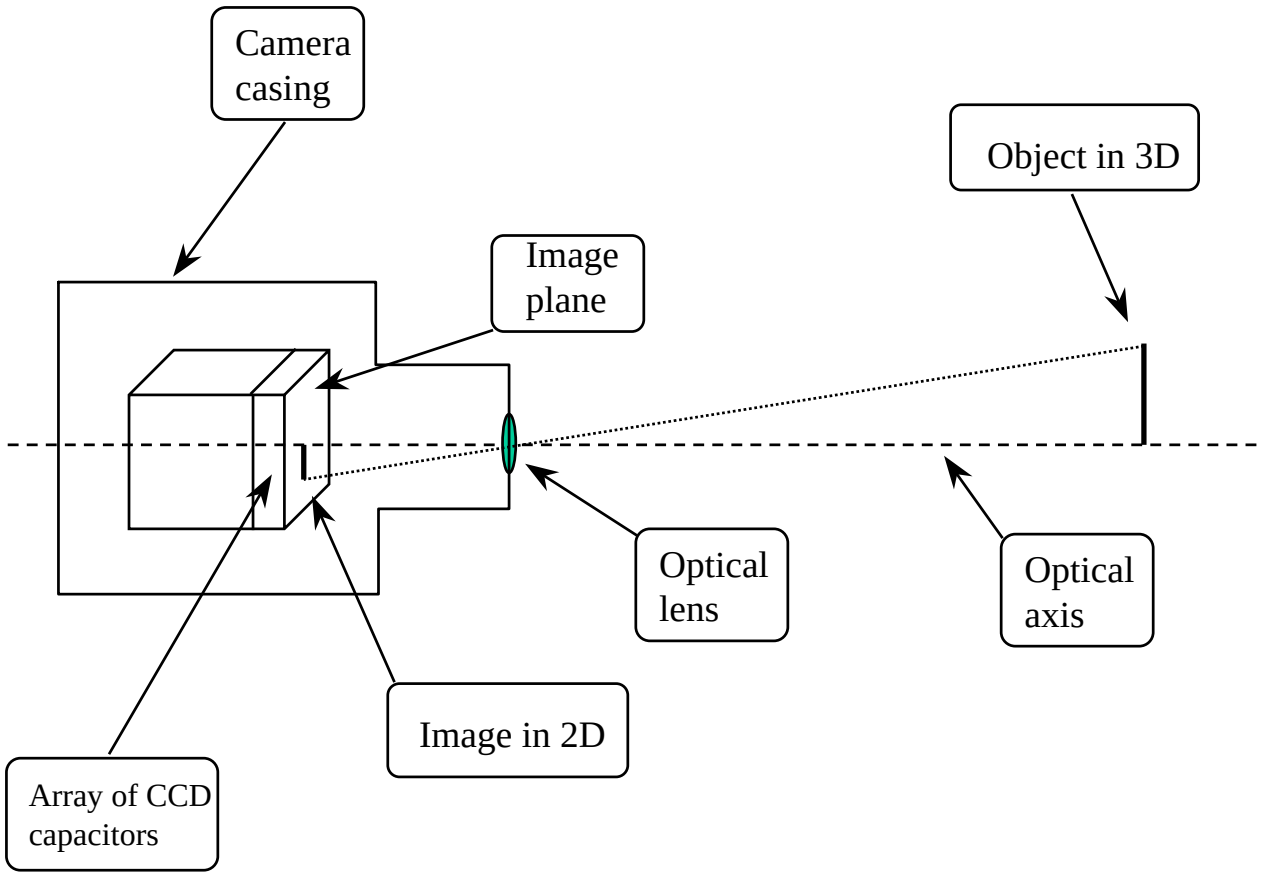




Questions:

What is the geometric relationship between an object and its image ? And, what are common computing platforms for image processing ?

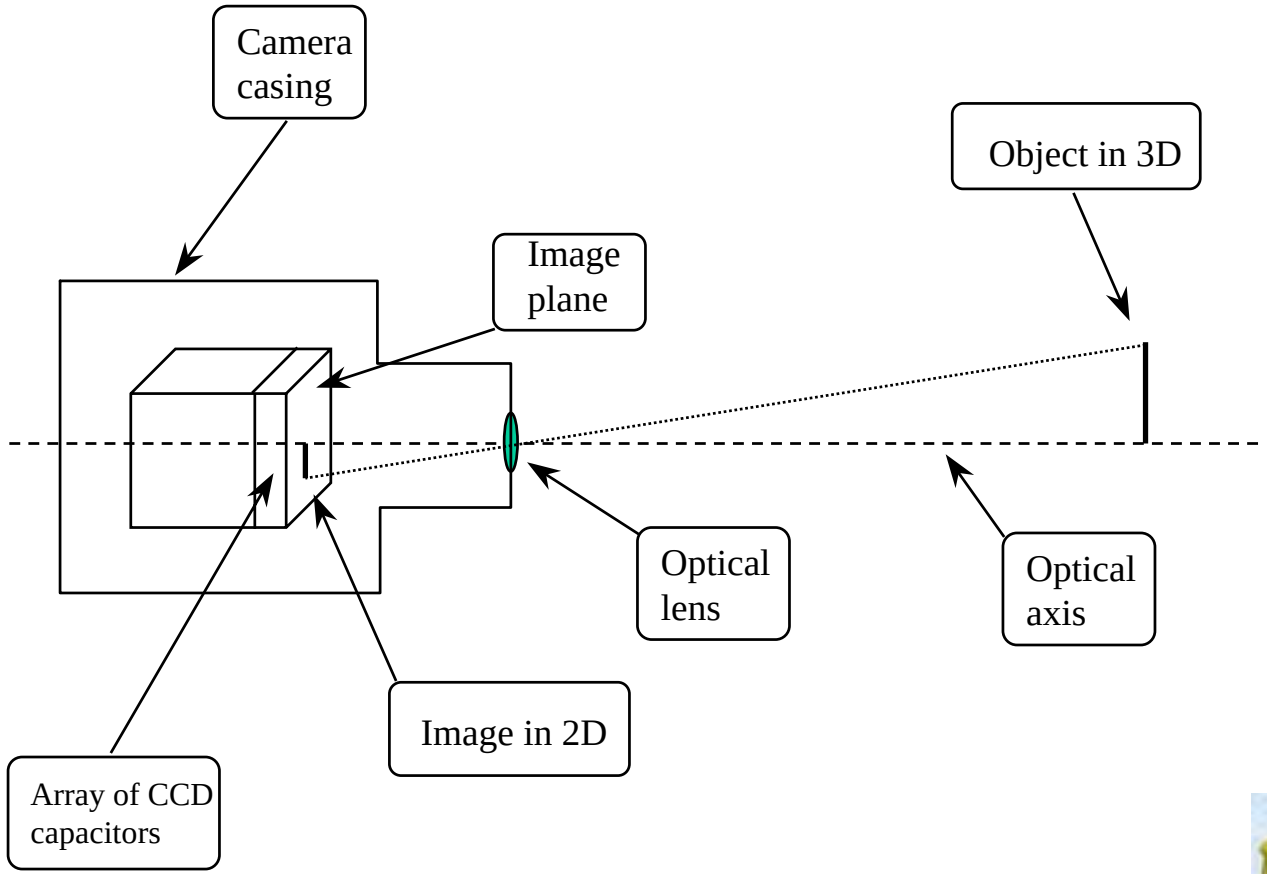
We know how analogue and digital images are created. The next question will be what is the mathematical modeling of image formation ?



Geometric Relationship Between An Object and Its Analogue Image

Step 1: Input: Object in 3D space.

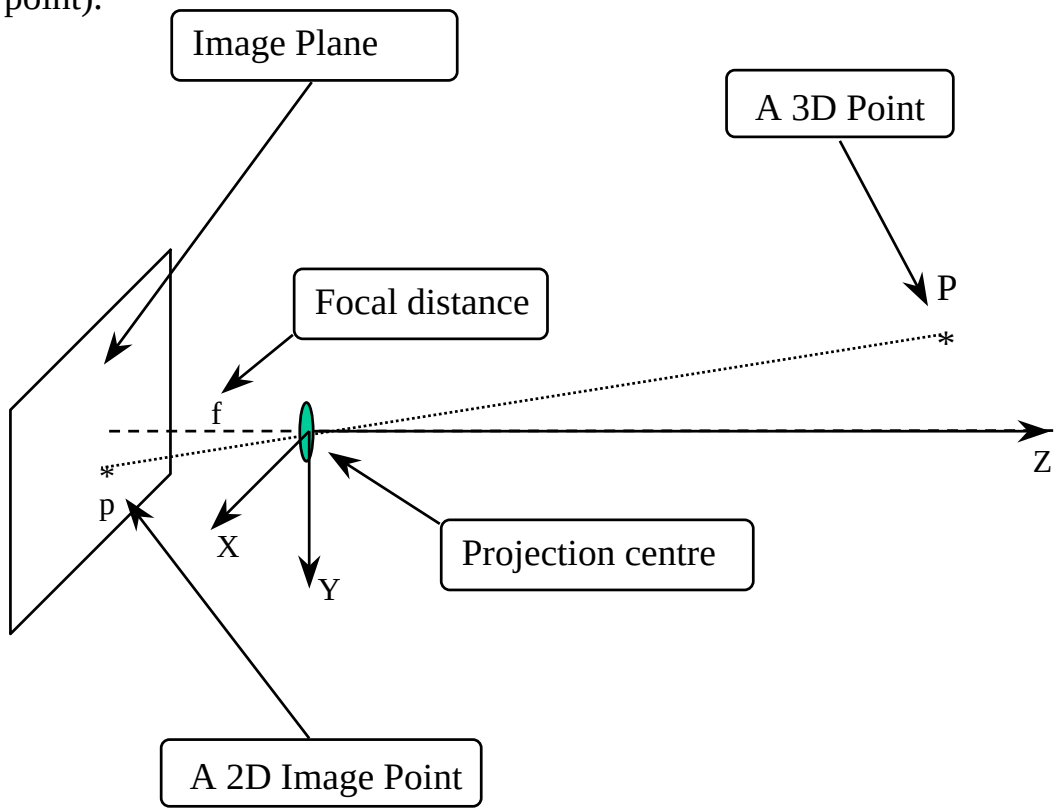
Step 2: Output: Analogue image in 2D space ("image plane").



Geometric Relationship Between An Object and Its Analogue Image

Step 3: Perspective projection:

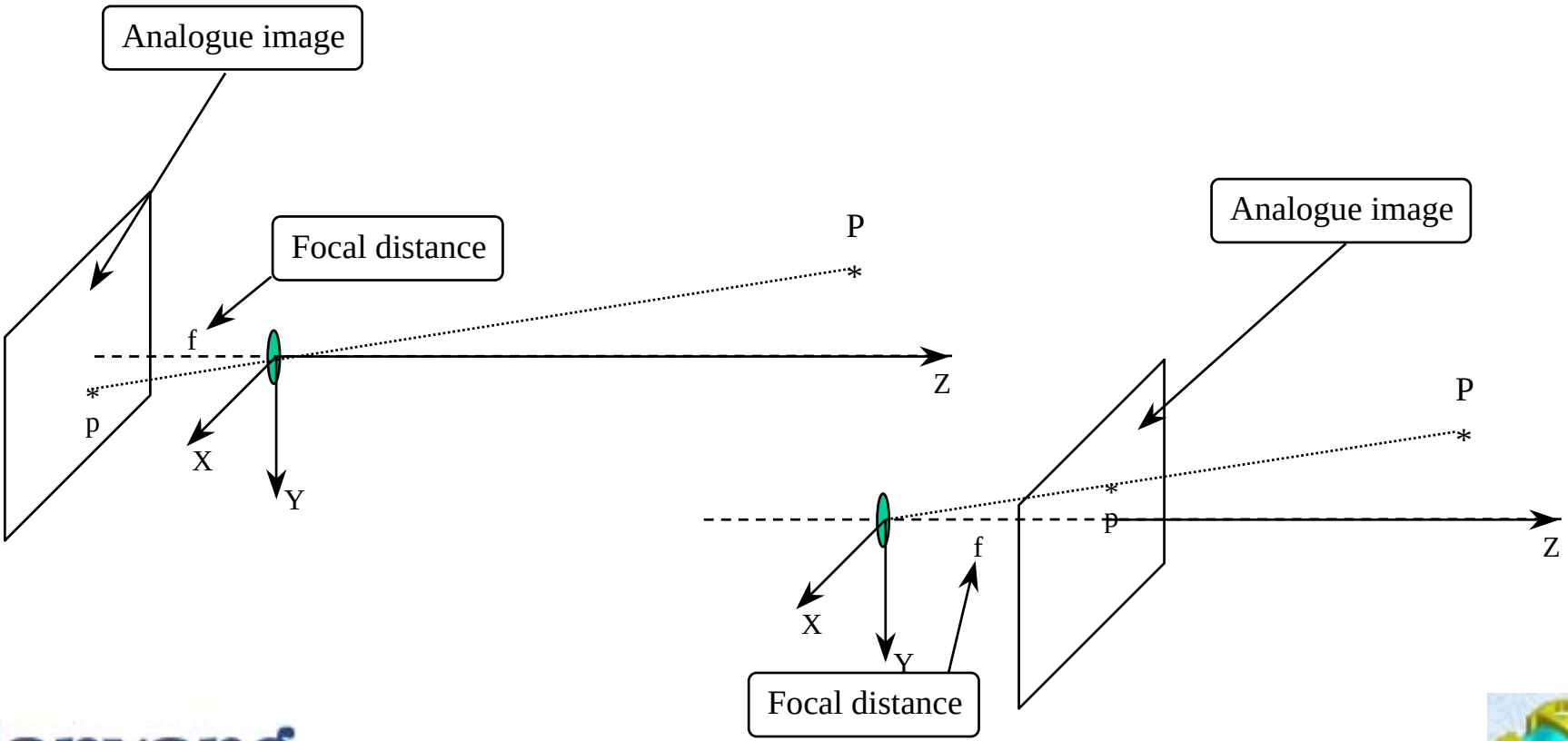
Because the lens is small compared to an object in 3D space, a lens can be considered as a "tiny hole" (called "pin-hole" model). Therefore, image formation is a perspective projection (it is a projection along a line and passing through a common point).



Geometric Relationship Between An Object and Its Analogue Image

Step 4: Geometric equivalence:

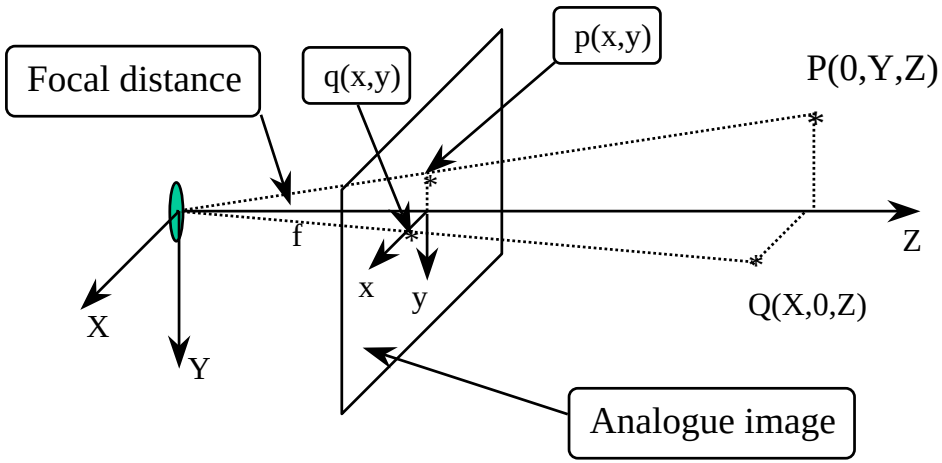
For the convenience of analysis, we can consider that the image plane is at the position (0, 0, f) instead of the position (0, 0, -f). This will not change the geometric relations of content inside an image.



Geometric Relationship Between An Object and Its Analogue Image

Step 5:Geometric model:

From the similitude of triangles, we can find out the relationships between the 3D coordinates (X,Y,Z) and image coordinates (x,y).



For x and X coordinates:

$$\frac{x}{X} = \frac{f}{Z}$$

$$x = f \bullet \frac{X}{Z}$$

For y and Y coordinates:

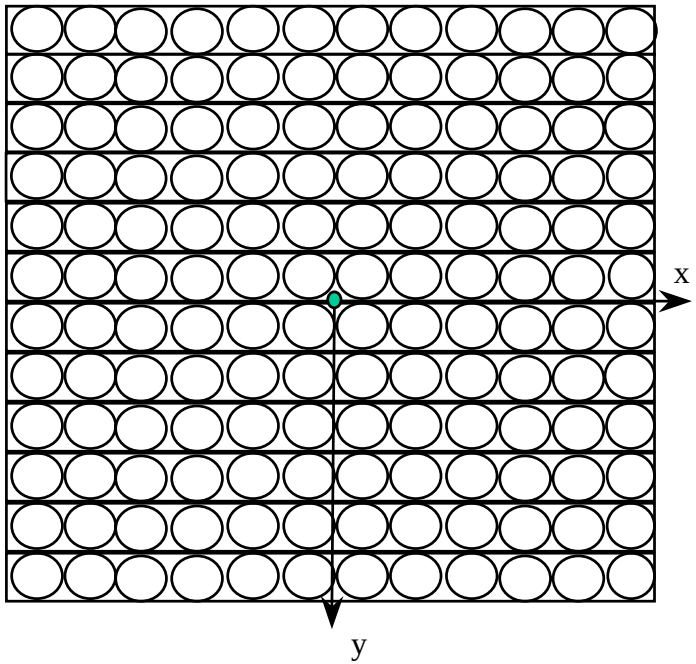
$$\frac{y}{Y} = \frac{f}{Z}$$

$$y = f \bullet \frac{Y}{Z}$$

Geometric Modeling of Digital Image

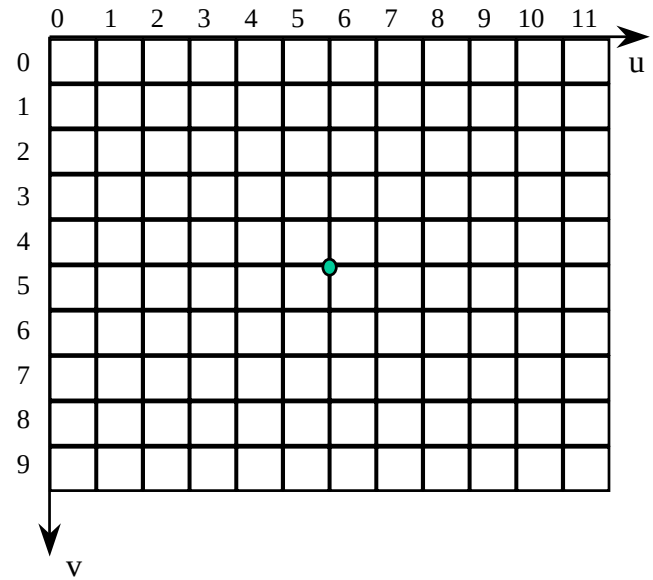
Step 1: Input:

Analogue image (with oxy coordinate system).



Step 2: Output:

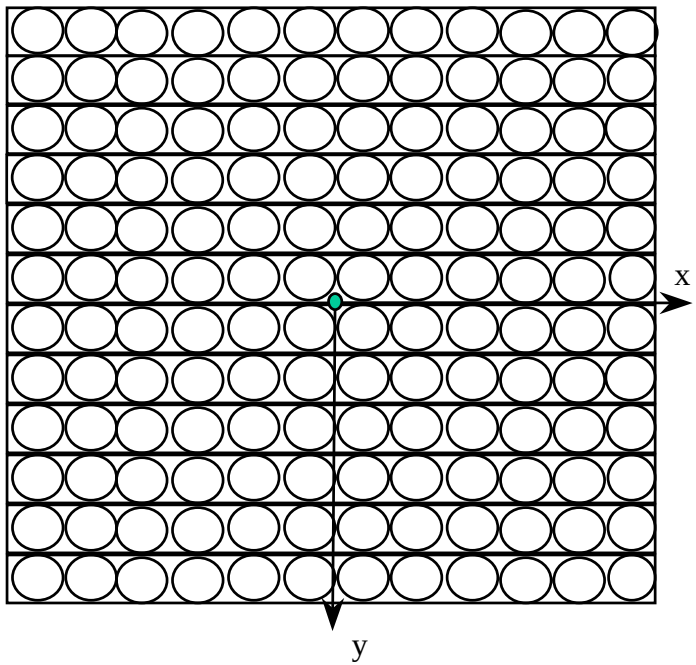
Digital image (with ouv coordinate system).



Geometric Modeling of Digital Image

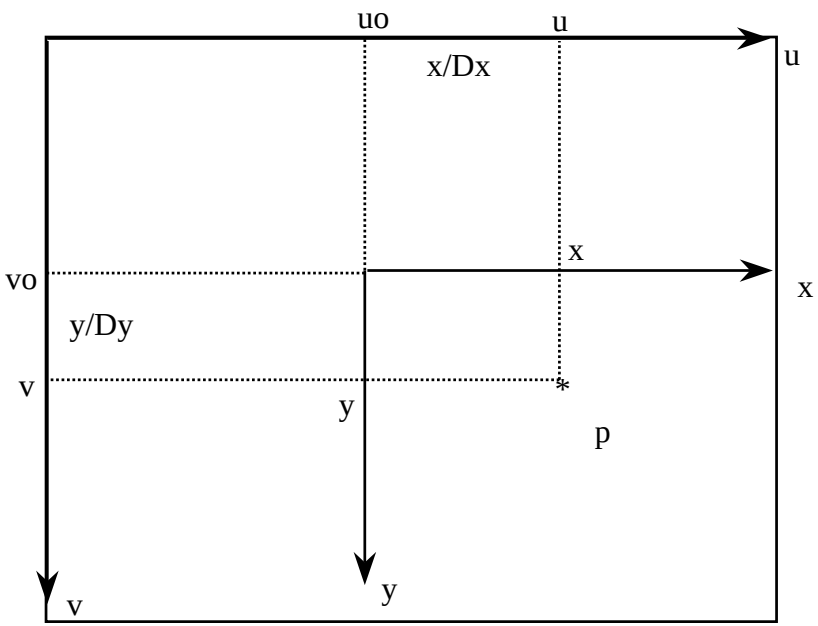
Step 3: Digitization parameters:

- spacing between rows is : Dy (mm)
- spacing between columns is : Dx (mm)



Geometric Modeling of Digital Image

Step 4: Geometric model:



$$u = u_0 + \frac{x}{D_x}$$

$$v = v_0 + \frac{y}{D_y}$$

(x, y) are called the real coordinates of an image point in the analogue image.

(u,v) are called the index coordinates of an image point in the digital image.

Example: Dx = 0.01mm/pixel

x = 1 mm

u0 = 128

u = ?

We now know:

1. How is an digital image created ?

2. How to relate a 3D object coordinate to its corresponding 2D image coordinate ?

Question:

How to process digital images in order to know:

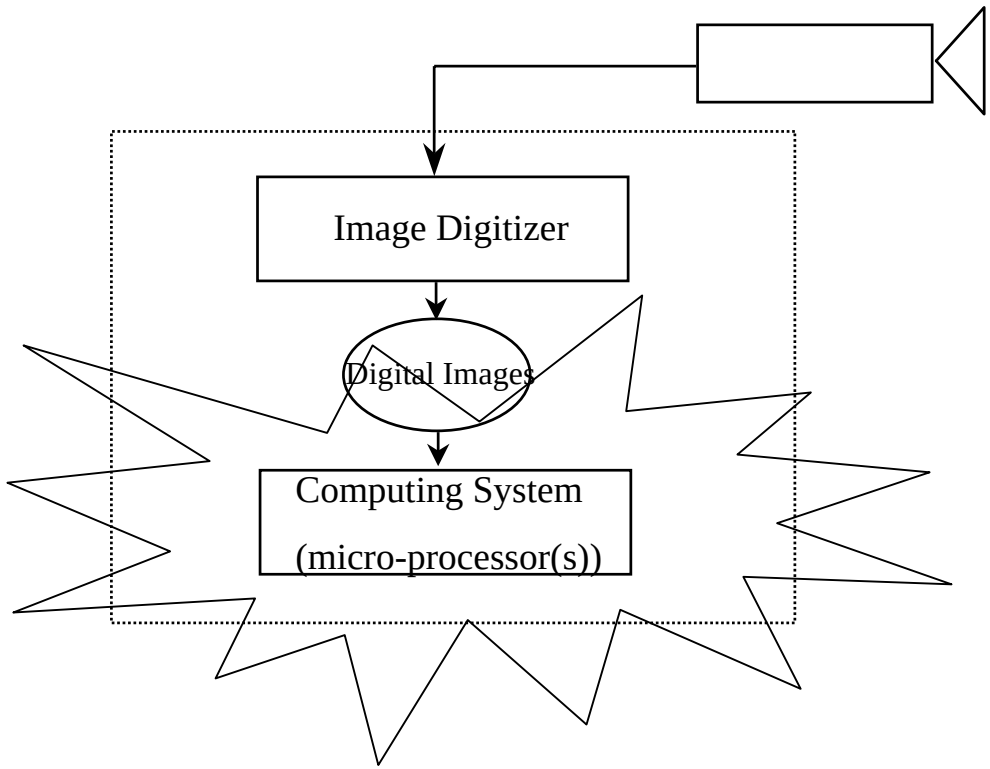
1. Where is an object inside an image plane ?

2. What is an object inside an image plane ?

What to use for image processing ?

ANSWER:

To use Computing System !



What are the common computing systems for machine vision ?

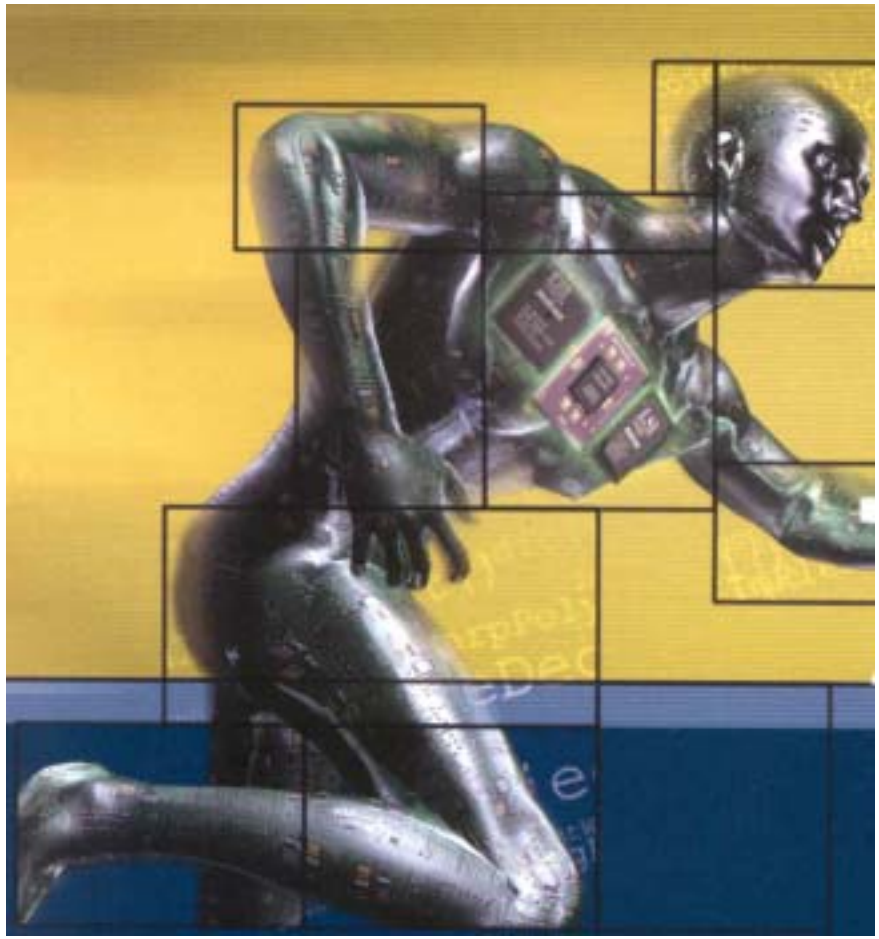
ANSWER:

1) Host processor system

2) pipeline system

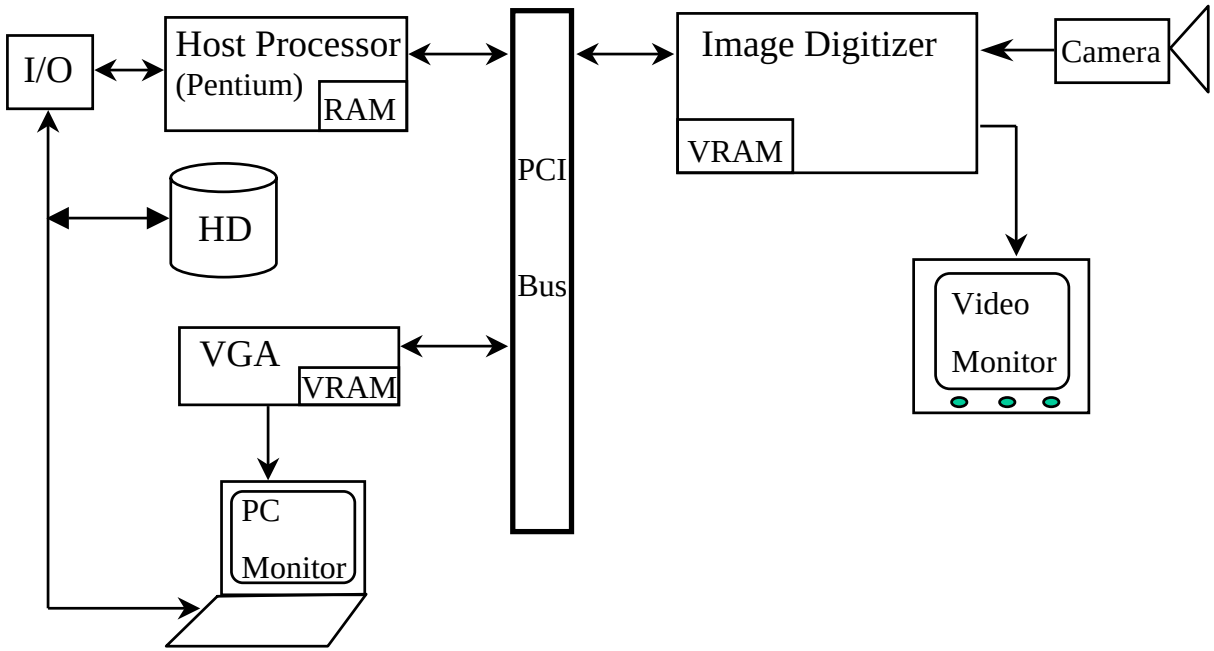
3) DSP system

4) MIMD parallel system



1. Host Processor System

Configuration:



Components:

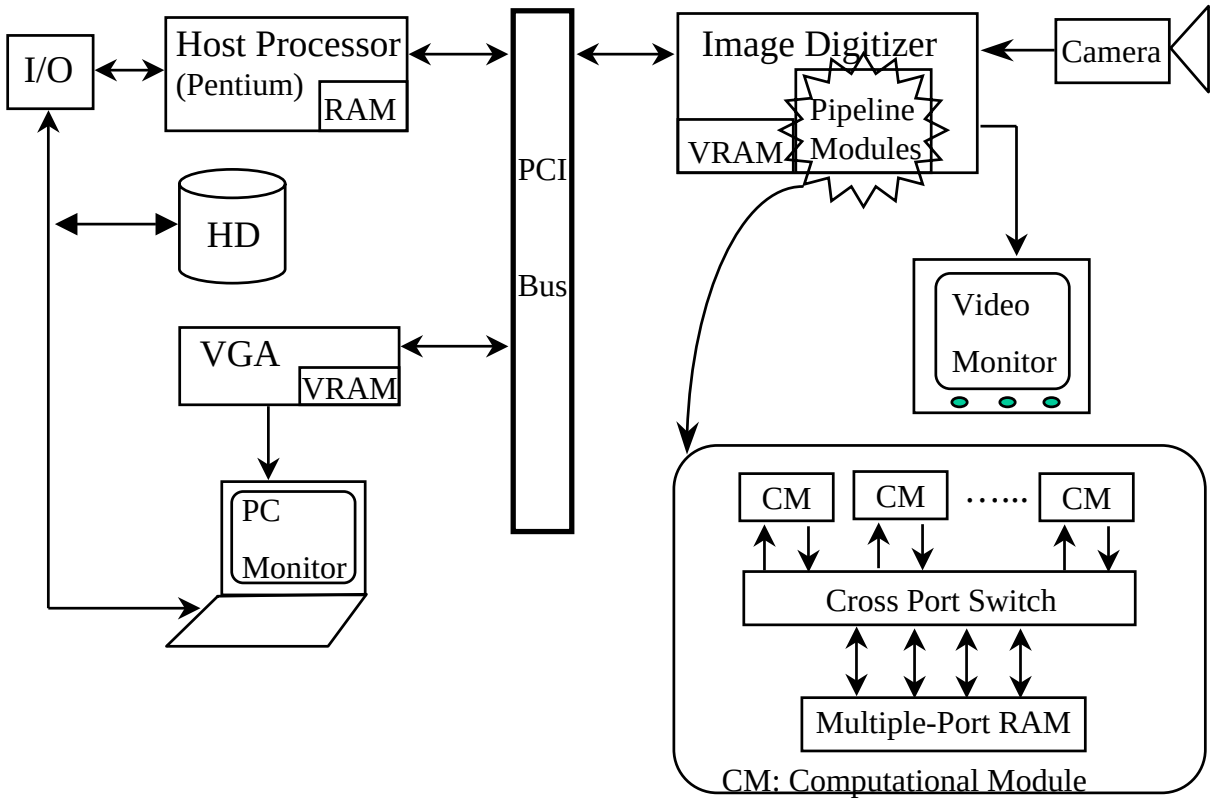
- Image digitizer;
- Host processor (eg, Pentium);
- PCI bus;
- VGA + PC Monitor;

Development Software:

- Win95, Win NT or UNIX.
- C/C++ programming language.
- image and graphics libraries.

2. Pipeline System

Configuration:

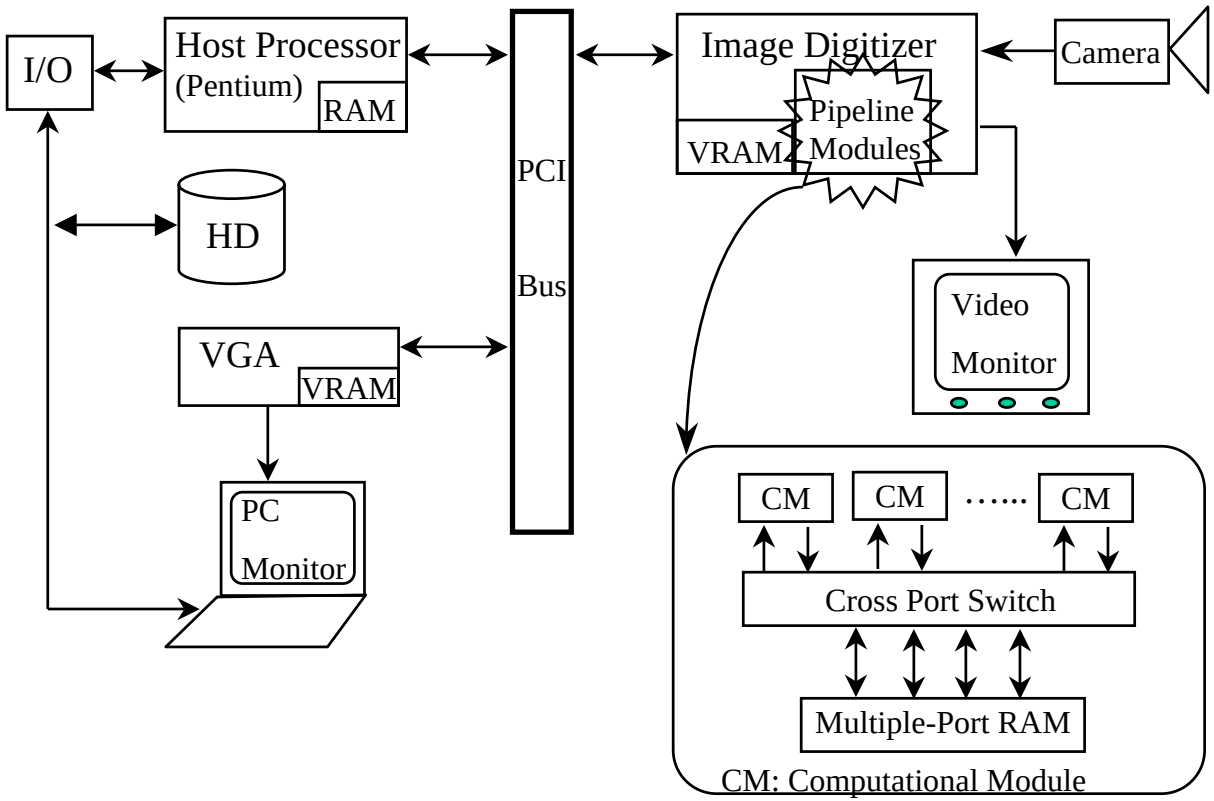


Components:

- Image digitizer;
- Cross port switch;
- Multiple port memory;
- Multiple computational modules;

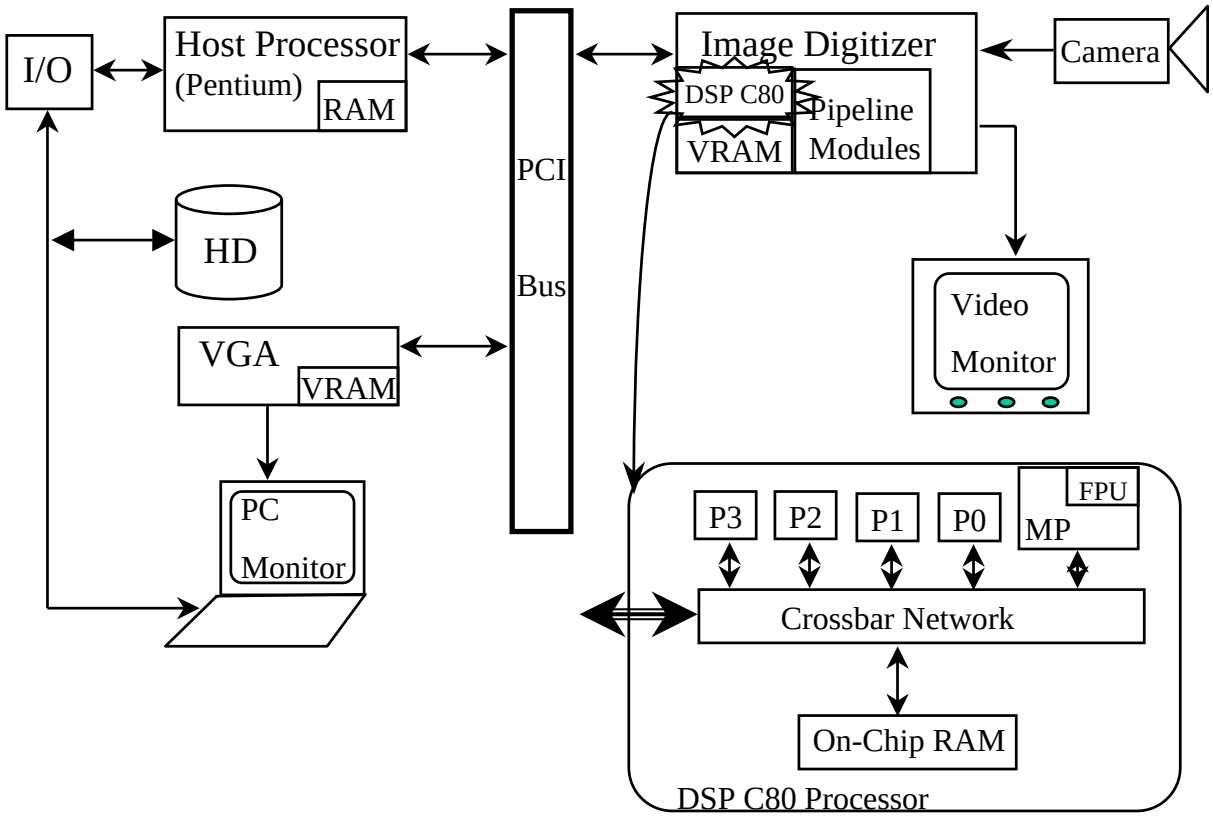
Development Software:

- Win95, Win NT or UNIX.
- C/C++ programming language.
- image and graphics libraries.



3. DSP System

Configuration:

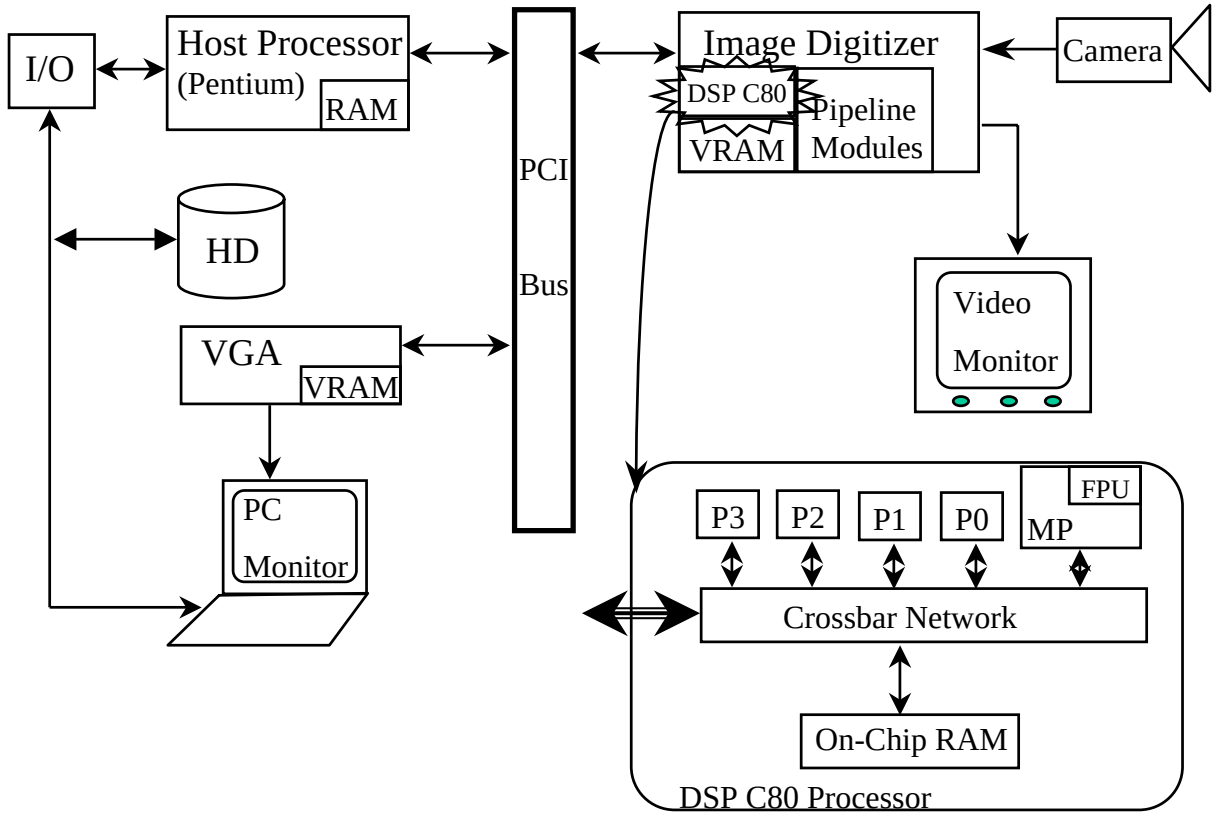


Components:

- Image digitizer;
- MP: Master Processor;
- FPU: Floating point unit;
- P0-3: Parallel processors;

Development Software:

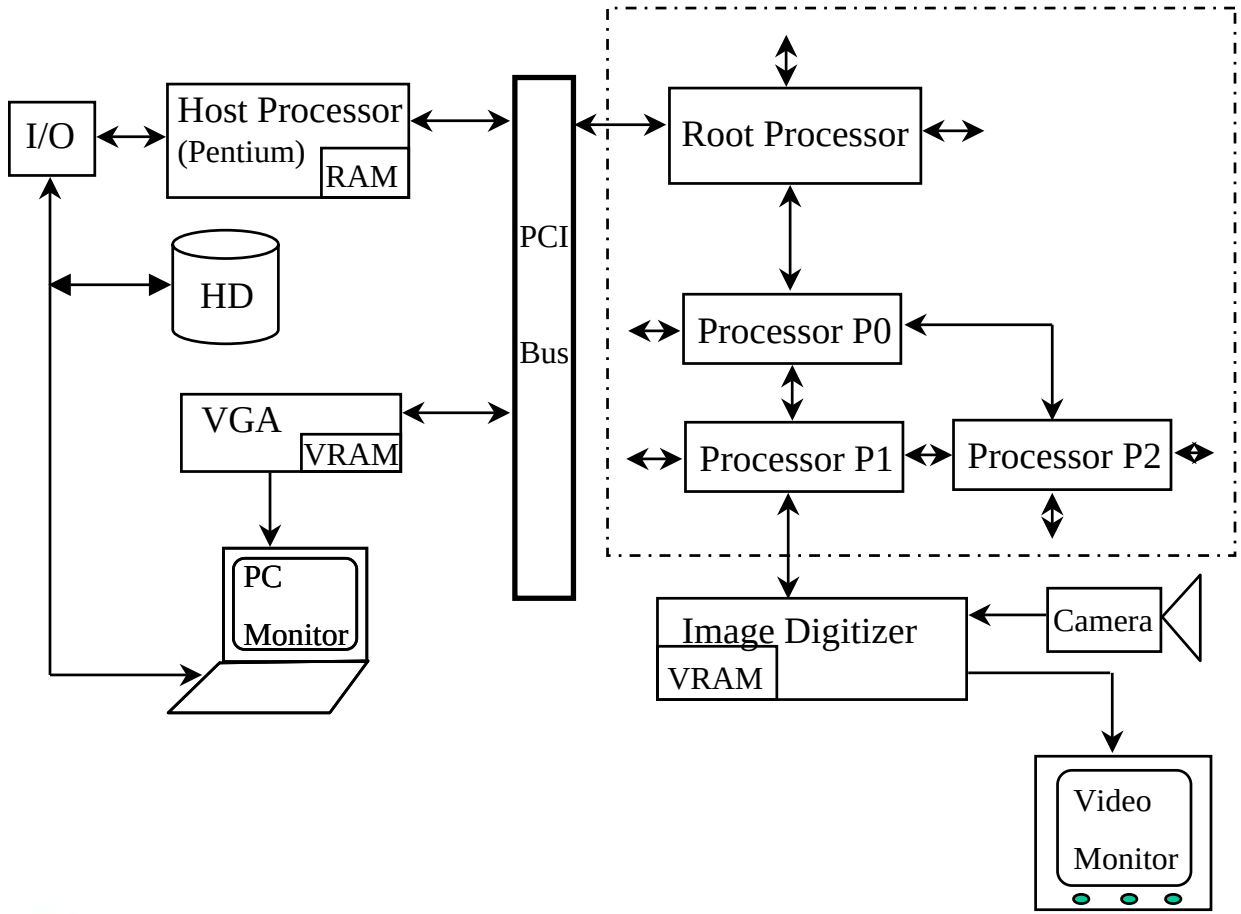
- Win95, Win NT or UNIX.
- TI (Texas Instrument) C programming language.
- image and graphics libraries.



4. MIMD Parallel System

(MIMD: Multiple Instructions and Multiple Data)

Configuration:

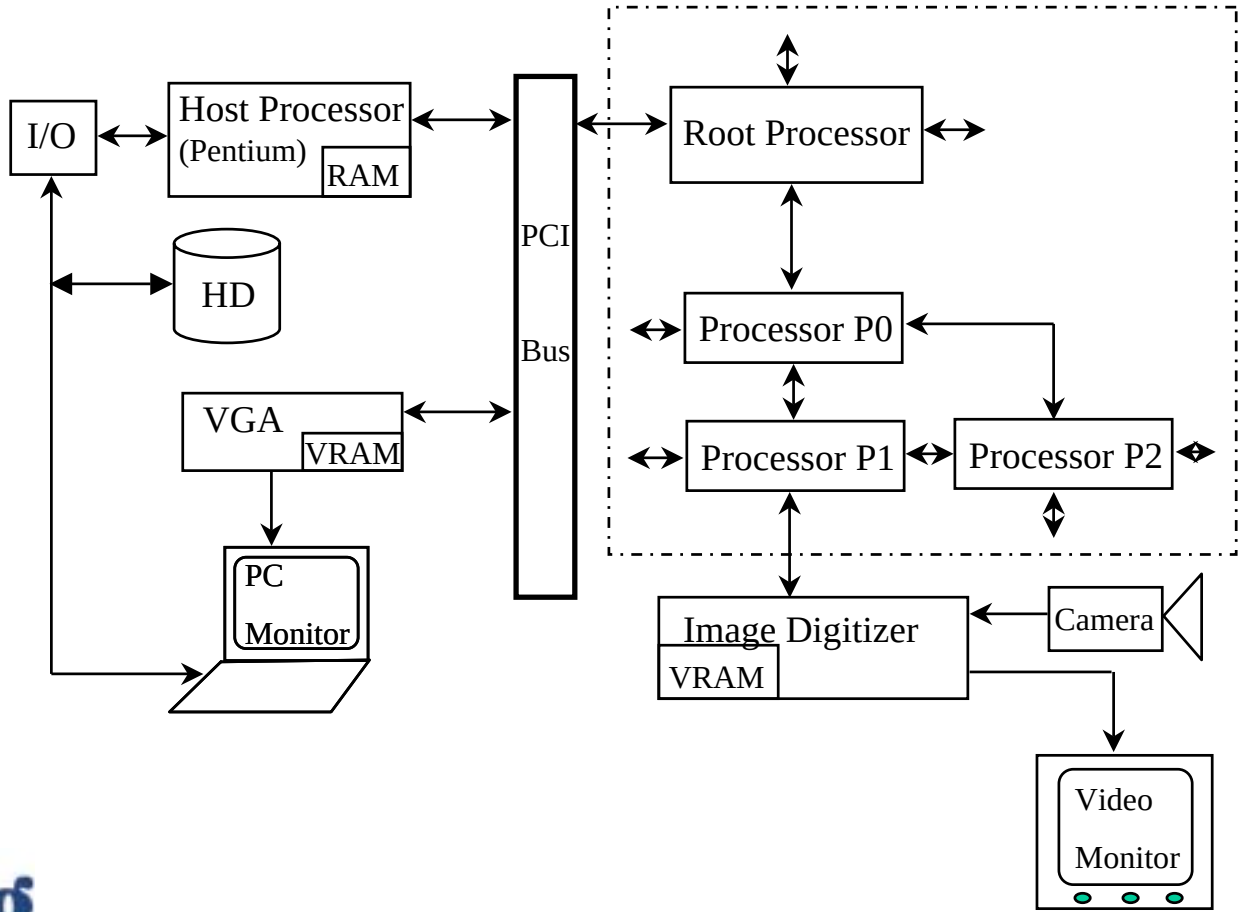


Components:

- Image digitizer;
- Parallel processors: Root, P0-2;
- Data links between parallel processors;

Development Software:

- Win95, Win NT or UNIX
- Parallel C
- Image and graphics libraries.



SUMMARY

1. The relationship between a 3D object coordinate and its 2D image coordinate is :

$$x = f \bullet \frac{X}{Z} \qquad y = f \bullet \frac{Y}{Z}$$

2. The relationship between the real coordinates of an image point and its index coordinates is:

$$u = u_0 + \frac{x}{D_x} \qquad v = v_0 + \frac{y}{D_y}$$

3. To process digital images, one has to use computing system.

4. There are four types of computing systems for machine vision:

- Host processor system
- Pipeline system
- DSP system
- MIMD parallel system