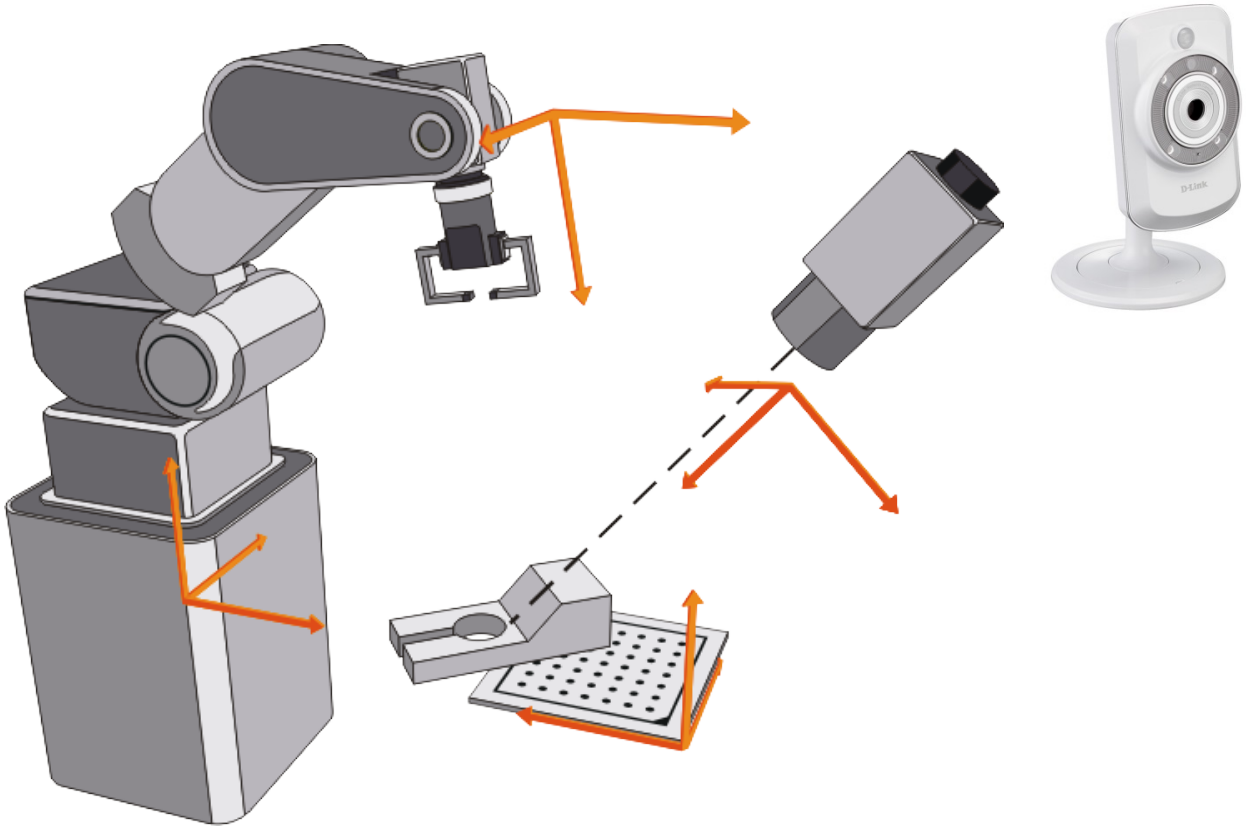
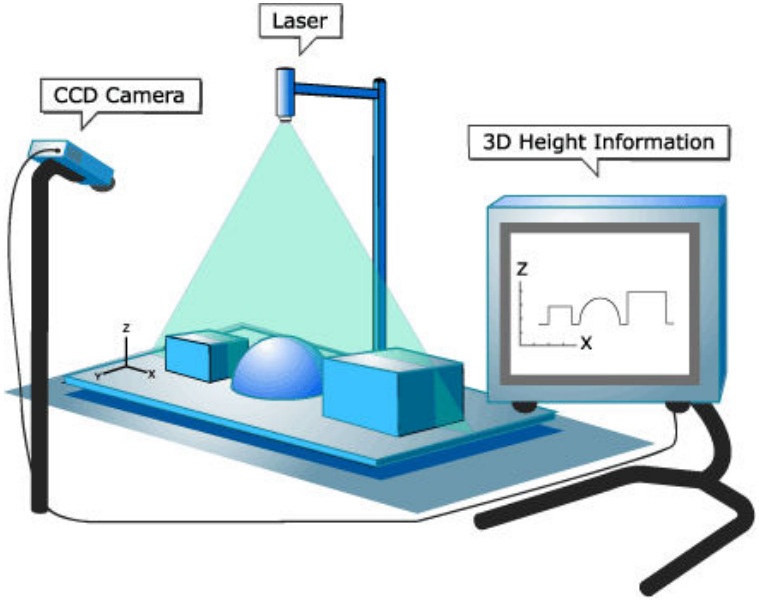
Robotic Vision




Laser
CCD Camera
3D Height Information
Z
X
z
x
y

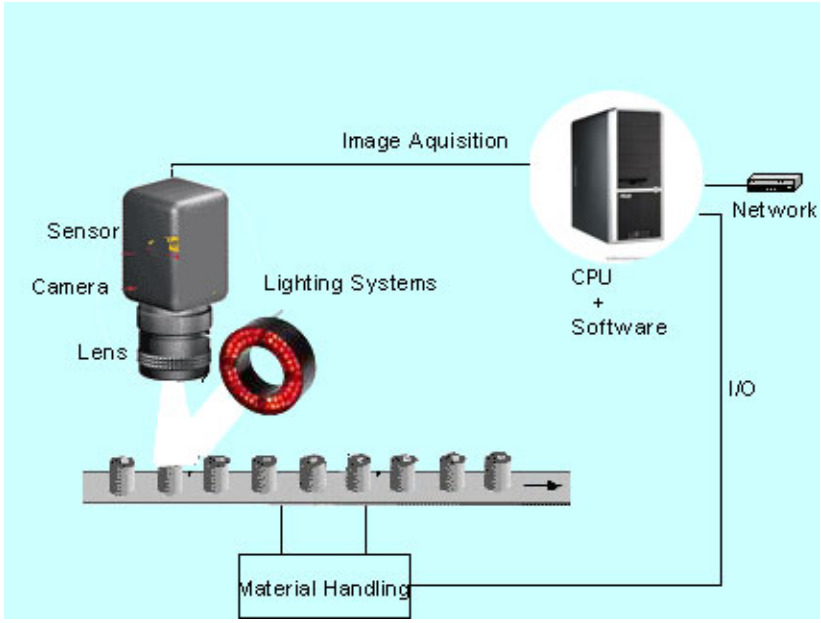
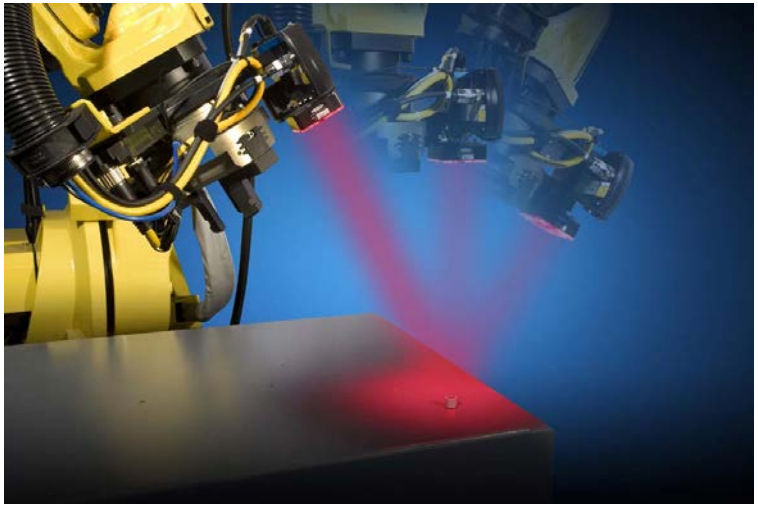
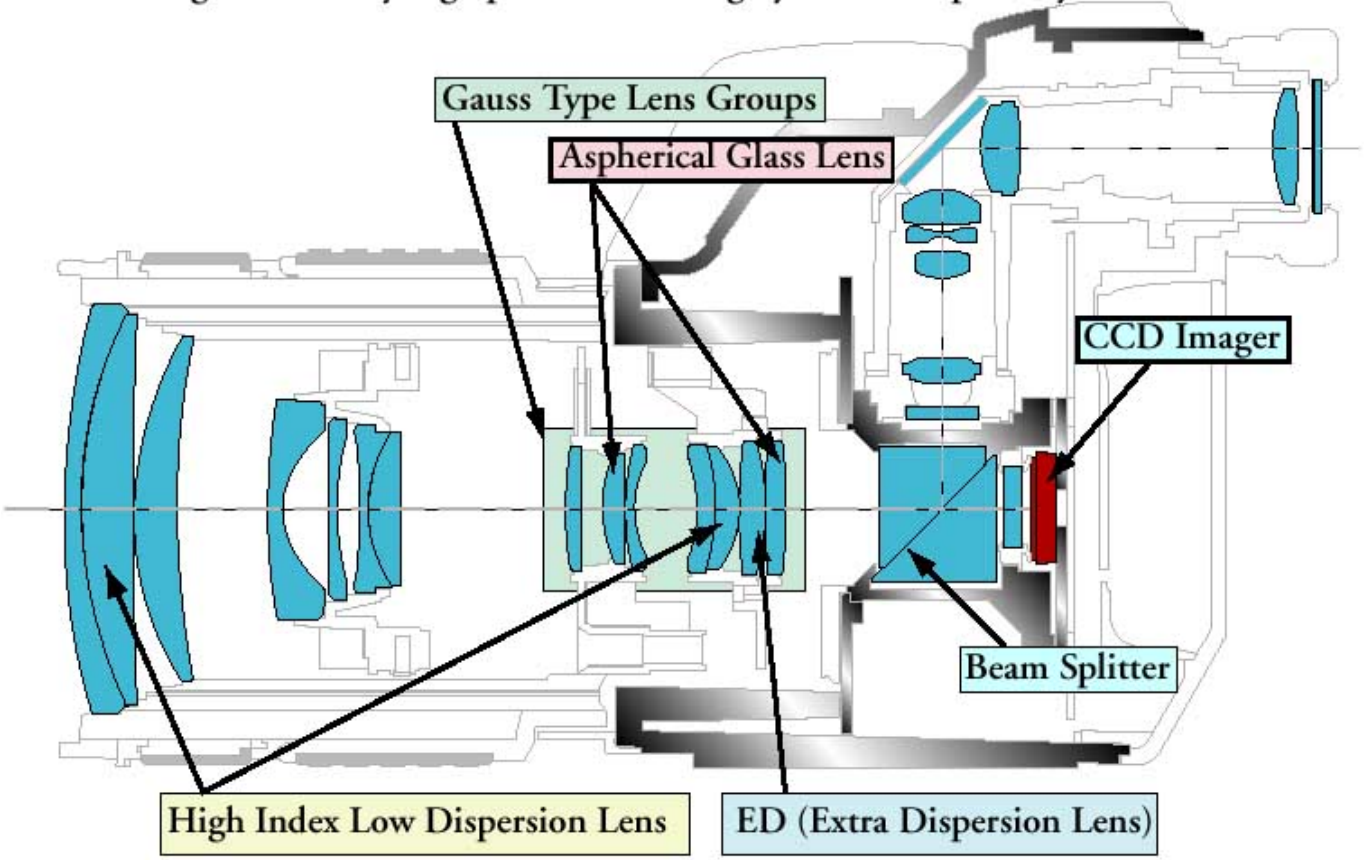


Image Aquisition
Network
Sensor
Camera
Lighting Systems
CPU
+
Software
Lens
I/O
Material Handling

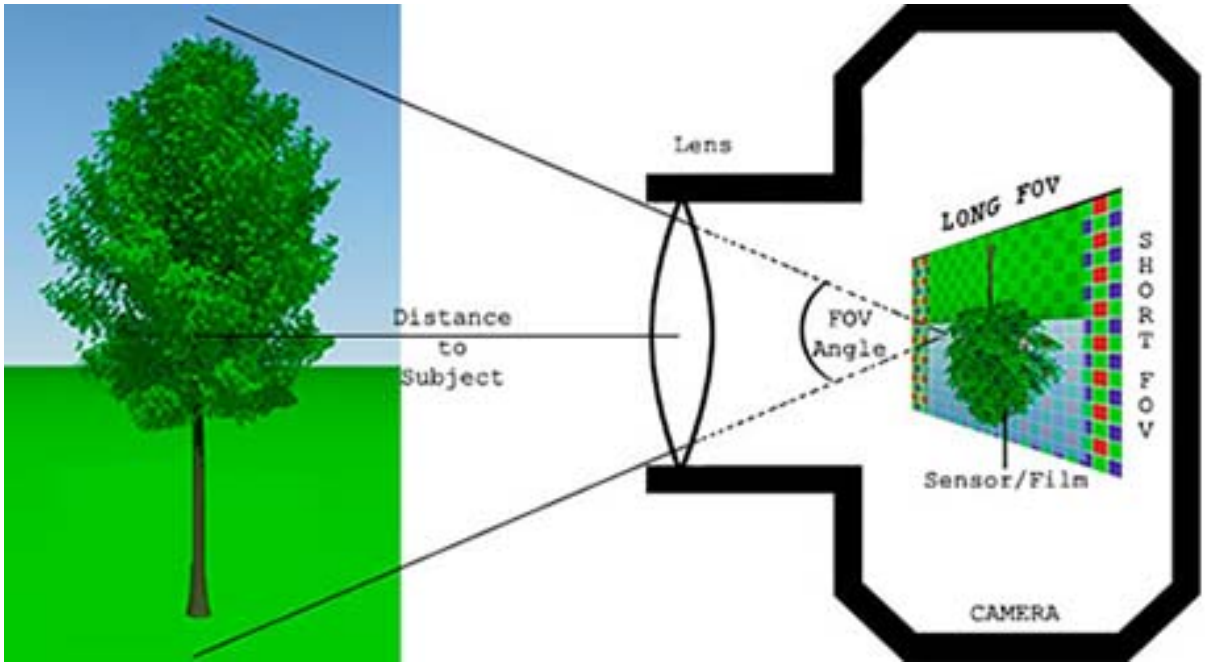


Imaging system

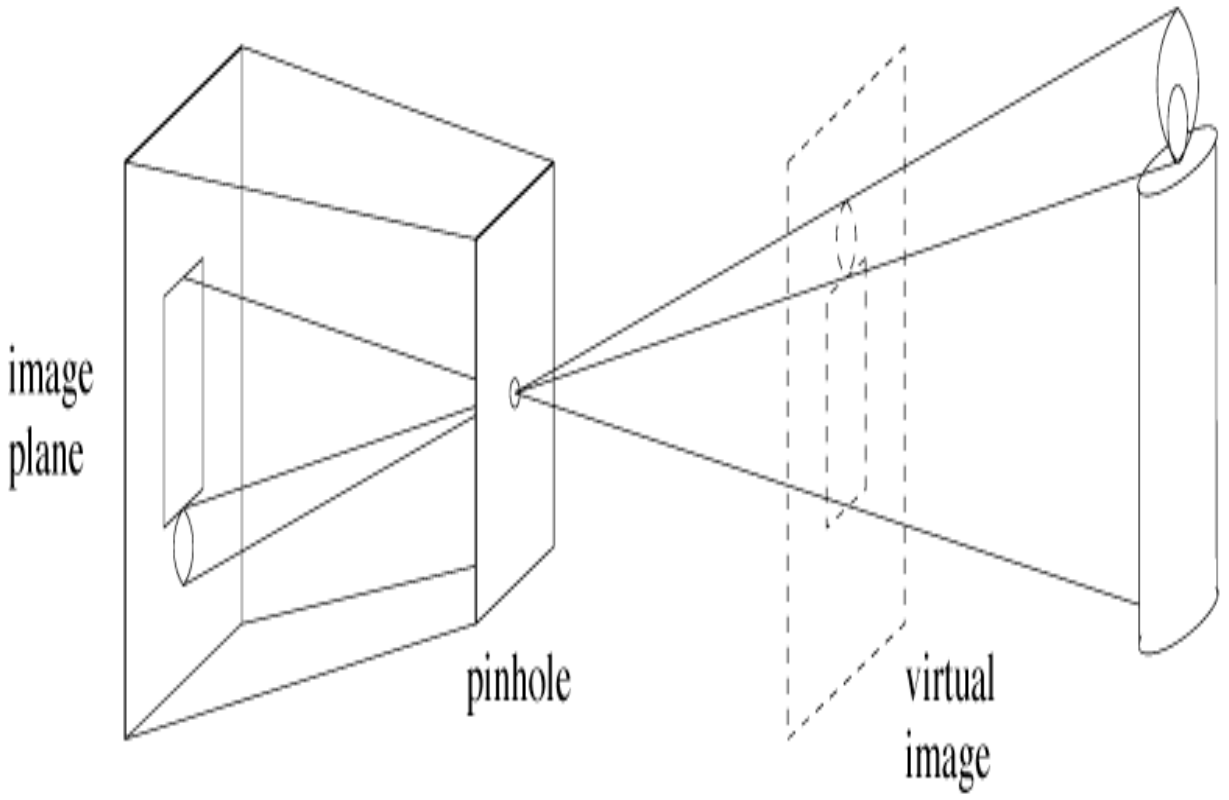
Exclusively developed 14 element, 11 group 4 X zoom for the E-10, designed as a very high precision and highly accurate optical system.



Simpler model..



Pinhole Camera Model



(Forsyth & Ponce, ”Computer Vision – A Modern Approach”, 2nd ed.)

Pinhole

Nautilus Pompilius

Perspective..

Perspective Transform

$$\mathbf{u} = f\,\frac{x}{z}$$

$$\mathbf{v} = f\,\frac{y}{z}$$

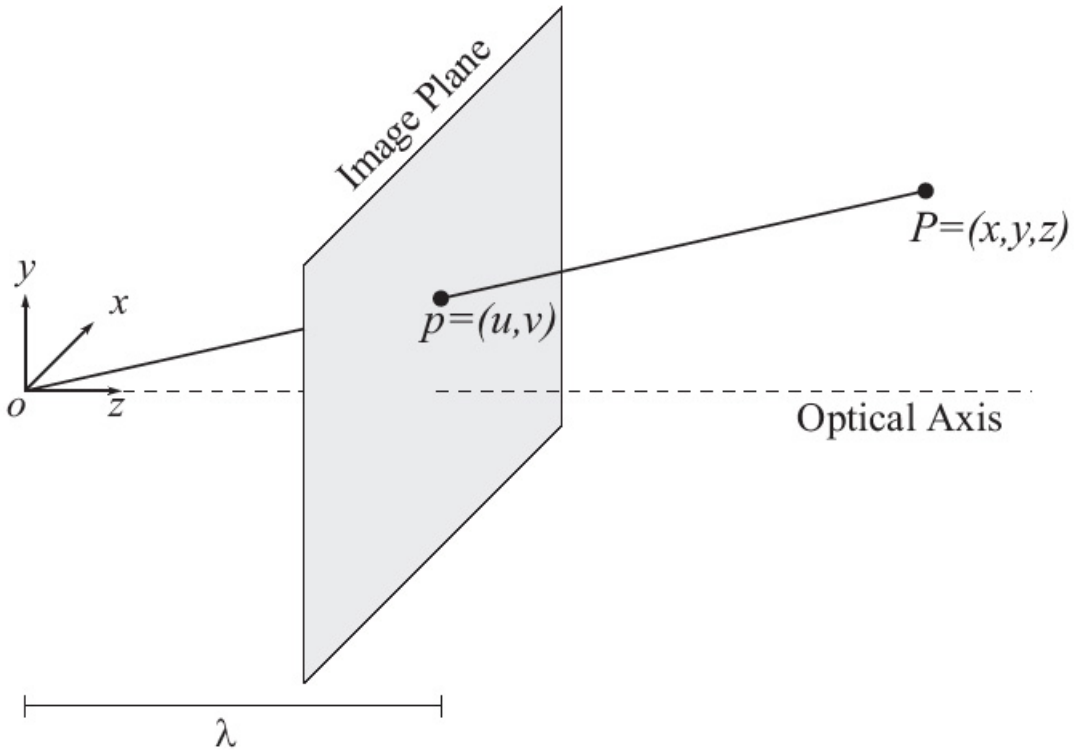
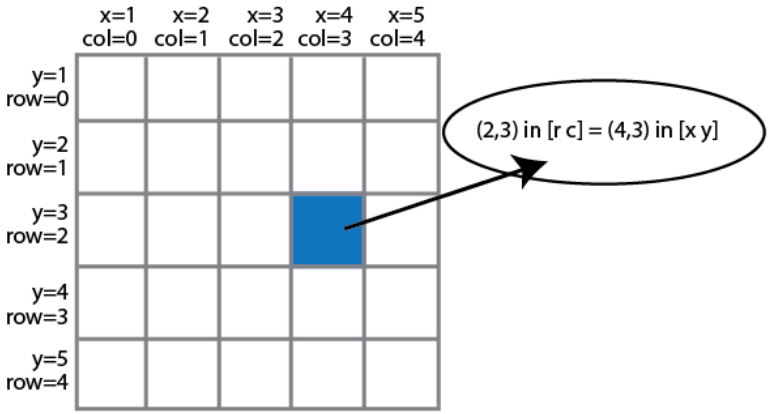


Figure 11.1: Camera coordinate frame.

Digital image coordinates

- $u=s_x (o_r - r)$
- $v=s_y (o_c - c)$



s is dimension of a pixel (horizontal/vertical directions)

[r c] are pixel coordinates

o is origo in image plane (principal optical axis)

Perspective transform

Δr = 100 pixels, k = 500, z = 50 m :

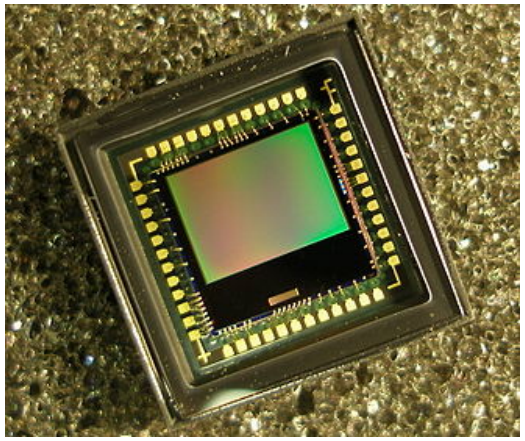
Δx = 10 m

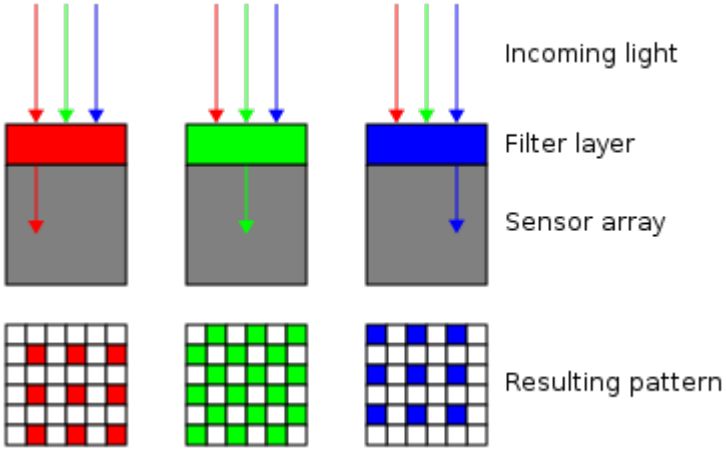
Δr = 100 pixels, k = 500, z = 1 m :

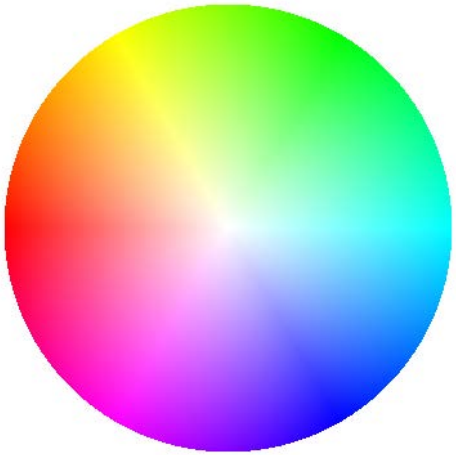
Δx = 0.2 m

$$\Delta \mathbf{r} = \frac{f}{s_x}\frac{\Delta x}{z} = \mathbf{k}\frac{\Delta x}{z}$$

Colors

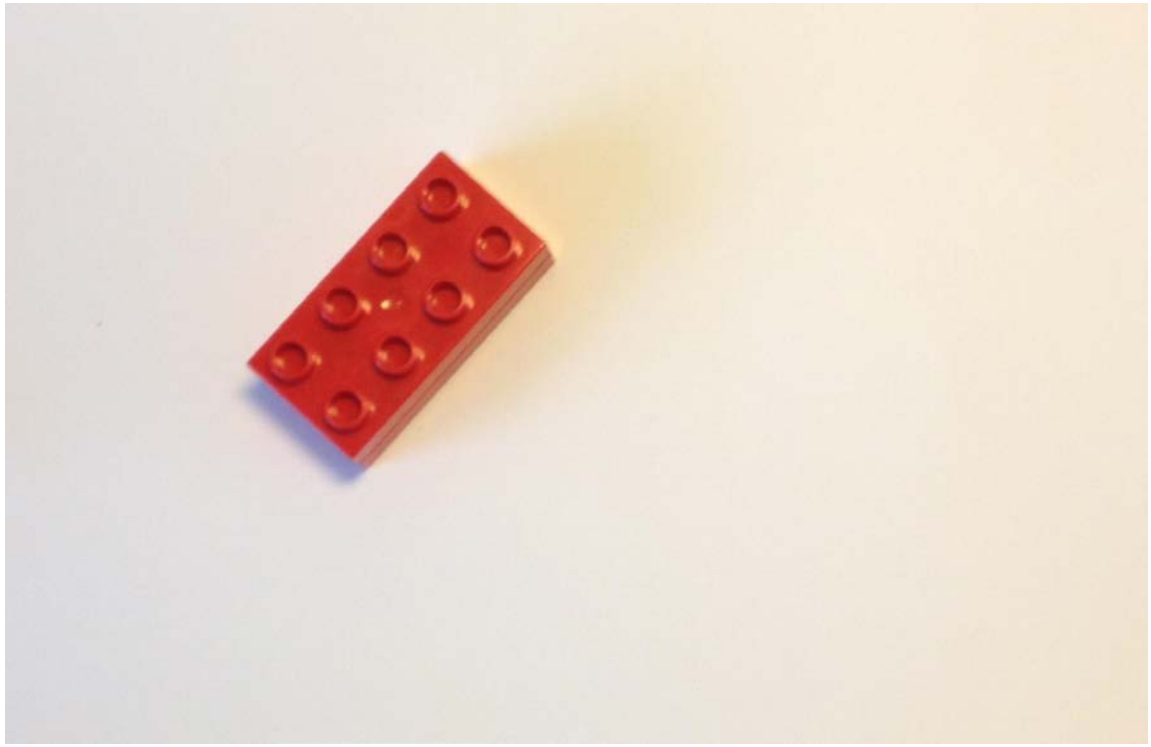



Incoming light
Filter layer
Sensor array
Resulting pattern



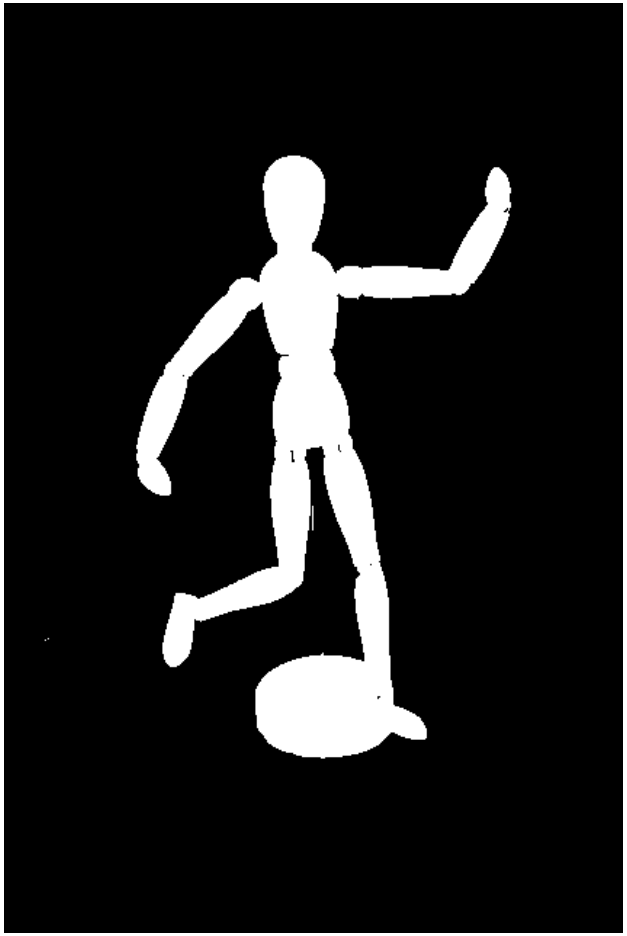
CASE: Object detection

Want to detect object, location and orientation/rotation

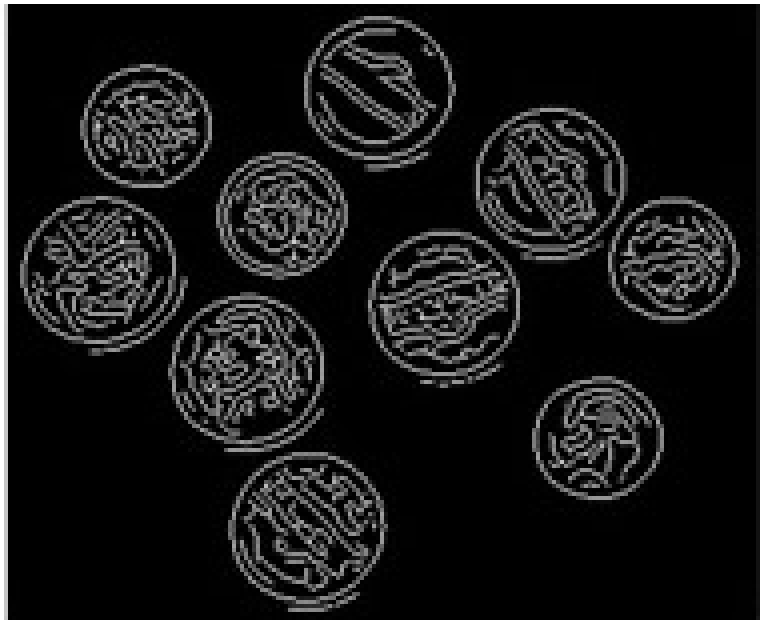


CASE: Object detection

Segmentation – find foreground/background objects



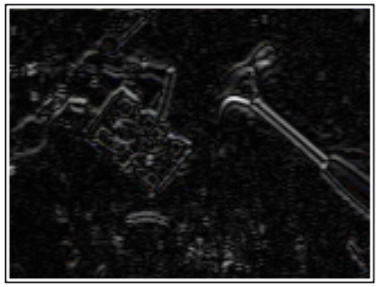
CASE: Object detection
Edge-based segmentation



CASE: Object detection
Aside - Edge detection

$$\begin{Bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{Bmatrix}$$

Horizontal Sobel

x  = 

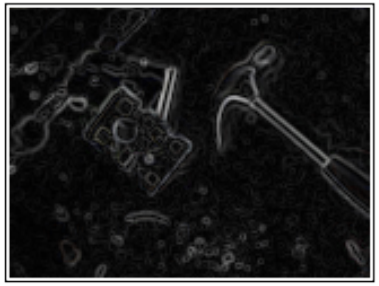
+

$$\begin{Bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{Bmatrix}$$

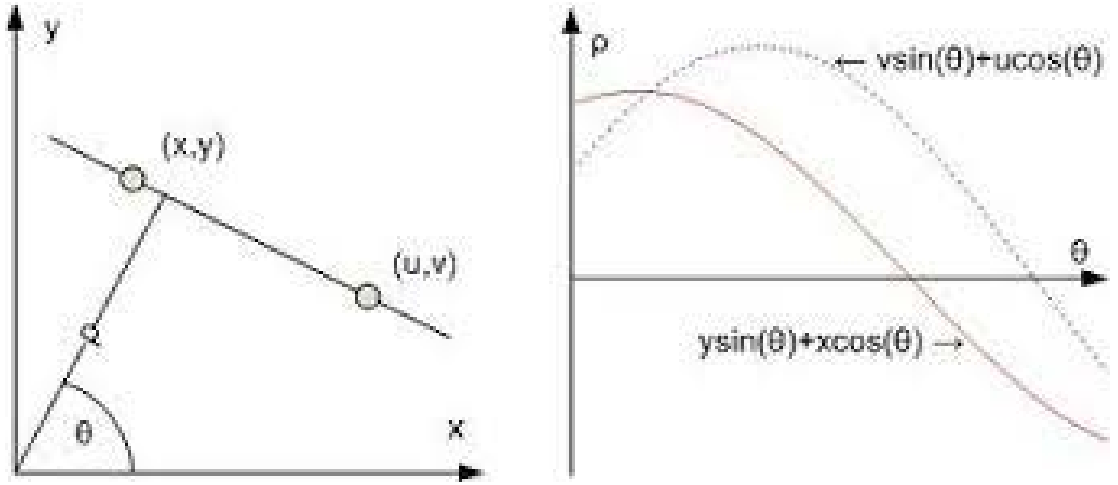
Vertical Sobel

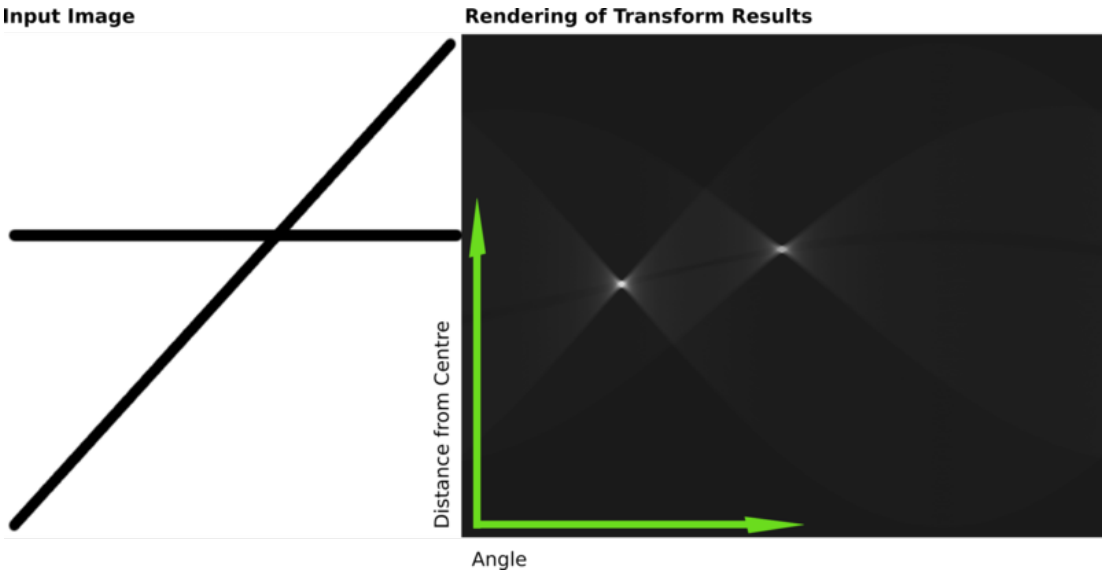
x  = 

↓

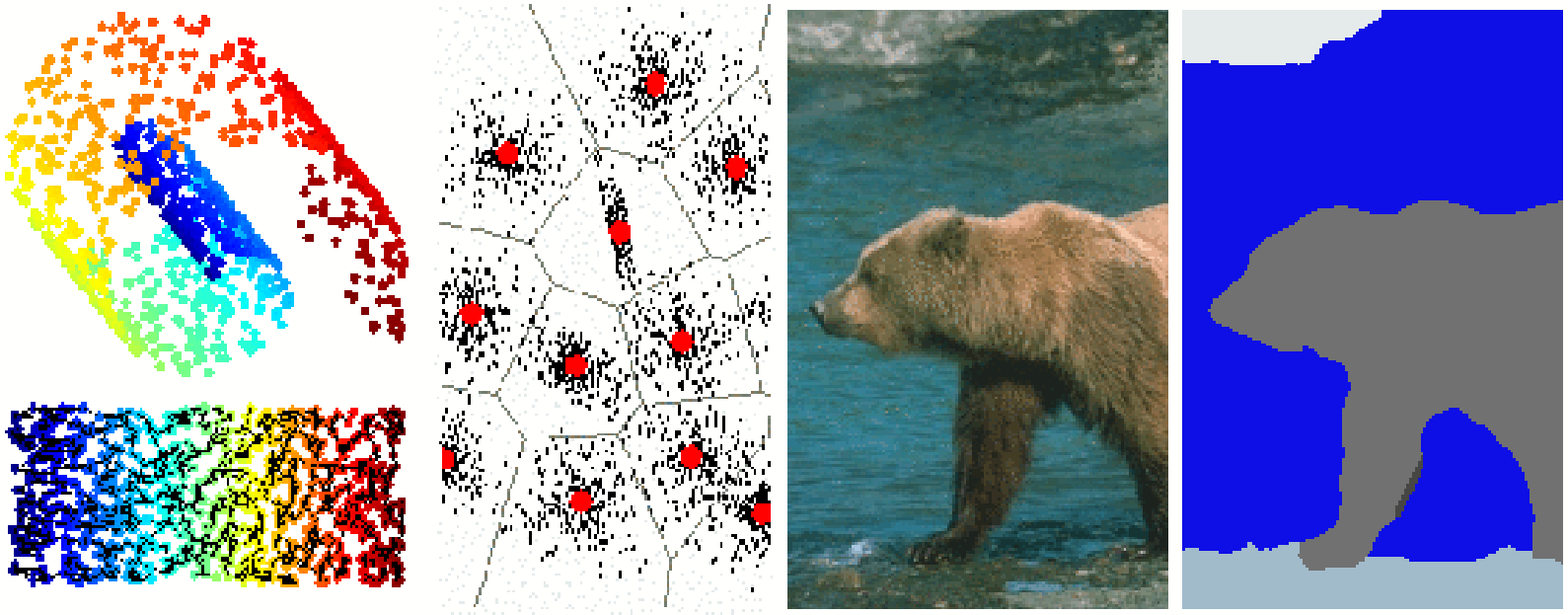


CASE: Object detection
Aside – Line fitting / Hough transform

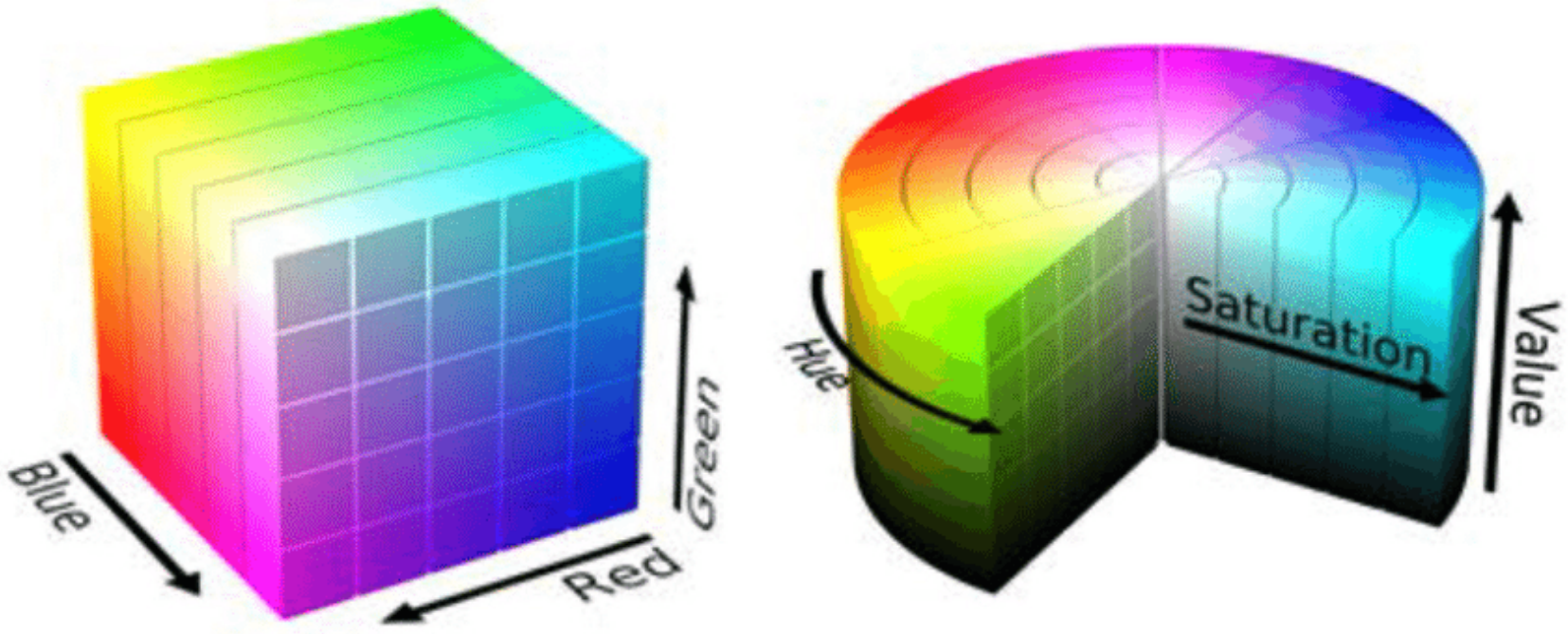




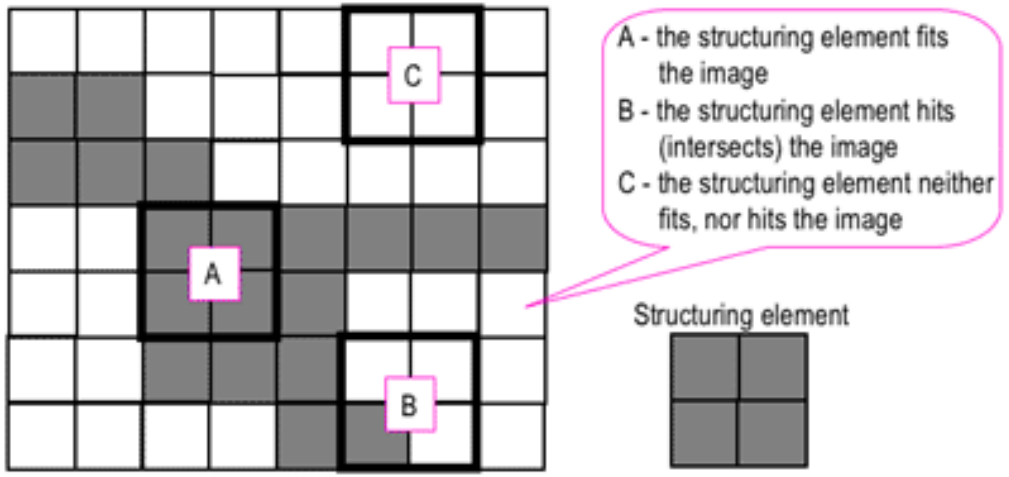
CASE: Object detection
Color-based segmentation



CASE: Object detection
Aside – color spaces



CASE: Object detection
Aside – morphological operations



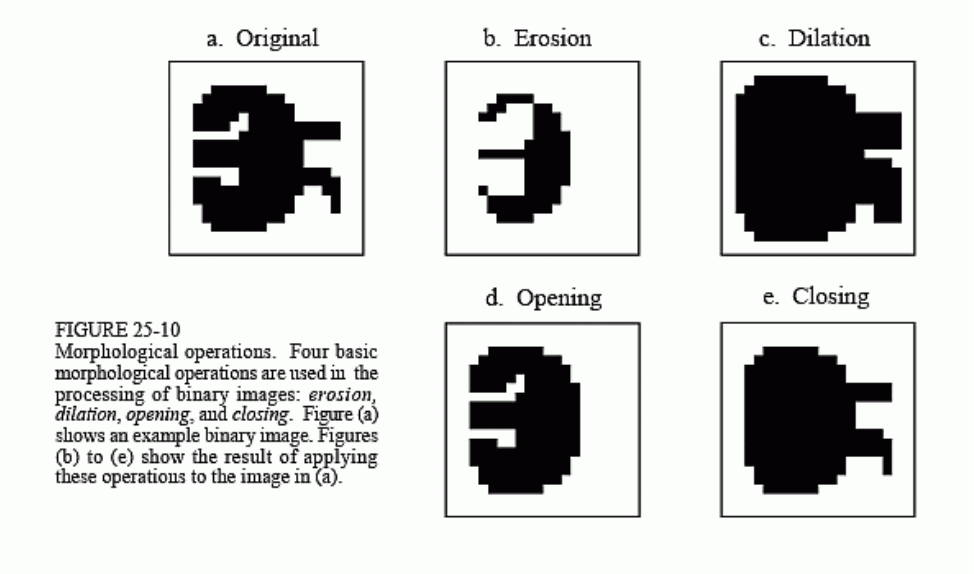


FIGURE 25-10
Morphological operations. Four basic morphological operations are used in the processing of binary images: *erosion*, *dilation*, *opening*, and *closing*. Figure (a) shows an example binary image. Figures (b) to (e) show the result of applying these operations to the image in (a).

CASE: Object detection
Region / blob properties

- Area, centroid, moments
- Contour extraction