Computer Vision

Can break down the process

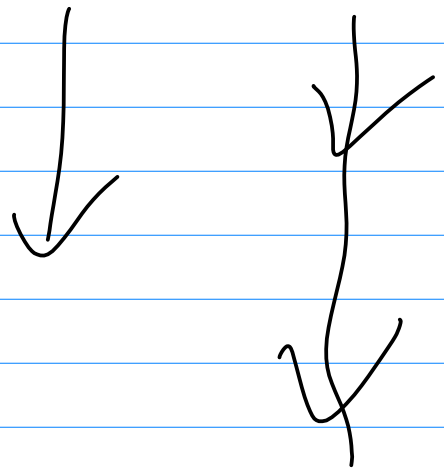
Sensing - getting the image
preprocessing - remove noise & enhance details
Segmentation - partition the image into areas of interest
description - compute "features" eg area, aspect ratio
recognition - Identify
interpretation - Assign a meaning to ensemble of objects

Subdivisions are not necessarily independent
Don't necessarily human vision
Provide a practical approach

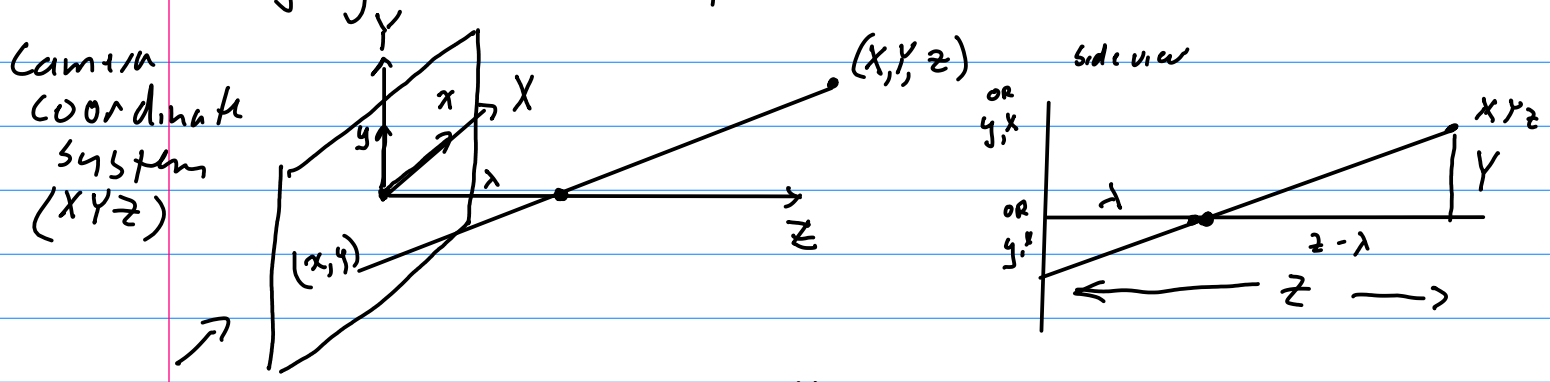
Sensing - digital camera

Resolution width & height in pixels
Intensity Gray levels

→



Imaging Geometry — pinhole camera model



$$\frac{X}{Z-\lambda} = \frac{-x}{\lambda} \qquad \frac{Y}{Z-\lambda} = \frac{-y}{\lambda}$$

$$x = \frac{\lambda X}{\lambda - Z} \qquad y = \frac{\lambda Y}{\lambda - Z}$$

$$\begin{bmatrix} wx \\ wy \\ wz \\ w \end{bmatrix} = \begin{bmatrix} \end{bmatrix} \begin{bmatrix} kX \\ kY \\ kZ \\ k \end{bmatrix}$$

$$\begin{bmatrix} kx \\ ky \\ kz \\ k \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & -\frac{1}{\lambda} & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

$kx = X$
$ky = Y$
$k = -\frac{1}{\lambda} Z + 1$
$k = \frac{\lambda - Z}{\lambda}$

image coordinates

projection matrix $\bar{P}$

real world coordinates

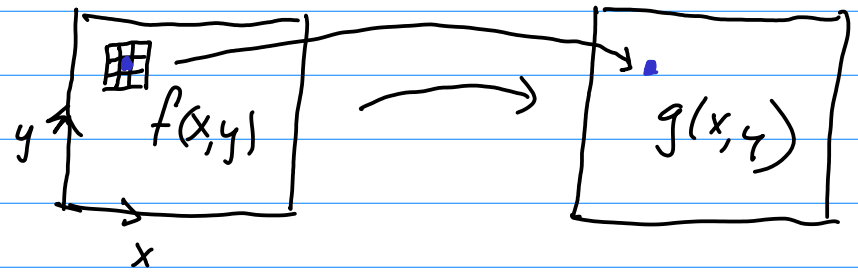
$$\begin{bmatrix} kx \\ ky \\ kz \\ k \end{bmatrix} = \bar{P} \; {}^{R}\bar{R}_{R} \; {}^{R}\bar{R}_{w} \; {}^{w}P \leftarrow \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$$

$= [\;][\;]$

${}^{R}R_{c}^{-1}$ ${}^{w}R_{R}^{-1}$

(Preprocessing)

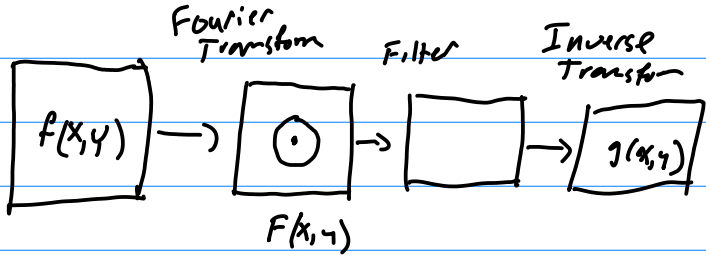
Blurring



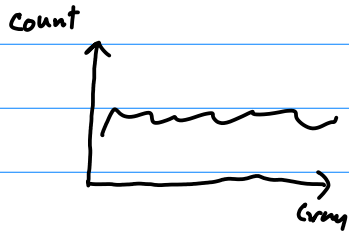
Spatial Domain

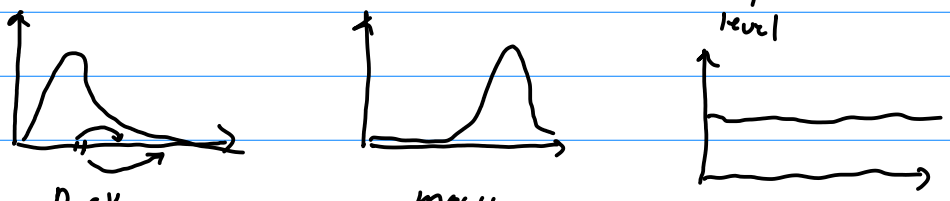
1) Neighborhood averaging

2) Frequency Domain

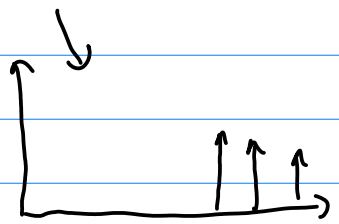


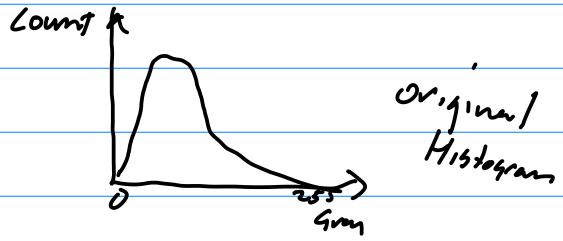
Histogram Equalization





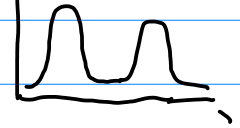
Result





Original Histogram

Another example

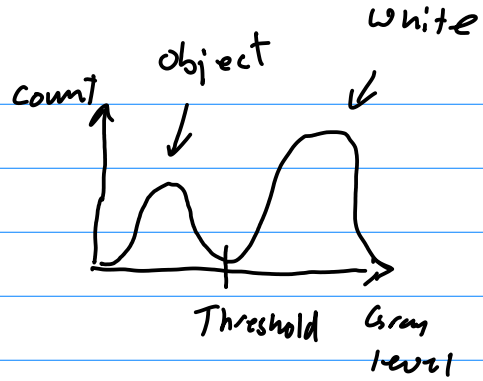


Integral Scaled

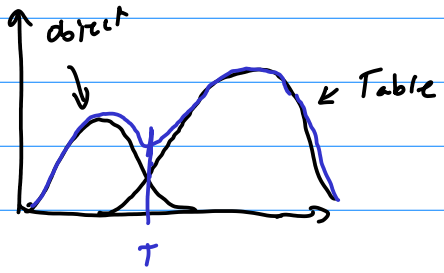
mapping

Segmentation

e.g. Thresholding



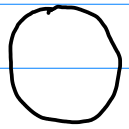
Histogram



Description:

e.g. Area
Perimeter
"Compactness" $\frac{\text{Perimeter}^2}{\text{Area}}$ ← Invariant to scale

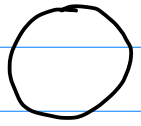
Want descriptors that are invariant to translation, rotation, & scale



$P = 2\pi r$
$A = \pi r^2$
$\frac{4\pi^2 r^2}{\pi r^2} = 4\pi$ smallest compactness

$P = 4$
$A = 1$
$\frac{P^2}{A} \frac{16}{1} = 16$

Aspect Ratio $= \frac{b}{a}$



Recognition