DIP EE4830 April 7, 2005

Lec # 10

Final Exam: May 12, 2005 Thursday
4:10 - 6:10 pm

Open Books/Notes.
Include All Material Covered.
Focus on Subjects after midterm.

Image Analysis Chap 10.

→ Edge Detection → Edge Map

provides info about lines, objects, shape.

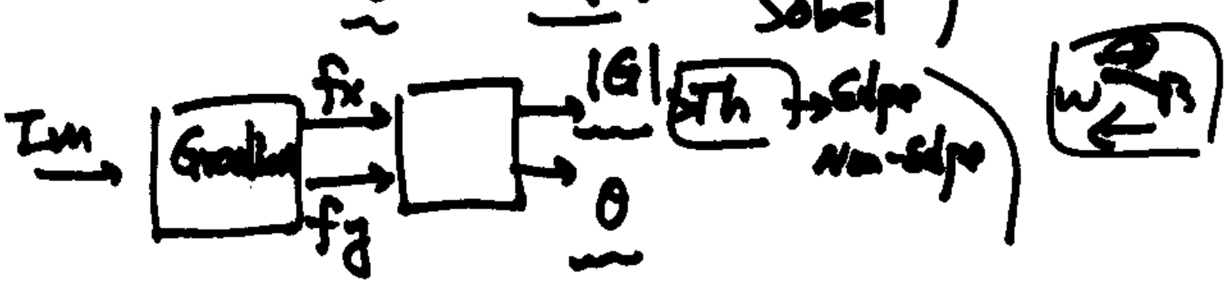
Basic features → Recognition, Interpretation

Binary Matrix

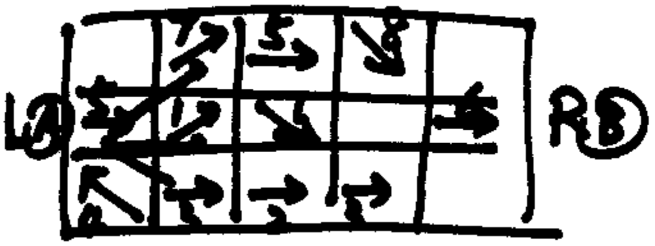
1 : Edge Pixel

0 : Non-Edge Pixel

Gradient : $\left(\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}\right)$ Canny, Sobel



point-by-point edge info
⇒ Link to find curve, contour



Criteria:

① Consistency of Gradient Direction

② Maximize the overall gradient magnitude.

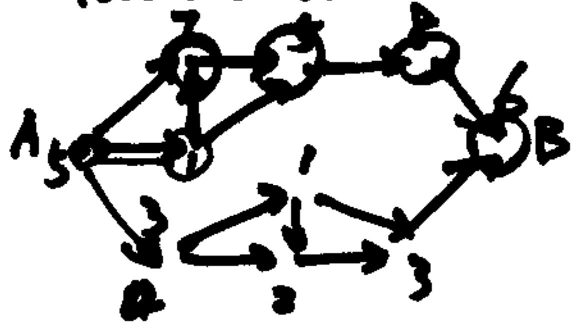
Find the most likely path from Ⓐ

4-Connectivity
8- 〃

Next-step Candidates:
within θ, $\theta \pm 45°$

$$|\theta_i - \theta_{i+1}| \le 45°$$

Possible Paths:



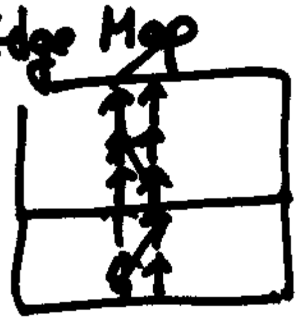
Graph

$$\sum_{i \in path} |g_i| = G_{total}(path)$$

Dynamic Programming.

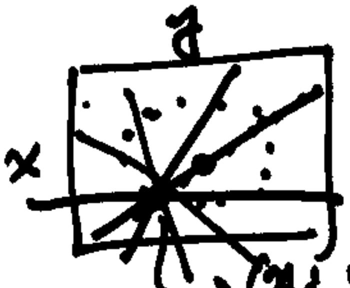
profile

thinning Edge Map



Hough Transform [1962]

Detect basic geometric shapes:
lines, circles, ellips, rectangles.

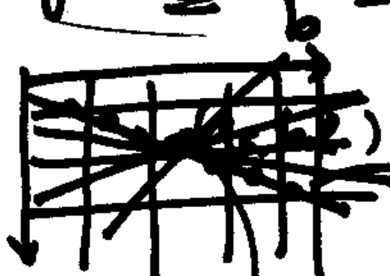


(x_i, y_i)

x-y plane → $\boxed{\text{parameter space}}$ of the shape

[Image space]

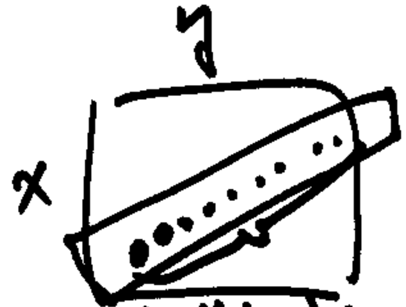
$y_i = \underline{a} x_i + \underline{b}$



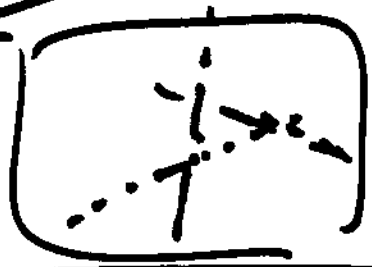
$b = -x_i a + y_i$

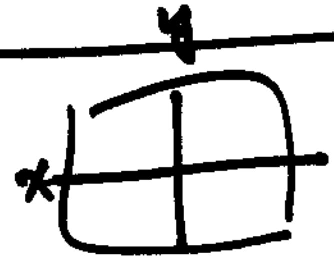
bin

(a_k, b_k)



(x_i, y_i)



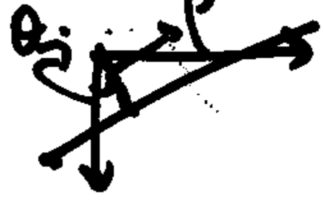


$y = b$ $x + b = 0$

$y = ax + b$

$a = \infty$

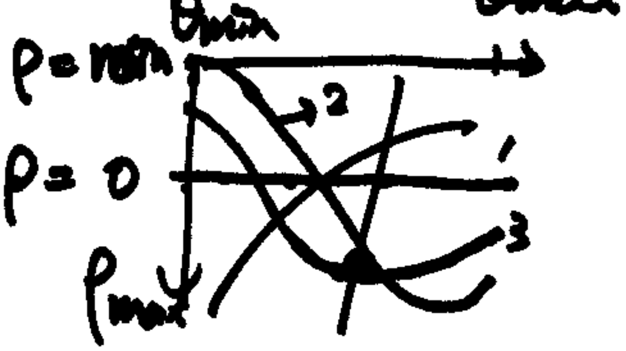
Polar Representation

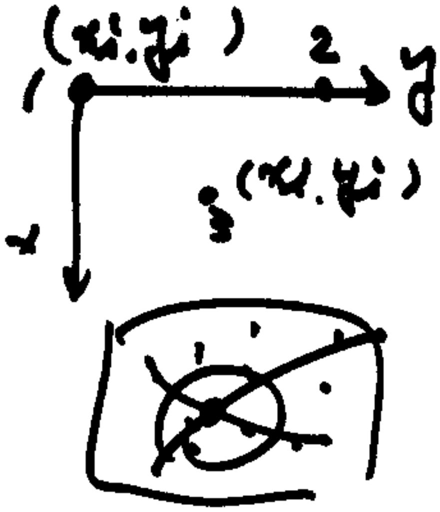


$\boxed{x\cos\theta + y\sin\theta = \rho}$: Shape

para. space (ρ, θ)

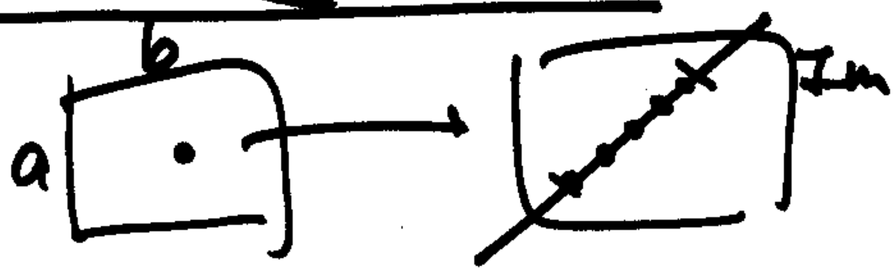
$$\rho = x\cdot\cos\theta + y\sin\theta$$





(x_i, y_i), $(a_1, a_2 \ldots a_k)$: para. vector
$= \vec{a}$

Shape Definition :
$g(x, y, \vec{a}) = 0$ Hough Transform.
Circle. Rectangle.



Represent Boundary

Set of Edge Points

$\Rightarrow$ <u>A Connected Contour</u>

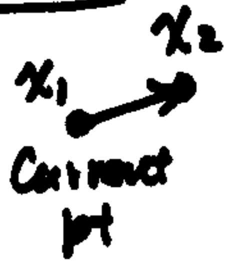
or Analytic Form

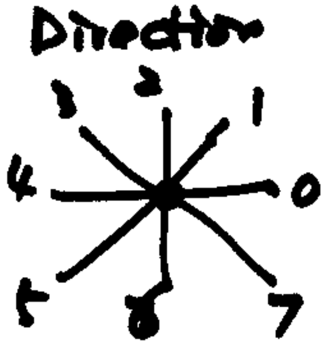
$A \to B \to C \cdots\cdots$

$x_1, y_1 \quad x_2, y_2 \quad \cdots\cdots$

$(x_1, y_1),\ 0,\ 1,\ 1,\ 3,\ 0,\ 2 \ \cdots$

<u>chain code</u>





Good for Compression

Bad for Matching

Fourier Descriptor :

$A \to B \to C \cdots$

$x_1 \quad x_2 \quad x_3$

$y_1 \quad y_2 \quad y_3$

u_1

$u_1 = x_1 + j y_1$

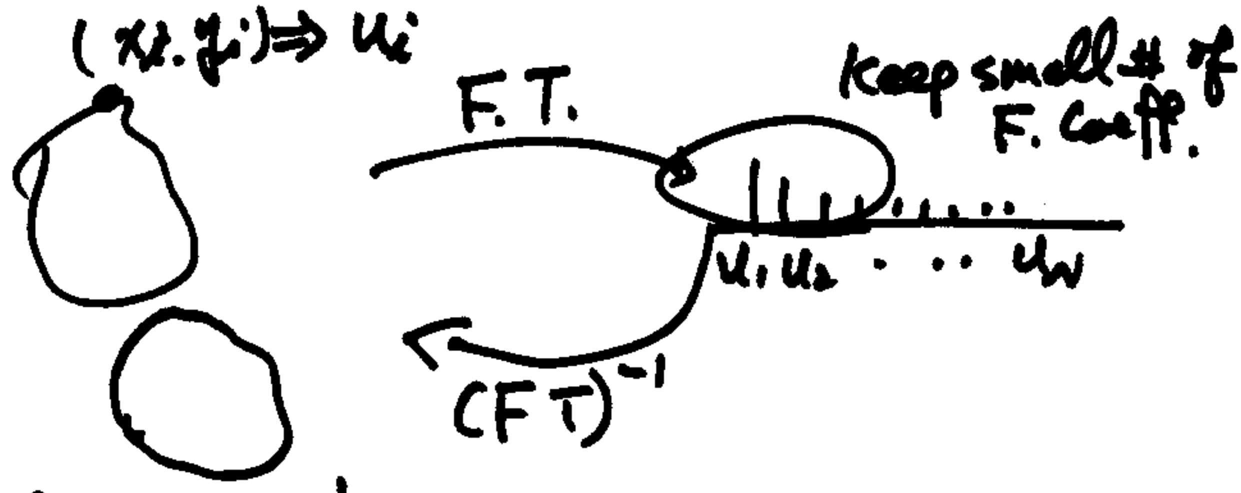
$\Rightarrow$ A sequence

$u_1, u_2 \cdots\cdots u_N$

$\Downarrow$ F.T.

$a_1, a_2 \cdots a_k \cdots a_N$

$$a(k) = \sum_{i=1}^{N} u(i) \exp(-j 2\pi k i / N)$$



Reconstructed Shape.

* Compression by removing high-freq. coeff.

<u>Matching</u> * Shape 1 $u_1 \cdots u_N$ shape 2 $v_1 \cdots v_N$

$$L_2(S_1, S_2) = \sum_{i=1}^{N} (u_i - v_i)^2$$

$$\simeq \sum_{i=1}^{N/k} (u_i - v_i)^2$$

<u>Invariance</u>:

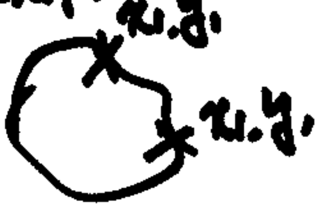
shift
scale
rotation
reflection

FT. $a(k) = \sum_{i=1}^{N} \underbrace{u(i)}_{\text{input. shape}} \exp(-j\,2\pi k i/N)$

$\downarrow$

F.D.

	shape $u(n)$	F.D $a(k)$
shift shape u_0	$u(n) + \underline{u_0}$	$\underline{a(0) + u_0}$ $a(k)$ unchanged $k \neq 0$ $a(k) + u_0 \delta(k)$
Scaling	$\alpha \cdot u(n)$	$\underline{\alpha\, a(k)}$
Rotation	$u(n) \cdot \underline{e^{j\theta}}$ $= (x + jy)(\cos\theta + j\sin\theta)$	$\underline{a(k) \cdot e^{j\theta}}$
starting pt. shift	$u(n - n_0)$	$\underline{a(k) \cdot e^{-j2\pi n_0 k/N}}$ linear phase.



Q: How to design a F.D. feature that's scale invariant? F.D ✗

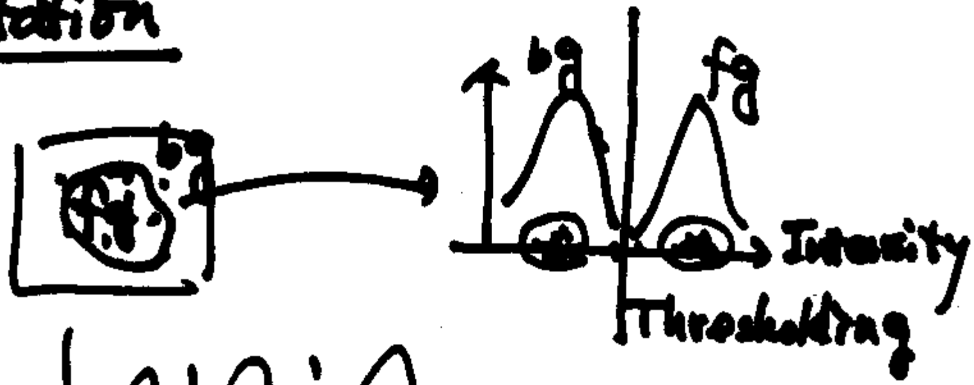
shift

rotation

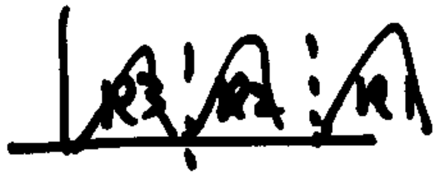
$\boxed{\dfrac{a(k)}{a(0)}}$ ✓

Region Segmentation

Histogram

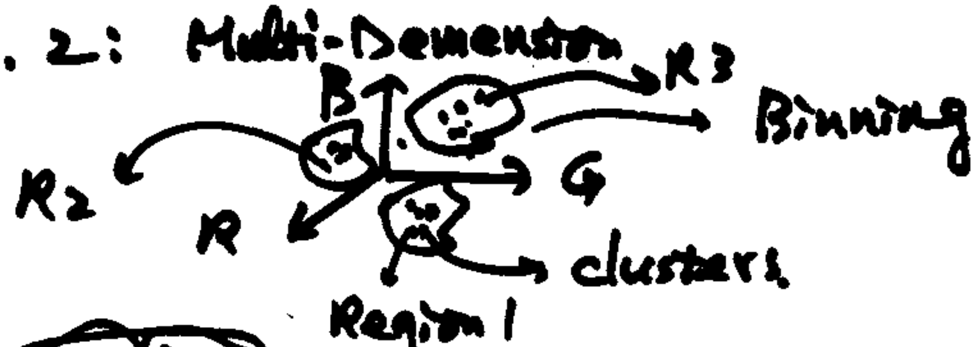


Extension 1 :



Multiple Th.

Ext. 2 : Multi-Demension



Color homogeneous Region.

Ext. 3 : Spatial Grouping.
(Split & Merge)

whether to merge R_1 & R_2 ?

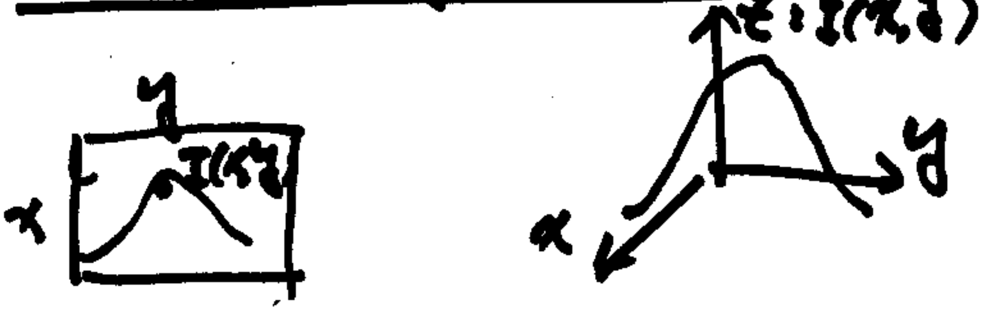
① Similarity(R_1, R_2)

② Edge in between

$$\frac{\#\text{Edge Pts}}{\#\text{Neighbor. Pts}}$$

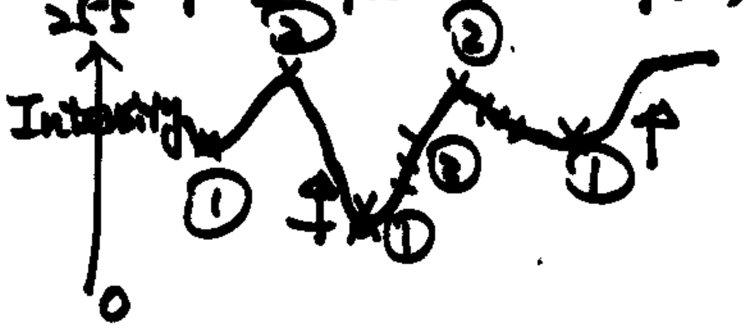
Ext 4 :

Watershed Segmentation ('79, '93, '99)



2D function in 3D space

1-D function $f(x)$



① : local minimum

② : ridge : watershed lines

③ : "catchman basin" "watershed"

"Flood"

① raise the flood level in each local min. region

② Water levels merge

- Build "Dams" to separate the waters

Locations of dam ⇒ points of boundary continuous.

1-D function