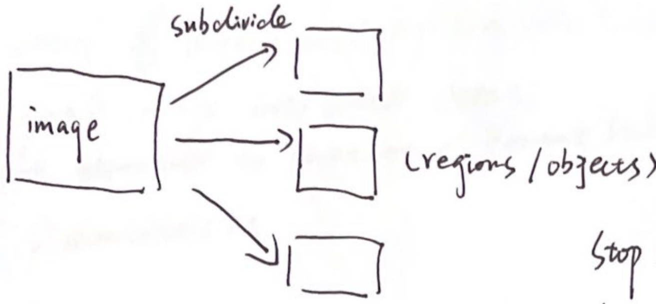
EE7403 LEC 6 Segmentation and Edge Detection

1. Intro.

Segmentation :



Stop when interested objects isolated.

Tranditional segmentation basedo on similarity or discontinuity.
(Thresholdiy) abrupt changes (Points, Line, Edge)

2. Segmentation by Thresholding

objects of interest uniform brightness placed agains a bg of different brightness.

e.g: handwritting, textwriting, finger prints, airplanes on a runaway

thresholded image $g(x,y)$: $g(x,y) = \begin{cases} 1 & \text{if } f(x,y) > T \\ 0 & \text{if } f(x,y) \leq T \end{cases}$

T is the threshold given by $T = T[x, y, p(x,y), f(x,y)]$

Global threshold : whole image

Local threshold : both $f(x,y)$ and its local neighbor property $p(x,y)$

Adaptive threshold : x, y coordinats

① global threshold (Heuristic Approach) If the gray value of object & bg are separated.

a. Select an initial estimate for T

b. Segment the image using T. This will produce 2 groups of pixels: G_1 consisting of all pixels with gray level values > T and G_2 consisting of all pixels with gray value ≤ T.

c. compute the average gray values μ_1 and μ_2 for the pixels in regions G_1 and G_2

d. compute a new threshold value $T = 0.5(\mu_1 + \mu_2)$

e. repeat steps 2 through 4 until the difference in T in successive iterations is smaller than a predefined parameter T_0

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② Adaptive local thresholding

If the gray value of object and bg are overlapped.

a. Subdivide original image into small areas.

b. utilize different threshold to segment different sub-image.

3. Detection of Discontinuities.

types { Point, Line, Edge } run a mask

① Point Detection

-1	-1	-1
-1	8	-1
-1	-1	-1

$R = \sum_{i=1}^{9} w_i z_i$

A point is detected at the location on which the mask is centered if $|R| \geq T$

② Line Detection

-1	-1	-1
2	2	2
-1	-1	-1

Horizontal

-1	-1	2
-1	2	-1
2	-1	-1

+45°

-1	2	-1
-1	2	-1
-1	2	-1

Vertical

2	-1	-1
-1	2	-1
-1	-1	2

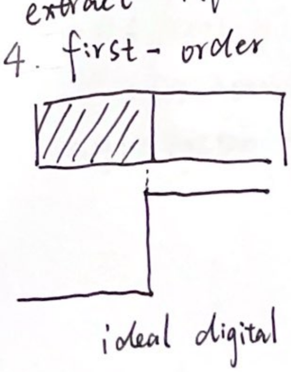
-45°

maximum result: when a line passed through the middle row of the mask with a constant bg.

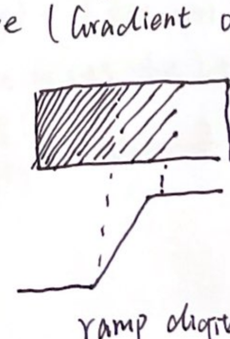
③ Edge Detection

extract information: Contour of objects. abrupt changes in brightness

4. first-order derivative (Gradient operator),



ideal digital edge



ramp digital edge.

first derivative

Second derivative

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Fairly little noise can have a significant impact on the two key deri.

2-dimensional first-order derivative must be greater than a threshold.

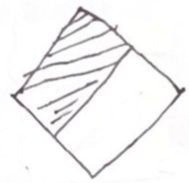
$$\nabla f(x,y) = \begin{bmatrix} G_x(x,y) \\ G_y(x,y) \end{bmatrix} = \begin{bmatrix} \frac{\partial f(x,y)}{\partial x} \\ \frac{\partial f(x,y)}{\partial y} \end{bmatrix}$$

$G_x(x,y)$ large

$G_y(x,y) = 0$

$G_x(x,y) = 0$

$G_y(x,y)$ large



$\left.\begin{matrix} G_x(x,y) \\ G_y(x,y) \end{matrix}\right\}$ non-zero.

the strength of the differentials is proportional to the degree of discontinuity.

=> enhances edges and other discontinuity (noise).

deemphasizes area with slowly varying grey-level values.

magnitude:

$$|\nabla f(x,y)| = [G_x^2(x,y) + G_y^2(x,y)]^{\frac{1}{2}}$$

direction:

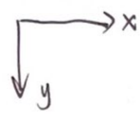
$$\varphi(x,y) = \tan^{-1}\left(\frac{G_y(x,y)}{G_x(x,y)}\right)$$

the directions of gradient $\perp$ direction of edge. the rate of change of f at (x,y) is mini.

Simple approximation of x- and y-differentials for

$$G_x(x,y) = f(x+1, y) - f(x-1, y). \quad \begin{bmatrix} 0 & 0 & 0 \\ +1 & 0 & -1 \\ 0 & 0 & 0 \end{bmatrix}$$

$$G_y(x,y) = f(x, y+1) - f(x, y-1) \quad \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & -1 & 0 \end{bmatrix}$$



$\Sigma h(i) f(x-i)$

very sensitive to noise. => smoothing prior to differentiation.

$$\nabla[h(x,y) * f(x,y)] = [\nabla h(x,y)] * f(x,y)$$

discrete image + smoothing filter => biased gradient direction

$$\hat{h}(x,y) = f(x+1, y) - f(x-1, y) + j(f(x, y+1) - f(x, y-1))$$

$$= \cos(a(x+1) + by) - \cos(a(x-1) + by) + j[\cos(ax + b(y+1)) - \cos(ax + b(y-1))]$$

$$\varphi(x,y) = \arctan\frac{Im\{\hat{\nabla} f(x,y)\}}{Re\{\hat{\nabla} f(x,y)\}} \neq \arctan\frac{b}{a}$$

5. Second-order derivative (Laplacian operator)

$$\nabla^2 f = \frac{\partial^2 f(x,y)}{\partial x^2} + \frac{\partial^2 f(x,y)}{\partial y^2}$$

$$\frac{\partial^2 f}{\partial x^2} = f(x+1, y) + f(x-1, y) - 2f(x,y)$$

$$\frac{\partial^2 f}{\partial y^2} = f(x, y+1) + f(x, y-1) - 2f(x,y)$$

$$\nabla^2 f = f(x+1, y) + f(x-1, y) + f(x, y+1) + f(x, y-1) - 4f(x,y)$$

4-neighbor Laplacian. 8-neighbor Laplacian

$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix} \quad h_L(x,y) \quad \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

$$\nabla^2 f(x,y) = h_L(x,y) * f(x,y)$$

Sensitive to noise ⇒ smoothing prior to.

Employed Gaussian-shaped smoothing. $h(x,y) = e^{-\frac{x^2+y^2}{2\sigma^2}} = e^{-\frac{r^2}{2\sigma^2}}$

linearity $\nabla^2 (h * f) = (\nabla^2 h) * f$

$$\Rightarrow \boxed{\nabla^2 h = -\left[\frac{r^2 - \sigma^2}{\sigma^4}\right] e^{-\frac{r^2}{2\sigma^2}}} \Rightarrow \begin{bmatrix} 0 & 0 & -1 & 0 & 0 \\ 0 & -1 & -2 & -1 & 0 \\ -1 & -2 & 16 & -2 & -1 \\ 0 & -1 & -2 & -1 & 0 \\ 0 & 0 & -1 & 0 & 0 \end{bmatrix}$$

the sum of the coefficient must be zero.