MODY

Image Segmentation

→ It is the process of dividing an image into regions that are connected & have some similarity within the region & some difference between adjacent regions.

→ There is 2 approaches : Similarity & discontinuity

Detection of Discontinuities

→ ~~Types~~

1) ~~Points~~

2)

→ The most common way to look for discontinuities is to scan a small mask over the image

→ There are 3 kinds of discontinuities of intensity :

1) **Points**

→ **Point detection**

$|R| \geq T$ ← a nonnegative threshold

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$ ← Point detection mask.

2) **Lines**

→ **Line detection**

- Only slighty more common than point detection is to find a one pixel wide lime in an image
- For digital images the only 3 point straight limes are only horizontal, vertical or diagonal ($+45°$ or $-45°$)

August							
W	M	T	W	T	F	S	S
31						1	2
32	3	4	5	6	7	8	9
33	10	11	12	13	14	15	16
34	17	18	19	20	21	22	23
35	24	25	26	27	28	29	30
36	31						

$$\underset{H}{\begin{bmatrix} -1 & -1 & -1 \\ 2 & 2 & 2 \\ -1 & -1 & -1 \end{bmatrix}} \quad \underset{V}{\begin{bmatrix} -1 & 2 & -1 \\ -1 & 2 & -1 \\ -1 & 2 & -1 \end{bmatrix}} \quad \underset{+45°}{\begin{bmatrix} -1 & -1 & 2 \\ -1 & 2 & -1 \\ 2 & -1 & -1 \end{bmatrix}} \quad \underset{-45°}{\begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}}$$

3) Edge

→ Edge Detection

• First order derivatives:

$$\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix} \rightarrow \text{vector}$$

$$\nabla f = mag(\nabla f) = [G_x^2 + G_y^2]^{1/2} \rightarrow \text{magnitude}$$

$$\alpha(x,y) = \tan^{-1}\left(\frac{G_x}{G_y}\right) \rightarrow \text{direction}$$

Roberts cross gradient Operators

$$\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \quad \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$$

Prewitt Operators

$$\begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix} \quad \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

Sobel Operators

$$\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \quad \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

• Second order derivatives (The Laplacian)

$$\nabla^2 f = \frac{\delta^2 f}{\delta x^2} + \frac{\delta^2 f}{\delta y^2}$$

0	-1	0
-1	4	-1
0	-1	0

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

Laplacian masks

The laplacian of a Gaussian (Also known as mexican hat)

$$\nabla^2 h(r) = -\left[\frac{r^2-\sigma^2}{\sigma^4}\right] e^{-\frac{r^2}{2\sigma^2}}$$

Edge linking & Boundary Detection local Processing

→ Two properties of edge points are useful for edge linking
- Magnitude of the detected edge points
- their direction

→ This is usually done in local neighborhoods.
→ Adjacent edge points with similar magnitude & directions are linked

Canny Edge Operator

→ Smooth image I with 2D Gaussian : $\boxed{G * I}$

→ Find local edge normal directions for each pixel : $\boxed{\bar{n} = \frac{\nabla(G * I)}{|\nabla(G * I)|}}$

→ Compute edge magnitudes : $\boxed{|\nabla(G * I)|}$

→ locate edges by finding zero-crossings along the edge normal directions : $\frac{\delta^2 (G * I)}{\delta \bar{n}^2} = 0$

Hough Transform

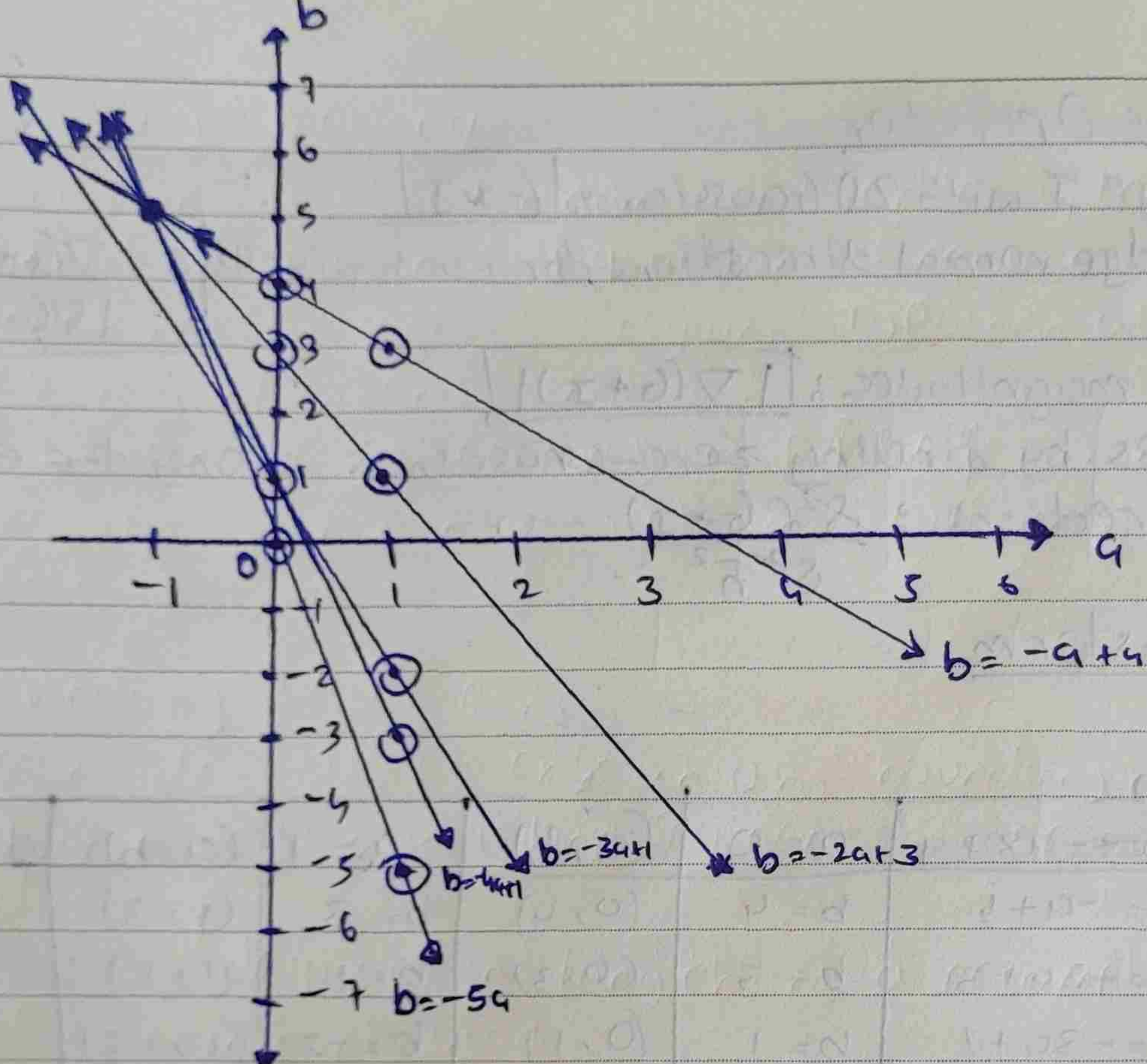
$y = ax + b$

$\therefore b = -ax + y$

eg)

Point	$b = -ax + y$	$a = 0$	(a, b)	$a = 1$	(a, b)
A(1,4)	$b = -a + 4$	$b = 4$	(0, 4)	$b = 3$	(1, 3)
B(2,3)	$b = -2a + 3$	$b = 3$	(0, 3)	$b = 1$	(1, 1)
C(3,1)	$b = -3a + 1$	$b = 1$	(0, 1)	$b = -2$	(1, -2)
D(4,1)	$b = -4a + 1$	$b = 1$	(0, 1)	$b = -3$	(1, -3)
E(5,0)	$b = -5a$	$b = 0$	(0, 0)	$b = -5$	(1, -5)

b



$\therefore a = -1 \;, \; b = 5$

$\therefore y = -x + 5$

Thresholding

1) Global
2) Adaptive

Region based Segmentation

1) **Region Growing**

→ Procedure in which Pixels are grouped into larger regions based on predefined Condition.

→ Approach

Select a pixel & grow the region from those region

a) Select a pixel
 - Arbitary pixel (x_1, y_1) → $\boxed{\text{seed pixel}}$

b) Examine the 4 nearest or 8 nearest neighbour
 - if cond^n is satisfied neighbouring pixel would be accepted

c) New pixel (x_2, y_2) → $\boxed{\text{current region}}$
 - 4 or 8 connectivity

d) repeat this till all pixels are converted.

e) All Pixel of one region are given a unique label.

Two assumption ⇒ Predefined cond^n ⇒ $\max(f(x,y)) - \min(f(x,y)) \le T$

Seed pixel to be chosen

~~2) Region Split~~

2) **Region Splitting**

→ Check homogenity property, where pixels are similar are grouped together

→ One method to divide a region is to use a quadtree Structure

3) **Region Merging** ⇒ We need check if the four adjacent homogenous regions arranged in a 2×2 fashion together satisfy the homogenity property

October

W	M	T	W	T	F	S	S
40				1	2	3	4
41	5	6	7	8	9	10	11
42	12	13	14	15	16	17	18
43	19	20	21	22	23	24	25
44	26	27	28	29	30	31	

Splitting & Merging

1) If region satisfies the homogenity criteria, leave it unmodified
2) If not split it into 4 quadrants & recursively appy 1 & 2 to each newly generated region, STOP when all regions satisfy the homogentity criterion.
3) If ~~two~~ any 2 adjacent regions R_i & R_j can be merged into a homogenous region, merge them. STOP when no merging is possible any more.

Boundary Descriptors

→ Chain Codes ⇒ Represents an obj boundary by a connected sequence of straight line segments of specified length & direction.
→ To avoid degradation & long chains a resampling of the image grid is commonly used.
→ The problem of chain code is the sequence depends on a starting point
→ Sol^n is to treat it as a circular sequence
→ The first difference of chain code is counting the no° of direction change between 2 adjacent elements of the code.
→ Shape number ⇒ The first difference of smallest magnitude

Signature

→ A simple functional representation that can be used to describe & reconstruct the boundary with appropriate accuracy.

Image moments

→ They are a set od statistical parameters to measure the distribution od where the pixels are & their intensities

$$M_{ij} = \sum_x \sum_y x^i y^j I(x,y)$$

Area: $M_{00} = \sum_x \sum_y I(x,y)$

Centroid: $\{\bar{x}, \bar{y}\} = \left\{ \frac{M_{10}}{M_{00}}, \frac{M_{01}}{M_{00}} \right\}$

eg)

0	0	0	0
1	1	1	1
1	1	1	1
0	0	0	0

$$\bar{x} = \frac{M_{10}}{M_{00}} = \frac{\sum\sum x\, I(x,y)}{\sum\sum I(x,y)}$$

$$= \frac{(2\times 1)\times 4 + (3\times 1)\times 4}{8}$$

$$= \frac{20}{8} = \frac{5}{2}$$

$$\bar{y} = \frac{M_{01}}{M_{00}} = \frac{\sum\sum y\, I(x,y)}{\sum\sum I(x,y)}$$

$$= \frac{1+2+3+4+1+2+3+4}{8} = \frac{20}{8} = \frac{5}{2}$$

Central Moment: $\sum_x \sum_y (x-\bar{x})^p (y-\bar{y})^q f(x,y) = \mu_{pq}$