Representation & Description

To recognise

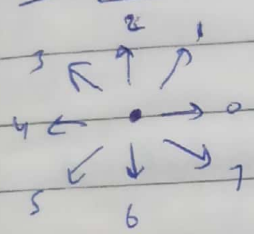
1) Boundary based approach
2) Region " "

1) In Boundary based app. we take control of the segment & represent it in some form which help to describe the boundary of object. In this case we are mainly interested in the shape of object.

2) In this we are interested in surface property of the object.

① Boundary.

1) Chain Code Representation

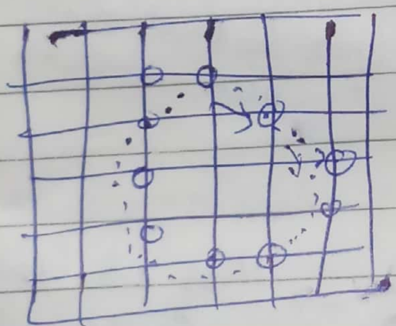


direction.

length move = 1 unit

but due to noise change. 11 → 20

~~so to overcome~~ this problem, we resample.



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chain code.

3 properties.

1) Rotation invariant
α. If rotate, then chain code should also be same.

2) Scaling Invariant

3) Translation invariant
If object is moved, then same code should be

If grid is increased, then image size is also increased.

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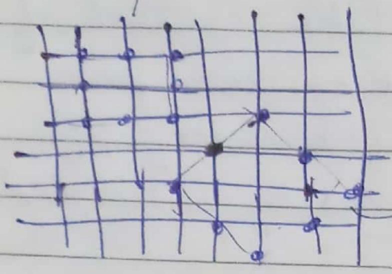

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45° change

Differentiatial chain code.

how much change to anticlockwise

0 0 6 6 4 4 2 2

0 6 0 6 0 6 0

7 7 5 5 3 3 1 1

0 6 0 6 0 6 0

Same.

Form cycle instead of chain, so what is lowest is considered.

7 7 6 5 4 3 4 2 2 1 0

0 7 7 7 7 1 6 0 7 7 but

Rotate so that it forms smallest number.

0 7 7 0 7 7 7 7 1 6 → this is lowest, so this is

✓ Shape no.

Descriptor which uses chain code

✓ Order no.

(Ch read)

ii) Polygon

the bound

polygon.

1) Polyg

2) Mini

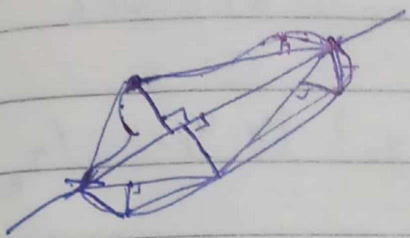
(book read)

3) Si

r(θ)

ii) Polygon approximation - In Polygon app., the boundary has to be approximated by a polygon.

1) Polygon splitting & merging



1) choose 2 points (farthest)

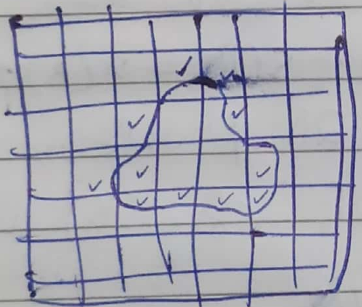
2) Draw line.

3) where $\perp^r$ is highest length.

3) If $\perp^r$ len < threshold, then stop process.

2) Minimum Perimeter Polygon

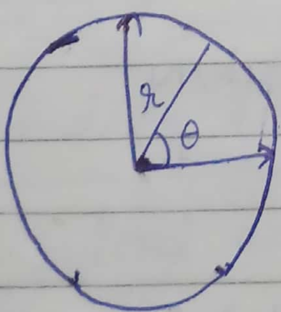
(book read)

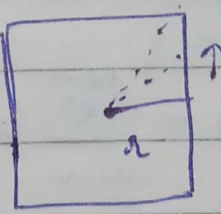


inner wall
outer wall

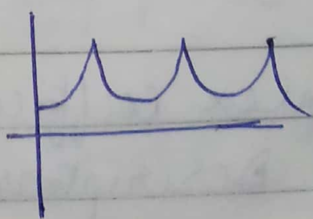
consider object rubber band

3) Signature - 1D mapping of boundary.



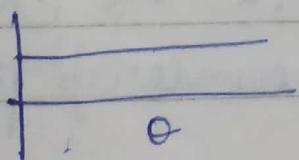


(can start from farthest pt., to take origin)



→ increase/decrease

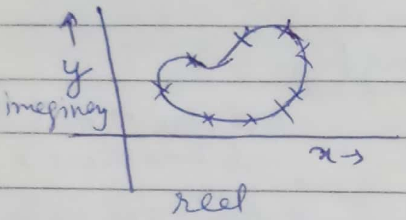
r(θ)



θ

Boundary based Descriptors

1) Fourier Descriptor - Now we are given N points digital boundary in XY plane.



N points $(x_0, y_0)\ (x_1, y_1) \cdots (x_{N-1}, y_{N-1})$

We consider $x(k) = x_k$ & $y(k) = y_k$.

$$s(k) = [x(k), y(k)], \quad k = 0, 1, \cdots N-1$$

Now each coordinate pair can be treated as a complex no: $s(k) = x(k) + j\,y(k)$

Now we can reduce a 2D problem to 1D problem. So DFT of $s(k)$ is

$$a(u) = \frac{1}{N}\sum_{k=0}^{N-1} s(k)\, e^{-j2\pi k/N} \qquad j = \sqrt{-1}$$

$k = 0, 1, \cdots N-1$

$$\text{IDFT}, \quad s(k) = \sum_{u=0}^{N-1} a(u)\, e^{j2\pi uk/N}$$

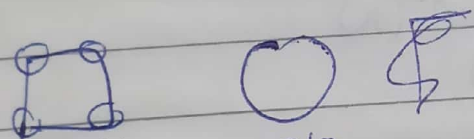
Here complex coefficients $a(u)$ are called Fourier Descriptors of boundary points.

To represent shape of image we don't consider all n-coefficients as Fourier Descriptors, rather we use M<N coefficients. During reconstruction of image we get approximate image using M no. of descriptors.

$$\hat{s}(k) = \sum_{u=0}^{M-1} a(u)\, e^{j\frac{2\pi uk}{N}}$$

$k = 0, 1, \dots, N-1$

IDFT. $\hat{s}(k) = \sum_{u=0}^{M-1} a(u)^{j2\pi uk/N}$



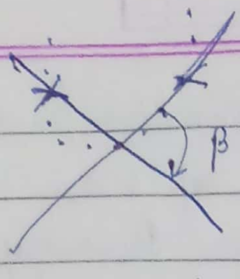
N=64 N=10

Fourier descriptors can be used to capture gross essence of boundary

Other Boundary Descriptors

1) Boundary straightness = $\dfrac{\text{No. of pixels where boundary direction changes abruptly}}{\text{Total no. of boundary points}}$

So smaller ratio, more straight the boundary



If β < threshold, so no change in boundary.

2) <u>Bending Energy</u> – can be computed from concept of curvature. (to bend a rod.)

More temperature ⇒ More energy
Less " Less "

$$B.E = \sum_{k=1}^{L} c^2(k)$$ c is curvature at pt. k

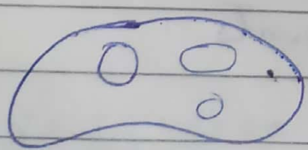
$$\text{Normalized } B.E. = \frac{1}{L} \sum_{k=1}^{L} c^2(k)$$

Region Based Shape Descriptors

Area = Total no. of pixels ~~belonging to that area.~~

1) Translation invariant ✓
2) Rotational " ✓
3) Scaling " ✗.

① <u>Euler No.</u> for small.



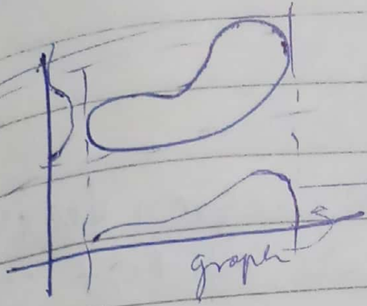
$$V = S - N$$

V → Euler no.
S → No. of connected components
N → No. of holes

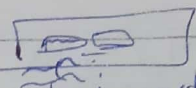
1 - 3
= -2

✓ Translation
✓ Rotation
✓ Scaling

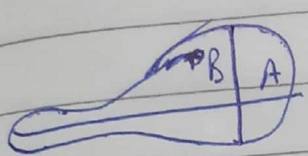
2) Horizontal & Vertical Profile



→ No. of pixels



3) Eccentricity

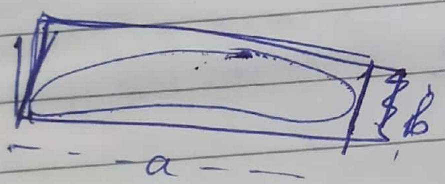


$= \frac{\text{length of A}}{\text{length of B}}$

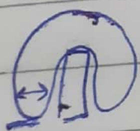
A → longest horizontal chord

B → longest vertical

4) Elongatedness $= \frac{a}{b}$



bounding rectangle



$= \frac{\text{area}}{\text{maximum fitness}^2}$

↳ No. of erosion steps needed to erode this object to null set.

5) Compactness $= \frac{\text{area}}{\text{perimeter}^2}$

For circle $= \frac{\pi r^2}{(2\pi r)^2} = \frac{1}{4\pi}$

For a straight long region ≈ 0
with small thickness

~~Statist~~ ✗

Texture - Approach to region description is to quantify its texture content. This descriptor provides measure of properties such as smoothness, coarseness & regularity.

2 approaches.

→ Statistical.

→ Spectral.

① Statistical Decriptors. → image grey level histogram.

1st moment → mean
2 → variance.

z_i - Intensity
$p(z_i)$ - greylevel histogram

For n^{th} order moment,

$$\mu_n(z) = \sum_{i=0}^{L-1} (z_i - m)^n \, p(z_i)$$

$$\text{mean } m = \sum_{i=0}^{L-1} z_i \, p(z_i)$$

Scanned by CamScanner

Palak Date Page

$n=0$ Sum of prob. = 1.

cause $z_i = m$

$\mu_0 = 1$ $\mu_1 = 0$

$\mu_2 =$

variance

2nd moment is important for texture description. It is measure of grey level contrast that can be used to establish descriptor of relative smoothness.

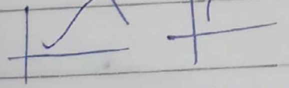
$$R = 1 - \frac{1}{1 + \underbrace{\sigma^2(z)}_{\mu_2}}$$

For smooth surface of uniform intensity, $\sigma^2(z) = 0$, so $R = 0$.

& As the variation of ~~Intensity value~~ μ_2 increases, ~~value of μ_2 increase~~ & R tends to approach 1.

$$3^{rd} \text{ moment } \mu_3 z = \sum_{i=0}^{L-1} (z_i - m)^3 p(z_i)$$

Tells Skewness



Left / Right Skewness

μ_4 kurtosis → to tell relative flatness of histogram

to know how high peak is

~~Co-o~~ They do not provide any information about the position of pixels. So for this we use Co-Occurence Matrix.

Cooccurence Matrix.

$p \Rightarrow$ position operator

matrix A size $L \times L$

gray level $0 \cdots L-1$

$z_0, z_1, \ldots z_{L-1}$

In matrix ~~A_{ij}~~ a_{ij} represent no. of times points with intensity value z_j occurs at a position determined by p relative to points with intensity z_i.

$$I = \begin{bmatrix} 0 & 0 & 0 & 1 & 2 \\ 1 & 1 & 0 & 1 & 1 \\ 2 & 2 & 1 & 0 & 0 \\ 1 & 1 & 0 & 2 & 0 \\ 0 & 0 & 1 & 0 & 1 \end{bmatrix}$$

$p \Rightarrow$ One pixel to the right

z_0, z_1, z_2

cooccurrence matrix

$$A = \begin{array}{c|ccc} & 00 & 01 & 02 \\ \hline 0 & 4 & 4 & 1 \\ 1 & 4 & 3 & 1 \\ 2 & 1 & 1 & 1 \end{array} \quad 3 \times 3$$

how many times 00 occurs

sum of elements

Every element in cooccurrence matrix indicates the joint probability of pair of points satisfying T → (position vector) with value z_i, z_j.

~~what~~ Set of descriptors that can be obtained from co-occurrence matrix.

1) Maximum Probability.

$\max_{i,j} \{ c_{i,j} \}$ indicates strongest response to T.

2) Element Difference moment of order k.

$\sum_i \sum_j (i-j)^k c_{i,j}$ → this value is low if higher values appear on main diagonal of A.

⇒ 0 if diag. same.

3) Inverse element difference of order k.

$\sum_i \sum_j c_{i,j} / (i-j)^k$. just gives inverse effect.

↳ value higher, if values on main diag. higher

4) Uniformity $\sum_{i,j} C_{i,j}^2$ If all values high, then this hight.

5) Entropy $\sum_{i,j}\sum C_{i,j} \log_2 C_{i,j}$

measure ~~degree~~ of randomness