DICOM : Digital Image Communication in Medicine
Deliniation, Detection, Comparision (Registration)

Tools :
Viewer software
analysis software - Mevis Lab, 3D slicer
Rapid prototyping programming language → MATLAB, IDL
Software liberaries - Open CV, ITK (insight toolkit)
2 D   2D, 3D, 4D

Delianation, Classification → analysis task would be typic of

Guide to Medical Image Analysis

Digital Image Acquisition:
X-Ray, Magnetic Resonance, Ultrasound, Nuclear

Image intensifiers, TFT, analogue for X-ray (static images)
Select Spatial resolution

Fluoroscopy & Angiography
movement of the organ - fluoroscopy → used for diagnosis ⇒ pacemaker

Angiography - focus on vascular system using contrast agent
Digital substraction Angiography DSA

Mammography
uses molybdenum → produce monochrome X-ray with peak energies 17-19 keV
Bremsstrahlung → Influence X ray tube
efficiency 1000:1 ratio mammography (TFT)

CT Computed Tomography
Project 2D images to 3D

Hounsfield Unit

$$HU(\mu) = 1000 \cdot \frac{\mu - \mu_{water}}{\mu_{water} - \mu_{air}}$$

Contrast enhancement:
CTA : computed Tomography Angiography
requires higher exposure than X ray

Magnetic Resonance Imaging (MRI)
Proton, neutron 65% H, 21% O C, N
Angular momentum - spin
MRI uses response of hydrogen nucleus
MRI do not use ionizing radiation
coronal & sagittal views
1 to 3 Tesla
use high magnetic field 0.00003 T - 0.00006 T
Radio frequency signals are passed to spin atoms.
$\omega = \gamma B_0$ Larmor frequency.

frequency encoding, filtered backpropogation

* K- space imaging (frequency space)
magnetic strength in terms of frequency.
phase encoding gradient 0 to 360°

MRI VS CT : Gantry is small in MRI, image need not be ⊥^{r}, spin density ρ, spin lattice relaxation T_1, Spin - spin relaxation T_2 determine resonance signal

No Hounsfield in MRI

MR sequences

echo spin sequence

echo time → time b/w 90° impulse & echo impulse

repitition time → time b/w measurement

EPI : echo planar imaging

phase encoding & frequency encoding

Phase shift gradient

RARE : Rapid Enhancement with Relaxtion Enhancement

Problems : - chemical shift of proton, Ghosting, Shading, Metal Artifacts

MR Angiography :

gadolinium

MIP : maximum intensity projection

BOLD Imaging :

Blood Oxygen Level Dependency

HB : Hemoglobin

Oxygenated heamoglobin → diamagnetic

deoxygenated hemoglobin → paramagnetic

fMRI - cortical activity

Perfusion Imaging :

relative ~~cet~~ cerebral blood volume (rCBV)

relative cerebral blood flow (rCBF)

mean transit time (MTT)

for tumor analysis, cardiac imaging

Ultrasound -
liver, gallbladder, pancreas, kidneys, spleen, heart, uterus
esophagus

Transrectal Ultrasound (TRUS) → imaging prostate
IVUS : Intravascular ultrasound → imaging organs from within

Doppler Imaging:
→ Doppler effect
→ diagnosing effects of vessel blockage due to stenosis

FUS → focused ultrasound Imaging
→ used for thermal ablation of tumors - overheat tumor cell
→ Inducing mechanical effect (moving stone in gallbladder)
Brain, prostate,

Artifacts of US Imaging:
Sound waves are attenuated
Absorption turns wave energy into heat
Wave may be scattered or
Interference & divergence waves cause deterioration

Image Analysis of US image:
→ Speed of sound in material
→ Refraction
→ Mirror echoes

Nuclear Imaging:
Radioactive tracer materials are injected in blood.
Brain activity, heart activity, Arthritis.
Images are created from measuring photon

Feb 6 - Feb 16
Ch 1 & 2 - MRI (39)
MCQ - 10
Feb 7

Techniques:

→ Scintigraphy
→ SPECT (Single Photon Emmission Computed Tomography)
→ PET (Possiton Emission Tomography)

Scintigraphy:

99 Tc (Technetium)

collimator , scintilator crystal

Projection of bones (skeleton)

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MRI → Diffusion Imaging
DTI : Diffusion Tensor Imaging
for fiber tracking (neurons connectivity)
MR fractography · connectionsism.

Image Analysis on MRI
better contrast for soft tissue
Shading effect
local homoginity
Noise in MR Imaging

Ultra sound
Use sound waves, 1-2 MHz, 1500 m/s
A-scan : sends single wave
B-scan : US scan images

Image Storage & Transfer

HL7 : Health Level 7 & DICOM
HIS : Hospital Information System
RIS: Radiology Information System
PACS: Picture Archiving & Communication System

HL7 - communication between clinical information system
DICOM - Standardize communication of Image
OSI: Open system interconnect
P, D, N, T, S, P, A
RIM: Reference Information Model

DICOM Standard - preserve sementacally relevant info:
→ Patient Information
→ Examination Information
→ Technical Information
→ Image

Two objects for communicating:
→ Composite : Patient details + Image + Report
→ Normal : report

Service for composite object:
C-STORE, C-FIND, C-GET, C-MOVE

Service for normal object:
N-CREATE, N-DELETE, N-SET, N-GET, N-ACTION,
N_EVENT-NOTIFY

IOD : Information Object Description
UID : Unique Identifier

IOD:

DIMSE: DICOM Message Service Element
SOP: Service object Pair

DICOM classes are static
client - server paradigm
SCP - Service Class Provider - server
SCU - Service Class User - client

Application Entities (AE)

communication session b/w two components.

→ Network Image Management (NIM)
→ Network Image Interpretation Management
→ Network Print Image
→ Image Procedure management
→ off-line storage media management

NIM involves sending images b/w two devices
Push mode → img sent from one device to another
Pull mode → img sent to departmental workstation
or used for information exchange
two phases of pull mode: request : C-FIND, image C-GET

Server: | Client:
Backend hospital IS ← Store — Doctor's Clinic
MR I Image
CT Image — downloaded →

AE ① Archive
AE ② MR system

② SCP DIMSE for IOD MR } Server
C-STORE, {C-FIND, C-GET}

SCP ...... CT
C-FIND, C-GET

SCU DIMSE for IOD MR } client
C-STORE

SCU ...... CT
C-STORE

__/__/__

Network Management Service
→ service, query / retrieve & storage.
→ C-STORE for storage
→ C-FIND, C-MOVE, C-GET for query

DICOM connectivity: problem statement, application entity specificati. communication profile, specialization

DICOM file format: highly variable, minimal effort → tagged format
Name of file is UID → 128 byte preamble, 4 byte identif-ication, manadatory set of data elements

Shadow grp → odd no. grp id.

little -endian

H2NS: Host To Network
ACR: American College of Radiology

luminance of grayscale ≥ 50 foot lamberts

Compression standard JPEG & JPEG2000

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Image Enhancement
→ Increase perception
→ Increase quality

Measure of Image Quality
→ Spatial Resolution: Structure,
→ Technical Resolution: 8 bits or 24 bits (RGB)
→ Contrast based Resolution: variable
→ Perceived Resolution: line pairs per millimeter (lpmm)

Gray level co-occurrence matrix (GLCM):

Modulation Transfer Function (MTF)
Signal to Noise Ratio (SNR)

Spatial Domain & Frequency Domain

SD ⇒ $g(x,y) = T[f(x,y)]$

T → Transformation

Types of IE in SD:
Single pixel method: Gray level, Arithmatic
Multiple pixel method: Spatial filtering

Gray-level transformation.

$s = T(r)$

r = i/p intensity   s = o/p intensity

windowing with window size

Contrast Stretching
M - input image, I - output image. Ni - no of pixel having
i^th gray level & frequency table is:

I	0	1	2	3	4	5	6	7
Ni	0	0	a	b	c	d	e	0

Compute output image frequency table:

$$g(f) = (f - f_{min}) \frac{I_{max} - I_{min}}{f_{max} - f_{min}} + I_{min}$$

$$= (f-2) \frac{7-0}{6-2} + 0$$

$$= (f-2) \times \frac{7}{4}$$

for 2a $= (2-2) \times \frac{7}{4} = 0$

for 3b $= (3-2) \times \frac{7}{4} = 1 \times 1.75 = 1.75 \simeq 2$

for 4c $= \cancel{2} \times \frac{7}{\cancel{4}_2} = 3.5 \simeq 4$

for 5d $= 3 \times 1.75 = 5.25 \simeq 5$

for 6e $= \cancel{4} \times \frac{7}{\cancel{4}} = 7$

~~for 7 $= -2 \times \frac{7}{4} = -2 \times 1.75 = -3.50$~~

output

I	0	1	2	3	4	5	6	7
Ni new	a	0	b	0	c	d	0	e

Q.

I	0	1	2	3	4	5	6	7	~~8~~
Ni	28	45	0	38	98	46	70	0	~~0~~

$$g(f) = (f-2) \; \cancel{\ldots} \; \frac{7-0}{6-0} + 0$$

$$= (f - 0) \frac{7}{6}$$

__/__/__

$\times \frac{7}{\cancel{6}} = 52.5 = 53$

$8 \times \frac{7}{6} = 44.3 = 44$

$98 \times \frac{7}{\cancel{6}} = 114.3 = 114$

for 5: $46 \times \frac{7}{6} = 53.6 = 57$

for 6: $70 \times \frac{7}{6} = 81.6 = 82$

I	0	1	2	3	4	5	6	7
Ni								

for 0 : 0

for 1: $\frac{7}{6} = 1.1 = 1$

for 2: $2 \times \frac{7}{6} = 2.3 \approx 2$

for 3 : $3 \times \frac{7}{6} = 3.5 = 4$

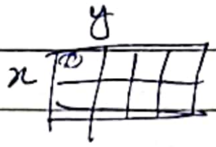
for 4 : $4 \times \frac{7}{6} = 4.6 \approx 5$

for 5: $5 \times \frac{7}{6} = 5.8 = 6$

for 6: $6 \times \frac{7}{6} = 7$

~~for~~	0	1	2	3	4	5	6	7
	28	45	0	0	38	98	46	70

Euclidean Distance: $\sqrt{2} = 1.414$



$D_e(p,q) = [(x-s)^2 + (y-t)^2]$

City block distance:

$D_4(p,q) = |x-s| + |y-t|$

```
    2
  2 1 2
2 1 0 1 2
  2 1 2
    2
```

Chess Board Distance

$D_8(p,q) = \max(|x-s|, |y-t|)$

```
2 2 2 2 2
2 1 1 1 2
2 1 0 1 2
2 1 1 1 2
2 2 2 2 2
```

Q. Compute Distance between two pixel

q: (1,1)

p: (2,2)

	1	2	3
1	q		
2		P	
3			

Euclidean $= \sqrt{1+1} = \sqrt{2}$

CB $= |1| + |1| = 2$

ChB $= \max(1,1) = 1$

Q. Use City block

	1	2	3
1		D	
2	A	P	C
3		B	

P(A) = (2,1) P(B) = (3,2)

P(C) = (2,3) P(D) = (1,2)

P(P) = (2,2)

P(A to P) = |0| + |1| = 1 P(P to C) = |0| + |1| = 1

P(A to B) = |1| + |0| = 1 P(P to D) = |0| + |1| = 1

Since the dist b/w all 4 are same i.e. 1

∴ A, B, C & D are neighbouring pixel of P.

using Chess Board for N_D

	1	2	3
1	a_1		a_2
2		P	
3	a_3		a_4

P(D) = (2,2) $P(a_1)$ = (1,1) $P_2(a_2)$ = (1,3)

$P(a_3)$ = (3,1) $P_4 = (a_4)$ = (3,3)

$P(a_1 p) = \max(|1|, |1|) = 1$ $P(a_3 p) = 1$

$P(a_2 p) = \max(|1|, |1|) = 1$ $P(a_4 p) = 1$ all are 1

Smoothing / averaging filter
Noise removal
Edge Detection
Contrast enhancement

$$\begin{bmatrix} \; & \; & \; \\ \; & \; & \; \\ \; & \; & \; \end{bmatrix} \times \begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & 0 \\ 0 & 1 & 0 \end{bmatrix} \quad \Sigma =$$

color value $\qquad\qquad$ kernel

$$\begin{matrix} 9 & 6 & 6 \\ 2 & 8 & 6 \\ 2 & 2 & 9 \end{matrix} \qquad\qquad \begin{matrix} -1 & -1 & -1 \\ -1 & 16 & -1 \\ -1 & -1 & -1 \end{matrix}$$

$$-8 - 6 - 6 - 2 + (16 \times 8) - 6 - 2 - 2 - 9 \,/\, 8$$

$$= 128 - 42/8 = 86/8 = 10.7 \approx 11$$

Histogram Processing

$$h(r_k) = n_k \qquad k = 0 \ldots\ldots L-1$$

$$p_r(r_k) = \frac{h(r_k)}{MN} = \frac{n_k}{MN}$$

MN = size of image $(M \times N)$

$$s_k = T(r_k) = (L-1) \sum_{j=0}^{k} p_r(r_j)$$

$k = 0 \ldots L-1$

r_k	n_k	$p_r(r_k) = n_k/MN$
0	790	0.19
1	1023	0.25
2	850	0.21
3	656	0.16
4	329	0.08
5	245	0.06
6	122	0.03
7	81	0.02

$MN = 4096$

$$s_0 = T(r_0) = 7 \sum_{j=0}^{0} p_r(r_j) = 7 p_r(r_0) = 1.33 \rightarrow 1$$

$$s_1 = 7 \times (0.25 + 0.19) = \cancel{.75} = 3.08 \simeq 3$$

$$s_2 = 7 \times (0.21 + 0.25 + 0.19) = 4.55 \rightarrow 5$$

$$s_3 = 7 \times (0.19 + 0.25 + 0.21 + 0.16) = 5.67 \rightarrow 6$$

$$s_4 = 7 \times (0.19 + 0.25 + 0.21 + 0.16 + 0.08) = 6.23 \rightarrow 6$$

$$s_5 = 7 \times (0.19 + 0.25 + 0.21 + 0.16 + 0.08 + 0.06) = 6.65 \rightarrow 7$$

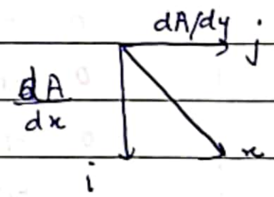
$$s_6 = 7 \times (0.19 + 0.25 + 0.21 + 0.16 + 0.08 + 0.06 + 0.03) = 6.86 \rightarrow 7$$

$$s_7 = 7 \times (0.19 + 0.25 + 0.21 + 0.16 + 0.08 + 0.06 + 0.03 + 0.02) = \underline{7}$$

AHE : Adaptive Histogram Equalization

CLAHE : Contrast limited adaptive histogram equalization

2D gradient Operator



$$\Delta A = \frac{dA}{dx} i + \frac{dA}{dy} j$$

$$\text{Magnitude} = \sqrt{\left[\frac{dA}{dx}\right]^2 + \left[\frac{dA}{dy}\right]^2}$$

$$B_i = \begin{bmatrix} -1 \\ 1 \end{bmatrix}$$

$$B_j = \begin{bmatrix} -1 & 1 \end{bmatrix}$$

$$\text{Orientation} = \tan^{-1}\left[\frac{dA/dy}{dA/dx}\right]$$

$$\Delta_i^2 A = A * B \qquad B_i = \begin{bmatrix} 1 \\ -2 \\ 1 \end{bmatrix}$$

$$B_j = \begin{bmatrix} 1 & -2 & 1 \end{bmatrix}$$

$$B = B_i + B_j$$

$$= \begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

$$L = -\Delta A^2$$

$$B = \begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

Laplacian filter

		0	0	10	10	10	10
0	1	0	0	10	10	10	10
0	1	0	0	10	10	10	10
0	1	0	0	10	10	10	10
0 1	0	0	0	10	10	10	10
0 1	0	0	0	10	10	10	10
1	0	0	0	0	0	0	
0		0	0	10	10	10	10

$$L_8 = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

$$L_4 = \begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

for L_4 Subsitute 0 Substitue 1

0	-10	20	10	20
0	-10	10	0	10
0	-10	10	0	10
0	-10	10	0	10
0	-10	20	10	20

0	-2		
0	-1		
0	-1		
0	-1	19	9
-0 -10	-2	-12	

for exam purpose

$$L_4 = \begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix} \qquad L_8 = \begin{bmatrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

Actual output

-2	-11	19	9	18	
-1	-10	10	0	9	substitute '1'
-1	-10	10	0	9	
-1	-10	10	0	9	
-2	-11	19	9	18	

Substitute boundary value for L-4

0	-10	10	0	0
0	-10	10	0	0
0	-10	10	0	0
0	-10	10	0	0
0	-10	10	0	0

Resolution Enhancement

Interpolation → zooming, shrinking, rotating, geometrically correcting digital image

Bilinear interpolation → 4 nearest neighbour

$$V(x,y) = ax + by + cxy + d$$

Shape-based interpolation

Sobel filter

$$g_x = \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix} * A \qquad g_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} * A$$

A is original source image

x increase in right direction & y increase in down direction

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$$g = \sqrt{g_x^2 + g_y^2}$$

gradient directon

$$\theta = \text{arc tan}\left[\frac{g_y}{g_x}\right] = \tan^{-1}\left[\frac{g_y}{g_x}\right]$$

0 0 0 10 10 10
0 0 0 0 0 0 0 10
0 0 0 10 10 10 0 10
0 0 0 10 10 10 0 10
0 0 0 10 10 10 0 10
0 0 0 10 10 10 0 10
0 0 0 10 10 10 0 10
0 0 0 0 0 0 0 10
0 0 10 10 10

$$h_x = \begin{matrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{matrix}$$

$$h_y = \begin{matrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{matrix}$$

zero . padding

g_x =

0	-30	-30	0	30
0	-40	-40	0	40
0	-40	-40	0	40
0	-40	-40	0	40
0	-30	-30	0	30

2 | 1500 -

border value

g_x =

0	-40	-40	0	0
0	-40	-40	0	0
0	-40	-40	0	0
0	-40	-40	0	0
0	-40	-40	0	0

zero padding g_y =

$$\begin{matrix} 0 & -10 & -30 & -40 & -30 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & -10 & -30 & -40 & -30 \end{matrix}$$

border value g_y =

$$\begin{matrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{matrix}$$

Zero padding g =

$$\begin{matrix} 0 & 10\sqrt{10} & 30\sqrt{2} & 40 & 30\sqrt{2} \\ 0 & 40 & 40 & 0 & 40 \\ 0 & 40 & 40 & 0 & 40 \\ 0 & 40 & 40 & 0 & 40 \\ 0 & 10\sqrt{10} & 30\sqrt{2} & 40 & 30\sqrt{2} \end{matrix}$$

Border value g =

$$\begin{matrix} 0 & 40 & 40 & 0 & 0 \\ 0 & 40 & 40 & 0 & 0 \\ 0 & 40 & 40 & 0 & 0 \\ 0 & 40 & 40 & 0 & 0 \\ 0 & 40 & 40 & 0 & 0 \end{matrix}$$

Laplacian of Gaussian [LOG] (Mexican hat filter)

$G_\sigma(r) =$

$D_{gauss,x} = \frac{\partial f_{Gauss}}{\partial x}(x,y)$

Gaussian kernel: Image array:

1/16	1/8	1/16
1/8	1/4	1/8
1/16	1/8	1/16

20	20	20	30	40	50	60
20	20	30	40	50	60	
25	25	35	45	55	65	
30	30	40	50	60	70	
35	35	45	55	65	75	
40	40	50	60	70	80	
40	40	50	60	70	80	

3	5	3
5	9	5
3	5	3

$\boxed{23.75}$

output:

28	33	43	53	58
30	35	45	55	60
35	40	50	60	65
40	45	55	65	70
43	48	58	68	73

Gaussian kernel applied to smooth image

56	36	16	-4	-24
52	32	12	-8	-28
40	20	0	-20	-40
32	12	-8	-28	-40
16	-4	-24	-44	-64

28	28	33
28	28	33
30	30	35

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5x5 Laplacian of gaussian mask

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

Gabor filter

Respond to edge & texture changes

$$g_{\sigma,\alpha,\gamma,\lambda,\psi}(x,y) = \exp\left(-\frac{s^2+\gamma t^2}{2\sigma^2}\right)\cos\left(2\pi\frac{s}{\lambda}+\psi\right)$$

$s = x\sin\alpha + y\cos\alpha \qquad t = x\cos\alpha - y\sin\alpha$

Types of Noise:

Gaussian Noise

Salt & Pepper Noise

Speckle Noise

Noise is usually modeled stationary, additive & with zero mean

$$g = f + n$$

Noise reduction scheme:

Linear filtering

Median filtering

Diffusion filtering

Bayesian image

$C_{mean,s} = \frac{1}{S^2}\left[\quad\right]_{image}$

$S = 3 \qquad S \times S$ matrix image size

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Binomial filter

$$c^{1D}_{binom,b} = \frac{1}{2^b} C^{1D}_{binom,l}$$

$[b^0] = [1]$ $\quad b^1 = [1, 1]$ $\quad b^2 = [1\ 2\ 1]$

$b^3 = [1\ 3\ 3\ 1]$ $\quad b^4 = [1\ 4\ 6\ 4\ 1]$

$$C_{Butterworth,\,\omega_{max}}(u,v) = \frac{1}{1 + \left(\left(u^2+v^2\right)/\omega^2_{max}\right)^K}$$

Hamming & Hann

$$C_{Ha,\,\omega_{max}}(u,v) = \begin{cases} \alpha - (1-\alpha)\cos\left(\frac{\sqrt{u^2+v^2}}{\omega_{max}}\pi\right) & u^2+v^2 < \omega^2_{max} \\ 0 & \text{otherwise} \end{cases}$$

$\alpha = 0.53836 \rightarrow$ Hamming window $\quad \alpha = 0.5 \rightarrow$ Hann window

Order Statistic filter

→ Median filter

$$\hat{f}(x,y) = \underset{(r,c) \in S_{xy}}{\text{median}} \{g(r,c)\}$$

→ Max & Min filter
 100   0

$$\begin{matrix} 0 & 1 & 0 & 6 & 7 \\ 2 & 0 & 1 & 6 & 5 \\ 1 & 1 & \boxed{7} & 5 & 6 \\ 1 & 0 & 6 & 6 & 5 \\ 2 & 5 & 6 & 7 & 6 \end{matrix}$$

Mean filter:

$$\frac{1+6+7+1+5+6+6}{9} = \frac{32}{9} = 3.55 \simeq 4$$

0 1 6
1 7 5
0 6 6

filter:

Median = 5

0 0 1 1 5 6 6 6 7

Max : 7 Min : 0

0 1 6
1 $\boxed{5}$ 5
0 6 6

$$\frac{30}{9} = \frac{10}{3} = 3.33 \simeq 3$$

0 1 6 1 5 5 0 6 6

0 0 1 1 5 5 6 6 6

Median : 5

Median:

1 1 6
1 5 6
2 6 6

Min:

0 0 0
0 0 1
0 0 5

Diffusion filtering

Median filter does not reduce noise & might alter the edge.

→ homogeneous diffusion
→ inhomogeneous diffusion
→ anisotropic diffusion incr decr.

Gradient Adaptive Smoothing
Bilateral filtering

Feature Detection

Canny edge detector
Edge Model → template
Contour Model → set of open & closed contour are searched in top-down fashion

Hough transformation
input img → compare with edge model
voting scheme → find straight line in images

Harris corner detector

$$H(x_0, y_0) = \sum_{x=x_0-K}^{x_0+K} \sum_{y=y_0-K}^{y_0+K} \omega(x,y) \begin{bmatrix} \left(\frac{\partial I}{\partial x}\right)^2 & \left(\frac{\partial I}{\partial x}\right)\left(\frac{\partial I}{\partial y}\right) \\ \left(\frac{\partial I}{\partial x}\right)\left(\frac{\partial I}{\partial y}\right) & \left(\frac{\partial I}{\partial y}\right)^2 \end{bmatrix}$$

corner : K_1 & K_2 are large
edge : either K_1 or K_2 is large
homogeneous : K_1 & K_2 will be low

Texture:
Kind of microstructure in a structured world
→ Repetition of pattern.

Deterministic texture pattern → manufactured object
Visible texture

Orientation, Periodicity, complexity

Texture measure:

→ Haralick's feature : Gray level co-ocurrence matrix [GLCM]

→ Spatial feature (Sobel)

→ Law's filter

Feature Detection

Agglomeration → cluster

Purpose of image segmentation → to generate pixel agglomeration, deliniation of specific feature

data knowledge & domain knowledge

Segmentation Strategies

→ Foreground Segmentation → focuses on single object in image

→ Hierarchical Segmentation → applies multi-resolution concept for gradual refinement

→ Multilayer Segmentation → carried out at different scale producing layer of segment.

Data Knowledge

Continuity in time & continuity in space.

Homogeneity of intensity.

Gaussian with zero mean value

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Otsu's Algorithm

$P_1(k) = \sum_{0}^{i} p_i$

$2/25 = 0$

$1 \times 3/25 = 3/..$

120	130	140	120	110
125	135	145	125	115
115	125	135	125	120
110	120	130	120	110
105	115	125	115	105

5x5

$MN = 25$

$p_i = \frac{n_i}{MN}$

④ cummulative mean $m(k)$

	①		② p_i	③ sum Cummulative $P_1(K)$
0	105 - 2	0 $\cancel{105}$ × 2/25	$p_0 = 2/25$	2/25 = 0
1	110 - 3	1 $\cancel{110}$ × 5/25	$p_1 = 3/25$	5/25 3/25
2	115 - 4	2 $\cancel{115}$ × 9/25	$p_2 = 4/25$	9/25 17/25
3	120 - 5	3 $\cancel{120}$ × 14/25	$p_3 = 5/25$	14/25
4	125 - 5	4 $\cancel{125}$ × 19/25	$p_4 = 5/25$	19/25
5	130 - 2	5 $\cancel{130}$ × 21/25	$p_5 = 2/25$	21/25
6	135 - 2	6 $\cancel{135}$ × 23/25	$p_6 = 2/25$	23/25
7	140 - 1	7 $\cancel{140}$ × 24/25	$p_7 = 1/25$	24/25
8	145 - 1	8 $\cancel{145}$ × 25/25	$p_8 = 1/25$	25/25

⑤ $m_G = \frac{0 \times 2}{25} + \frac{1 \times 3}{25} + \frac{2 \times 4}{25} + \frac{3 \times 5}{25} + \frac{4 \times 5}{25}$

$+ \frac{5 \times 2}{25} + \frac{6 \times 2}{25} + \frac{7 \times 1}{25} + \frac{8 \times 1}{25} = \cancel{30.28}$

$= 3.32$

$$\sigma_B^2(k) = \frac{[m_G P_1(k) - m(k)]^2}{P_1(k)\,[1 - P_1(k)]} \quad k = 0 \ldots L-1$$

$k = 0$

$$= \frac{(3.32 \times 2/25 - 0 \times 2/25)^2}{2/25\,[1 - 2/25]}$$

$$= \frac{(3.32 \times 2/25 - 0)^2}{2/25 \times 23/25} = \cancel{0.0839}$$

$= 0.958$

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for $k=1$

$$\frac{\left[3.32 \times 5/25 - 1 \times 3/25\right]^2}{\left(5/25 \times 20/25\right)}$$

$$= 1.84$$

$$K = \cancel{7} \qquad \frac{\left[3.32 \times \frac{24}{25} - 7 \times 1/25\right]^2}{24/25 \times 1/25}$$

$$= 220.09$$

$K = 3$

$$p_i = \frac{n_i}{MN} \qquad P_1(K) = \sum_{i=0}^{k} p_i \quad K = 0 \dots L-1$$

$$\eta(K^*) = \frac{\sigma_B^2(k)}{\sigma_G^2}$$

$$m(k) = \sum_{i=0}^{k} i p_i \qquad K = 0 \dots L-1$$

$$m_G = \sum_{i=0}^{L-1} i p_i \qquad M_G = 3.32$$

		p_i	P_i	$m(k)$	σ_B
105	2	2/25	2/25	0	0.958
110	3	3/25	5/25	3/25	1.849
115	4	4/25	9/25	8/25	3.32
120	~~4~~5	5/25	14/25	15/25	6.43
125	5	5/25	19/25	20/25	16.27
130	2	2/25	21/25	10/25	42.45
135	2	2/25	23/25	12/25	90.04
140	1	1/25	24/25	7/25	220.099
145	1	1/25	25/25	8/25	Not defined

$$\sigma_B(6) = \frac{\left(3.32 \times 2/25 - 0\right)^2}{2/25 \times 23/25} = \frac{246}{25} \times \frac{625}{46}$$

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$$g(x,y) = \begin{cases} 1 & f(x,y) > T \\ 0 & f(x,y) \leq T \end{cases}$$ 120

RAG

Q.

	0	1	2	3	4
0	120	130 ✓	140 ✓	120	110
1	125 ✓	135 ✓	145 ✓	125 ✓	115
2	115	120 ✓	135 ✓	125 ✓	120
3	110	120	130 ✓	120	110
4	105	115	125 ✓	115	105

Seed point (2,2) Threshold = 10

135

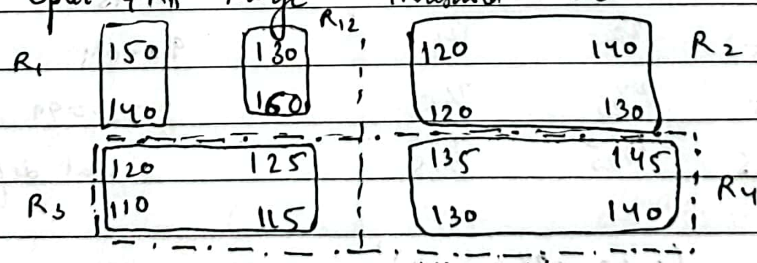
Neighbour: (1,2) (3,2) (2,1) (2,3)

(1,2) (3,2) < 10 Region 1

(1,2) (3,2) Neighbours: (1,1) (1,3) (3,1) (3,3)

0 0 0 0 0

Split & R_{11} merge threshold = 20



Min = 110 Max = 160

diff = 160 − 110 = 50

$R_1 \to$ splitting

No splitting $R_{2,3,4}$

Merge R_3 & R_4

$R_{11} \to R_3 \Rightarrow$ Not Possible

110 = 20

5 − 125 = 20

_/_/__

Q.

120	125	130	135	140
110	115	120	125	130
100	105	110	115	120
90	95	100	105	110
80	85	90	95	100

t = 115

255	255	255	255	255
0		255	255	255
0	0	0		255
0	0	0	0	0
0	0	0	0	0

Q.

	0	1	2	3	4
0	120	130 x	140 x	120	110
1	125 x	135 x	145 x	125 x	115
2	115	125 x	135 x	125 x	120
3	110	120	130 x	120	110
4	105	115	125 x	115	105

125, 130, 135, 140, 145

Q.

a_1	a_2	a	b
150	130	120	140
140 a_3	160 a_4	120	130
120	125	135	145
110	115 c	130	d 140

t = 20

140

160 - 110 = 50

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3	5	7	3	4	2	1
2	4	9	10	22	9	3
3	5	12	11	15	10	3
5	6	11	9	17	19	1
2	3	11	12	18	16	2
3	6	8	10	18	9	5
4	6	7	8	3	3	1

0	1	0	0	7	7	7	7	
1	0	2	2	7	7	7	7	
0	2	2	2	7	7	7	7	✓
4	4	2	2	7	7	7	7	
0	0	1	1	3	3	7	7	✓
1	1	2	2	3	7	7	7	
2	4	3	0	5	7	7	7	✓
2	3	3	5	5	0	7	7	

k-means problem

mean-shifting theory (steps)

K-SOM problem

2-3 iteration $\Delta w_{ij} = \begin{cases} \alpha(x_i - w_{ij}) & \text{neuron } j \text{ wins} \\ 0 & \text{neuron } j \text{ loss} \end{cases}$

dice coefficient

$f(v) = 1 \qquad g(v) = 1$

$f \rightarrow$ generated $\qquad g \rightarrow$ ground Truth

$$d = \frac{2|F \cap G|}{|F| + |G|}$$

(Tanimoto) Jaccard coefficient :

$$j = \frac{|F \cap G|}{|F \cup G|}$$

Hausdroff distance

$$h = \max\left(\inf_{f \in F} d(f, G), \inf_{g \in G} d(g, F) \right)$$

Q. $g = 120$ $\quad f = 110$ $\quad F \cap G = 100$

$$d = \frac{200}{120 + 110} = \frac{200}{230} = \frac{20}{23} = \cancel{0.45}\ 0.869$$

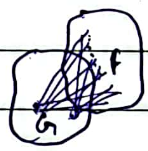
$$j = \frac{100}{130} = \frac{10}{13} = 0.769 =$$

$$F \cup G = 110 + 120 - 100 = 130$$

Q. Set A: $\{(1,2)\ (3,4)\ (5,6)\ (7,8)\}$ G

Set B: $\{(2,2)\ (4,4)\ (6,6)\ (8,8)\}$ F

Euclidican distance.



(1,2) to set B all value

$$\sqrt{(2-1)^2 + (2-2)^2} = 1$$

$$\sqrt{(4-1)^2 + (2-4)^2} = \sqrt{13}$$

$$\sqrt{(6-1)^2 + (6-2)^2} = \sqrt{41}$$

$$\sqrt{(8-1)^2 + (8-2)^2} = \sqrt{85}$$

Do corresponding calculation to nearest point

(1,2) to (2,2)

(3,4) to (4,4)

& vice versa

(4,4) to set A

$$\sqrt{\quad}$$

Sensitivity $\quad S_v = \dfrac{TP}{T} = \dfrac{TP}{TP + FN}$

Specificity $\quad S_p = \dfrac{TN}{N} = \dfrac{TN}{TN + FP}$

Chapter -4 (Books)
Representing, Storing & Visualization 3D Data

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Precision = $\frac{TP}{TP+FP}$

$F_\beta = (1+\beta^2) \cdot \frac{Pr.\ Rc}{\beta^2 . Pr + Rc} = \cancel{(1+\beta)^2}$

$ROC\ f(x) = (Sv(\alpha)\quad 1 - Sp(\alpha))$

Measures of quality: