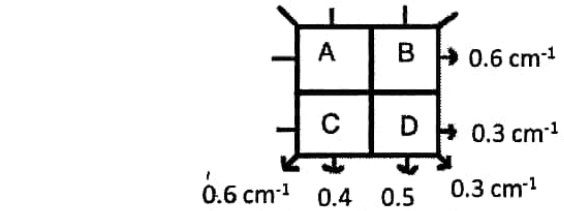
Mansoura University	Faculty of Engineering	Biomedical Engineering (BME) Program
		Time allowed: 60 min
		Exam is one page
		Assume any missing data
		Include and name all steps

Question # 1: [10 points] Mark true or false. If false, correct only the underlined words

1. X-ray imaging is excellent for imaging the soft tissues in brain
2. Computed tomography capture a 2D image of the object
3. The measure signal resulting from nuclear imaging is proportional to the number of molecular water in the tissue
4. The radiation resulting from x-ray imaging is safe
5. Gas filled and bony structures cannot be imaged using ultrasound imaging because they reflect ultrasound waves

Question # 2: [5 points] If the linear attenuation coefficient of water is 0.2 cm-1. Reconstruct the image values in **Fig. 1** using the iterative arithmetic reconstruction technique [i.e., compute the linear attenuation coefficient at each pixel of the image (i.e., the values A, B, C, and D)]. Compute the Hounsfield unit (CT number) at each pixel. Use the table given to determine the location of each pixel in the body.



Vertical, horizontal, and diagonal projections of a CT image

Hounsfield units in the body

Bone	+400 → +1000
Soft tissue	+40 → +80
Water	0
Fat	−60 → −100
Lung	−400 → −600
Air	−1000

Fig. 1 A CT image projections (left) and CT numbers in body (right)

Question #3: [5 points] The distance map function of a manually segmented registered training image of size 7x7 is computed as shown in Fig. 2. Compute all values of the distance map function and determine the values of the training image

?	?	?	?	?	?	?
?	1.4	1	1	1	1.4	?
?	1	0	0	0	1	?
?	1	0	-1	0	1	?
?	1	0	0	0	1	?
?	1.4	1	1	1	1.4	?
?	?	?	?	?	?	?

Fig. 2 A distance map function of a manually segmented registered training image

Scanned by CamScanner

Question #4: [5 points] If the intensity model of the object versus the back ground, where the object label is "1" and the background label is "0", is computed as follow:

Grey level, q	0	1	2	3	4	5	6	7	8	9
p(q,x=0)	0	0.025	0.025	0.025	0.045	0.055	0.05	0.05	0.1	?
p(q,x=1)	0.12	0.105	?	0.05	0.05	0.045	0.025	0.025	0.025	0

Assuming equal prior probabilities of the object and the background. Compute the marginal distribution of the grey level image p(y=q). Classify the following test image using the Bayes classifier.

Test Image

8	2	0	9
3	2	1	7
4	1	7	8
5	5	6	8

Question #5: [5 points] Using the expectation-Maximization algorithm (EM algorithm), the E-step responsibilities for 3x3 image were calculated as follows:

Image, Y

7	5	4
3	2	1
4	1	0
5	5	6

$\pi(x=0|\mathbf{Y})$

1	1	0.8
1	0.1	0
1	0	0
0.9	1	1

$\pi(x=1|\mathbf{Y})$

0	0	0.2
0	0.9	1
0	1	1
0.1	0	0

Compute the M-step. (i.e., find the updated prior portability, updated mean and variance for both the object and background distributions)

Hint: For K distributions, the rebonsability of each point at step m (in an image Y of size $I \times J$) is given by:

$$\pi_r^{[m]}(\omega_r \mid Y(i,j)=q)=\frac{w_r^{[m]}\varphi(q \mid \mu_r^{[m]},\sigma_r^{[m]})}{\sum_{l=1}^{K} w_l^{[m]}\varphi(q \mid \mu_l^{[m]},\sigma_l^{[m]})},\quad 1\le i\le I, 1\le j\le J$$

The prior probability (w_r at step $m+1$) is given by:

$$w_r^{[m+1]}=p(\omega_r)=\frac{\sum_{i=1}^{I}\sum_{j=1}^{J}\pi_r^{[m]}(\omega_r \mid Y(i,j)=q)}{\sum_{l=1}^{K}\sum_{i=1}^{I}\sum_{j=1}^{J}\pi_l^{[m]}(\omega_r \mid Y(i,j)=q)} \qquad 1\le r\le K$$

The mean and variance of each class are given by:

$$\mu_r^{[m+1]}=\frac{\sum_{i-1}^{I}\sum_{j=1}^{J}\pi_r^m Y(i,j)}{\sum_{i-1}^{I}\sum_{j=1}^{J}\pi_r^m} \qquad \left(\sigma_r^{[m+1]}\right)^2=\frac{\sum_{i-1}^{I}\sum_{j=1}^{J}\pi_r^m\left(Y(i,j)-\mu_1^{[M]}\right)^2}{\sum_{i-1}^{I}\sum_{j=1}^{J}\pi_r^m} \qquad 1\le r\le K$$

خالص امنياتى بالتوفيق

د. أحمد النقيب

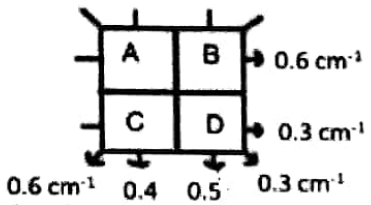
تمت الاسئلة

Scanned by CamScanner

Question # 1: [10 points] Mark true or false. If false, correct only the underlined words

1. (x) air (lungs) and bones
2. (x) 3D or 4D
3. (x) MRI
4. (x) harmful
5. (x) absorb ultrasound waves

Question # 2: [5 points] If the linear attenuation coefficient of water is 0.2 cm-1.



Vertical, horizontal, and diagonal projections of a CT image

Hounsfield units in the body

Bone	+400 → +1000
Soft tissue	+40 → +80
Water	0
Fat	−60 → −100
Lung	−400 → −600
Air	−1000

Initial

0	0
0	0

vertical

0.2	0.25
0.2	0.25

0.45 0.45

Horizontal

0.275	0.325
0.125	0.175

0.45 0.45

Diagonal

0.2	0.4
0.2	0.1

$1000 * (Mu - 0.2)/0.2$

0 water	1000 bone
0 water	-500 Lung

Question #3: [5 points]

distance map

2.8	2.23	2	2	2	2.23	2.8
2.23	1.4	1	1	1	1.4	2.23
2	1	0	0	0	1	2
2	1	0	-1	0	1	2
2	1	0	0	0	1	2
2.23	1.4	1	1	1	1.4	?
2.8	2.23	2	2	2	2.23	2.8

training image

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

Question #4: [5 points]

Grey level, q	0	1	2	3	4	5	6	7	8	9
p(q,x=0)	0	0.025	0.025	0.025	0.045	0.055	0.05	0.05	0.1	0.125
p(q,x=1)	0.12	0.105	0.055	0.05	0.05	0.045	0.025	0.025	0.025	0
P(q)	0.12	0.13	0.08	0.075	0.095	0.1	0.075	0.75	0.125	0.125

Test Image

8	2	0	9
3	2	1	7
4	1	7	8
5	5	6	8

classification

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

Scanned by CamScanner

Question #5: [5 points] Using the expectation-Maximization algorithm (EM algorithm), the E-step responsibilities for 3x3 image were calculated as follows:

Image, Y

7	5	4
3	2	1
4	1	0
5	5	6

$\pi(x = 0|\mathbf{Y})$

1	1	0.8
1	0.1	0
1	0	0
0.9	1	1

$\pi(x = 1|\mathbf{Y})$

0	0	0.2
0	0.9	1
0	1	1
0.1	0	0

W1=7.8/(7.8+4.2)=0.65 W2=0.35

Mu1= (7+5+0.8*4+ 3+2*0.1+4+5*0.9+5+6)/7.8=4.86

Mu2=(0.2*4+0.9*2+1+1+0.1*5)/4.2=1.214

Assume Mu1(initial)=4.8 and Mu2 (initial)=1.2

Var1=[(7-4.8)^2+(5-4.8)^2+0.8*(4-4.8)^2+(3-4.8)^2+(2-4.8)^2*0.1+(4-4.8)^2+ (5-4.8)^2*0.9+(5-4.8)^2+(6-4.8)^2)]/7.8

Var2=[0.2*(4-1.2)^2+0.9*(2-1.2)^2+(1-1.2)^2+(0-1.2)^2 (1-1.2)^2+0.1*(5-1.2)^2]/4.2

Scanned by CamScanner