Model Answer . Fall 2018-2019
ECE491] Medical Imaging

Medical Imaging, ECE 491	**Final Exam**	**Total Grade=50 Points**	**December 30th, 2018**

Mansoura University	Faculty of Engineering	Biomedical Engineering (BME) Program
		Time allowed: 120 min
		Exam is 4 pages
		Assume any missing data
		Include and name all steps

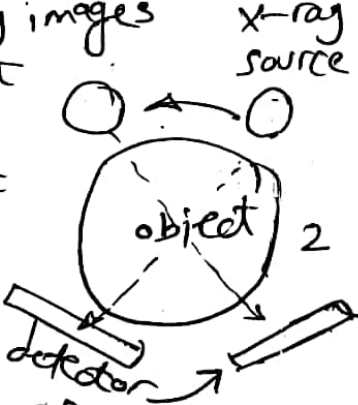<u>**Question #1 [5 points, equally distributed]**</u> Fill in the table below:

1.1. A data of size 100 sample is used for train and test using 5-fold cross validation. One should do a number of ......experiments with the number of training samples per experiment equals to .....

1.2. In Expectation-Maximization algorithm, the maximization step maximizes.....with respect to......

1.3. High frequency ultrasonic images (5-15MHz) has .... spatial resolution and...... penetration capabilities (select either low or high in each space)

1.4. To provide an average velocity measurement over large area, one should use ..... ultrasonic

1.5. The time constant of the decay of the relaxation process of hydrogen protons in the direction of the main magnet is described using .. ....-weighted MRI

1.1	five, 80 samples	1
1.2	the Likelihood (responsability) w.r.t M, σ	1
1.3	high, low	1
1.4	continious ~~mete~~ wave doppler	1
1.5	T1—weighted	1

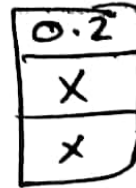| **Question # 2:** [5 points] Draw an illustration of CT image formation. List one advantage and one disadvantage and one application	**Question # 3:** [5 points] Describe how nuclear imaging is produced. Why beta particle are used in tumor therapy and not used in nuclear imaging.
• Take x-ray images at different angle * • Reconstruct cross-section image • advantage: 3D 1 • disadvantage: harmful 1 • application: follow lung nodules 1	• Introduce a radio-active isotope in the body 3 • Use a gama-camera detector to detect the radioactive decay • Beta particles have high energy and small half-valve layers so they are able to kill cancer cells only 2 • nuclear images require lower safe energy & higher HVL

Question # 4: [5 points] If the vertical projection of 3 pixel in a column is 0.8 cm^{-1}. One of the pixels is a water tissue with an attenuation coefficient of 0.2 cm^{-1}. The other two pixels are of same tissue. Determine their attenuation coefficient and their Hounsfield units

$$0.8 = 0.2 + 2\mu x \quad\quad 2$$

$$\mu x = \boxed{0.3}\, cm^{-1} \quad\quad 1$$

$$HU = 1000\,\frac{\mu x - \mu water}{\mu water} \quad\quad 1$$

$$HU = 1000\,\frac{0.3 - 0.2}{0.2} = \boxed{500} \quad\quad 1$$

0.2
X
X

↓

0.8

Question # 5: [5 points] A chest CT training image, composed of two classes, with number of pixels of each class shown in Figure. If the means μ and variances σ^2 of two image classes are estimated from training image. Describe how to build a parametric supervised model for each class intensity distribution. How to use this model in lung segmentation?

$$P(X = lung) = \frac{46870}{46870 + 86472}$$

$$P(X = lung) = 0.35|5$$

$$P(X = chest) = 0.6485 \quad\quad 1$$

*Assume that classes follow Gaussian distribution

$$\therefore P(X = lung \mid y) = \frac{P(y \mid X = lung)\, P(X = lung)}{P(y)} \quad\quad 1$$

$$= \frac{0.35\,\frac{1}{\sqrt{2\pi\sigma_1^2}}\, e^{-\frac{(y-\mu_1)^2}{2\sigma_1^2}}}{P(y)}$$

Similarly:

$$P(X = chest \mid y) = 0.65\,\frac{1}{\sqrt{2\pi\sigma_2^2}}\, e^{-\frac{(y-\mu_2)^2}{2\sigma_2^2}}\quad\frac{1}{P(y)} \quad\quad 1$$

For classification (using Bayes classifier):

for agey level y:

    if $P(X = lung \mid y) \geqslant P(X = chest \mid y) \Rightarrow$ select lung.   2

    otherwise $\Rightarrow$ select chest

Original image   Class 1: chest μ_1, σ_1^2 Class 2: Lung μ_2, σ_2^2

No_Pixels = 86472   No_Pixels = 46870

Question # 6: [5 points] A given image Y with two classes $x = 0$ and $x = 1$. Compute only the prior probabilities and the mean of class $x = 0$ in the M-step of EM algorithm, for the following estimated 4x3 E-step responsibility $\pi(x = 0|Y)$ for class $x = 0$:

Image; Y			$\pi(x = 0|Y)$		
7	5	6	1	1	0.9
8	4	1	1	0.1	0
4	1	0	0	0	0
2	2	4	0	0	0

$$P(w_0) = \frac{\sum\sum \pi_0}{\sum\sum \pi_0 + \sum\sum \pi_1} = \frac{4}{12} = \boxed{\frac{1}{3}}$$

$\leftarrow$ size of image

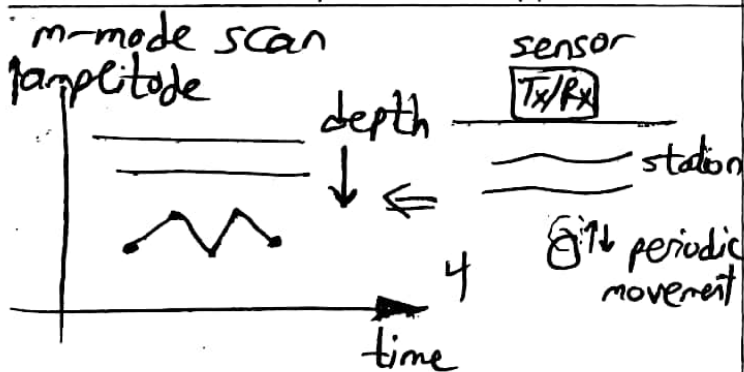$$P(w_1) = 1 - P(w_0) = \boxed{\frac{2}{3}}$$

$$\therefore \mu(\text{class } x=0) = \frac{\sum\sum Y(i,j)) \pi_0}{\sum\sum \pi_0} \cdot \frac{1}{1} = \frac{7+5+0.9\times6+8+0.1\times4}{4}$$
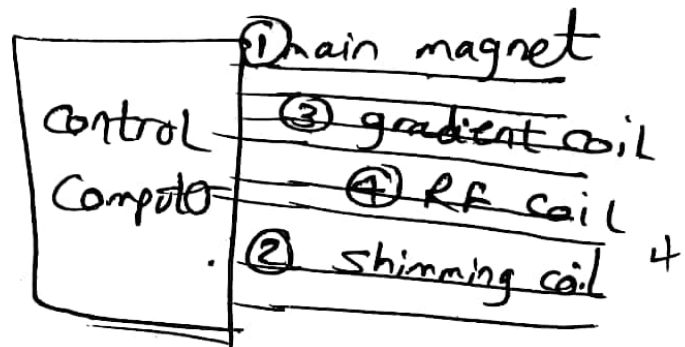
$$\mu_0 = \boxed{6.45}$$

Question # 7: [5 points] Sketch an M-mode ultrasonic scan example. List one application

application:
infant cardiac imaging

Question # 8: [5 points] Sketch an MRI scanner. What is the condition that an atom is MRI active?

* atom is MRI active if the total number of protons and neutrons is an odd number

Question # 9: **[5 points]** Given a probabilistic shape model **for the object** Pshape(object) estimated from 5 training images.

- What is the condition needed for the training images to estimate the shape model from them?
- How many training images are labeled as background for the shaded pixel?
- Classify the test image based on this model.

Pshape(object)			Test image		
1	1	0.8	9	8	7
0.6	0.4	1	4	5	2
0	0.2	0	0	1	0

• They must be registered 1

• One pixel from the 5 images 1

classification $\Rightarrow$

3

1	1	1
1	0	1
0	0	0

1 → object

0 → Background

Question # 10: **[5 points]** A Doppler shift ultrasound scanner transmits an ultrasound wave with a frequency of **2MHz**. A blood cell moving with a velocity of 2000 m/sec away from the transducer. Compute the frequency of the received echo from the moving blood cell. Recalculate the frequency if the blood cell is stationary and no longer moving [due to a clot (تجلط)].

Assume that $c = 350$ m/s 1 (any speed is acceptable)

$$f_r = \frac{f_t\, c}{c+u}\cdot 2 = \frac{2\times10^6 \times 350}{350 + 2000} = 0.15\ MHz$$

* if $\boxed{u=0}$ $\Rightarrow$ $f_r = f_t = \boxed{2} MHz$ 1

"Note that the velocity of the blood is unrealistic"

د. أحمد النقيب   خالص امنياتى بالتوفيق   تمت الاسئلة