Department of Electrical Engineering
Indian Institute of Technology Kharagpur

Medical Image Analysis (EE61008)

End-Semester Examination **Spring, 2014-15**

Credits: 4 Full Marks: 80 Duration of Examination: 3 hours

Date: Tuesday, 28 April 2015, 9-12 AM

Instructions:

1. All questions are compulsory. Marks are indicated in parentheses.
2. Please write your name, roll number, subject name and code, date and time of examination on the answer script before attempting any solution.
3. Use of only electronic calculators is permitted.
4. No extra resources viz. graph papers, log-tables, trigonometric tables would be required.

Question 1:

Identify the following in Fig. 1

(a) Organ? (1) Liver

(b) Plane of imaging? (Transverse, Sagittal, Coronal) (1) Transverse

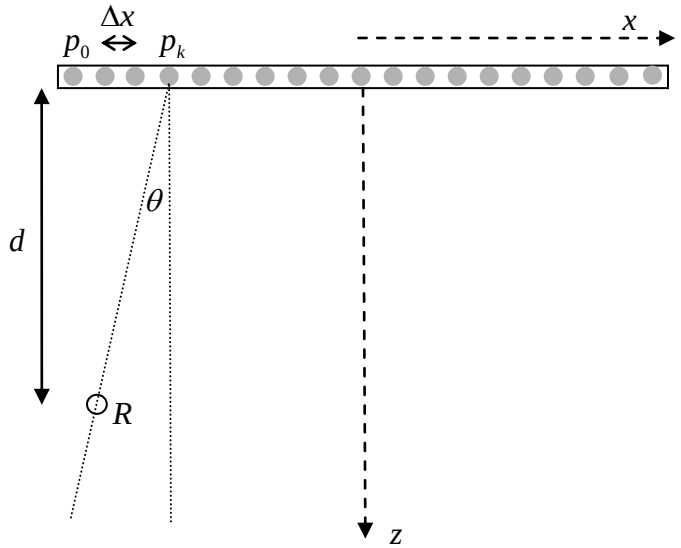
(c) Modality of Imaging? (1) Ultrasound

(d) Structure / anatomical location of interest? (1) Abdomen (Lower)

Fig. 1.

Question 2:

A linear geometry ultrasound transducer has the elements arranged as per the following configuration. The velocity of sound in the media it propagated through it is c and the frequency of the transducer is f.



Let $t_{k,R}$ be the time taken by the ultrasonic pulse originating at the transducer element p_k to reach the point marked as R. Similarly the time taken by the ultrasonic pulse echoed from R to reach the transducer element p_k be $t_{R,k}$. Please answer the following.

(a) Prove that $t_{k,R} = t_{R,k}$ under the specified conditions. (5)

Compute distance between p_k and R. Since speed of sound is same in the same media, so you would mathematically deduce that t_{k,R} = t_{R,k}

(b) If P_k^0 is the power of the ultrasonic pulse emitted at p_k, then what is the power of the echo pulse received at p_{k+1}? (10)

(c) What will be the change in the pressure of the received echo pulse at p_{k+1} if the operating frequency is changed from 10MHz to 40MHz? (6)

Attenuation at 40MHz is higher than at 10MHz

Question 3:

Consider that you are provided with a 2.5T MRI scanner which has a slice encoding gradient of 40 mT/M. If you are typically required to scan a whole human body (height = ~200 cm), then answer the following

(a) What would be the minimum and maximum magnetic field created in the slide encoding direction? (3)

Min = 2.5 T and Max = 2.58 T

(b) What would be the step size in scanning frequency needed to achieve a slice resolution of 4 mm? (8)

Freq. step size = 6.8128 kHz

(c) What would be the range of Larmour frequencies generated by activating only the slice encoding gradient in this configuration? (4)

f_min = 106.45 MHz and f_max = 109.86 MHz

Question 4:

Consider the challenge of registering the image B on to the image A, such that the image B can be rotated by some predefined angle about the underlined pixel.

$$A = \begin{bmatrix} 128 & 150 & 176 & 0 \\ 160 & 168 & 1 & 0 \\ 157 & \underline{0} & 0 & 1 \\ 163 & 129 & 150 & 160 \end{bmatrix} \quad B = \begin{bmatrix} 138 & 0 & 0 & 1 \\ 163 & 1 & 0 & 150 \\ 157 & \underline{0} & 138 & 164 \\ 163 & 129 & 150 & 160 \end{bmatrix}$$

(a) Evaluate the quality-of-fit measure (QoF) by rotating B and matching it to A at the following angles (0°, 45°, 90°, 135°, 180°) counter-clockwise about the underlined pixel using the following metrics.

i. Mean square deviation (5)

ii. Correlation coefficient (5)

(b) Find the best match based on these metrics and report on the angle of rotation corresponding to the best match? (5)

180 degs

Question 5:

Compute the edge weights at the underlined pixel location in a random walks solver for the 8-connected graph representation of an ultrasound image where similarity across pixels in a scan-line is 100 times less likely to be compared to similarity of pixels along a scan-line. Pixels across diagonal are 10 times more likely to be similar compared to similarity across scan-lines. The scan-lines are vertical. (10)

$$g = \begin{bmatrix} 67 & 72 & 1 & 0 & 10 & 11 \\ 5 & 32 & 1 & 1 & 9 & 57 \\ 15 & 23 & 0 & \underline{2} & 11 & 20 \\ 10 & 10 & 1 & 0 & 1 & 23 \\ 10 & 3 & 1 & 1 & 2 & 22 \\ 10 & 10 & 1 & 1 & 2 & 29 \end{bmatrix}$$

beta_v = 100 beta_H , and beta_D = 10 beta_H.

Question 6:

(a) Compute the TP, FP, TN, FN, Precision, Recall, Sensitivity, Specificity, F-Score, Accuracy for the following RGB color image segmentation problem of optical microscopic histology I and its ground truth M. Seed for Class 0 is {(9,9,9)} and Class 1 is {(0,0,0)}. (10)

$$I = \begin{bmatrix} (1,1,2) & (1,1,1) & (0,0,1) & (10,2,4) \\ (0,1,2) & (1,3,4) & (10,1,2) & (1,3,1) \\ (0,0,0) & (9,9,9) & (9,8,9) & (10,2,10) \\ (1,1,1) & (1,2,1) & (9,10,11) & (10,11,10) \end{bmatrix} \quad M = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 \end{bmatrix}$$

(b) Find the entropy of class distribution of the two classes? (5)

seg = [1 1 1 0; 1 1 1 1; 1 0 0 0; 1 1 0 0]