EE 637 Midterm Exam #2

Session 35

April 6, Spring 2001

Name: ____________________________________

Instructions:

- Follow all instructions carefully!
- This is a 50 minute exam containing **three** problems.
- You may **only** use your brain and a pencil (or pen) to complete this exam. You **may not** use your book, notes or a calculator.

Good Luck.

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Problem 1.(33pt)

An image is partitioned into 4 clusters. For each cluster, there are two features:

$$\begin{aligned} N_i &= \text{\# of pixels} \\ \mu_i &= \text{average pixel gray level} \end{aligned}$$

The features for each cluster are listed below.

Cluster Feature Table

index i	N_i	μ_i
1	10	1.0
2	10	16.0
3	10	20.0
4	10	3.0

The distance between each cluster pair is measured by

$$d_{i,j} = (N_i + N_j) * |\mu_i - \mu_j| \ ,$$

and if clusters i and j are merged to form cluster k then the features for cluster k are computed as

$$\begin{aligned} N_i &\leftarrow N_i + N_j \\ \mu_i &\leftarrow \frac{N_i \mu_i + N_j \mu_j}{N_i + N_j} \ . \end{aligned}$$

a) Merge the two nearest clusters to form a 3 cluster partition of the image. (You may label the new cluster with index $i = 5$.)

   i. Specify the distance between the merged clusters.

   ii. Specify the clusters that are merged.

   iii. Write out the new "Cluster Feature Table" for the three remaining clusters.

b) Repeat the steps of a) to form a 2 cluster partition of the image. (You may label the new cluster with index $i = 6$.)

c) Repeat the steps of a) to form a 1 cluster partition of the image. (You may label the new cluster with index $i = 7$.)

d) Draw a binary tree which shows the clustering process. Label each leaf node of the tree with the associated cluster index, and label internal nodes of the tree with the associated cluster distance.

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Problem 2.(33pt)

Let $X(m,n)$ be a gamma corrected image with $\gamma = 2.2$; let $Y(m,n)$ be a linear lumanance version of the same image, and let $Z(m,n)$ be a gamma corrected version of the same image but with $\gamma = 1.8$. Assume that each image is scaled to the range 0 to 255.

a) Calculate an expression for $Y(m,n)$ in terms of $X(m,n)$.

b) Calculate an expression for $Z(m,n)$ in terms of $X(m,n)$.

c) Further assume that $Y(m,n)$ a gray ramp computed in a C program using the following C code.

```
unsigned char Y[256][256];
for(i=0; i<256; i++)
for(j=0; j<256; j++) {
  Y[i][j] = j;
}
```

The 2-D array, `Y[i][j]`, is written out to a file in tiff gray level image format, and subsequently displayed on a CRT with $\gamma = 1.0$.

i. Which side of the image will appear dark?

ii. What artifacts are you likely to see in the image and why?

iii. What part of the image will these artifacts appear in and why?

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Problem 3.(34pt)

Imagine that you have an (r, g, b) display device, and the color transformation to XYZ is given by

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} r \\ g \\ b \end{bmatrix} .$$

a) What is the white point of the display device?

b) What are the chromaticity values of the **R**, **G**, and **B** primary colors?

c) Sketch the standard chromaticity diagram and label the three points corresponding to the primaries of the display device.

d) Indicate which colors can and cannot be displayed by this device.

e) Can this device be built? Why or why not?

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