南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

Course Name： EE326 Digital Image Processing **Dept.：** EEE

Exam Duration： 2 hours **Exam Paper Setter：** Yu Yajun

Question No.	1	2	3	4	5	6	7	8	9	10
Score	25	20	25	30	-	-	-	-	-	-

This exam paper contains 4 questions and the score is 100 in total. (Please hand in your exam paper, answer sheet, and your scrap paper to the proctor when the exam ends.)

1. (i) Image subtraction is used often in industrial application for detecting missing components in product assembly (装配). The approach is to store a "golden" image that corresponds to a correct assembly; this image is then subtracted from incoming images of the same product. Ideally, the differences would be zero if the new products are assembled correctly. Difference images for productions with missing components would be nonzero in the area where they differ from the golden image. **What conditions do you think have to be met in practice for this method to work?**

   (ii) Give a single linear intensity transformation function for spreading the intensities of an image to the lowest intensity being C and the highest being $L-1$. (Hint: you may sketch the input versus output intensity transfer characteristics and use geometrical relation to find the transformation function).

   (iii) Two images, $f(x,y)$ and $g(x,y)$, have histograms h_f and h_g. Give the condition under which you can determine the histograms of $f(x,y)+g(x,y)$, and describe the histogram of the resultant image.

(25 marks)

2. The image in Fig. 1 is composed of stripes and borders with solid colors indicated by the words shown. All colors are at maximum intensity and saturation, except that the gray border has intensity level 128. Assume that the maximum value of each channel for color images is 255.

   (i) Sketch the RGB component (one image for each component) of the image as they would appear on a monochrome monitor by indicating the gray level for each stripe.

(ii) Sketch the HSI component (one image for each component) of the image as they would appear on a monochrome monitor by indicating the gray level for each stripe and the gray border. You may refer to the illustration of HSI model shown in Fig. 2.

(20 Marks)

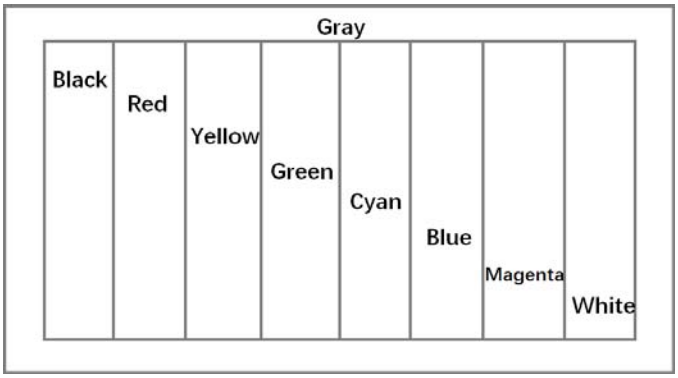

Fig. 1

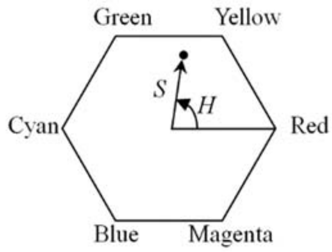

Fig. 2

3. The basic global thresholding for the image segmentation can be realized by using the following iterative algorithm.

Step 1. Select an initial estimate for the global threshold T.

Step 2. Segment the image $f(x,y)$ using T by

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

This will produce two groups of pixels: G_1 consisting of all pixels with intensity values $> T$, and G_2 consisting of pixels with values $\le T$.

Step 3. Compute the mean intensity values m_1 and m_2 for the pixels in G_1 and G_2, respectively.

Step 4. Compute a new threshold value: $T = \frac{1}{2}(m_1 + m_2)$

Step 5. Repeat Steps 2 through 4 until difference between values of T in successive iterations is smaller than a predefined parameter ΔT.

Answer the following questions:

(i) Restate the basic global thresholding algorithm so that it uses the histogram of an image instead of the image itself.

(ii) Give an explanation why the initial threshold in the basic global thresholding algorithm must be between the minimum and maximum values in the image. (Hint: Construct an example of histogram that shows the algorithm failing for a threshold value selected outside this range).

(iii) Assume that the intensity level of images is in the range $[0,\ L-1]$. Prove that if the histogram of an image is uniform overall all possible intensity levels, the basic global thresholding algorithm converges to the average intensity level of the image, $(L-1)/2$.

(25 Marks)

4. Consider a binary image shown in Fig. 3. The black border was added for clarity. It is not part of the data. The white and black in the image are assumed with intensity values of 1 and 0, respectively.

Fig. 3

(i) Sketch the horizonal intensity profile through the middle of the image.

(ii) Draw what the profile would look like after the image has been blurred by an averaging mask of size $n \times n$, with coefficients equal to $1/n^2$. Assume that the size of the mask is much smaller than the image, so that image border effect are not a concern near the center of the horizontal intensity profile.

(iii) Suppose that we compute the gradient magnitude of the original image and the blurred image using the Prewitt masks. Sketch the horizontal intensity profiles of the two gradient images. The Prewitt mask is given in Figure 4(a).

(iv) Suppose that we compute the gradient magnitude using Laplacian operator. Sketch the horizontal intensity profiles of the two Laplacian images, assuming that the Laplacian is computed using the 3 × 3 mask given in Figure 4(b).

(**Note:** Answer this question without generating the images. Simply provide sketches of the profiles that show what you would expect the profiles of the images to look like).

(30 Marks)

−1	−1	−1
0	0	0
1	1	1

−1	0	1
−1	0	1
−1	0	1

Fig. 4(a)

1	1	1
1	−8	1
1	1	1

Fig. 4(b)

-- End of Exam Paper --