International Institute of Information Technology, Hyderabad
(Deemed to be University)

Digital Image Processing (CSE/ECE 478) - Monsoon-2018

Mid-semester Examination 1

Maximum Time : 90 Minutes Total Marks : 100

Roll No. _____ Programme _____ Date _____

Room No. _____ Seat No. _____ Invigilator Sign. _____

Marks secured

Multiple Choice Questions

Question:	1	2	3	4	5	6	7	8	9	10	Total
Points:	2	2	2	2	2	2	3	5	5	5	30
Score:											

Long Questions

Question:	11	12	13	14	15	Total
Points:	15	5	15	20	15	70
Score:						

General Instructions to the students

1. Place your Permanent / Temporary Student ID card on the desk during the examination for verification by the Invigilator.
2. **QUESTION BOOKLET NEEDS TO BE RETURNED ALONG WITH ANSWER SHEETS. PLEASE TIE TOGETHER YOUR ANSWER SHEETS AND QUESTION BOOKLET, WITH THE BOOKLET ON TOP.**
3. Multiple-choice questions can be answered within the question booklet itself.
4. **No questions will be answered during the exam. Make necessary assumptions and proceed.**

Best of Luck

Multiple Choice Questions

For the following questions, circle ALL the correct answers. (Note: Partial marks will not be given for partially correct answers.)

1. (2 points) In 4-neighbors and 8-neighbours of a pixel p, how far are each of the neighbours located from p ?

   A. one pixel apart for both 4-neighbor and 8-neighbor

   B. 4 pixels apart for 4-neighbor and 8-neighbor

   C. 4 pixels apart for 4-neighbor and 8 pixels apart for 8-neighbor

   D. None of the above

2. (2 points) Assume a 8-bit grayscale image of size 256×128 as input. Applying which of these filters on input image does not involve floating point operations ?

   A. 3×3 `min` filter B. 5×5 `average` filter C. 3×3 Gaussian filter D. 7×7 `median` filter

3. (2 points) The process of digital image creation involves digitization of intensities in the range of the signal. This process is called _____

   A. Finite Resampling B. Quantization C. Sampling D. Contrast Stretching

4. (2 points) Which of the following is a second-order derivative operator?

   A. Histogram B. Gaussian C. Laplacian D. Sobel

5. (2 points) Suppose h_A is the histogram of image A. Histogram equalization is a special form of histogram matching where we try to find a transformation of A such that,

   A. h_A matches a monotonically increasing histogram.

   B. h_A matches a uniformly distributed histogram.

   C. h_A matches the histogram of an image of same size as A, but all intensity values are 255.

   D. h_A matches a Gaussian distributed histogram.

6. (2 points) For the histograms shown below which statements are true?

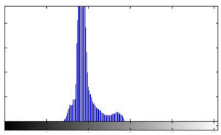
   

   Image A histogram

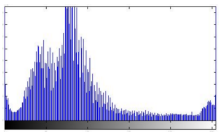
   

   Image B histogram

   A. B has higher contrast compared to A

   B. A and B are both have the same contrast

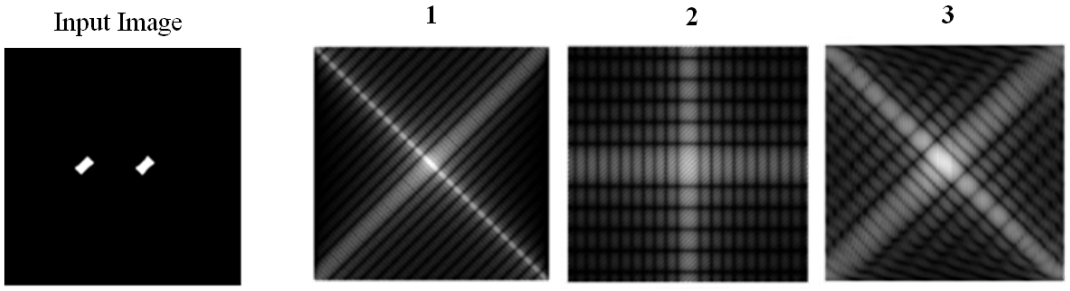
   C. A has higher contrast compared to B

   D. There is no information about contrast.

7. (3 points) A 32×32 grayscale image with 64 possible intensity values (gray levels) requires _____ bits of storage.

   A. 8192 B. 6144 C. 65536 D. 4096

8. (5 points) Which images is most likely the fourier transform of input image?



A. 1 B. 2 C. 3 D. Image obtained by adding images 1 and 2

9. (5 points) $x(t) = A\cos t + B\sin t$ is a periodic function with period,

A. 2π B. π C. $(A+B)\pi$ D. $\sqrt{(A^2+B^2)}\pi$

10. (5 points) Function f is used to convert the 8-bit left image to the binary image on the right. What values of K_1, and K_2 would produce the image on the right? (Assume gray value of IKEA lettering in the left image to be 128.)

$$z' = f(z) = \begin{cases} 0, & \text{if } K_1 < z < K_2 \\ 1, & \text{otherwise} \end{cases}$$

A. $K_1 = 0$, $K_2 = 255$

B. $K_1 = 16$, $K_2 = 32$

C. $K_1 = 100$, $K_2 = 200$

D. $K_1 = 200$, $K_2 = 255$

Long Questions

Write detailed answers. Adequately explain your assumptions and thought process.

11. (15 points) Prove or disprove: bilateral filter (definition below) is a non-linear filter. A is linear if it satisfies $A(f+g) = A(f) + A(g)$ and $A(cf) = c\,A(f)$, c is a constant.

In the bilateral filter, the output pixel value depends on a weighted combination of neighboring pixel values

$$g(i,j) = \frac{\sum_{k,l} f(k,l)w(i,j,k,l)}{\sum_{k,l} w(i,j,k,l)}.$$

The weighting coefficient $w(i,j,k,l)$ depends on the product of a *domain kernel*

$$d(i,j,k,l) = \exp\left(-\frac{(i-k)^2+(j-l)^2}{2\sigma_d^2}\right),$$

and a data-dependent *range kernel*

$$r(i,j,k,l) = \exp\left(-\frac{\|f(i,j)-f(k,l)\|^2}{2\sigma_r^2}\right).$$

When multiplied together, these yield the data-dependent *bilateral weight function*

$$w(i,j,k,l) = \exp\left(-\frac{(i-k)^2+(j-l)^2}{2\sigma_d^2} - \frac{\|f(i,j)-f(k,l)\|^2}{2\sigma_r^2}\right).$$

12. (5 points) Suppose the total number of pixels in a grayscale image is M and the total number of possible intensity levels in the image is L (e.g. for an 8-bit image, $L = 256$). Suppose n_j represents the number of pixels in the image that have intensity value $r_j, 0 \leqslant r_j \leqslant (L-1)$. Performing histogram equalization on the image maps intensity $r_k, 0 \leqslant r_k \leqslant (L-1)$ to a new intensity value $s_k, 0 \leqslant s_k \leqslant (L-1)$. Write the formula for s_k in terms of k, n_j, L and M.

13. (15 points) What would be the loss of information for 2-bit and 3-bit quantization of the following 8-bit images? Measure loss in terms of mean squared error (MSE) between normalized intensities before and after quantization. The MSE between two arrays a, b of length n is given as $e = \frac{\sum_{j=1}^{j=n}(a_j - b_j)^2}{n}$. Intensities in a k-bit image can be normalized by dividing each pixel intensity by $2^k - 1$.

0	255	0	255
255	0	255	0
0	255	0	255
255	0	255	0

112	96	80	64
256	16	32	48
128	144	160	176
240	224	208	192

14. (20 points) Consider the following 1×8 image and 1x3 filters. What would be the result images produced by applying the filters to the input image in the following ways? (Stride refers to the shift/increment in filter position at each step)

100	100	0	20	40	80	100	100

Input image

1	0	-1

Filter 1

-1	2	-1

Filter 2

- No padding, stride = 1
- Zero padding by 1 pixel on both ends, stride = 1
- No padding, stride = 2
- Zero padding by 1 pixel on both ends, stride = 2

15. (15 points) Your have taken a picture of your friend but she is not happy with the photo and want you to edit it such that the background is blurred while she is looking sharp with all the details. Assuming that you are given a binary mask image where 0 indicates background and 1 indicates foreground, write pseudo-code that uses the input image and the binary mask and produces the desired effect using spatial filtering operations. Make necessary assumptions regarding size of the picture and mask. Also make sure you include enough detail/comments in the pseudo-code.

Input Image


Foreground Mask

Edited Image