INDIAN INSTITUTE OF INFORMATION TECHNOLOGY, ALLAHABAD

End Semester Examination May 2018

IHM2015005

Date of Examination (Meeting): 01/05/2018 (2:00PM-5:00PM)

Program Code & Semester: B.Tech.(IT), Dual degree B.Tech-M.Tech. - 6th Sem.
Paper Title: Image and Video Processing
Paper Code: IIVP632C
Paper Setter: Dr. Pavan Chakraborty and Dr. S. K. Singh

Max Marks: 75 **Duration: 3 Hours**

Note: Simple Scientific Calculator allowed. Answers should be brief and to the point.

Q1. Suppose that we have an image with 8 vertical strips of same widths but constant shades. The shades are quite distinct and can be perceived uniquely by the human eyes. Suppose a human observer is tracing the image along a horizontal line then plot the intensity profile as perceived by him/her. The intensity profile only depends upon the brightness of the image or something else? If yes, then suggest the image processing solutions to perceive the brightness as a simple function of illumination.

[2]

Q2. Suppose that a flat area with the centre at (x_0, y_0) is illuminated by a light source with intensity distribution,

$$I(x,y) = Ke^{-[(x-x_0)^2+(y-y_0)^2]}$$

Assume that the reflectance of the area is constant and equal to 1, and K=255. If the resulting image is digitized with the k-bits of intensity resolutions and an eye can detect an abrupt change of 16 shades of intensity between adjacent pixels, what value of k will cause the visible false contouring.

[2]

Q3. SMART an indigenously developed Robot at IIITA, worked mainly as a lab guide. The robot has a camera on its forehead. At specific locations of the lab, visible to the camera of the robot, are color sheet of A4 size paper attached as color tags. They serve as markers to different locations of the lab. Note that these colors are unique and does not form part of any other object in the lab. The robot identifies these colors and moves towards them. It stops at a safe distance from the colored marker and through a speech to text engine describe the lab equipment in front of which it is standing. Please note, the indoor lights of the lab are regulated and the range of RGB values $\{(R_1^i|R_2^i)\ \ (G_1^i|G_2^i)\ \ (B_1^i|B_2^i)\}$ of all the color $tags(i)$ are pre-programmed in the robot. Please note due to illumination, a single colored sheet shows a rage in RGB values: $\{(R_1 \mid R_2)\ (G_1 \mid G_2)\ (B_1 \mid B_2)\}$.

Describe the image processing steps (Through a pseudo code) done by the robot as it captures the images from the streaming video of its camera.

(a). Robot rotates on the spot and identifies the location through color tags, towards which the robot has to move.

(b). Robot centers the location of the color tag to the image center and moves towards the marker.

(c). Robot stops at a safe distance from the colored marker. (Note, due to perspective projection an object appears bigger in the image when it is closer and occupies a large part of the image).

[2+2+2=6]

Q4. Why there is a need of low pass filtering in the form of smoothing by using averaging or Gaussian or any other method, while finding the edges or lines, which are mainly the fine details or high-pass features of the images? Justify your answer using a suitable example. We know very well that the Prewitt operator is used to extract the edges and lines. Do the Prewitt also apply the low pass filtering before the fine details extraction? If yes then prove the same.

[5]

Q5. Why the second derivative filters are more suitable for image processing applications over the first derivative filters? Consider the following spatial domain image enhancement process,

$$g(x,y) = Af(x,y) - \nabla^2 f(x,y)$$

Where $g(x,y)$ is the enhanced version of the original image$f(x,y)$? What is the effect on the enhanced image while taking the value of the coefficient A 1 and 1.5 respectively? Is it possible to get the $g(x,y)$ using some filter-mask processing? If yes then derive the 3x3 mask for the same? What is the effect on computational complexity?

[5]

Q6. The results obtained by a single pass, through an image of some 2-D mask can be achieved also by two pass using 1-D masks. For example, the same result of using a $3x3$ smoothing mask with coefficient $1/9$ can be obtained by a pass of the mask M_1 followed by the second pass of the mask M_2 on the result obtained in the first pass. Where $M_1 = [1 \quad 1 \quad 1]$ & $M_2 = [1 \quad 1 \quad 1]^T$. The final result is then scaled by $1/9$. Show that, the Sobel mask can also be implemented with the help of two masks to be used in two pass process.

[5]

Q7. A certain imaging geometry produces a blurring degradation that can be modeled as the convolution of the sensed image with the spatial circularly symmetric function, $h(r) = \left[\frac{(r^2-\sigma^2)}{\sigma^4}\right] e^{-r^2/2\sigma^2}$ i.e. $r^2 = x^2 + y^2$. Find out the degradation function in frequency domain. Now using the obtained degradation function give the expression for the Wiener filter, assuming that the ratio of the power spectra of noise and undegraded signal is constant.

[10]

Q8. Consider a problem of image blurring caused by the uniform acceleration in y-direction during the capturing of an outdoor scene. If the image device is at rest at $t = 0$ and accelerates with a uniform acceleration $y_0(t) = at^2/T$ for a time duration T, which is also the exposure time of scene to the imaging device. It has been observed that the captured image has been degraded and looks blurry in the y-direction. It is required to remove this kind of motion blur from the captured image. How this motion blur can be removed? Suggest a possible solution for the same. Is it possible to model the degradation caused by the blurring, if yes then find the degradation / blurring function $H(u,v)$. Assume that the imaging device's shutter opening and closing time are infinitesimal.

[10]

Q9. Suppose that an image the gray level probability density functions shown in figure-1. Here, $p_1(z)$ corresponds to the object and $p_2(z)$ corresponds to the background. Assume that, the areas occupied by the foreground (object) and background is same in the digital image. You are required to recognize the object present in the image using traditional handcrafted feature based techniques. For recognition it is required to separate the object form the background. How this object can be separated from the background? Find the optimal threshold between the object and the background pixels.

[5]

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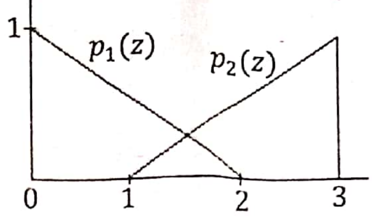

Figure-1

Q10. Let A denote the set shown shaded in the figure-2. Refer to the structuring elements as shown (the black dots denote the origin). Sketch the results of the following morphological operations (a)-(b).

[2.5x2=5]

(a). $(A \ominus B^4) \oplus B^2$
(b). $(A \ominus B^1) \oplus B^3$ where $\ominus$ is erosion and $\oplus$ is dilation operators.

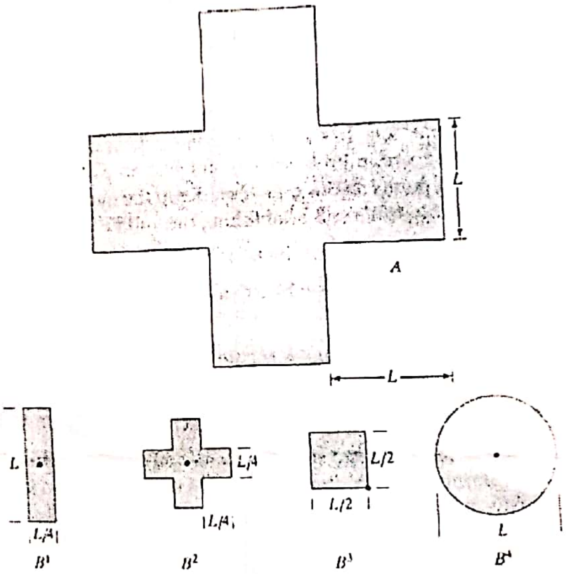

Figure-2

Q11. Why the Butterworth filters are preferred over the other ideal filters? The transfer function of the Butterworth low pass filter (BLPF) of order n and cutoff frequency D_0 from the origin is given as,

$$H_{lp}(u,v) = \frac{1}{1 + [D(u,\ v)/D_0]^{2n}}$$

Where, $D(u,v) = \left[\left(u - \frac{M}{2}\right)^2 + \left(v - \frac{N}{2}\right)^2\right]^{1/2}$ and u, v are the frequency axes for an MxN image. The response of the filter depends upon the parameters D_0 and n.

(a). What are effects of D_0 and n on filtered image output?

(b). Is there any relation of the transfer functions of BLPF and BHPF? If yes then find out the transfer function of the 2nd order BHPF.

(c). If the cutoff frequencies for the 2nd order BLPF and BHPF are D_1 & D_2 then suggest how to realize the 2nd order Butterworth Band Pass Filter (BBPF) and Band reject Filter (BBRF) using the cascaded arrangements of the transfer functions in the frequency domain.

[3+2+5=10]

Q12. A ceiling fan rotates with an angular velocity ω. One of the fan blades is colored differently and can act as a marker. A video camera with 25 frames per second takes the video of this fan. In the video the fan is seen to rotate in the opposite direction and makes a full rotation in 72 frames.

(a). What is the perceived angular velocity ω_p in Hz. of the ceiling fan?

(b). What is the actual angular velocity ω in Hz. of the ceiling fan?

(c). What should be the video camera frame rate per second so that the fan appears to move forward by 5^o in every frame?

[1+2+2=5]

Q13. All of us have come across bar codes on several products. It is used to encode a unique 12 digit number. The black and white strips are always printed of width equal to some multiple (either 1, 2, 3 or 4) of a unit width. The table shown below gives the bar code for each number. For example, the number 7 is given by a sequence of White "W", Black "B", White "W" and Black "B" strips each of width 1, 3, 1, and 2 units respectively. Note that each number uses a total 7 unit width strips. The bar code always begins and ends with a sequence of Black-White-Black strips of unit width. In between, the strips encoding the 12-digit number are printed. Design a system that automatically decodes this number from an image (without using character recognition). Describe your system briefly as a flowchart, starting from image acquisition to decoding the 12 digit number, specifying the inputs and outputs of each module. Clearly state the assumptions used and issues involved. Assumptions, if too restrictive, may cost you marks.

[5]

Number	W	B	W	B
0	3	2	1	1
1	2	2	2	1
2	2	1	2	2
3	1	4	1	1
4	1	1	3	2
5	1	2	3	1
6	1	1	1	4
7	1	3	1	2
8	1	2	1	3
9	3	1	1	2

Reallife examples have been shown below.