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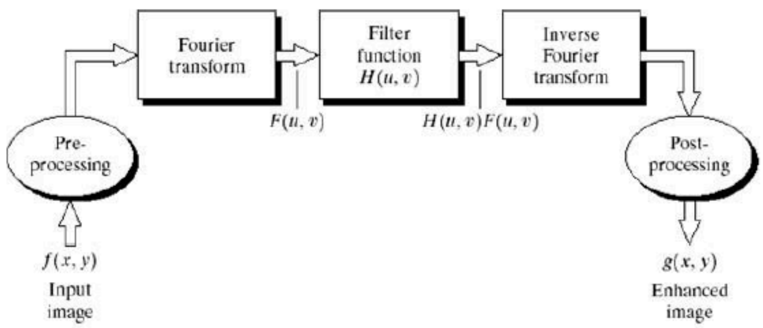
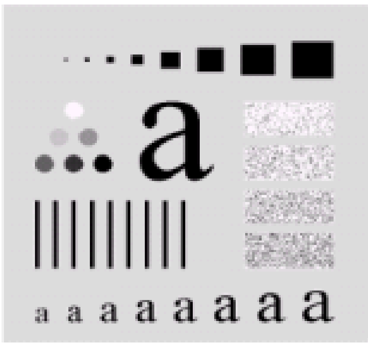
Internal Assessment Test 3 – Jan 2024
SOLUTION AND SCHEME

Sub:	Digital Image Processing					Sub Code:	18CS741	Branch :	CSE	
Date:		Duration:	90 mins	Max Marks:	50	Sem / Sec:	7(A,B,C)			OBE

	Answer any FIVE FULL Questions	MARKS	CO	RBT
1a	List out the various steps involved in filtering in frequency domain. Sol: Steps involved: (2)  Basic steps for filtering in the frequency domain.	2	2,3	L2
1b	What is the techniques of image smoothing and explain how it is achieved in the frequency domain of an image Sol: (2) Smoothing is achieved in the frequency domain by dropping out the high frequency components. The basic model for filtering is: $G(u,v) = H(u,v)F(u,v)$ where $F(u,v)$ is the Fourier transform of the image being filtered and $H(u,v)$ is the filter transform function.	2	2,3	L3

<table>
<tr>
<td>1c</td>
<td>

Suppose you have an image given below, explain how smoothing can be achieved by various frequency domain filters and discuss on the outputs. (with result of filtering of cutoff radius = 15)



(a) Ideal low pass filters. (2)

- Changing the distance changes the behavior of the filter. The transfer function for the ideal low pass filter can be given as:

$$H(u,v) = \begin{cases} 1 & \text{if } D(u,v) \le D_0 \\ 0 & \text{if } D(u,v) > D_0 \end{cases}$$

- where D0 is a positive constant and *D(u,v)* is the distance between a point (u, v) in the frequency domain and the centre of the frequency rectangle; that is,

$$D(u,v) = \left[(u - M/2)^2 + (v - N/2)^2\right]^{1/2}$$

- Where, as before, P and Q are the padded sizes.

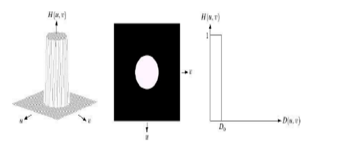


Figure : a. Perspective plot of an ideal lowpass-filter transfer function b. Filter defined as image c. Filter radial cross section

For an ILPF cross section, the point of transition between H(u,v) = 1 and H(u, v) = 0 is called the cutoff frequency.

(b) Butterworth Low pass filters (2)

- The transfer function of a Butterworth low pass filter of order *n* with cut-off frequency at distance *D0* from the origin is defined as:

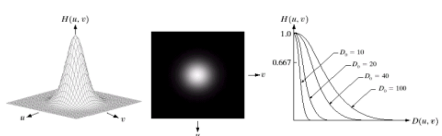
$$H(u,v) = \frac{1}{1 + \left[D(u,v)/D_0\right]^{2n}}$$

- Unlike the ILPF, the BLPF transfer function does not have sharp discontinuity that gives a clear cutoff between passed and filtered frequencies

(c) Gaussian Low pass (2)

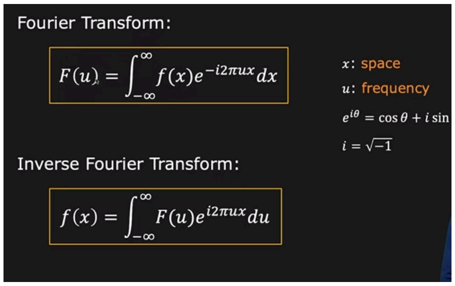
The transfer function of a Gaussian lowpass filter is defined as:

$$H(u,v) = e^{-D^2(u,v)/2D_0^2}$$

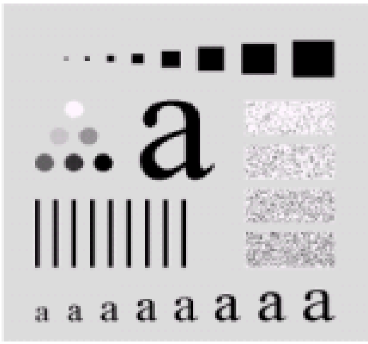


Result of image analysis

</td>
<td>6</td>
<td>2,3</td>
<td>L3</td>
</tr>
</table>

2a	Define 1D & inverse Fourier transform Sol: definition (2)  	2	2,3	L2
2b	What is the techniques of image sharpening and explain how it is achieved in the frequency domain of an image. Sol: (2) ● Edges and fine detail in images are associated with high frequency components hence image sharpening can achieved in the frequency domain by highpass filtering ● *High pass filters* – only pass the high frequencies, drop the low ones High pass frequencies are precisely the reverse of low pass filters	2	2,3	L3

<table>
<tr>
<td>2c</td>
<td>
Suppose you have an image given below, explain how sharpening can be achieved by various frequency domain filters and discuss on the outputs. (with result of filtering of cutoff distance $D_0 = 15$)

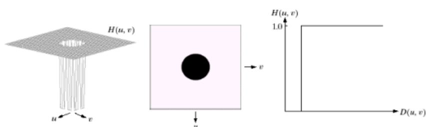


(a) High pass filters.(2)

The ideal high pass filter is given as:

$$H(u,v) = \begin{cases} 0 & \text{if } D(u,v) \le D_0 \\ 1 & \text{if } D(u,v) > D_0 \end{cases}$$

where D_0 is the cut off distance as before

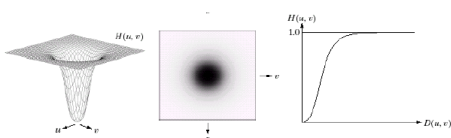


(b) Butterworth high pass filters (2)

The Butterworth high pass filter is given as:

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

where n is the order and D_0 is the cut off distance as before

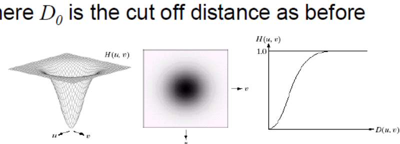


(c) Gaussian high pass (2)

The Gaussian high pass filter is given as:

$$H(u,v) = 1 - e^{-D^2(u,v)/2D_0^2}$$

where D_0 is the cut off distance as before



Result analysis of image
</td>
<td>6</td>
<td>2,3</td>
<td>L3</td>
</tr>
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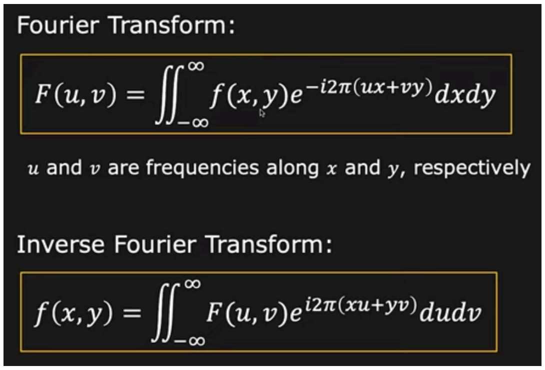
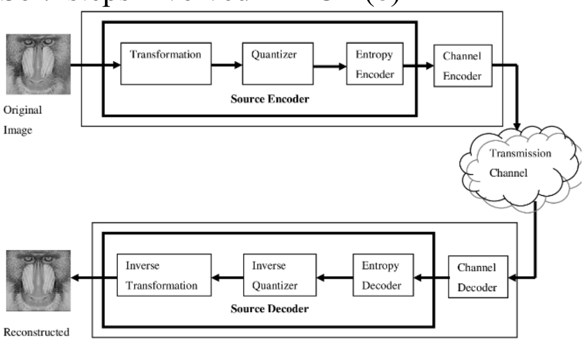
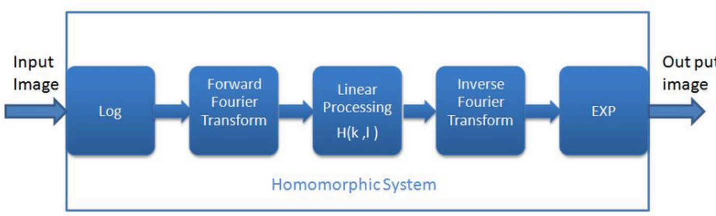
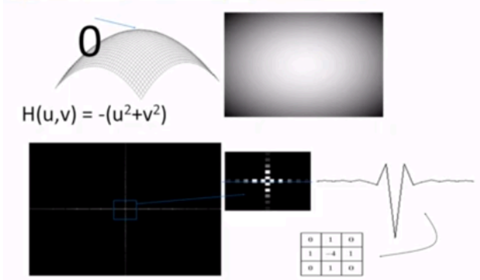
<table>
<tr><td>3a</td><td>Define 2D Fourier transform & inverse
Sol: definition (2)

</td><td>2</td><td>2,3</td><td>L2</td></tr>
<tr><td>3b</td><td>Explain the various steps involved in Discrete Cosine Transformation (DCT)
Sol: steps involved in DCT (8)

</td><td>8</td><td>2,3</td><td>L3</td></tr>
<tr><td>4a</td><td>What is homomorphic filtering, and give the steps involved in homomorphic filtering
Sol: homomorphic filtering & steps(2)

</td><td>2</td><td>2,3</td><td>L3</td></tr>
</table>

<table>
<tr><td>4b</td><td>Define laplacian in frequency domain.
Sol:
Topic Name : Laplacian in the Frequency Domain
• Spatial-domain Laplacian (2nd derivative)
$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$$
• Fourier transform
$$\Im\left[\frac{\partial^n f(x)}{\partial x^n}\right] = (ju)^n F(u)$$
$$\Im\left[\frac{\partial^2 f(x,y)}{\partial x^2} + \frac{\partial^2 f(x,y)}{\partial y^2}\right] = (ju)^2 F(u,v) + (jv)^2 F(u,v) = -(u^2+v^2)F(u,v)$$
Topic Name : Laplacian in the Frequency Domain

</td><td>2</td><td>2,3</td><td>L2</td></tr>
<tr><td>4c</td><td>Explain the following properties of Fourier Transform
a) translation
b) rotation
c) periodicity

Sol: properties (2*3=6m)
Translation and Rotation
Multiplying f(x,y) by the exponential shifts the original of DFT to (u_0, v_0).
Multiplying F(u,v) by the exponential shifts the original of (x,y) to (x_0, y_0).
$$f(x-x_0, y-y_0) \Leftrightarrow F(u,v)e^{j2\pi(x_0u/M+y_0v/N)}$$
$$F(u-u_0, v-v_0) \Leftrightarrow f(x,y)e^{-j2\pi(u_0x/M+v_0y/N)}$$
Periodicity
The Fourier transform and inverse are infinitely periodic on the u and v directions. (k1 and k2 are integers).
$$F(u,v) = F(u+k_1M, v) = F(u, v+k_2N) = F(u+k_1M, v+k_2N)$$
$$f(x,y) = f(x+k_1M, y) = f(x, y+k_2N) = f(x+k_1M, y+k_2N)$$
To show the origin of F(u,v) at the center we shift the data by M/2 and N/2
$$f(x,y)(-1)^{x+y} = F(u+M/2, v+N/2)$$</td><td>6</td><td>2,3</td><td>L2</td></tr>
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<td>5a</td>
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Explain about

a) region growing mechanism in image segmentation

b) region splitting and merging mechanism in image segmentation

Sol:

Region growing (5)

- It is a process of grouping the pixels or subregions to get a bigger region present in an image

- **Selection of the initial seed:** Initial seed that represent the ROI should be given typically by the user. Can be chosen automatically. The seeds can be either single or multiple

- **Seed growing criteria:** Similarity criterion denotes the minimum difference in the grey levels or the average of the set of pixels. Thus, the initial seed 'grows' by adding the neighbours if they share the same properties as the initial seed

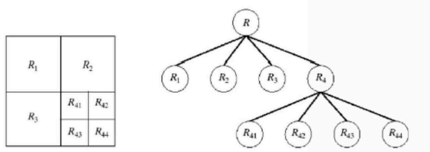
- **Terminate process:** If further growing is not possible then terminate region growing process

Region splitting and merging (5)

- The main problem with region splitting is determining where to split a region.
- One method to divide a region is to use a quadtree structure.
- Quadtree: a tree in which nodes have exactly four descendants.

a b

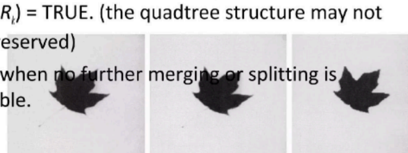
FIGURE 10.42
(a) Partitioned image.
(b) Corresponding quadtree.



- The split and merge procedure:
  - Split into four disjoint quadrants any region R_i for which $P(R_i)$ = FALSE.
  - Merge any adjacent regions R_j and R_k for which $P(R_j \cup R_k)$ = TRUE. (the quadtree structure may not be preserved)
  - Stop when no further merging or splitting is possible.

a b c

FIGURE 10.43
(a) Original image. (b) Result of split and merge procedure.
(c) Result of thresholding (a).



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<td>10</td>
<td>2,3</td>
<td>L3</td>
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</table>

6a	Explain about variable threshold and basic global threshold Sol: Basic global threshold (2) **Iterative algorithm for <u>automatic</u> estimation of threshold T:** (1) Select an initial estimate for T (2) Segment image using $T \longrightarrow$ Group G_1 (values $> T$), Group G_2 (values $\leq T$) (3) Compute average intensity values for G_1, $G_2 \longrightarrow m_1$, m_2 (4) Compute a new threshold value $T = \frac{1}{2}(m_1 + m_2)$ (5) Repeat (2) through (4) until the difference in T in successive iterations is smaller than $\triangle T$ **Average intensity is good initial estimate for T** Variable threshold (2) The variable threshold method sets a lower threshold for an image that is out of focus and a higher threshold for when the particle is in focus. This results in less change in reported area when the particle focus changes.	4	2,3	L3
6b	Given an image, discuss on how automatic image thresholding can be achieved using Otsu's method.  Sol: (6) Otsu's method Otsu's method (1979) maximizes between-class variance Based entirely on computations performed on histogram (1-D) of image <u>Summary of Otsu's algorithm</u> (1) Compute normalized histogram of the image, $p_i = \frac{n_i}{MN}, \; i = 0, \ldots, L-1$ (2) Compute cumulative sums, $P_1(k) = \sum_{i=0}^{k} p_i, \; k = 0, \ldots, L-1$ (3) Compute cumulative means, $m(k) = \sum_{i=0}^{k} i\, p_i, \; k = 0, \ldots, L-1$ (4) Compute global intensity mean, $m_G = \sum_{i=0}^{L-1} i\, p_i$ (5) Compute between-class variance, $\sigma_B^2(k) = \frac{[m_G P_1(k) - m(k)]^2}{P_1(k)[1 - P_1(k)]}, \; k = 0, .., L-1$ (6) Obtain the Otsu threshold, k^*, that is the value of k for which $\sigma_B^2(k^*)$ is a maximum – if this maximum is not unique, obtain k^* by avaraging the values of k that correspond to the various maxima detected (7) Obtain the separability measure $\eta(k^*) = \frac{\sigma_B^2(k^*)}{\sigma_G^2}$	6	2,3	L3

CI **CCI** **HOD**