Image Processing

Unit 1.

* High Pass VS LowPass filters

Lowpass Filtering → Used to pass low frequency Signals.
→ Strength of the Signal is reduced & frequencies which are passed is higher than the cutt-off frequency.

1) Ideal Lowpass filter
↳ Used to cut-off all the high-frequency components of F.T.

This is Transfer function of an ideal lowpass filter

$$\boxed{H(u,v) = \begin{cases} 1 & \text{if } D(u,v) \le D0 \\ 0 & \text{if } D(u,v) > D0 \end{cases}}$$

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

Lowpass filter (Smoothing)

2) Butterworth Lowpass Filter.
↳ Used to remove high-frequency noise with very minimal loss of signal components.

$$\boxed{H(u,v) = \frac{1}{1+\left[\frac{D(u,v)}{D0}\right]^{2n}}}$$

3) Gaussian Lowpass Filters.
Transfer function of Gaussian Lowpass filter
↳ :

$$\boxed{H(u,v) = e^{-D^2(u,v)/2D_0^2} \quad (8)}$$

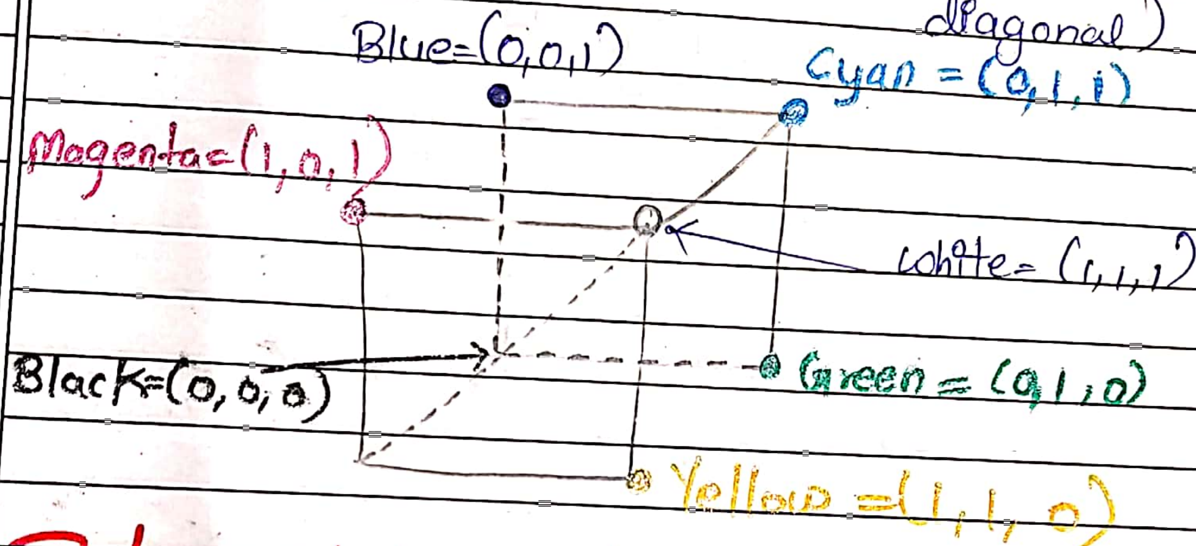
* High Pass Filters (Sharpening)
↳ Used for passing high-frequencies but the strength of the frequency is lower as compared to cut off frequency.
It also has standard forms such as
1.) Ideal highpass filter.
2) Butterworth highpass filter
3.) Gaussian " "

Scanned with CamScanner

...Singh Charitable Trust's (Regd.)
Thakur College of Engineering & Technology
(ISO 9001 : 2000 Certified)
Shyamnarayan Thakur Marg, Thakur Village, Kandivli (East), Mumbai - 400 101.
Tel. : 6730 8000, 6730 8106, 6730 8107 • Telefax : 2846 1890
Email : tcet@thakureducation.org • Website : www.tcetmumbai.in

* Intro to Color Spaces:-

RGB Cube (Grays on dotted main diagonal)



Below table is 100% RGB color bar contains values for 100% amplitude, 100% saturated & for test video test Signal

	Normal Range	white	yellow	Cyan	Green	Magenta	Red	Blue	Black
R	0 to 255	255	255	0	0	255	255	0	0
G	0 to 255	255	255	255	255	0	0	0	0
B	0 to 255	255	0	255	0	255	0	255	0

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(ISO 9001 : 2000 Certified)
Shyamnarayan Thakur Marg, Thakur Village, Kandivli (East), Mumbai - 400 101.
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IMAGE TRANSFORMATION

→ Image is obtained in spatial co-ordinates (x,y) or (x,y,z)

Spatial Means - Relating to or Occupying Space
Eg. Population.

→ Types of Transformations -

1. Fourier Transformation :
   - Used for Image Processing.
   - intensity of image is transformed into frequency variation & then to frequency domain.
   - Used for Slow varying intensity Images such as background of a passport size photo can be represented as low-frequency components & the edges can be represented as high frequency components.
   - low-frequency components can be removed using filters of FT domain.

2-D Fourier Transform.

$$v(k,l) = \sum_{m=0}^{N-1}\sum_{n=0}^{N-1} u(m,n) W_N^{km} W_N^{ln}, \quad W_N \triangleq \exp\left(\frac{-j2\pi}{N}\right)$$

$$u(m,n) = \frac{1}{N^2}\sum_{k=0}^{N-1}\sum_{l=0}^{N-1} v(k,l) W_N^{-km} W_N^{-ln}.$$

$$v(k,l) = \frac{1}{N}\sum_{m=0}^{N-1}\sum_{n=0}^{N-1} u(m,n) W_N^{km} W_N^{ln}$$

$$u(m,n) = \frac{1}{N}\sum_{k=0}^{N-1}\sum_{l=0}^{N-1} v(k,l) W_N^{-km} W_N^{-ln}$$

Unitary DFT Pair.

* Matrix Notation :-

$$\boxed{V = FUF \iff U = F^* V F^* \qquad F = \left\{\frac{1}{\sqrt{N}} W_N^{km}\right\}_{k,n=0}^{N-1}}$$

* Properties of F.T. :

1.) Symmetric Unitary
2.) Periodic Extension
3.) Sampled Fourier
4.) Fast
5.) Conjugate Symmetry
6.) Circular Convolution.

* Discrete Cosine Transformation (DCT)
→ In this, co-efficients carry information about the pixels of the image.
→ DCT is used for lossy compression

1 Dimension DCT :-

$$C = \{c(k,n)\}$$

$$c(k,n) = \begin{cases} \frac{1}{\sqrt{N}} & k=0,\ 0 \le n \le N-1 \\ \frac{2}{\sqrt{N}} \cos\left(\frac{\pi(2n+1)k}{2N}\right) & 1 \le k \le N-1,\ 0 \le n \le N-1 \end{cases}$$

$$v(k) = \alpha(k) \sum_{n=0}^{N-1} u(n) \cos\left(\frac{\pi(2n+1)k}{2N}\right), \quad 0 \le k \le N-1$$

$$\alpha(0) \triangleq \frac{1}{\sqrt{N}}, \quad \alpha(k) \triangleq \frac{2}{\sqrt{N}}, \quad 1 \le k \le N-1$$

$$u(n) = \sum_{k=0}^{N-1} \alpha(k)\, v(k) \cos\left(\frac{\pi(2n+1)k}{2N}\right), \quad 0 \le n \le N-1$$

2-Dimension DCT :-

$$\boxed{- A = A^{*} = C}$$

* Properties of DCT :
→ Real & Orthogonal : $C = C^* \rightarrow C^{-1} = C^T$
→ Not Real Part of DFT
→ Fast Transform
→ Excellent Energy Compaction (Highly Correlated Data)

* Gray Level Transformations

All Image Processing techniques focused on gray level transformation as it operates directly on pixels. The gray level image involves 256 levels of gray & in a histogram, horizontal axis spans from 0 to 255, & the vertical axis depends on the no. of pixels in the image.

Formula for image enhancement technique

$$\boxed{s = T * r}$$

Where T is transformation, r is the value of pixels, s is pixel value before & after processing.

Let,
$r = f(x,y)$
$s = g(x,y)$
'r' & 's' are used to denote gray levels of 'f' & 'g' at (x,y)

* There are 3 types of transformation.
1.) Linear
2.) Logarithmic
3.) Power law

} Refer PPT

* **Image Enhancement :-**

→ Main objective of Image Enhancement is to process the given image into a more suitable form for a specific application. It makes an image more noticeable by enhancing the features such as edges, boundaries, or contrast.

2 types of IE Methods :-
1.) Spatial domain techniques
2.) Frequency domain technique.

Image Enhancement

Point operation	Spatial Operation	Transform Operation	Pseudocoloring
• Contrast Stretching	• Noise Smoothing	• Linear filtering	• False Coloring
• Noise Clipping	• Median filtering	• Root filtering	• Pseudo Coloring
• Window Slicing	• LP HP & BP filtering	• Homomorphic filtering	
• Histogram Modeling	• Zooming		