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Computer Vision

Assignment - 2

Date:

1) What is image processing?

- It is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful informations from it.
- It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image.
- It basically includes the following three steps:

  - Importing the image via image acquisition tools;
  - Analysing and manipulating the image;
  - Output in which result can be altered image or report that is based on image analysis.

2) Explain the key stages in Digital Image Processing.

Ans - There are mainly three types of steps for digital image processing as discussed earlier.
- Now, if we talk about phases of digital Image processing.

1. ACQUISITION - It could be as simple as being given an image which is in digital form.

- The main work involves:
  a) Scaling
  b) Color conversion (RGB to Gray or vice-versa)

2. IMAGE ENHANCEMENT - It is amongst the simplest and most appealing in areas of Image Processing it is also used to extract some hidden details from an image and is subjective.

3. IMAGE RESTORATION - It also deals with appealing of an image but it is objective.

4. COLOR IMAGE PROCESSING - It deals with pseudocolor and full color image processing color models are applicable to digital image processing.

5. WAVELETS & MULTI-RESOLUTION PROCESSING - It is foundation of representing images in various degrees.

6. IMAGE COMPRESSION - It involves in developing some functions to perform this operation. It maily deals with image size or res.

7. MORPHOLOGICAL PROCESSING - It deals with tools for extracting image components that are useful in the representation & description of ~~sp~~ shape.

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8. SEGMENTATION PROCEDURE - It includes partitioning an image into its constituent parts or objects. Autonomous segmentation is the most difficult task in Image Processing.

9. REPRESENTATION & DECRIPTION - It follows output of segmentation stage, choosing a representation is only the part of solution for transforming raw data into processed data.

10. OBJECT DETECTION AND RECOGNITION - It is a process that assigns a label to an object based on its descriptor.

3) Write difference between Enhancement and Restoration.

- The difference between Enhancement and Restoration is given below:

- Enhancement:
  - Largely a subjective process
  - Priori knowledge about the degradation is not a must (sometime no degradation is involved)
  - Procedures are heuristic and take advantage of the psychophysical aspects of human visual system.

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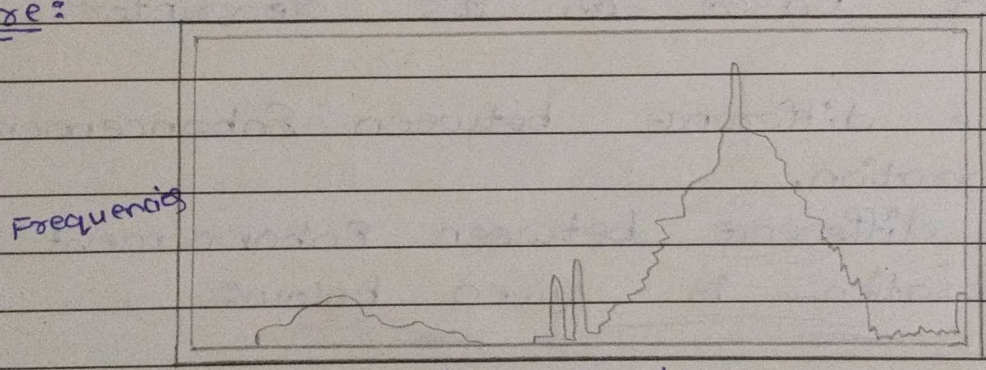
- **Restoration:**
- More an objective process
- Images are degraded.
- Tries to recover the image by using the knowledge about the degradation.

4) Explain Image Histograms and Histogram stretching with example.

- **Image Histogram:**
- The histogram of an image shows us the distribution of grey levels in image.
- Massively useful in image processing especially in segmentation.

Figure:



- **~~Image~~ Histogram Stretching:**
- One way to increase the dynamic range is by using a technique known as histogram stretching.
- In the method, we do not alter the basic shape of the histogram, but we spread it so as to cover the entire dynamic range.

$$\boxed{S = T(r) = \frac{S_{max} - S_{min}}{R_{max} - R_{min}} (R - R_{min}) + S_{min}}$$ Remember

- ↳ S_{max} = Max grey level of output image
- ↳ S_{min} = Min " " " " "
- ↳ r_{max} = Max " " " input "
- ↳ r_{min} = Min " " " input "

Example: $R_{min} = 2$, $R_{max} = 6$, $S_{min} = 0$, $S_{max} = 7$, $r = [2,6]$

Put the given value in eqn

$$S = \frac{7-0}{6-2}(r-2) + 0$$

$$S = \frac{7}{4}(r-2)$$

$\Rightarrow r = 2: S = \frac{7}{4}(r-2) = 0$

$\Rightarrow r = 3: S = \frac{7}{4}(3-2) = 1.72 \approx 2$

$\Rightarrow r = 4: S = \frac{7}{4}(4-2) = 3.2 \approx 4$

$\Rightarrow r = 5: S = \frac{7}{4}(5-2) = 5.25 \approx 5$

$\Rightarrow r = 6: S = \frac{7}{4}(6-2) = 7$

- Here, are all the slope value at different range.

5) Explain Arithmetic Mean Filter with example.

Ans - An arithmetic mean filter operation on an image removes short tailed noise such as uniform and gaussian type noise from the image at the cost of blurring the image.

- It is defined as the average of all pixels within a local region of an image.
- It is defined as:

$$\bar{x} = \frac{1}{n}(x_1 + \cdots + x_n)$$

- Pixels that are included in the averaging operation are specified by a mask.
- The larger the filtering mask becomes the more predominant the ~~buit~~ blurring becomes and less high spatial frequency detail that remains in the range.

• Example: 3, 9, 4, 52, 3, 8, 6, 2, 2, 9

Step: 1 1st take windowing size,
we can take any size for windowing

$\boxed{\ }\boxed{\ }$, $\boxed{\ }\boxed{\ }\boxed{\ }$, $\boxed{\ }\boxed{\ }\boxed{\ }\boxed{\ }$, ...

Step: 2

Normal: 3, 9, 4, 52, 3, 8, 6, 2, 2, 9

○ Padding: $\boxed{0}\boxed{3}\boxed{9}$ $\boxed{3}\boxed{9}\boxed{4}$ $\boxed{9}\boxed{4}\boxed{52}$ . . . $\boxed{2}\boxed{9}\boxed{0}$

- Replication: | 3 | 3 | 9 | | 3 | 9 | 4 | ... | 2 | 9 | 9 |

- Trimming: | 3 | 9 | 4 | | 9 | 4 | 52 | ... | 2 | 2 | 9 |

• There are different kinds mean filters all of which exhibit slightly different behaviour:

↳ Geometric Mean
↳ Harmonic Mean
↳ Contraharmonic Mean

6) Explain an Order Statistics Filters with example.
- Spatial filters that are based on ordering the pixel values that make up the neighborhood operated on by the filter
- Useful spatial filters include
  - Median filter
  - Max and Min filter
  - Midpoint filter
  - Alpha trimmed mean filter

- <u>Median Filter</u>

$$\hat{f}(x, y) = \underset{(s,t)\in S_{xy}}{\text{median}} \{g(s,t)\}$$

- Excellent at noise removal, without the smoothing effects that can occur with

other smoothing filters.
Particularly good when salt and pepper noise is present.

Examples $\hat{f}(x,y) = median(g(s,t))$

3, 9, 4, 52, 3, 8, 6, 2, 2, 9

(1) Replication:-

| 3 | 3 | 9 | = 3

| 3 | 9 | 4 | → | 3 | 4 | 9 | = 4

| 9 | 4 | 52 | → | ~~3~~ 4 | 9 | 52 | = 9

| 4 | 52 | 3 | → | 3 | 4 | 52 | = 4

| 52 | 3 | 8 | → | 3 | 8 | 52 | = 8

| 3 | 8 | 6 | → | 3 | 6 | 8 | = 6

| 8 | 6 | 2 | → | 2 | 6 | 8 | = 6

| 6 | 2 | 2 | → | 2 | 2 | 6 | = 2

| 2 | 2 | 9 | → | 2 | 2 | 9 | = 2

| 2 | 9 | 9 | = 9

3	4	9	4	8	6	6	2	2	9

(ii) Padding:

0	3	9

= 3

2	9	0

→

0	2	9

= 2

3	4	9	4	8	6	6	2	2	2

(iii) Trimming

↳ without effect boundary value

3	4	9	4	8	6	6	6	2	2	9

- **Max and Min Filter**

↳ Max Filter

$$\hat{f}(x,y) = \max_{(s,t)\in S_{xy}} \{g(s,t)\}$$

↳ Min Filter

$$\hat{f}(x,y) = \min_{(s,t)\in S_{xy}} \{g(s,t)\}$$

- Max filter is good for pepper noise and min is good for salt noise.

Example: 3, 9, 4, 52, 8, 6, 2, 2, 9

(i) Replication

	max	min	mid
[3 | 3 | 9] =	4	3	3.5 ≈ 4
[3 | 9 | 4] =	9	3	6
[9 | 4 | 52] =	52	4	28
[4 | 52 | 3] =	52	3	27.5 ≈ 28
[52 | 3 | 8] =	52	3	≈28
[3 | 8 | 8] =	8	8	≈6
[8 | 6 | 2] =	8	2	≈5
[6 | 2 | 2] =	6	2	≈6
[2 | 2 | 9] =	9	2	≈6
[2 | 9 | 9] =	9	2	≈6

max : [4 | 9 | 52 | 52 | 52 | 8 | 8 | 6 | 9 | 9]

min : [3 | 3 | 4 | 3 | 3 | 3 | 2 | 2 | 2 | 2]

(ii) Trimming :

[3 | 3 | 9] = 3 3 = 3

[2 | 2 | 9] = 9 9 = 9

max : [3 | 9 | 52 | 52 | 52 | 8 | 8 | 6 | 9 | 3]
min : [3 | 3 | 4 | 3 | 3 | 3 | 2 | 2 | 2 | 9]

(iii) Padding : [0 | 3 | 9] = 9 0 = 5

[2 | 9 | 0] = 9 0 = 5

max : [9 | 9 | 52 | 52 | 52 | 8 | 8 | 6 | 9 | 3 9]
min : [0 | 3 | 4 | 3 | 3 | 3 | 2 | 2 | 2 | 0]

- Midpoint Filter

$$\hat{f}(x, y) = \frac{1}{2}\left[\max_{(s,t)\in S_{xy}}\{g(s,t)\} + \min_{(s,t)\in S_{xy}}\{g(s,t)\}\right]$$

Good for random Gaussian and uniform noise.

(i) Replication:
midpoint = | 5 | 6 | 28 | 28 | 28 | 6 | 5 | 6 | 6 | 6 |

(ii) Trimming:
midpoint = | 3 | 6 | 28 | 28 | 28 | 6 | 5 | 6 | 6 | 9 |

(iii) Padding:
midpoint = | 5 | 6 | 28 | 28 | 28 | 6 | 5 | 6 | 6 | 5 |

- Alpha-Trimmed Mean Filter

$$\hat{f}(x, y) = \frac{1}{mn-d}\sum_{(s,t)\in S_{xy}} g_r(s,t)$$

- we can delete the $d/2$ lowest and $d/2$ highest grey levels.
- so $g_r(s,t)$ represents the remaining $mn - d$ pixels

7) Explain Discrete Fourier Transform (DFT).

- The DFT is one of the most powerful tools in digital signal processing which enables us to find the spectrum of a finite-duration signal.
- There are many circumstances in which we need to determine the frequency content of a time-domain signal.
- For example, we may have to analyze the spectrum of the output of an LC oscillator to see how much noise is present, in the produced sine wave.

- The DFT of $f(x,y)$ for $x = 0, 1, 2, \dots M-1$ and $y = 0, 1, 2, \dots N-1$, denoted by $F(u,v)$ is given by the equation.

$$F(u,v) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} f(x,y)\, e^{-j2\pi(ux/M + vy/N)}$$

for $u = 0, 1, 2, \dots M-1$ and $v = 0, 1, 2, \dots N-1$

- The DFT of a two dimensional image can be visualised by showing the spectrum of the image component frequencies.

- Inverse DFT :- It is really important to note that the Fourier transform is completely reversible

$$f(x,y) = \frac{1}{MN} \sum_{u=0}^{M-1} \sum_{v=0}^{N-1} F(u,v)\, e^{j2\pi(ux/M + vy/N)}$$

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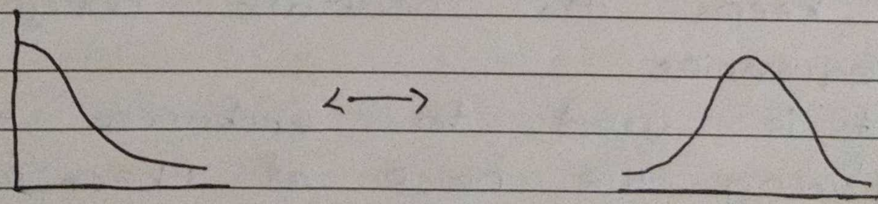
8) Explain the major Filter Categories.

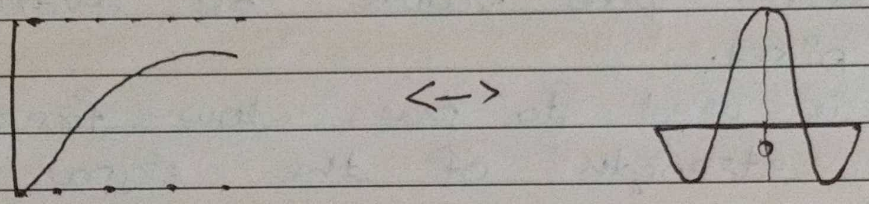
-> Typically, filters are classified by examining their properties in the frequency domain.

- **Low-Pass**: A low-pass filters is the basis for most smoothing methods. An image is smoothed by decreasing the disparity between pixel values by averaging near by pixel.
  - It is used to pass low-frequency signals.
  - The strength of the signal is reduced & frequencies which are passed is higher than the cutoff frequency.
  - The amount of strength reduced for each frequency depends on the design of the filters.
  - Smoothing is low pass operation is the frequency domain.
  - Preserve low frequencies, useful for noise suppression.

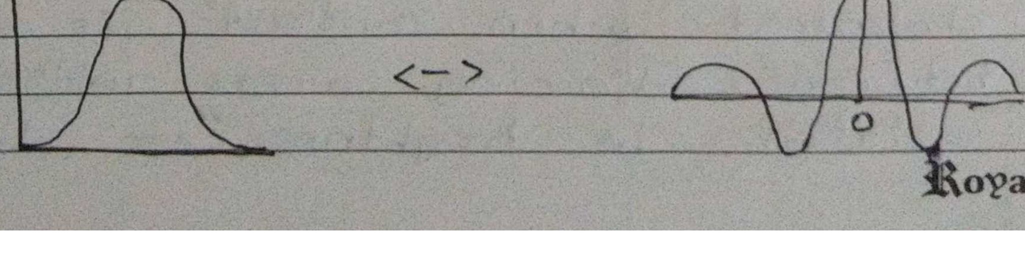


- **High-Pass**: It is the basis for most sharpenting methods. An image is sharpened when contrast is enhanced between adjoining areas with little variation in brightness or darkness.

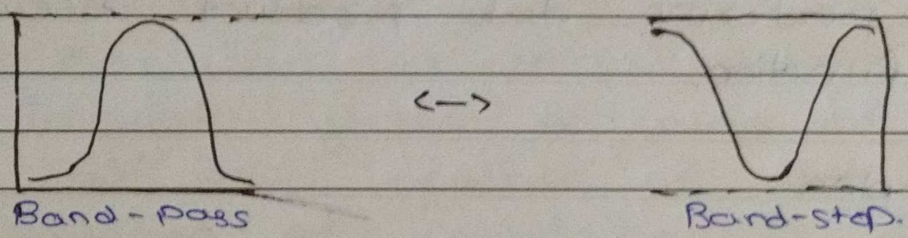
- Sharpening is a highpass operation in the frequency domain.
- It also has standard forms such as Ideal highpass filter, Butterworth highpass filter, Gaussian highpass filter,
- Preserves high frequencies - useful for edge detection.



- **Band-Pass Filter:** It is a device that passes frequencies within a certain range & rejects (alternates) frequencies outside that range.
- It is useful when the general location at the noise in the frequency domain is known.
- It removes the very low frequency & the very high frequency components that mean it keeps the moderate range band of frequencies.
- It is used to enchances edges while reducing the noise at the same time.
- Preserves frequencies within a certain band.



- **Band-Stop Filters**:- It is also known as band rejection filters.
- It is a filters that passes most frequencies unaltered, but alternates those in a specific range to very low levels.
- It is the opposite of a band-pass filters.
- A notch filters is a band-stop filter with a narrow stopband (high Q factor)
- It is useful when the general location of the noise in the frequencey domain is known



- A band reject filter blocks frequencies within the chosen range & lets frequencies outside of the range pass through.

Q4 Discuss the filtering correlation and filtering convolution.

→ **Filtering Correlation**:- It is a process of moving a filter mask often referred to as kernel over the image & computing the sum of products at each location.
- Correlation is the function of displacement of filter.
- In other words, the first value of the

correlation corresponds to zero displacements of the filter, the second value corresponds to one unite of ~~th~~ displacement & so on

- The equation of correlation is defind as follows.

$$g(x,y) = \sum_{s=a}^{a} \sum_{t=b}^{b} w(s,t)\, f(x+s; y+t)$$

$$g = w \cdot f$$

- If performs dot product between weights & function.

· Examples:

2	2	2	3
2	1	3	3
2	2	1	2
1	3	2	2

original

1	-1	-1
1	2	-1
1	1	1

Mask value

5	10	10	15
3	4	6	11
7	11	4	9
-5	4	4	5

output

- The corelation operation in 2D is very straight forward. This also helps us achieve two very popular properties.

1) Translational Invariance
2) Locality

- It has a limitation or characteristic property that when it is applied on a discrete unit impulse, yields a result that is a copy of the filters but ~~rotat~~ related by an angle of 180 degrees.

- **Filtering Convalution**:- It is very similar to the correlation operation but has a slight difference.
- In convalution operation, the kernel is first flipped by an angle of 180 degrees & is then applied to the image
- The fundamental property of convalution is that convalving a kernel with a discrete unit impulse yields a copy of the kernel at the location of the impulse.
- The equation of correlation is defined as follow:

$$g(x,y) = \sum_{s=-a}^{a} \sum_{t=-b}^{b} w(s,t)\, f(x-s,\, y-t)$$

$$g = w * f$$

- It performs cross product between weights & function.

- Example:-

1	-1	-1
1	2	-1
1	1	1

convolution kernal w

$\xrightarrow[180°]{\text{Rotate}}$

1	1	1
-1	2	1
-1	-1	1

(Mask)

2	2	2	3
2	1	3	3
2	2	1	2
1	3	2	2

original

5	4	4	-2
9	6	14	5
11	7	6	5
9	12	8	5

output Image

Step: 1 $2(2) + 2(1) + (-2) + 1$

$= 4 + \cancel{2} - \cancel{2} + 1$

$= \boxed{5}$

- The same properstion of Translational Invariance & Locality are followed by convalution operation as well.