

AN1621 DIGITAL IMAGE PROCESSING

1. Define image.

Image can be defined as a 2-D light intensity function $f(x,y)$, where x and y denotes spatial co-ordinates and the value of 'f' at any point is directly proportional to the brightness (or) gray level of the image at that point.

2. What is digital image processing?

Processing a 2-D picture by a digital computer.

3. Define digital image.

A digital image is an array of real (or) complex numbers that is represented by a finite number of bits.

4. List out the applications of image processing.

- Remote sensing via satellites and other spacecrafts.
- Image transmission and storage for business applications.
- Medical imaging, radar, sonar and acoustic image processing.
- Robotics
- Automated inspection of industrial parts.

5. List out the fundamental steps in image processing.

- Image acquisition
- Preprocessing
- Segmentation
- Representation and Description
- Recognition and Interpretation
- Knowledgebase

6. List out the types of storage.

- Short term storage
- On line storage
- Archival storage

7. What are the three important membranes in a human eye?

- Cornea & Sclera
- Choroids
- Retina

8. What is photopic (or) bright light vision?

The cones in each eye numbers between 6 to 7 million. They are located in the central portion of the retina called the fovea and are highly sensitive to color. Each cone is connected to its own nerve end; hence human beings can resolve fine details with these cones. Therefore cone vision is called photopic (or) bright light vision.

9. What is scotopic (or) dim light vision?

The number of rods in the eye is much larger. (i.e) 75 to 150 million are distributed over the retinal surface. The rods are distributed over larger area and several rods are connected to a single nerve end and hence human being has less detail with these rods. Therefore rod vision is called scotopic (or) dim light vision.

10. What is blind spot?

The absence of receptors (cones and rods) is called blind spot.

11. What is sampling and Quantization?

Digitizing the co-ordinates is called image sampling where as digitizing the amplitude values are called image quantization.

12. How many samples and gray levels are required for good approximation?

The resolution of an image depends strongly on number of samples and gray levels. The more these parameters are increased the closer the digital array approximates the original image.

13. What are neighbors of a pixel?

A pixel p at coordinates (x,y) has four neighbors. (i.e) 2 horizontal and 2 vertical neighbors then it is said to be 4-neighbors of p which is represented as $N_4(p)$. If a pixel at coordinates (x,y) has eight neighbors (i.e) 4-neighbors plus 4-diagonal neighbors then it is said to be 8-neighbors of p which is represented as $N_8(p)$.

14. Define connectivity.

If two pixels are connected (i.e)

- a. If they are adjacent in some sense.
 - b. If their gray levels satisfy a specified criterion of similarity.
- then it is said to be connectivity.

15. Define 4-connectivity.

Two pixels p and q with values from V are 4-connected if q is in the set $N_4(P)$.

16. Define 8-connectivity.

Two pixels p and q with values from V are 8-connected if q is in the set $N_8(P)$.

17. Define m-connectivity.

Two pixels p and q with values from V are m-connected if

- a. q is in the set $N_4(P)$ (or)
- b. q is in the set $N_D(p)$ and the set $n_4(p) \cap N_4(q)$ is empty.

18. Define adjacency.

A pixel p is adjacent to pixel q if they are connected.

19. Define path.

A path from pixel p with co-ordinates (x,y) to pixel q with co-ordinates (s,t) is a sequence of distinct pixels with co-ordinates

$(x_0, y_0), (x_1, y_1), \dots, (x_n, y_n)$

Where $(x_0, y_0) = (x, y)$ and

$(x_n, y_n) = (s, t)$, (x_i, y_i) is adjacent to $(x_{i-1}, y_{i-1}), 1 \leq i \leq n$ and n is the length of the path.

20. What is the use of distance measure?

It is used for calculating distance between two pixels. For pixels p,q and z with co-ordinates (x,y), (s,t) and (u,v) respectively, D is a distance function (or) metric if

- a. $D(p,q) \geq 0$ ($D(p,q) = 0$ iff $p=q$)
- b. $D(p,q) = D(q,p)$ and
- c. $D(p,z) \leq D(p,q) + D(q,z)$

21. List out the color models.

- a. RGB
- b. CMY
- c. YIQ
- d. HSI
- e. HSV

22. What is an objective fidelity criterion?

The level of information loss between an input image and the output image is known as objective fidelity criterion.

23. How the operations take place in subjective fidelity criterion?

In subjective fidelity criteria the evaluations can be made using an absolute rating scale (or) by means of side-by-side comparisons of input image and the estimated image.

24. Define orthogonal matrix.

An orthogonal matrix is a matrix in which its inverse is equal to its transpose.(i.e)

$$A^{-1} = A^T$$

25. Define unitary matrix.

A Matrix is said to be unitary if its inverse is equal to the conjugate transpose.

$$A^{-1} = A^{*T}$$

26. Define toeplitz matrix.

Toeplitz matrix(T) is a matrix that has constant elements along the main diagonal and the subdiagonals. This means the elements $t(m,n)$ depends only on the difference $m-n$ (i.e) $t(m,n) = t_{m-n}$. This can be represented as

$$T = \begin{matrix} & t_0 & t_{-1} & t_{-2} \dots \dots \dots t_{-N+1} \\ & t_1 & t_0 & t_{-1} \dots \dots \dots t_{-N+2} \\ t_2 & t_1 & t_0 \dots \dots \dots t_{-N+3} \\ \cdot & \cdot & \dots \dots \dots \cdot \\ \cdot & \cdot & \dots \dots \dots \cdot \\ t_{N+1} \dots \dots \dots t_2 & t_1 & t_0 \end{matrix}$$

27. Define circulant matrix.

If the elements in the matrix are represented in a circular fashion then the matrix is said to be circulant matrix.

$$C = \begin{matrix} & 1 & 2 & 3 & 4 \\ & 4 & 1 & 2 & 3 \\ C = & 3 & 4 & 1 & 2 \\ & 2 & 3 & 4 & 1 \end{matrix}$$

28. What is the use of transformation?

It is a process of transforming spatial time domain representation into spatial frequency domain representation.

29. What is the transform based on statistical properties?

Hotelling (or) KL Transform

30. Give the relation for Hotelling transform.

$$\mathbf{y} = \mathbf{A}(\mathbf{X} - \mathbf{m}_x)$$

31. Give the relation for 2-D DCT.

$$c(u,v) = \alpha(u) \alpha(v) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x,y) \cos\left[\frac{(2x+1)u\pi}{2N}\right] \cos\left[\frac{(2y+1)v\pi}{2N}\right]$$

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

32. Give the relation for 1-D inverse DCT.

$$f(x) = \sum_{u=0}^{N-1} \alpha(u) c(u) \cos\left[\frac{(2x+1)u\pi}{2N}\right]$$

for $x = 0,1,2, \dots, N-1$

33. Give the relation for 1-D inverse DST.

$$f(x) = \frac{1}{\sqrt{N+1}} \sum_{u=0}^{N-1} s(u) \sin\left[\frac{\pi(u+1)(x+1)}{N+1}\right]$$

for $x = 0,1,2, \dots, N-1$

34. Give the relation for 2-D DST.

$$s(u) = \frac{1}{\sqrt{N+1}} \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x,y) \sin\left[\frac{\pi(u+1)(x+1)}{N+1}\right] \sin\left[\frac{\pi(v+1)(y+1)}{N+1}\right]$$

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

35. Define Image Enhancement?

Image Enhancement is used for sharpening of image or to improve the quality of the image.

35. What is spatial domain method?

This refers to the image plane itself & is based on direct manipulation of pixels in an image.

36. What is frequency domain method?

This is based on modifying the Fourier transform of an image.

37. What is image subtraction?

The difference between two images $f(x,y)$ & $h(x,y)$

$$(i.e). g(x,y) = f(x,y) - h(x,y)$$

38. Define Histogram?

Histogram of an image represents the relative frequency of occurrence of the various gray levels in an image.

(i.e). Histogram of a digital image with gray levels in the range $[0, L-1]$ is a discrete function.

39. What is the use of a mask?

It is used for noise reduction, region thinning & edge detection. It can also be called as template, filter & window.

40. Define neighborhood averaging?

The response (R) can be obtained by finding the average of all the pixels in the area of the mask.

41. Give the applications of sharpening filter.

- a. Electronic printing
- b. Medical imaging
- c. Industrial inspection
- d. Autonomous target detection

42. What is the use of high pass filters?

These filters attenuate/eliminate low frequency components and pass the high frequency components. This is mainly used for sharpening of edges and other sharp details.

43. What is unsharp masking?

The process of subtracting the blurred image from the original image is called unsharp masking.

44. What is the use of low pass filters?

These filters attenuate/eliminate high frequency components and pass the low frequency components.

45. Define image restoration.

Restoration is a process that attempts to reconstruct/recover an image that has been degraded by using some prior knowledge about the noise.

46. How an image is formed?

Objects that are imaged either reflect (or) transmit the radiant energy that propagates through the space. Now the radiant energy is intercepted by the energy transformation system (or) image formation system to produce a brightness pattern on a 2-D plane.

47. What is geometric model?

Transforming a 3-D object plane (or) scene plane into a 2-D image plane is known as geometric model.

48. What is photometric model?

Assigning intensity to an image point that corresponds to some of the points in the object plane is known as photometric model.

49. List the various forms of degradation.

- a. Sensor noise
- b. Blur due to camera misfocus
- c. Relative object camera motion
- d. Random atmospheric turbulence
- e. Thermal noise

51. Give the relation for degradation model.

$$g(x,y) = H[f(x,y)] + \eta(x,y)$$

52. How the degradation model can be solved if $M=N=512 \times 512$ (i.e) H is of size 262144×262144 ?

To obtain f directly it requires 262144 simultaneous linear equations. (i.e) huge amount. So the complexity of this problem can be reduced by taking the circulant properties of H . (i.e) Diagonalization of the matrix H .

53. What is the use of algebraic approach to image restoration?

The main objective of image restoration is to estimate an original image 'f' from a degraded image 'g' with some knowledge of H and n .

54. Give the relation for unconstrained restoration.

$$\hat{f} = H^{-1} g$$

55. Give the relation for constrained restoration.

$$f = \left(\frac{H}{H + \gamma} \right)^{T-1} \frac{T}{Q} g$$

56. What is block code?

If each source symbol is mapped into a fixed sequence of code words then it is said to be block code.

S1-> 01

S2-> 001

S3-> 10

57. What is instantaneous code?

If a codeword is not a prefix of any other codeword then it is said to be instantaneous code (or) prefix code.

S1-> 01

S2-> 10

S3-> 001

58. What is uniquely decodable code?

If a codeword is not a combination of any other codeword then it is said to be uniquely decodable code.

S1->101

S2->0

S3->100

59. List out the steps in binary shift code.

- Arrange the source symbols along with its probabilities in decreasing order.
- Divide the total number of symbols into symbol blocks of equal size.
- Coding the individual elements within all blocks identically.
- Add special shift up/shift down symbols to identify each block.

60. Define B-code?

Each codeword is made up of continuation bits(C) and information bits. The purpose of continuation bit is to separate individual code words. Therefore alternately 0 and 1 can represent the continuation bit.

61. Define B2-code?

If two information bits are used per continuation bit then B-code is said to be B2-code.

62. What is inter pixel redundancy?

The value of any pixel in an image can be reasonably predicted from the value of its neighbors. (i.e) the pixel have been guessed on the basis of the values of its neighbors. This is termed as inter pixel redundancy.

63. What is the use of bit plane coding?

It is based on the concept of decomposing a multilevel image into a series of binary images and compressing each binary image by using a well-known binary compression method.

64. What are the operations takes place in binary coding and gray code in bit plane decomposition?

In binary coding, if a small change in the pixel values which increases the complexity of the bit planes.

In gray code, if a small change in the pixel values which will not affect the bit planes.

65. What is constant area coding?

It is a compression method to compress the binary image by using special codes to identify large areas of contiguous 1's (or) 0's.

66. Define white block skipping?

In WBS, we consider two regions.

- a. If few solid black areas are expected they are grouped with mixed intensity regions and
- b. White region

Here if white areas are more , they are assigned a code 0 and all other blocks by a 1 followed by a bit pattern of the block.

67. What is 1-D run-length coding?

In 1-D run length coding each row of an image is identified by a sequence of successive runs of black and white pels.

68. What is relative address coding?

It is based on tracking the binary transitions that begin and end with black to white and white to black runs by comparing the current line and the preceding lines.

69. Define DDC?

If each contour is identified by the boundary points and a set of directionals then it is said to be direct contour tracing.

70. Define PDQ?

If the front and back contours of each object of an image are traced simultaneously to generate a sequence of pairs (Δ' , Δ'')

Where Δ' represents the difference between starting co-ordinates of front contours on adjacent lines and

Δ'' represents difference between front and back contour lengths.

71. What is the use of start message in contour tracing and coding?

Start message is used to represent the starting of new contours.

72. What is the use of merge message in contour tracing and coding?

Merge message is used to represent the end of old contours.

73. What is adaptive transform coding?

The transform encoding steps, which can be adapted to local image, is called adaptive transform coding.

74. What is zonal coding?

In transform coding the retained coefficients are selected on the basis of maximum variance is called zonal coding.

75. What is threshold coding?

In transform coding the retained coefficients are selected on the basis of maximum magnitude is called threshold coding.

76. What are the coding systems used in JPEG?

- a. Lossy baseline coding system
- b. Extended coding system
- c. Lossless independent coding system

77. List out the various steps of JPEG encoder.

- i. Block preparation
- ii. Transformation
- iii. Quantization
- iv. Entropy encoding
- v. Frame building

78. Define (Skip, Value)?

Skip represents the number of zero's in the run and value represents the next non-zero coefficient.

79. Define vectoring?

Converting 2-D representation to a 1-D vector is known as vectoring.

80. What is MPEG?

MPEG-Motion Pictures Expert Group (MPEG)

MPEG was formed by the ISO to formulate a set of standards relating to a range of multimedia applications that involves the use of video with sound.

81. What is H.261?

H.261 video compression standard has been defined by the ITU-T for the provision of video telephony and video conferencing over an ISDN.

82. What is image segmentation?

Image segmentation subdivides an input image into its constituent parts (or) objects.

83. What are the types of image segmentation?

- Autonomous segmentation
- Rugged/Rough segmentation
- Weak/Erratic segmentation

84. What is feature thresholding?

- Selection of appropriate feature to obtain a useful result.
- Selection of threshold is a non-trivial task.

85. Define discontinuity.

It is an approach to partition the image based on abrupt changes in intensity (or) gray level.

- (e.g) Point detection
- Line detection
- Edge detection

86. Define similarity.

It is an approach based on partitioning an image into regions according to a set of predefined criteria.

(e.g) Thresholding, region growing, region splitting and region merging.

87. What is isolated point?

A point whose gray level is significantly different from its background (or) neighbors.

88. Define edge.

An edge is the boundary between two regions with relatively distinct gray levels.

89. What is the operation takes place for the first derivative operator?

Positive at the leading edge of the transition and negative at the trailing edge and zero in the areas of the constant gray level.

90. What is the operation takes place for the second derivative operator?

Positive for the part associated with the dark side of the edge and negative for the part associated with the light side of the edge and zero in the area's of the constant gray level.

91. What is the use of gradient and laplacian operator?

The magnitude (or) sign of the gradient operator is used to detect the presence of an edge in an image where as the magnitude (or) sign of the laplacian operator is used to detect whether an edge pixel lies on the dark side (or) light side.

92. What is single level thresholding?

If a histogram is represented by two modes and a single threshold value then it is said to be single level thresholding.

93. What is multi level thresholding?

If a histogram is represented by more than two modes and more than one threshold value then it is said to be multi level thresholding.

94. How a thresholding function can be represented?

$$T=T[x,y,p(x,y),f(x,y)]$$

95. What is global thresholding?

When T depends on $f(x,y)$ then the threshold is called global thresholding.

96. What is global thresholding?

When T depends on $f(x,y)$ & $p(x,y)$ then the threshold is called local thresholding.

97. What is dynamic/adaptive thresholding?

When T depends on $f(x,y)$, $p(x,y)$ and spatial co-ordinates x,y then the threshold is called dynamic/adaptive thresholding.

98. Define region growing.

Region growing is a procedure that groups pixels (or) sub regions into larger regions.

99. What is pixel aggregation?

This starts with a set of seed/starting points and the region grows by grouping pixels that have similar properties such as gray level, color and texture.

100. What is the operation takes place in region growing process?
The absolute difference between the gray level of the pixel and the gray level of the seed is less than the threshold T.
101. What are fundamental difficulties in region growing process?
i. Selection of initial seeds that properly represent regions.
ii. Selection of suitable properties for including points in various regions during growing process
102. How Region growing process can be stopped?
a. Depends on the nature of the problem.
b. Growing region should stop when no pixels satisfy the criteria for inclusion in regions.
103. Define region splitting.
It subdivides an image initially into a set of arbitrary, disjoint regions (or) quadrants until $P(R_i) = \text{TRUE}$
104. Define quad tree.
A quad tree is a tree in which each node has exactly 4 descendants.
105. Define region merging.
Merge only adjacent regions whose combined pixels satisfy the predicate(P) (i.e) Two adjacent regions R_i and R_j are merged only if
 $P(R_i \cup R_j) = \text{TRUE}$
106. Write split and merge algorithm.
i. Split into four disjointed quadrants for any region R_i where
 $P(R_i) = \text{FALSE}$
ii. Merge any adjacent regions R_i and R_j for which $P(R_i \cup R_j) = \text{TRUE}$
iii. Stop when no further merging/splitting is possible.

BIG QUESTIONS

1. Explain the fundamental steps of image processing?
 - Image acquisition
 - Preprocessing
 - Segmentation
 - Representation and Description
 - Recognition and Interpretation
 - Knowledge base

2. Explain the elements of digital image processing?
 - Image acquisition
 - Storage
 - Processing

- Communication &
 - Display
3. Explain the basic relationship between pixels?
 - Neighbors of a pixel
 - Connectivity
 - Adjacency
 - Path
 - Distance measures
 - Arithmetic operators
 4. Explain Convolution function for discrete functions?
 - 1-D discrete Convolution function
 - 2-D discrete convolution function
 5. Explain Convolution function for continuous functions?
 - 1-D continuous Convolution function
 - 2-D continuous Convolution function
 6. Explain image fidelity criteria?
 - Objective fidelity criteria
 - Subjective fidelity criteria
 7. Explain the properties of 2-D Fourier transform?
 - Separability
 - Translation
 - Periodicity and conjugate symmetry
 - Rotation
 - Distributivity
 - Scaling
 - Average value
 - Laplacian
 8. Explain discrete Fourier transform?
 - 1-D discrete Fourier transform
 - 2-D discrete Fourier transform
 - 1-D inverse discrete Fourier transform
 - 2-D inverse discrete Fourier transform
 9. Explain the transform based on statistical properties?
 - Mean
 - Variance

- Co-Variance
- Hotelling transform relation
- Reconstructed equation

10. Explain Wavelet transform?

- Short term fourier transform
- Continuous wavelet transform
- Discrete wavelet transform

11. Explain SVD transform, Haar transform and Slant transform?

- Relation for SVD transform
- Calculate 4 X 4 Haar matrix
- Calculate 4 X 4 Slant matrix

12. Explain walsh transformation?

- 1-D walsh transform
- 2-D walsh transform
- 1-D inverse walsh transform
- 2-D inverse walsh transform

13. Explain hadamard transformation?

- 1-D Hadamard transform
- 2-D Hadamard transform
- 1-D inverse Hadamard transform
- 2-D inverse Hadamard transform
- 1-D ordered Hadamard transform
- 2-D ordered Hadamard transform
- 1-D ordered inverse Hadamard transform
- 2-D ordered inverse Hadamard transform

14. Explain Image enhancement for point processing?

- Image negative
- Contrast stretching
- Compression of Dynamic range
- Gray level slicing & Intensity level slicing
- Bit plane slicing

15. Explain Histogram for image Enhancement?

- Definition of Histogram
- Histogram processing
- Histogram Equalization

16. Explain spatial filtering for spatial domain?

- Smoothing filters

- Sharpening filters
- Derivative filters

17. Explain Spatial filtering for frequency domain?

- Low pass filtering
 1. Ideal low pass filter
 2. Butter worth low pass filter
- High pass filtering
 1. Ideal low pass filter
 2. Butter worth low pass filter

18. Explain Degradation model for Image restoration?

- 2-D continuous degradation model
- 1-D Discrete degradation model
- 2-D Discrete degradation model

19. Explain Algebraic approach for image restoration?

- Unconstrained approach
- Constrained approach

20. Explain Weiner filter?

- Representation of R_f and R_n correlation matrices
- Representation of R_f and R_n as block circulant matrices
- Relation for wiener filter, parameterized wiener filter, ideal wiener filter

21. Explain geometric transformation for image restoration?

- Spatial transformation
- Gray-level Interpolation

22. Explain the removal of blur caused by uniform linear motion?

- Derivation

23. Explain Bit plane coding?

- Bit plane decomposition
- Constant area coding
- Run-length coding
- Contour tracing and coding

24. Explain Variable length codes?

- Huffman code
- Truncated Huffman code
- B2- Code
- Huffman shift code

- Binary shift code
25. Explain transform coding?
- Block diagram
 - Transform selection
 - Sub image size selection
 - Bit Allocation
 1. Zonal coding
 2. Threshold coding
26. Explain JPEG Standard?
- Block diagram of encoder
 1. Transformation
 2. Quantization
 3. Entropy encoding
 4. Frame building
 - Block diagram of decoder
27. Explain MPEG Standard?
- MPEG –I
 - MPEG - II
 - MPEG – IV
 - Introduction to H .261
28. Explain Region oriented segmentation?
- Region growing
 - Region Splitting
 - Region Merging
29. Explain Thresholding function?
- Single level thresholding
 - Multi level thresholding
 - Global thresholding
 - Local thresholding
 - Dynamic thresholding
30. Explain threshold selection method based on boundary characteristics?
- Explanation
 - Representation of laplacian and gradient for a dark background and light object.
 - Representation of laplacian and gradient for a light background and dark object.
31. Explain Optimum thresholding?
- Explanation for probability density function
 - Derivation

32. Explain in detail about edge detection?

- Gradient operator
- Laplacian operator