

UNIT I - DIGITAL IMAGE FUNDAMENTALS

Introduction – Origin – Steps in Digital Image Processing – Components – Elements of Visual Perception – Image Sensing and Acquisition – Image Sampling and Quantization – Relationships between pixels - color models.

PART A**1. Define Brightness. [May/June 2015] [Nov/Dec 2012]**

Brightness of an object is the perceived luminance of the surround. Two objects with different surroundings would have identical luminance but different brightness.

2. Define Contrast [May/June 2015] [Nov/Dec 2012]

It is defined as the difference in intensity between the highest and lowest intensity levels in an image.

3. What is Hue & Saturation? [May/June 2014]

Hue is a color attribute that describes a pure color where saturation gives a measure of the degree to which a pure color is diluted by white light.

4. Define subjective brightness and brightness adaptation [May/June 2014]

Subjective brightness means intensity or luminance as preserved by the human visual system. Brightness adaptation means the human visual system can operate only from scotopic to glare limit. It cannot operate over the range simultaneously. It accomplishes this large variation by changes in its overall intensity.

5. What is simultaneous contrast? [May/June 2015] [Nov/Dec 2012]

The region reserved brightness not depend on its intensity but also on its background. All centre square have same intensity. However they appear to the eye to become darker as the background becomes lighter.



a b c

Examples of simultaneous contrast. All the inner squares have the same intensity, but they appear progressively darker as the background becomes lighter.

6. What is monochrome image and gray image? [Nov/Dec 2012, Apr/May 2016]

Monochrome image is a single color image with neutral background. Gray image is an image with black and white levels which has gray levels in between black and white. 8-bit gray image has 256 gray levels.

7. Define checker board effect and false contouring. [Nov/Dec 2012, 16, May/June 2013]

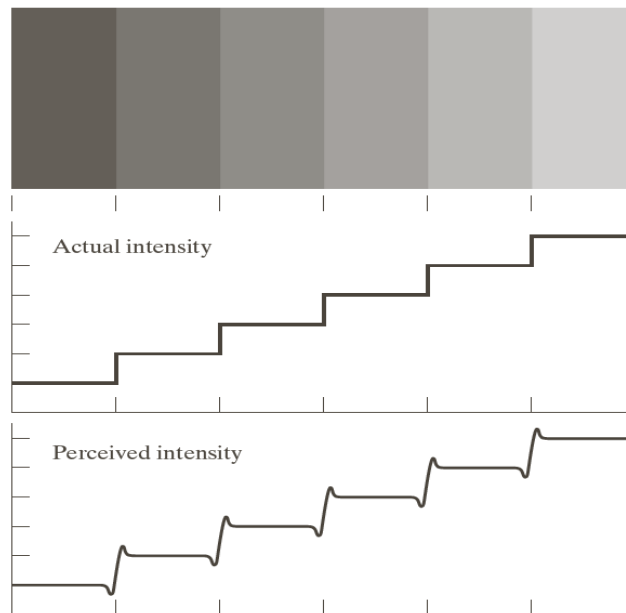
Checkerboard pattern or effect is a degradation that results due to the reduction in spatial resolution. When lower resolution images are replicated to larger size, the pixel values are replicated to fill the display area leading to checkerboard effect. The insufficient number of intensity levels in smooth areas of digital image gives false contouring.

8. Compare RGB and HIS color image models [May/June 2013]

RGB Model	HSI model
<ul style="list-style-type: none"> • RGB means red, green and blue color. • It represents colors of the image. • It is formed by either additive or subtractive model. • It is subjective process 	<ul style="list-style-type: none"> • HSI represents hue, saturation and intensity of colors. • It decides the type of the color. • It numerically represents the average of the equivalent RGB value.

9. What is Mach Band Effect? [Nov/Dec 2016, May/June 2013/14/15]

It is based on the fact that Human Visual System tends to overshoot or undershoot around the boundary of regions of different intensities.



As shown above, although, the intensity of the stripes is constant, HVS perceive a brightness pattern that is strongly scalloped, especially near the boundaries. These seemingly scalloped bands are called Mach Band after Ernst Mach.

10. When is fine sampling and coarse sampling used? [Apr/May 2017]

Fine or dense sampling can be used in areas where the image details are very fine and coarse sampling can be used in areas with coarse or little details. This process is called as non uniform sampling.

11. What is the function of an image sensor? [Apr/May 2017]

The first step in the image processing is image acquisition that is to acquire a digital image. An imaging sensor is used to acquire the image.

12. Define the term “Quantization”. [Nov/Dec 2017]

Quantization is defined as the process of digitizing the amplitude value of the image. Quantization is the primary factor that determines the gray level resolution of the image.

13. Distinguish between photopic and scotopic vision. [Nov/Dec 2017]

Photopic vision (Cones)	Scotopic vision (Rods)
Cones are responsible for photopic or bright light vision	Rods are responsible for scotopic or dim light vision
6 to 7 million cones are present in each eye.	75 to 150 million rods are present in each eye.
Each cone is connected to its own nerve end which helps to resolve fine details	Several rods are connected to a single nerve hence the amount of details discernible is less.

14. Define the term ‘Image’

An image may be defined as two dimensional light intensity function $f(x, y)$ where x and y denote spatial co-ordinate and the amplitude or value of ‘ f ’ at any point (x, y) is called intensity or grayscale or brightness of the image at that point.

15. What is a digital image?

An image may be defined as two dimensional light intensity function $f(x, y)$ where x and y denote spatial co-ordinate and the amplitude or value of ‘ f ’ at any point (x, y) is called intensity or grayscale or brightness of the image at that point. When x, y and the amplitude values of ‘ f ’ are all finite discrete quantities it is called a digital image.

16. What is a pixel?

A digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are referred to as picture elements, image elements, pels or pixels.

17. What are the applications of digital image processing?

- Remote sensing via satellite and spacecrafts
- RADAR and SONAR
- Biomedical applications-ECG, EEG, EMG etc.,
- Robotics
- Military applications
- Astronomy etc

18. What are the steps involved in DIP?

- Image Acquisition
- Image enhancement and restoration
- Segmentation
- Color image processing
- Morphological processing
- Representation and Description
- Recognition and Interpretation
- Image compression.

19. What is morphological processing?

Morphological processing deals with tools for extracting image components that are useful in the representation and description of shape.

20. Specify the elements of DIP system?

- Image Sensors
- Specialized image processing hardware

- Image processing software
- Computer
- Mass storage
- Image displays

21. Define Radiance and Luminance.

Radiance is the total amount of energy that flows from the light source and is usually measured in Watts (W). Luminance gives a measure of the amount of energy an observer perceives from a light source; unit is lumens (lm).

22. What is Pseudo-color image processing?

It is the method in which to a particular monochrome intensity or range of intensities a color is assigned and processed. Thus in pseudo color image processing, full colors are not used.

23. What do you mean by Color model?

A color model is a specification of 3D-coordinates system and a subspace within that system where each color is represented by a single point.

24. List the hardware oriented color models and their applications.

- RGB model--- used for color monitors & color video camera
- CMY/CMYK model---used for color printing
- HSI model----used for color image processing
- YIQ model---used for color picture transmission

25. Define resolution.

Resolution is defined as the smallest number of discernible detail in an image. Spatial resolution is the smallest discernible detail in an image, unit is line pairs /unit distance, dots per unit distance or dpi (dots per inch). Gray level resolution or Intensity resolution refers to the smallest discernible change is gray level.

26. What is meant by illumination and reflectance?

Illumination is the amount of source light incident on the scene. It is represented as $i(x, y)$. Reflectance is the amount of light reflected by the object in the scene. It is represented by $r(x, y)$.

27. Define sampling.

Sampling means digitizing the co-ordinate value (x, y) of the image. Sampling is the primary factor that determines the spatial resolution of the image.

28. Write the expression to find the number of bits to store a digital image?

The number of bits required to store a digital image is

$$b = M \times N \times k$$

Where $M \times N$, refers to the size of the image and k refers to the number of bits per pixel. When $M=N$, this equation becomes $b=N^2k$

29. Find the number of bits required to store a 256 X 256 image with 32 gray levels?

Given:

32 gray levels i.e., $L=32$

$$L = 2^k = 32,$$

Therefore, $k = 5$ bits $\Rightarrow 256 * 256 * 5 = 3,27,680$ bits.

30. What do you meant by Zooming and shrinking of digital images?

Zooming may be viewed as over sampling. It involves the creation of new pixel locations and the assignment of gray levels to those new locations. Shrinking may be viewed as under sampling. To shrink an image by one half, we delete every alternate row and column.

31. Define $N_4(p)$.

A pixel p at coordinates (x,y) has four horizontal and vertical neighbors whose coordinates are given by $(x+1,y),(x-1,y),(x,y+1),(x,y-1)$. This set of pixels are called 4- neighbors of p denoted by $N_4(p)$.

	$(x,y-1)$	
$(x-1,y)$	$p(x,y)$	$(x+1,y)$
	$(x,y+1)$	

4 neighbors; the set of horizontal and vertical neighbors

32. Define $N_D(P)$.

The four diagonal neighbors of p have coordinates $(x+1,y+1),(x+1,y-1),(x-1,y+1),(x-1,y-1)$ and are denoted by $N_D(p)$.

$(x-1,y-1)$		$(x+1,y-1)$
	$p(x,y)$	
$(x-1,y+1)$		$(x+1,y+1)$

Diagonal neighbors; the set of 4 diagonal neighbors.

33. Define $N_8(p)$.

Diagonal neighbors together with the 4-neighbors are called 8-neighbors of p , denoted by $N_8(p)$. Some of the points in $N_D(p)$ and $N_8(p)$ fall outside the image if $f(x,y)$ is on the border of the image if $f(x,y)$ is on the border of the image. Eight neighbors is non-uniform distance from P . Effectively we have $N_8(p)=N_4(p)+N_D(p)$.

$(x-1,y-1)$	$(x,y-1)$	$(x+1,y-1)$
$(x-1,y)$	$p(x,y)$	$(x+1,y)$
$(x-1,y+1)$	$(x,y+1)$	$(x+1,y+1)$

Eight neighbors

34. What are the types of adjacency and define them.

Three types of adjacency: 4 –adjacency,8-adjacency and m-adjacency

4-adjacency : Two pixels p and q are 4- adjacent if q is in the set $N_4(p)$.

8-adjacency: Two pixels p and q are 8- adjacent if q is in the set $N_8(p)$

m-adjacency: Let V be the set of gray level values used to define adjacency.

Two pixels p and q with values from V are said to m-adjacent if q is in $N_4(p)$ (or) q is in $N_D(P)$ and the set $N_4(p) \cap N_4(q)$ has no pixels whose values are from V .

35. Define connectivity and list their types.

Two pixels are said to be connected if they are neighbors and their gray levels satisfy a specified criterion of similarity

Types of connectivity: 4 connectivity, 8 connectivity and m-connectivity (mixed connectivity)

36. What is Moire pattern (or) How is aliasing defined with respect to images?

If the two dimensional function (i.e., the image) is under sampled then a phenomenon called aliasing corrupts the sampled images. The corruption is in the form of additional frequency components being introduced into the sampling function. These are called aliasing frequencies. The effect of aliased frequencies can be seen in the form of ‘Moire Patterns’.

37. How to overcome the effect of false contouring?

False contouring can be held below the level of visibility by using the following two methods.

- Contrast Quantization
- Pseudorandom Quantization (Dither).

38. What is dither (Pseudorandom Quantization)?

Dither is a method used to reduce the effect of false contouring. A small amount of uniformly distributed pseudorandom noise is added to the luminance samples before quantization. This pseudorandom noise is called dither.

PART - B

1. What are the elements of digital image processing system? Explain the function of each element in detail. [Nov/Dec 2017, Apr / May 2017, Apr / May 2014, Nov/Dec 2011]
2. a) Discuss the effect of non-uniform sampling and quantization. [Apr/May 2017]
b) Explain how color images are represented using HIS color space model. [Apr/May 2017]
3. Explain in detail about the phenomenon of image sampling. Illustrate how aliasing happens if sampling theorem is violated. [Nov/Dec 2017]
4. a) With necessary diagrams explain how an analog image is converted into digital image.
(or)
With necessary diagrams explain sampling and quantization. [Nov/Dec'16, Apr/May'15, Apr/May'13]
b) What is meant by image sensing? Explain in detail the construction and operation of various image acquisition devices. [Nov/Dec 2016]
5. a) What is a color model? What are its types? Explain RGB and HIS models with necessary diagrams. [Nov/Dec 2015, 2016]
b) Explain the various distance measures used for image analysis. [Nov/Dec 2016]
6. Explain digital camera working principle. [Nov/Dec 2015]