Pattern recognition and Image Processing

Previous Solution

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Spring 2017

1a) What is digital image processing? Discuss the applications of digital image processing?

Answer:

Digital Image Processing means processing digital image by means of a digital computer. We can also say that it is a use of computer algorithms, in order to get enhanced image either to extract some useful information. It is the manipulation of the digital data with the help of computer hardware and software to produce digital maps in which the specific information has been extracted and highlighted.

Application areas:

1. Industrial machine vision applications.
   - Automated visual inspection.
   - Process control.
   - Parts identification.
   - Robotic guidance and control.
2. Space exploration.
3. Astronomy.
4. Diagnostic medical imaging.
   - Medical image processing
   - Medical image reconstruction

Application areas (continue…)

5. Scientific analysis
6. Military guidance and reconnaissance/investigation
7. Remote sensing
   - Meteorology
   - Natural resource location
   - Environmental monitoring
   - Cartography

Application areas (continue…)

8. Information technology system (DIP- document image processing)
   - Image data compression
   - Analysis of document content
9. Telecommunications
   - Facsimile
   - Videotext
   - Video conferencing and video phones

Application areas (continue…)

10. Security, surveillance and law enforcement
    - Verification of identity
    - Monitoring and surveillance
    - Forensic investigations
11. Entertainment and consumer electronics
12. Printing and the graphics arts

1b) What is the Advantages of gray scale image over color image?

Answer:

It helps in simplifying algorithms and as well eliminates the complexities related to computational requirements.

It makes room for easier learning for those who are new to image processing. This is because grayscale compressors an image to its barest minimum pixel.

It enhances easy visualisation. It differentiates between the shadow details and the highlights of an image because it is mainly in 2 spatial dimensions (2D) rather than 3D.

Colour complexity is also reduced. A typical 3D image requires camera calibration on brightness among others. The grayscale conversion option is very useful for captured images which do not need to match coloured detail.

1c)Define Image Resolution? Find the resolution of 21” monitor working on 1600 X 900 screen?

Ans:

Resolution is a measurement of the number of pixels -- picture elements or individual points of color -- that can be contained on a display screen or in a camera sensor. In practical terms, resolution describes the sharpness, or clarity, of an image or picture. It is expressed in terms of the number of pixels that can be displayed both horizontally and vertically.

Resolution is an important factor to measure the visual quality of digital images, photos and videos. A higher resolution signifies the picture contains more pixels, which means it can display more visual information. As a result, a high-resolution picture is sharper and clearer than a low-resolution one.

1d) Briefly describe the fundamental steps of Digital IP?

Ans:

https://www.ques10.com/p/33595/what-is-image-processing-explain-fundamental-steps/

2a) **Describe the necessity of IP in office automation?**

Ans:

2b)Describe the technique of format images in the eye?

Ans:

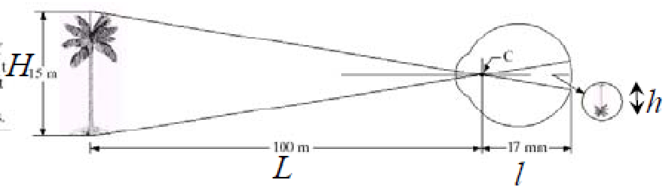
https://byjus.com/question-answer/in-human-eye-the-image-of-an-object-is-formed-at/

How does the human eye work?

Light passes through the cornea and the pu pil, is focused by the lens and its projected onto the black wall of the eye, which is called retina.The retina is made up of several layers of cells.It is on the back of the of the retina where i mages are captured, much like film in a camera.Two kinds of light-sensitive receptor cells, called rods and cones, convert light into " messages". These messages are sent to the brain via the optic nerve.Each eye has what is called a blind spot.This is where the optic nerve leaves the eye and there are no rods and cones.One does not usually notice the blind spot in each eye because the left eye sees what the right eye misses and vice versa.

How's an object seen at the back of the eye?

FIGURE 2.3 Graphical representation of the eye looking at a palm tree. Point C is the optical center of the lens.



The focal lenght (distance bet center of the lens and the retina) varies from 17 mm to 14 mm (as the refractive power of the lens increases from its minimum to its maximum). Recall that $H/L = h/l$

Perception takes place by the relative excitation of light receptors, which transform radiant energy into electrical impulses that are ultimately decoded by the brain.

Rod cells enable us to see in dim light.Rod cells perceive black, white and grays, but not color.At night, it is the rod cells that enable us to see in black, white, and shades of gray.Cone cells do not respond to dim light but do allow us to see colors in a lighted environment. They also detects fine details.

2c)Describe various types of sensors to acquire images?

Ans:

https://buzztech.in/image-acquisition-in-digital-image-processing/

2d) Define pixel neighbors and distance measures?

Ans:

A pixel's neighborhood is some set of pixels, defined by their locations relative to that pixel, which is called the *center pixel*. The neighborhood is a rectangular block, and as you move from one element to the next in an image matrix, the neighborhood block slides in the same direction.

https://aishack.in/tutorials/pixel-neighbourhoods-connectedness/

3a) what is meant by image enhancement?Mention the applications of image enhancement?

Ans:

https://slideplayer.com/slide/4047739/

3b)Briefly describe with example Gray-level-Slicing and Bit plane slicing?

Ans:

https://www.icsid.org/uncategorized/what-is-gray-level-slicing-in-image-processing/

3c)Describe the necessity of smoothing filtering? Explain high pass filtering technique with example?

Ans:

https://www.slideshare.net/hiiampallavi15/smoothing-in-digital-image-processing

Smoothing

- Smoothing is often used to reduce noise within an image.
- Image smoothing is a key technology of image enhancement, which can remove noise in images. So, it is a necessary functional module in various image-processing software.
- Image smoothing is a method of improving the quality of images.
- Smoothing is performed by spatial and frequency filters

2

3d) Describe first order derivative and second order derivative filtering?Give necessary example

Ans:

Alternative 1st and 2nd Derivatives

- Sharpening filters are based on computing spatial derivatives of an image.
- The first-order derivative of a one-dimensional function $f(x)$ is

$$\frac{\partial f}{\partial x} = f(x+1) - f(x)$$

- The second-order derivative of a one-dimensional function $f(x)$ is

$$\frac{\partial^2 f}{\partial x^2} = f(x+1) + f(x-1) - 2f(x)$$

1st & 2nd Derivatives Comparisons

- Observations:
  - 1st order derivatives generally produce thicker edges
  - 2nd order derivatives have a stronger response to fine detail e.g. thin lines
  - 2nd order derivatives produce a double response at step changes in grey level
- The 2nd derivative is more useful for image enhancement than the 1st derivative
  - Stronger response to fine detail
  - Simpler implementation
  - Because these kernels approximate a second derivative measurement on the image, they are very sensitive to noise. To counter this, the image is often Gaussian smoothed before applying the Laplacian filter

4a) Justify the statement, “applying low pass filter on an image in a blurrier image”

Ans:

https://cdn.diffractionlimited.com/help/maximdl/Low-Pass_Filtering.htm

4b)Given a gray scale image of 3 X 3 size. Find the gradient magnitude of pixel “A” .

4c) math

https://www.youtube.com/watch?v=4Mw4qHH202w

4d) Define image subtraction and image averaging?

Ans:

Image subtraction or pixel subtraction is **a process whereby the digital numeric value of one pixel or whole image is subtracted from another image**. This is primarily done for one of two reasons – levelling uneven sections of an image such as half an image having a shadow on it, or detecting changes between two images.
Subtraction : g(x,y)= f1(x,y) - f2(x,y)

Image averaging is **a digital image processing technique that is often employed to enhance video images that have been corrupted by random noise**. The algorithm operates by computing an average or arithmetic mean of the intensity values for each pixel position in a set of captured images from the same scene or view field.

Signal Averaging: g(x,y)= 1/n(f1(x,y) + f2(x,y) + ……..+ fn(x,y))

Spring 2022

1a) One picture is worth more than ten thousand words? Explain
Ans:

The phrase "One picture is worth more than ten thousand words" suggests that a single image can convey information or evoke emotions more effectively than a large amount of written or spoken language. In the context of image processing, this phrase is particularly relevant because digital images can often convey complex information or ideas in a way that is more easily understood than through written or spoken language.

One reason why a picture may be more effective than words is that the human brain can process visual information much more quickly than text. Images can be processed by the brain in parallel, allowing us to quickly and easily extract information from them. This is particularly true for images that are well-designed and visually engaging, which can capture and hold our attention more effectively than blocks of text.

Image processing can help to enhance and manipulate images to make them even more effective at conveying information or emotions. For example, image segmentation algorithms can be used to highlight specific areas of an image, making it easier for viewers to understand the important features of the image. Image enhancement algorithms can be used to improve the clarity, contrast, and color of an image, making it more visually appealing and engaging.

In summary, digital image processing provides powerful tools for enhancing and manipulating images, making them more effective at conveying complex ideas and emotions. By doing so, images can be more easily understood and remembered than written or spoken language, supporting the notion that "One picture is worth more than ten thousand words."

1b) Why convolution mask operation and correlation is used in the image processing? With the proper example.

1c)

1d) A digital image is a representation of a two dimensional image as a finite set of digital values. Explain the answer with mathematical formula

Ans:

Let represent a continuous image function of two continuous variables, *s* and *t*. We convert this function into a *digital image* by sampling and quantization. Suppose that we sample the continuous image into a 2-D array, containing *M* rows and *N* columns, where are discrete coordinates. x = 0, 1, 2, Á , M - 1, y = 0, 1, 2, Á , N - 1.

for example, the value of the digital image at the origin is , and the next coordinate value along the first row is . Here, the notation (0, 1) is used to signify the second sample along the first row. It *does not* mean that these are the values of the physical coordinates when the image was sampled. In general, the value of the image at any coordinates is denoted , where *x* and *y* are integers. The section of the real plane spanned by the coordinates of an image is called the *spatial domain*, with *x* and *y* being referred to as *spatial variables* or *spatial coordinates*.

when working with gray-scale sets whose elements are expressed as triplets of the form, where *x* and *y* are spatial coordinates and *z* is the value of *f* at coordinates .

this concept graphically.

We conclude from the previous paragraph that the representations in Figs. 2.18(b) and (c) are the most useful. Image displays allow us to view results at a glance. Numerical arrays are used for processing and algorithm development. In equation form, we write the representation of an $M \times N$ numerical array as

$$f(x,y) = \begin{bmatrix} f(0,0) & f(0,1) & \cdots & f(0,N-1) \\ f(1,0) & f(1,1) & \cdots & f(1,N-1) \\ \vdots & \vdots & & \vdots \\ f(M-1,0) & f(M-1,1) & \cdots & f(M-1,N-1) \end{bmatrix} \qquad (2.4\text{-}1)$$

Both sides of this equation are equivalent ways of expressing a digital image quantitatively. The right side is a matrix of real numbers. Each element of this matrix is called an *image element, picture element, pixel*, or *pel*. The terms *image* and *pixel* are used throughout the book to denote a digital image and its elements.

In some discussions it is advantageous to use a more traditional matrix notation to denote a digital image and its elements:

$$\mathbf{A} = \begin{bmatrix} a_{0,0} & a_{0,1} & \cdots & a_{0,N-1} \\ a_{1,0} & a_{1,1} & \cdots & a_{1,N-1} \\ \vdots & \vdots & & \vdots \\ a_{M-1,0} & a_{M-1,1} & \cdots & a_{M-1,N-1} \end{bmatrix} \qquad (2.4\text{-}2)$$

2a) same as spring 2017

2b) i and ii same

iii) why histogram equalization not produce a perfectly flat histogram?

Ans:

Actually, histogram equalization is in general non-invertible.

In global histogram equalization, it can happen that pixels with different values in the original image are mapped to the same value, and therefore the operation is not invertible.

The discrete histogram equalization technique does not, in general, yield a flat histogram. Equalization is used to get a flat histogram independently of continuous or discrete distribution values, it is still difficult for equalizing the low contrast image.

In the continuous domain (used during the conceptual discussion of the process in most books), there is an infinite number of values in any interval.

In reality (i.e., when working with digital images), the histogram is discrete which means there is a fixed number of values in a range. When this range is stretched, the number of values in it is maintained. The discrete equalization process merely remaps one intensity value to another; it does not redistribute the intensity values. This means pixels which have equal intensities will still have equal intensities after the process.

Since we cannot split pixels of the same value to be mapped to different ones, complete flat histograms are not achievable in general. All pixels having the same value in the original image are mapped to the same value after global equalization.

Chatgpt said that ……… :)

Histogram equalization is a technique used in digital image processing to improve the contrast and visual appearance of an image. The basic idea of histogram equalization is to redistribute the pixel intensities of an image so that they are spread out uniformly across the available intensity range. This is achieved by transforming the original image so that its histogram has a uniform distribution.

However, it is important to note that histogram equalization does not always produce a perfectly flat histogram. This is because some images may have extreme pixel intensities that are very rare or occur only in specific regions of the image. When these rare pixel intensities are redistributed to the full range of intensities, the histogram may still have some peaks or valleys, even after equalization.

In addition, the exact shape of the histogram after equalization can depend on the specific method used to perform the equalization. For example, different equalization techniques may produce slightly different results in terms of the shape of the histogram.

Despite these limitations, histogram equalization is still a powerful tool for improving image contrast and visual appearance. By redistributing pixel intensities, histogram equalization can help to reveal details that may have been hidden in the original image due to poor contrast or lighting conditions. While it may not always produce a perfectly flat histogram, it can still significantly improve the overall visual quality of an image.

2c) ii) performance of median filtering is better than average filtering. explain this

Ans:

The performance of median filtering is often better than average filtering in certain types of image processing tasks, such as removing noise from images. This is because median filtering preserves edges and sharp features in an image better than average filtering.

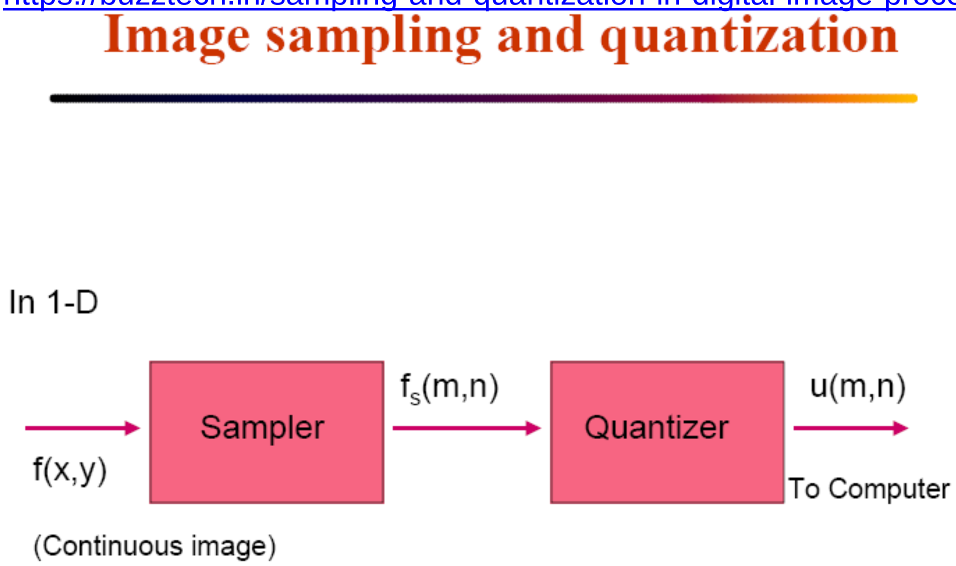
Average filtering works by replacing each pixel in an image with the average value of its neighboring pixels. This can smooth out the image and remove noise, but it can also blur edges and details in the image.

In contrast, median filtering replaces each pixel with the median value of its neighboring pixels. This has the effect of removing outliers and noise in the image while preserving edges and sharp features.

For example, if a pixel in an image has a high value compared to its neighboring pixels, it will be replaced with a value close to the median of its neighbors. In contrast, if the same pixel were processed with average filtering, it would be replaced with a value closer to the average of its neighbors, which may not preserve the sharpness of edges and features. Therefore, in situations where preserving edge and feature details is important, median filtering can be a better choice than average filtering. However, in situations where a smoother image is desired, or where preserving fine details is not as important, average filtering may be more suitable. The choice of filtering technique depends on the specific requirements of the image processing task at hand.

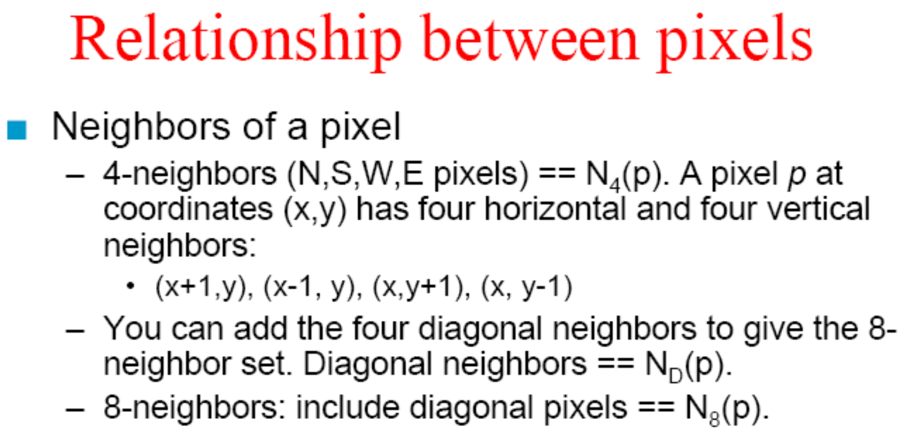
Spring 2019

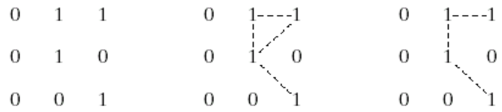
1a) short notes on sampling and quantization? Why these methods are important in digital image processing?
Ans:
https://buzztech.in/sampling-and-quantization-in-digital-image-processing/



1b) Explain the basic relationship between pixels. How to a pixel is represented in a image with mathematics?
Ans:

https://slideplayer.com/slide/12398875/





a b c

FIGURE 2.26 (a) Arrangement of pixels; (b) pixels that are 8-adjacent (shown dashed) to the center pixel; (c) *m*-adjacency.

Connectivity-contd.

- 4-adjacency: Two pixels p and q with values in V are 4-adjacent if q is in the set $N_4(p)$.
- 8-adjacency: q is in the set $N_8(p)$.
- m-adjacency: Modification of 8-A to eliminate multiple connections.
  - q is in $N_4(p)$ or
  - q in $N_D(p)$ and $N_4(p) \cap N_4(q)$ is empty.

Connected components

- Let S represent a subset of pixels in an image.
- If p and q are in S, p is connected to q in S if there is a path from p to q entirely in S.
- Connected component: Set of pixels in S that are connected; There can be more than one such set within a given S.

1c) How can you differentiate between monocular and binocular vision?

Ans:

Monocular vs. Binocular vision

Human are able to see with both eyes-call this binocular vision (both eye are in the front of the face, and the eyes point in same direction)

Some animal species (most birds-their eyes are opposite side of the face and point in opposite direction) have one eyed vision or monocular vision, which means their eyessee the world separately and produce two pictures rather than one.

BV is responsible for depth perception, is important for athletes who must quickly and accurately judge the distance between player, the ball, the boundary lines and other objects.

Monocular vs. Binocular View

- Monocular view: one eye only! Many optical instruments are designed from one eye view.
- Binocular view: two eyes with each seeing a separate picture of the world.
  - Increase the field of view: fish, rabbits can see 360.
  - Overlapping view: predators with two eyes in the front.

1d) same as previous

2a) Find the conceptual relationship between between RGB and HSI colour models?

RGB and HSI are two common color models used in digital image processing. The RGB color model represents colors as a combination of red, green, and blue primary colors, while the HSI color model represents colors as a combination of hue, saturation, and intensity. The conceptual relationship between RGB and HSI can be described as follows:

Hue: The hue component in HSI represents the actual color of an object or image, regardless of its brightness or saturation. In the RGB color model, hue is not represented explicitly, but it can be inferred from the combination of red, green, and blue values.

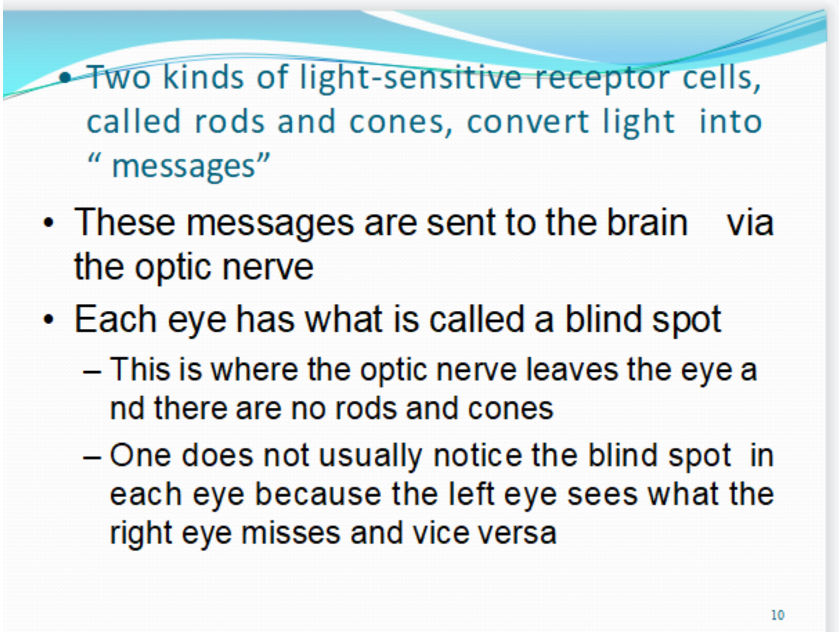
Saturation: Saturation in the HSI model represents the purity of the color, or how vivid it appears. In the RGB model, saturation can be calculated as the difference between the maximum and minimum color values.

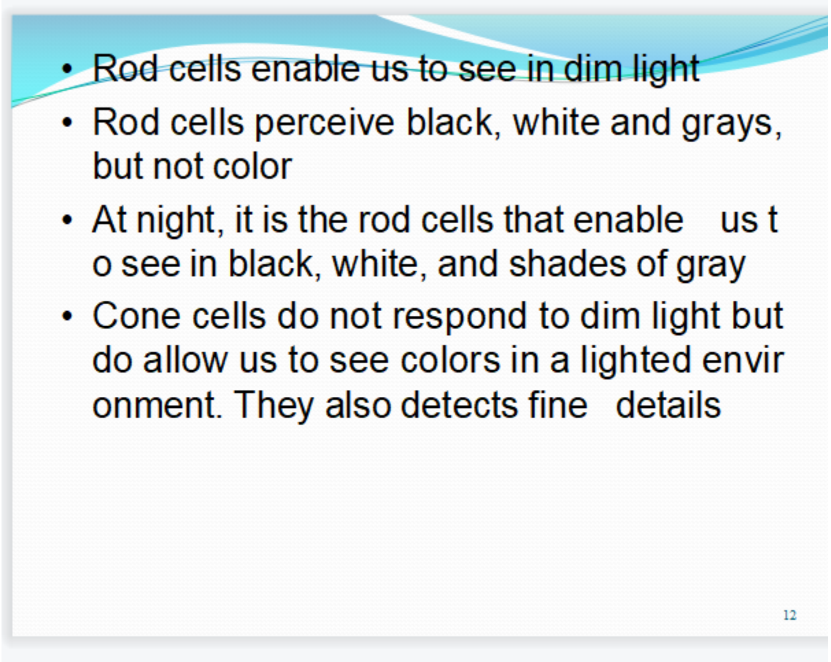
Intensity: In the HSI model, intensity represents the brightness or lightness of the color. In the RGB model, intensity can be calculated as the average of the red, green, and blue values. The conversion between RGB and HSI color models is often used in image processing applications, as it allows for the manipulation of color values in a more intuitive way.

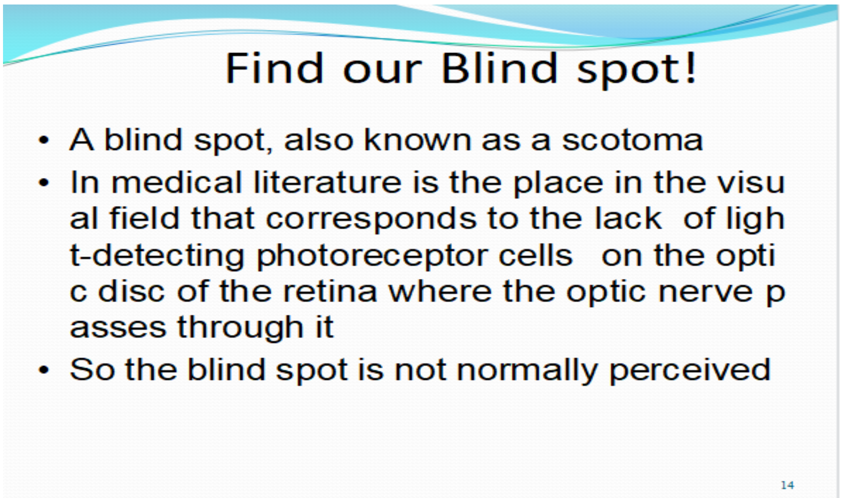
The conversion from RGB to HSI involves calculating the hue, saturation, and intensity values from the red, green, and blue values, while the conversion from HSI to RGB involves calculating the red, green, and blue values from the hue, saturation, and intensity values.

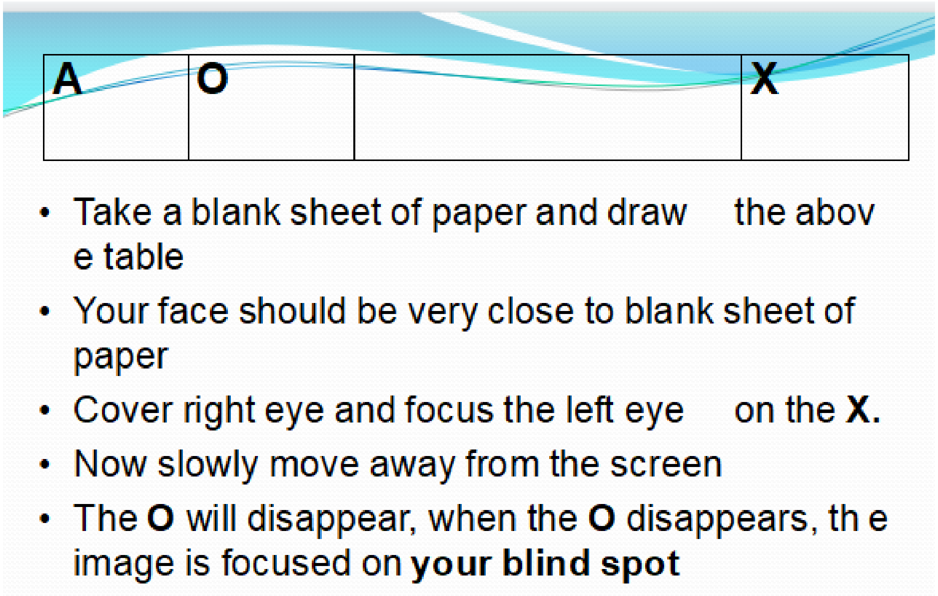
2b) Form a mathematical formation of digital image. analyse the steps involved in digital image processing.

2c) what are the types of light receptors ?explain the process to identify our eyes blind spot.









2d) In digital image processing high colour image is presented by 12 bit where 24 bit image is presented by true colour justify the statement.

In digital image processing, the number of bits used to represent a pixel determines the number of possible color or grayscale values that can be assigned to that pixel. The more bits used to represent each pixel, the more possible color or grayscale values that can be assigned, resulting in a higher color depth and greater color accuracy.

A 12-bit color image can represent up to 4096 possible colors, while a 24-bit color image can represent up to 16.7 million possible colors. This is because a 12-bit color image assigns 12 bits (or 2^12 = 4096 possible values) to each of the red, green, and blue color channels, while a 24-bit color image assigns 8 bits (or 2^8 = 256 possible values) to each of the red, green, and blue color channels.

A 24-bit color image is often referred to as "true color" because it can represent a wide range of colors with a high degree of accuracy. This is because the human eye is capable of distinguishing between millions of different colors, and a 24-bit color image can reproduce many of these colors with a high level of fidelity.

In contrast, a 12-bit color image may not be able to reproduce as many colors with the same degree of accuracy, but it can still provide a high level of color detail and accuracy for many applications, such as medical imaging or scientific analysis, where color accuracy is critical.

In summary, while a 12-bit color image can provide a high level of color accuracy for many applications, a 24-bit color image provides a much wider range of colors and greater color accuracy, which is why it is often referred to as "true color."

2e) which filter is suitable for impulse or salt pepper noise describe in brief.

Impulse or salt and pepper noise is a type of noise that can occur in digital images due to errors in the image acquisition or transmission process. This type of noise can manifest as random black and white pixels scattered throughout the image, which can significantly degrade the image quality.

To remove impulse or salt and pepper noise from an image, several filters can be used, including median filter, adaptive median filter, and alpha-trimmed mean filter.
Among these filters, the median filter is considered to be the most effective for removing impulse or salt and pepper noise. The median filter replaces each pixel in the image with the median value of the neighboring pixels, effectively smoothing out the noise while preserving the edges and details in the image.

The steps involved in applying a median filter to an image with impulse or salt and pepper noise are as follows:

1. Define a window size, usually an odd number (e.g., 3x3, 5x5, 7x7).
2. Move the window over each pixel in the image, and collect the values of all the pixels within the window.
3. Sort the pixel values in ascending order and replace the center pixel with the median value.
4. Repeat the process for all pixels in the image.

The median filter is effective for removing impulse or salt and pepper noise because it is able to identify and remove the outliers that represent the noisy pixels while preserving the underlying structure and details in the image.

In summary, the median filter is a suitable filter for removing impulse or salt and pepper noise from digital images, as it is able to effectively smooth out the noise while preserving the edges and details in the image.

3a) How is a monochrome image enhanced by histogram equalization.

Histogram equalization is a widely used technique in digital image processing for enhancing the contrast of a monochrome image. The technique works by redistributing the pixel intensity values in the image to make the histogram more evenly spread across the intensity range.

The steps involved in histogram equalization are as follows:

1. Compute the histogram of the image, which represents the distribution of pixel intensity values in the image.
2. Compute the cumulative distribution function (CDF) of the histogram by summing the values of the histogram bins.
3. Normalize the CDF to scale the values between 0 and 1.
4. Compute the new pixel intensity values by mapping the original pixel intensities to their corresponding values in the normalized CDF.

The result of histogram equalization is a new image with enhanced contrast, where the dark and light areas of the image are more distinct and the details in the image are more visible.

The reason histogram equalization works well for enhancing monochrome images is that it takes advantage of the full range of pixel intensities available in the image. Often, monochrome images have a narrow range of pixel intensities, which can result in low contrast and poor visibility of image details. Histogram equalization helps to spread out the pixel intensities, so that all intensity values are used, resulting in a more balanced distribution of intensity values across the image.

However, it's important to note that histogram equalization may not always be the best technique for enhancing an image, as it can also result in the amplification of noise in the image. Other techniques, such as adaptive histogram equalization or contrast stretching, may be more suitable for certain types of images or specific applications.

3b) Explain spatial filtering in image enhancement explain different types of thresholding operation in short?

Spatial filtering is a type of image enhancement technique that operates on individual pixels of an image based on their surrounding pixels. The technique works by applying a filter kernel to the image, which performs a mathematical operation on the pixel values within the kernel. The result of the operation is then assigned to the central pixel of the kernel.

The main goal of spatial filtering is to enhance the image by smoothing out noise, sharpening edges, or highlighting certain features of the image. The type of filter used depends on the desired outcome and the characteristics of the image.

There are several types of spatial filters used in image enhancement, including:

Mean filter: This filter replaces each pixel with the average of the surrounding pixels within a defined window. It is used for smoothing the image and reducing noise.

Gaussian filter: This filter applies a weighted average to the pixels within a window, where the weights are based on a Gaussian distribution. It is used for smoothing the image and reducing noise while preserving edges.

Laplacian filter: This filter highlights the edges of an image by detecting areas of rapid intensity change. It is used for sharpening the image.

Sobel filter: This filter detects edges in the image by computing the gradient in the horizontal and vertical directions. It is used for edge detection.

Thresholding is another important technique used in image processing, particularly for image segmentation. Thresholding involves dividing the pixels in an image into two groups based on their intensity values: those above a certain threshold and those below it.

There are several types of thresholding operations used in image processing, including:

Global thresholding: This involves selecting a single threshold value that separates the pixels into two groups based on their intensity values.

Otsu's thresholding: This technique uses a statistical method to automatically determine the optimal threshold value based on the histogram of the image.

Adaptive thresholding: This involves applying a local threshold value to each pixel based on the intensity values of its neighboring pixels. It is used for images with non-uniform lighting or uneven contrast.

In summary, spatial filtering and thresholding are important techniques in image processing for enhancing and segmenting images, respectively. Different types of filters and thresholding operations are used depending on the characteristics of the image and the desired outcome.

3c) Is monochrome image more suitable for image segmentation than colour image?why?

In certain situations, monochrome images can be more suitable for image segmentation than color images. This is because monochrome images only have one color channel, whereas color images typically have multiple color channels (such as red, green, and blue).

By using monochrome images for segmentation, we can simplify the segmentation task by reducing the complexity of the image data. Monochrome images can also provide better contrast and clarity in certain scenarios, making it easier to distinguish between different regions or objects in the image.

However, it is important to note that color images can also be very useful for segmentation in many cases. Color can provide important contextual information that can help to differentiate between similar objects or regions in an image. Color can also be useful in situations where the texture or pattern of an object is important for segmentation.

Ultimately, the choice between using monochrome or color images for segmentation will depend on the specific characteristics of the images and the goals of the segmentation task.

3d)Define temporal processing.explain different operations of temporal processing with examples.

4a) How gray level slicing enhance the image? differentiate between color image and monochrome image.

A color image and a monochrome image are two different types of images based on the number of color channels they contain:

Color Image: A color image is an image that contains multiple color channels such as red, green, and blue (RGB). Each pixel in a color image is represented by three values, corresponding to the intensity of each of the three color channels. Color images are used to represent images that have a wide range of colors, such as photographs or digital paintings.

Monochrome Image: A monochrome image, also known as a grayscale image, is an image that only contains one color channel. Each pixel in a monochrome image is represented by a single value that corresponds to the brightness of the pixel. Monochrome images are used to represent images that have a limited range of colors, such as medical images or black and white photographs.

In summary, the key difference between a color image and a monochrome image is the number of color channels they contain. Color images contain multiple color channels to represent a wide range of colors, while monochrome images only contain one color channel to represent a limited range of colors.

4b)Define otsu method. give suitable examples

Otsu's method, also known as the maximum variance method, is a widely used image segmentation algorithm that automatically determines the threshold value for separating the foreground and background pixels in a grayscale image.

The Otsu method works by finding the threshold that maximizes the variance between the two classes of pixels (foreground and background). It assumes that the image contains two classes of pixels that can be separated by a threshold value, and seeks to find the threshold that maximizes the variance between these classes.

Suitable examples where Otsu's method can be used include:

Medical Imaging: Otsu's method can be used to segment medical images such as X-rays, CT scans, or MRIs, to separate the background from the objects of interest (such as tumors, bones, or organs).

Object Detection: Otsu's method can be used to segment objects from the background in images of natural scenes or in computer vision applications such as object detection.

Character Recognition: Otsu's method can be used to separate characters from the background in document images, making it useful for optical character recognition (OCR) applications.

Overall, Otsu's method is a simple yet powerful algorithm that can be applied to a wide range of image segmentation tasks.

4c)math same

Autumn 2019

1a) write the similarity and differences between camera and eye
Ans:

EYE	CAMERA
•The lens and cornea focus light onto the back of the retina •Muscles change the shape of the lens to focus the image •The mussels in the iris regulate the amount of light that reaches the retina	•The lens focuses light onto a light-sensitive surface called film •The lens of a camera can be moved back or forward to focus images •The aperture, like the iris, regulate the amount of light that reaches the retina

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EYE	CAMERA
•As light enters the eye and passes through the lens and cornea, it refracts, or bends. When the light refract s, it turns the image upside down and backward onto the retina	•Light that enters the camera refracts and turns images, upside down and back ward onto the film

Differences between a camera and an eye

- *Main difference:* An eye is a physiological computational element but a camera is a mechanical device. Eye doest work independently and its operation correlated with brai n, whereas a camera that does what let it to do
- *Retina and film:* Retina can automatically change its sen sitivity to light sensitivity depending upon the amount of il lumination presented to it. On the other hand in the came ra can never change their sensitivity automatically
- *Binocular vision:* an eye has a blind spot through which a ll nerves leave to brain. So, normally all living beings hav e two eyes. The part of image that blind spot of one eye cannot cover will cover by the second eye.

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- Unlike eyes, *cameras don't have any blind spot* and hen ce need only one lens. That is most cameras don't hav e "binocular vision" which is a key characteristic of eye.
- *Automatic focusing:* Eye has automatic focusing capabili ty which is controlled by brain. It is neurological. Eyes ca n focus objects at any distance automatically but in the c ase of cameras it is to be accomplished by a photograph er. So it is manual in cameras.

1b) Explain the fundamental steps of digital image processing

Ans:

Same as spring 2017

1c) Describe grayscale image and colour image. give necessary examples

Ans:

Grayscale Images

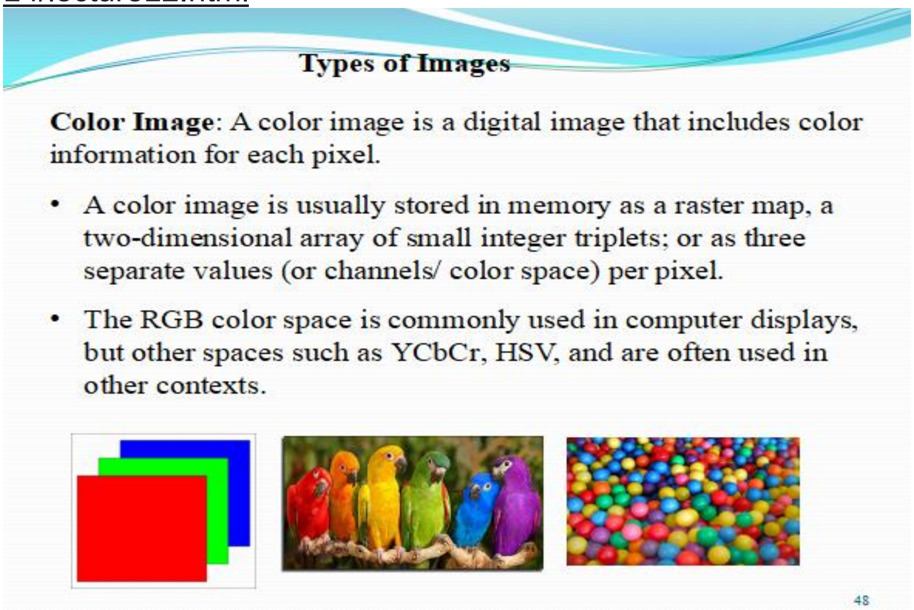
A grayscale (or graylevel) image is simply one in which the only colors are shades of gray. The reason for differentiating such images from any other sort of color image is that less information needs to be provided for each pixel. In fact a `gray' color is one in which the red, green and blue components all have equal intensity in RGB space, and so it is only necessary to specify a single intensity value for each pixel, as opposed to the three intensities needed to specify each pixel in a full color image.

Often, the grayscale intensity is stored as an 8-bit integer giving 256 possible different shades of gray from black to white. If the levels are evenly spaced then the difference between successive graylevels is significantly better than the graylevel resolving power of the human eye.

Grayscale images are very common, in part because much of today's display and image capture hardware can only support 8-bit images. In addition, grayscale images are entirely sufficient for many tasks and so there is no need to use more complicated and harder-to-process color images.

Color images:

https://homepages.inf.ed.ac.uk/rbf/CVonline/LOCAL_COPIES/OWENS/LECT14/lecture12.html



1d) same

2a) Find the conceptual relationship between RGB and HSI colour model

2b) describe the mathematical formation of analogue image. analyse the step involved in digitalize the analogue image.

Ans:

Analog Image mathematical model

A Simple Image Model

- Illumination & reflectance components:
  - Illumination: $i(x,y)$
  - Reflectance: $r(x,y)$
  - $f(x,y) = i(x,y) \cdot r(x,y)$
  - $0 < i(x,y) < \infty$

    and $0 < r(x,y) < 1$

    (from total absorption to total reflectance)

Analog Image mathematical model

- Amount of light incident by object or point:

Illumination (meaning:source of light) $i(x,y)$

The value of $i(x,y)$ is between 0 and α.

Some typical values of $i(x,y)$

Clear Sunny day	10,000	ft-candles.
Cloudy day	1,000	ft-candles.
Clear full moon	0.01	ft-candles.
Typical office	100	ft-candles.

- Amount of light reflected on object or point:

Reflectance or $r(x,y)$. and $0<r(x,y)<1$.

$r=0$ no reflection; total absorption

$r=1$ full reflection; no absorption

Some typical values of $r(x,y)$

Black velvet	0.01
Stainless steel	0.65
White wall	0.8
Silver-plated metal	0.9
Snow	0.93

Conversion of Analog Image into Digital Image:

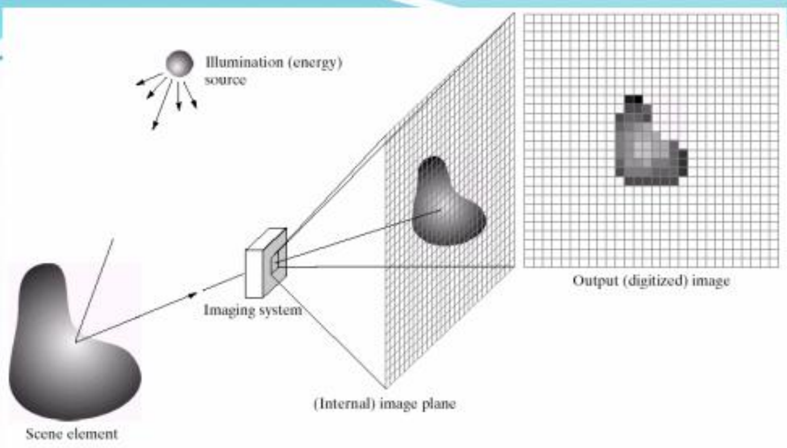
Image Sampling and Quantization

There are numerous ways to acquire images but our objective to *generate digital images from sensed data*. To create digital image, we need to convert the continuous sensed data into digital form. This involves two processes: ***sampling*** and ***quantization***.

•The basic idea behind sampling and quantization is illustrated in Fig. 2.16. Fig. 2.16 (a) shows a continuous image, f(x, y), that we want to convert digital form. *An image may be continuous* with respect to *the x- and y- coordinates and also in amplitude*. To convert it to digital form, we have to sample the function in both coordinates and in amplitude.

•Digitizing the coordinate values is called ***sampling***.

•Digitizing the amplitude values is called the ***quantization.***



a b c d e

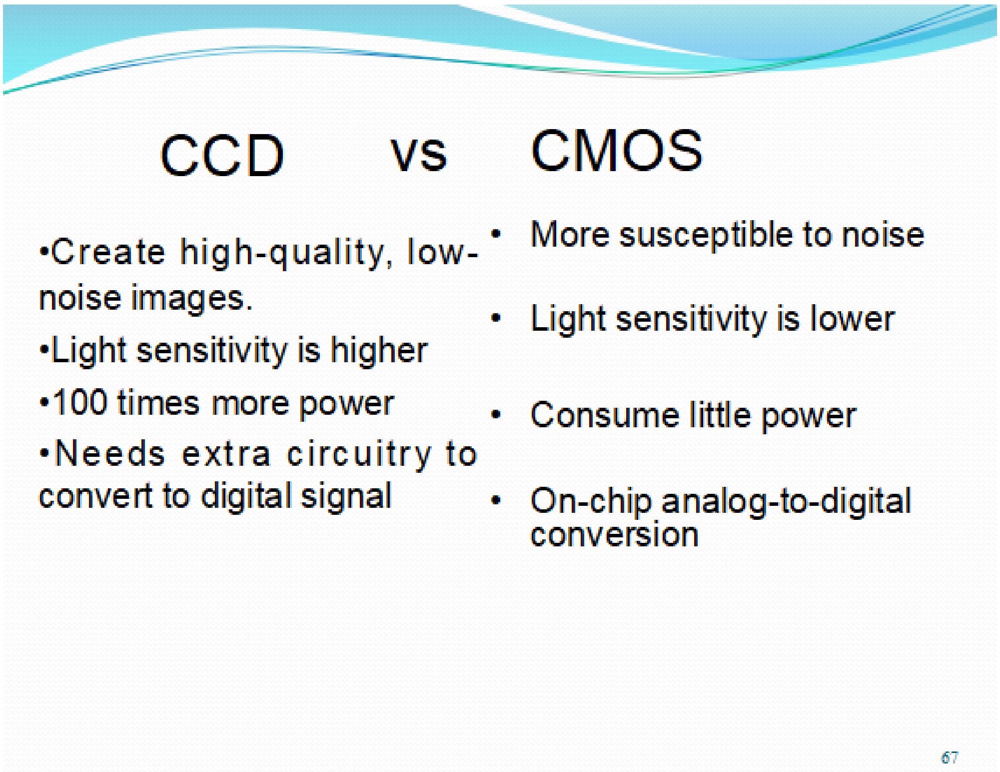
FIGURE 2.15 An example of the digital image acquisition process. (a) Energy ("illumination") source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.

$f(x,y) = i(x,y)r(x,y)$, illumination & reflectance

2c) how can you differentiate between monocular and Binocular vision

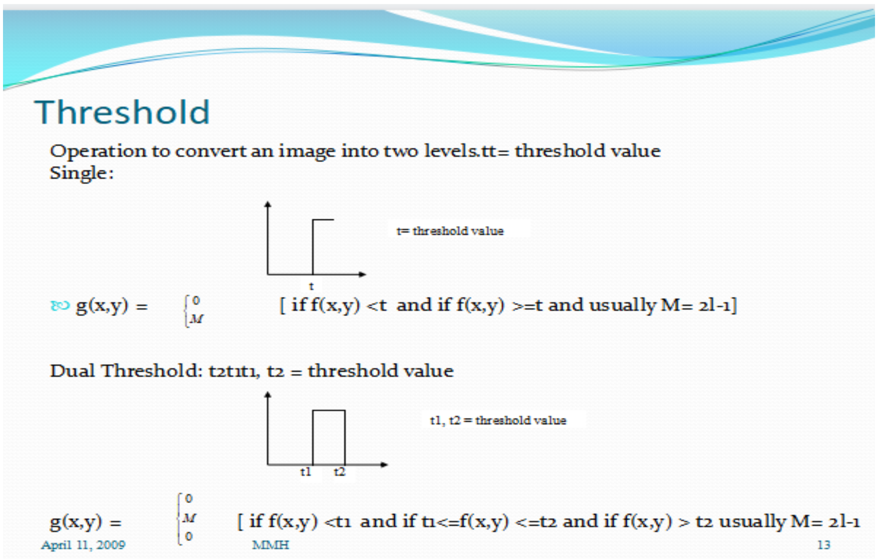
2d) write the differences between CCD and CMOS camera

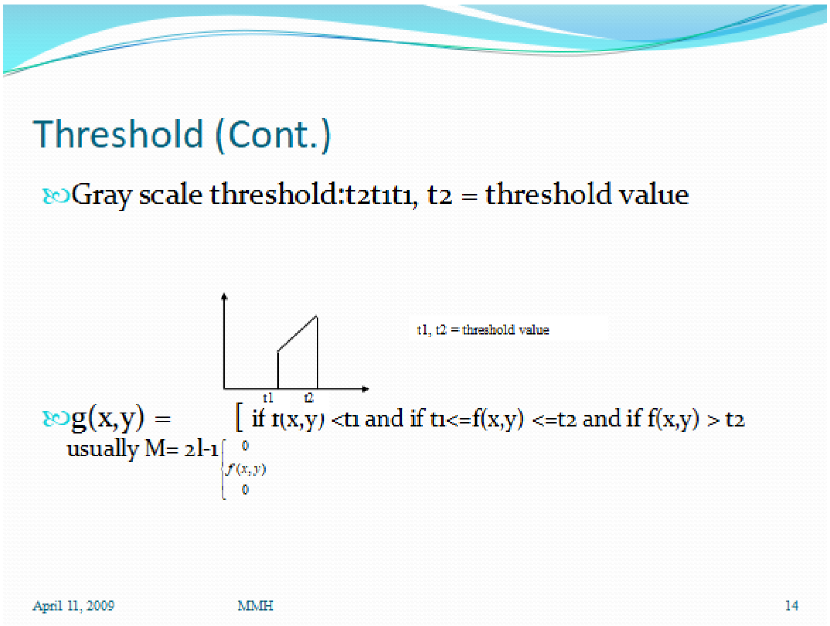
Ans:



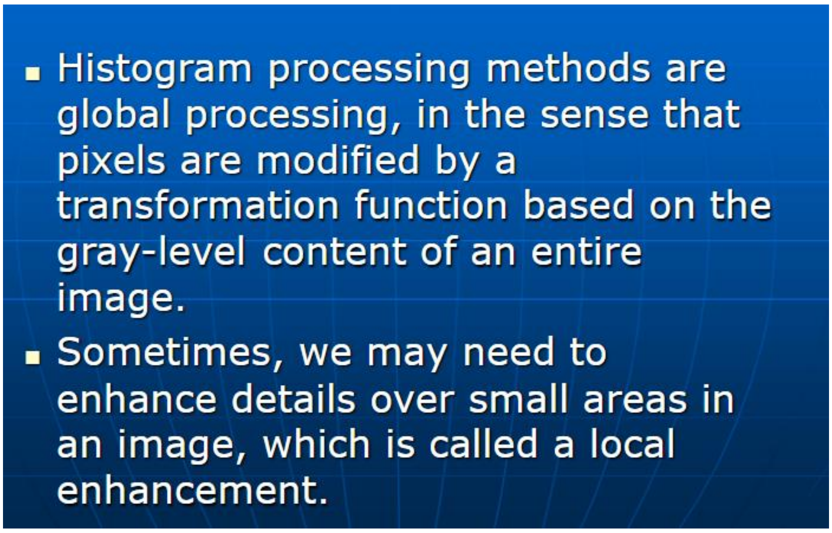
3a) describe the necessity of smoothing filtering. explain the average filtering technique with example

3b) explain different types of thresholding operation in short
Ans:





3c) write the difference between local and global histogram



Histogram is a graphical representation of the distribution of pixel intensities in an image. Histograms can be computed at a local or global level, depending on the region of the image used for computing the histogram. The key differences between local and global histograms are as follows:

Local Histogram: A local histogram is computed over a small region or a sub-image of the original image. The local histogram represents the distribution of pixel intensities within that region, which may differ from the distribution in other regions of the image. Local histograms can be used to capture local texture or contrast information in an image.

Global Histogram: A global histogram is computed over the entire image, representing the overall distribution of pixel intensities in the image. The global histogram can be used to characterize the overall brightness or contrast of the image.
In summary, the key difference between local and global histograms is the region of the image used for computing the histogram. Local histograms capture local texture or contrast information, while global histograms represent the overall distribution of pixel intensities in the image. Both types of histograms have their own advantages and can be useful in different image processing tasks.

3d) describe first order derivative and second order derivative filtering. give necessary example

In image processing, first-order and second-order derivative filters are used for edge detection and feature extraction. These filters are applied to an image to compute the gradient of the image, which represents the rate of change of pixel intensities in the x and y directions.

First-order derivative filtering: First-order derivative filters, such as the Sobel or Prewitt filters, compute the gradient of an image by convolving the image with a small kernel that approximates the derivative in the x and y directions. The resulting image highlights the edges and boundaries in the original image. For example, in edge detection applications, the Sobel filter can be used to extract the edges of an image.

Second-order derivative filtering: Second-order derivative filters, such as the Laplacian filter, compute the rate of change of the gradient of an image. These filters are used for detecting the locations of corners and other high-frequency features in an image. The Laplacian filter can be applied to an image to enhance the edges and corners.

Example: One example of using first-order derivative filters is in the detection of lane markings in autonomous vehicles. The Sobel filter can be used to extract the edges of the lane markings, which can then be used for navigation. Another example of second-order derivative filtering is in the detection of blood vessels in medical images. The Laplacian filter can be used to detect the location of blood vessels by enhancing the edges and corners in the image.

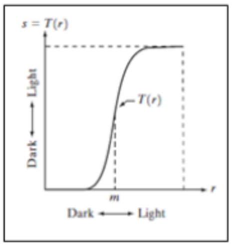
4a) how contrast stretching enhance the image. explain in brief
Ans:

https://slideplayer.com/slide/3532752/

- **Contrast Stretching :**

  If T(r) has the form as shown in the figure below, the effect of applying the transformation to every pixel of f to generate the corresponding pixels in g would:

  Produce higher contrast than the original image, by:
  - Darkening the levels below m in the original image
  - Brightening the levels above m in the original image



  So, Contrast Stretching: is a simple image enhancement technique that improves the contrast in an image by 'stretching' the range of intensity values it contains to span a desired range of values. Typically, it uses a linear function

4b) define various types of sensors to acquire images

There are many types of sensors that can be used to acquire images, each with their own advantages and disadvantages. Here are some common types of sensors used for acquiring images:

CCD (Charge-Coupled Device) Sensors: CCD sensors are used in digital cameras and are commonly used for capturing high-quality images. They produce low noise images with high dynamic range, making them suitable for a wide range of applications.

CMOS (Complementary Metal-Oxide-Semiconductor) Sensors: CMOS sensors are similar to CCD sensors but use less power and are more cost-effective. They are commonly used in mobile phones and other portable devices.

Thermal Sensors: Thermal sensors detect differences in temperature to create images that can be used for medical diagnosis, security, and environmental monitoring. They are commonly used in applications such as thermography and thermal imaging.

Infrared Sensors: Infrared sensors detect infrared radiation to create images that can be used for night vision, remote sensing, and medical imaging. They are commonly used in surveillance, military, and medical applications.

Radar Sensors: Radar sensors use radio waves to detect objects and create images. They are commonly used in automotive applications for object detection and collision avoidance.

Lidar Sensors: Lidar sensors use laser light to detect objects and create images. They are commonly used in autonomous vehicles and robotics for navigation and object detection.

In summary, there are many different types of sensors used for acquiring images, each with their own strengths and weaknesses. The choice of sensor depends on the specific application and the desired image quality and features.

4c) calculate and draw the histogram from the following image and equalize it

Ans : same

Autumn 2017

Repeat question