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COMPUTER ENGINEERING
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1. Differences between computer vision and digital image processing

COMPUTER VISION	DIGITAL IMAGE PROCESSING
This is use computers to emulate human vision	This is use computers to process images.
An example is to recognise objects, defect for automatic driving,	An example is to enhance the image for later use
The goal is image understanding	The goal is image processing

2. Origin of DIP

   One of the first applications of digital images was in the newspaper industry, when pictures were first sent by submarine cable between London and New York. This transmission took about a week. In early 1920s, Bartlane picture transmission system was introduced and time in transferring images reduced. This was done by use of specialized equipment for cable transmission and reconstruction at receiving end.

   The history of digital image processing is intimately tied to the development of the digital computer.

3. Categories of digital storage
   i. Short term storage – stores images required during processing. It includes frame buffers used for temporary storage
   ii. Online storage – stores images that are called upon frequently. It is used for fast recall and retrieval. On-line storage generally takes the form of magnetic disks or optical-media storage.
   iii. Archival storage – a permanent (long term) storage characterized by infrequent access. Archival storage uses magnetic tapes.

4. Working principle of x-ray tube

   The x-ray tube is a relatively simple electrical device typically containing two principle elements: a cathode and an anode. The cathode is heated to a high temperature, causing free electrons to be released. As the electrical current flows through the tube from cathode to anode, the electrons undergo an energy loss, which results in the generation of x-radiation. The energy (penetrating power) of X-rays is controlled by a voltage applied across the anode, and by a current applied to the filament in the cathode.

5. Basic procedures for generating ultrasound images
   i. The ultrasound system (a computer, ultrasound probe consisting of a source and receiver, and a display) transmits high-frequency sound pulses into the body.
   ii. The High-frequency sound waves travel from the probe into the body and hit a boundary between tissues. Some of the sound waves are reflected back to the probe, while some travel on further until they reach another boundary and get reflected.
   iii. The probe collects the sounds that bounce back and are relayed to the computer.
   iv. The machine calculates the distance from the probe to the tissue or organ boundaries using the speed of sound in tissue and the time of each echo's return.
   v. The system displays the distances and intensities of the echoes on the screen, forming a two-dimensional image. Advancements in ultrasound technology include three-dimensional (3-D) ultrasound that formats the sound wave data into 3-D images.

6. a. Angiograph is an image of the inside of blood vessels and organs of the body, with particular interest in the arteries, veins, and the heart chambers. Angiography is another major application in an area called contrast enhancement radiography.

   b. In the first image, the catheter is inserted into the large blood vessel on the lower left of the picture. A catheter is a small, flexible, hollow tube that is threaded into the blood vessel and guided to the area to be studied. When the catheter reaches the site under investigation, an X-ray contrast medium is injected through the tube. This

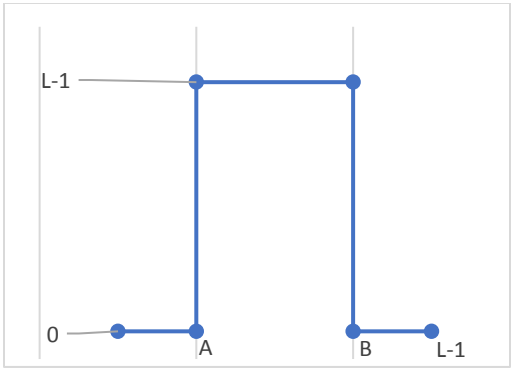
enhances contrast of the blood vessels and enables the radiologist to see any irregularities or blockages.

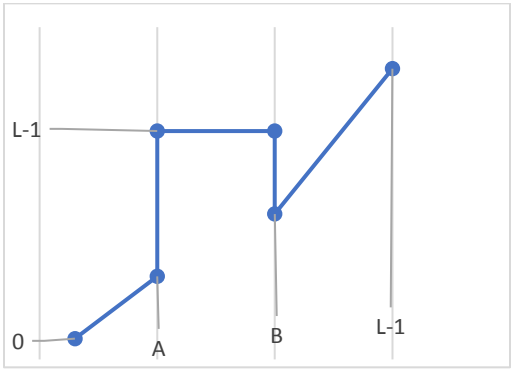
Intensity-level slicing is used to highlight the major blood vessels that appear brighter as a result of an injected contrast medium.

In the second image, the range of interest has its intensity increased (white colour) and the intensity of the other areas reduced (black colour).

In the third image, the range of interest has its intensity increased (white colour) and the intensity of the other areas were left (remained unchanged)

c. Graphical illustrations to explain the transformation:





Where A-B represents the region of interest

7. a.

i. spatial domain - this is the plane containing the pixels of an image. It is the section of the real plane spanned by the coordinates of an image.

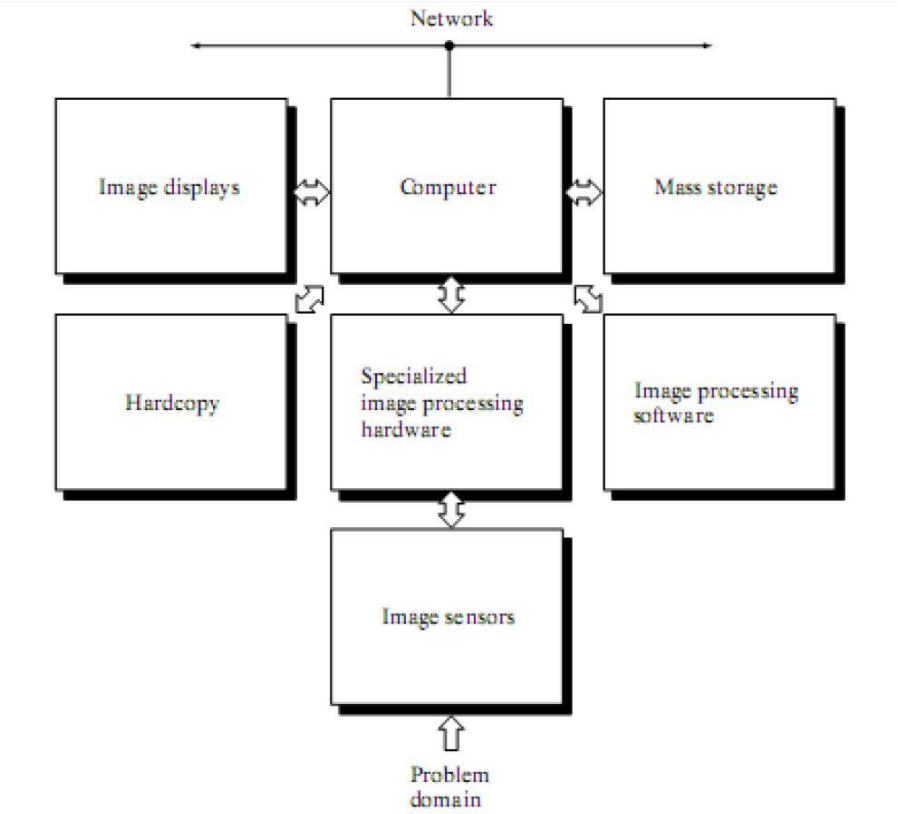
ii. spatial filtering - Spatial filtering deals with performing operations, such as image sharpening, by working in a neighborhood of every pixel in an image.

iii. image enhancement – this is the manipulation of an image so that the result is more suitable than the original for a specific application.
iv. contrast stretching – this is the process of expanding the range of intensity levels in an image so that it spans full intensity range of the recording medium or display device.

b. Decomposing an image into its bit planes is useful for analyzing the relative importance of each bit in the image, a process that aids in determining the adequacy of the number of bits used to quantize the image.

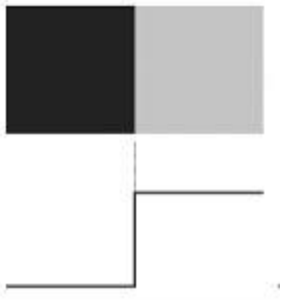
c. Components of a general-purpose image processing system:
    i. Image Processing Hardware: this is the dedicated hardware that is used to process the instructions obtained from the image sensors. It passes the result to general purpose computer. It consists of the digitizer plus hardware that performs other primitive operations.
    ii. Computer: this is used in the image processing system is the general-purpose computer that is used by us in our daily life. It can range from a PC to a supercomputer.
    iii. Image Processing Software: this is the software that includes all the mechanisms and algorithms that are used in image processing system. It consists of specialized modules that perform specific tasks.
    iv. Mass Storage: this is a must in image processing applications this stores the pixels of the images during the processing.
    v. Hard Copy Device: image is processed and then it is stored in the hard copy device. Devices for recording images include laser printers, film cameras, heat-sensitive devices, inkjet units, and digital units, such as optical and CDROM disks, or any external device.
    vi. Image Display: it includes the monitor or display screen that displays the processed images. Image displays in use today are mainly color monitors.
    vii. Networking: this is the connection of all the above elements of the image processing system. Because of the large amount of data inherent in image

processing applications, the key consideration in image transmission is bandwidth.

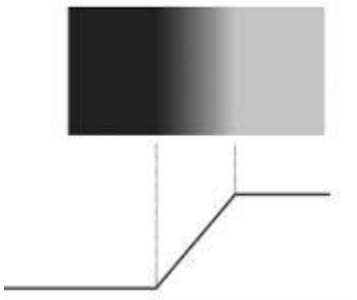


8. Edge detection is an abrupt change in intensity between two regions. Edge detection has beneficial applications in the fields such as machine vision, pattern recognition and biomedical imaging etc. Edge detection highlights high frequency components in the image. Edge detection is a challenging task.

9. Edge models:
    i. Step model - A step edge involves a transition between two intensity levels occurring ideally over the distance of 1 pixel.



ii. Ramp model - The slope of the ramp is inversely proportional to the degree of blurring in the edge. In this model, there is no thin path.



iii. Roof-edge model - Roof edges are models of lines through a region, with the base (width) of a roof edge being determined by the thickness and sharpness of the line. Roof edges arise, for example, in range imaging, when thin objects (such as pipes) are closer to the sensor than their equidistant background.

10.

i. Factors responsible for the occurrence of disconnection of edges

- Noise
- Non-uniform illumination

ii. Sobel mask is more preferable to prewitt mask because it has better noise-suppression (smoothing) characteristics.

11.

i. Edge pixels – an edge pixel is one in which the intensity of the image function changes abruptly

ii. Edge detectors - they are local image processing methods designed to detect an edge pixel

iii. Morphological watershed segmentation - in watershed segmentation, an image is regarded as a topographic landscape with ridges and valleys. The elevation values of the landscape are typically defined by the gray values of the respective pixels or their gradient magnitude. Based on such a 3D representation the watershed transform decomposes an image into catchment basins.

12. Two criterias used for establishing similarity in edges pixel are:

i. the strength (magnitude)

$$M(x,y) = mag\ (\nabla f) = \sqrt{gx^2 + gy^2}$$

ii. the direction of the gradient vector

$$\propto (x,y) = \tan^{-1}\left(\frac{gy}{gx}\right)$$

13. Approach based on the Hough transform is as follows:

i. Obtain a binary edge image

ii. Specify subdivisions in the $\rho\theta$-plane.

iii. Examine the counts of the accumulator cells for high pixel concentrations.

iv. Examine the relationship (principally for continuity) between pixels in a chosen cell.

14. i. the difficulty encountered in implementing Hough transform using slope-intercept representation of straight lines is that the slope of the line approaches infinity as the line approaches the vertical direction.

ii. This problem can be solved by using the normal representation of a line: $xcos\theta + ysin\theta = \rho$

15. Light is a type of electromagnetic radiation that can be sensed by the human eye. The colors that humans perceive in an object are determined by the nature of the light reflected from the object. A body that reflects light relatively balanced in all visible wavelengths appears white to the observer. However, a body that favors reflectance in a limited range of the visible spectrum exhibits some shades of color.

16. Difference between colors of light and pigments

Colors of light	Pigments
Primary color of light is defined as any of three primary colors of light from which all colors can be obtained by additive mixing	In pigment, a primary color is defined as one that subtracts or absorbs a primary color of light and reflects or transmits the other two.
The primary colors of light are red, green and blue. The secondary colors of light are magenta, cyan, and yellow.	The primary colors of pigments are magenta, cyan, and yellow. The secondary pigment colors are red, blue, and green.
You subtract colors to get to white.	You subtract colors to get to white.

17. Attributes of a colour are:
    i. Brightness - embodies the achromatic notion of intensity
    ii. Hue - attribute associated with the dominant wavelength in a mixture of light
    iii. Saturation - refers to the relative purity or the amount of white light mixed with a hue
18. Full-color image processing consists images acquired by colour TV camera or colour scanner. Each component can be processed using gray-scale processing techniques or by working with color pixels directly, treating each pixel as a vector. It is used in a broad range of applications, including publishing, visualization, and the Internet.
    Pseudo-color processing consists of assigning colors to gray values based on a specified criterion. It is used is for human visualization and interpretation of gray-scale events in an

image or sequence of images. Slicing and color coding are examples of pseudo-color image processing.

19. Motivation to use colour:

    • Powerful descriptor that often simplifies object identification and extraction from a scene

    • Humans can discern thousands of colour shades and intensities, compared to about only two dozen shades of gray