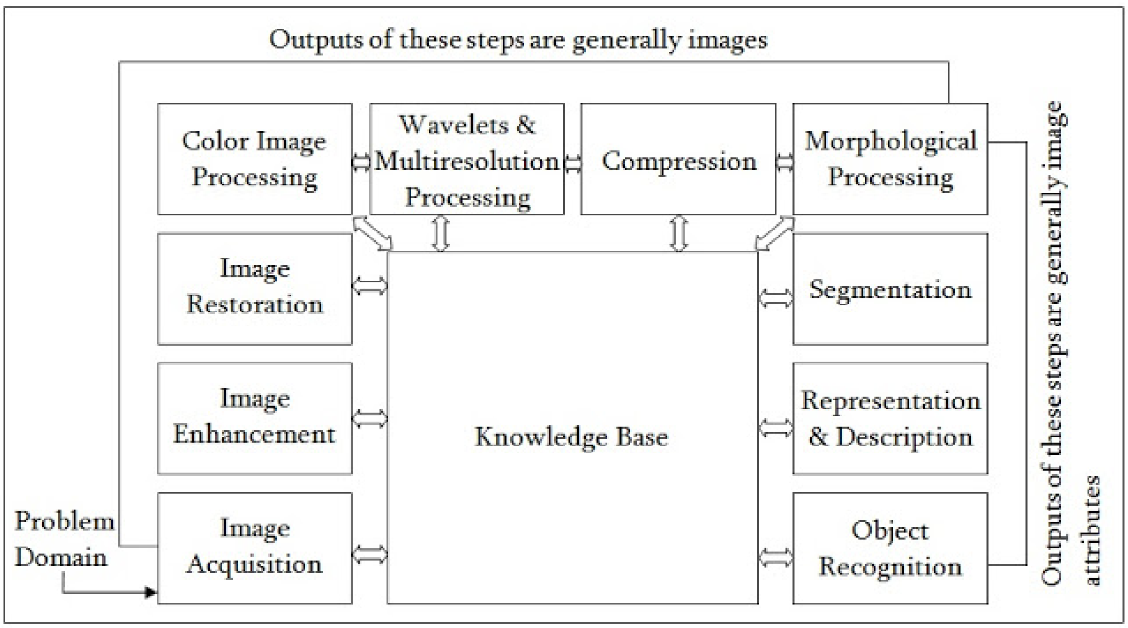
Title: Introduction to image processing.

Explanation:

An **image** may be defined as a 2-D function f(x, y), where x and y are spatial (time or plane) co-ordinates and the amplitude 'f' at any pair of coordinates (x,y) is called the intensity or gray level of the image at that point. When f, x and y are finite and discrete, we can call the image a digital one.

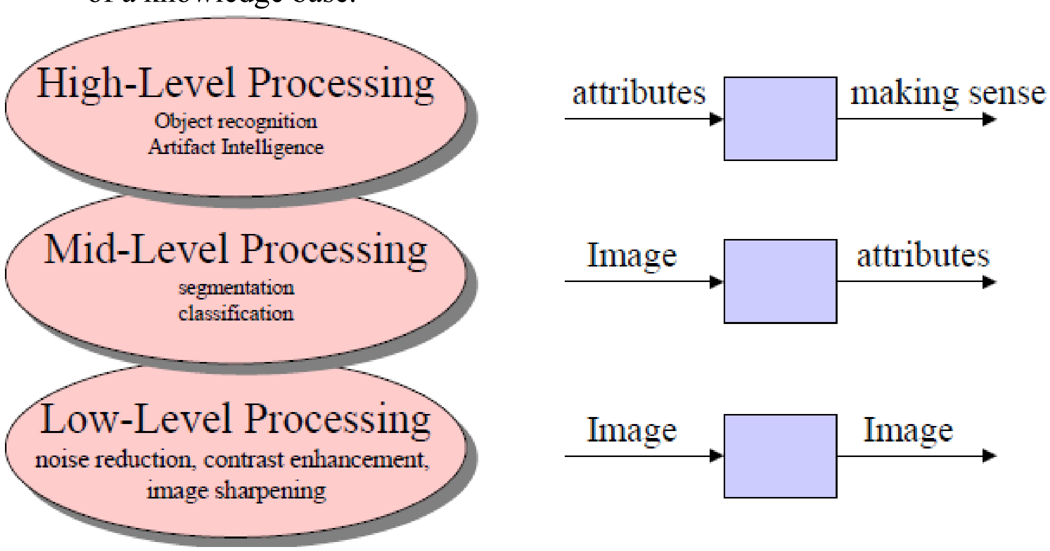
Digital image processing refers to the manipulation of an image by means of a processor.

Fundamental steps in digital image processing:



- Image acquisition:
  - Involves pre-processing such as scaling.
- Image enhancement:
  - A subjective quality improvement process.
  - Brings out the details that are obscured or simply highlight certain features of interest in an image.
- Image restoration:
  - For improving the appearance of an image.
  - It is an objective quality improvement process in the sense that restoration techniques tend to be based on mathematical or probabilistic models of image degradation.
- Colour image processing:
  - For the processing of colour images.
- Wavelets:
  - Foundation for representing images in various degrees of resolution.

- Compression:
    - For reducing the storage space to save an image or the bandwidth required to transmit it.
- Morphological processes:
    - Tools for extracting image components those are useful in the representation and description of an image.
- Segmentation:
    - Partition of an image into its constituent parts or objects.
- Representation and description:
    - Always follow the output of segmentation, which usually is raw pixel data, constituting either boundary or region of an image.
    - Boundary representation is appropriate when the focus is on external characteristics such as corners and inflections.
    - Region representation is appropriate when the focus is on internal properties such as texture or skeletal shape.
    - Description (feature selection) deals with extracting attributes that result in some quantitative information of interest or are basic for differentiating one class of objects from another.
- Image recognition:
    - Process that assigns a label to an object based on its descriptors.
- Knowledge base:
    - Knowledge about a problem is coded into an image processing system in the form of a knowledge base.



Questions:

1. Define digital image processing.
2. Explain the different steps involved in digital image processing.

Title: Elements/Components of an image processing system

Explanation:

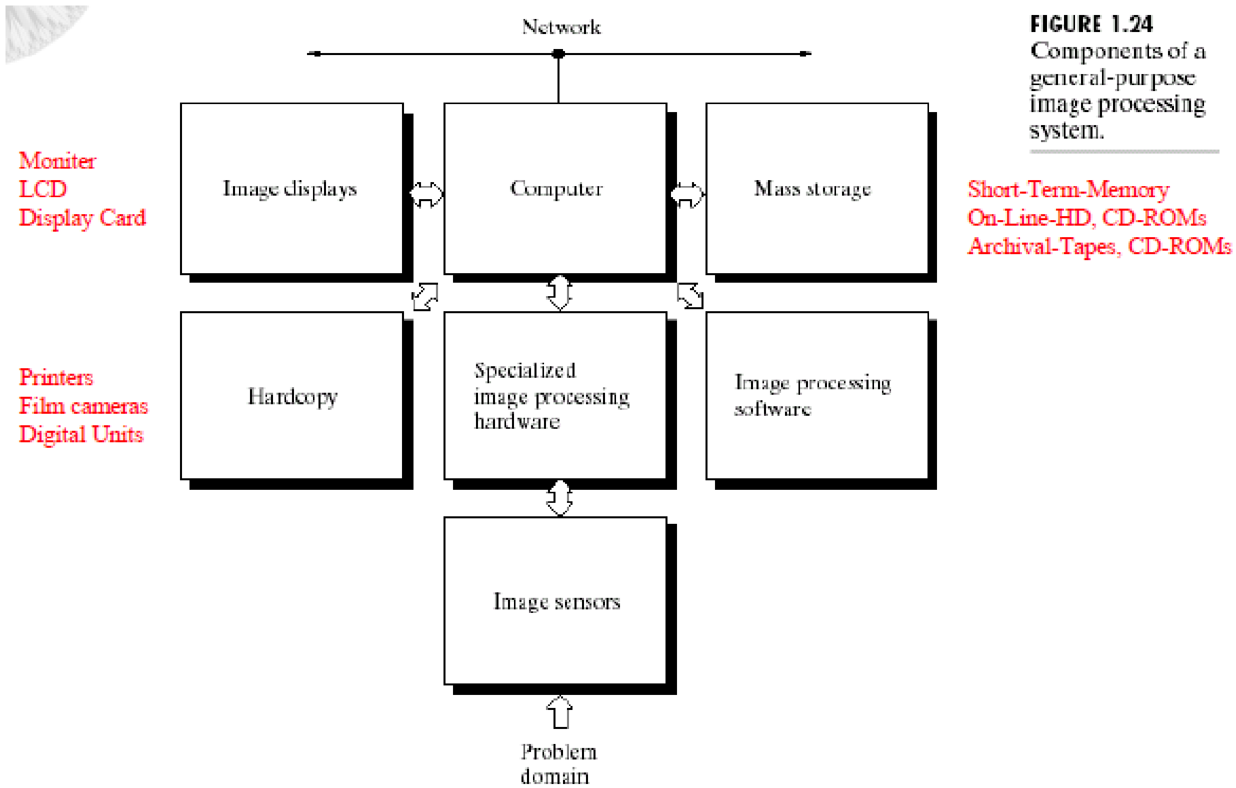


FIGURE 1.24 Components of a general-purpose image processing system.

- With reference to sensing, two elements are required to acquire digital images. The first is a physical device that is sensitive to the energy radiated by the object we wish to image. The second, called a digitizer, is a device for converting the output of the physical sensing device into digital form. For instance, in a digital video camera, the sensors produce an electrical output proportional to light intensity. The digitizer converts these outputs to digital data.
- Specialized image processing hardware usually consists of the digitizer just mentioned, plus hardware that performs other primitive operations, such as an arithmetic logic unit (ALU), which performs arithmetic and logical operations in parallel on entire images. One example of how an ALU is used is in averaging images as quickly as they are digitized, for the purpose of noise reduction. This type of hardware sometimes is called a front-end subsystem, and its most distinguishing characteristic is speed. In other words, this unit performs functions that require fast data throughputs (e.g., digitizing and averaging video images at 30 framess) that the typical main computer cannot handle.

- The computer in an image processing system is a general-purpose computer and can range from a PC to a supercomputer. In dedicated applications, some times specially designed computers are used to achieve a required level of performance, but our interest here is on general-purpose image processing systems. In these systems, almost any well equipped PC-type machine is suitable for offline image processing tasks.
- Software for image processing consists of specialized modules that perform specific tasks. A well-designed package also includes the capability for the user to write code that, as a minimum, utilizes the specialized modules. More sophisticated software packages allow the integration of those modules and general-purpose software commands from at least one computer language.
- Mass storage capability is a must in image processing applications. An image of size 1024*1024 pixels, in which the intensity of each pixel is an 8-bit quantity, requires one megabyte of storage space if the image is not compressed. When dealing with thousands, or even millions, of images, providing adequate storage in an image processing system can be a challenge. Digital storage for image processing applications falls into three principal categories: (1) short-term storage for use during processing, (2) on-line storage for relatively fast re-call, and (3) archival storage, characterized by infrequent access.
- Image displays in use today are mainly color (preferably flat screen) TV monitors. Monitors are driven by the outputs of image and graphics display cards that are an integral part of the computer system. Seldom are there requirements for image display applications that cannot be met by display cards available commercially as part of the computer system. In some cases, it is necessary to have stereo displays, and these are implemented in the form of headgear containing two small displays embedded in goggles worn by the user.
- Hardcopy devices for recording images include laser printers, film cameras, heat-sensitive devices, inkjet units, and digital units, such as optical and CD-ROM disks. Film provides the highest possible resolution, but paper is the obvious medium of choice for written material. For presentations, images are displayed on film transparencies or in a digital medium if image projection equipment is used. The latter approach is gaining acceptance as the standard for image presentations.
- Networking is almost a default function in any computer system in use today. Because of the large amount of data inherent in image processing applications, the key consideration in image transmission is bandwidth. In dedicated networks, this typically is not a problem, but communications with remote sites via the Internet are not always as efficient. Fortunately, this situation is improving quickly as a result of optical fiber and other broadband technologies.

Questions:

1. Explain the elements of a digital image processing system.

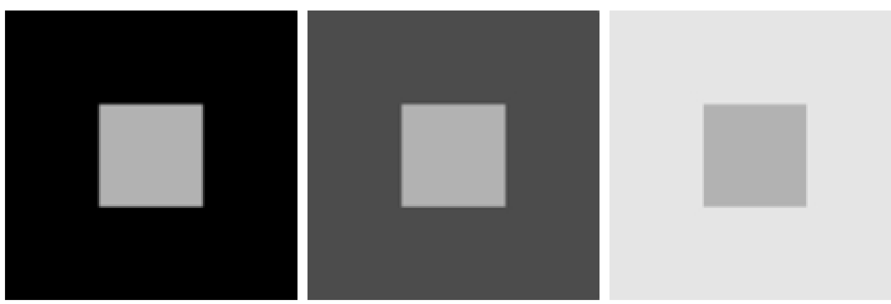
Brightness:

Digital images are displayed as a discrete set of intensities. The eye’s ability to discriminate between different intensity levels is an important consideration in presenting image-processing results. The range of light intensity levels to which the human visual system can adapt is enormous—on the order of 10^{10}—from the scotopic threshold to the glare limit. Experimental evidence indicates that subjective **brightness** (intensity as perceived by the human visual system) is a logarithmic function of the light intensity incident on the eye. **Brightness** is an attribute of visual perception in which a source appears to be radiating or reflecting light. In other words, brightness is the perception elicited by the luminance of a visual target. It is not necessarily proportional to luminance. This is a subjective attribute/property of an object being observed and one of the color appearance parameters of color appearance models.

Contrast:

Contrast is the difference in luminance or colour that makes an object (or its representation in an image or display) distinguishable. In visual perception of the real world, contrast is determined by the difference in the color and brightness of the object and other objects within the same field of view. Contrast is the relative brightness of an object with respect to other.

As an example, consider the following figure. All the inner squares have the same intensity, but they appear progressively darker as the background becomes lighter.



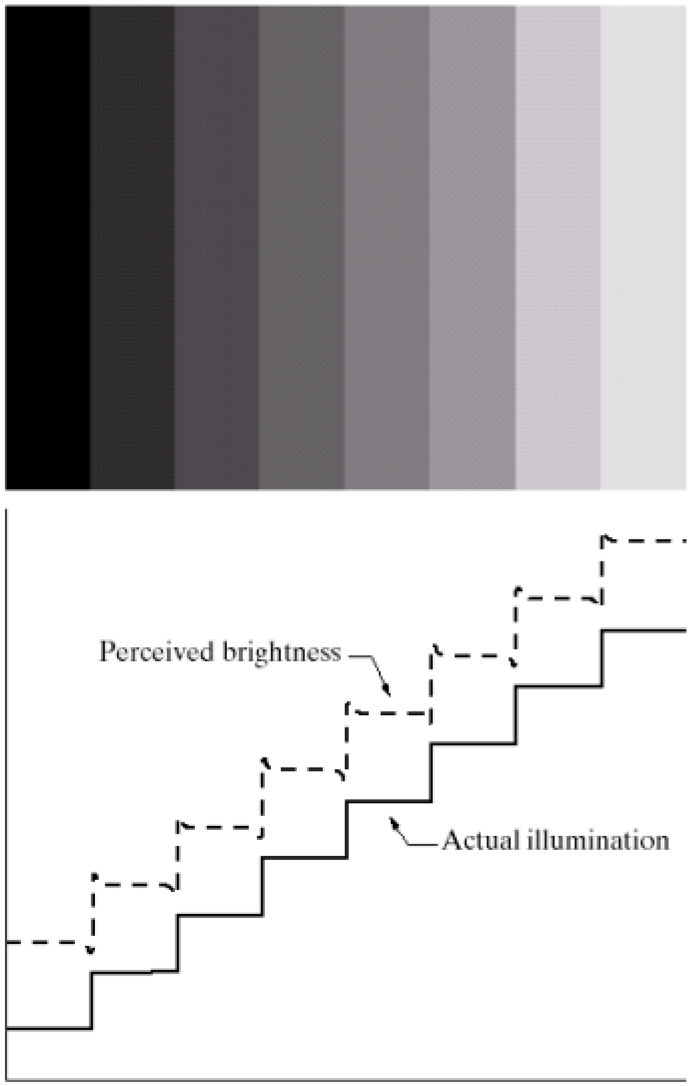
Hue:

This is the predominant spectral color in the light. Hue is one of the main properties (called color appearance parameters) of a color, defined technically, as "the degree to which a stimulus can be described as similar to or different from stimuli that are described as red, green, blue and yellow"

Saturation:

Saturation indicates the spectral purity of the color in the light. That means amount of white light in a colour. It is the "colorfulness of an area judged in proportion to its brightness",[6][2] which in effect is the perceived freedom from whitishness of the light coming from the area.[7] A note accompanying this definition in effect indicates that an object with a given spectral reflectance exhibits approximately constant saturation for all levels of illumination, unless the brightness is very high.

Mach band effect:



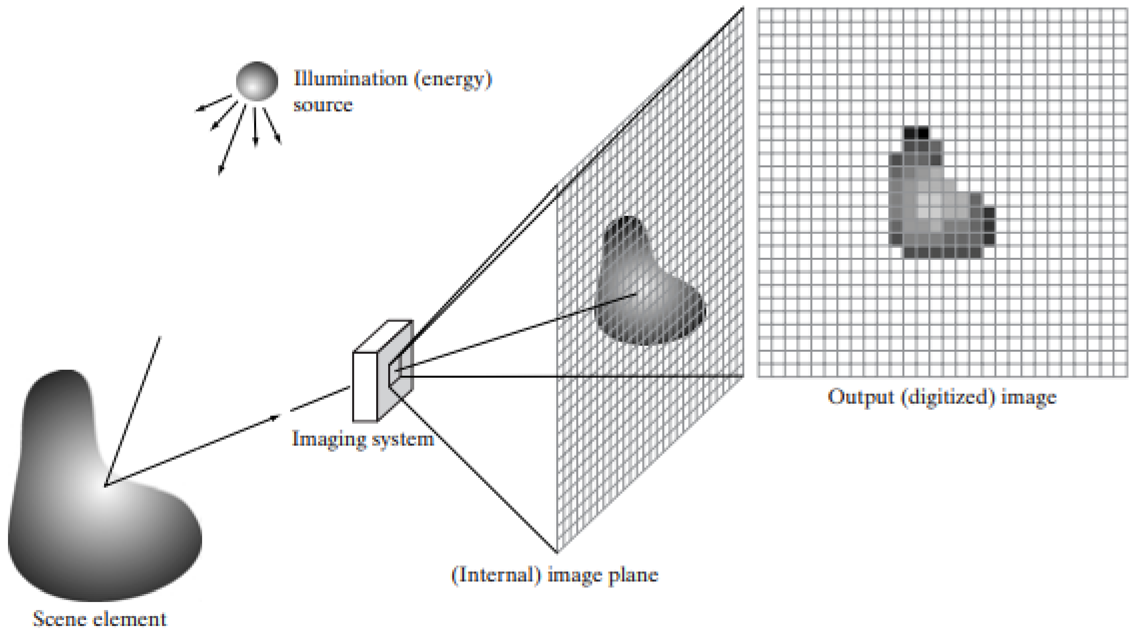
The visual system tends to undershoot or overshoot around the boundary of regions of different intensities. Above figure shows an example of this phenomenon. Although the intensity of the stripes is constant, we actually perceive a brightness pattern that is strongly scalloped, especially near the boundaries. These seemingly scalloped bands are called Mach bands after Ernst Mach, who first described the phenomenon in 1865.

Questions:

1. Define the following.
    a) Brightness
    b) Contrast
    c) Hue
    d) Saturation
    e) Mach band effect

Title: Elements of visual perception-simple image formation model

Explanation:



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.

Digital images can be represented by two-dimensional functions of the form f(x, y). The value or amplitude of f at spatial coordinates (x, y) is a positive scalar quantity whose physical meaning is determined by the source of the image. Most of the images in which we are interested in this book are monochromatic images, whose values are said to span the gray scale. When an image is generated from a physical process, its values are proportional to energy radiated by a physical source (e.g., electromagnetic waves). As a consequence, f(x, y) must be nonzero and finite; that is,

The function f(x, y) may be characterized by two components:
(1) The amount of source illumination incident on the scene being viewed, and
(2) The amount of illumination reflected by the objects in the scene.
Appropriately, these are called the illumination and reflectance components and are denoted by i(x, y) and r(x, y), respectively. The two functions combine as a product to form f(x, y):

Where

And

The above equations indicate that reflectance is bounded by 0 (total absorption) and 1 (total reflectance).The nature of i(x, y) is determined by the illumination source, and r(x, y) is determined by the characteristics of the imaged objects. It is noted that these expressions also are applicable to images formed via transmission of the illumination through a medium, such as a chest X-ray.

Questions:

1. Explain a simple image formation model.