EE410
Digital Image Processing

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Introduction

- Image Processing is concerned with manipulation and analysis of pictures by computer.
- The applications of digital imaging is fast growing in the areas of (and not limited to):
  - Education
  - Medicine
  - Industry
  - Military
  - Security
  - Media and Entertainment

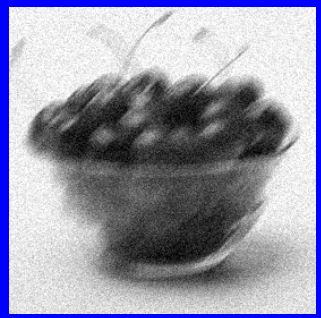
Examples of Applications

- Finger Prints
- Face Recognition
- Human Aging
- Medical Diagnosis
- Film Making
- Document Management
- Machine Vision
- Industrial Applications

Example of Digital Images

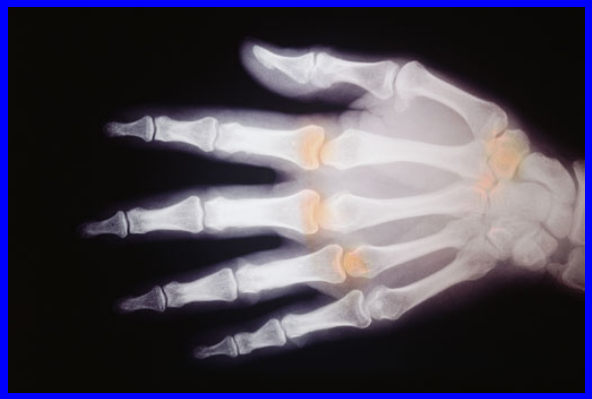
Color Original

Gray scale Original

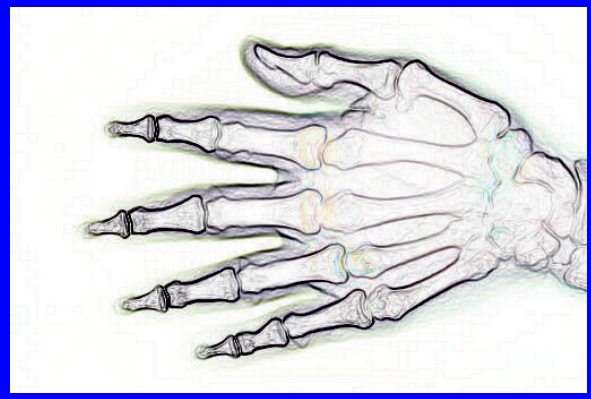


Distorted Image

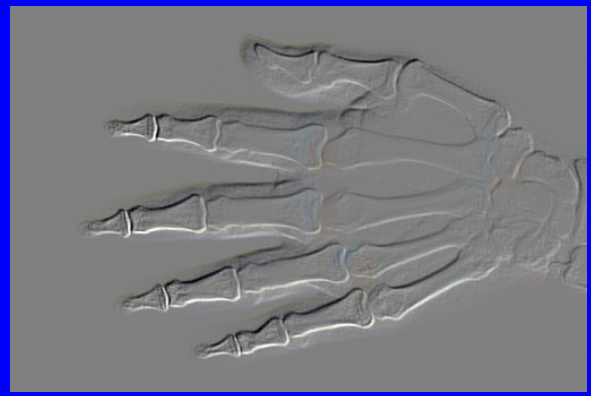
Example of Digital Image



Original



Edge detected



Embossed

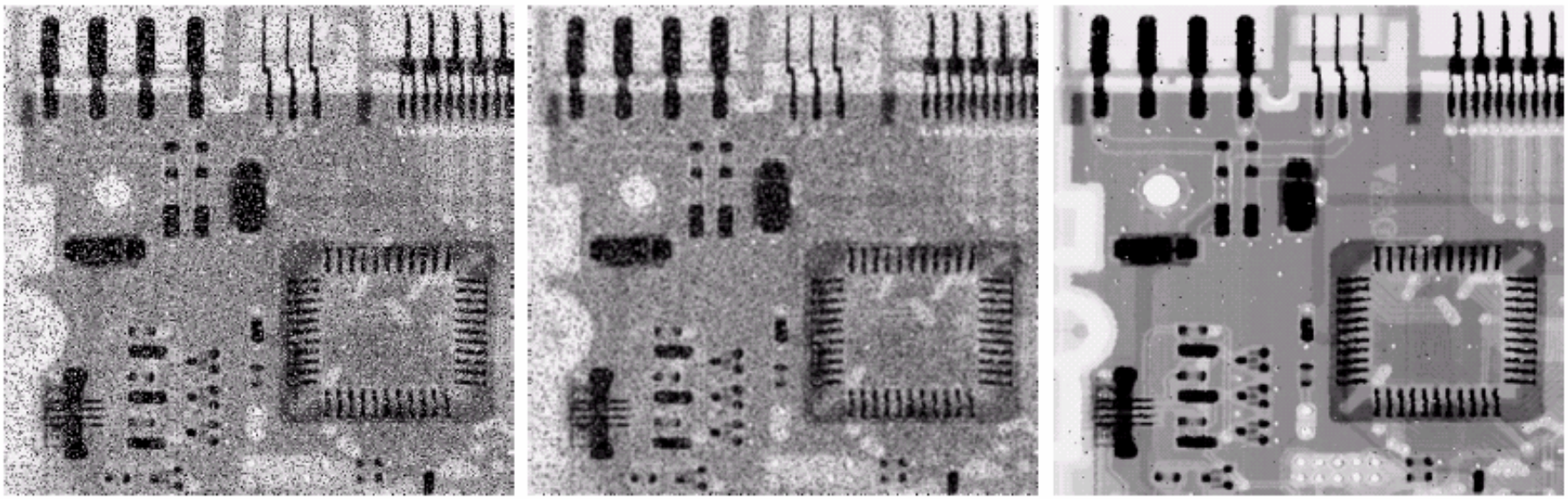
Why Processing ?

- In some cases, it is expected to have distorted images due to problems in the imaging system.
- Machine and human vision requires good quality images.
- Distorted images may lead to the wrong decision.

Processing Techniques

- Image processing major sub-areas include:
  - Digitization : Transforming the image into a digital form
  - Enhancement: Improving image quality
  - Restoration: Reproducing the original image
  - Reconstruction: Reforming the actual appearance
  - Encoding: Reducing the size or securing the image
  - Segmentation: Grouping the image content and parts
  - Recognition: Identifying the image parts
  - Description: Describing the parts

Filtering

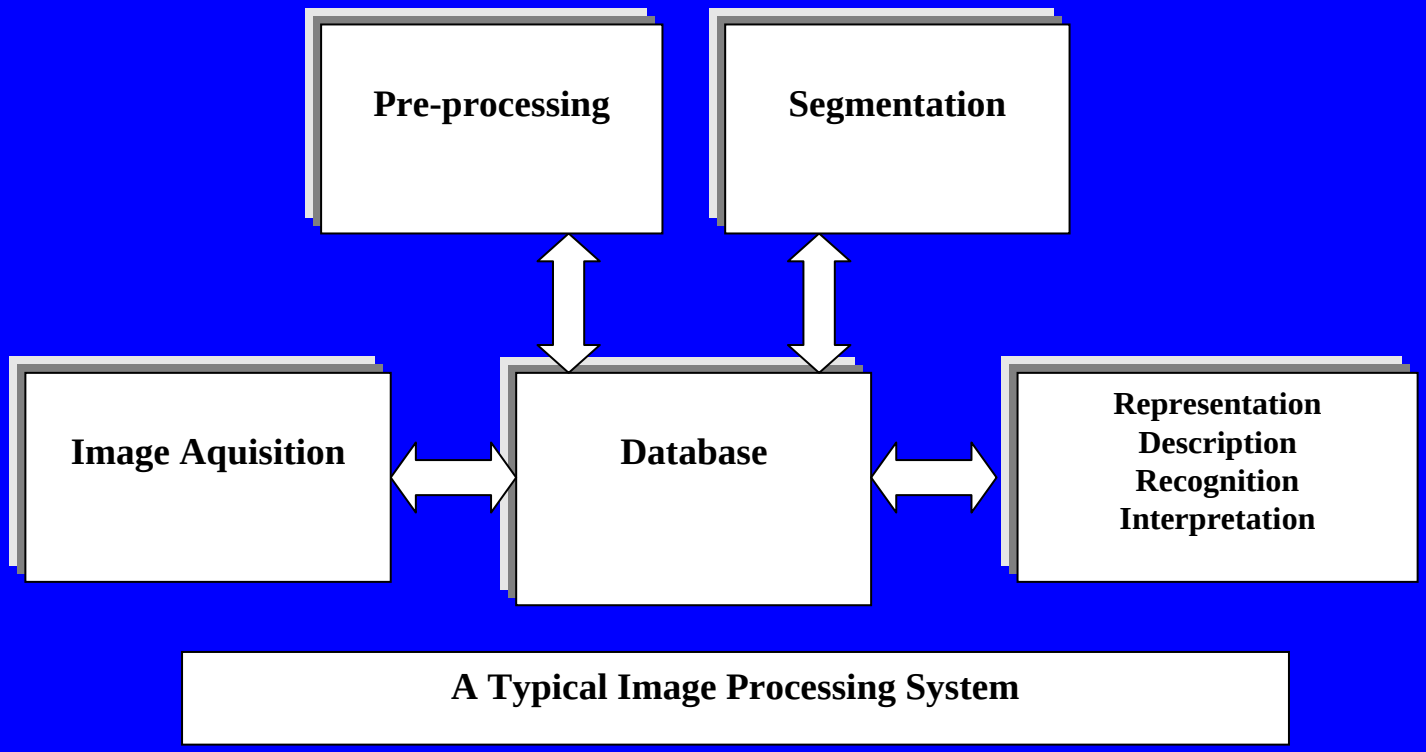


a b c

FIGURE 3.37 (a) X-ray image of circuit board corrupted by salt-and-pepper noise. (b) Noise reduction with a 3×3 averaging mask. (c) Noise reduction with a 3×3 median filter. (Original image courtesy of Mr. Joseph E. Pascente, Lixi, Inc.)

Typical Imaging System

- Stages of image processing



Elements of Digital Image Processing System

Camera

Color Scanner

Image Capture Board

Computer System

Mass Storage Device

Image Printer

Image Capture Board
(frame grabber)

- It has the following parts:
  - AD converter
  - frame buffer
  - processor
- It does the following tasks:
  - image acquisition
  - storage
  - low level processing
  - display

Image Scanner
(Digitizer)

- It converts a image on film or print into a digital image.
- It is either mechanical or flying spot scanner.
- Mechanical scanner is either flat-bed or drum.
- In mechanical scanner the film and sensing assembly are mechanically transported past one another while readings are made.
- In flying spot scanner the film and the sensor are static, what moves is a point of light on the face of a cathode-ray tube, or a laser beam directed by mirror.

Image Scanner
(continues)

- In all scanners a very focused beam of light is directed through the film or onto the print at a known coordinate point. The light transmittance or reflectance is measured, transformed from analog to digital form.
- A single photo-sensor can be used as in flying-spot scanners, or an array of photo-sensors can be used.
- Examples: Microdensiometers, flying spots scanners, image dissectors

Camera

- Videocon Camera
  - operates on the principle of photo-conductivity.
  - the resistance of the tube surface decreases on illumination.
  - when the tube surface is scanned by an electron beam a current that represents the video signal is produced.
- Solid-state array Camera
  - contain array of ***photosites***
  - ***A photosite*** has a voltage output proportional to the intensity of the incident light.

Image Printer

- Used to obtain a hard copy of the digital image.
- Image can be printed on:
  - Dot matrix printers using Half toning and dithering techniques.
  - Laser printers
  - Thermal printers
  - Inkjet printers

Mass Storage Device

- Stores the image data; 512x512 image requires 0.25 Mbytes of storage.
- Common storage media
  - Magnetic Hard Disks of capacities > 1.2 Gbytes.
  - CD-ROM of capacities > 600 Mbytes.
  - Optical disks of capacities 256 Mbytes- 6 Gbytes.
  - Magnetic tapes with capacity of 6.4 Kbytes/inch.
  - WORM disks of capacities > 1 Gbyte.
  - Floptical disks of capacities 20 Mbytes- 128 Mbytes

Computer System

- A powerful computer that is mainly used for processing the image.
- It can be a UNIX workstation or a high end Pentium based PC.
- It allows sophisticated image processing algorithm to be programmed and executed easily.
- C programming is commonly used for this purpose.
- Special packages such as MATLAB.

Characteristics of Human Visual System

- Why study HVS?
  - because it helps in designing image processing techniques, since human observer is the main customer.
  - one should know about subjective image quality and image fidelity when designing a system for picture digitization, coding, or enhancement.
  - when analyzing the structure of a picture, one wants to extract picture parts that corresponds to those seen by humans, and describe them in terms corresponding to those used by humans.

The Human Eye

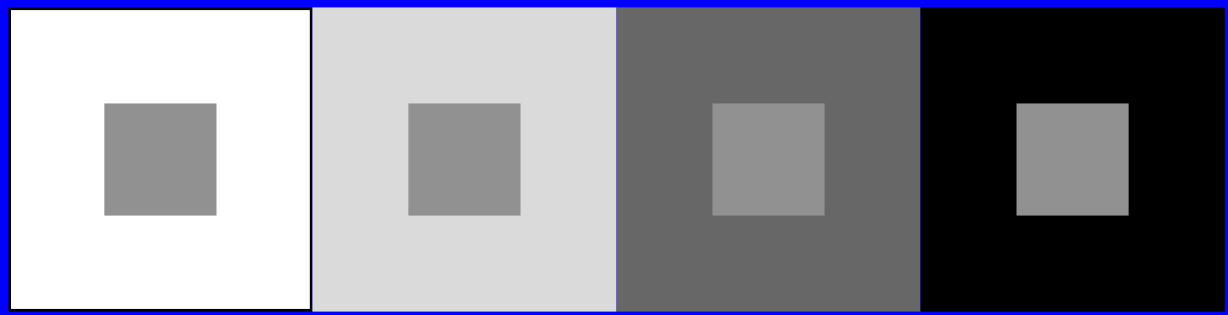
- The inner most layer of the eye is called the *Retina*.
- The Retina contains millions of discrete light receptors that are concentrated in the *fovea*:
  - Cons: 7 million; responsible for photopic vision (bright-light vision.)
  - Rods: 75-150 million; responsible for scotopic vision (night vision.)

Brightness Adaptation

- HVS can adapt to a range of light intensity levels in the order of 10^{10}, however, not simultaneously.
- It can achieve this using brightness adaptation, in which it adapts itself to the external conditions.
- At each adaptation level, only a few intensity levels can be distinguished.
- A range of over 100 intensity levels is necessary to obtain a smooth display of a large class of image types.

Simultaneous Contrast

- Apparent brightness depends strongly on the local background



Colors

- Lights of different wave lengths have different colors
- There are seven visible spectral colors: red, orange, yellow, green, cyan, blue, violet.
- Mixing lights with different wave lengths produces new colors.
- Any color can be produced by mixing the three primary colors: red, green, and blue.

Color cont.

- Each color is characterized by: hue, saturation and brightness.
- Hue is the attribute of light that distinguishes a red colored light from a green light or yellow light.
- Saturation is the attribute that distinguishes a spectral light from a pastel light of the same hue.

Contrast

- Contrast range:
  - is the difference between maximum and minimum values in the image.
- Contrast ratio:
  - is the ratio of the maximum to minimum values in the image
- Poor contrast in pictures:
  - results from a reduced or nonlinear image brightness range.