Al-Mustaqbal University
College of Sciences
Intelligent Medical System Department

جامعة المستقبل
AL MUSTAQBAL UNIVERSITY

كلية العلوم

قسم الانظمة الطبية الذكية

Lecture (1 & 2): introduction to image processing

Subject: image processing
Level: Third
Lecturer: Asst. Lecturer Qusai AL-Durrah

Introduction

The rapid evolution of computing and digital technologies has transformed how we acquire, represent, and manipulate visual information. Every second, vast quantities of images are generated across scientific, medical, industrial, and personal domains. Unlike text or numerical data, images contain high-dimensional visual structures that require advanced techniques for storage, analysis, and interpretation.

Computer Imaging is the field dedicated to this challenge, focusing on both the **processing of images for human interpretation** and the **extraction of information for computer-based decision-making**. It encompasses two closely related but distinct subfields:

- **Computer Vision**: Automated image analysis and interpretation designed to support computational decision-making without direct human involvement.
- **Image Processing**: Enhancing, restoring, or compressing images to improve their quality and usability for human observation.

Applications of image processing span diverse environments such as **medical diagnostics, law enforcement, manufacturing automation, satellite imaging, and virtual reality**. With the increasing availability of digital devices and sensors—from medical scanners to smartphones—image processing has become a cornerstone of modern science and technology.

This lecture provides an overview of the fundamental concepts in image processing, including digitization, restoration, enhancement, compression, and the role of the human visual system. It also highlights the interdisciplinary foundations of the field, bridging electrical engineering, computer science, and human perception.

Activity 1 – Brainstorming

Where do you think image processing is used in your daily life?

Learning Outcomes

By the end of this lecture, students will be able to:

1. **Define computer imaging** and distinguish between its two main categories: computer vision and image processing.
2. **Explain the historical origins** of image processing and its relationship to electrical engineering and computer science.
3. **Describe key processes** in image processing: image restoration, enhancement, and compression.
4. **Illustrate the concept of digitization**, including sampling and quantization, and explain its role in converting analog signals into digital images.
5. **Recognize the role of the human visual system (HVS)** in shaping the design and application of image processing techniques.
6. **Identify major application domains** of computer imaging, particularly in healthcare, manufacturing, law enforcement, and scientific research.

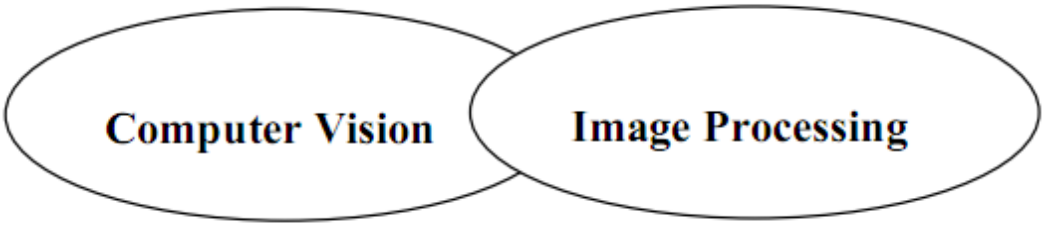
1.1 Computer Imaging

Can be defined as an acquisition and processing of visual information by computer. Computer representation of an image requires the equivalent of many thousands of words of data, so the massive amount of data required for image is a primary reason for the development of many sub areas with field of computer imaging, such as image compression and segmentation. Another important aspect of computer imaging involves the ultimate “receiver” of visual information in some case the human visual system and in some cases the human imaging can be separate into two primary categories :

1. Computer Vision.
2. Image Processing.

(In computer vision application the processed images output for use by a computer, whereas in image processing applications the output images are for human consumption).

These two categories are not totally separate and distinct. The boundaries that separate the two are fuzzy, but this definition allows us to explore the differences between the two and to understand how they fit together (Figure 1.1).



Computer imaging can be separated into two different but

overlapping areas.

Figure (1.1) Computer Imaging.

Historically, the field of image processing grew from electrical engineering as an extension of the signal processing branch, whereas are the computer science discipline was largely responsible for developments in computer vision.

1.2 Computer Vision

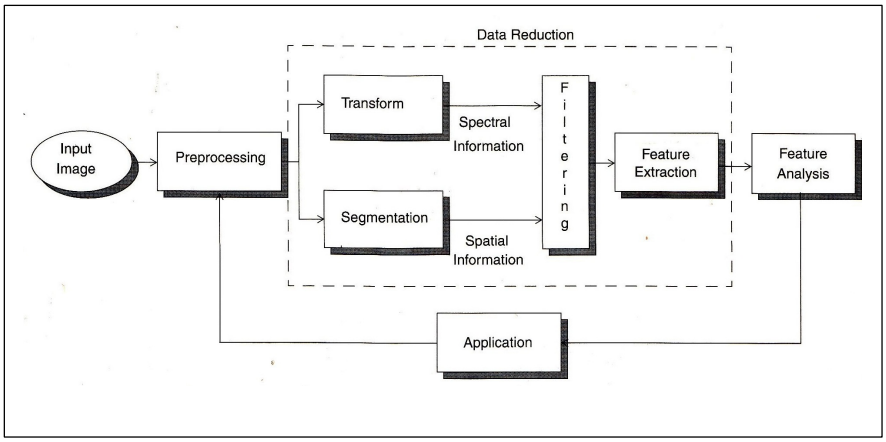
Computer vision computer imaging where the application doses not involve a human being in visual loop (image to model). One of the major topics within this field of computer vision is image analysis (Figure (1.1)).

1. **Image Analysis:** involves the examination of the image data to facilitate solving vision problem.

The image analysis process involves two other topics:

• **Feature Extraction:** is the process of acquiring higher level image information, such as shape or color information.

• **Pattern Classification:** is the act of taking this higher –level information and identifying objects within the image.



Computer vision systems are used in many and various types of environments, such as:

1. Manufacturing Systems
2. Medical Community
3. Law Enforcement
4. Infrared Imaging
5. Satellites Orbiting.

1.3 Image Processing

Image processing is computer imaging where application involves a human being in the visual loop (image to image). In other words the image is to be examined and acted upon by people.

Activity 2 – Raise Your Hand

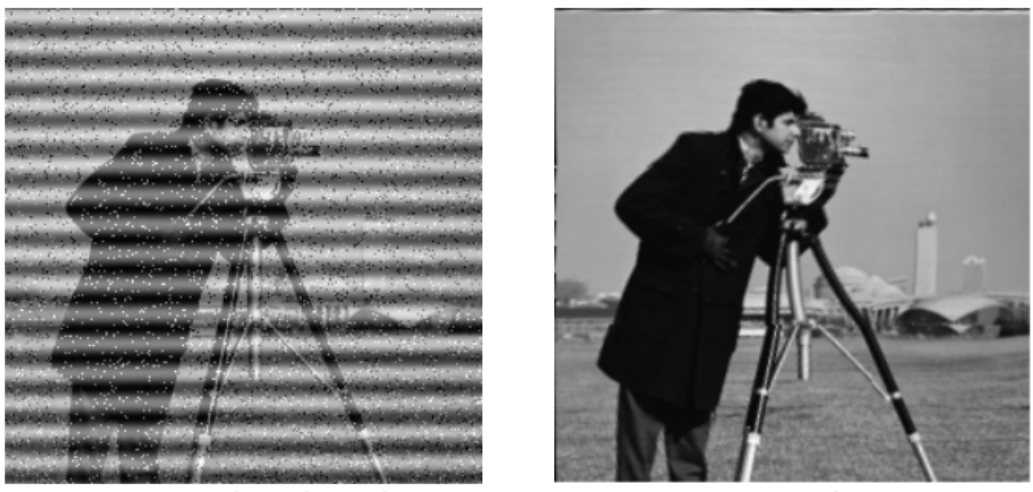
If an MRI scan is analyzed automatically by a computer to detect tumors, is this image processing or computer vision?

The major topics within the field of image processing include:

1. Image restoration.
2. Image enhancement.
3. Image compression.

1.3.1 Image Restoration

Is the process of taking an image with some known, or estimated degradation, and restoring it to its original appearance. Image restoration is often used in the field of photography or publishing where an image was somehow degraded but needs to be improved before it can be printed(Figure 1.3).



a. Image with distortion b. Restored image

Figure (1.3) Image Restoration

1.3.2 Image Enhancement

Involves taking an image and improving it visually, typically by taking advantages of human Visual Systems responses. One of the simplest enhancement techniques is to simply stretch the contrast of an image.

Enhancement methods tend to be problem specific. For example, a method that is used to enhance satellite images may not suitable for enhancing medical images.

Although enhancement and restoration are similar in aim, to make an image look better. They differ in how they approach the problem. Restoration method attempt to model the distortion to the image and reverse the degradation, where enhancement methods use knowledge of the human visual systems responses to improve an image visually.

a. image with poor contrast b. Image enhancement by contrast stretching

Figure (1.4) Image Enhancement

1.3.1 Image Compression

Involves reducing the typically massive amount of data needed to represent an image. This done by eliminating data that are visually unnecessary and by taking advantage of the redundancy that is inherent in most images.

Image processing systems are used in many and various types of environments, such as:

1. Medical community
2. Computer – Aided Design
3. Virtual Reality

a. Image before compression

(92) KB

b. Image after compression

(6.59) KB

Figure (1.5): Image Compression

1.4 Computer Imaging Systems

Computer imaging systems are comprised of two primary components types, hardware and software. The hardware components can be divided into image acquiring sub system (computer, scanner, and camera) and display devices (monitor, printer). The software allows us to manipulate the image and perform any desired processing on the image data.

1.5 Digitization

The process of transforming a standard video signal into digital image. This transformation is necessary because the standard video signal in analog (continuous) form and the computer requires a digitized or sampled version of that continuous signal. The analog video signal is turned into a digital image by sampling the continuous signal at affixed rate. In the figure below we see one line of a video signal being sampled (digitized) by instantaneously measuring the voltage of the signal at fixed intervals in time.

The value of the voltage at each instant is converted into a number that is stored, corresponding to the brightness of the image at that point.

Note that the brightness of the image at that point depends on both the intrinsic properties of the object and the lighting conditions in the scene.

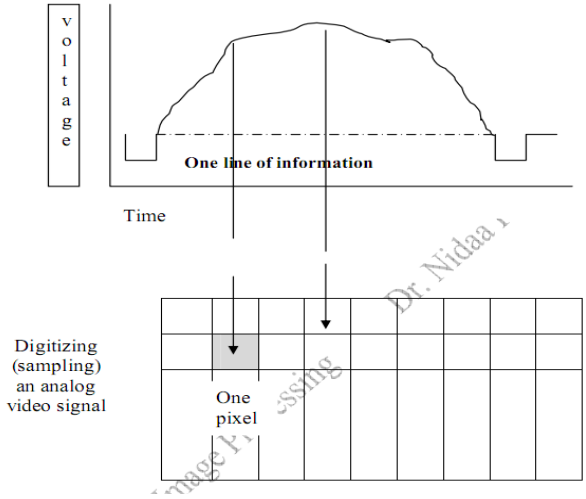


Figure (1.6): Digitizing (Sampling) an Analog Video Signal

The image can now be accessed as a two-dimension array of data, where each data point is referred to a pixel (picture element) for digital images we will use the following notation:

I(r,c) = The brightness of image at the point (r,c)

Where r= row and c= column.

"When we have the data in digital form, we can use the software to process the data".

The digital image is 2D- array as:

$$\begin{pmatrix} I(0,0) & I(0,1) \ldots\ldots\ldots\ldots\ldots\ldots\ldots I(0,N-1) \\ I(1,0) & I(1,1) \ldots\ldots\ldots\ldots\ldots\ldots\ldots I(1,N-1) \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ I(N-1,0) & I(N-1,1) \ldots\ldots\ldots\ldots\ldots\ldots I(N-1,N-1) \end{pmatrix}$$

In above image matrix, the image size is (NXN) [matrix dimension] then:

$$N_g = 2^m$$

Where N_g denotes the number of gray levels and m is the no. of bits that is contained in a digital image matrix.

Example: If we have (6 bit) in 128 X 128 image. Find the no. of gray levels to represent it, then find the no. of bit in this image?

Solution:

$N_g = 2^6 = 64$ Gray Level

$N_b = 128 * 128 * 6 = 9.8304 * 10^4$ bit

Activity 3 – Paper & Pen

If you have a simple 4×4 image matrix and grayscale values (0–255). Calculate the total data size if each value is stored using 8 bits.

1.6 The Human Visual System

The Human Visual System (HVS) has two primary components:

- Eye.
- Brian.

* The structure that we know the most about is the image receiving sensors (the human eye).

* The brain can be thought as being an information processing unit analogous to the computer in our computer imaging system.

These two are connected by the optic nerve, which is really a bundle of nerves that contains the path ways for visual information to travel from the receiving sensor (the eye) to the processor (the brain).

Activity 4 – Agree or disagree

Do you believe computer algorithms will ever fully replace the human eye and brain in medical image analysis? Yes or No?"

Homework Assignment 1 (Google Classroom)

Write a short report (1–2 pages) about **one real-world application** of image processing (choose from medical imaging, satellite analysis, security cameras, social media filters, etc.).

Include:

1. A short description of the application.
2. The main image processing techniques involved.
3. Why this application is important.

Deadline: Next week.

Submission: Upload your report as word or PDF file on Google Classroom.