



Image Processing

Lecture 1: Introduction and Overview

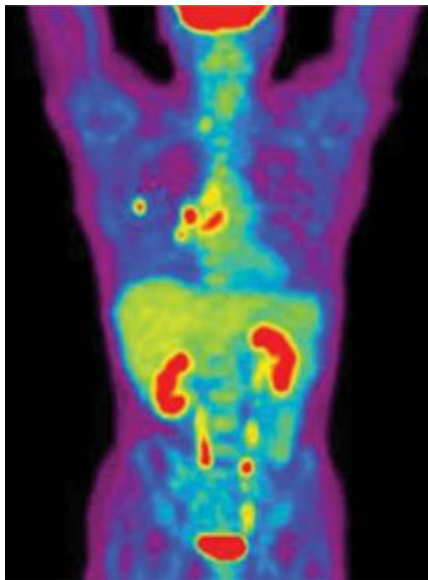
Introduction

- **What is an image?** An image is *a visual representation of an object, a person, or a scene* produced by *an optical device* such as a mirror, a lens, or a camera.
- The need to *extract information from images* and interpret their contents has been one of the driving factors in the development of image processing during the past decades.
- Image processing applications cover a wide range of human activities, such as the following:

Applications

- **Medical Applications:** *Diagnostic imaging modalities* such as digital radiography, PET (positron emission tomography), computed tomography (CT), computerized axial tomography (CAT), magnetic resonance imaging (MRI), and functional magnetic resonance imaging (fMRI), etc. , *have been adopted by the medical community on a large scale.*

PET



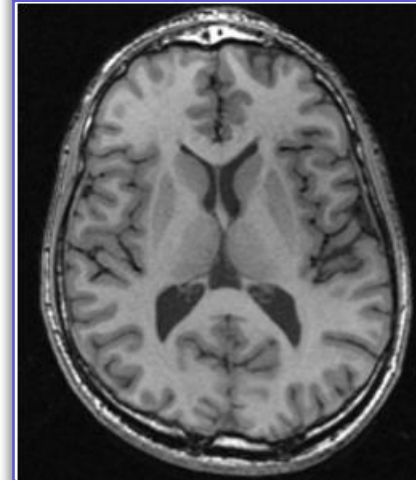
CT



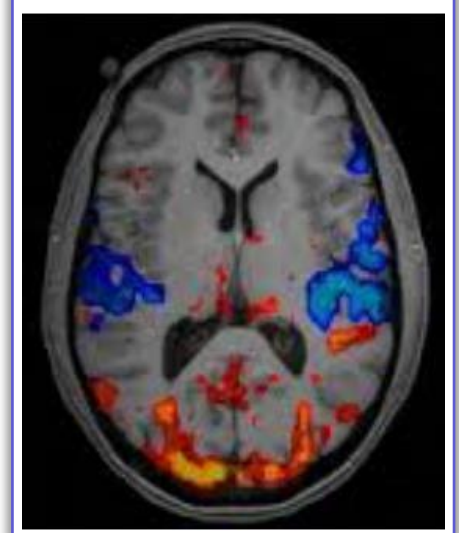
CAT



MRI



fMRI



Applications

- **Law Enforcement and Security:** *Surveillance applications* have become one of the most intensely researched areas within the video processing community. *Biometric techniques* (e.g., fingerprint, face, iris, and hand recognition), which have been the subject of image processing research for more than a decade, have recently become commercially available.

Number Plate Recognition



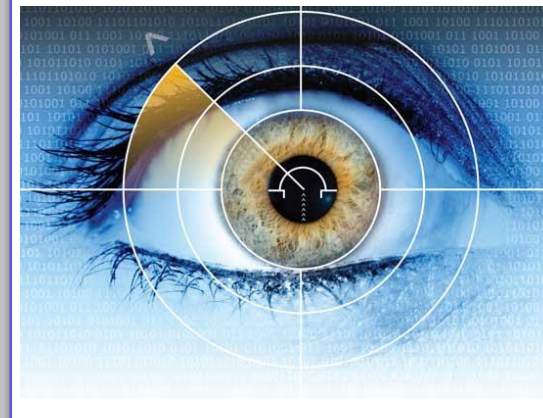
Fingerprint Recognition



Hand Recognition



Iris Recognition

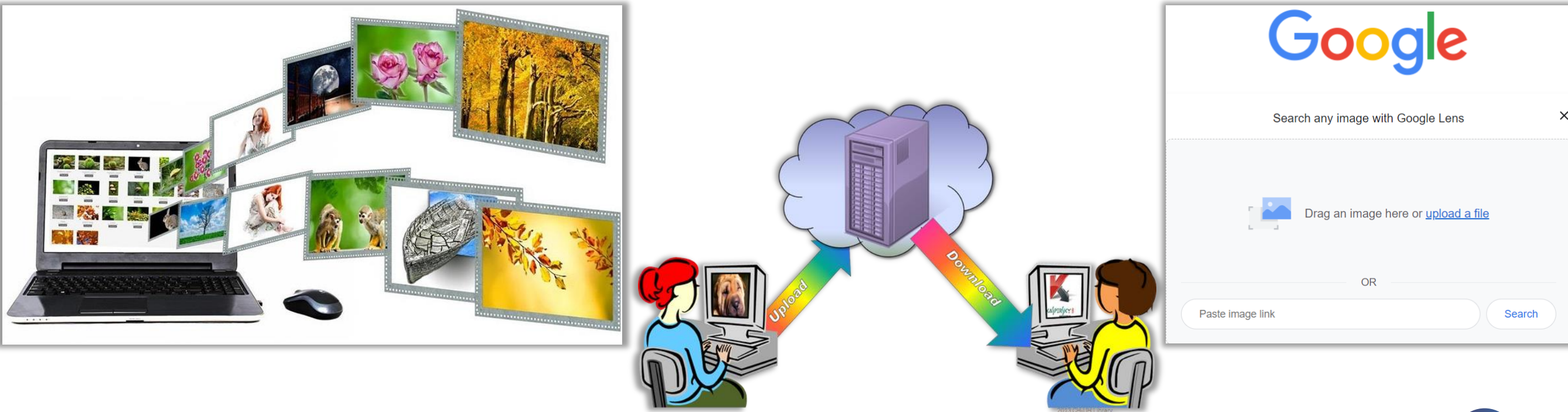


Face Recognition



Applications

- **The Internet, Particularly the World Wide Web:** There is *a huge amount of visual information* available on the Web. Collaborative image and video *uploading, sharing, and tagging* have become increasingly popular. *Finding and retrieving images* on the web based on their contents remains an open research challenge.



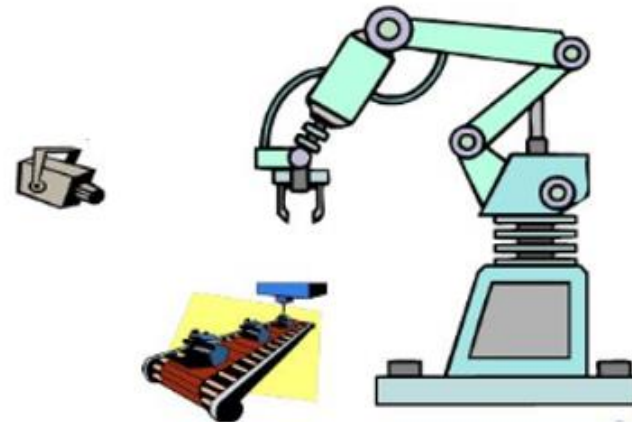
Applications

- **Industrial Applications:** Image processing systems have been successfully used in manufacturing systems for many tasks, such as quality control, control of automated guided vehicles (AGVs), etc.

Control AGVs



Quality Control Process



Applications

- **Consumer Electronics:** Software packages to *enhance, edit, organize, and publish images* and videos have grown in sophistication while keeping a user-friendly interface. High-definition TVs, monitors, DVD players, and personal video recorders (PVRs) are becoming increasingly popular and affordable. Image and video have also successfully made the leap to other devices, such as personal digital assistants (PDAs), cell phones, etc.

TVs



PDAs



Cell Phones



Applications

- **Military Applications:** Some of the most challenging and performance-critical scenarios for image processing solutions have been developed for *military needs*, ranging from *detection of soldiers or vehicles* to *missile guidance* and object recognition and reconnaissance tasks using *unmanned aerial vehicles* (UAVs). In addition, military applications often require the use of different imaging sensors, such as range cameras and thermographic forward-looking infrared (FLIR) cameras.

UAVs

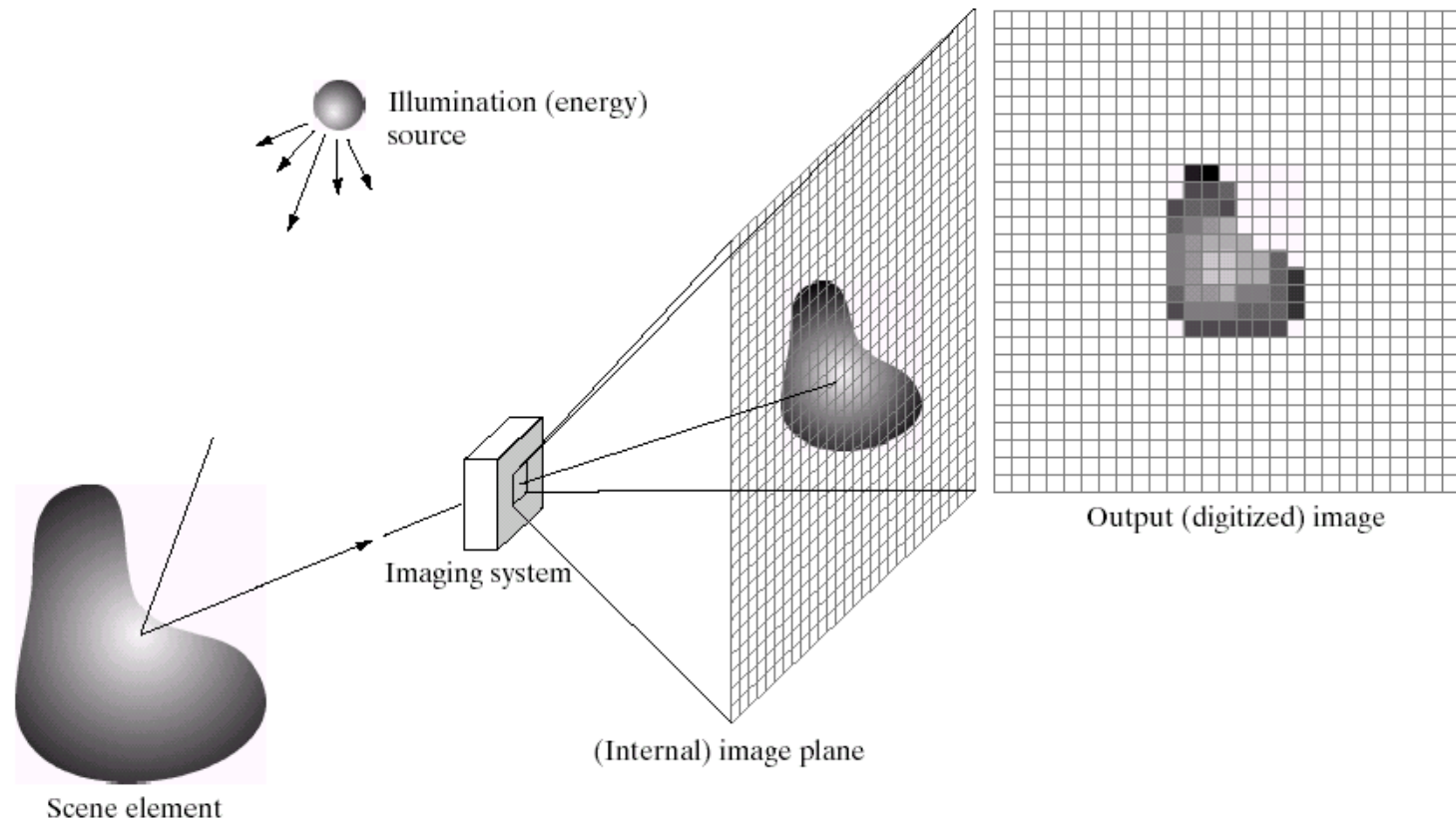


FLIR Camera



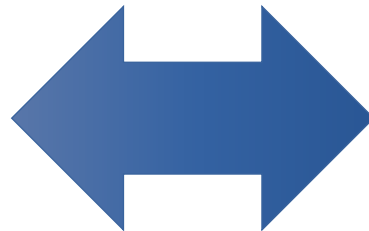
What Is A Digital Image?

- **A digital image is** a representation of a two-dimensional image using a finite number of points, usually referred to as *picture elements or pixels*.



What Is A Digital Image?

- **Each pixel** *is represented by one or more numerical values.*
- For intensity (grayscale) images, a single value representing the intensity of the pixel (usually in a $[0, 255]$ range) is enough.
- For color images, three values (e.g., representing the amount of red (R), green (G), and blue (B)) are usually required.



```
08 02 22 97 38 15 00 40 00 75 04 05 07 78 52 12 50 77 91 08
49 49 99 40 17 81 18 57 60 87 17 40 98 43 69 48 04 56 62 00
81 49 31 73 56 79 14 29 93 71 40 67 53 88 30 03 49 13 36 66
52 70 95 23 04 60 11 42 69 24 68 56 01 32 56 71 37 02 36 91
22 31 16 71 51 67 63 89 41 92 36 54 22 40 40 28 66 33 13 80
24 47 32 60 99 03 45 02 44 75 39 53 78 36 84 20 35 17 12 50
32 98 81 28 64 23 67 10 26 38 40 67 59 54 70 66 18 38 64 70
67 26 20 68 02 62 12 20 95 63 94 39 63 08 40 91 66 49 94 21
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20 73 35 29 78 31 90 01 74 31 49 71 48 86 81 16 23 57 05 54
01 70 54 71 83 51 54 69 16 92 33 48 61 43 52 01 89 19 67 48
```

What Is Digital Image Processing?

- **Digital image processing** refers to processing or *modifying digital images by* means of a *digital computer*.
- **The changes** that take place in the images are usually *performed automatically* and rely on *carefully designed algorithms*.
- On the other hand, **image manipulation** is the process of *making changes in images manually* such as touching up a photo using an airbrush tool in a photo editing software, in which the success of the task depends on human ability and dexterity.

Image Processing Operations – Sharpening

- **Sharpening:** A technique by which the edges and fine details of an image are enhanced for human viewing.



Image Processing Operations – Noise Removal

- **Noise Removal:** Image processing filters can be used to reduce the amount of noise in an image before processing it any further. Depending on the type of noise, *different noise removal techniques are used.*

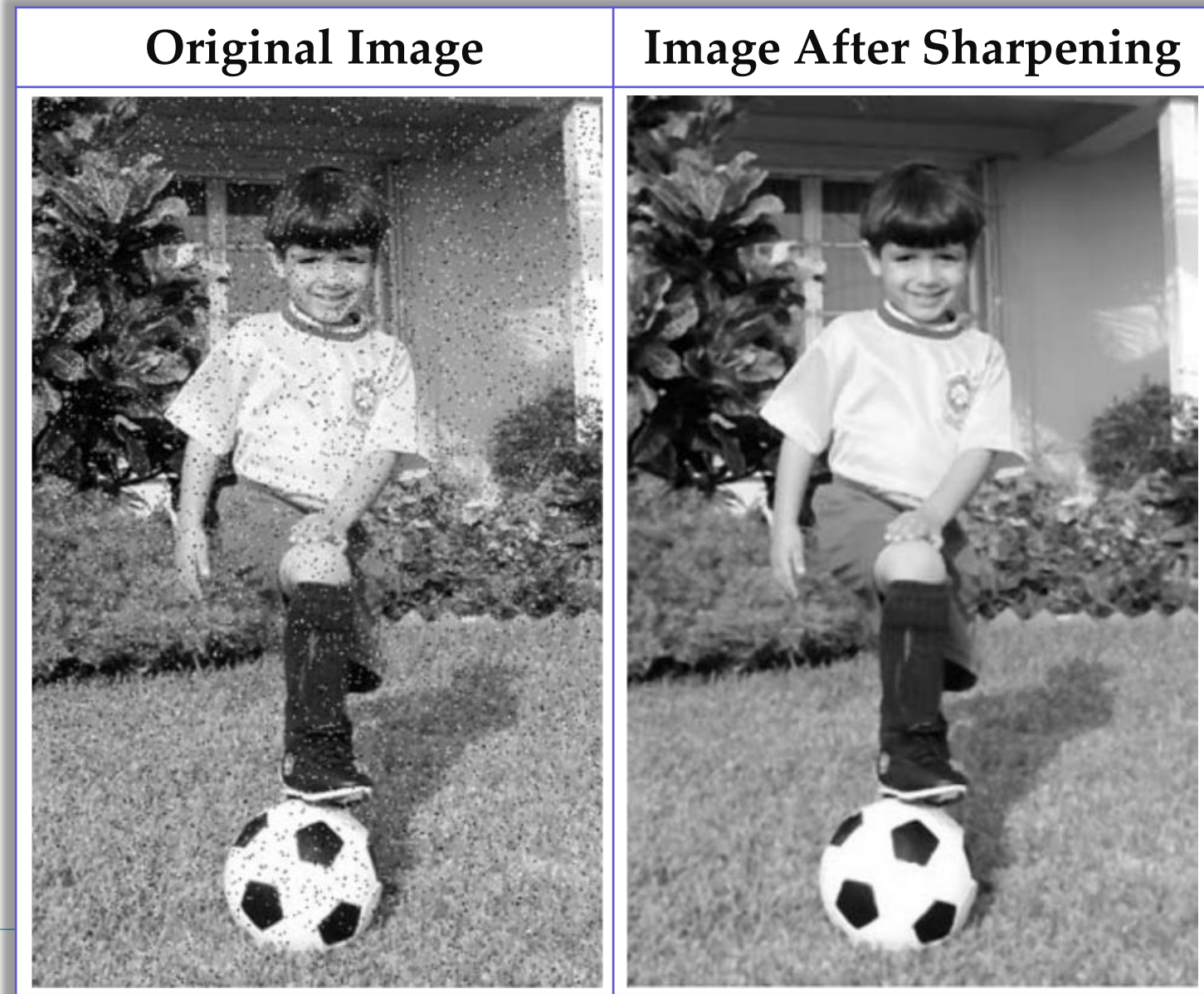


Image Processing Operations – Deblurring

- **Deblurring:** the process of removing the blurring artifacts from images.

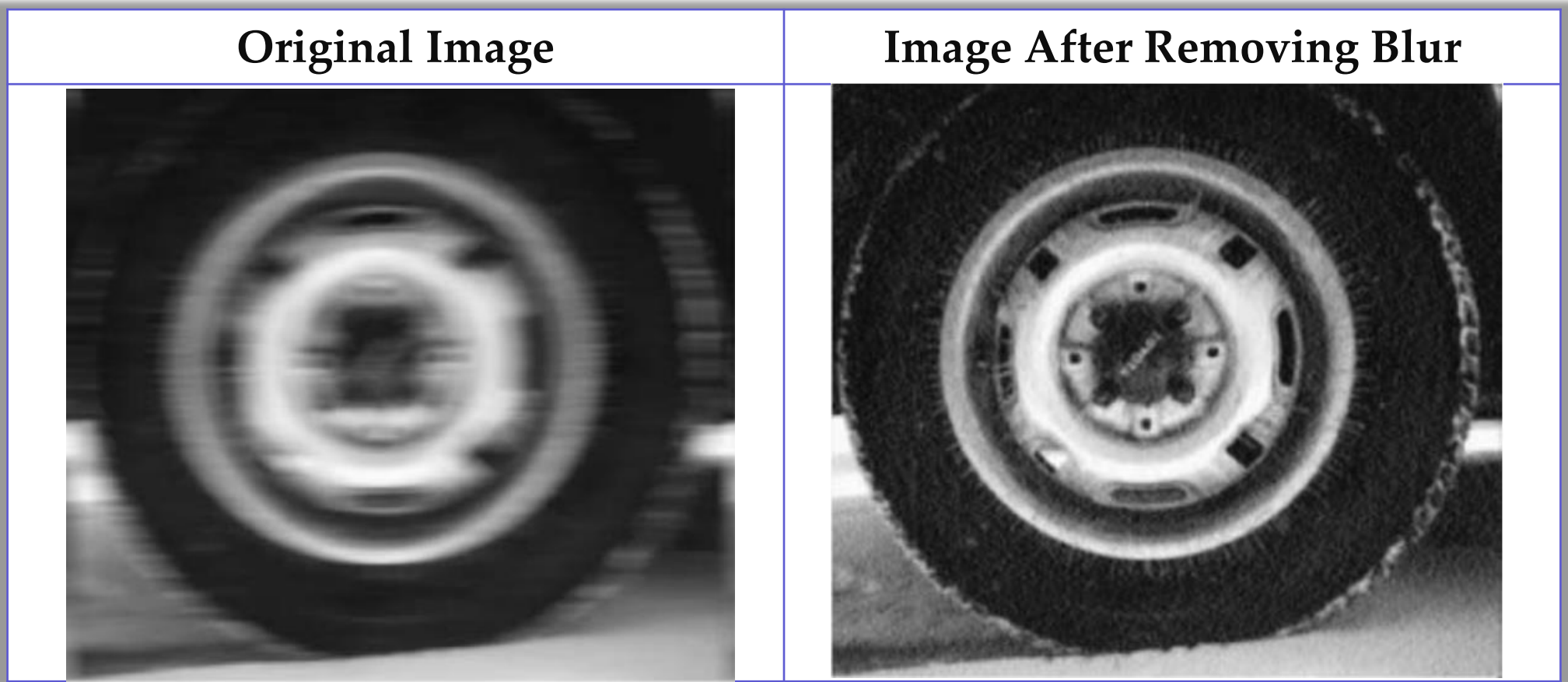


Image Processing Operations – Edge Extraction

- **Edge Extraction:** Extracting edges from an image is a *fundamental preprocessing step* used to *separate objects from one another* before identifying their contents.

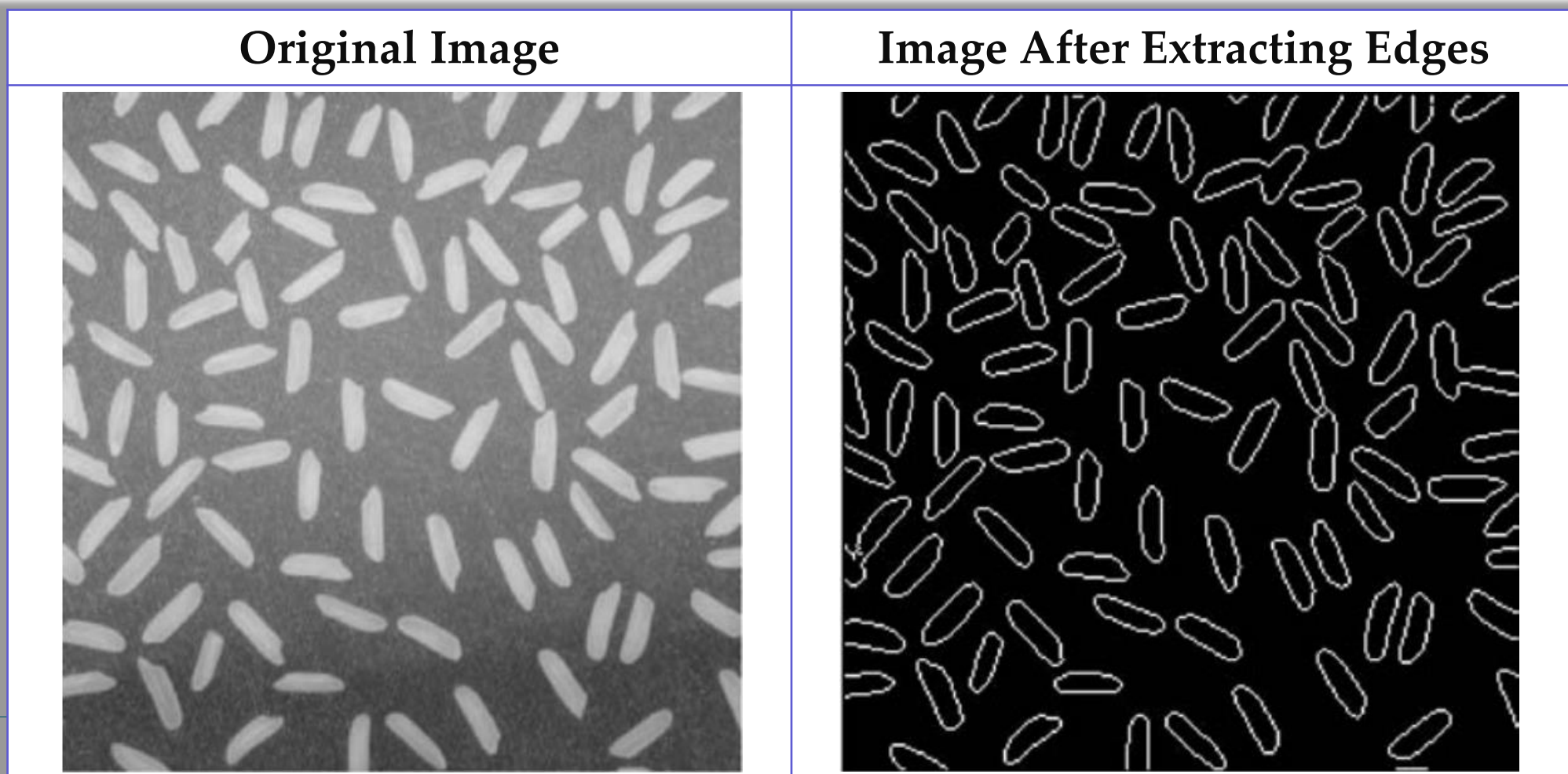


Image Processing Operations – Binarization

- **Binarization:** In many image analysis applications, it is often necessary to reduce the number of gray levels in a monochrome image to simplify and speed up its interpretation. *Reducing a grayscale image to only two levels of gray (black and white)* is usually referred to as binarization.

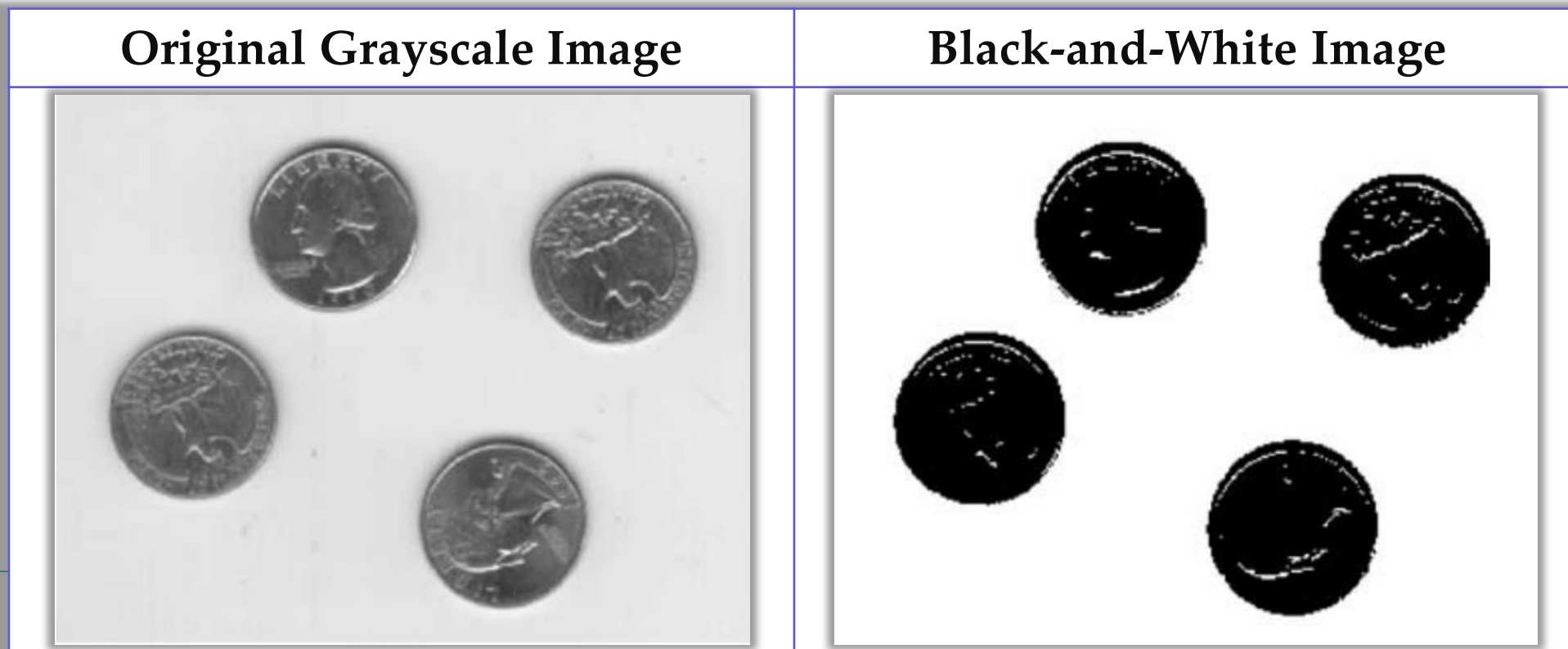


Image Processing Operations – Contrast Enhancement

- **Contrast Enhancement:** In order *to improve an image for human viewing* as well as make other image processing tasks (e.g., edge extraction) easier, it is often necessary *to enhance the contrast of an image*.

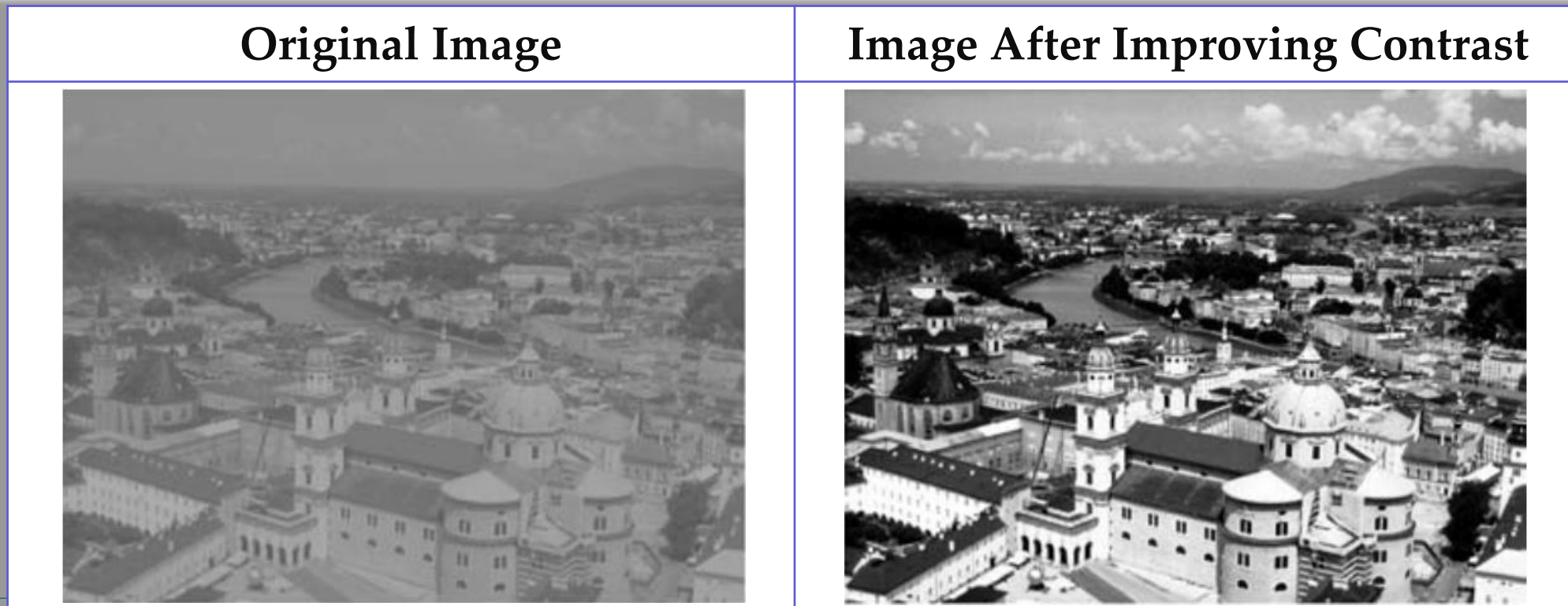


Image Processing Operations – Blurring

- **Blurring:** It is sometimes necessary to *blur an image in order to minimize the importance of texture and fine detail in a scene*, for instance, in cases where objects can be better recognized by their shape.

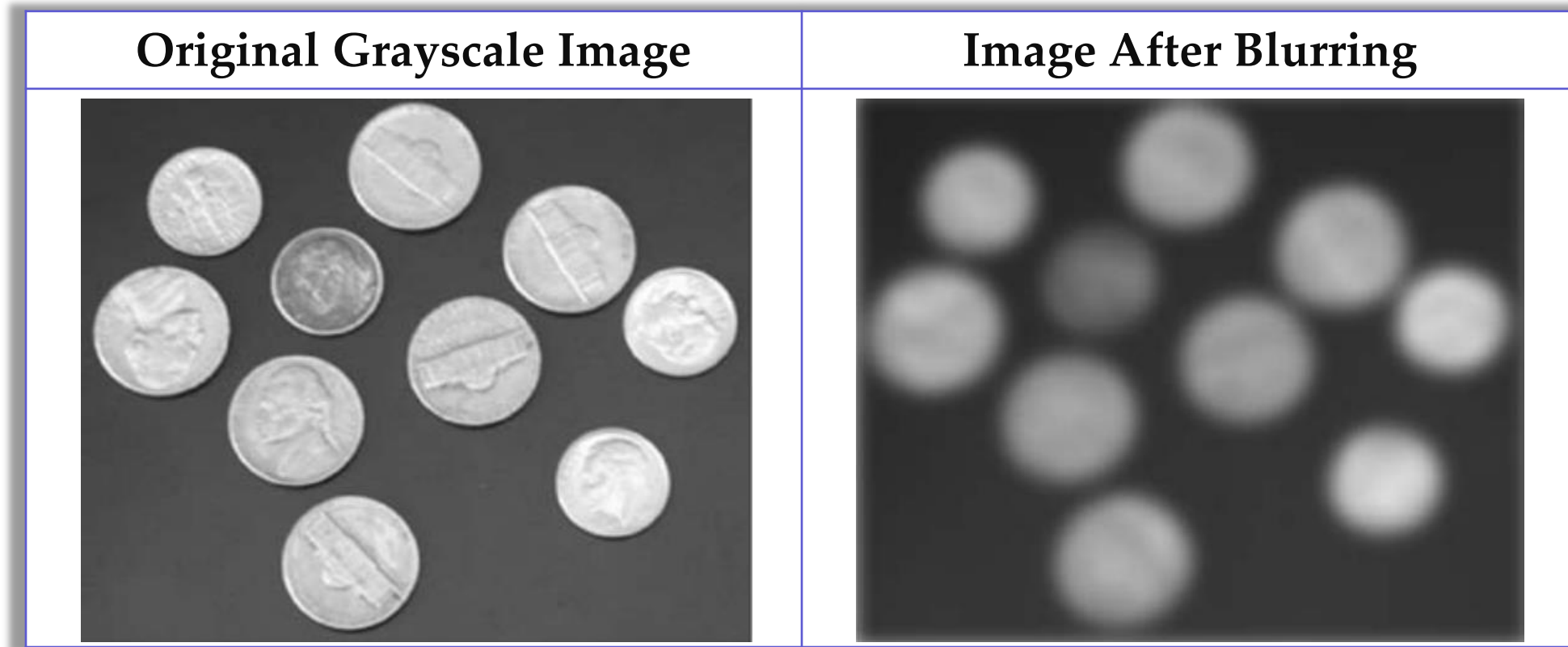


Image Processing Operations – Segmentation

- **Object Segmentation and Labelling:** The task of *segmenting and labeling objects within a scene* is a prerequisite for most object recognition and classification systems. Once the relevant objects have been segmented and labeled, their relevant *features can be extracted* and used to classify, compare, cluster, or recognize the objects in question.

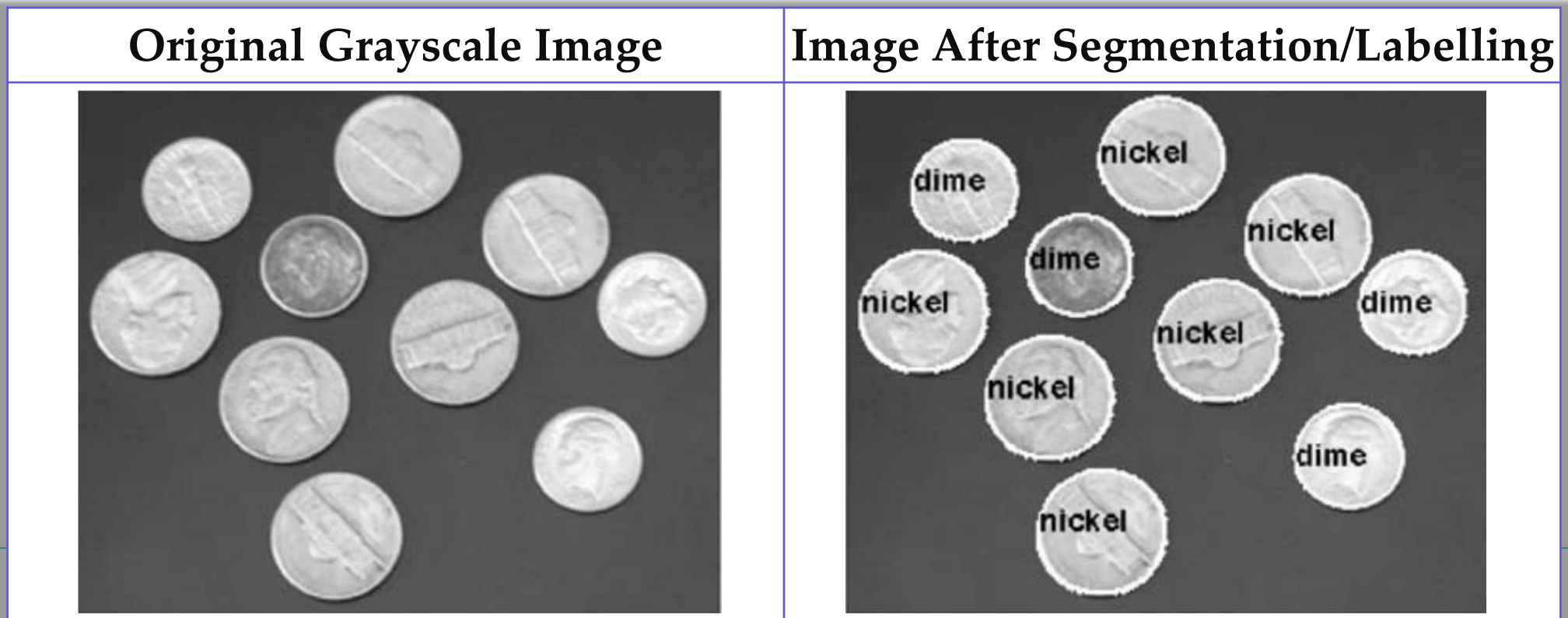


Image Processing Operations – Reconstruction

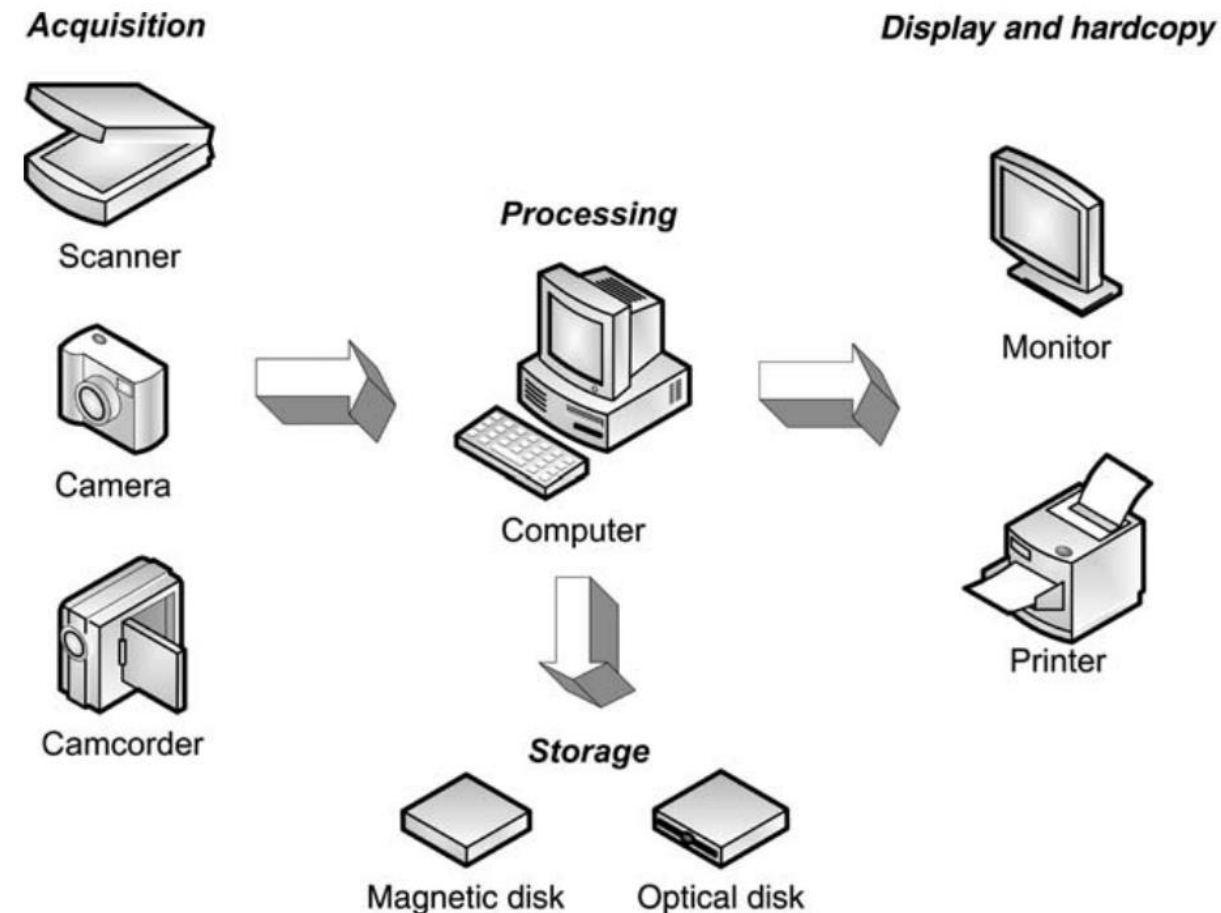
- **Image Reconstruction:** Image processing can be used to *recover and fill in the missing or corrupted parts of an image*. This involves using image processing systems that have been trained extensively with existing photo datasets to create newer versions of old and damaged photos.



Components of Digital Image Processing System

- The *hardware components of a digital image processing system* typically include the following:

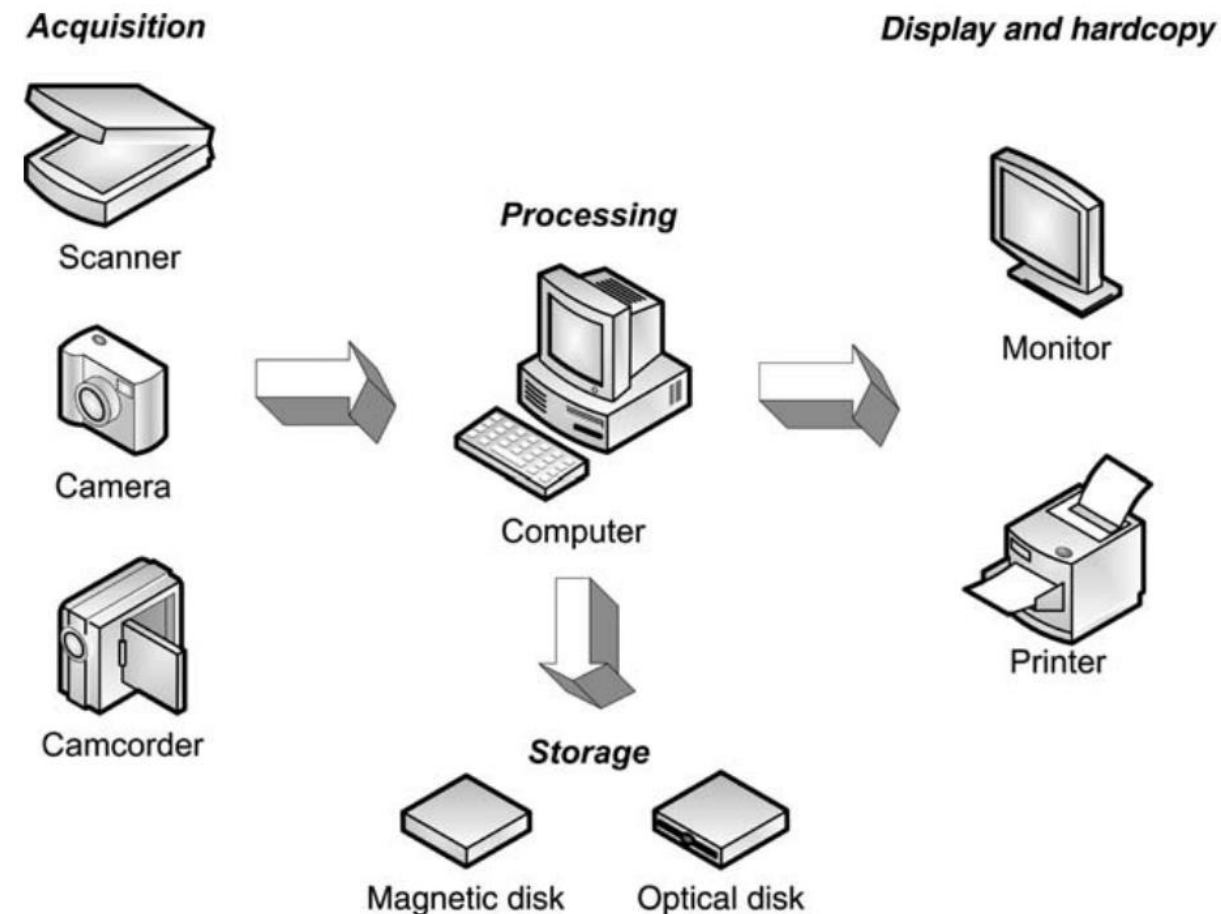
- **Acquisition Devices:** Responsible for *capturing and digitizing images* or video sequences. Examples of general-purpose acquisition devices include scanners, cameras, and camcorders. Acquisition devices can be interfaced with the main computer in a number of ways, for example, USB, FireWire, Camera Link, or Ethernet.



Components of Digital Image Processing System

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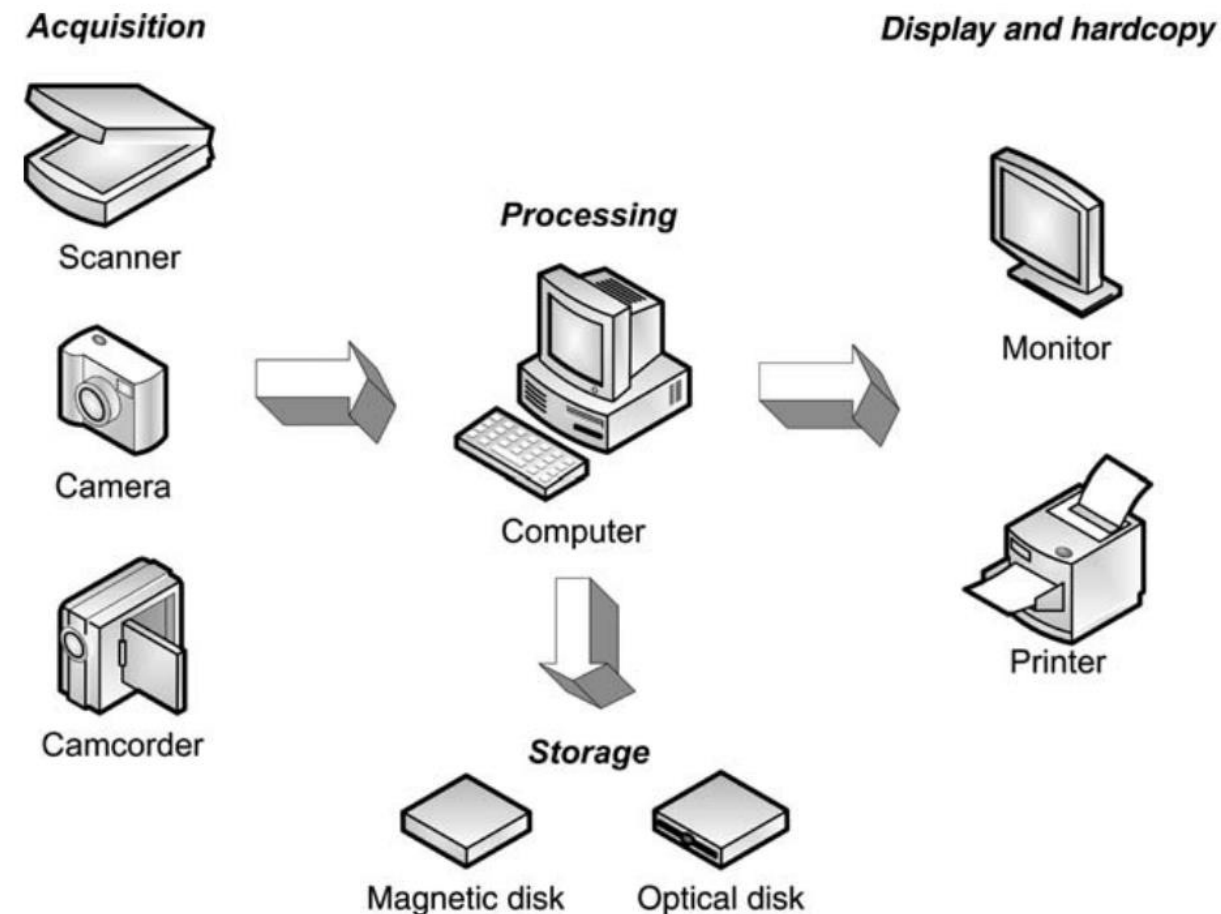
- **Processing Equipment:** The main *computer itself*, in whatever size, shape, or configuration. Responsible for running software that allows the processing and analysis of acquired images.



Components of Digital Image Processing System

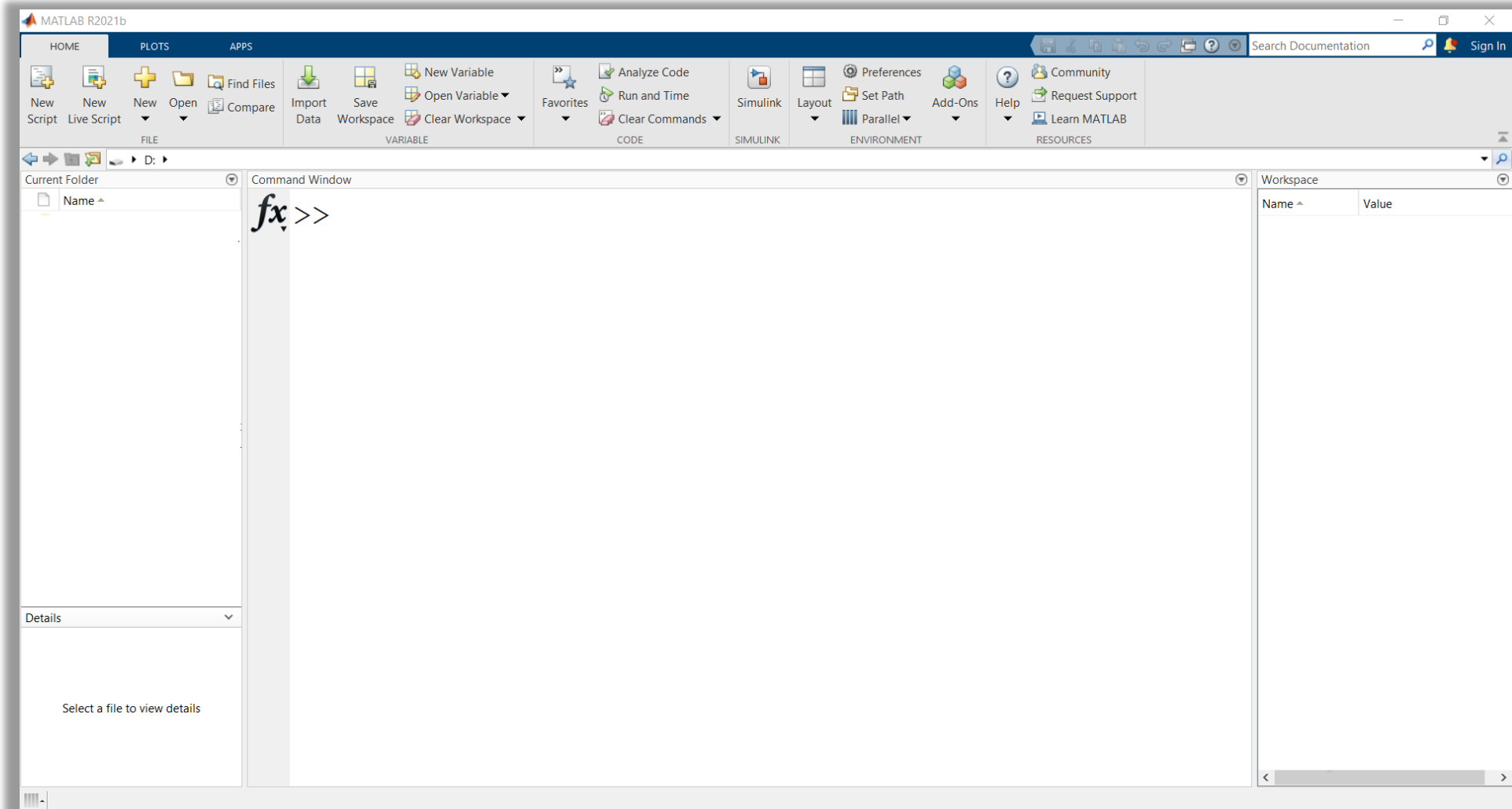
■ The *hardware components of a digital image processing system* typically include the following:

- **Display and Hardcopy Devices:** Responsible for *showing the image contents for human viewing*. Examples include color monitors and printers.
- **Storage Devices:** Magnetic or optical disks responsible for *long-term storage of the images*.



MATLAB

- The software of choice is **MATLAB**. It is an abbreviation for matrix laboratory.



MATLAB

- **MATLAB** is a multi-platform, data analysis, prototyping, and visualization tool with built-in support for matrices and matrix operations, rich graphics capabilities, and *a friendly programming language and development environment*.
- **MATLAB** has become very popular with engineers, scientists, and researchers in both industry and academia, due to many factors, such as *the availability of an Image Processing Toolbox (IPT)* that includes multiple algorithms and workflow applications that can be used for noise reduction, image enhancement, image segmentation, and other tasks.
- **MATLAB** offers programmers *the ability to edit and interact with the main functions and their parameters*, which leads to valuable time savings in the software development cycle.

Thank
You