Introduction to Image Processing

Dept. Medical Instrument Devises

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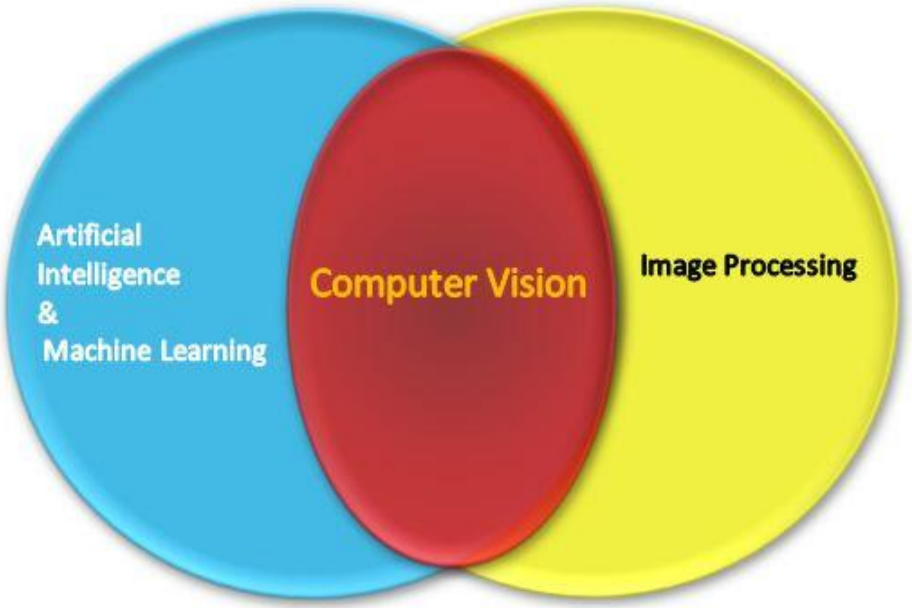
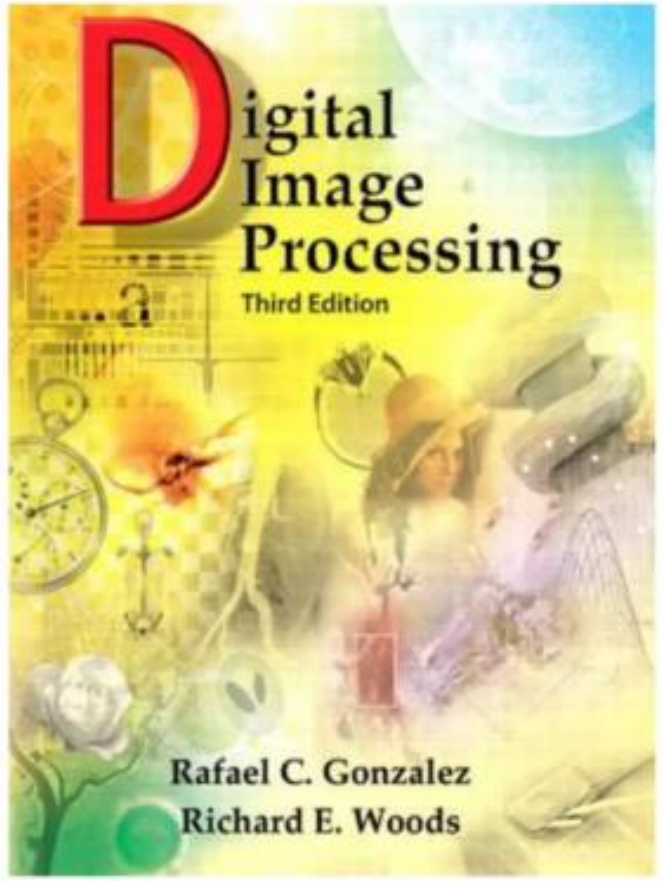


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What is Image?

- An image is a spatial representation of a two-dimensional or three-dimensional scene.
- An image is an array, or a matrix pixels (picture elements) arranged in columns and rows.



Digital Image Processing...Why?

- Interest in digital image processing methods stems from two principal application areas:

1. Improvement of pictorial information for human interpretation.
2. Processing of image data for storage, transmission, and representation for autonomous machine perception .

- **Definition of Image Pixel :** is a type of digital image that is made up of individual picture elements, or "pixels." Each pixel in a pixel image represents a single point in the image and can be thought of as a tiny square or dot of color. The arrangement of these pixels forms the overall image.
- **A pixel value**, often referred to simply as "**pixel intensity**" or "**pixel color value**," is a numerical representation of the color or grayscale intensity of a single pixel in a digital image.

Digital Image Processing

- DIP Definition: Discipline in which both Input and out of process are Image .

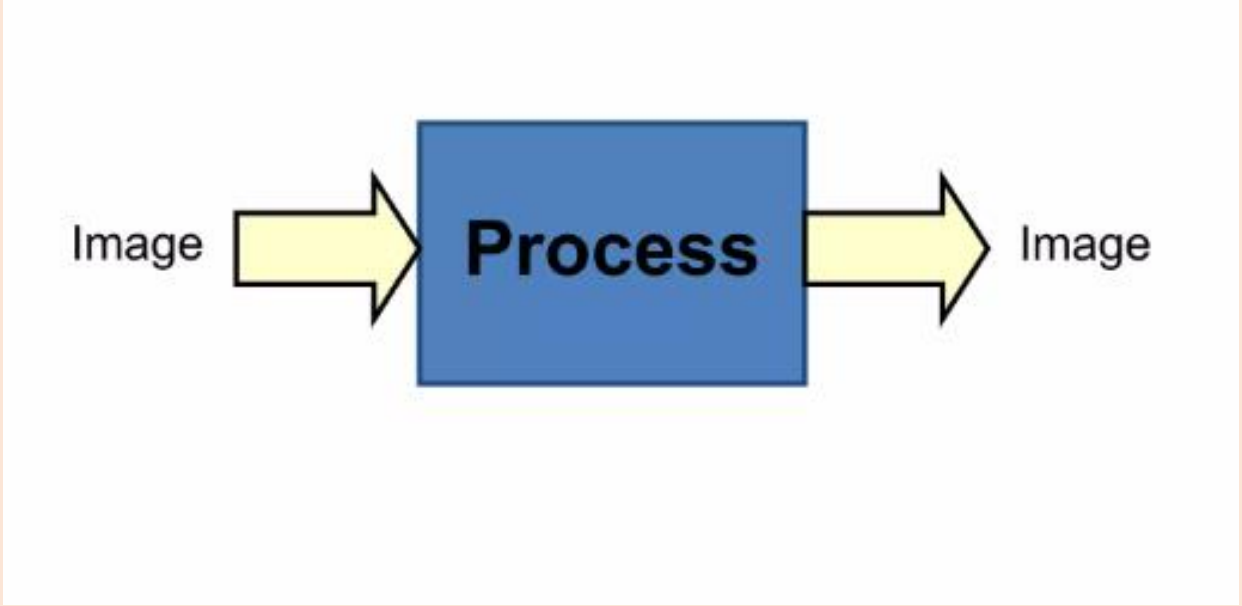


Fig 1. Process of DIP.

What is Digital Image...?

- An image may be defined as a two-dimensional function, f(x, y), where x and y are spatial (plane) coordinates, and the amplitude of f at any pair of coordinates (x, y) is called the intensity or gray level of the image at that point.
- Digital Image: When x, y and the intensity values of f are all finite, discrete quantities, we call the image a digital image.
- Color Image:

$$f(x,y) = \begin{bmatrix} r(x,y) \\ g(x,y) \\ b(x,y) \end{bmatrix}$$

The field of digital image processing refers to processing digital images by means of a digital computer.

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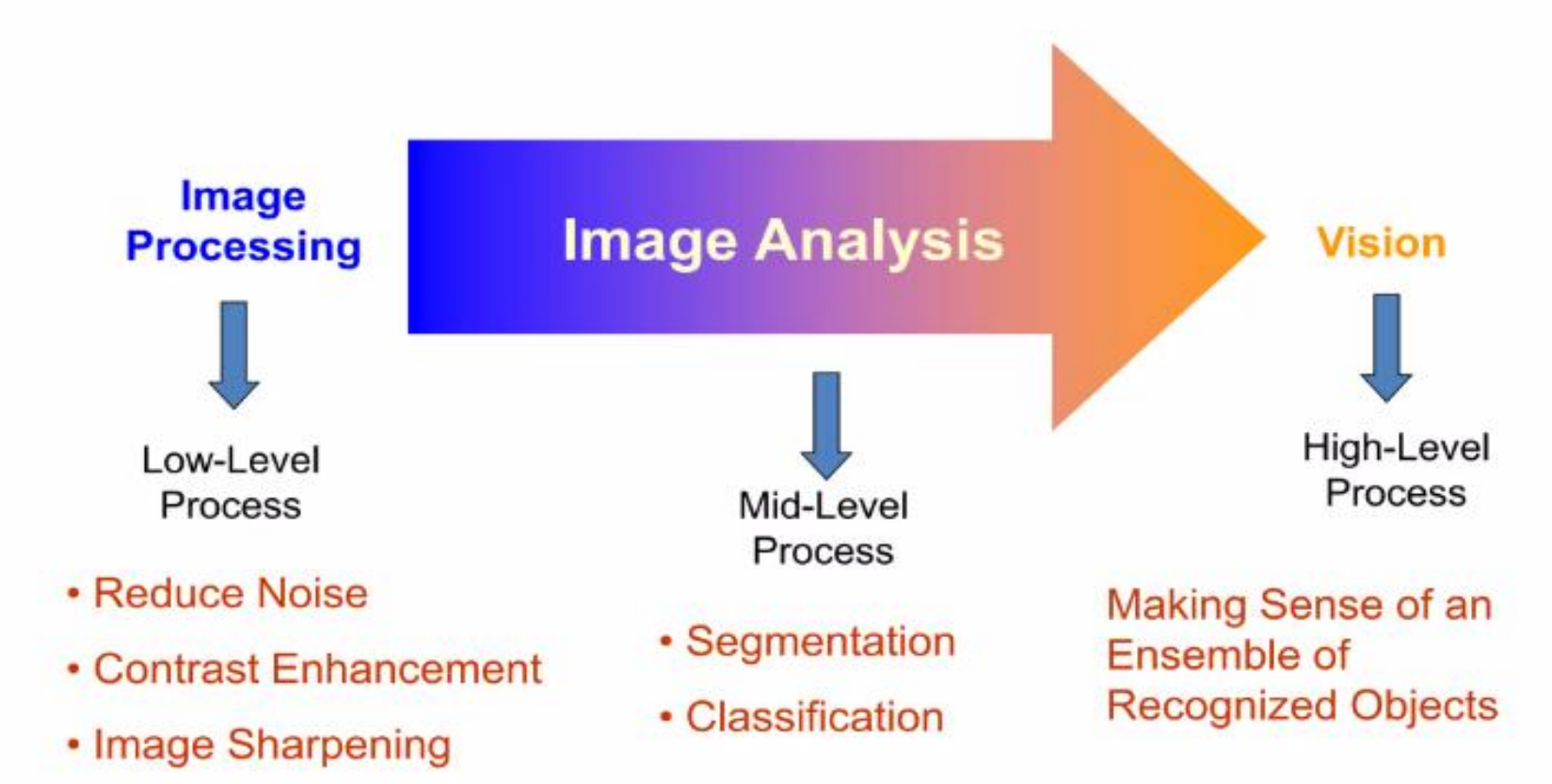


Fig 2. Block Diagram of DIP.

Origins of Digital Image

- 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.
- Introduction of the Bartlane cable picture transmission system in the early 1920s reduced the time required to transport a picture across the Atlantic from more than a week to less than three hours.

Steps in DIP

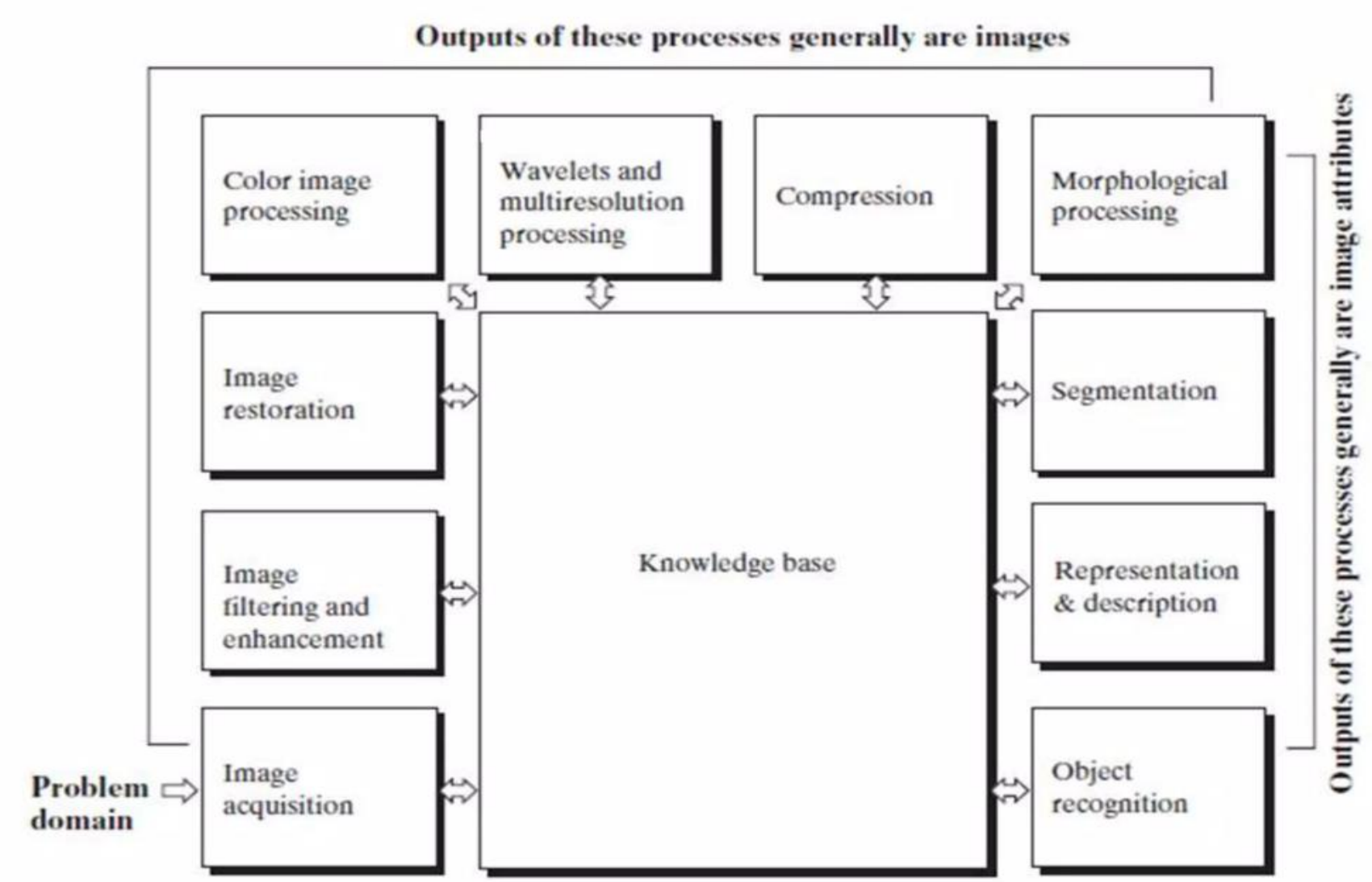
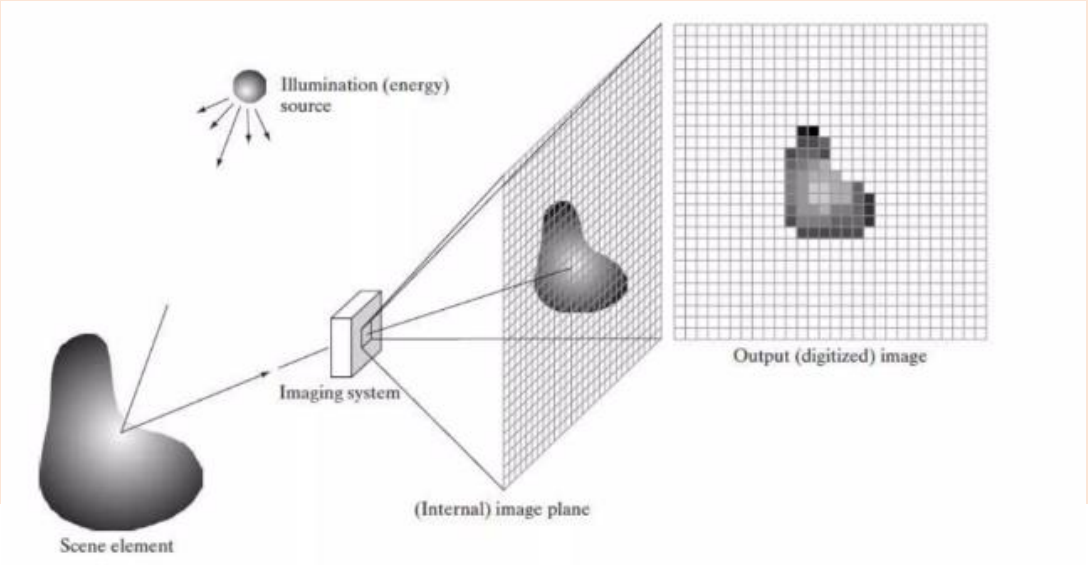


Fig 3. General steps in DIP.

1. Image acquisition ?

- **Image acquisition** is the process of capturing or obtaining a digital image from a physical source, such as a camera, scanner, or other imaging device. It is the first step in the digital image processing pipeline and involves converting real-world scenes or objects into a digital format that can be stored, manipulated, and analyzed using computers.



2. Image Enhancement

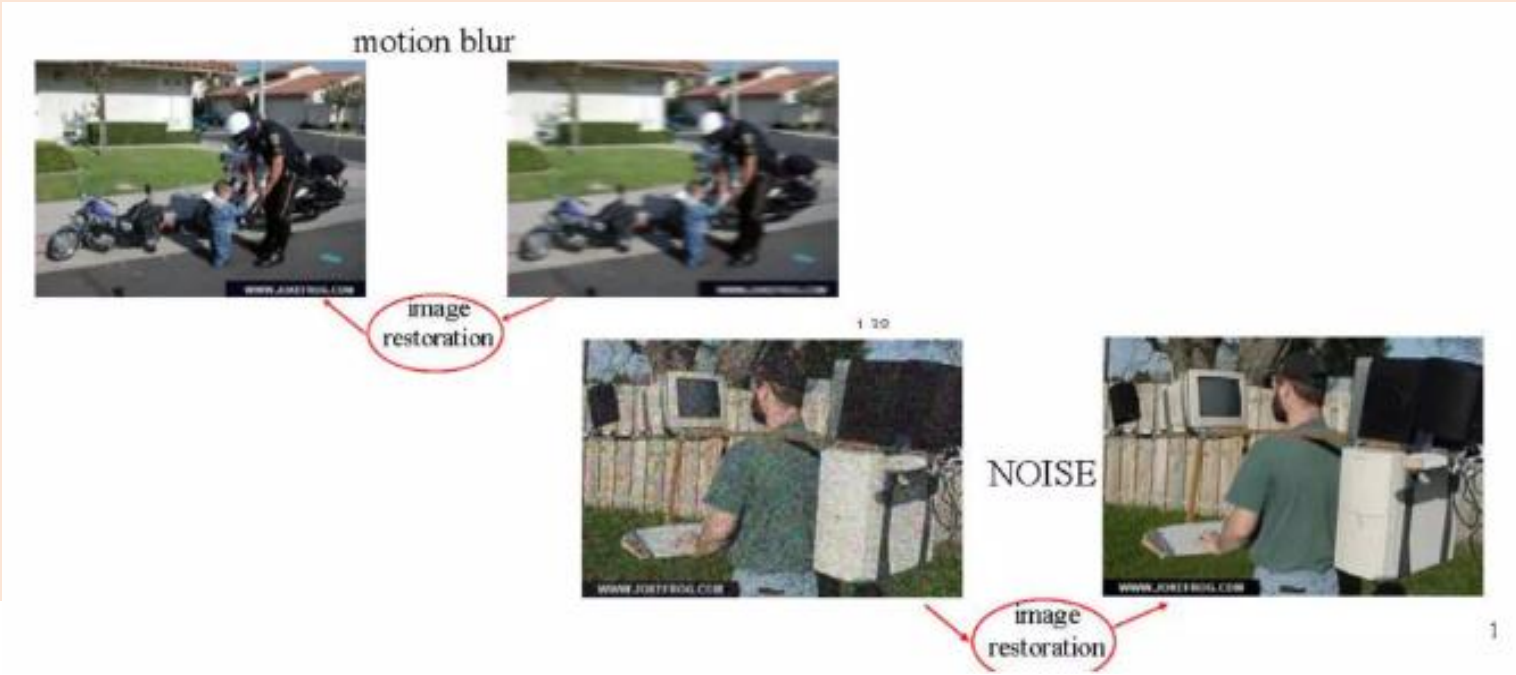
Image enhancement is a set of techniques used to improve the visual quality of a digital image or to extract information from it by emphasizing certain features or reducing unwanted characteristics. The goal of image enhancement is to make the image more suitable for specific analysis, visualization, or human perception. It is commonly employed in fields like computer vision, medical imaging, remote sensing, and photography.

- For example, a method that is quite useful for enhancing X-ray images may not be the best approach for enhancing satellite images taken in the infrared band of the electromagnetic spectrum.



3. Image restoration

- **Image restoration** is a process in digital image processing aimed at improving the quality and fidelity of a degraded or corrupted image. The goal of image restoration is to recover the original, undistorted image or an image as close to the original as possible by reducing the effects of various degradations, such **as noise, blurring**, and other **artifacts**. Image restoration techniques are widely used in applications such as photography, medical imaging, satellite imaging.



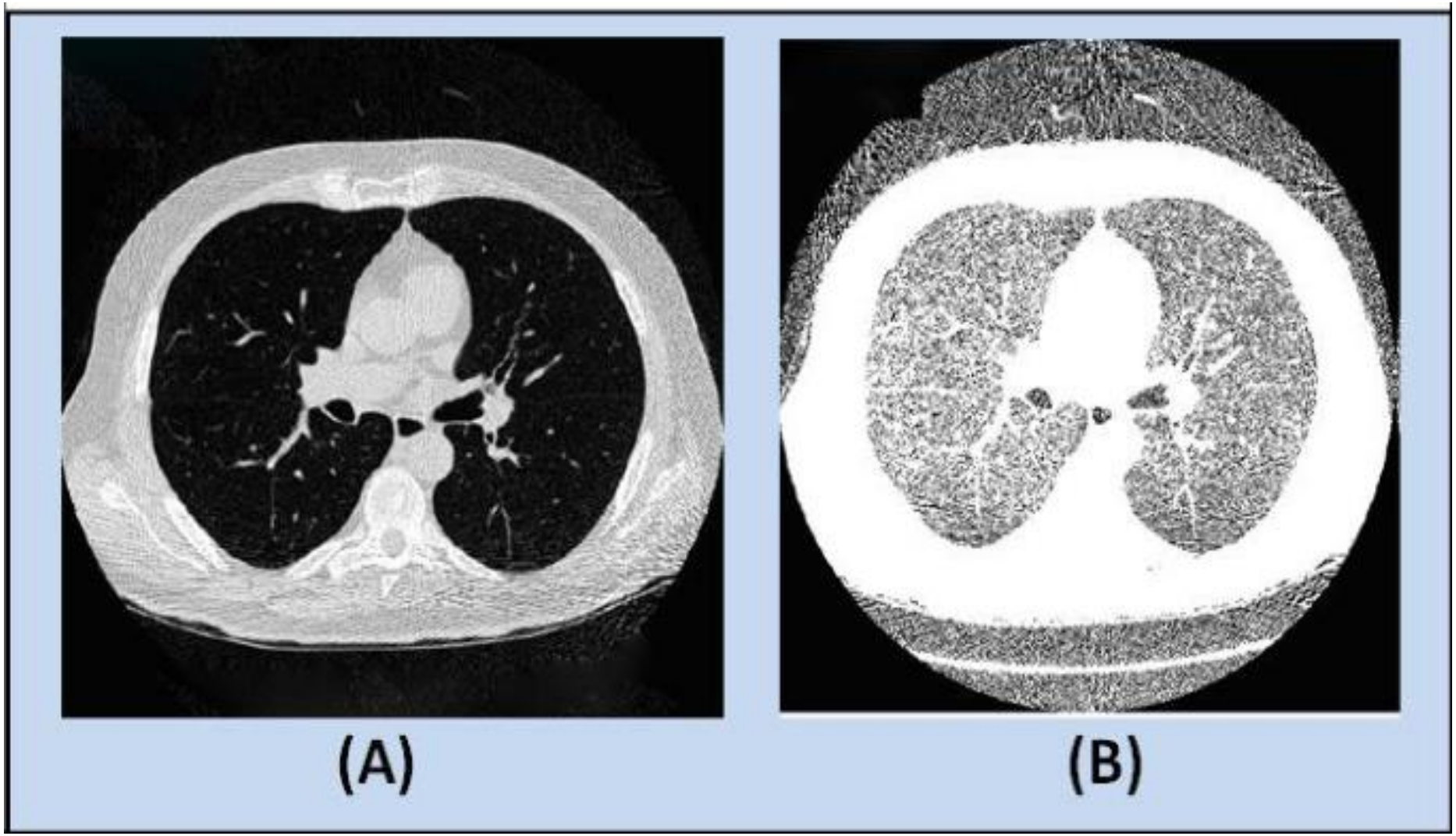
4. Color Image Processing

- **Color image processing** is a branch of digital image processing that focuses on manipulating and analyzing images containing color information. In color images, each pixel is represented by a combination of color channels, often in the RGB (Red, Green, Blue) color model. Color image processing techniques aim to enhance, segment, filter, or extract information from these multi-channel images. It involves operations that consider color attributes to achieve various goals, such as color correction, object recognition, image segmentation, and color-based feature extraction. Color image processing is widely used in applications like computer vision, medical imaging, and multimedia.

5. Wavelet

- Wavelets are mathematical functions or basis functions used in signal processing and image analysis. Wavelet transforms are used to decompose a signal or an image into different frequency components, making it possible to analyze and manipulate different scales and features within the data. Wavelets have the advantage of providing both time and frequency localization, which is useful for tasks like image compression, denoising, and feature extraction. Wavelet-based techniques, such as the discrete wavelet transform (DWT) and the continuous wavelet transform (CWT), are widely employed in various applications, including image compression (e.g., JPEG 2000), image denoising, and pattern recognition.

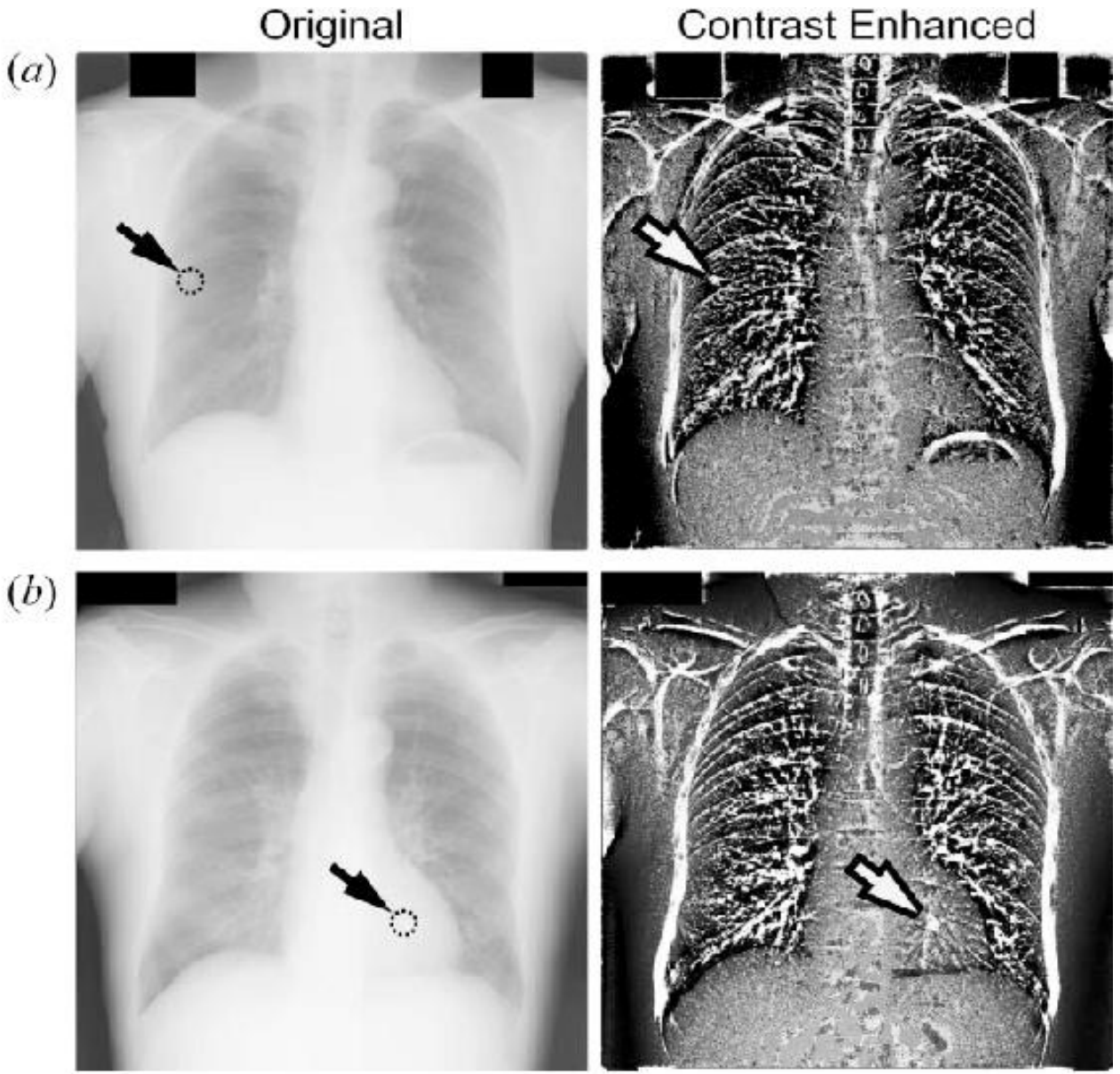
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6. Morphological Processing:

- **Morphological processing** is a branch of image processing that focuses on the analysis and manipulation of the shapes and structures within binary or grayscale images. It draws inspiration from mathematical morphology and uses operations like dilation, erosion, opening, closing, and hit-or-miss transforms to extract and enhance features within images. Morphological operations are particularly useful for tasks such as image **segmentation**, **object detection**, and **shape analysis**. They are widely applied in fields like **computer vision**, **pattern recognition**, and **medical imaging**.
- Binary morphological operations work with **binary images**, where pixels are either foreground (object) or background, while grayscale morphological operations are used on grayscale images to process image intensity values.

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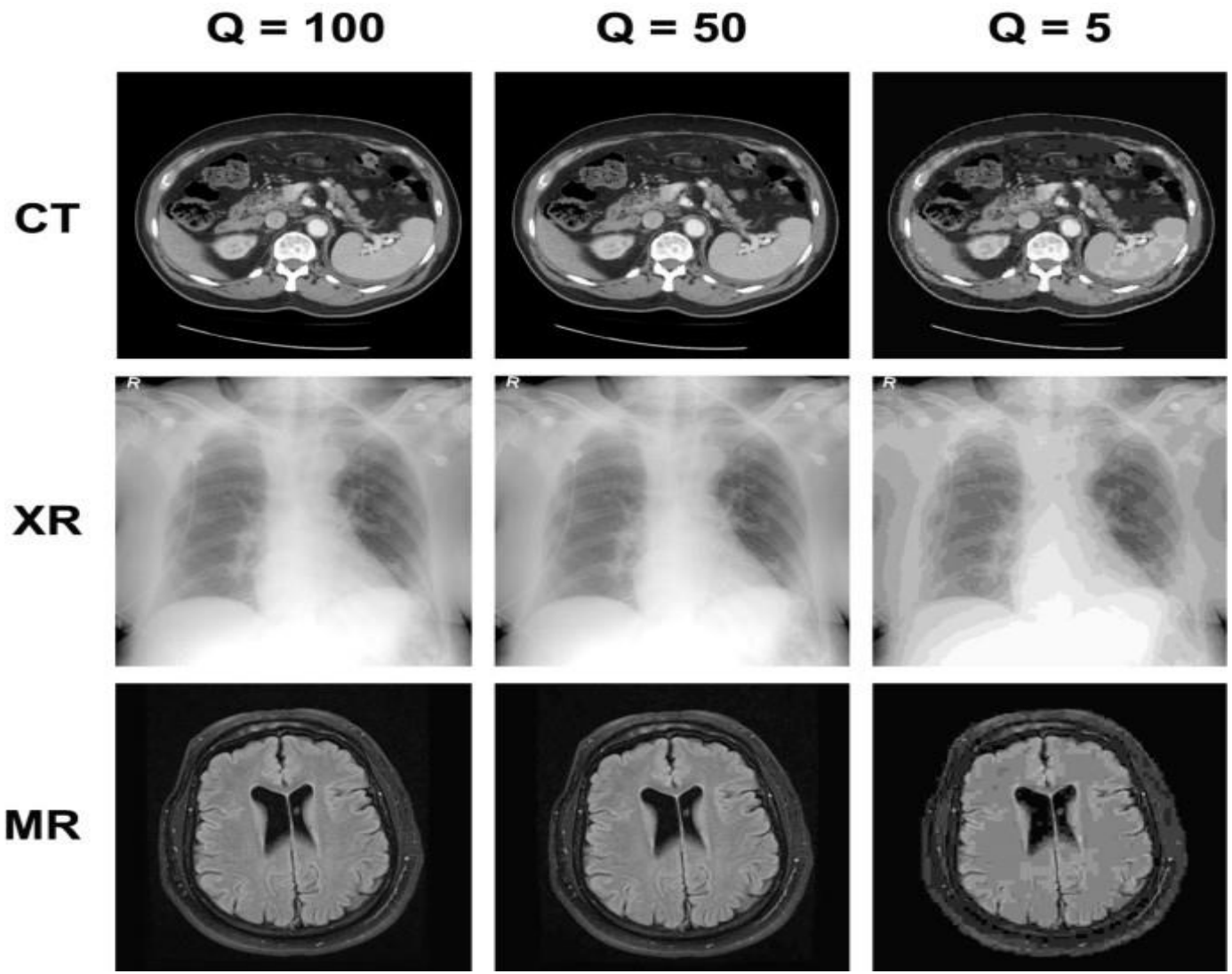


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7. Compression:

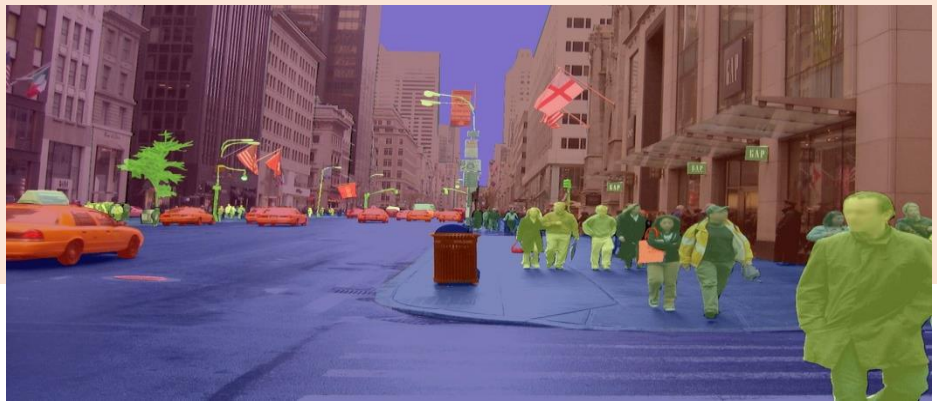
- **Compression** refers to the process of reducing the size of a digital file, such as an image, video, or data, to make it more efficient for storage, transmission, or processing. The primary purpose of compression is to decrease the amount of data needed to represent the original content while maintaining an acceptable level of quality.
- There are two main types of compression: **lossless compression**, which retains all the original data and can be perfectly reconstructed, and **lossy compression**, which achieves higher compression ratios but sacrifices some data quality by discarding certain information that is less perceptually important.

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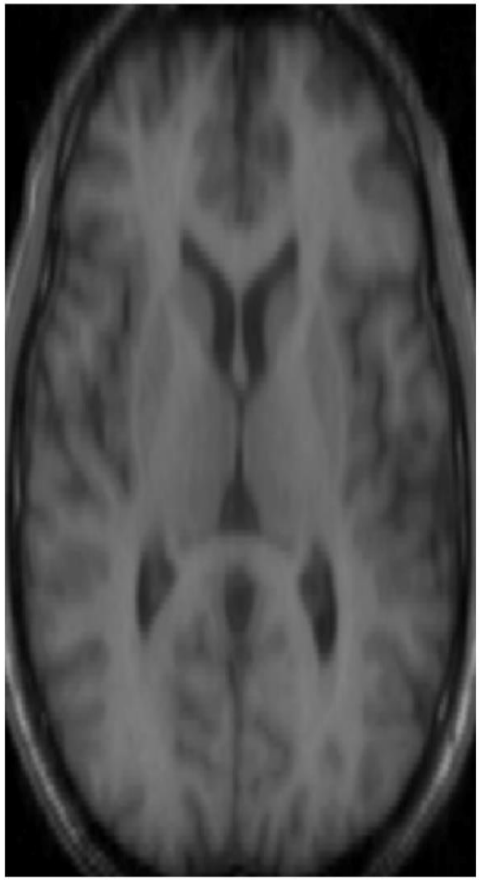


8. Segmentation:

- Image segmentation is a fundamental task in digital image processing that involves dividing an image into meaningful and homogeneous regions or objects. The goal of segmentation is to simplify and extract valuable information from an image by identifying regions that share common characteristics, such as color, texture, or intensity.
- The result of segmentation is typically a set of image regions, often referred to as "segments" or "regions of interest," where each segment corresponds to a distinct object or part of the image. Image segmentation is used in various applications, including object recognition, medical image analysis, computer vision, and autonomous navigation.



Cont.



(a) Axial slice



(b) Tissue segmentation



9. Representation and description

- Representation and description almost always follow the output of a · segmentation stage, which usually is raw pixel data.

■ **Boundary representation** is appropriate when the focus is on external shape characteristics, such as corners and inflections.

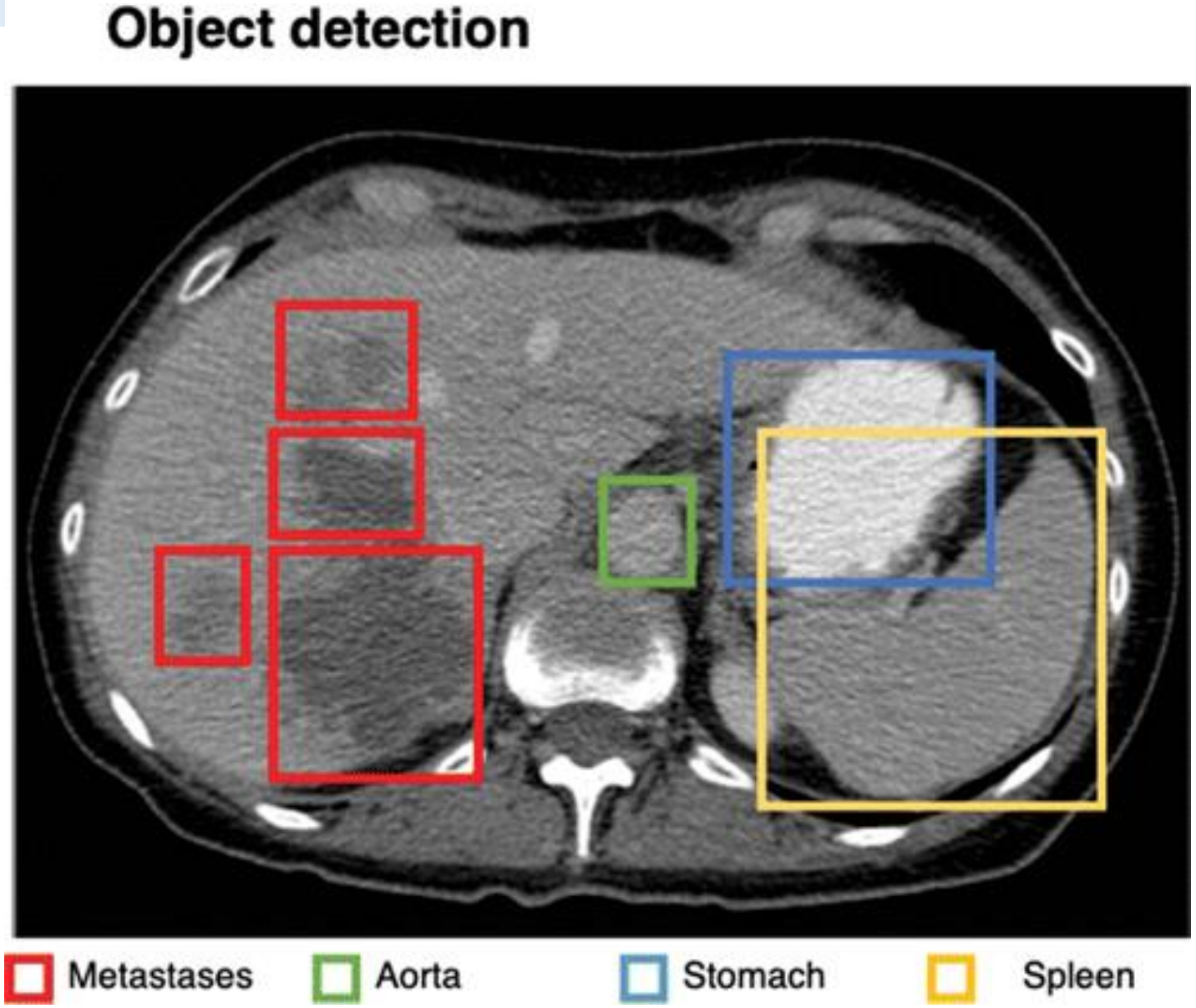
■ **Regional representation** is appropriate when the focus is on internal properties, such as texture or skeletal shape. Description, also called feature selection, deals with extracting attributes that result in some quantitative information of interest or are basic for differentiating one class of objects from another.

10. Object Recognition

. **Object recognition**, also known as object detection or object identification, is a computer vision task that involves identifying and locating specific objects or patterns within a digital image or video stream. The goal of object recognition is to enable machines, such as computers or robots, to understand and interpret visual data by recognizing objects, distinguishing one object from another, and determining their spatial location in the scene.

- Recognition is the process that assigns a label (e.g., "vehicle") to an object based on its descriptors. Digital image processing with the development of methods for recognition of individual objects.

Cont.



11. Knowledge Base

· Knowledge Base: Knowledge about a problem domain is coded into an image processing system in the form of a knowledge database.

- · This knowledge may be as simple as detailing regions of an image where the information of interest is known to be Located.
- · The knowledge base can also be complex, such as an interrelated list of all major possible defects in a materials inspection problem.
- · In addition to guiding the operation of each processing module, the knowledge base also controls the interaction between modules.

Thank you for listening

Questions??

