



DIGITAL IMAGE PROCESSING-1

Lecture 4-5: Unit 1

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Introduction to DIP

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Last Session

- Digital image fundamentals
- History of DIP
- Types of images
- Fields that use DIP in EM Spectrum
- Applications of DIP

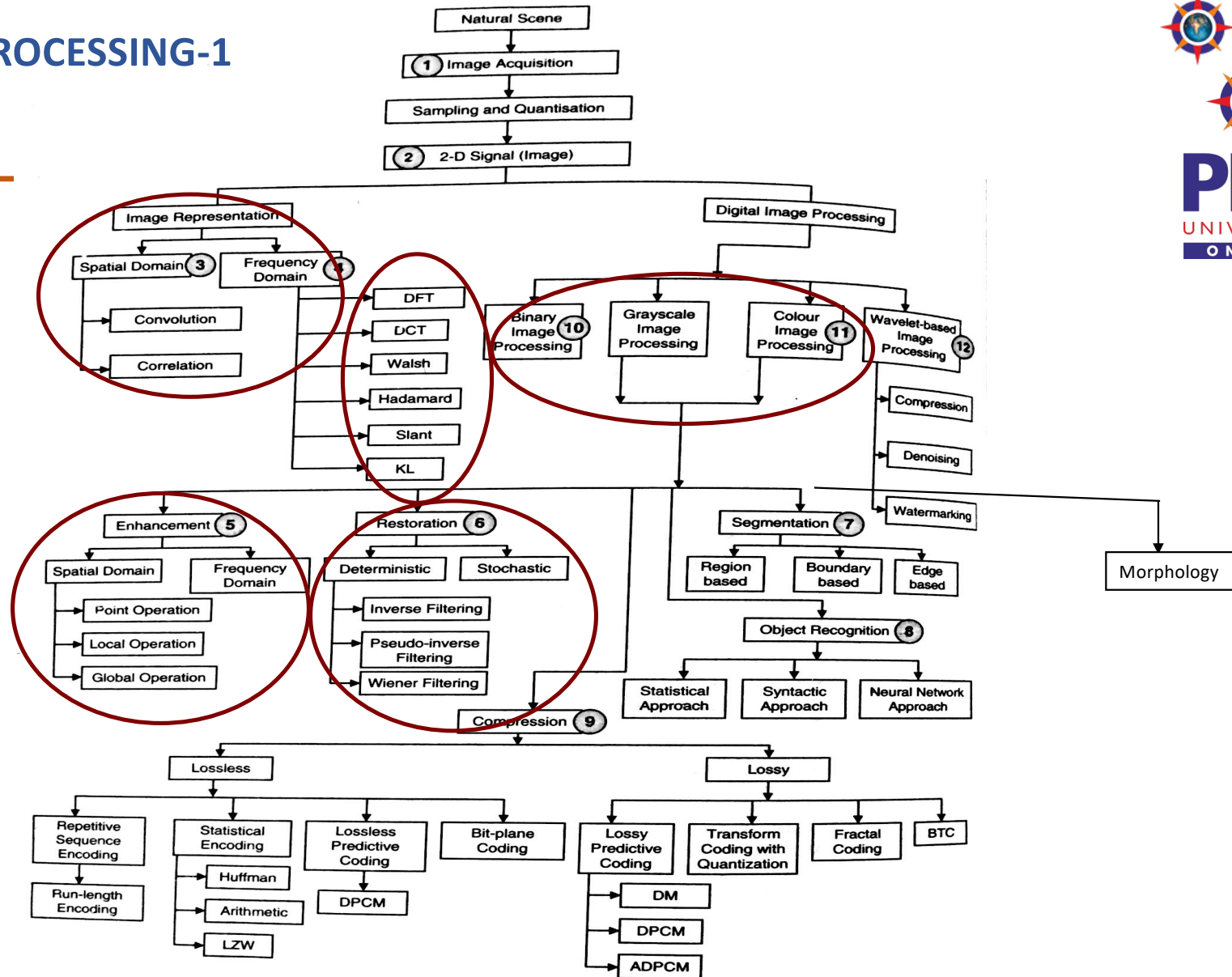
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Today's Session

- Fundamental Steps in DIP
- Components of an Image processing System
- Fundamentals of DIP
 - Visual perception
 - Image formation model
 - Image Sensing and acquisition

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DIP Overview



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Course Overview

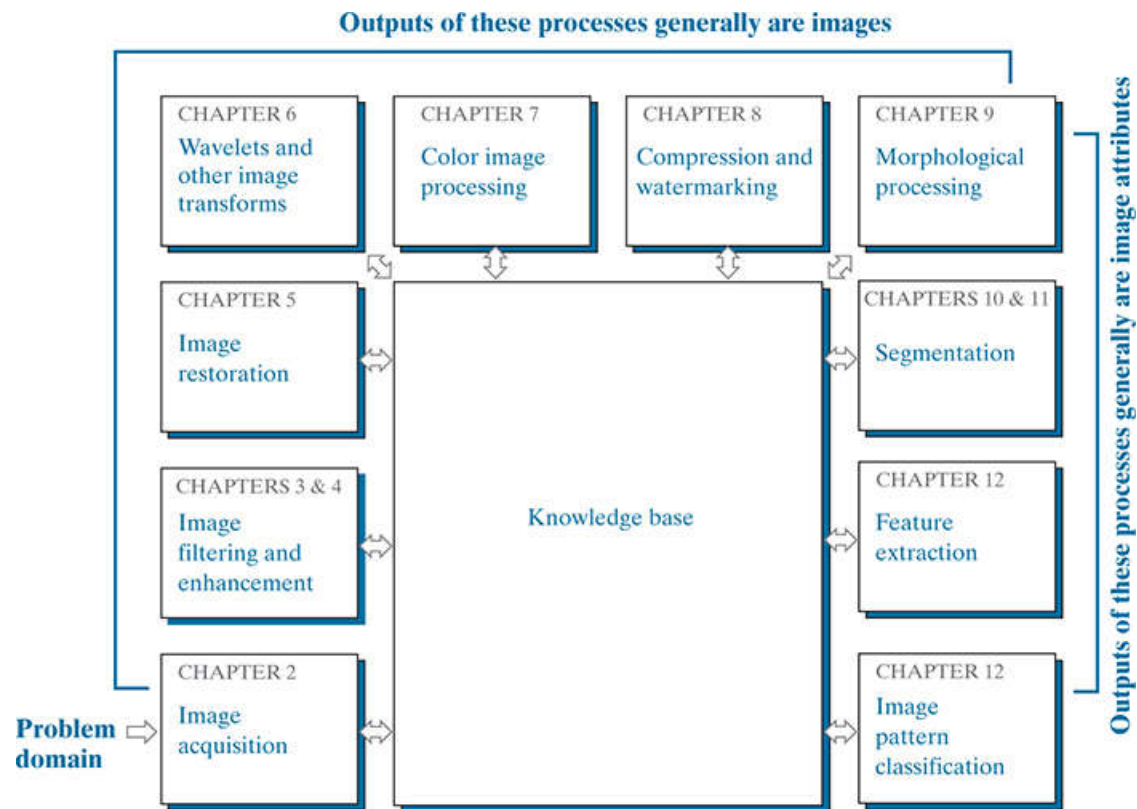


Modules (55 Hrs):

- **Unit 1: Digital Image Fundamentals**
- **Unit 2: Image Transforms**
- **Unit 3: Image Enhancement in spatial and frequency domains**
- **Unit 4: Image filtering and restoration**
- **Unit 5: Color Image processing**

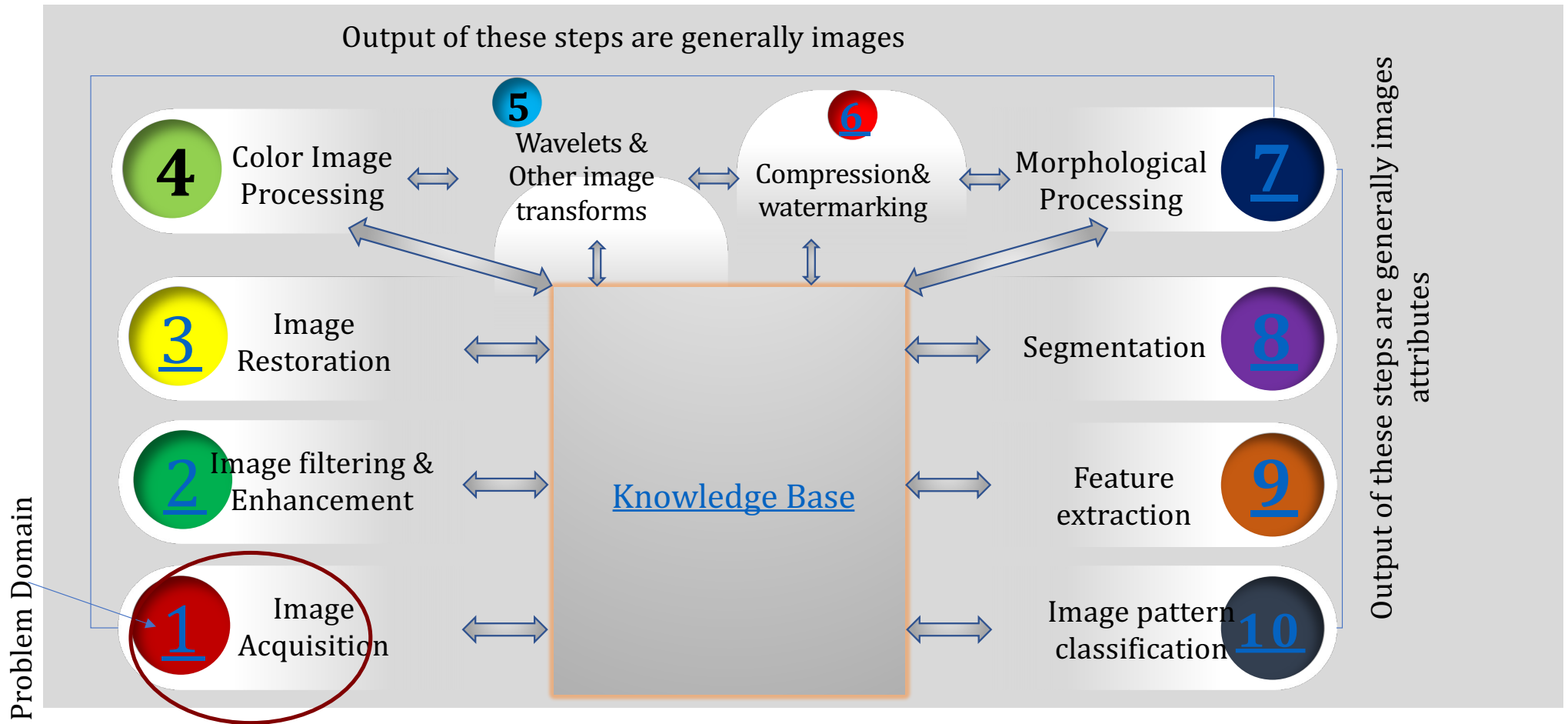
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Fundamental Steps in Digital Image Processing



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Fundamental Steps in Digital Image Processing



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Image Acquisition

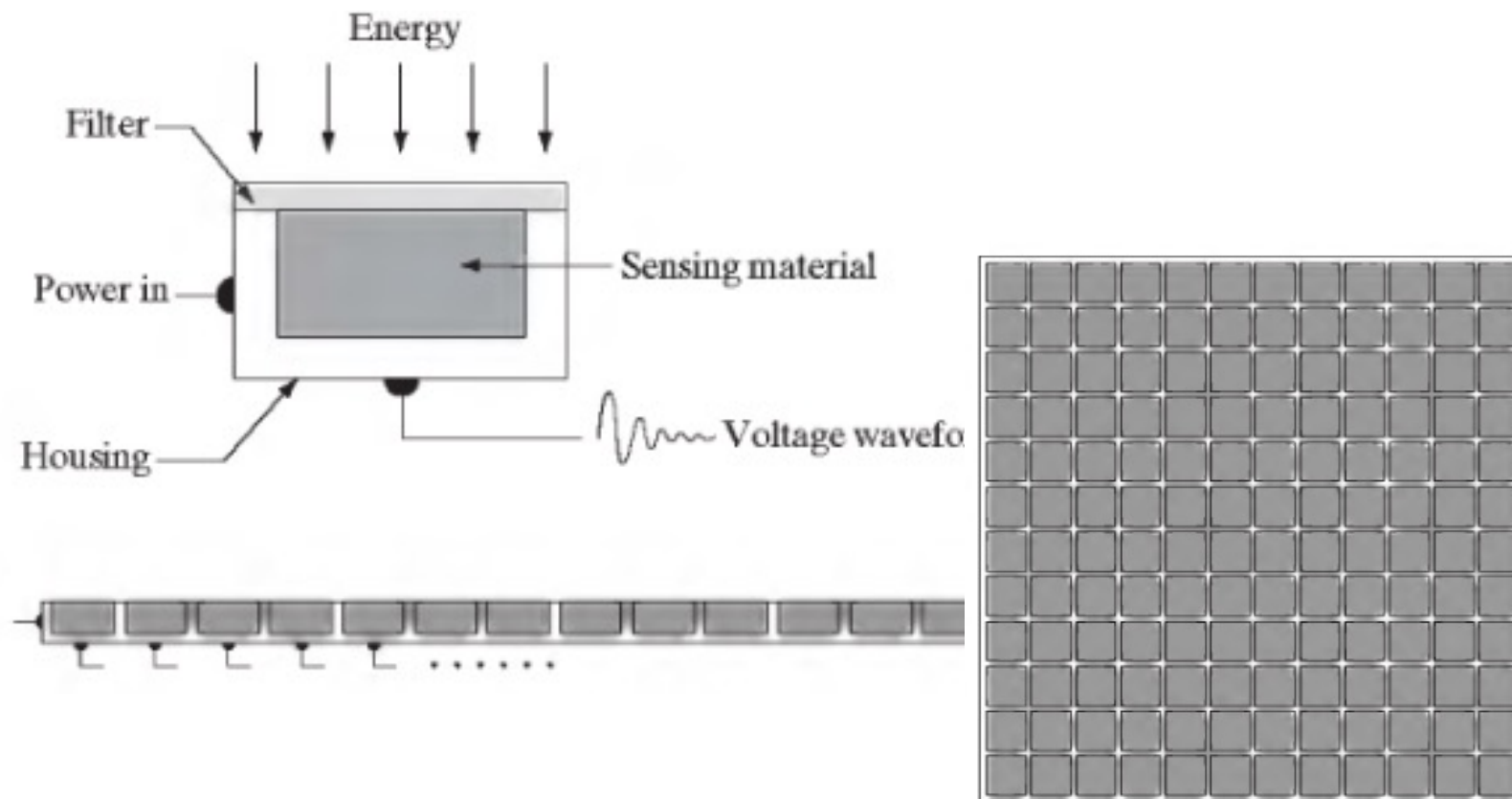


- Origin of digital images
- Image acquisition stage involves preprocessing (eg. Scaling)

• Image courtesy: kalyan5.blogspot.in

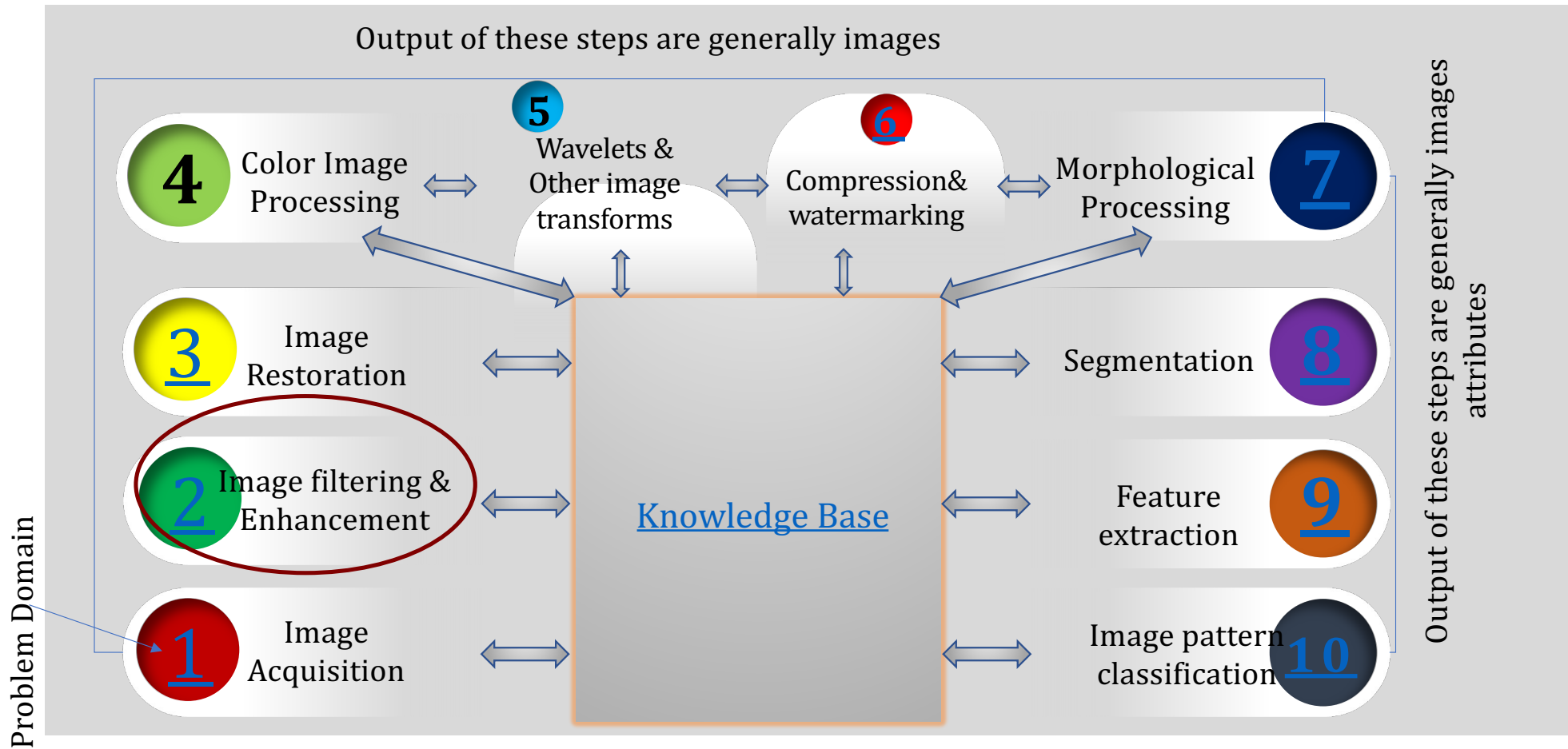
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Image Acquisition



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Fundamental Steps in Digital Image Processing



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Image Enhancement

- Process of manipulating image, so that the result is more suitable than original image for a specific application
- What is good enhancement result?
 - (subjective: should satisfy human visual system)



Note: Method used for enhancing x ray images may not be best approach for enhancing satellite images.

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Fundamental Steps in Digital Image Processing

Image Enhancement

Input Image



Enhanced Image

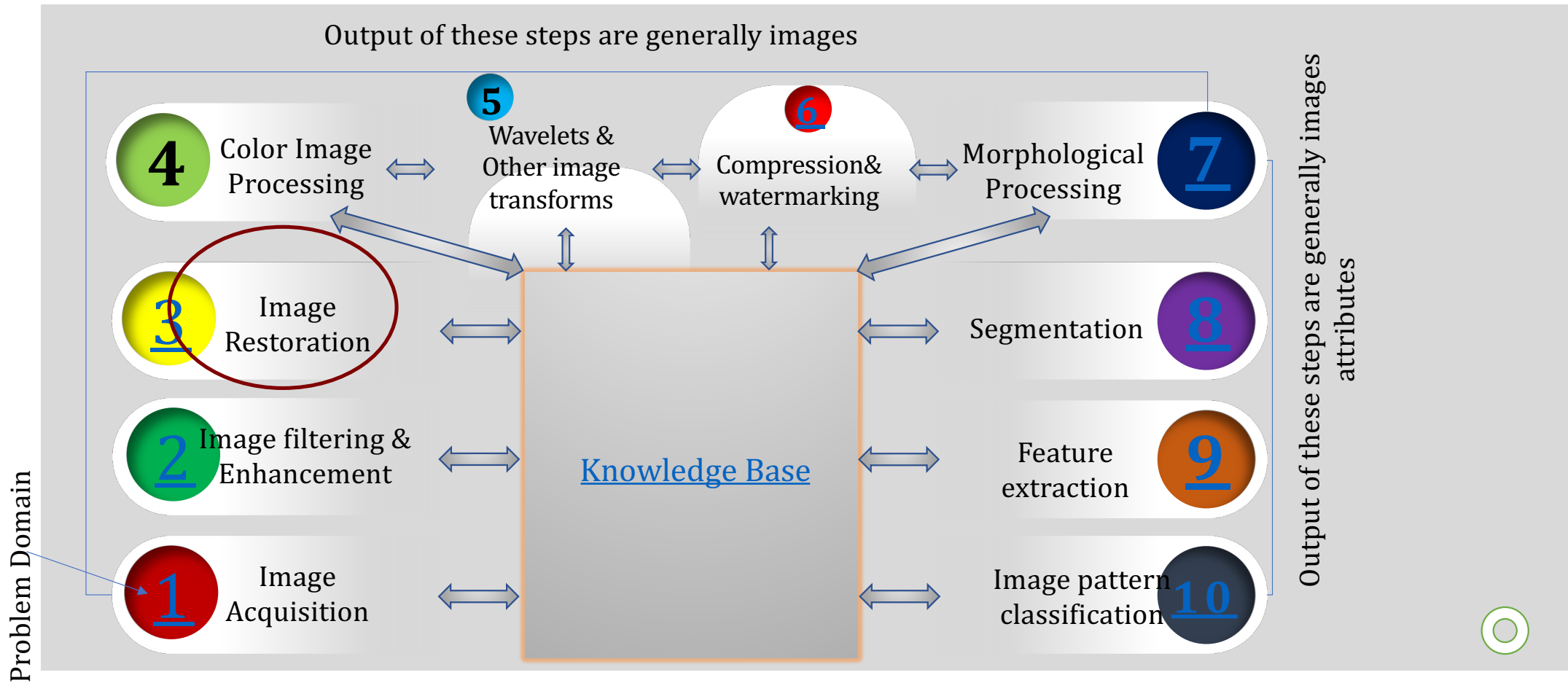


Image Courtesy: <https://www.mathworks.com/help/releases/R2020a/images/low-light-image-enhancement.html>



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Fundamental Steps in Digital Image Processing



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Image Restoration

- Image restoration attempts to recover the image that has been degraded by a degradation phenomenon like blur, noise.
- Restoration techniques model the degradation and apply the inverse process in order to recover the original image
 - Deals with improving the appearance of an image
 - It is objective



Original image



Blurred image



Image restored by Wiener filter



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Fundamental Steps in Digital Image Processing

Image Restoration

Blurred Input Image



Restored Image

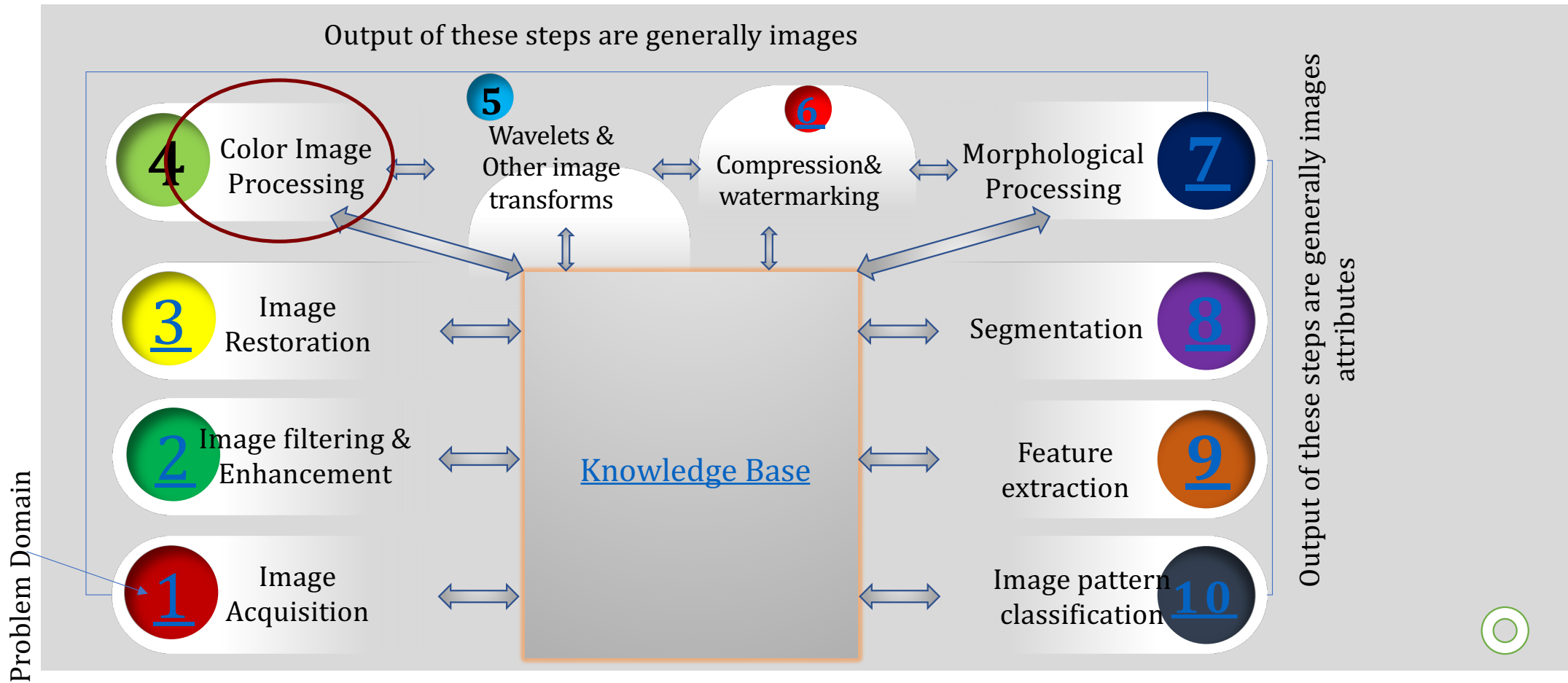


Image Courtesy: <https://www.mathworks.com/help/releases/R2020a/images/low-light-image-enhancement.html>



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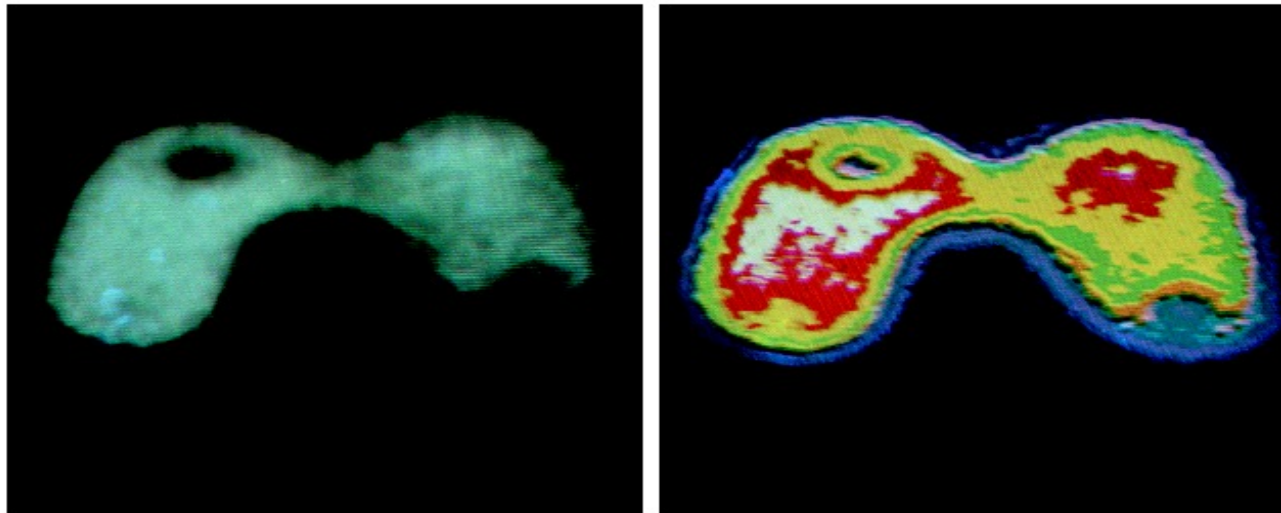
Fundamental Steps in Digital Image Processing



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Color Image Processing

- Processing operations on color image
- Color is used as the basis for extracting features of interest in an image



a b

FIGURE 6.20 (a) Monochrome image of the Picker Thyroid Phantom. (b) Result of density slicing into eight colors. (Courtesy of Dr. J. L. Blankenship, Instrumentation and Controls Division, Oak Ridge National Laboratory.)

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Color Image Processing



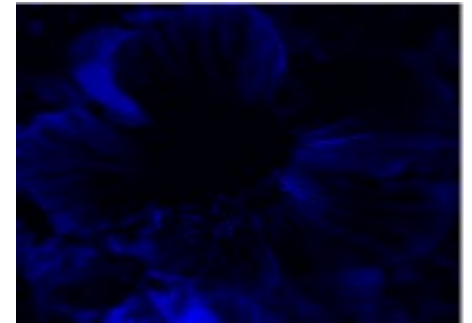
Input Image



Red



Green

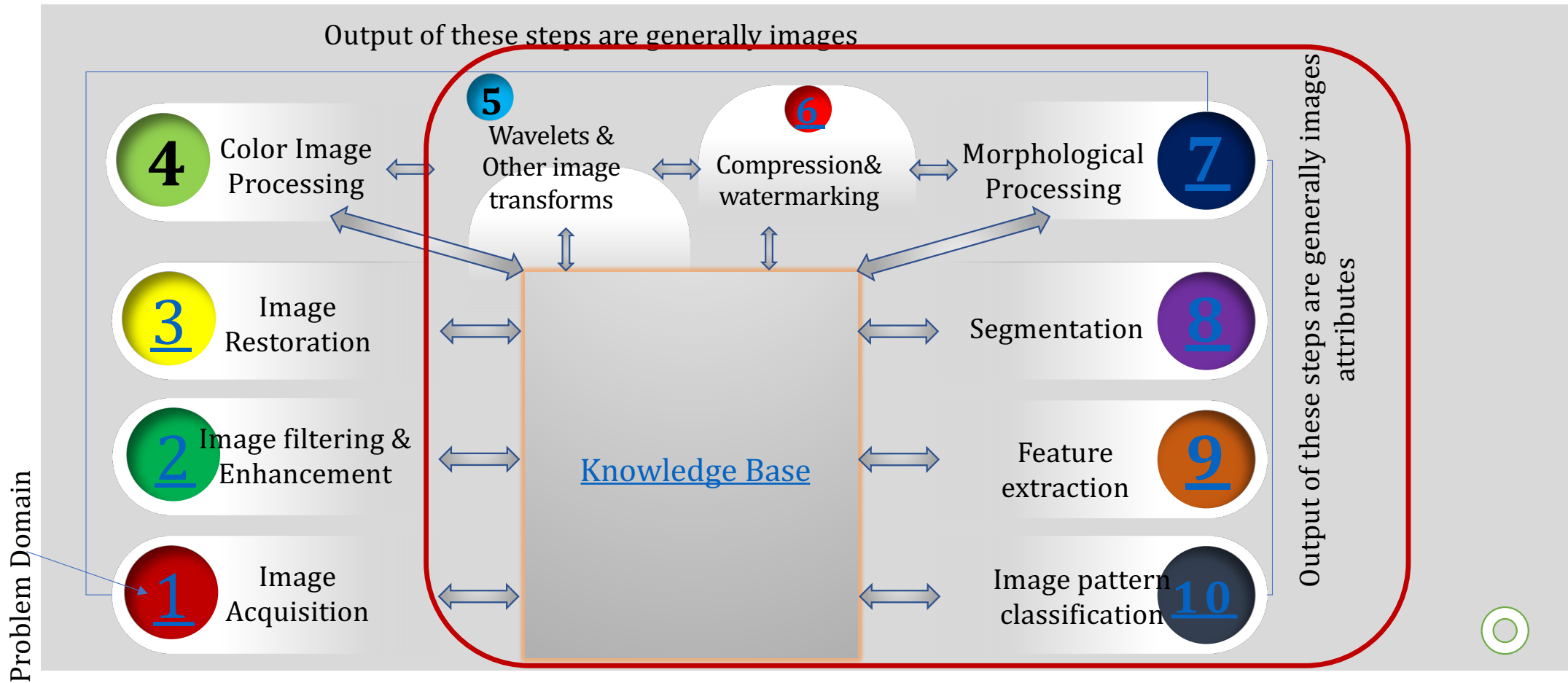


Blue

- An important area because of the use of digital images for real-time applications.

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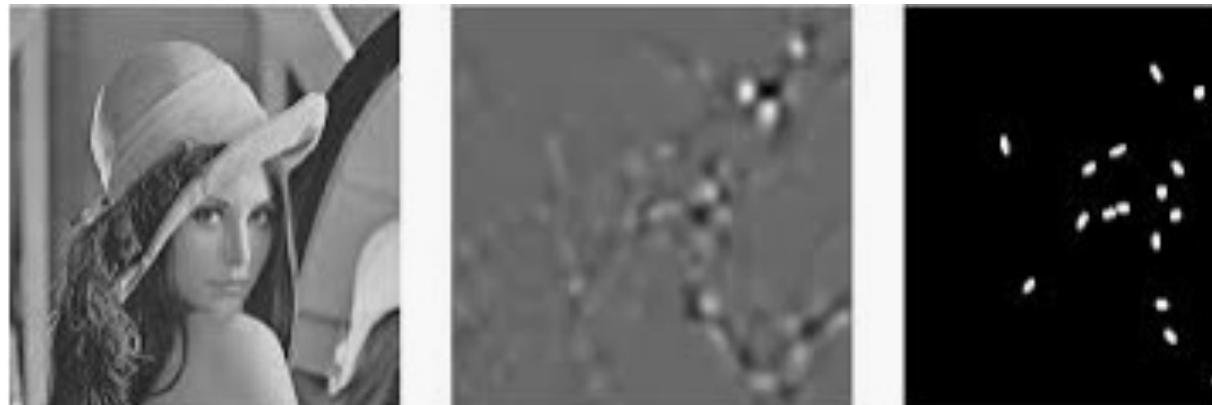
Fundamental Steps in Digital Image Processing



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Fundamental Steps in Digital Image Processing

Wavelets and other transforms



- Wavelets: Time-frequency transform
- Foundation for representing images in various degrees of resolution.

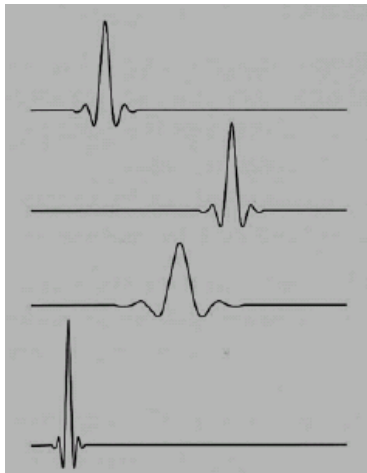
Image Courtesy: Barina, D. (2016). Gabor Wavelets in Image Processing. ArXiv, abs/1602.03308.



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Fundamental Steps in Digital Image Processing

- Wavelets (small waves)
- Wavelets are the mathematical functions that represent scaled and translated(shifted) copies of mother wavelet.
- Wavelet transforms decompose images in spatial and frequency attributes simultaneously (multiresolution)



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Fundamental Steps in Digital Image Processing

Wavelets Transforms



(a)



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Fundamental Steps in Digital Image Processing

Image compression

- Deals with the techniques for **reducing the storage required** to save an image or the **bandwidth required** to transmit it.
- JPEG (Join Photographic Experts Group)- Image compression standard
- MPEG (Motion Picture Experts Group)- Video Compression standard



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Fundamental Steps in Digital Image Processing

Image compression



Image courtesy: <https://support.cloudflare.com/hc/en-us/articles/360000607372-Using-Cloudflare-Polish-to-compress-images>

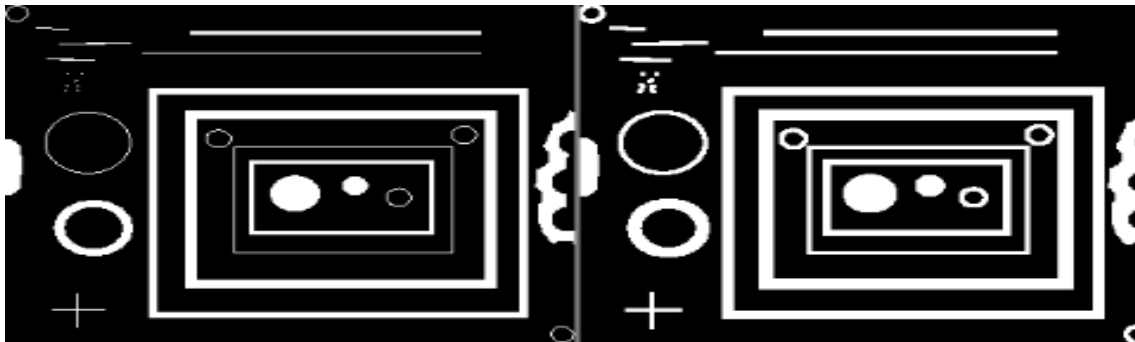


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Fundamental Steps in Digital Image Processing

Morphological Processing

- Morphology is concerned with image analysis methods whose outputs describe image content or image attributes
- Eg. Finger print recognition



Dilation

Image courtesy:

https://in.mathworks.com/help/images/morph_dilate.png

Erosion

Image courtesy:

https://in.mathworks.com/help/images/morph_erode.png



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Fundamental Steps in Digital Image Processing

Segmentation

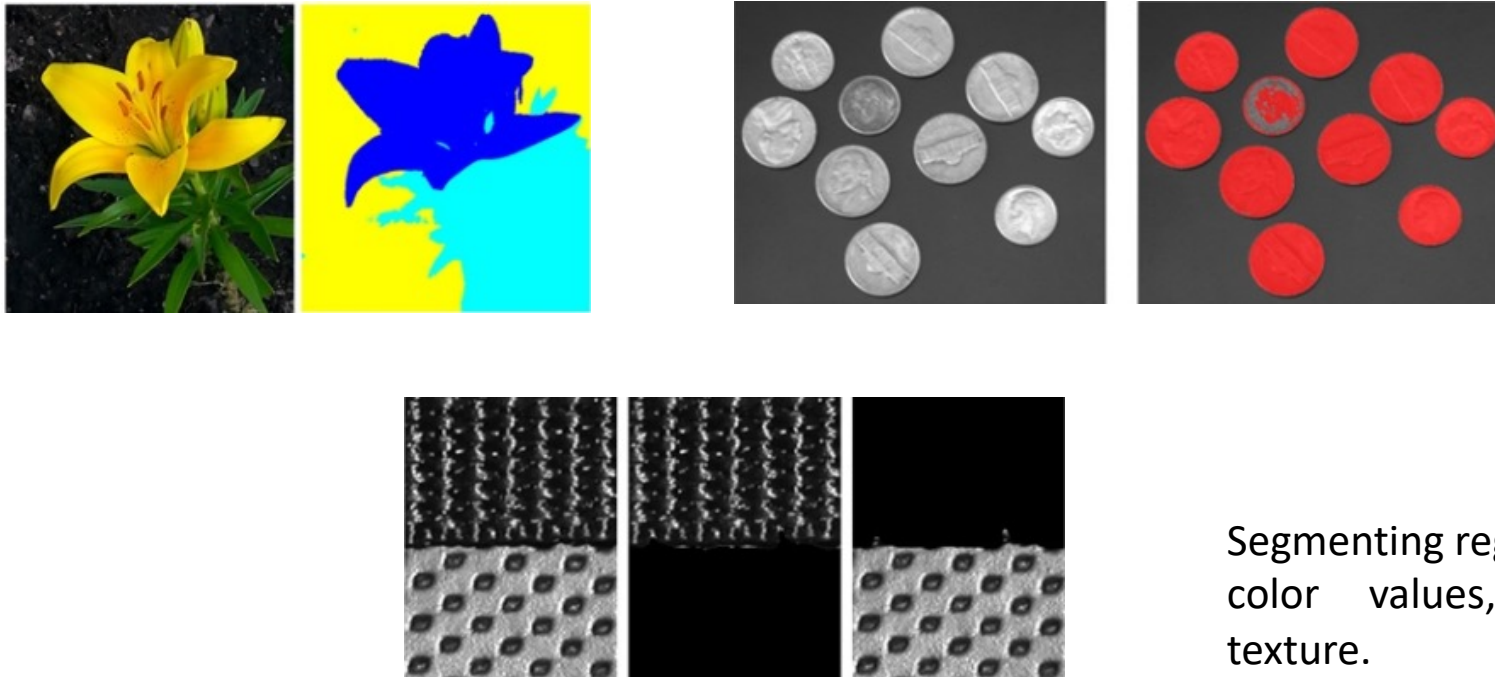
- Partition image into its constituent parts or objects
 - Eg: detecting tumors, detecting missing components in electronic board or broken connections



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Fundamental Steps in Digital Image Processing

Segmentation



Segmenting regions based on color values, shapes, or texture.

Image Courtesy: <https://in.mathworks.com/discovery/image-segmentation.html>



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Fundamental Steps in Digital Image Processing

Feature Extraction

- Almost always follows the output of a segmentation stage
- Converting data to a form suitable for computer processing
- Feature extraction (extracting information of interest)

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Fundamental Steps in Digital Image Processing

Object Recognition

- Recognition is a process that assigns a label to an object based on its descriptors
- Deals with development of methods for recognition of individual objects

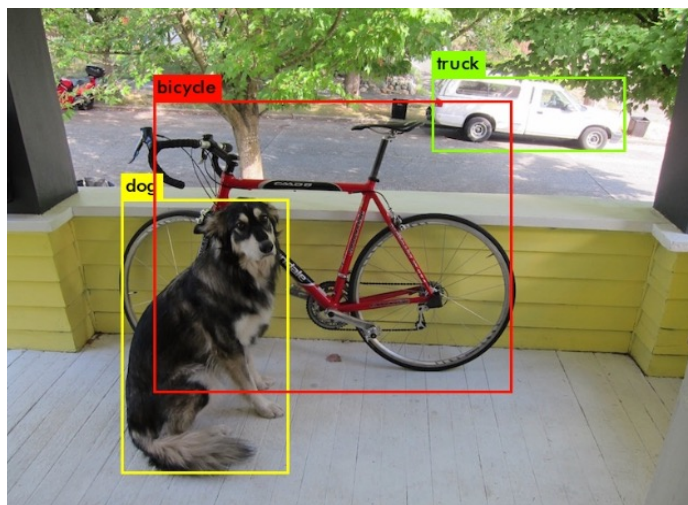
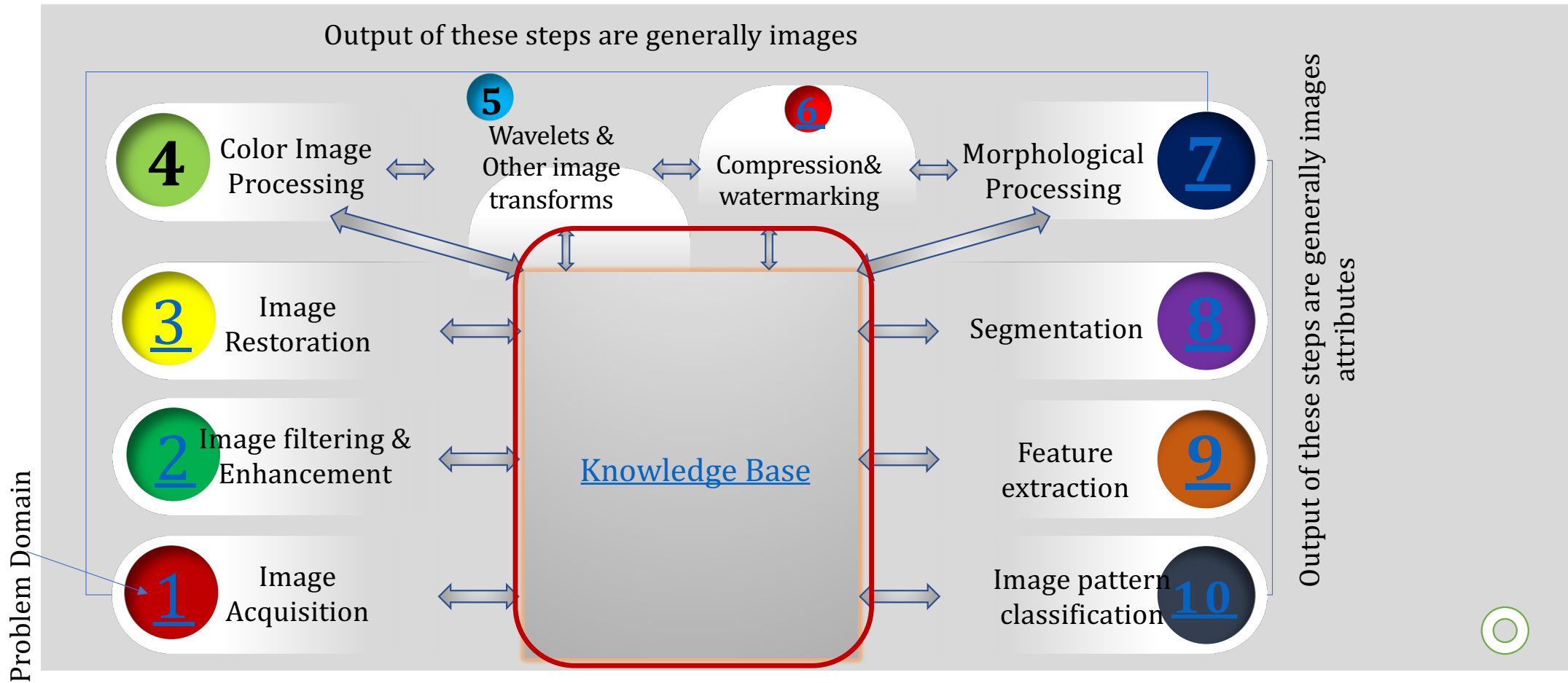


Image courtesy: <https://pjreddie.com/darknet/yolo/>



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Fundamental Steps in Digital Image Processing



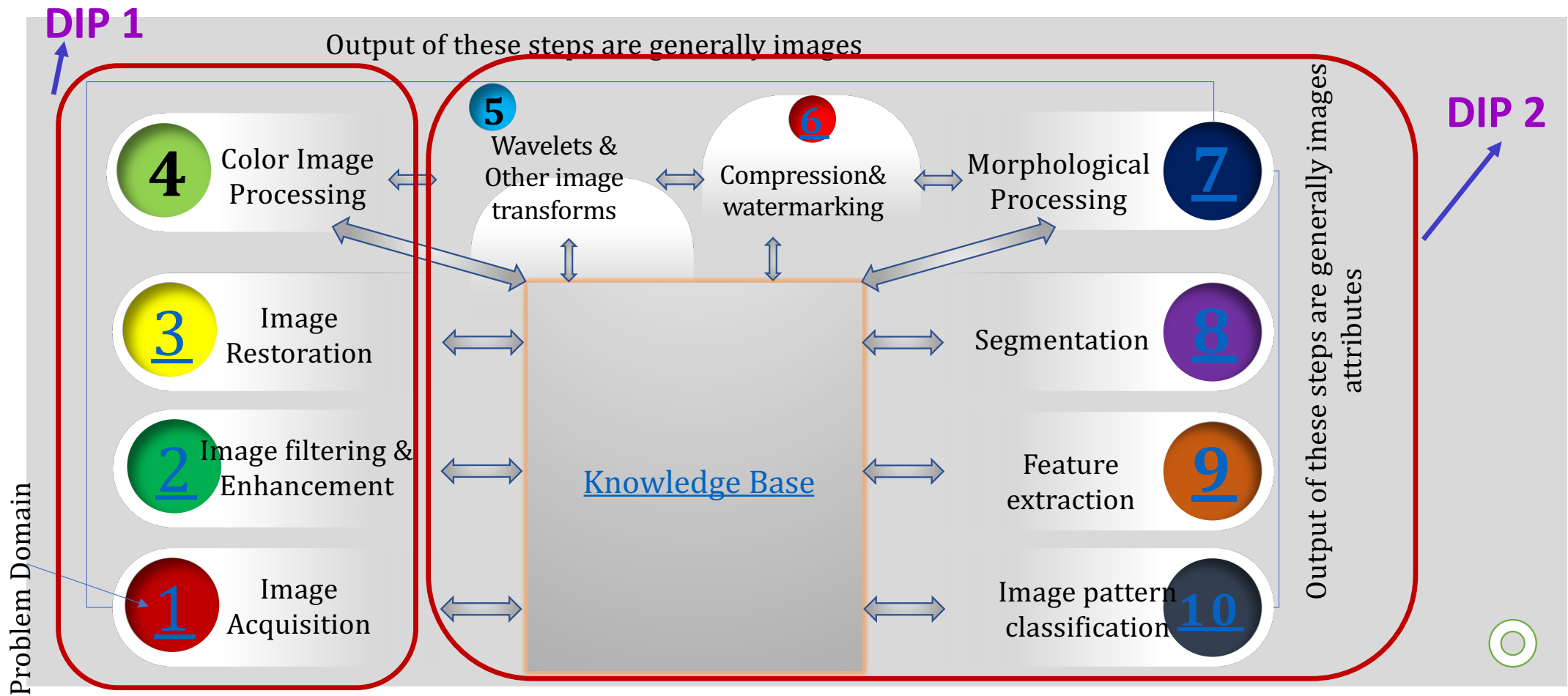
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Knowledge Base

- Need of prior knowledge about a problem domain
 - Eg: Knowledge base can be list of all possible defects in material inspection problem
- There has to be two way interaction between knowledge base and processing modules
- Knowledge about a problem is coded into an image processing system in the form of knowledge database

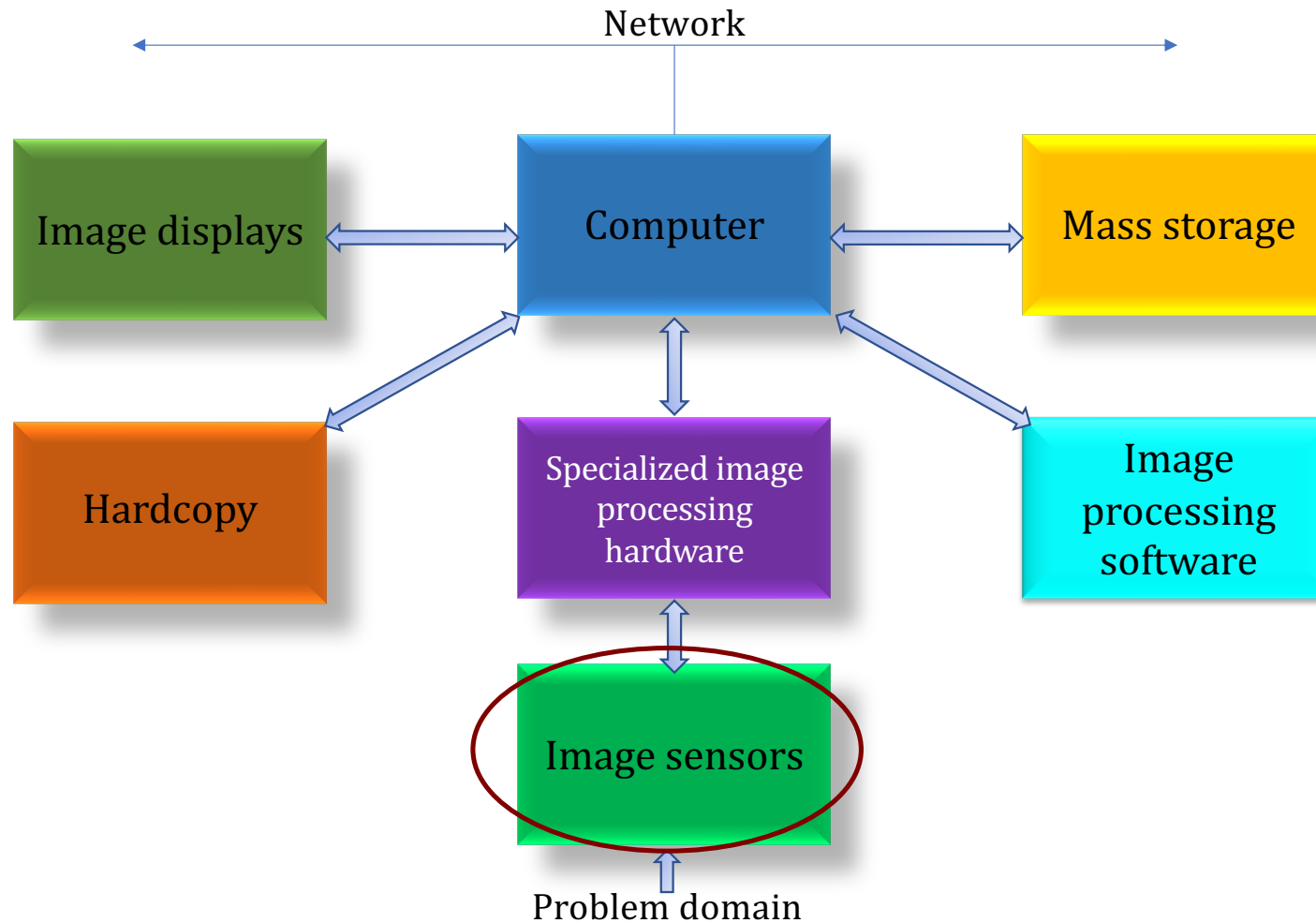
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Fundamental Steps in Digital Image Processing



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Components of an Image Processing System



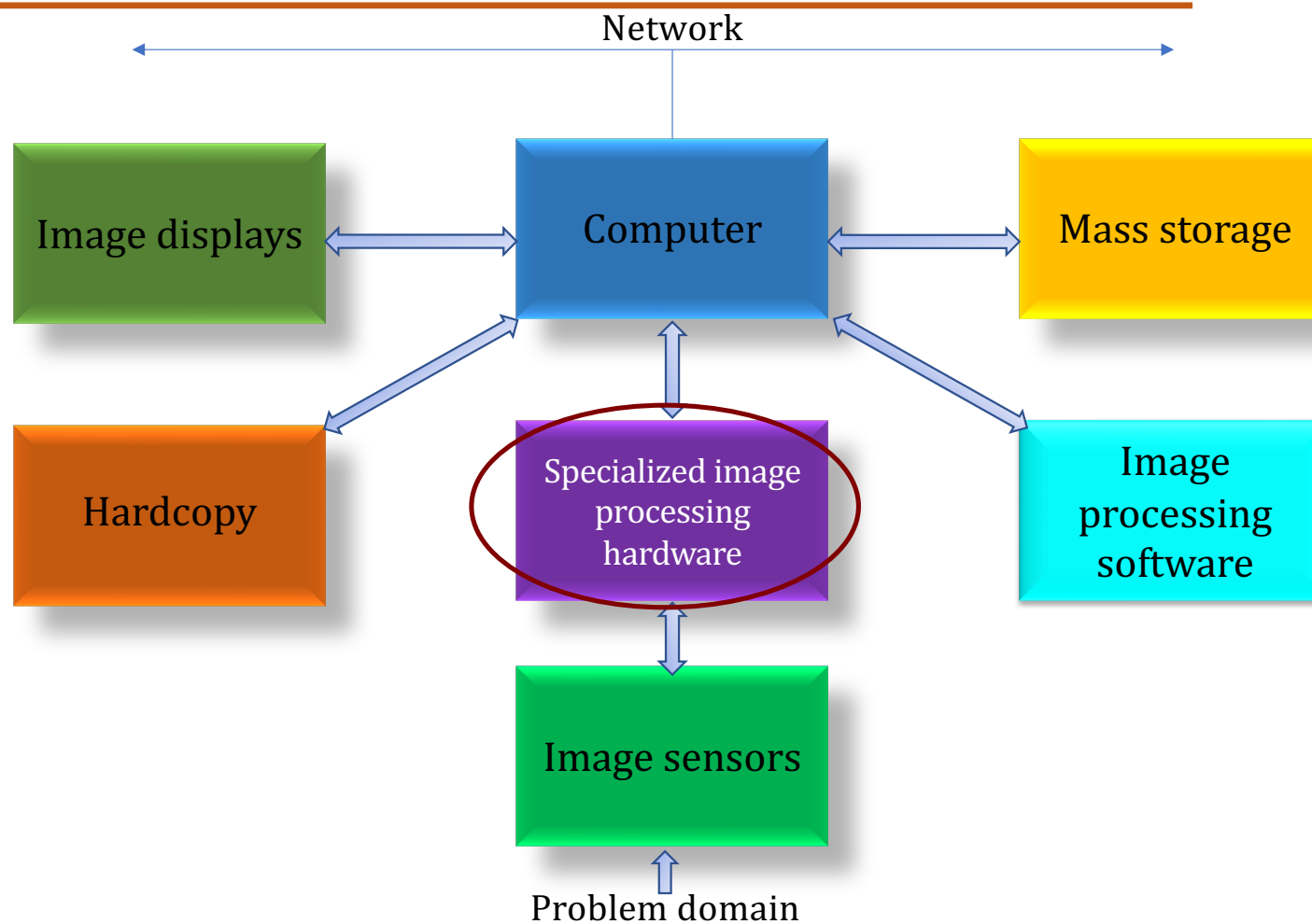
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Image Sensors

- With reference to sensing, two elements are required to acquire digital image.
 - A physical device that is sensitive to the energy radiated by the object we wish to image

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Components of an Image Processing System



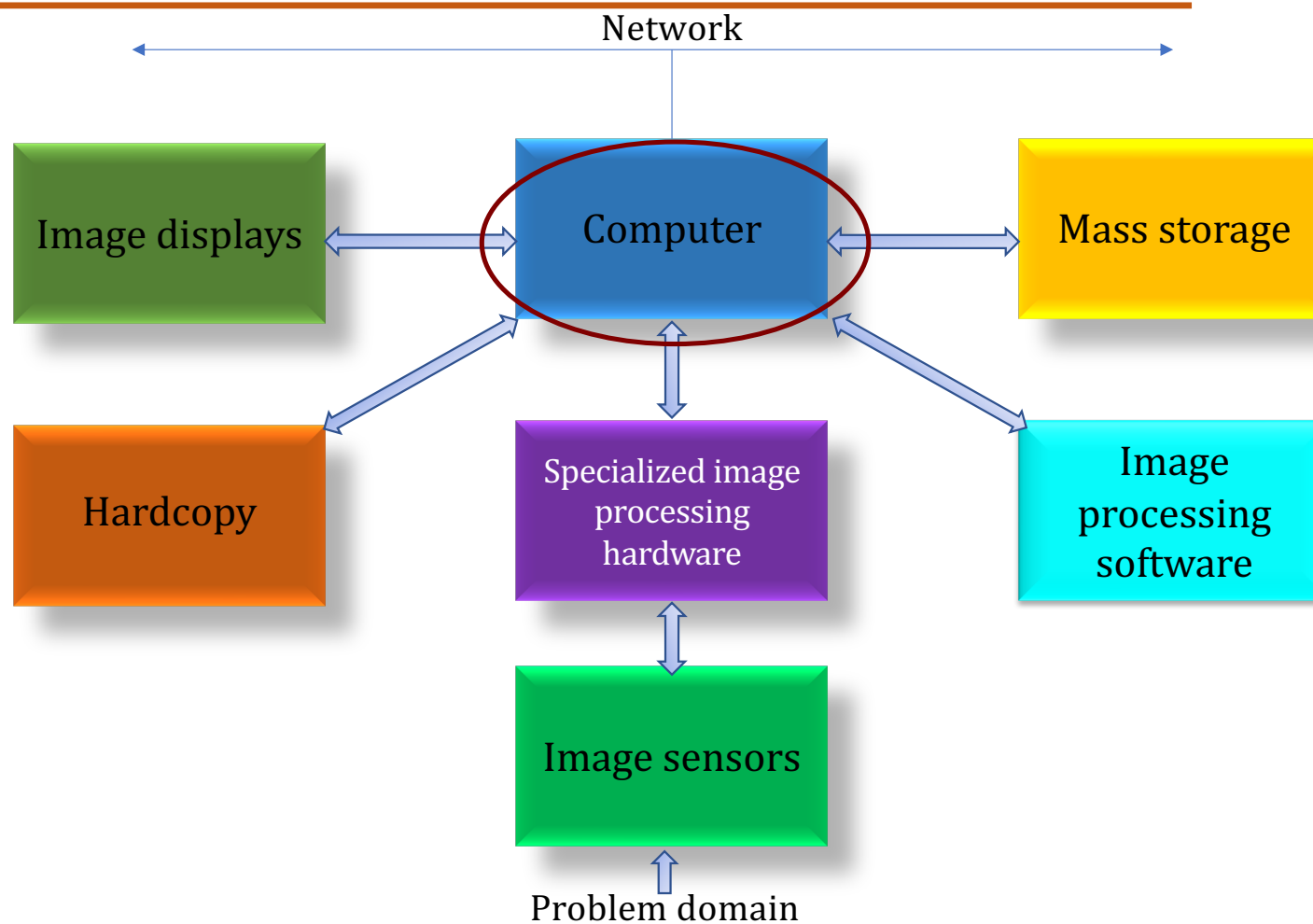
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Specialized Image Processing Hardware

- It consists of
 - **The digitizer:** A device for converting the output of the physical sensing device into digital form.
 - For instance, in a digital video camera, the sensors (CCD chips) produce an electrical output proportional to light intensity. The digitizer converts these outputs to digital data.
 - **Hardware (that performs other primitive operations) such as an arithmetic logic unit(ALU)**
 - which performs arithmetic operations like addition and subtraction and logical operations in parallel on images

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Components of an Image Processing System



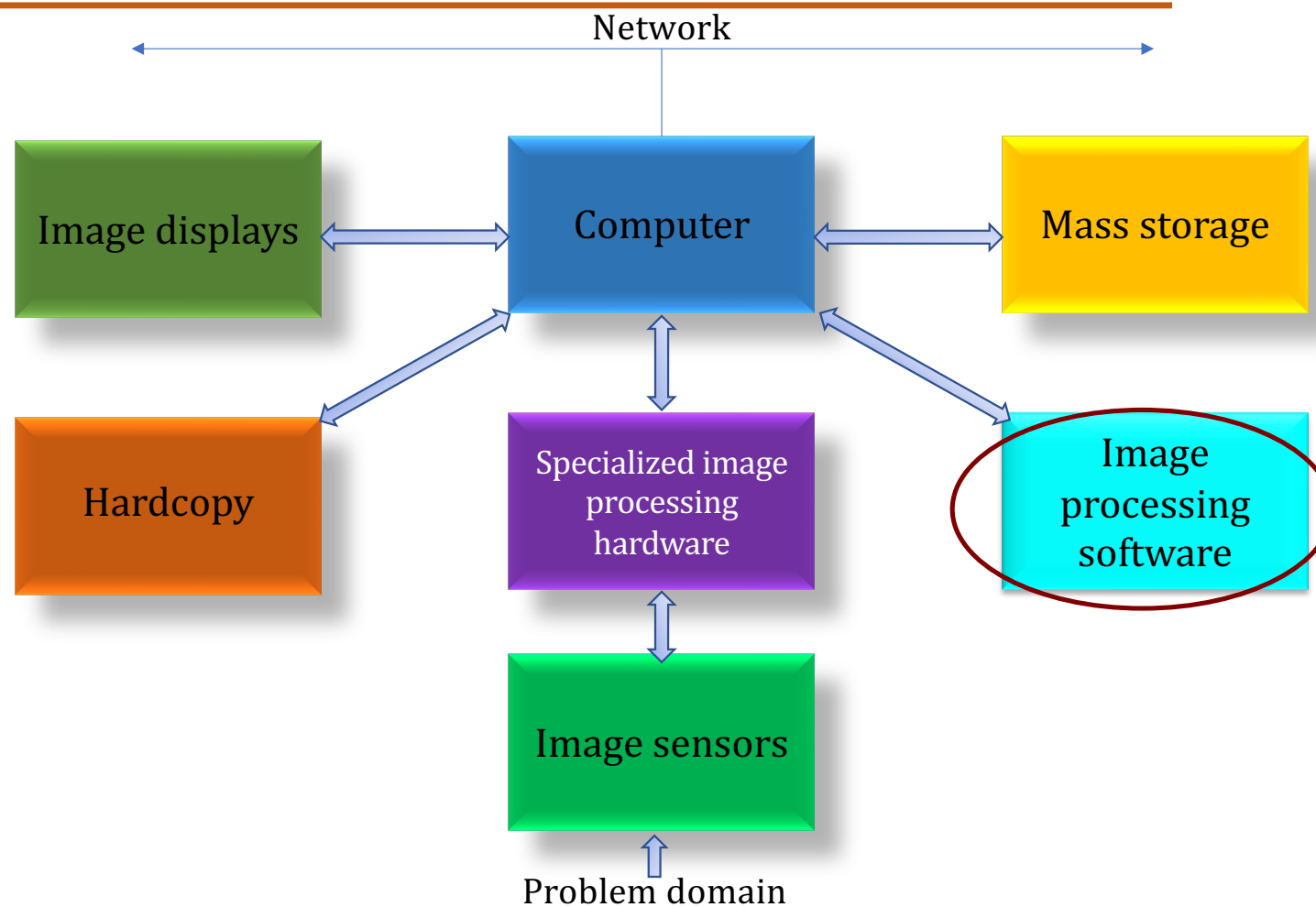
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Computer

- It is a general purpose computer and can range from a PC to a supercomputer depending on the application.
- In dedicated applications, sometimes specially designed computers are used to achieve a required level of performance

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Components of an Image Processing System



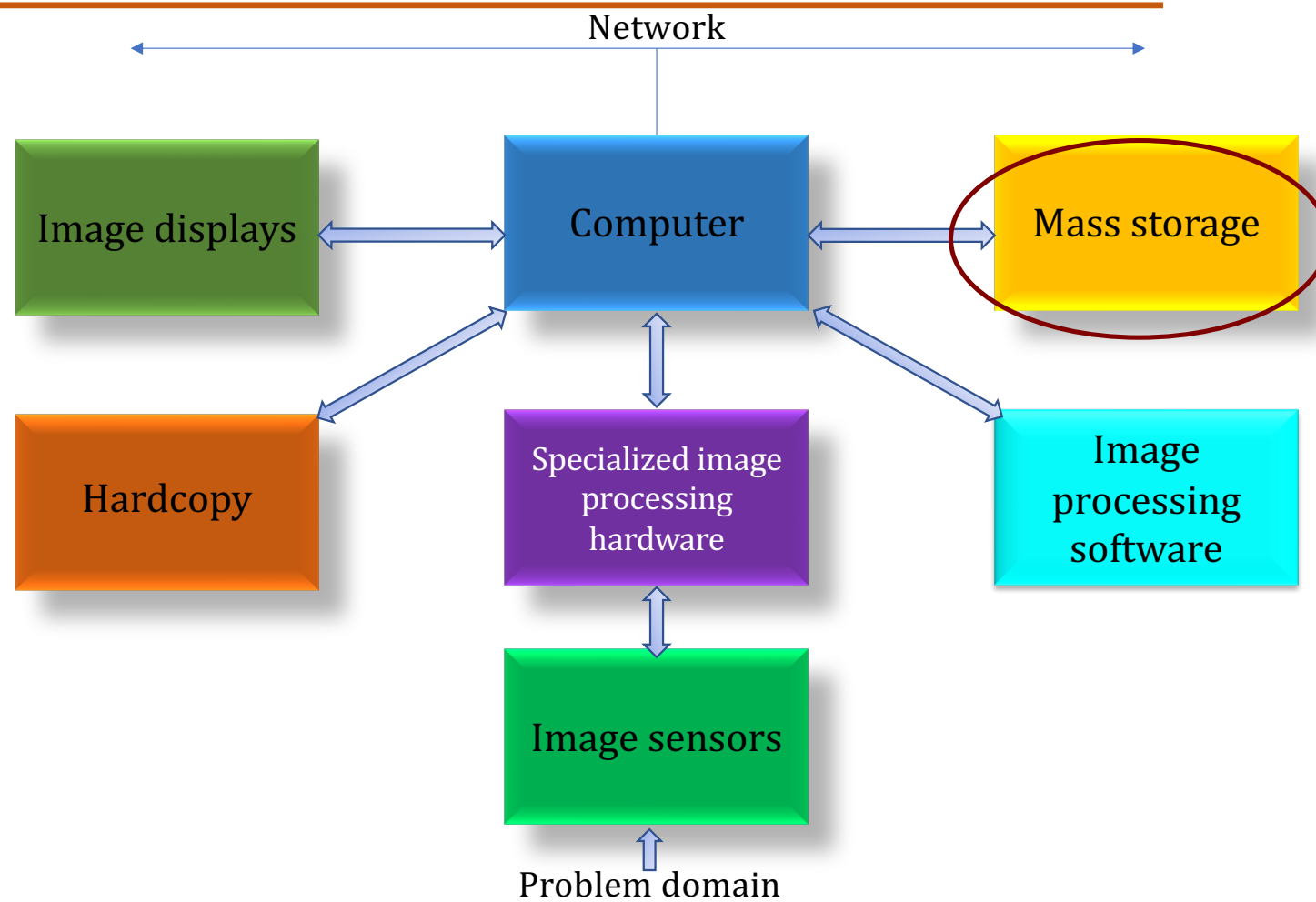
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Image Processing Software

- It consist of specialized modules that perform specific tasks
- A well designed package also includes capability for the user to write code
- More sophisticated software packages allow the integration of these modules.

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Components of an Image Processing System



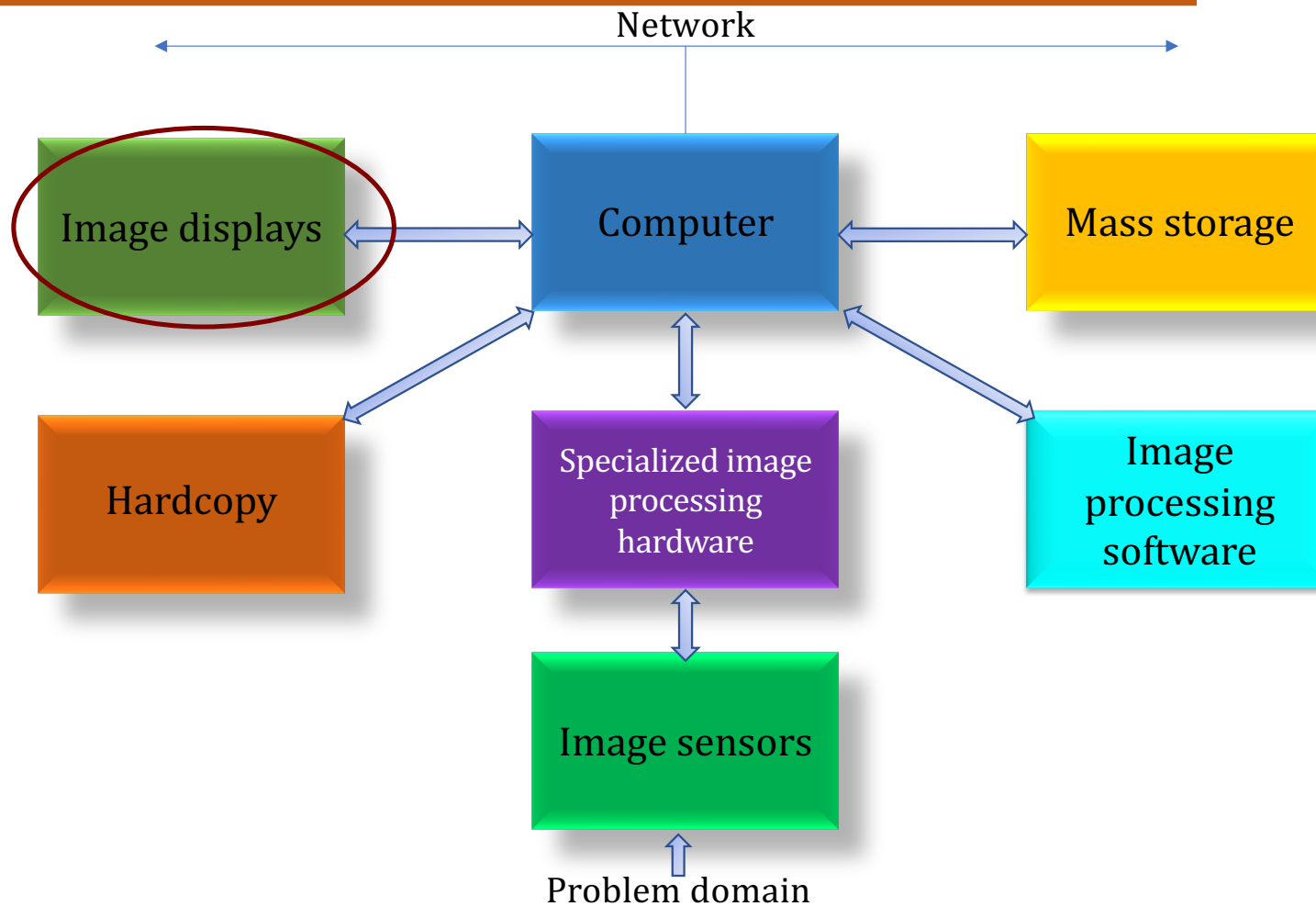
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Mass Storage

- This capability is a must in image processing applications.
 - An image of size 1024x1024 pixels ,in which the intensity of each pixel is an 8- bit quantity requires one megabytes of storage space if the image is not compressed
- Image processing applications fall into three principal categories of storage
 - Short term storage for use during processing
 - On line storage for relatively fast retrieval
 - Archival storage such as magnetic tapes and disks

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Components of an Image Processing System



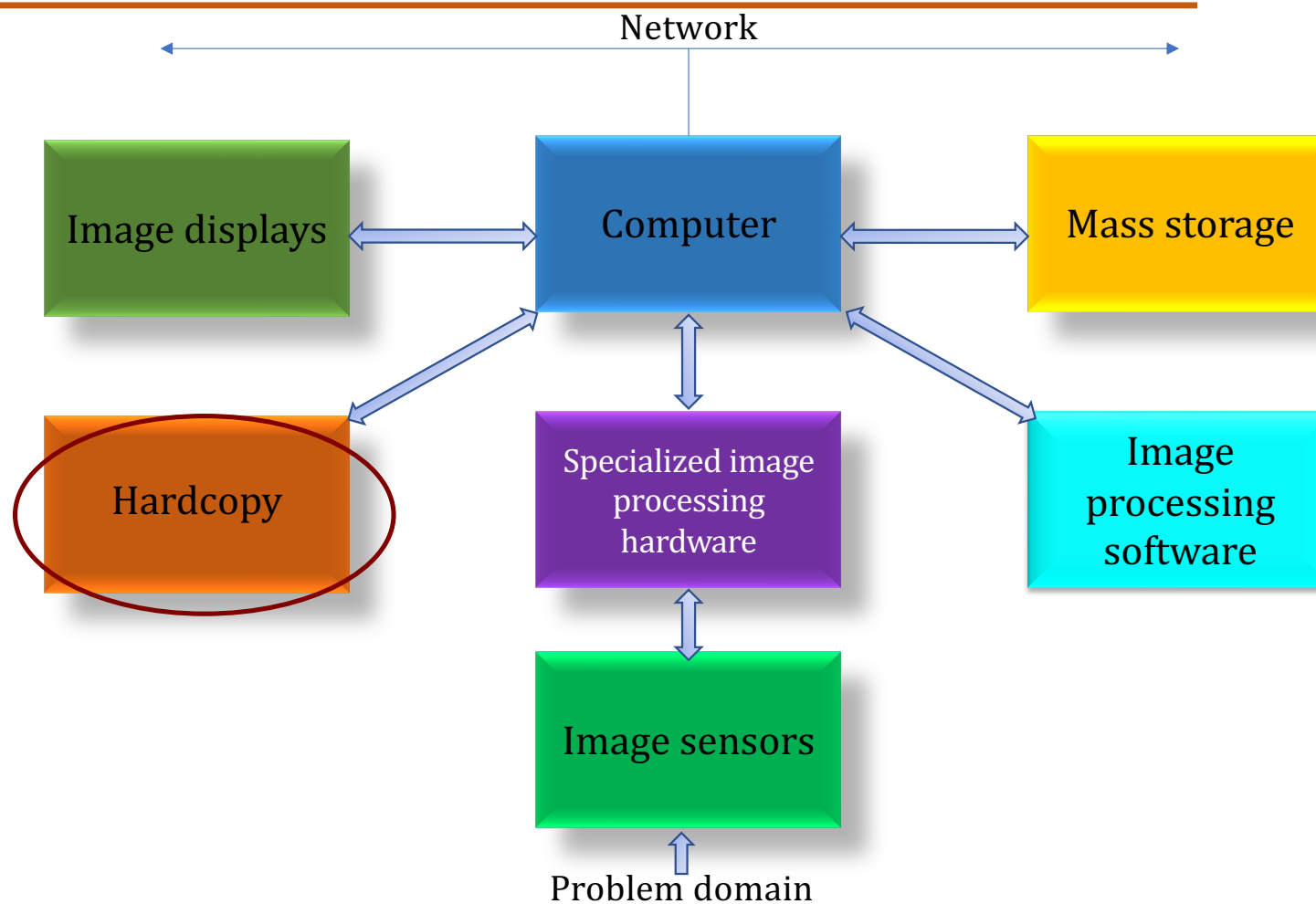
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Image Displays

- Image displays in use today are mainly color TV monitors.
- These monitors are driven by the outputs of image and graphics display cards that are an integral part of computer system

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Components of an Image Processing System



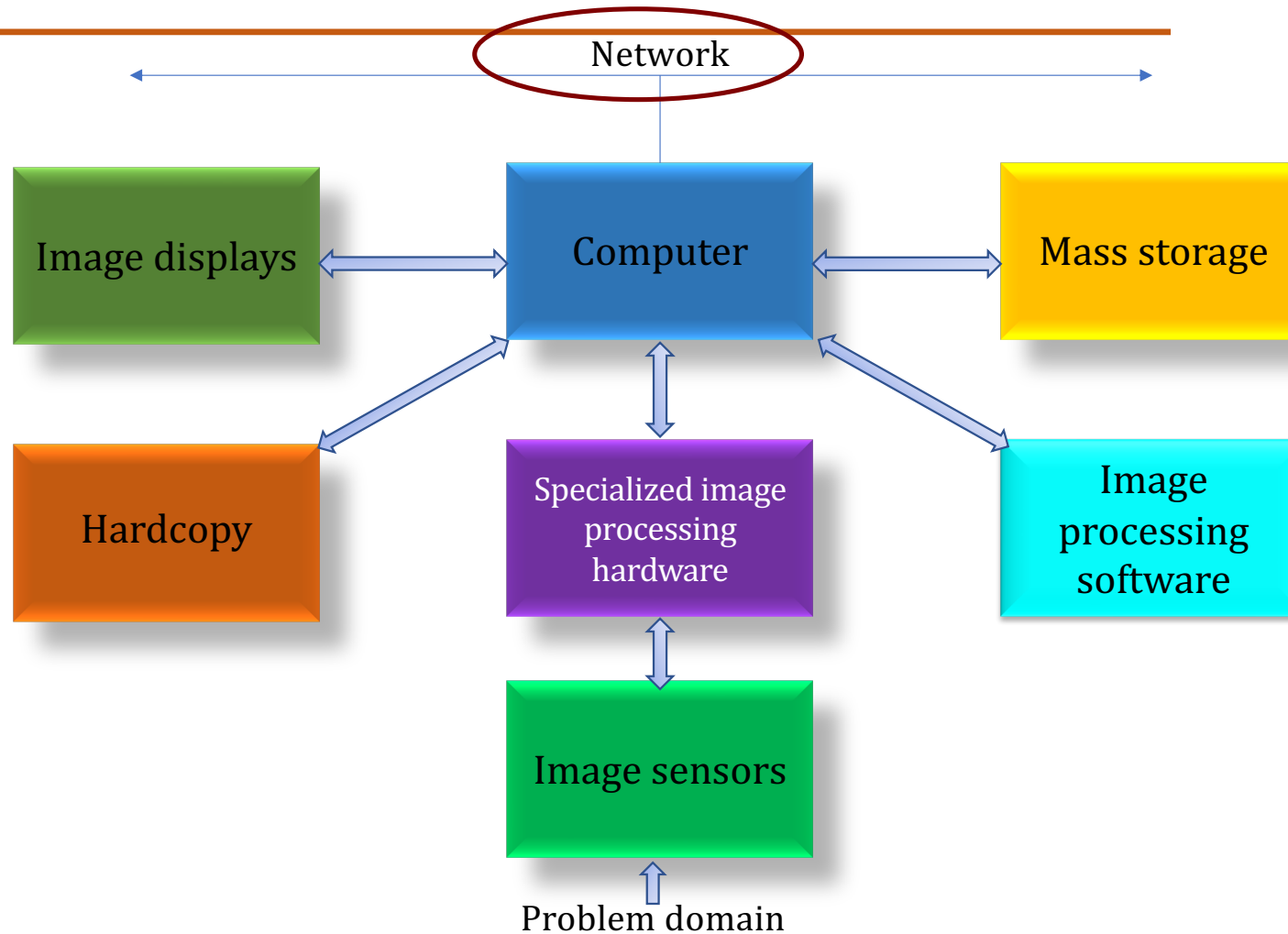
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Hard Copy Devices

- The devices for recording image includes laser printers, film cameras, heat sensitive devices inkjet units and digital units such as optical and CD ROM disk.
 - Films provide the highest possible resolution, but paper is the obvious medium of choice for written applications.

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Components of an Image Processing System



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Network

- It is almost a default function in any computer system in use today because of the large amount of data inherent in image processing applications.
- It is the key consideration in image transmission bandwidth.

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Digital Image Fundamentals

- Digital Image Fundamentals
 - **Elements of visual perception**
 - Image Sensing and acquisition
 - Image Formation Model
 - Image Sampling and Quantization
 - Representation of Digital Image

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Visual Perception

- The elementary mechanics of how images are formed and perceived by humans
- Learning the physical limitations of human vision in terms of factors that also are used in work with digital images.
 - Factors such as how human and electronic imaging devices compare in terms of resolution
 - Their ability to adapt to changes in illumination are important from a practical point of view



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Elements of Visual Perception

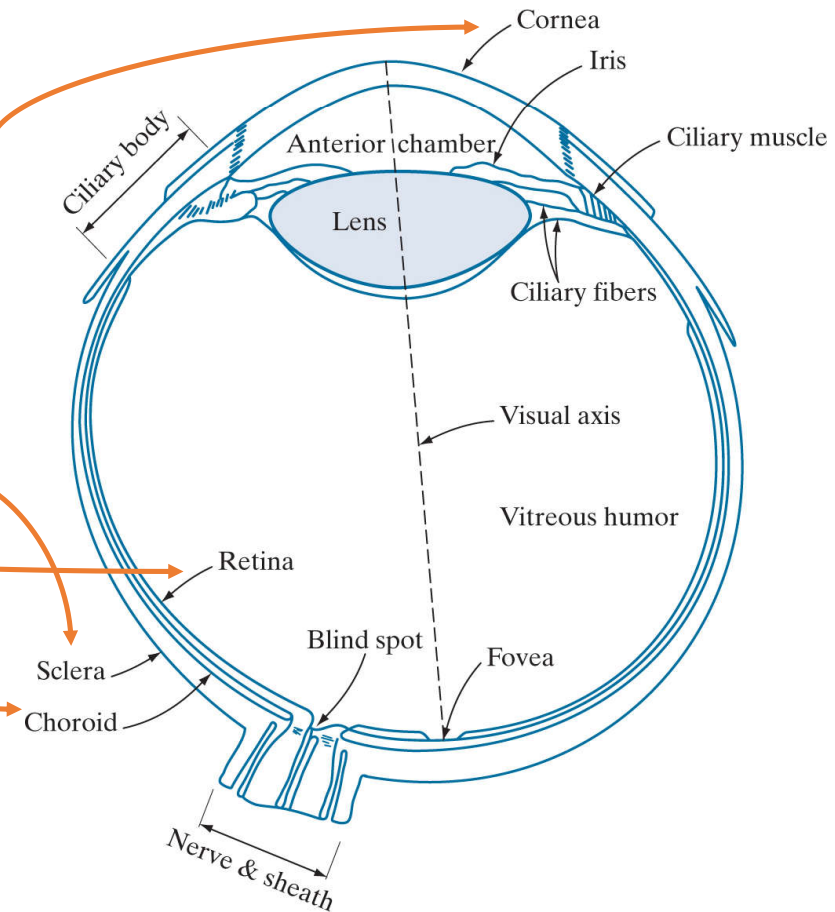
- Structure of the Human eye
- Image formation in the eye
- Brightness adaptation
- Brightness discrimination

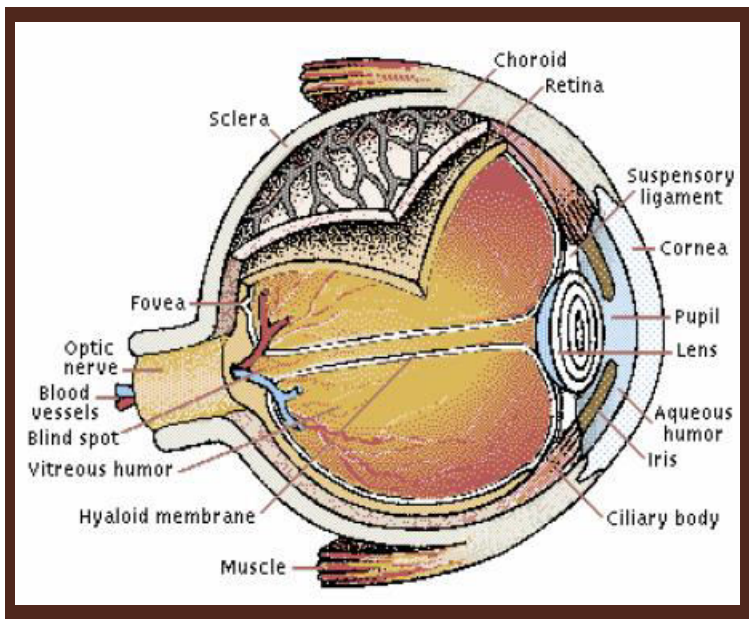


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Structure of the Human Eye

- Three membranes enclose the eye
 - Outer cover: Cornea and Sclera
 - Choroid
 - Retina (innermost membrane)





- The amount of light entering the eye is controlled by the pupil, which dilates and contracts accordingly.
- The cornea and lens, whose shape is adjusted by the ciliary body, focuses the light on retina, where receptors convert it into nerve signals that pass to brain

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Elements of Visual Perception

- Structure of the Human eye
- Image formation in the eye
- Brightness adaptation
- Brightness discrimination

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Image Formation

- When eye is properly focused, light from an object outside is imaged on the retina
- Pattern light is formed by distribution of discrete light receptors over surface of retina
- Two classes of receptors:
 - Cones and Rods

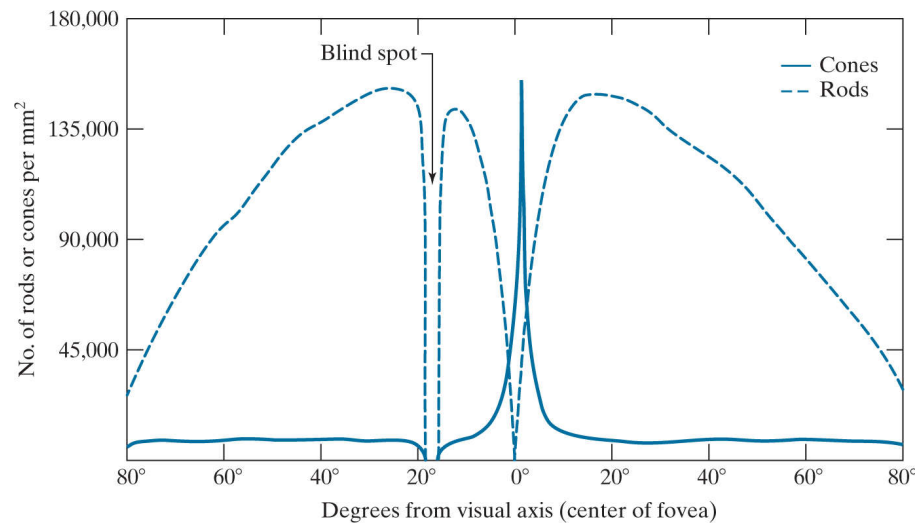
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Elements

- Cones:
 - 6-7 million in each eye
 - Photonic or bright-light vision
 - Highly sensitive to color
- Rods:
 - 75-150 million
 - Not involved in color vision
 - Sensitive to low level illumination
(scotopic or dim-light vision)
- An object appears brightly colored in daylight will be seen colorless in moonlight(why)?

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Cross Section of the Eye



- Blind spot → the absence of receptors area
- Receptor density is measured in degrees from the fovea
- Cones are most dense in the center of the retina (in the area of the fovea)
- Rods increase in density from the center out to approx. 20° off axis & then decrease in density out to the extreme periphery of the retina

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Image Formation in the Eye

- **Focal Length:** Distance between center of lens and retina.
 - Vary between 14-17 mm
- When the eye focuses on a nearby object, lens strongly refracts.

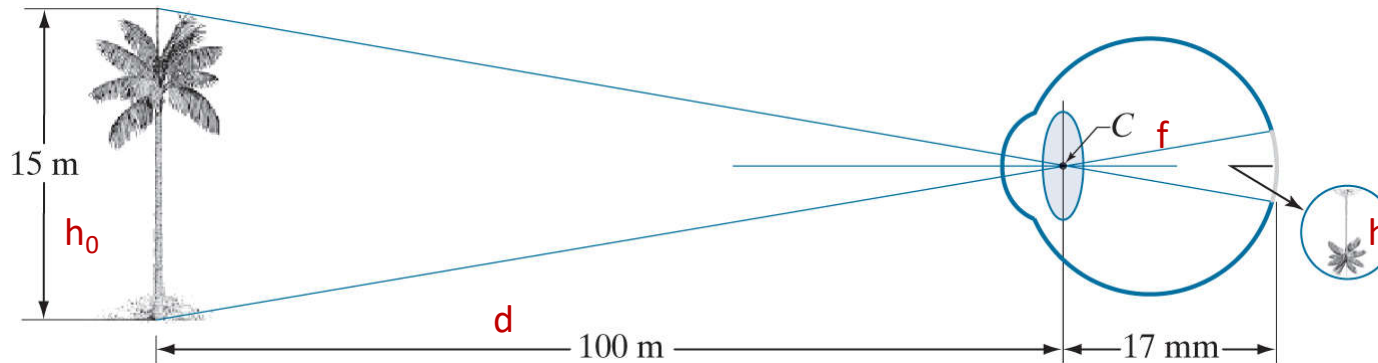


FIGURE 2.3

Graphical representation of the eye looking at a palm tree. Point C is the focal center of the lens.

$$\frac{15}{100} = \frac{h}{17}$$

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Next Session

- Digital Image Fundamentals
 - Elements of visual perception Cont...
 - Image Sensing and acquisition
 - Image Formation Model
 - Image Sampling and Quantization
 - Representation of Digital Image

DIGITAL IMAGE PROCESSING-1

Next Session

- Image Sampling and Quantization
- Representation of Digital Image



THANK YOU

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