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.

Image Concepts

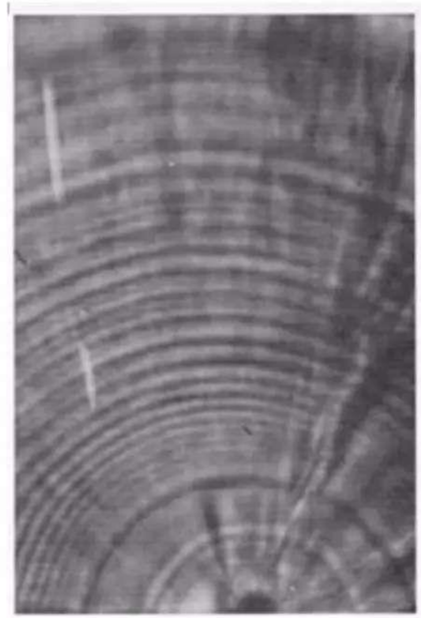
- An image is a function of intensity values over a 2D plane *I(r,s)*
- Sample function at discrete intervals to represent an image in digital form
  - matrix of intensity values for each color plane
  - intensity typically represented with 8 bits
- Sample points are called pixels

Digital Images

- Samples = pixels
- Quantization = number of bits per pixel
- Example: if we would sample and quantize standard TV picture (525 lines) by using VGA (Video Graphics Array), video controller creates matrix 640x480pixels, and each pixel is represented by 8 bit integer (256 discrete gray levels)

Image Representations

- Black and white image
  - single color plane with 2 bits
- Grey scale image
  - single color plane with 8 bits
- Color image
  - three color planes each with 8 bits
  - RGB, CMY, YIQ, etc.
- Indexed color image
  - single plane that indexes a color table
- Compressed images
  - TIFF, JPEG, BMP, etc.



4 gray levels

2gray levels

Digital Image Representation (3 Bit Quantization)

111	111	011	011	011	011	111	111
111	011	111	111	111	111	011	111
000	111	001	111	111	001	111	000
010	111	111	111	111	111	111	010
000	111	100	111	111	100	111	000
000	111	111	100	100	111	111	000
111	000	111	111	111	111	000	111
111	111	000	000	000	000	111	111

Digital Image Processing

DIP Definition:

A Discipline in Which Both the Input and Output of a Process are Images.

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.

What is Digital Image...?

- An Image:

$$g(x, y)$$

Discretization

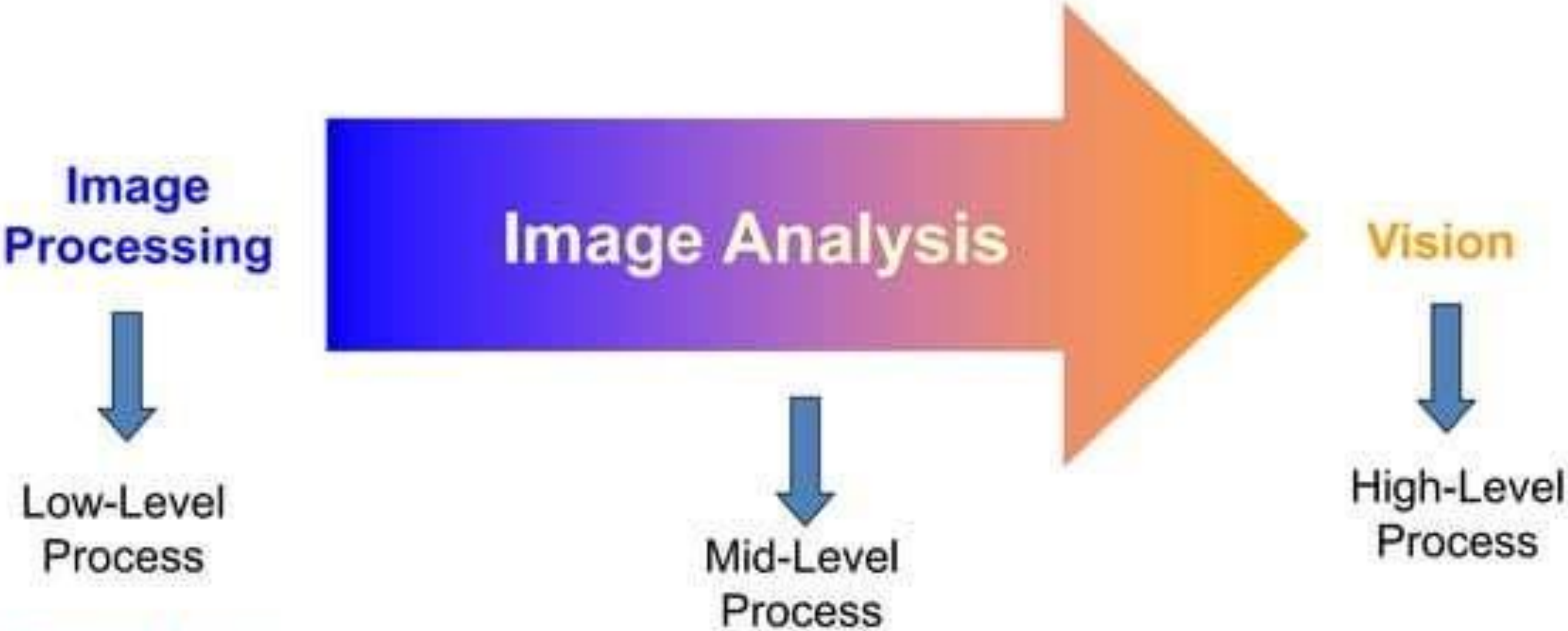
$$g(i, j)$$

Quantization

$f(i, j)$ Digital Image

$f(i_0, j_0)$: Picture Element, Image Element, Pel, Pixel

Digital Image Processing



- Reduce Noise
- Contrast Enhancement
- Image Sharpening

- Segmentation
- Classification

Making Sense of an Ensemble of Recognized Objects

Pixel and Resolution

- **Pixel (Picture Element):** A pixel is the smallest part of a computer picture. It shows one spot in the whole photo. Every little square has information about **color, brightness** and **position**. When these squares are put together with others they make a complete picture that we can see. Pixels are the parts that make up digital screens. They arrange together to show letters, pictures and videos.

Resolution

- Image resolution refers to the number of pixel(picture element) that make up an Image. The resolution usually expressed as the number of pixel per unit of length.
- Higher resolution result in more detailed and sharper image , while lower resolution may appear blurry or pixelated.
- It's usually measured by width and height size. Using more details gives better results in pictures. **Usual measurements for resolution are** **pixels per inch (PPI)** for pictures that get printed and pixels per centimeter (PPCM

JPEG, GIF, and PNG

- **JPEG**: Joint Photographic Experts Group
- **GIF**: Graphics Interchange Format
- **PNG**: Portable Network Graphics
- BMP (Bitmap)
- TIFF (or TIF, for the file extension; Tagged Image File Format)

JPEG and PNG

JPEG

- A common format for web images and Microsoft Office documents. JPEGs use "lossy" compression, which means that the image quality decreases as the file size decreases.

PNG

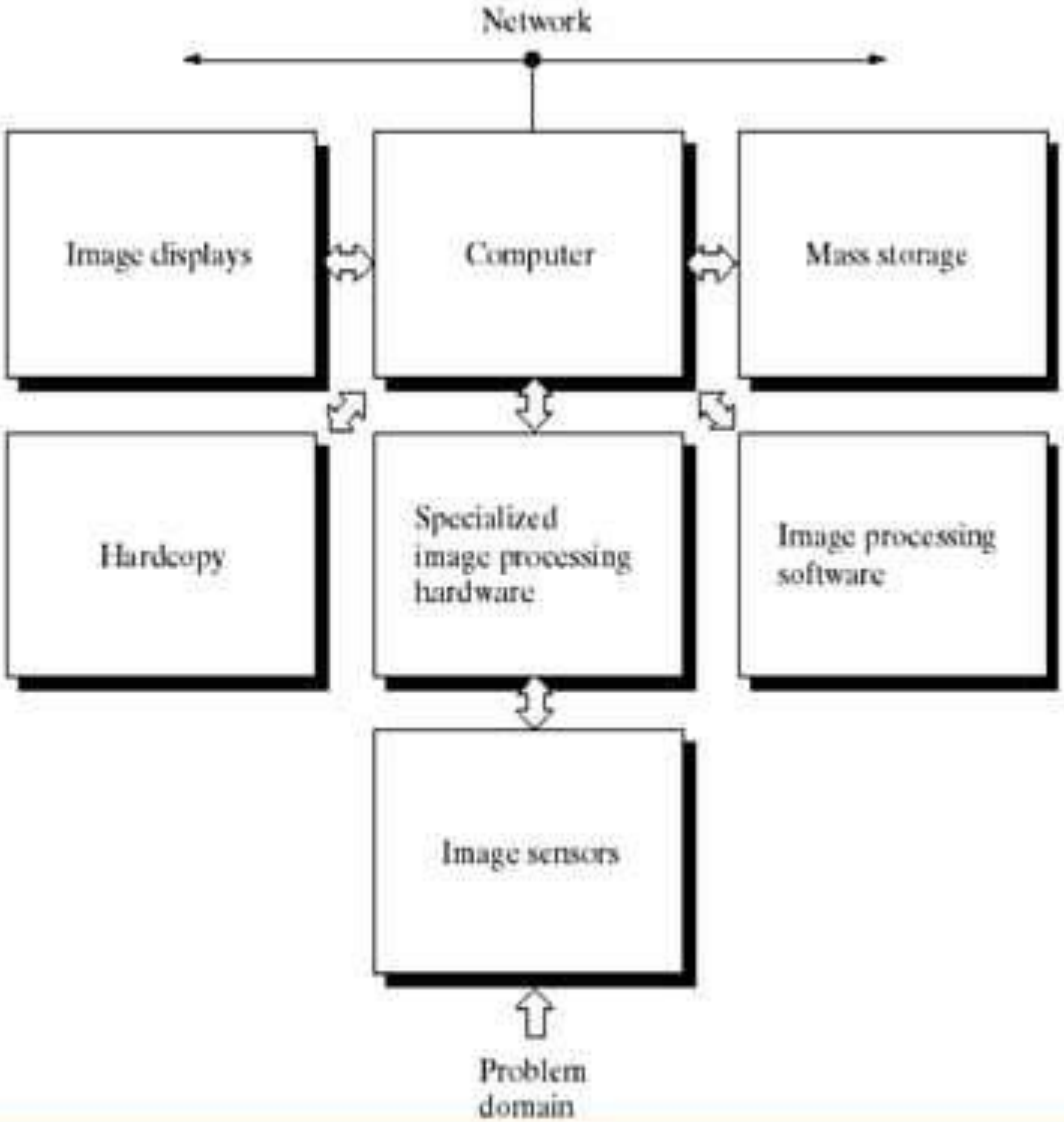
- A format for photos and pictures that need a transparent background or animations. PNGs use "lossless" compression, which means that the image quality is the same before and after compression.

GIF

- A format that can reduce the size of images and short animations. GIF is the only format that supports animation, making it suitable for ads, banners, and memes.

Components of Digital Image Processing

Components of DIP



Components of DIP

- ***<u>Specialized image processing hardware</u>*** usually consists of the digitizer, plus hardware that performs other primitive operations, such as an arithmetic logic unit (ALU), that performs arithmetic and logical operations in parallel on entire images.

- This type of hardware sometimes is called a *front-end subsystem*, and its most distinguishing characteristic is speed.

Components of DIP

- The ***Computer*** in an image processing system is a general-purpose computer and can range from a PC to a supercomputer.

- In dedicated applications, sometimes custom computers are used to achieve a required level of performance, but our interest here is on general-purpose image processing systems.

- In these systems, almost any well-equipped PC-type machine is suitable for off-line image processing tasks.

Components of DIP

- ***Software*** for image processing consists of specialized modules that perform specific tasks.

- More sophisticated software packages allow the integration of those modules and general-purpose software commands from at least one computer language.

Components of DIP

- ***<u>Mass storage</u>*** capability is a must in image processing applications.
- An image of size 1024 * 1024 pixels, in which the intensity of each pixel is an 8-bit quantity, requires one megabyte of storage space if the image is not compressed.
- Digital storage for image processing applications falls into three principal categories:
  - <u>Short-term storage</u> for use during processing,
  - <u>On-line storage</u> for relatively fast recall, and
  - <u>Archival storage</u>, characterized by infrequent access.
- Storage is measured in:
  - bytes,
  - Kbytes,
  - Mbytes,
  - Gbytes, and
  - Tbytes.

Components of DIP

- ***Image Displays*** in use today are mainly color (preferably flat screen) TV monitors.
- Monitors are driven by the outputs of image and graphics display cards that are an integral part of the computer system.
- In some cases, it is necessary to have stereo displays, and these are implemented in the form of headgear containing two small displays embedded in goggles worn by the user.

Components of DIP

- ***Hardcopy devices*** for recording images include laser printers, film cameras, heat-sensitive devices, inkjet units, and digital units, such as optical and CDROM disks.

- ***Networking*** is almost a default function in any computer system in use today.

  In dedicated networks, this typically is not a problem, but communications with remote sites via the Internet are not always as efficient.

Application Areas of Digital Image Processing

Application Areas of DIP

- Today, there is almost no area of technical endeavor that is not impacted in some way by digital image processing.

- Gamma-Ray Imaging
- X-Ray Imaging
- Imaging in the Ultraviolet Band
- Imaging in the Visible and Infrared Bands
- Imaging in the Microwave Band
- Imaging in the Radio Band

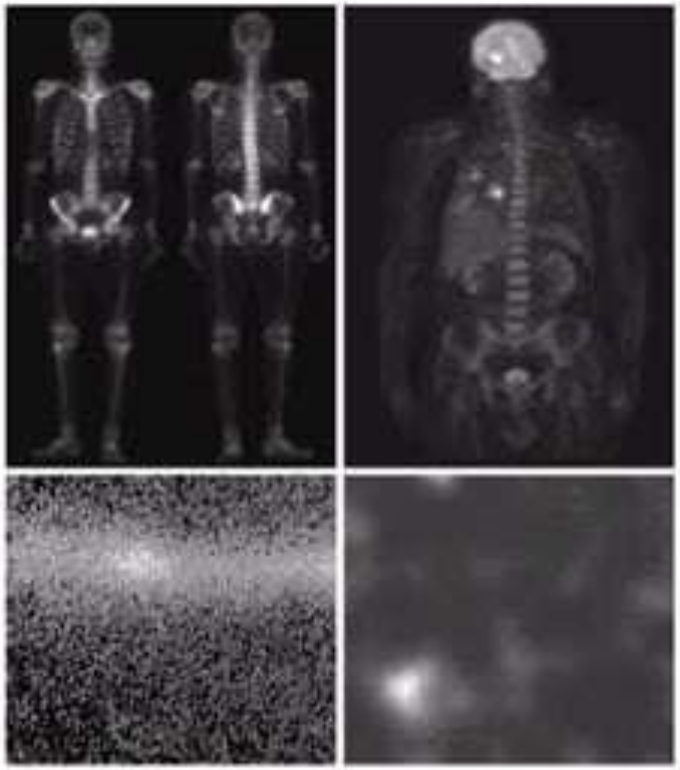
Application Areas of DIP

- **Gamma-Ray Imaging**
- Major uses of imaging based on gamma rays include nuclear medicine.
- In nuclear medicine, the approach is to inject a patient with a radioactive isotope that emits gamma rays as it decays.
- Images are produced from the emissions collected by gamma ray detectors.

Application Areas of DIP

- **Gamma-Ray Imaging**
- Bone Scan: Images of this sort are used to locate sites of bone pathology, such as infections or tumors.
- PET: Positron Emission Tomography: The patient is given a radioactive isotope that emits positrons. When a positron meets an electron, both are annihilated and two gamma rays are given off.
- Cygnus Loop: superheated stationary gas cloud
- Reactor Valve: Image of gamma radiation from a valve in a nuclear reactor. An area of strong radiation is seen in the lower left side of the image.

Bone scan PET



Cygnus loop Reactor valve

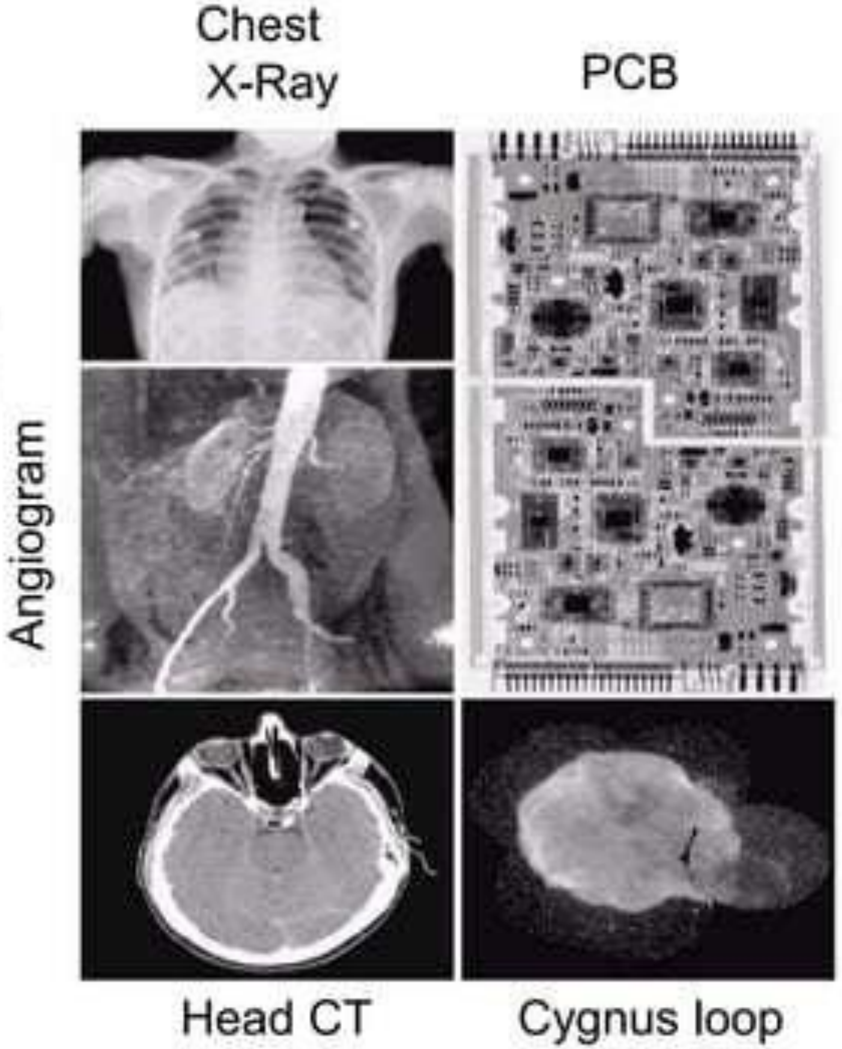
Application Areas of DIP

- **X-Ray Imaging:**

- X-rays are oldest source of EM radiation used for imaging.
- X-rays are used in medical diagnostics, industry and other areas, like astronomy.
- X-rays for medical and industrial imaging are generated using an X-ray tube. The cathode is heated, causing free electrons to be released. These electrons flow at high speed to the positively charged anode. When the electrons strike a nucleus, energy is released in the form of X-ray radiation.
- The energy (penetrating power) of X-rays is controlled by a voltage applied across the anode and by a current applied to the filament in the cathode.

Application Areas of DIP

- **X-Ray Imaging**
- Chest X-ray: generated by placing the patient between an X-ray source and a film sensitive to X-ray energy.
- Angiography: It is another major application in contrast enhancement radiography. This procedure is used to obtain images (called *angiograms) of blood vessels.*
- CAT: Computerized Axial Tomography
- PCB: X-rays are used to examine circuit boards for flaws in manufacturing, like missing components or broken traces.
- Cygnus Loop: X-ray imaging in astronomy



Application Areas of DIP

- **Imaging in the Ultraviolet Band**
- Ultraviolet light is used in fluorescence microscopy.
- The ultraviolet light is not visible, but when a photon of ultraviolet collides with an electron of a fluorescent material, it elevates the electron to a higher energy level.
- Excited electron relaxes to a lower level and emits light in the form of a lower-energy photon in the visible (red) light region.
- Thus, only the emission light reaches the eye or other detector.
- The resulting fluorescing areas shine against a dark background with sufficient contrast to permit detection.

Application Areas of DIP

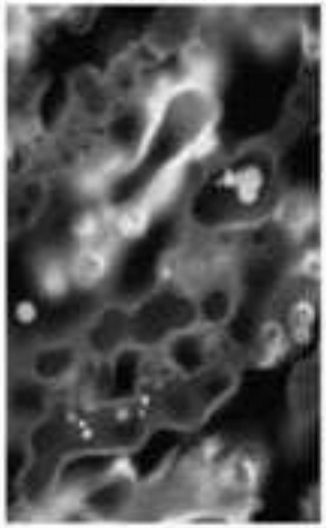
- **Imaging in the Ultraviolet Band**

- Normal Corn: fluorescence microscope image of normal corn

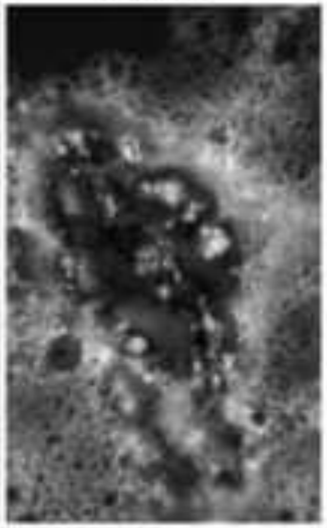
- Smut Corn: corn infected by “smut,” a disease of cereals, corn, grasses, onions, and sorghum that can be caused by any of more than 700 species of parasitic fungi. Corn smut is particularly harmful because corn is one of the principal food sources in the world.

- Cygnus Loop: Image in the high-energy region of the ultraviolet band.

Normal corn



Smut corn



Cygnus Loop

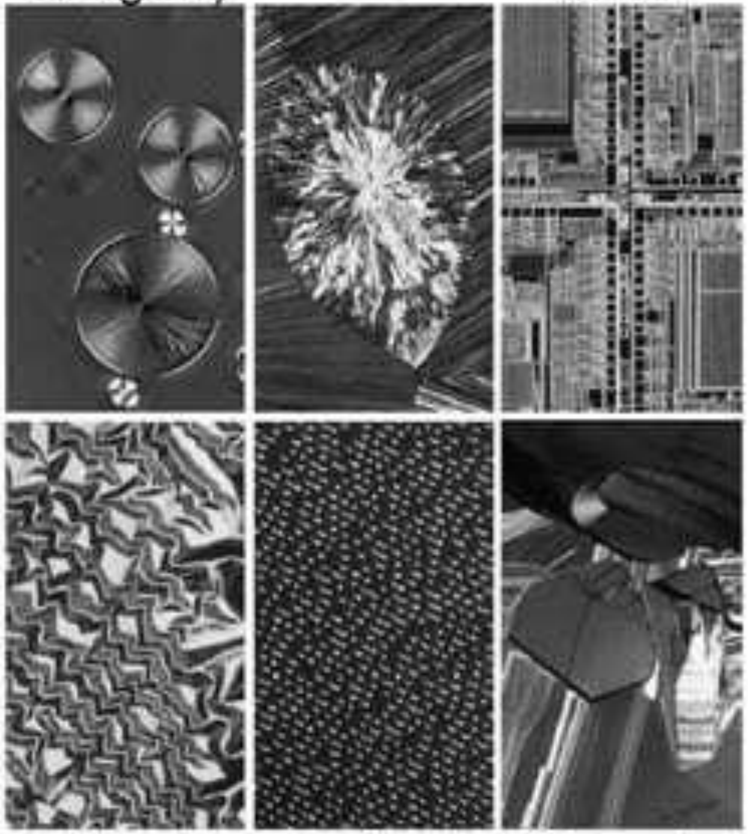
Application Areas of DIP

- **Imaging in the Visible and Infrared Bands:**

- The infrared band often is used in conjunction with visual imaging

- Figure shows several examples of images obtained with a light microscope. The examples range from pharmaceuticals and micro inspection to materials characterization

Taxol (anticancer agent) | Cholesterol | Microprocessor

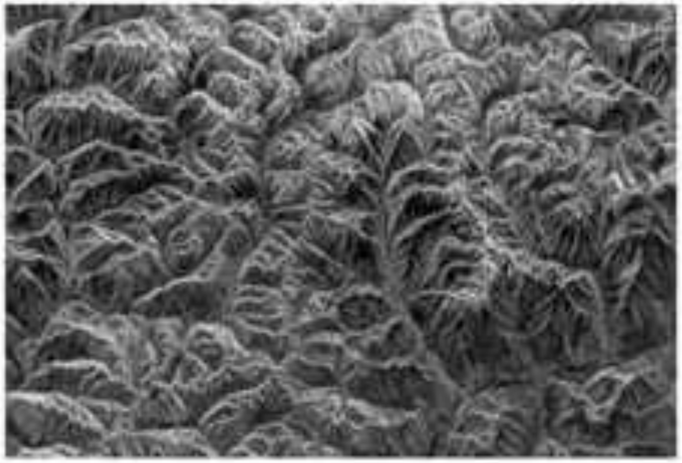


Nickel oxide thin film | Surface of audio CD | Organic superconductor

Application Areas of DIP

- **Imaging in the Microwave Band:**

- The dominant application of imaging in the microwave band is radar. The unique feature of imaging radar is its ability to collect data over virtually any region at any time, regardless of weather or ambient lighting conditions.



Spaceborne radar image of mountains in southeast Tibet. (Courtesy of NASA.)

- Figure shows a spaceborne radar image covering a rugged mountainous area of southeast Tibet. the clarity and detail of the image, unencumbered by clouds or other atmospheric conditions that normally interfere with images in the visual band.

Application Areas of DIP

- **Imaging in the Radio Band:**

- In medicine, radio waves are used in magnetic resonance imaging (MRI).

- This technique places a patient in a powerful magnet and passes radio waves through body in short pulses.

- Each pulse causes a responding pulse of radio waves to be emitted by the patient's tissues.

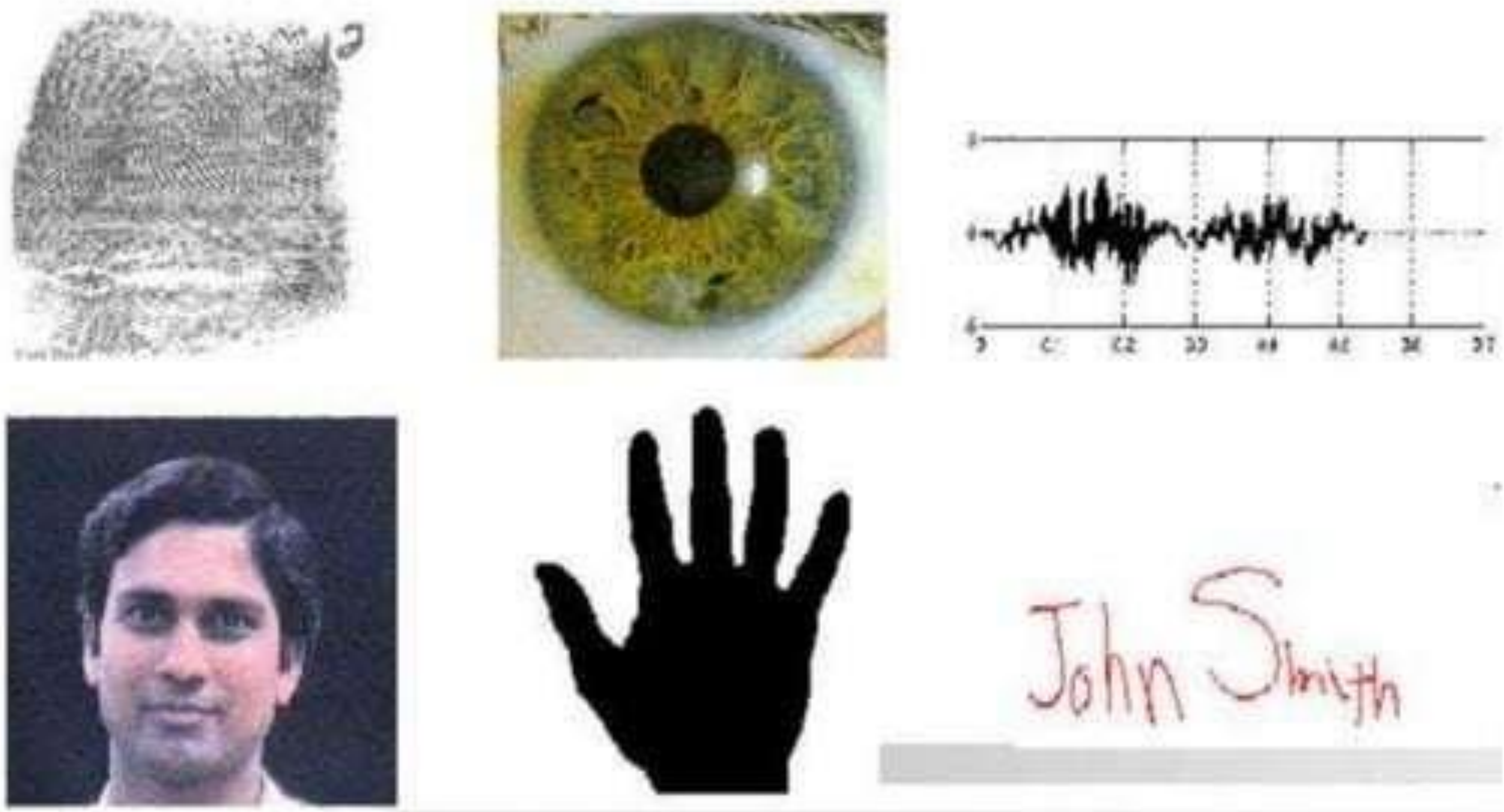
- The location from which these signals originate and their strength are determined by a computer.

MRI images of a human knee

MRI images of a human Spine

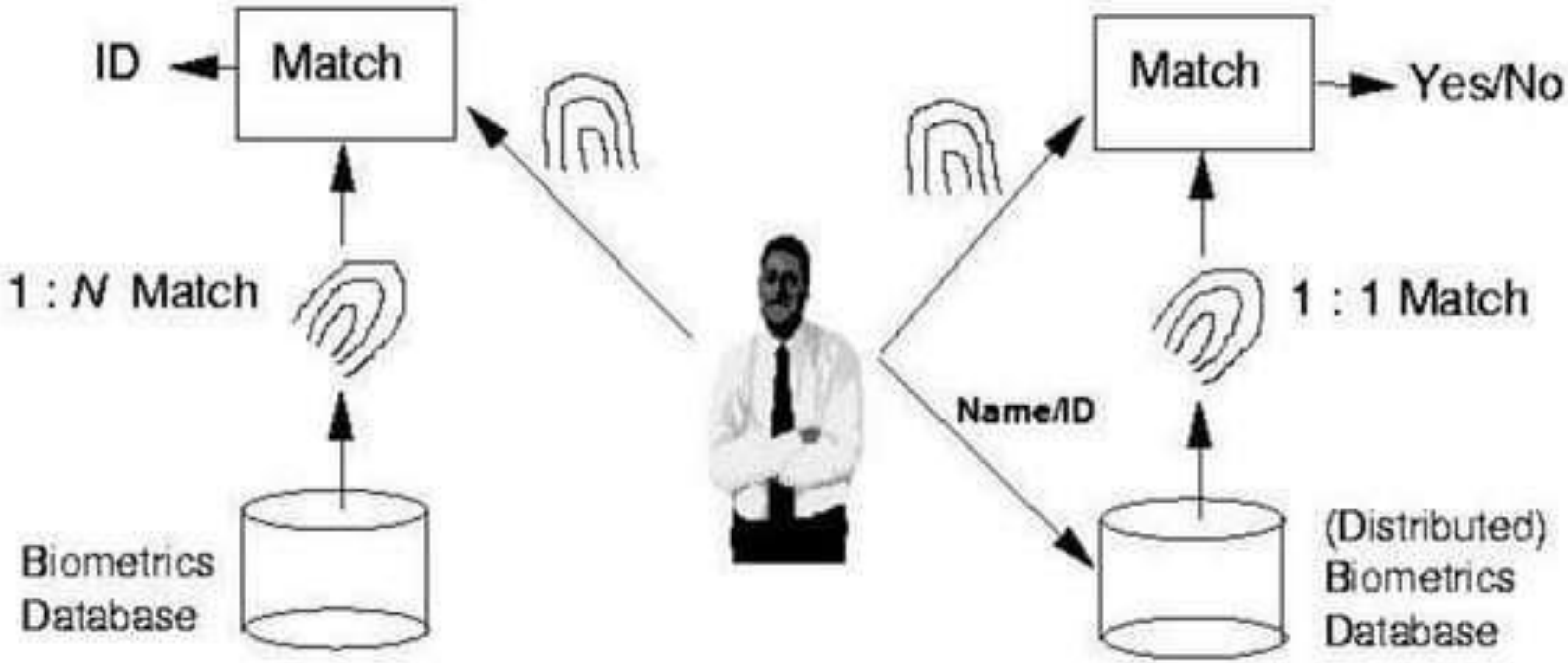
Applications & Research Topics

- Biometrics



Applications & Research Topics

- Fingerprint Verification / Identification



Applications & Research Topics

- Object Recognition

Applications & Research Topics

- Target Recognition

  Department of Defense (Army, Air force, Navy)

Applications & Research Topics

- Interpretation of Aerial Photography

Applications & Research Topics

- Autonomous Vehicles
  Land, Underwater, Space

Introduction

- The characteristics of color image are distinguished by its properties brightness, hue and saturation.
- simplifies object extraction and identification.
  - ✓ Motivation to use color
  - ✓ Brightness
  - ✓ Hue

Motivation to use color:

- Powerful descriptor that often simplifies object identification and extraction from a scene
- Humans can discern thousands of colour shades and intensities, compared to about only two dozen shades of gray

Hue:

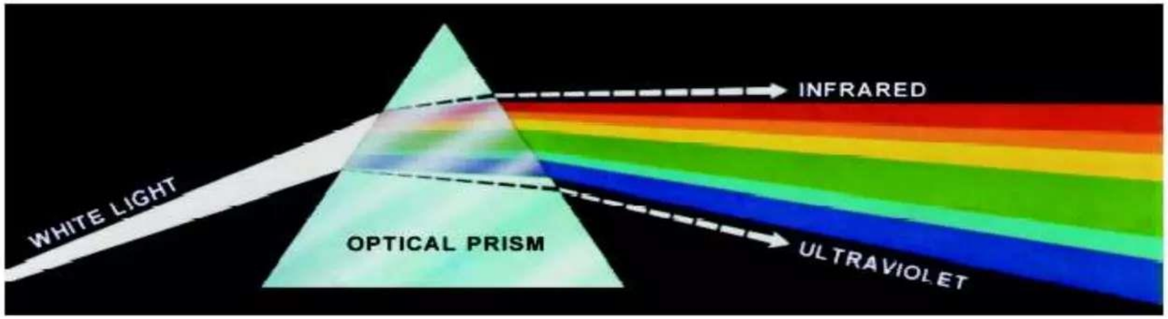
- Attribute associated with the dominant wavelength in a mixture of light waves
- Hue is somewhat synonymous to what we usually refer to as "colors". Red, green, blue, yellow, and orange are a few examples of different hues.
- Mean wavelength of the spectrum

Brighuness:

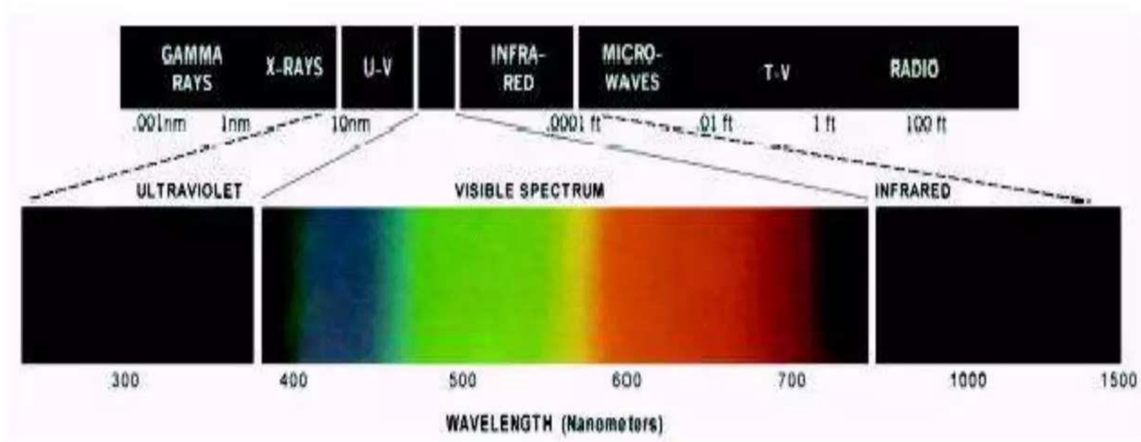
- Intensity
- Perceived luminance
- Depends on surrounding luminance

Color Fundamental:

- In 1666 Sir Isaac Newton discovered that when a beam of sunlight passes through a glass prism, the emerging beam is split into a spectrum of colors



- A chromatic light source, there are 3 attributes to describe the quality:



- Primary colors can be added to produce the *secondary colors of light:*
  - ✓ Cyan (green plus blue)
  - ✓ Yellow (red plus green)
  - ✓ Magenta (red plus blue)

- The three basic quantitles useds to describe the quantity of a chromatic light source are:
  - ✓ Radiance
  - ✓ Luminance
  - ✓ Brightness

Radiance:

- The total amount of energy that flows from the light source (measured in watts)

Luminance:

- The amount of energy an observer *perceives* from the light source (measured in lumens)
- we can have high radiance, but low luminance

Brightness:

- A subjective (practically unmeasurable) notion that embodies the intensity of light

Standard Dynamic Range

High Dynamic Range

Changing brightness and contrast

- **Changing brightness and contrast**: To adjust the brightness and contrast of an image in Python, we can use the OpenCV or Pillow library.

For example, to increase the brightness of an image using OpenCV, we can use the cv2.add() function, and to adjust the contrast, we can use the cv2.convertScaleAbs() function.

Color Models:

- Color, by defining a 3D coordinate system, and a subspace that contains all constructible colors within a particular model.

- A color model is an abstract mathematical model describing the way colors can be represented as tuples of numbers, typically as three or four values or color components.

- Each color model is oriented towards either specific hardware (RGB,CMY,YIQ), or image processing applications (HSI).

- Any color that can be specified using a model will correspond to a single point within the subspace it defines

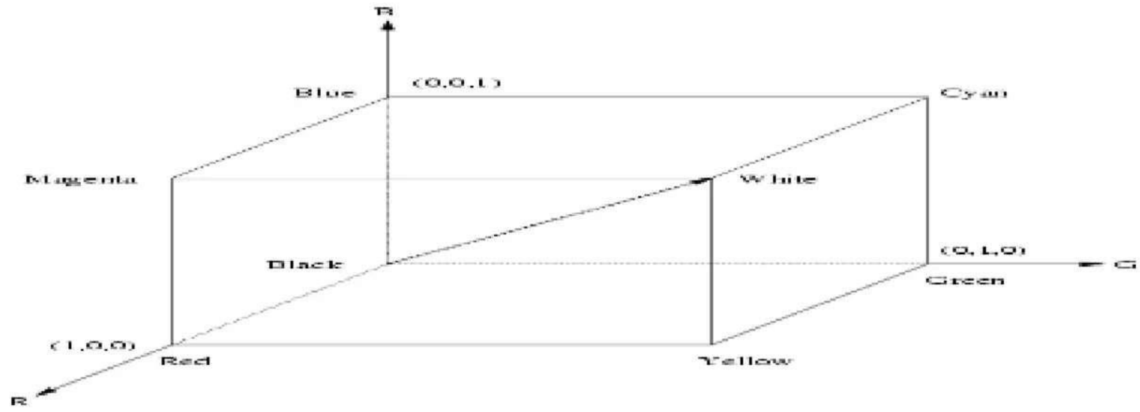
TYPES OF COLOR MODELS:

- ✓ RGB Model
- ✓ CMY Model
- ✓ HSI Model
- ✓ YIQ Model

RGB Model:

- Color monitor, color video cameras
- In the RGB model, an image consists of three independent image planes, one in each of the primary colors: red, green and blue.
- Specifying a particular colour is by specifying the amount of each of the primary components present.
- The geometry of the RGB colour model for specifying colors using a Cartesian coordinate system. The greyscale spectrum,

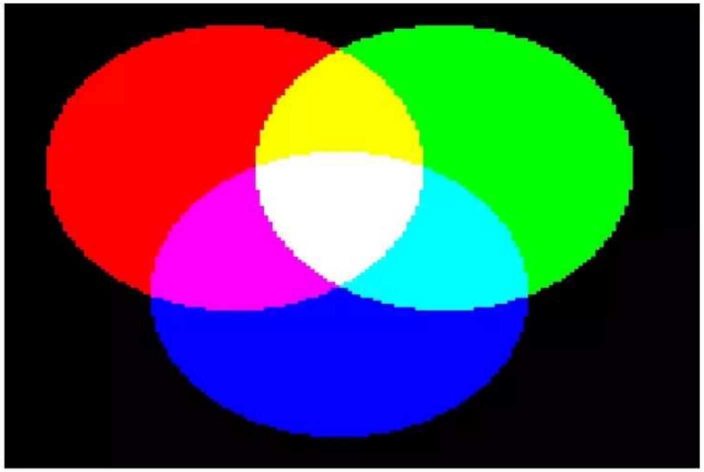
.

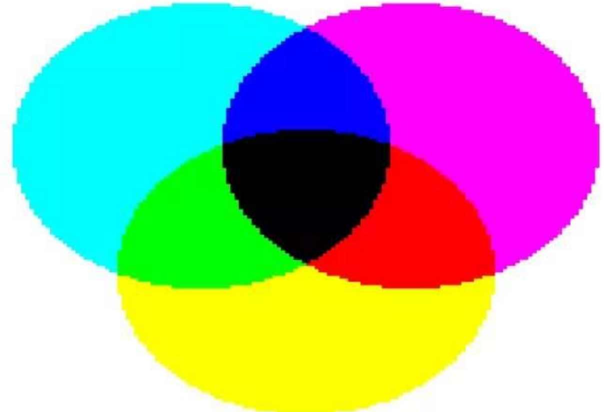


- The RGB color cube. The grayscale spectrum lies on the line joining the black and white vertices.

CMY Model:

- The CMY (cyan-magenta-yellow) model is a *subtractive* model appropriate to absorption of colors, for example due to pigments in paints
- Whereas the RGB model asks what is added to black to get a particular color, the CMY model asks what is subtracted from white.
- In this case, the primaries are cyan, magenta and yellow, with red, green and blue as secondary colors

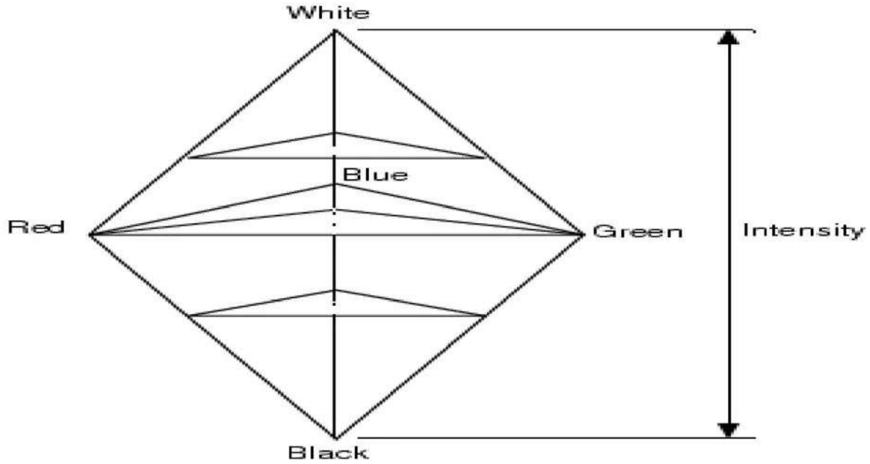


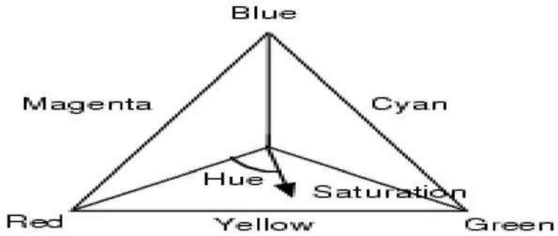


- The relationship between the RGB and CMY

HSI Model:

- As mentioned above, colour may be specified by the three quantities hue, saturation and intensity.
- This is the HSI model, and the entire space of colors that may be specified in this way is shown





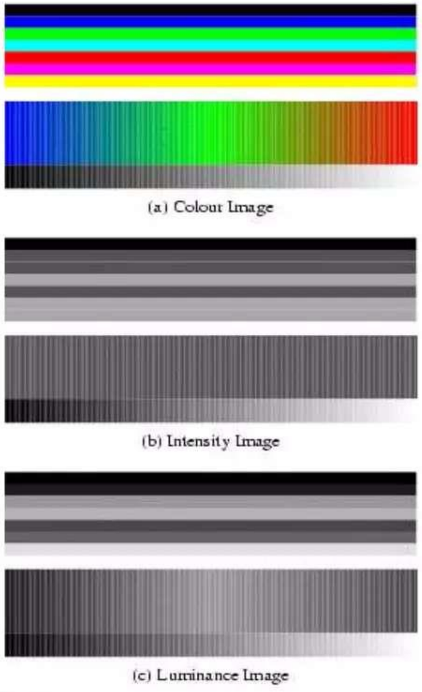
- Conversion between the RGB model and the HSI model is quite complicated. The intensity is given by

$$I = R+G+B$$

- where the quantities R, G and B are the amounts of the red, green and blue components, normalised to the range [0,1]. The intensity is therefore just the average of the red, green and blue components.
- The saturation is given by: $S = 1 - \min$

YIQ Model:

- The YIQ (luminance-inphase-quadrature)model is a recoding of RGB for colour television, and is a very important model for colour image processing. The importance of luminance was discussed in
- The conversion from RGB to YIQ is given by:
- The luminance (Y) component contains all the information required for black and white television, and captures our perception of the relative brightness particular colors.



What is Hue?

- The ***hue*** of a color is a component of its chromaticity. Red, green, and blue are the three main colors of light. It is why televisions, computers, and other electronic color visual displays use a ratio of red, green, and blue phosphors to generate all electrically conveyed colors.
- Hue is a single value that describes the color of something and is typically measured in degrees.
- It has the colors red, orange, yellow, green, blue, purple, and magenta all the way back to red.
- Although, magenta and pink colors are not light frequencies, and a rainbow may prove it.
- It begins with red and progresses to different colors, but it doesn't contain magenta and pink because they are not genuine frequencies humans can see.

What is Saturation?

- **Saturation**: The intensity of a color. As saturation increases, colors appear sharper or purer. As saturation decreases, colors appear more washed-out or faded
- ***Saturation*** is defined by the purity of the color and its distance from the grey color. If a color has much more greyness, it has a lower saturation level. Moreover, saturation could be viewed as the hue's dominance in the color.
- The outermost edge of the hue wheel includes the pure hue; as you move inside the wheel to the centre, which contains grey, the hue steadily drops, and the saturation likewise falls.
- It relates to a physical property known as the excitation property, which measures the percentage of brightness mixed with the dominant or pure color.

Saturation

- Saturation: Saturation refers to the intensity of colors in an image, and it can be adjusted to make an image look more or less vivid. To adjust saturation in Python, you can use the cv2.cvtColor() function in OpenCV to convert an image from one color space to another, and then adjust the saturation channel.
- For example, to increase the saturation of an image using
- the HLS color space, you can use the following code:

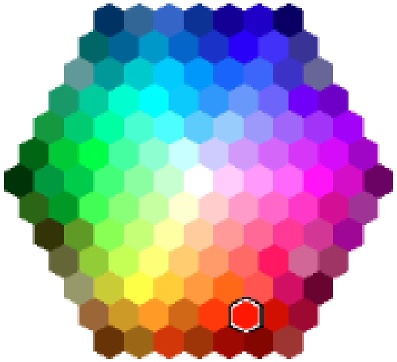
The HIS color model:

- The RGB and CMY color models are not suited for describing colors in terms of human interpretation. When we view a color object, we describe it by its hue, saturation, and brightness(intensity). Hence the HSI color model has been presented.
- The HSI model decouples the intensity component from the color-carrying information (hue and saturation) in a color image. As a result, this model is an ideal tool for developing color image processing algorithms.

- The hue, saturation, and intensity values can be obtained from the RGB color cube.

- That is, we can convert any RGB point to a corresponding point is the HSI color model by working out the geometrical formulas.

Pick a Color:



Or Enter a Color:

Color value OK

Or Use HTML5:

Selected Color:

Black Text

Shadow

White Text

Shadow

Red

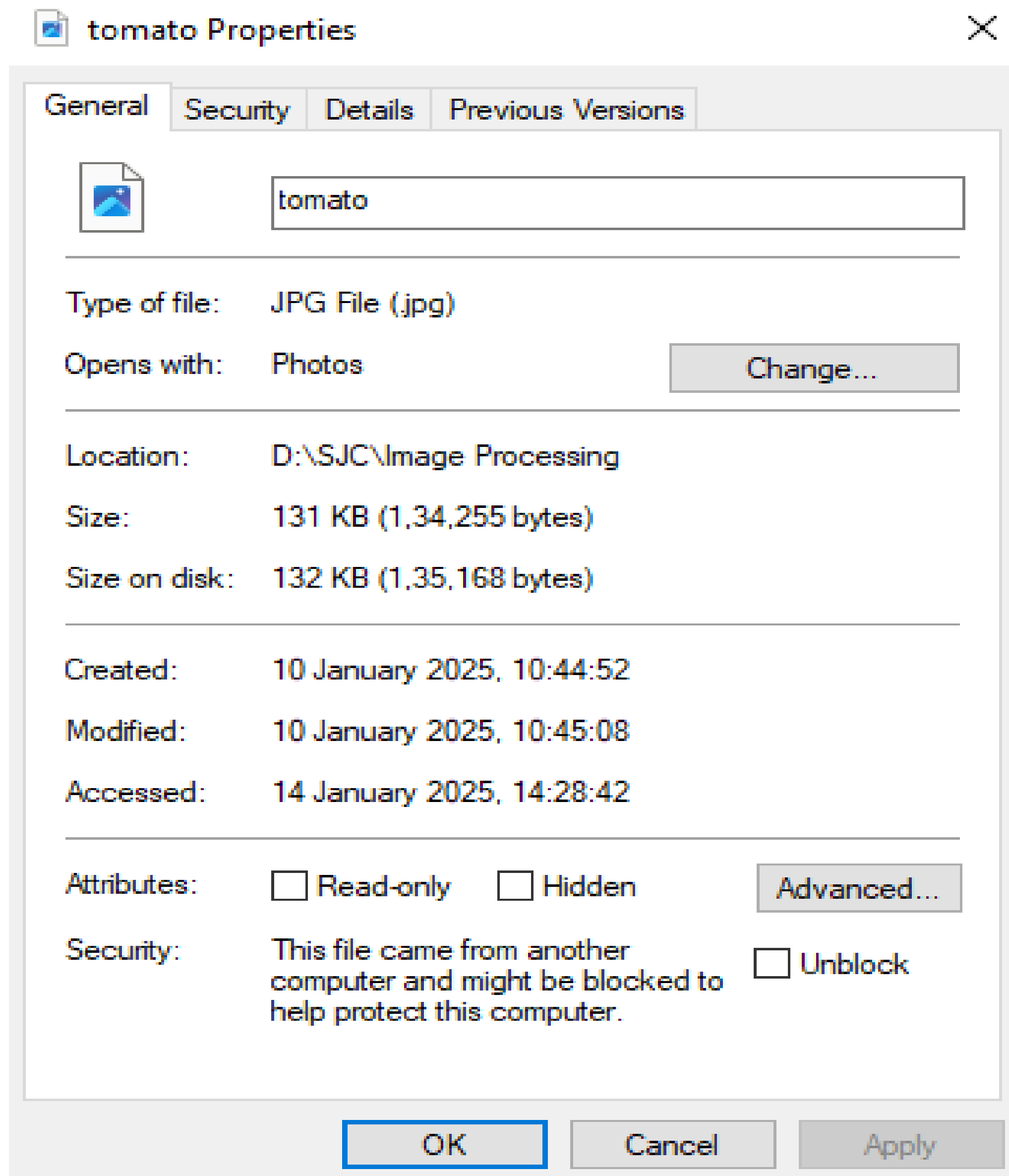
#ff0000

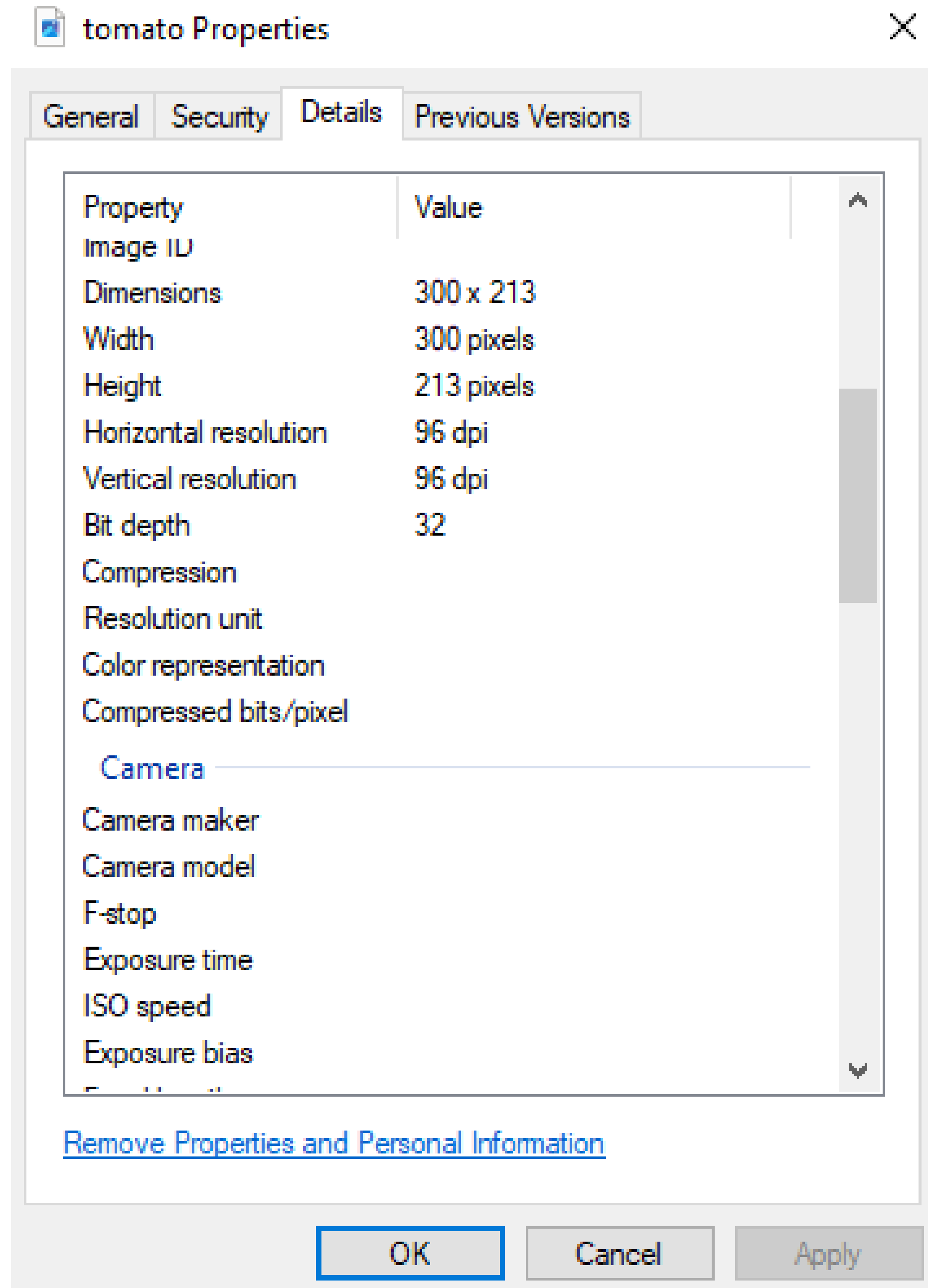
rgb(255, 0, 0)

hsl(0, 100%, 50%)

Lighter / Darker:

100%	#ffffff
95%	#ffe6e6
90%	#ffcccc
85%	#ffb3b3
80%	#ff9999
75%	#ff8080
70%	#ff6666
65%	#ff4d4d
60%	#ff3333
55%	#ff1a1a
50%	#ff0000
45%	#e60000
40%	#cc0000
35%	#b30000
30%	#990000
25%	#800000
20%	#660000
15%	#4d0000
10%	#330000
5%	#1a0000
0%	#000000


tomato Properties
General
Security
Details
Previous Versions
tomato
Type of file: JPG File (.jpg)
Opens with: Photos
Change...
Location: D:\SJC\Image Processing
Size: 131 KB (1,34,255 bytes)
Size on disk: 132 KB (1,35,168 bytes)
Created: 10 January 2025, 10:44:52
Modified: 10 January 2025, 10:45:08
Accessed: 14 January 2025, 14:28:42
Attributes:
Read-only
Hidden
Advanced...
Security: This file came from another computer and might be blocked to help protect this computer.
Unblock
OK
Cancel
Apply



tomato Properties
General
Security
Details
Previous Versions
Property
Value
Image ID
Dimensions
300 x 213
Width
300 pixels
Height
213 pixels
Horizontal resolution
96 dpi
Vertical resolution
96 dpi
Bit depth
32
Compression
Resolution unit
Color representation
Compressed bits/pixel
Camera
Camera maker
Camera model
F-stop
Exposure time
ISO speed
Exposure bias
Remove Properties and Personal Information
OK
Cancel
Apply

Hue

	Hue	Hex	Rgb	Hsl
	0	#ff0000	rgb(255, 0, 0)	hsl(0, 100%, 50%)
	15	#ff4000	rgb(255, 64, 0)	hsl(15, 100%, 50%)
	30	#ff8000	rgb(255, 128, 0)	hsl(30, 100%, 50%)
	45	#ffbf00	rgb(255, 191, 0)	hsl(45, 100%, 50%)
	60	#ffff00	rgb(255, 255, 0)	hsl(60, 100%, 50%)
	75	#bfff00	rgb(191, 255, 0)	hsl(75, 100%, 50%)
	90	#80ff00	rgb(128, 255, 0)	hsl(90, 100%, 50%)
	105	#40ff00	rgb(64, 255, 0)	hsl(105, 100%, 50%)
	120	#00ff00	rgb(0, 255, 0)	hsl(120, 100%, 50%)
	135	#00ff40	rgb(0, 255, 64)	hsl(135, 100%, 50%)
	150	#00ff80	rgb(0, 255, 128)	hsl(150, 100%, 50%)
	165	#00ffbf	rgb(0, 255, 191)	hsl(165, 100%, 50%)
	180	#00ffff	rgb(0, 255, 255)	hsl(180, 100%, 50%)
	195	#00bfff	rgb(0, 191, 255)	hsl(195, 100%, 50%)
	210	#0080ff	rgb(0, 128, 255)	hsl(210, 100%, 50%)
	225	#0040ff	rgb(0, 64, 255)	hsl(225, 100%, 50%)
	240	#0000ff	rgb(0, 0, 255)	hsl(240, 100%, 50%)
	255	#4000ff	rgb(64, 0, 255)	hsl(255, 100%, 50%)
	270	#8000ff	rgb(128, 0, 255)	hsl(270, 100%, 50%)
	285	#bf00ff	rgb(191, 0, 255)	hsl(285, 100%, 50%)
	300	#ff00ff	rgb(255, 0, 255)	hsl(300, 100%, 50%)

Saturation

	Sat	Hex	Rgb	Hsl
	100%	**#ff0000**	**rgb(255, 0, 0)**	**hsl(0, 100%, 50%)**
	95%	#f90606	rgb(249, 6, 6)	hsl(0, 95%, 50%)
	90%	#f20d0d	rgb(242, 13, 13)	hsl(0, 90%, 50%)
	85%	#ec1313	rgb(236, 19, 19)	hsl(0, 85%, 50%)
	80%	#e61919	rgb(230, 25, 25)	hsl(0, 80%, 50%)
	75%	#df2020	rgb(223, 32, 32)	hsl(0, 75%, 50%)
	70%	#d92626	rgb(217, 38, 38)	hsl(0, 70%, 50%)
	65%	#d22d2d	rgb(210, 45, 45)	hsl(0, 65%, 50%)
	60%	#cc3333	rgb(204, 51, 51)	hsl(0, 60%, 50%)
	55%	#c63939	rgb(198, 57, 57)	hsl(0, 55%, 50%)
	50%	#bf4040	rgb(191, 64, 64)	hsl(0, 50%, 50%)
	45%	#b94646	rgb(185, 70, 70)	hsl(0, 45%, 50%)
	40%	#b34d4d	rgb(179, 77, 77)	hsl(0, 40%, 50%)
	35%	#ac5353	rgb(172, 83, 83)	hsl(0, 35%, 50%)
	30%	#a65959	rgb(166, 89, 89)	hsl(0, 30%, 50%)
	25%	#9f6060	rgb(159, 96, 96)	hsl(0, 25%, 50%)
	20%	#996666	rgb(153, 102, 102)	hsl(0, 20%, 50%)
	15%	#936c6c	rgb(147, 108, 108)	hsl(0, 15%, 50%)
	10%	#8c7373	rgb(140, 115, 115)	hsl(0, 10%, 50%)
	5%	#867979	rgb(134, 121, 121)	hsl(0, 5%, 50%)
	0%	#808080	rgb(128, 128, 128)	hsl(0, 0%, 50%)

Lightness

	Light	Hex	Rgb	Hsl
	100%	#ffffff	rgb(255, 255, 255)	hsl(0, 100%, 100%)
	95%	#ffe6e6	rgb(255, 230, 230)	hsl(0, 100%, 95%)
	90%	#ffcccc	rgb(255, 204, 204)	hsl(0, 100%, 90%)
	85%	#ffb3b3	rgb(255, 179, 179)	hsl(0, 100%, 85%)
	80%	#ff9999	rgb(255, 153, 153)	hsl(0, 100%, 80%)
	75%	#ff8080	rgb(255, 128, 128)	hsl(0, 100%, 75%)
	70%	#ff6666	rgb(255, 102, 102)	hsl(0, 100%, 70%)
	65%	#ff4d4d	rgb(255, 77, 77)	hsl(0, 100%, 65%)
	60%	#ff3333	rgb(255, 51, 51)	hsl(0, 100%, 60%)
	55%	#ff1a1a	rgb(255, 26, 26)	hsl(0, 100%, 55%)
	50%	**#ff0000**	**rgb(255, 0, 0)**	**hsl(0, 100%, 50%)**
	45%	#e60000	rgb(230, 0, 0)	hsl(0, 100%, 45%)
	40%	#cc0000	rgb(204, 0, 0)	hsl(0, 100%, 40%)
	35%	#b30000	rgb(179, 0, 0)	hsl(0, 100%, 35%)
	30%	#990000	rgb(153, 0, 0)	hsl(0, 100%, 30%)
	25%	#800000	rgb(128, 0, 0)	hsl(0, 100%, 25%)
	20%	#660000	rgb(102, 0, 0)	hsl(0, 100%, 20%)
	15%	#4d0000	rgb(77, 0, 0)	hsl(0, 100%, 15%)
	10%	#330000	rgb(51, 0, 0)	hsl(0, 100%, 10%)
	5%	#1a0000	rgb(26, 0, 0)	hsl(0, 100%, 5%)

RGB (Red, Green, Blue)

Red	Green	Blue
82	135	188

rgb(82, 135, 188)

#5287bc

Regions and Boundaries:

- A subset R of pixels in an image is called a Regionof the image if R is a connected set.
- The boundaryof the region R is the set of pixels in the region that have one or more neighbors that are not in R.
- If R happens to be entire Image?

Distance measures:

Given pixels p, q and z with coordinates (x, y), (s, t), (u, v)respectively, the distance function D has following properties:a.

Arithmetic Operation Between Images

- There are Array Operations which are carried out between corresponding pixels pairs. The four arithmetic operations are denoted as

- $A(x,y) = f(x,y)+g(x,y)$
- $S(x,y) = f(x,y)-g(x,y)$
- $p(x,y) = f(x,y)*g(x,y)$
- $D(x,y) = f(x,y)/g(x,y)$

- These all arithmetic operations are performed between corresponding pixels pairs.

Important Points

- If the result is a floating point number, round off its value
- If the result is above the pixel range, select the max range value
- If the result is below the pixel range, select the min range value
- If the result is infinity, write it as zero

- import cv2
- import matplotlib.pyplot as plt
- import numpy as np   # Load the image image = cv2.imread('D://SJC//Image Processing//images//image2.jpg') plt.subplot(1, 2, 1)
- plt.title("Original")
- plt.imshow(image)
- brightness = 10
- contrast = 2.3
- image2 = cv2.addWeighted(image, contrast, np.zeros(image.shape, image.dtype), 0, brightness
- cv2.imwrite('modified_image.jpg', image2)
- plt.subplot(1, 2, 2) plt.title("Brightness & contrast") plt.imshow(image2) plt.show()

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localhost:8888/notebooks/Desktop/Image%20practical/Brightness.ipynb?

jupyter **Brightness** Last Checkpoint: 22 hours ago

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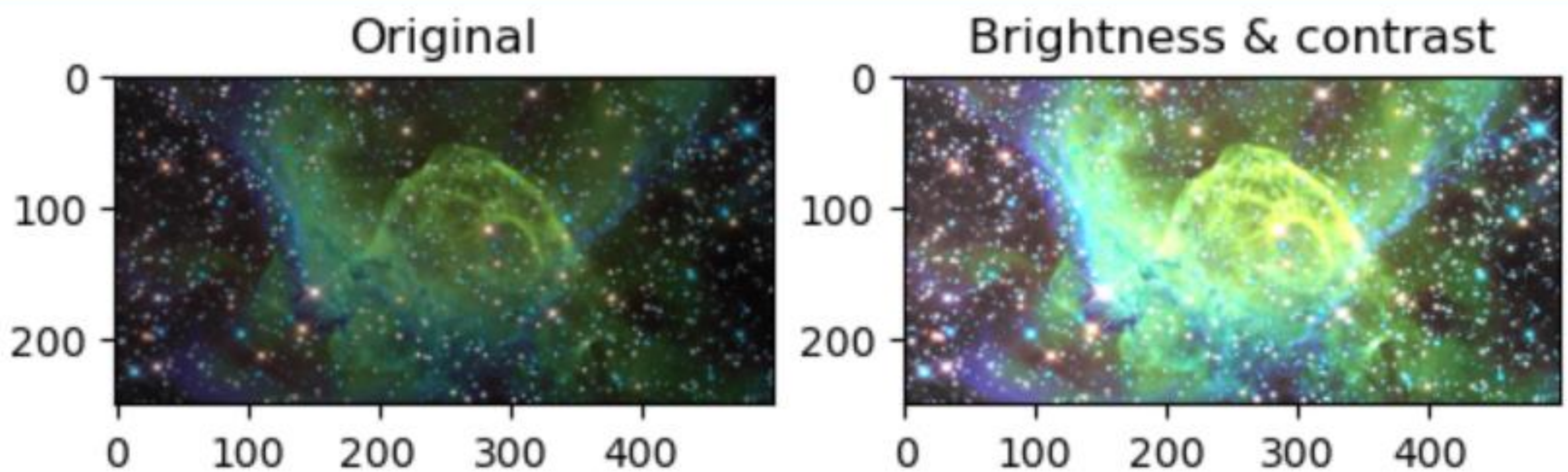
Code JupyterLab

```
plt.subplot(1, 2, 2)
plt.title("Brightness & contrast")
plt.imshow(image2)
plt.show()
```



[3]:

```
import cv2
img = cv2.imread('D://SJC//Image Processing//images//image2.jpg')
alpha = 1.5 # Increase brightness
```

Addition

Addition

0 - 255

$$\overset{A}{\begin{bmatrix} 0 & 100 & 10 \\ 4 & 0 & 10 \\ 8 & 0 & 5 \end{bmatrix}} + \overset{B}{\begin{bmatrix} 10 & 100 & 5 \\ 2 & 0 & 0 \\ 0 & 10 & 10 \end{bmatrix}} = \begin{bmatrix} 10 & 200 & 15 \\ 6 & 0 & 10 \\ 8 & 10 & 15 \end{bmatrix}$$

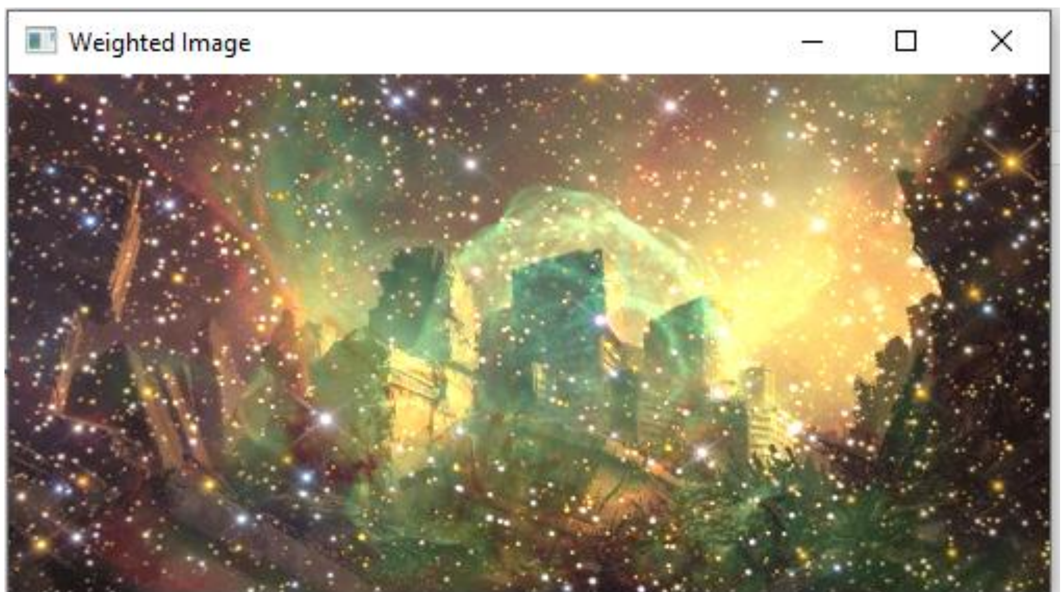
Uses

- Addition of noisy images for noise reduction.

Uses:

- Changing Image Background
- Watermark Images

- import cv2
- first_img = cv2.imread("D://SJC//Image Processing//images//iamge1.jpg")
- second_img = cv2.imread("D://SJC//Image Processing//images//image2.jpg")
- weightedSum=cv2.add(first_img , second_img)
- cv2.imshow('Weighted Image', weightedSum) cv2.waitKey(0)cv2.destroyAllWindows()


Weighted Image

Subtraction

Subtraction

0 - 255

$$\overset{A}{\begin{bmatrix} 0 & 100 & 10 \\ 4 & 0 & 10 \\ 8 & 0 & 5 \end{bmatrix}} - \overset{B}{\begin{bmatrix} 10 & 100 & 5 \\ 2 & 0 & 0 \\ 0 & 10 & 10 \end{bmatrix}} = \begin{bmatrix} 0 & 0 & 5 \\ 2 & 0 & 10 \\ 8 & 0 & 0 \end{bmatrix}$$

Uses

- Enhancement of differences between images.
- Mask mode radiography in medical imaging.

Multiplication

Multiplication

0-255

$$\begin{bmatrix} 0 & 100 & 10 \\ 4 & 0 & 10 \\ 8 & 0 & 5 \end{bmatrix} * \begin{bmatrix} 10 & 100 & 5 \\ 2 & 0 & 0 \\ 0 & 10 & 10 \end{bmatrix} = \begin{bmatrix} 0 & 255 & 50 \\ 8 & 0 & 0 \\ 0 & 0 & 50 \end{bmatrix}$$

Uses

- Shading correction

Division

0.5 → 0

Division

$$\overset{A}{\begin{bmatrix} 0 & 100 & 10 \\ 4 & 0 & 10 \\ 8 & 0 & 5 \end{bmatrix}} / \overset{B}{\begin{bmatrix} 10 & 100 & 5 \\ 2 & 0 & 0 \\ 0 & 10 & 10 \end{bmatrix}} = \begin{bmatrix} 0 & 1 & 2 \\ 2 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

Uses

- Shading correction