IMAGE PROCESSING

WEEK-1

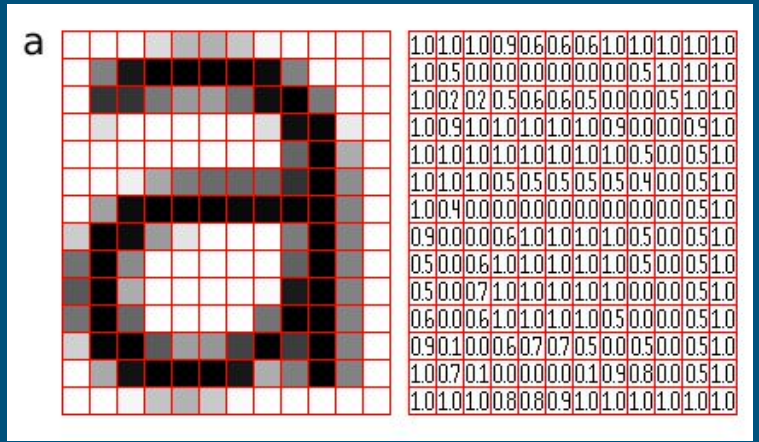
1. INTRODUCTION TO IMAGES AND FORMATS

- **What is an image?**
- **Definition:**

  An image is a numerical matrix(a grid of numbers) that represents the intensity or color of each point(pixel) in the picture.

- In simple terms:

  An image is an mosaic of tiny dots called pixels.Each pixel is a building block containing color and intensity information,which together create the complete picture.



- Why image is important in computer vision?
- Computer vision uses images to:

1. Detect objects
2. Recognize faces
3. Classify images(eg. Dogs vs. cats)
4. Track movements
5. Read text(OCR)
6. Understand scenes(autonomous cars)

- **Types of digital images-**

a. Raster images(Bitmap images)-

- These images are made up of of pixels(tiny dots of colors).
- **Characteristics:**

a. Lose quality when zoomed in
b. Store color values for every pixel
c. Very common in AI and ML

- **Examples:**

a. Photos from phones
b. Screenshots
c. Computer vision datasets(CiFAR-10,MNIST,ImageNet)

- **Common raster formats:**

a. JPEG
b. PNG
c. GIF
d. TIFF
e. BMP

b. Vector images-

- These images are made of mathematical curves and shapes(not pixels).

- Characteristics:

a. Doesn’t lose quality when zoomed in
b. Great for printing and resizing
c. Not used in computer vision tasks.

- Examples:

a. Logos
b. Icons
c. Illustrations
d. SVG graphics

- Common vector formats:

a. SVG
b. AI
c. EPS
d. PDF

In computer vision,raster images are classified into:

1. Binary images: Only two color: black-(0) and white-(1)
   - **Used in-** Thresholding, Mask processing, OCR(optical character recognition)

2. Grayscale images: Only shades of gray(0-255)
   - **Used in-** Edge detection, Medical imaging , Classical computer vision(Canny,etc)

3. Color images(RGB images): Three channels: Red, Green, Blue
   - **Used in-** Object detection, Classification, Segmentation

4. Multispectral images: More than three channels(eg. 7-15 channels)
   - **Used in-** Satellite imaging, Agriculture, Environment monitoring

5. Hyperspectral images: Hundreds of channels(100-200+ channels)
   - **Used in-** Minerals analysis, Medical diagnosis, Scientific imaging

6. 3D images: contain depth information in addition to 2D pixels
   - **Used in-** CT scans, MRI scans, VR,AR furnitures(eg;ikea), e-commerce virtual(lensk)

- **Image formats:**

- **JPEG/JPG(Joint Photographic Experts Group):**
  - It is an raster image format
  - Why? :
    - Small size images
    - Is good quality for natural images
  - Use cases:
    - Photos(camera,phones)
    - Social media images
    - Web photos
    - Machine learning dataset(CIFAR)

- **PNG(Portable network graphics)-**
  - It is an raster image format.
  - Why? :
    - High quality
    - No loss of details
    - Transparent backgrounds
  - Use cases:
    - Logos
    - Icons
    - Web graphics needing transparency
    - Screenshots

- **GIF(Graphics interchange format):**
  - It is an raster image format
  - Why? :
    - Lightweight animations
  - Use cases:
    - Short animations
    - Memes
    - Simple graphics with few colors

- **BMP(Bitmap image file):**
  - It is an raster image format.
  - Why? :
    - Pure pixels data,no loss
  - Use cases:
    - Raw image data
    - Image processing experiments
    - Medical imaging

- **TIFF(Tagged image file format):**
  - It is an raster image format.
  - Why? :
    - Very high quality images
    - Can store multiple layers and channels
  - Use cases:
    - High-quality photography
    - Medical imaging(X-ray,MRI)
    - Satellite images
    - Document scanning
    - Printing industry

- **WEBP(Web picture format):**
  - It is an raster image format
  - Why? :
    - Better compression than JPG and PNG
    - Google recommends it for web performance

- Use cases:
  - Modern websites
  - Performance-optimized web graphics
  - Replacing JPG/PNG

- **HEIF/HEIC(High efficiency image format):**
- It is an raster image
- Why?:
  - Superior compression and quality
  - Supports depth maps
- Use cases:
  - Iphone and high-end cameras
  - Storing high-quality photos with small file size

- **RAW image formats(CR2,NEF,ARW,DNG):**
  - It is an raster image formats.
  - Why?:
    - Maximum details
    - Best for editing or ML processing
  - Use cases:
    - Professional photography
    - Image processing
    - Computer vision research

- **SVG(Scalable vector graphics):**
  - It is an vector image format.
  - Why?:
    - Infinite scalability
    - Very small size
  - Use cases:
    - Logos,icons,diagrams,illustrations
    - Wen and UI designs

- **EPS(Encapsulated postscript):**
  - It is an vector image format.
  - Use cases:
    - Print media
    - High-resolution graphics
    - Professional logos

- **PDF(Portable document format):**
  - It is an hybrid image format(vector+raster)
  - Use cases:
    - Documents with images
    - Print-ready designs
    - Multi-page graphics
- **HDR/EXR(High dynamic range images):**
  - It is an raster image format
  - Use cases:
    - Visual effects, lightweight environments
    - Gaming,scientific imaging

- Color spaces-
  - Color Spaces is a specific organisation of colors that helps in the representation and reproduction of digital images.
  - Types of color spaces are-

1. RGB - Red green Blue- it combines the three colors in various ways to produce hues.
2. HSV - Hue, saturation and value - which represents the color in terms of the shade,vibrancy and brightness.
3. Grayscale image- it strips away color to focus on shades of grey highlighting texture and contrast.
4. BGR(Blue green red)- this is an additive color spaces, it is an color model that stores pixel values in the order:[BLUE,GREEN,RED],this format is used in opencv2
5. CMYK(Cyan-magenta-Yellow-key(Black))- this subtractive color model is used for printing.this is used in printing presses,packaging,high quality color prints.Key is the volume of black

- BIT Depth:
- Bit depth refers to the number of bits used to represents the color(intensity) of each pixels
- More bits=more colors and shades
- Less bits=less colors or shades
- BIT depth in grayscale image:
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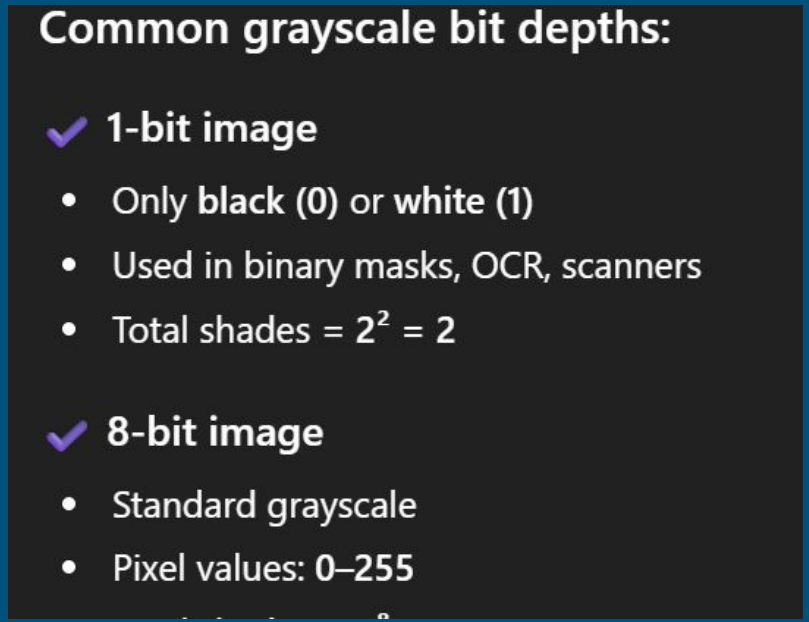

- Bit depth in color images(RGB):
- Have 3 channels(R,G,B)
- Used in:
  - Raw camera images
  - HDR imaging
  - High-end sensors
  - Professional color grading

8-bit per channel (most common)

- Red: 0–255
- Green: 0–255
- Blue: 0–255
- Total colors:

  256 × 256 × 256 = 16.7 million colors

This is the **standard for photos, computer vision datasets, webcams, screens.**

- EXIF:
- EXIF standards for -Exchable image file format
- It is a standard that stores extra information inside image files images like JPEG,TIFF,Raw
- This metadata includes:
  - Camera settings
  - Date and time
  - Gps location
  - Image processing
  - Device information
- Where it is used?:
  - Computer vision
  - Forensics
  - Map and location apps
- Formats that does not support EXIF
  - PNG
  - GIF
  - BMP

- **codes:**
- Hands on - https://colab.research.google.com/drive/1ov7DY8HomVY3fu8MiS-R-nXRQ17CbpjR#scrollTo=9fwq4qfzKiPU
- POC -
- Show how the same ML model (e.g., ResNet) performs differently on:
- JPEG (low quality)
- PNG (high quality)
- WEBP (compressed)
- https://colab.research.google.com/drive/1FKHTct1V13nu0KFRR8ajkXBdGP9_U4Ce#scrollTo=oLPZbxd9M5Xw