

# Tutorial 1

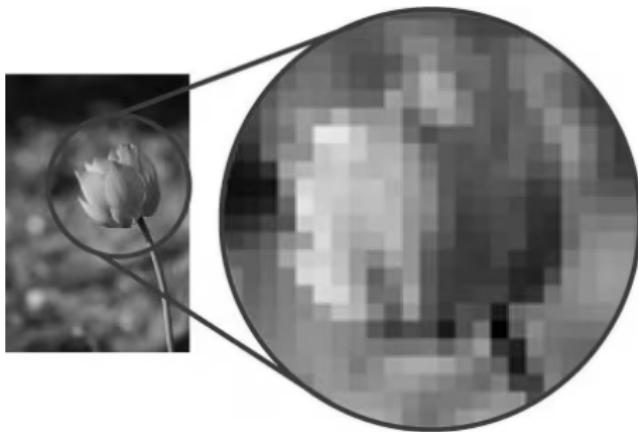
CS385: Computer Vision  
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# What is Bits Per Pixel (BPP)?

- BPP determines the number of bits used to represent a pixel in an image.
- Higher BPP means more colors and better image quality.
- The number of colors grows exponentially with BPP.

# What is a Pixel?

- A pixel (picture element) is the smallest unit of a digital image.
- Every digital image is made up of pixels.
- It stores a value proportional to the light intensity at its location.
- When zoomed in, pixels appear as small squares.



# What is Bit Depth?

- Bit depth refers to the number of bits used to represent each pixel in an image.
- Higher bit depth means more color information per pixel.
- More color information allows more accurate representation of color tones.

# Understanding the Formula

- The number of bits per pixel ( $k$ ) determines how many unique values (or shades) a pixel can have.
- The formula for image depth is given by:

$$L = 2^k$$

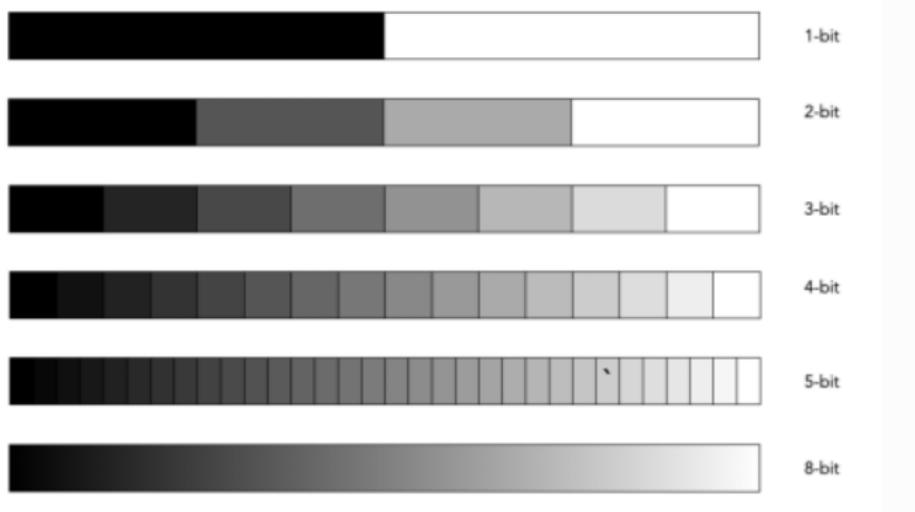
where  $L$  is the number of intensity levels, and  $k$  is the number of bits used per pixel.

- This means:
  - If  $k = 1$  (1-bit image), then  $L = 2^1 = 2$  (Black & White image: 0 = black, 1 = white).
  - If  $k = 2$ , then  $L = 2^2 = 4$  (4 grayscale levels).
  - If  $k = 8$ , then  $L = 2^8 = 256$  (Standard grayscale image with shades from 0 to 255).

## Example Calculation

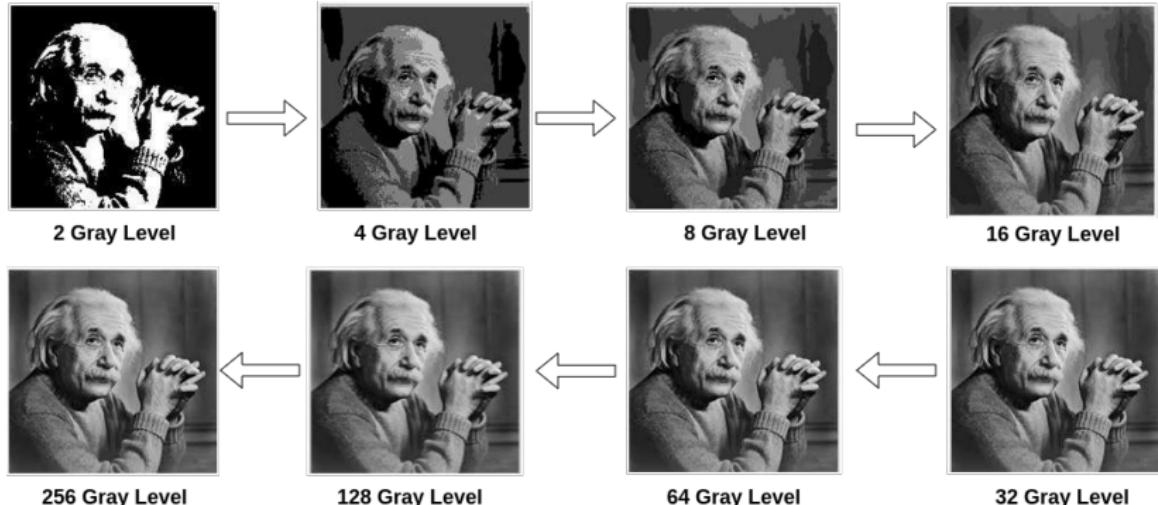
- For an **8-bit grayscale image**:
  - $k = 8$ , so  $L = 2^8 = 256$  intensity levels.
  - Each pixel can take values from **0 (black) to 255 (white)**.
  - There are **254 shades of gray** in between.

# Bit Depth Examples



- **1-bit Image:** Only black and white (2 colors).
- **4-bit Image:** Can represent 16 grayscale shades.
- **8-bit Image:** Supports 256 colors or grayscale levels.

# Effect of Reducing Gray level



- Higher bit depth improves image quality and color accuracy.

# Number of Colors per BPP or Shades

Bits Per Pixel	Number of Colors
1 bpp	$2^1 = 2$ colors
2 bpp	$2^2 = 4$ colors
3 bpp	$2^3 = 8$ colors
4 bpp	$2^4 = 16$ colors
5 bpp	$2^5 = 32$ colors
6 bpp	$2^6 = 64$ colors
7 bpp	$2^7 = 128$ colors
8 bpp	$2^8 = 256$ colors
10 bpp	$2^{10} = 1024$ colors
16 bpp	$2^{16} = 65,536$ colors
24 bpp	$2^{24} = 16.7$ million colors
32 bpp	$2^{32} = 4.29$ billion colors

- Formula:  $2^{\text{bpp}}$

# Color Values

- Pixel values determine colors in an image.
- 0 pixel value always denotes black color.
- Possible color value is calculated as:
- **Color** =  $2^{BPP} - 1$
- Example:
  - For 1 BPP:  $2^1 - 1 = 1$  (Black: 0, White: 1)
  - For 8 BPP:  $2^8 - 1 = 255$  (Black: 0, White: 255)

## Tutorial - Question 1

If an image has a color depth of 12 bits per pixel (bpp), how many different colors can it represent? Use the formula  $2^{bpp}$  to calculate the answer.

## Answer - Question 1

**Using the formula:**  $2^{12} = 4096$  colors.

# Image Storage Requirements

- Image size depends on:
  - Number of rows
  - Number of columns
  - Bits per pixel (BPP)
- Formula: **Size of an image** = Rows × Columns × BPP
- Example:
  - A grayscale image with rows and column 1024x1024 (8 BPP):
  - Size =  $1024 \times 1024 \times 8 = 8388608$  bits
  - Convert to bytes:  $8388608/8 = 1048576$  bytes
  - Convert to KB:  $1048576/1024 = 1024$  KB

## Tutorial - Question 2

**An image has a rows and column of  $2048 \times 2048$  pixels and is a grayscale image (8 BPP). Calculate its size in MB.**

## Answer - Question 2

$$\begin{aligned}\text{Size} &= 2048 \times 2048 \times 8 \\ &= 33554432 \text{ bits}\end{aligned}$$

$$\text{Convert to bytes: } 33554432/8 = 4194304 \text{ bytes}$$

$$\text{Convert to KB: } 4194304/1024 = 4096 \text{ KB}$$

$$\text{Convert to MB: } 4096/1024 = 4 \text{ MB}$$

## Tutorial - Question 3

**A  $1920 \times 1080$  image has 24 BPP. Calculate its size in MB.**

## Answer - Question 3

$$\begin{aligned}\text{Size} &= 1920 \times 1080 \times 24 \\ &= 49766400 \text{ bits}\end{aligned}$$

$$\text{Convert to bytes: } 49766400/8 = 6220800 \text{ bytes}$$

$$\text{Convert to KB: } 6220800/1024 = 6075 \text{ KB}$$

$$\text{Convert to MB: } 6075/1024 \approx 6 \text{ MB}$$

# What is Resolution?

- Resolution refers to the total number of pixels in a digital image.
- For example, if an image has  $M$  columns and  $N$  rows, then its resolution can be defined as  $M \times N$  (Width  $\times$  Height).
- Example: A  $1920 \times 1080$  image has:
  - 1920 pixels (Width)
  - 1080 pixels (Height)

# Pixel Resolution and Image Quality

- Resolution is defined by two numbers (width x height).
- Higher pixel resolution results in better image quality.
- Example: An image of 4500 x 5500 resolution.

# Megapixels

- Megapixels are calculated using pixel resolution:
- Formula:  $\frac{\text{Width} \times \text{Height}}{1,000,000}$
- Example:  $2500 \times 3192 \text{ resolution} = \frac{2500 \times 3192}{1,000,000} = 8 \text{ MP (approx.)}$

# Aspect Ratio

- Aspect ratio is the ratio of width (columns) to height (rows) of an image.
- It is written as two numbers separated by a colon (e.g., 8:9).
- Different images and screens have different aspect ratios.
- Example: 1.33:1 (or 4:3) - This means the width is 1.33 times the height. - Common in older TV screens and standard monitors.
- Common aspect ratios:  
1.33:1, 1.37:1, 1.43:1, 1.50:1, 1.56:1, 1.66:1, 1.75:1, 1.78:1, 1.85:1, 2.00:1, etc.

## Question 4

### Given:

- Aspect ratio = 6:2 (simplified to 3:1).
- Total pixel resolution = 480,000 pixels.
- The image is a grayscale image (8 bit per pixel).

### Calculate:

- The dimensions of the image (width and height).
- The size of the image in bytes.

# Answer

## 1. Dimensions of the Image:

- Aspect ratio:  $\frac{c}{r} = 6 : 2 = c = 6r/2$
- Total pixels:  $c \times r = 480,000 = c = 480000/r.$
- Comparining both  $6r/2 = 480000/r$  into the equation:

$$r = 400.$$

- Therefore,  $c = (6 \times 400)/2 = 1200$  pixels.

## 2. Size of the Image:

- The image is grayscale, so each pixel takes 8 bit. Size = rows \* cols \* bpp

Size of image in bits =  $400 * 1200 * 8 = 3840000$  bits

Size of image in bytes = 480000 bytes

Size of image in KB = ??.

## Tutorial - Question 5

**What is the aspect ratio of an image with dimensions 1920x1080?**

## Answer - Question 5

**Aspect Ratio:**  $\frac{1920}{1080} = 16 : 9.$