

Tutorial 1

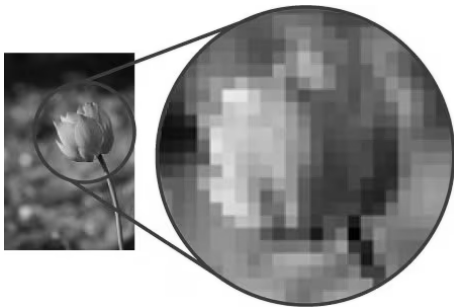
CS385: Computer Vision
Indian Institute of Technology Patna

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:

$$L = 2^k$$

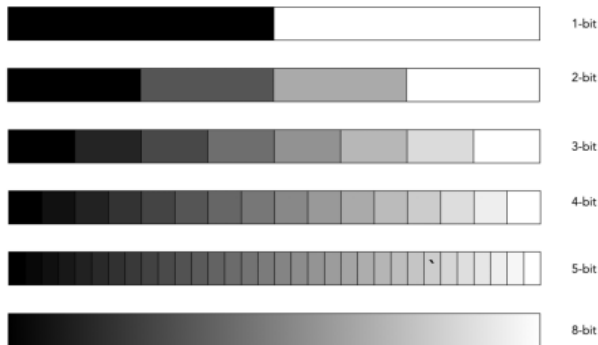
where L is the number of intensity levels, and k is the number of bits used per pixel.

- This means:
 - If **k = 1** (1-bit image), then **L = 2¹ = 2** (Black & White image: 0 = black, 1 = white).
 - If **k = 2**, then **L = 2² = 4** (4 grayscale levels).
 - If **k = 8**, then **L = 2⁸ = 256** (Standard grayscale image with shades from 0 to 255).

Example Calculation

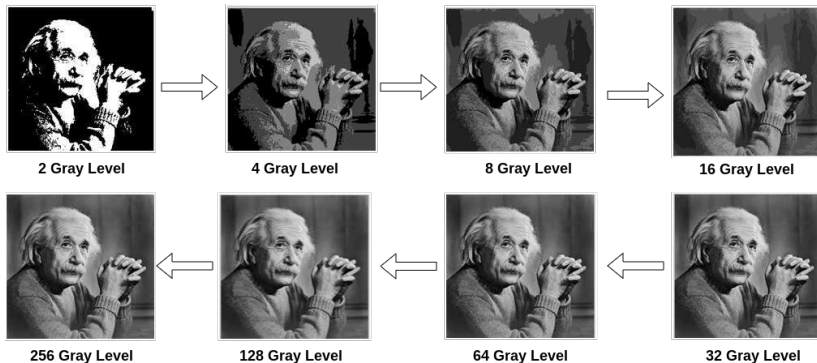
- For an **8-bit grayscale image**:
 - $k = 8$, so $L = 2^8 = 256$ intensity levels.
 - Each pixel can take values from **0 (black) to 255 (white)**.
 - There are **254 shades of gray** in between.

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^{bpp}

- 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 \times Columns \times 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

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

Answer - Question 2

$$\text{Size} = 2048 \times 2048 \times 8$$

$$= 33554432 \text{ bits}$$

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

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

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

A 1920×1080 image has 24 BPP. Calculate its size in MB.

Answer - Question 3

$$\text{Size} = 1920 \times 1080 \times 24$$

$$= 49766400 \text{ bits}$$

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

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

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

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 1920×1080 image has:
 - 1920 pixels (Width)
 - 1080 pixels (Height)

Pixel Resolution and Image Quality

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

Megapixels

- Megapixels are calculated using pixel resolution:
- Formula: $\frac{\text{Width} \times \text{Height}}{1,000,000}$
- Example: 2500×3192 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.

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 = ??.

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

Answer - Question 5

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