**Topic: Representation of (bitmap) images**

Reading Time: 20 mins

**·        Note\* Highlight important/core points while reading**

·        Read the content and write the answers given in the document in your words, to get the solid grip on topic.

**Representation of Bitmap Images**

Computers store images as a grid of small **squares** called **pixels**. Each pixel has a **binary value** that determines its **color**. A collection of these pixels forms a **bitmap image**.

**1. How is a Bitmap Image Stored?**

A **bitmap image** is stored as a **series of binary numbers**, where each pixel's value represents a specific **color**.

* A **black and white (monochrome)** image requires **1 bit per pixel**.
  + **1-bit color depth** means each pixel is either **black (0)** or **white (1)**.
* A **grayscale or simple colored** image can use **more bits per pixel**.
* A **higher bit depth** allows more colors to be represented.

**2. Color Depth and Pixel Representation**

The **number of bits per pixel (bpp)** determines how many different colors a pixel can have.

|  |  |  |
| --- | --- | --- |
| **Bits per Pixel** | **Number of Colors** | **Binary Representation** |
| **1-bit** | **2** (Black & White) | 0 = Black, 1 = White |
| **2-bit** | **4** Colors | 00, 01, 10, 11 |
| **3-bit** | **8** Colors | 000, 001, 010, 011, 100, 101, 110, 111 |
| **8-bit** | **256** Colors | 00000000 to 11111111 |
| **24-bit (True Color)** | **16.7 million colors** | RGB: 8 bits per color channel |

Image ‘A’ has the highest resolution and ‘E’ has the lowest resolution. ‘E’ has become pixelated (‘fuzzy’). This is because there are fewer pixels in ‘E’ to represent the image.

**3. How Many Bits Are Needed for an Image?**

To calculate **the number of bits required to store an image**, use:

Total bits=Width×Height×Bits per pixel\text{Total bits} = \text{Width} × \text{Height} × \text{Bits per pixel}Total bits=Width×Height×Bits per pixel

Example:

* **Image size**: 100 × 100 pixels
* **Color depth**: 8-bit (256 colors)

100×100×8=80,000 bits=10,000 bytes=10KB100 × 100 × 8 = 80,000 \text{ bits} = 10,000 \text{ bytes} = 10 KB100×100×8=80,000 bits=10,000 bytes=10KB

Larger images and higher color depth require **more storage space**.

**4. RGB Color Model (24-bit True Color)**

Most modern images use the **RGB color model**:

* **R (Red)**, **G (Green)**, **B (Blue)**
* Each color has **8 bits** (values from 0 to 255).
* **Total colors:** 224=16.72^{24} = 16.7224=16.7 million.

**Example: 24-bit Color Representation**

|  |  |  |
| --- | --- | --- |
| **Color** | **RGB Value (Decimal)** | **Binary Representation** |
| **Red** | (255, 0, 0) | 11111111 00000000 00000000 |
| **Green** | (0, 255, 0) | 00000000 11111111 00000000 |
| **Blue** | (0, 0, 255) | 00000000 00000000 11111111 |
| **White** | (255, 255, 255) | 11111111 11111111 11111111 |
| **Black** | (0, 0, 0) | 00000000 00000000 00000000 |

**5. Resolution and Image Quality**

**What is Resolution?**

* **Resolution = Number of pixels in an image** (Width × Height).
* **Higher resolution = More detail = Larger file size.**

|  |  |
| --- | --- |
| **Resolution** | **Example Use** |
| **640 × 480 (VGA)** | Old computer screens |
| **1280 × 720 (HD)** | Standard HD screens |
| **1920 × 1080 (Full HD)** | Modern TVs and monitors |
| **4K (3840 × 2160)** | High-resolution displays |

**6. Comparing Bitmap and Vector Images**

|  |  |  |
| --- | --- | --- |
| **Feature** | **Bitmap Image** | **Vector Image** |
| **Storage** | Stored as pixels (grid) | Stored as mathematical shapes |
| **Scalability** | Loses quality when resized | Can be resized without losing quality |
| **File Size** | Larger for high resolution | Smaller for simple graphics |
| **Examples** | Photographs, screenshots | Logos, illustrations |

**Bitmap file formats**: PNG, JPEG, BMP, GIF.  
**Vector file formats**: SVG, AI, EPS.

**A-Rated Questions/Answers By Examiner**

**Q1: How many colors can a 3-bit per pixel image display?**

**Answer:** A **3-bit image** can display **8 colors**, since **23=82^3 = 823=8**.

**Q2: How many bits are required to store a 10 × 10 image with 2-bit color depth?**

**Answer:**

10 × 10 × 2 = 200 bits

or

25 bytes(since1byte = 8bits)

**Q3: What is the main difference between a bitmap and a vector image?**

**Answer:**

* **Bitmap images** are made of **pixels** and lose quality when resized.
* **Vector images** use **mathematical formulas** and can be resized without losing quality.

**Q4: Convert the binary color code 110 (3-bit color depth) to decimal. What color does it represent?**

**Answer:**

* 110₂ = 6₁₀
* If using a **grayscale palette**, 6 represents a **dark gray**.

**Q5: Why do high-resolution images require more storage?**

**Answer:** Higher resolution means **more pixels**, and each pixel needs to be stored as a **binary value**. This increases the **file size** of the image.

### Write your Answers on your Notebook and Verify it on Next Screen

**Q6: How many bytes are needed to store a 1920 × 1080 image with a 24-bit color depth?**

**Q7: What are the advantages and disadvantages of using a bitmap image?**

**Q8: How does increasing the color depth affect an image?**

**Q9: Convert the RGB value (128, 64, 32) into its 24-bit binary representation.**

**Q10: Why do vector images not lose quality when resized?**

**6. Answer:**

* **Formula:**  
  **Total bits = Width × Height × Bits per pixel**  
  **Total bits = 1920 × 1080 × 24 = 49,766,400 bits**
* Convert bits to bytes:  
  **49,766,400 ÷ 8 = 6,220,800 bytes (≈ 6.22 MB)**

**Answer:** A **1920 × 1080** image with **24-bit color** requires approximately **6.22 MB** of storage.

**7. Answer:**

**Advantages:**

* **High detail and color accuracy**, making it ideal for photos.
* **Widely supported** across different software and devices.

**Disadvantages:**

* **Large file sizes**, especially for high-resolution images.
* **Loss of quality when resized**, leading to pixelation.

**Answer:** Bitmap images offer **high detail** but have **large file sizes** and **lose quality when resized**.

**8. Answer:**

* **Higher color depth = More colors available** → Produces more realistic images.
* **Increases file size**, since each pixel requires more bits.
* **Example:**
  + **8-bit image**: 256 colors.
  + **24-bit image**: 16.7 million colors (True Color).

**Answer:** **Increasing color depth improves image quality** but **increases file size**.

**9. Answer:**

1. Convert each color channel (R, G, B) into **8-bit binary**:
   * **128 (Red) →** 10000000
   * **64 (Green) →** 01000000
   * **32 (Blue) →** 00100000
2. Combine them:  
   **10000000 01000000 00100000**

**Answer:** **(128, 64, 32) in 24-bit binary is** 10000000 01000000 00100000.

**10. Answer:**

* **Vector images are stored as mathematical equations,** not pixels.
* When resized, the software **recalculates the shapes and curves**, keeping them sharp.
* **Bitmap images, on the other hand, become pixelated when stretched.**

**Answer:** **Vector images use mathematical formulas**, allowing them to be **resized without losing quality**.