Multimedia

The word multi and media are combined to form the word multimedia. The word “multi” signifies “many.” Multimedia is a type of medium that allows information to be easily transferred from one location to another. It is the presentation of text, pictures, audio, and video with links and tools that allow the user to navigate, engage, create, and communicate using a computer.

**Representing Images**

**Digital images Representation**

A digital image representation refers to the way in which visual information is encoded and stored in a digital format. There are two main types of digital image representations:

1. **Bitmap/Raster Graphics (Digital Images)**: These are composed of a grid of pixels, where each pixel represents a specific color or grayscale value. Examples include photographs, scanned images, and bitmapped graphics.
2. **Vector Graphics**: These are mathematically defined geometric shapes and lines represented using equations and curves. Examples include logos, illustrations, icons, and fonts.

**Bitmap/Raster Graphics (Digital Images)**: **Digital Image**

In bitmap/raster graphics, an image is composed of a grid of pixels, where each pixel represents a specific color or grayscale value. The image data is stored as a collection of these pixel values, typically in a raster scan order (row by row, top to bottom). Bitmap images are made up of a grid of pixels, each of which is assigned a color and arranged in a pattern to form the image.

A black and white crossword puzzle

Description automatically generatedTo create the picture, a grid can be set out and the squares colored (1 – black and 0 – white). In order for the computer to interpret the image (create the grid), it has to have what is called metadata.

What is a Metadata?

The metadata must be located in a fixed position of the image file, so it can be found and read by any software that displays or uses it. Usually, the metadata is found at the beginning of the file in an area that is referred to as the **file header**.

Metadata includes the **file header** with data about the file itself, such as:

* file type
* date created
* author
* including image size
* number of colours, etc.

An image file also includes metadata about the image data itself, such as:

* the height and width of the image - this defines how many rows and columns the pixels are to be arranged in.
* the resolution
* the colour depth

Without this metadata, the image data would not be correctly interpreted, meaning the image could not be correctly displayed

One way to organize image metadata is by using the Exif (exchangeable image file format) specification, which includes a wide range of metadata tags, such as detailed camera settings and time and date information.

**Key characteristics of raster graphics:**

Resolution-dependent: Image quality depends on the number of pixels (resolution).

Pixel-based: Each pixel has a specific color or grayscale value.

Bitmap/Raster format: Examples include JPEG, PNG, BMP, TIFF, etc.

Suitable for complex images like photographs, digital art, and scanned images.

**What is a Pixel**

To store an image on a computer, the image is broken down into tiny elements called pixels. A pixel (short for picture element) and it is the smallest element found in a digital display or image. **(Tiny dots that makes up an image or electronic display)**.

A pixel (picture element) is the smallest addressable unit on a display or in a digital image. Each pixel represents a specific color value. The color value of a pixel is determined by its bit depth or color depth.

In order for the computer to store the image, each pixel is represented by a binary value. We call this representation of colours a “bit-plane”.

**Bit Depth/Color Depth:**

Bit depth, also known as color depth or pixel depth, refers to the number of bits used to represent the color of a single pixel. The higher the bit depth, the more colors can be represented.

Common bit depths include:

* 1-bit 1 bit per pixel (0 or 1): two possible colours (Black and white) (monochrome/black and white)
* 2 bits per pixel (00 to 11): four possible colours (Red, Blue, Green White)
* 3 bits per pixel (000 to 111): eight possible colours
* 4 bits per pixel (0000 – 1111): 16 possible colours
* 6 bits per pixel (0000 0000 0000 0000 – 1111 1111 1111 1111): over 65 0000 possible colours
* 8-bits per pixel (00000000- 11111111) (256 colors)
* 24-bit per pixel (16.7 million colors)
* 32-bit per pixel (16.7 million colors with an additional 8 bits for alpha transparency)

Resolution

Two Types

* Image Resolution - how many pixels an image contains per inch/cm
* Screen Resolution - the number of pixels per row by the number of pixels per column.

**Image Resolution:**

Image resolution refers to the number of pixels in an image, expressed as width × height. Image quality is affected by the resolution of the image.

The higher resolution means more pixels, resulting in a sharper and more detailed image. A high-resolution image has more pixels, so it looks a lot better when it is enlarged or stretched. The higher the resolution of an image, the larger its file size will be. It is expressed as dots per inch (dpi), or pixels per inch (ppi), eg:

• 72dpi = 72 dots per inch

• 200 ppi = 200 pixels per inch

In a low-resolution image, the pixels are larger and therefore, fewer are needed to fill the space. Low resolution, or low-res, images will appear pixelated and blurred after printing – even though they might look perfect on your computer screen. That’s because there aren’t enough pixels per inch to maintain a sharp image at large document dimensions.

Screen Resolution:

Screen resolution refers to the number of pixels that can be displayed on a screen or monitor. It is expressed in the same way as image resolution (width × height). Common screen resolutions include 1366×768, 1920×1080 (Full HD), and 3840×2160 (4K).

Screen resolution, also known as display resolution, refers to the number of pixels that screens can display both vertically and horizontally. The images of display models like smartphones, tablets, digital televisions, and computer monitors are made of thousands of pixels (px).

The more pixels the screen has, the more information users can see with less scrolling.

A screen might have

• Low resolution: Low-resolution screens have fewer pixels

• High resolution: High-resolution screens have more pixels

• Smart resolution: This is a recommended resolution that saves power

## The main difference between low and high resolution is in that high-resolution screen can show more of what needs to be displayed without having to do much scrolling.

## However, it also means that the text, images and icons presented on high-resolution screens will be sharper as well. The higher the resolution, the more pixels are available so the picture is more sharper and clearer.

Calculating file size of a Bitmapp image

To calculate the file size of a bitmap image, you need to consider the following factors:

1. **Image Dimensions**: The width and height of the image in pixels.
2. **Bit Depth**: The number of bits used to represent the color information of each pixel. Common bit depths are 1 (monochrome), 4 (16 colors), 8 (256 colors), and 24 (true color with 16.7 million colors).
3. **Color Channels**: For color images, there are multiple color channels, typically three (Red, Green, Blue) or four (Red, Green, Blue, **Alpha**).

***(What is a alpha channel****?)*

*The alpha channel in an image refers to an additional channel that stores transparency information for each pixel. It is used to create smooth transparency effects and to allow the background to show through partially transparent pixels.*

*In a typical RGB (Red, Green, Blue) image, each pixel has three color channels that represent the intensity of red, green, and blue light. The alpha channel is an additional fourth channel that specifies the opacity or transparency level of each pixel. The alpha channel values typically range from 0 to 255 (or 0 to 1.0 in floating-point representations):*

* *An alpha value of 0 means the pixel is fully transparent (invisible).*
* *An alpha value of 255 (or 1.0) means the pixel is fully opaque (solid).*
* *Intermediate values between 0 and 255 represent varying levels of transparency, allowing for smooth blending between the image and the background.*

*Images with an alpha channel are often referred to as having an "RGBA" color model, where "A" stands for "Alpha" or transparency. These images have four channels instead of three (RGB) and require more memory and storage space compared to images without an alpha channel.*

*The alpha channel is particularly useful in various applications, such as:*

* *Image compositing: Allowing seamless integration of multiple images or layers by controlling the transparency of each layer.*
* *User interfaces: Creating visually appealing interfaces with transparent or semi-transparent elements, such as windows, menus, or icons.*
* *Graphics and design: Enabling advanced effects like drop shadows, glows, and smooth edges in graphic design and digital artwork.*
* *Video editing: Blending videos with background images or other video clips using transparency masks.*

*The alpha channel provides an additional level of control over pixel transparency, enabling more realistic and sophisticated visual effects in digital imaging and graphics applications.)*

The formula to calculate the file size of a bitmap image is as follows:

File Size (in bytes) = (Width × Height × Bit Depth) / 8

For a true color (24-bit) bitmap image with no alpha channel, the formula becomes:

File Size (in bytes) = Width × Height × 3

Calculate a bitmap image with a width of 1024 pixels, a height of 768 pixels, and a bit depth of 24 (true color).

File Size = 1024 × 768 × 24 / 8

= 2,359,296 bytes

= 2.25 MB (approximately)

**Note** that the above calculation doesn't consider any additional metadata or compression that may be applied to the image file format. It represents the raw, uncompressed bitmap data size.

In practice, most image file formats like JPEG, PNG, or GIF apply compression algorithms to reduce the file size while maintaining reasonable image quality. The actual file size on disk may differ from the calculated value due to the compression method used.

**Important to note** that the formula given above does not explicitly take color channels into account. This formula calculates the file size based solely on the image dimensions (width and height) and the bit depth, which represents the number of bits used to store the color information for each pixel.

The bit depth implicitly accounts for the number of color channels. For example:

* For a monochrome (black and white) image, the bit depth is typically 1, representing 2 possible colors (black or white).
* For an image with 256 colors, the bit depth is typically 8, allowing for 2^8 = 256 different color values.
* For a true color image with 16.7 million colors, the bit depth is typically 24, which is achieved by having 3 color channels (Red, Green, Blue) with 8 bits per channel (8 bits × 3 channels = 24 bits).

So, while the formula doesn't explicitly mention color channels, the bit depth value encapsulates the information about how many color channels are used and how many bits are allocated for each channel.

However, for true color images with an alpha channel (for transparency), you need to adjust the formula to account for the additional alpha channel. In that case, the formula becomes:

File Size (in bytes) = (Width × Height × Bit Depth × Number of Channels) / 8

For a true color image with an alpha channel (32 bits per pixel), the formula would be:

File Size (in bytes) = Width × Height × 32 / 8

= Width × Height × 4

Here, the bit depth of 32 is divided into 4 channels: Red (8 bits), Green (8 bits), Blue (8 bits), and Alpha (8 bits).

So, while the original formula doesn't explicitly mention color channels, it relies on the bit depth value to implicitly account for the number of color channels used in the image.

Example

Calculate the file size of a bitmap image with the following specifications:

* Width: 1920 pixels
* Height: 1080 pixels
* Bit Depth: 24 bits (true color, RGB)

To calculate the file size without considering the alpha channel, we use the formula:

File Size (in bytes) = Width × Height × Bit Depth / 8

File Size = 1920 × 1080 × 24 / 8

= 6,220,800 bytes

= 6.22 MB (approximately)

**With Alpha Channel (RGBA)**

* Width: 1920 pixels
* Height: 1080 pixels
* Bit Depth: 32 bits (true color with alpha channel, RGBA)

File Size (in bytes) = Width × Height × Bit Depth

File Size = 1920 × 1080 × 32

= 8,294,400 bytes

= 8.29 MB (approximately)

In this case, the file size is larger than the previous example because each pixel requires 32 bits (4 bytes) of data to store the RGB color information and the alpha (transparency) value.

Note that these calculations assume an uncompressed bitmap format. In practice, most image file formats (e.g., JPEG, PNG, GIF) apply compression algorithms to reduce the file size, and the actual file size on disk may be different from the calculated value.

**VECTOR Graphics**

Vector graphics are a type of digital imagery that uses mathematical equations and geometric primitives (basic shapes) to represent images. Unlike raster graphics, which store images as a grid of pixels, vector graphics store images as a series of drawing commands or instructions.

These images tend to be smaller than bitmap images because a bitmap image has to store color information for each individual pixel that forms the image, with the vector image it just has to store the mathematical formulas that make up the image, which take up less space.

**Drawing Objects**

In vector graphics, images are created using basic drawing objects or primitives/basic shapes. These drawing objects are the fundamental building blocks of vector graphics. Some common drawing objects include:

1. **Lines**: are the most basic drawing object in vector graphics. They are defined by their start and end points, which are specified using coordinate pairs (x, y). Lines can have different stroke properties, such as
   * Color
   * Width
   * line style (solid, dashed, dotted, etc.).
2. **Curves**: Created using mathematical equations such as
   * Bézier Curves: Defined by control points and tangent lines. They are widely used in vector graphics and fonts due to their smooth and precise nature.
   * Splines: Curves that pass through a set of specified points, providing more control over their shape.
   * Quadratic and Cubic Curves: Curves defined by one or more control points, respectively, in addition to their start and end points. such as Bézier curves or splines.
3. **Shapes**: Geometric shapes
   * Rectangles: Defined by their position, width, and height.
   * Circles and Ellipses: Defined by their center point, radius (for circles), and major and minor axes (for ellipses).
   * Polygons: Defined by a series of connected line segments, forming a closed shape with any number of sides.
   * Stars and Polygrams: Specialized polygons with intersecting lines or curves, creating star-like shapes.like rectangles, circles, ellipses, and polygons.
4. **Text**: Text objects that can be scaled, rotated, and styled without losing quality. Text objects are defined by their content (characters), font family, size, style (e.g., bold, italic), and other typographic properties.
5. Groups and Layers  
   Most vector graphics applications allow grouping multiple drawing objects together, treating them as a single unit. This simplifies editing and manipulation, as the entire group can be transformed or styled simultaneously.

Layers are another organizational tool in vector graphics, allowing you to separate drawing objects onto different layers, enabling better control over visibility, stacking order, and editing.

Properties  
Each drawing object in vector graphics has associated properties that define its appearance and behavior. Some common properties include:

* + Fill: The interior color, gradient, or pattern of a shape or text object
  + Stroke: The outline or border of an object, defined by its color, width, and line style.
  + Opacity: Controls the transparency level of an object.
  + Transformations: Properties that control the position, rotation, scaling, and skewing of an object.
  + Blending Modes: Determine how an object blends with the objects behind or in front of it.
  + Filters and Effects: Various effects like drop shadows, glows, and blurs can be applied to drawing objects.

**Drawing List**

The drawing list, also known as the display list or the render list, is a sequential list of drawing commands or instructions that specify how a vector graphic should be rendered or displayed. It serves as a structured representation of the vector graphic, containing all the necessary information about the drawing objects, their properties, and their order of rendering.

The drawing list typically follows a hierarchical structure, where drawing objects can be nested within other objects or groups. This hierarchical structure allows for efficient editing, manipulation, and reuse of objects within the vector graphic.

The components and structure of a drawing list:

1. **Drawing Commands**: Each entry in the drawing list is a drawing command that corresponds to a specific drawing object or operation. Examples of drawing commands include:
   * Draw a line
   * Draw a rectangle
   * Draw a curve (e.g., Bézier curve)
   * Draw text
   * Apply a transformation (e.g., translate, rotate, scale)
   * Push/pop group (for nested objects)
2. **Object Properties**: Along with the drawing command, each entry in the drawing list may also include properties or attributes associated with the drawing object. These properties define the appearance and behavior of the object, such as fill color, stroke style, opacity, and transformations.
3. **Drawing Order**: The drawing list maintains the order in which drawing objects should be rendered. Objects at the beginning of the list are drawn first, and subsequent objects are drawn on top of the previously rendered objects. This order is crucial for achieving the desired visual representation, especially when objects overlap or when transparency is involved.
4. **Grouping and Nesting**: The drawing list supports grouping and nesting of drawing objects. Groups are treated as a single unit, allowing for efficient manipulation and transformation of multiple objects simultaneously. Nested groups and objects are processed in a specific order, ensuring correct rendering and handling of overlapping and transparency.
5. **Coordinate System**: The drawing list operates within a defined coordinate system, typically using Cartesian coordinates (x, y) or another appropriate coordinate system for the specific vector graphics application.

**Advantages of Vector Graphics**

Vector graphics offer several advantages over raster graphics:

1. Can be scaled to any size without losing quality or becoming pixelated.
2. Smaller file sizes compared to high-resolution raster graphics.
3. Individual drawing objects and their properties can be easily modified, enabling efficient editing and manipulation.
4. Not tied to a specific resolution, making them suitable for various output devices and media. (image independence)

Vector graphics, while offering several advantages over raster graphics, also have some limitations and disadvantages.

1. vector graphics are excellent for simple shapes and illustrations, rendering highly complex graphics with numerous intricate details can be computationally expensive and slow. Raster graphics may be more efficient for handling extremely complex imagery.
2. Use a limited color depth resulting in banding or harsh transitions in gradients and color blends, especially when working with images that require smooth color transitions.
3. Not well-suited for representing highly detailed, photographic, or natural imagery. Raster graphics are better at capturing the nuances and details found in photographs and natural scenes.
4. Formats like SVG (Scalable Vector Graphics) are widely supported, some older software or devices may have limited or no support for vector graphics, potentially causing compatibility issues.
5. Editing tools may have limited capabilities compared to raster graphics editing software, especially when it comes to advanced image manipulation techniques like blending modes, filters, and advanced color adjustments.
6. Some printing devices or output technologies may not handle vector graphics as efficiently as raster graphics, potentially leading to quality issues or longer processing times.
7. Primarily two-dimensional, and while some vector graphics software supports basic 3D capabilities, they are generally not as robust or feature-rich as dedicated 3D modeling and rendering software.
8. Excel in certain areas like logo design, typography, and technical illustrations, they may not be the best choice for other applications like photo editing, video editing, or scientific imaging, where raster graphics are more commonly used.

Vector graphics are widely used in applications such as illustration, logo design, technical drawings, cartography, and user interface design, where scalability, editability, and resolution independence are essential.