# 1.2 Multimedia: Graphics

A large part of using modern computers involves sending pictures and films to each other, along with using a graphical user interface. All of this involves computers saving and processing images.

Bitmapped Graphics

- In bitmapped graphics, the image is divided into a grid of picture elements or **pixels,** each pixel containing a colour value.

- They are characterised by only two parameters, the number of pixels and the information content (colour depth) per pixel.

- When an image is loaded, the binary codes that represent the colour of each pixel are transferred to memory. The term bitmap comes from the way that each binary code is 'mapped' to a single location in memory.
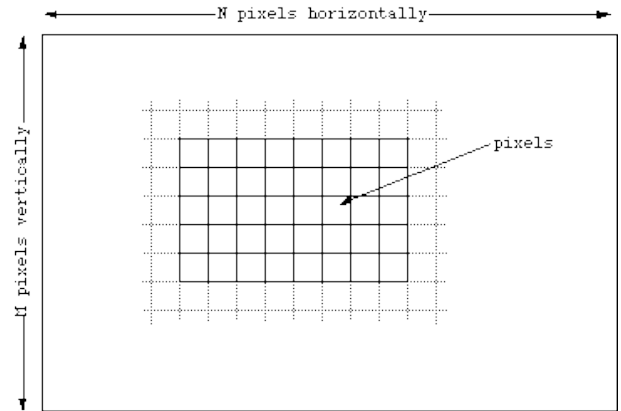
In bitmap graphics, the picture is made up of a series of square pixels of different colours. The colours available determine the type of bitmap:
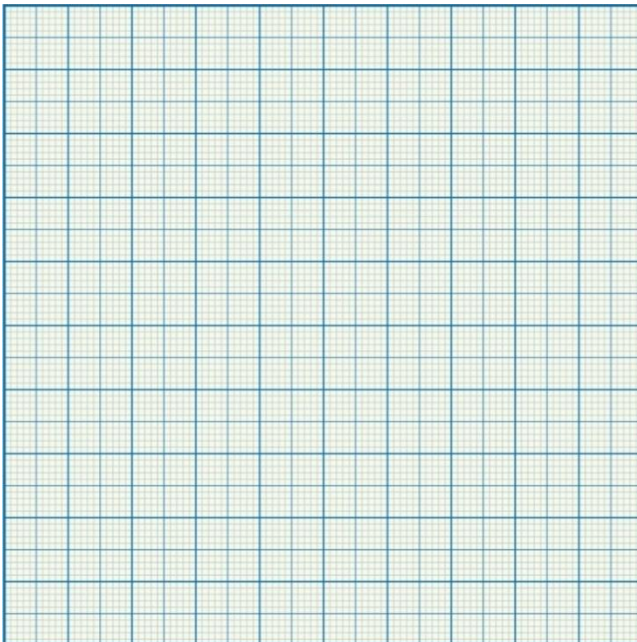
```
1 0 0 0 0 0 0 0 0 0 0 0
0 0 1 0 0 0 0 0 0 0 0 0
1 0 0 0 1 0 1 0 1 0 0 0
0 0 1 0 0 0 0 1 1 1 0 0
1 0 0 0 0 0 1 0 0 0 1 0
0 0 0 0 0 1 1 1 1 1 1 1
0 0 0 0 0 1 0 0 0 0 0 1
0 0 0 0 0 1 0 0 1 1 1 1
0 0 0 0 0 1 0 0 1 0 0 1
0 0 0 0 0 1 0 0 1 1 1 1
0 0 0 0 0 1 0 0 1 0 0 1
0 0 0 0 0 1 0 0 1 1 1 1
0 0 0 0 0 1 0 0 1 1 1 1
0 0 0 0 0 1 0 0 0 0 0 1
0 0 0 0 0 1 0 0 0 0 0 1
0 0 0 0 0 1 1 1 1 1 1 1
```

This graphic show how graphics are stored in the computer's memory; the picture is drawn on a 16 x 12 grid. Grid squares which are 'on' are represented by a '1' and grid squares that are 'off' are represented by a '0'. The amount of memory required to store this graphic would be 16 x 12 bits, which is 192 bits.

Terminology Associated with Bitmaps

Pixels: an individual picture element is the smallest possible addressable area defined by a solid colour, represented as binary and stored as bits, in an image.

A bitmapped image is encoded by assigning a solid color to each pixel. Each pixel will be a single colour intensity and saturation
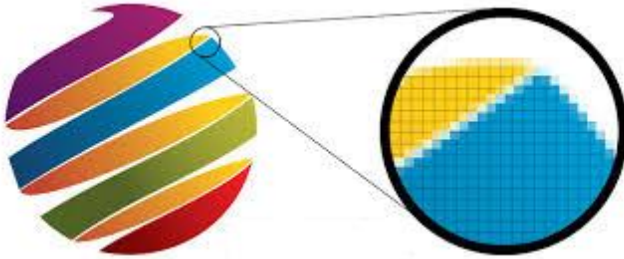

This example shows a Bitmap image with a portion greatly enlarged, in which the individual pixels are rendered as little squares and can easily be seen.

All bitmap images are stored as an array of pixels. A monochrome bitmap will store a 1 for a black pixel and 0 for a white pixel (or vice-versa depending on the encoding protocol).

This image could be represented by the following 35 binary digits (5 bytes):

00100 01010 01010 10001 11111 10001 00000

It would also be necessary to store the dimensions of the image.
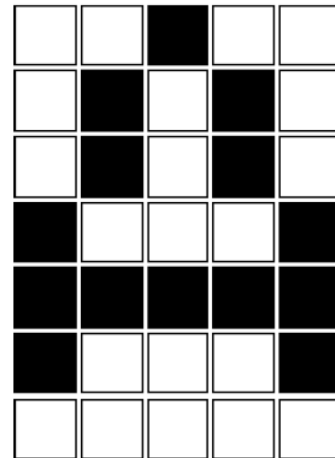
File Header: out of data (block of bytes) at the beginning of the file and is used to identify the file. A typical application reads this block first to ensure that the file is actually a BMP file and that it is not damaged.
It varies between the file formats, but generally defines the contents of the file and list specific file attributes.

BMP File Format
Also known as bitmap image file or device independent bitmap (DIB) file format or simply a bitmap, is a raster graphics image file format used to store bitmap digital images, independently of the display.

The BMP file format is capable of storing two-dimensional digital images both monochrome and color, in various color depths, and optionally with data compression, alpha channels, and color profiles

Size	Purpose
2 bytes	The first 2 bytes of the BMP file format are the character "B" then the character "M" in ASCII encoding. **BM** – Windows 3.1x, 95, NT, ... etc.
4 bytes	The size of the BMP file in bytes
2 bytes	Reserved; actual value depends on the application that creates the image
2 bytes	Reserved; actual value depends on the application that creates the image
4 bytes	The offset, i.e. starting address, of the byte where the bitmap image data (pixel array) can be found.

Metadata: Image files usually also contain metadata. Metadata means 'data about data' and provides information about the image.

The information includes:

- filename
- file format - eg JPEG, GIF or PNG
- dimensions
- resolution
- colour depth
- time and date the image was last changed
- camera settings when the photo was taken

Image Resolution: how many pixels an image contains per inch/cm.
measured in dots per inch (dpi); this value determines the amount of detail an image has
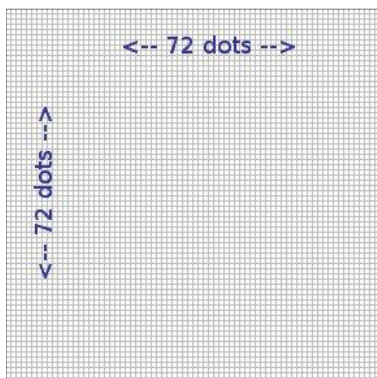
Resolution is often given in dots per inch e.g. an image is 72 dots per inch. This means that there are 72 dots in each inch running horizontally, and 72 dots in each inch running vertically.

Therefore in this image which is of 1 inch x 1 inch, there would be

72 x 72 = 5184 pixels

In this image,
Each row contains 500 pixels and there are 1200 rows.
Resolution describes the image size as the number of pixels it contains,

Image Resolution = width x height

= 500 x 1200

= 600,000 pixels (pixels or individual dots of color)

Suppose a graphic to be stored is 1 inch by 2 inches, and contains 90dpi.

The Image resolution is = (1 inch x 90dpi)x (2 inch x 90dpi)

= 90 x 180

=16,200 pixels

Screen Resolution: the number of pixels per row by the number of pixels per column
The screen resolution or monitor resolution tells you how many pixels your screen can display horizontally and vertically.

This is the value quoted for a monitor specification, such as 1024 x 768. The larger the numbers, the more picture elements will be displayed

The VDU screen is also divided into pixels. The higher the resolution of the display, the greater the number of pixels for the given screen. Having more pixels does not make an image sharper, but the size of each pixel does. The smaller the pixels on screen, the better.

Typical display resolutions are,

- 1440 x 900
- 1024 x 768
- 800 x 600
- 640 x 480
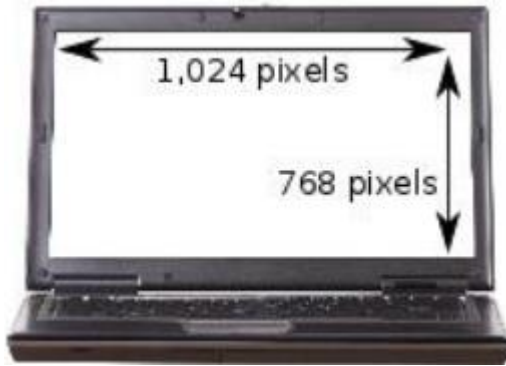
Work out how many pixels are required to display a single frame on this VGA screen.

Screen Resolution = width x height

Height = 768 Width = 1024

Area = width * Height = Total Pixels

Area = 768 * 1024 = 786,432 pixels

Similarly Pixels per inch (PPI) is a measurement used to define the resolution of a computer display. This metric evaluates the picture/image quality that a particular computing or output display device is able to display.

For example:
Monitor which is 14 x 10 inches (screen dimensions) and 1440 x 900 (resolution in pixel), will have 1440/14 = 102.9 pixel per inch (ppi) on the horizontal axis and 900/10 = 90 (ppi) in the vertical axis.

Bit depth

Bit depth also known as **colour depth**, is either the maximum number of bits used to represent the colour of single pixel., in a bitmapped image or video frame buffer, or the number of bits used for each color component of a single pixel.

The more bits, the greater the range of colours that can be displayed and therefore have better colour quality.

To control the color of each pixel on the screen, the operating system must dedicate a small amount of memory to each pixel. In aggregate this memory dedicated to the display screen is often referred to as "video RAM" or "VRAM" (Video Random Access Memory).

There are multiple different colour formats:

Monochrome (Black and White)

At a very simple level each pixel could be controlled by one bit. This means that each pixel is mapped to one bit in memory. Bit count could be set to either zero (0) or one (1) representing on or off which in this case would be black and white.
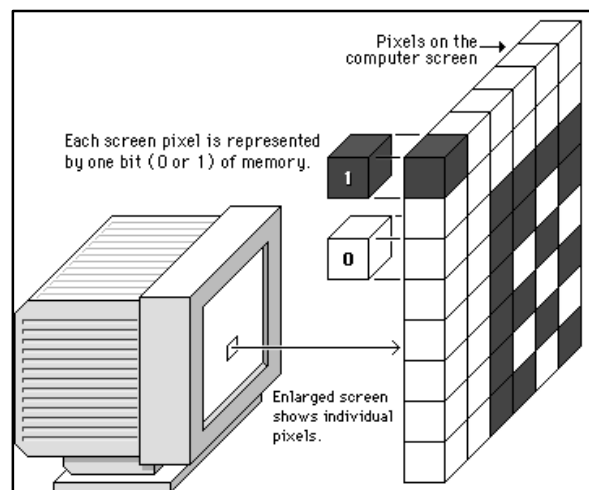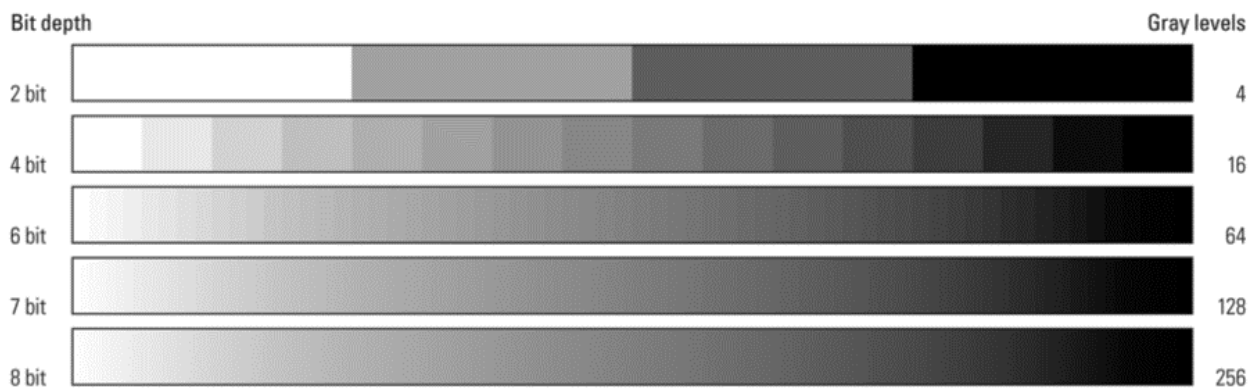
Grayscale images

To get more than two gray values, we need a code with more than one bit per pixel.

1 - Bit		2 - Bit		3 - Bit	
■	0	■	00	■	000
□	1	■	01	■	001
		■	10	■	010
		□	11	■	011
				■	100
				■	101
				■	110
				□	111

The number of possible gray levels is controlled by the number of bits/pixel, or the 'bit depth' of the image.

Grayscale images commonly have 256 different gray values, numbered 0 - 255. Each pixel can then be stored in 8 bits, or 1 byte. [00000000 → 11111111]

0 = black   255 = white

256 Colours (8 Bit Colour)

A byte is used to represent a palette of 256 colours.

If more bits of memory are dedicated to each pixel in the display, more colors can be managed. When 8 bits of memory are dedicated to each pixel, each pixel could be one of 256 colors.

(256 = 2^8; in other words, 256 is the maximum number of unique combinations of 0s and 1s you can make with 8 bits.)

This kind of computer display is called an "8-bit" or "256-color" display, and is common on older laptop computers and desktop machines.
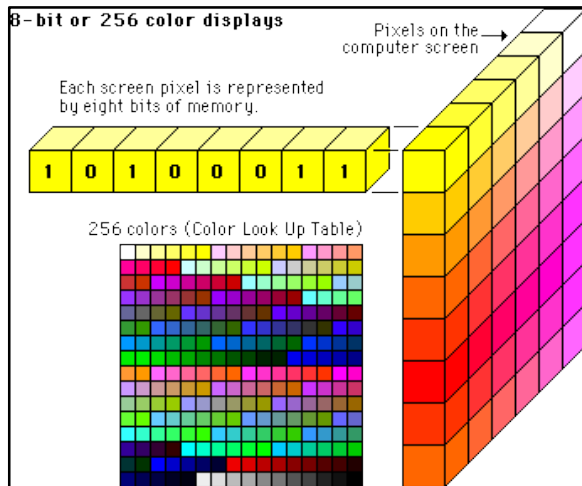

This format allows each pixel to be one of the 256 colours stored in the palette, and due to the palette being saved with the file it makes it a slightly bigger file than it would normally be.

True-color (24-bit)

If still more memory is dedicated to each pixel, nearly photographic color is achievable on the computer screen. "True-color" or "24-bit" color displays can show millions of unique colors simultaneously on the computer screen.

True-color images are composed by dedicating 24 bits of memory to each pixel; 8 each for the red, green, and blue components (8 + 8 + 8 = 24)
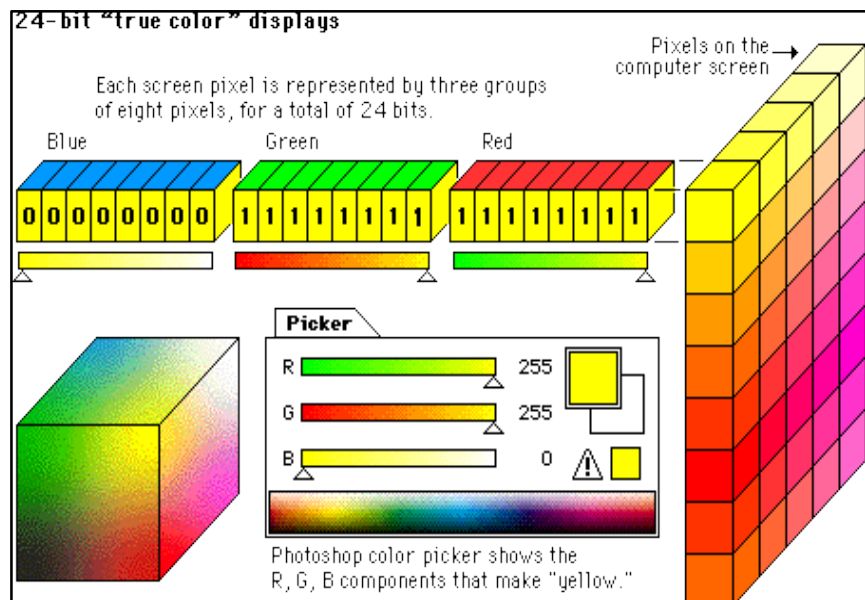
Colour depth	Description	Number of colours per pixel
1 bit	Mono-chrome, only stores black and white	$2^1=2$
2 bit	Stores 4 colours:	$2^2=4$
4 bit	Stores limited colours	$2^4 = 16$
8 bit	Close to reality	$2^8 =256$
24 bit	Hard to see any difference between reality	$2^{24} =16777216$

Perform calculations:

Estimating the file size for bitmapped images of different resolutions

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File size = Resolution (number of pixel) ×Bit Depth (colour depth)

$$\text{File size} = \frac{\text{(Horizontal pixels × Vertical pixels) × Bit Depth}}{\text{8(to convert to bytes) × 1024 (kilobytes)}}$$