A-Level
Computer Science

Images

Lesson Objectives

Students will learn:

- How images are stored and displayed
- What the different types of images are
- What properties determine the quality of an image
- Resolution and pixel density
- How to estimate the size of an image file
- Metadata of an image file

1.

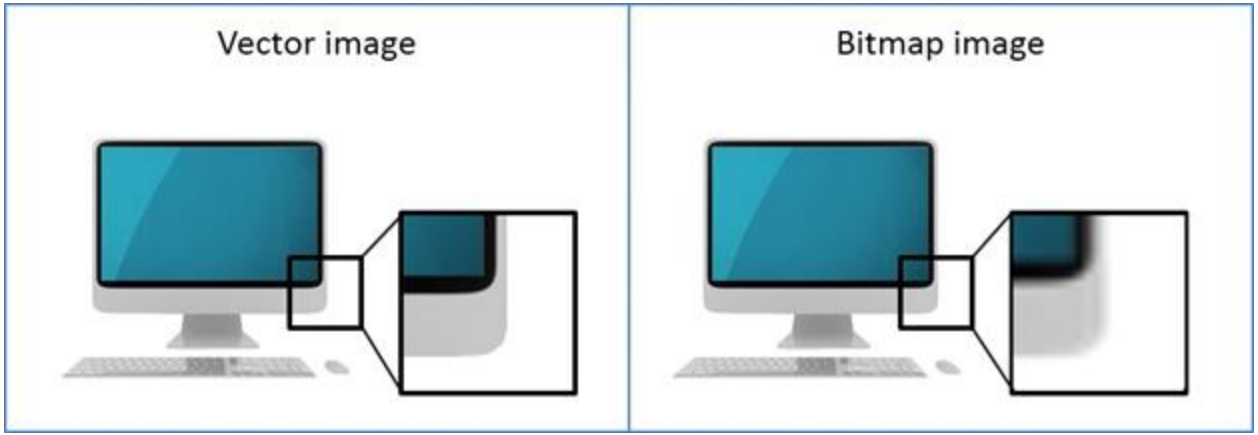
Content

What is an image made of?

- Images are made of tiny elements called pixels (picture elements).
- The higher the number of pixels, the higher the resolution of the image will be; therefore, more memory is occupied by the image.

Types of image format

- There are two types of image files: Bitmaps and Vectors.



Bitmaps

- Bitmap images, also known as pixel maps or raster graphics, are made of an organised grid of coloured squares called pixels.
- When bitmaps are enlarged or zoomed in, the pixels are over-stretched, and the image loses quality.
- JPEG, GIF and PNG are a few examples of bitmaps. These file formats are widely used in digital cameras and smartphones.
- The colour of each pixel in an image is stored as a binary value. For a black-and-white image, the colour white is represented using the binary value 1 and black is represented using 0.

Vectors

- A vector uses coordinates and geometrical shapes such as lines and curves to define an image.
- Hence, a vector image is more efficient than a bitmap image, as it needn’t store a binary value for each pixel.
- Vector images do not lose resolution when scaled.
- A vector image contains a drawing list in its file header. It consists of:
  - A command that describes the shape of the object
  - Attributes of each object such as position, line colour, the thickness of a line, fill colour

Vectors

- A vector uses coordinates and geometrical shapes such as lines and curves to define an image.
- Therefore, a vector image is more efficient than a bitmap image as it needn’t store a binary value for each pixel.
- Vector images do not lose resolution when scaled.
- Scalable Vector Graphics (SVG) is an example of a vector image. It is an open standard.
- Vector graphics are widely used in animated movies, Adobe Portable Document Format (PDF), AutoShapes in MS-Office, etc.

Vectors

- For example,
  - Circle (centre = 0,0; radius = 5; fill = green; bordercolour = black; weight = 2 px)
  - Rectangle (position = 3,10; width = 10; height = 5; fill = blue; bordercolour = None)
- When vector images are printed, they are converted to bitmap image so that image matches the format supported by printers.
- Scalable Vector Graphics (SVG) is an example of a vector image. It is an open standard. Vector graphics are widely used in animated movies, Adobe Portable Document Format (PDF), AutoShapes in MS-Office, etc.

Bitmap	Vector
Made of tiny pixels	Uses coordinates and geometrical shapes such as lines and curves to define an image
When bitmaps are enlarged or zoomed in, the pixels are over-stretched, and the image loses quality.	Vector images do not lose resolution when scaled.
Pixels can be edited without changing the design of the image.	To edit vector images, the geometric shape needs to be changed. Individual pixels cannot be modified.
Larger file size	Does not require a large file size. Easier to transmit or load.
The image is more realistic.	Image is not very realistic.
Examples: .jpeg, .bmp and .png	Examples: .svg, .cgm and .odg

Bitmaps vs. vectors

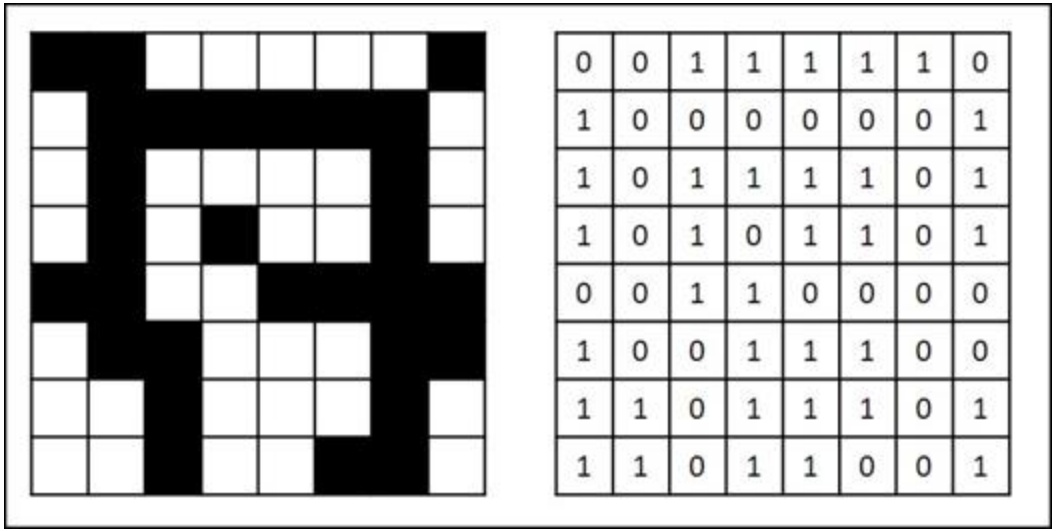
- Based on the requirement, it can be chosen whether to use a vector image or bitmap image.
- For example, if the image is expected to be resized, then the vector image is suitable as bitmaps may lose quality due to resizing.
- If images need to look more realistic, then bitmap images are used.
- If there are restrictions to the size of the file, then vector images are preferred.
- To modify photographs, bitmap images are preferred.

Storing and displaying images

- Irrespective of the type of image, all images are displayed as a grid of pixels when the output is through a monitor or printer.
- A vector image is rasterised or converted to a grid of pixels for display.

Storing a black-and-white image

- The computer stores binary value 1 for white and binary value 0 for black for each row of the image.
- This process becomes complex when the number of rows and columns of the image increases, and different colours are included.



0	0	1	1	1	1	1	0
1	0	0	0	0	0	0	1
1	0	1	1	1	1	0	1
1	0	1	0	1	1	0	1
0	0	1	1	0	0	0	0
1	0	0	1	1	1	0	0
1	1	0	1	1	1	0	1
1	1	0	1	1	0	0	1

Colour Depth

- Colour depth is the number of bits used to indicate the different colours of a pixel.
- In case of a black-and-white image, the colour depth is 1.
- A 2-bit colour depth can represent four different colours.

Binary code	Colour
00	Black
01	Dark grey
10	Light grey
11	White

Colour depth

- As the number of bits increases, more colours can be used.
- An image with colour depth n can represent 2^n different colours.
- Most computer systems and digital systems use a 24-bit system that can represent over 16 million colours per pixel.
- With an increase in colour depth, the size of the file also increases.

Colour depth: Example

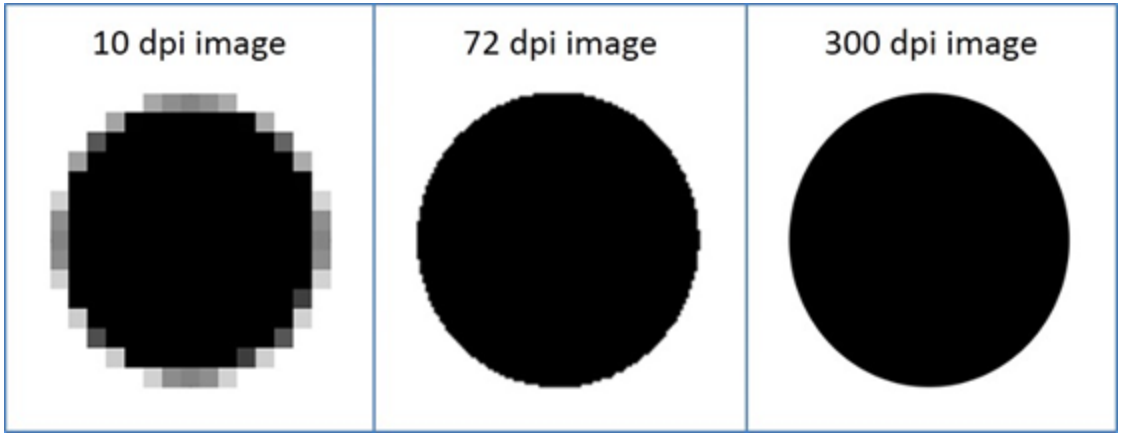
Resolution

- The image resolution is the number of pixels that make up an image.
- Screen resolution is the number of horizontal pixels and the number of vertical pixels that make up a screen display.
- For example, if the screen resolution is lower than the image resolution, the image will be displayed at a lower quality by removing some pixels or cropping the image or sometimes, rotating the image. However, the image with lower resolution gets pixelated when we try to zoom in or enlarge it.

Resolution

- The pixel density of an image is measured in dots per inch or pixel per inch. It is the number of pixels or dots in a unit.
- Magazines and books have higher resolution compared to the images on a computer screen.
- An image on a website usually has a resolution of 72 dpi. An image in a book has a resolution of 300 or even 600 dpi.
- An image with a resolution of 300 dpi contains a grid of 300 pixels wide and 300 pixels high in a grid.

Resolution



Pixel density

- Pixel density for a screen is calculated using the following steps.
- Calculating the pixel density of Samsung Galaxy S10 phone which has a resolution of 1440 × 3040 pixels and a 6.1 inches display

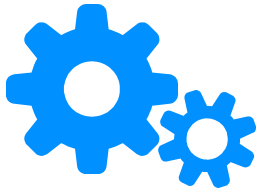
i. Add the squares of resolution sizes, $1440^2 + 3040^2 = 11315200$

ii. Taking the square root of the result in (i), $\sqrt{11315200} = 3363.81$

iii. Divide by the screen size, $3363.81 \div 6.1 = 551$ ppi (pixels per square inch)

Estimating the size of image file

- The size of an image file is estimated by multiplying the width and height of the image in pixels and colour depth in bits per pixel.



Estimating an image file size: Example

height = 1010 pixels, width = 562 pixels & colour depth = 8 bits.

File size = 1010 × 562 × 8 = 4540960 bits

4540960 ÷ 8 = 567620 bytes = 0.568 megabytes

Compression

- Even though the calculated file is 0.567 MB (in the previous slide), the actual file size is considerably less when the image is stored in the form of a jpg.
- This is because of file compression. Large areas of similar data are compressed.

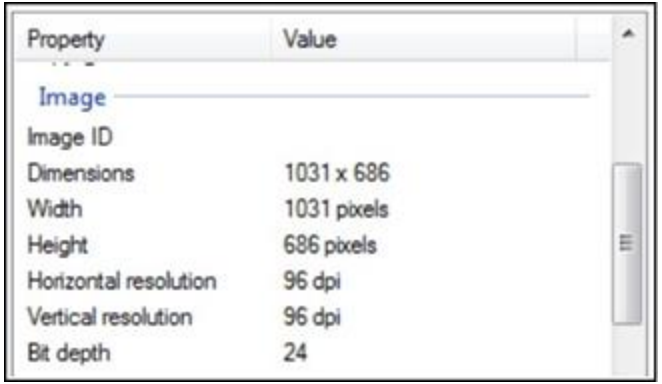
Metadata

Metadata is ‘data about data’. An image file has metadata that stores information such as:

- Filename and format
- Dimensions, resolution & colour depth of the image
- Date and place when the photo was taken
- Time and date when the photo was changed
- Camera settings when the photo was taken

Metadata

- Photos captured using a mobile phone when GPS is ON, automatically stores the location exactly where this photo is taken.
- With an image's metadata, we can find the date, time and location where a photo was captured.
- A part of the metadata is shown.



Property	Value
Image	
Image ID	
Dimensions	1031 x 686
Width	1031 pixels
Height	686 pixels
Horizontal resolution	96 dpi
Vertical resolution	96 dpi
Bit depth	24

Let’s review some concepts

Image

Images are made of tiny elements called pixels (picture elements).

Two types: Bitmaps and vectors

Colour Depth

Colour depth is the number of bits used to indicate the different colours of a pixel.

An image with colour depth n can represent 2^n different colours.

Image types

In bitmaps, the colour of each pixel in an image is stored as a binary value. A vector uses coordinates and geometrical shapes such as lines and curves to define an image.

Resolution

The image resolution is the number of pixels that make up an image. Screen resolution is the number of horizontal pixels and the number of vertical pixels that make up a screen display.

Displaying images

Irrespective of the type of image, all images are displayed as a grid of pixels when the output is through a monitor or printer.

Pixel density

It is the number of pixels or dots in a unit.

Metadata

Metadata is ‘data about data’.

2.

Activity

Activity-1

Duration: 10 minutes

1. Estimate the file size of an image file with the height of 1210 pixels, width of 729 pixels and a colour depth of 16 bits.
2. The actual size of an image file in question 1 that is stored in a computer is less than the calculated value. Why?
3. How many different colours can be represented by a colour depth of 16 bits?

3.

End of topic questions

End of topic questions

1. What are the two different file formats available for an image file? How are they different?
2. What is the resolution of the image file?
3. What information is stored in metadata of an image file?
4. What effects are observed when the colour depth of an image file is increased?

End of topic questions

5. A bitmapped image for a logo in the shape of a home is given. This image consists of white, black, blue and green colours only.
   a) Why must we need at least two bits to represent each bit?
   b) A black pixel is coded as 00. The third line from the top is coded as 11001111 11001111.
      i. What is the coding for the 4th line from the top?
      ii. Calculate the minimum file size of this image in bytes.
      iii. What items do you require to store this image as a vector graphic?
      iv. What are the advantages of storing an image as a vector graphic?

End of topic questions

6. Calculate the pixel density of Apple iPad Pro, which has a resolution of 2732 × 2048 pixels and a 12.9 inches display.