Graphics 1

Representing Graphical Data

Cunliffe & Elliott, chapter 4
Chapman & Chapman, chapters 3,4

Representing Graphical Data

- Logical and Physical Representation
- Use of colour:
  - Pixels
  - Colours
  - Transparency
  - Palettes
- Types of representation:
  - Bitmaps
  - Vector data
  - Other ways

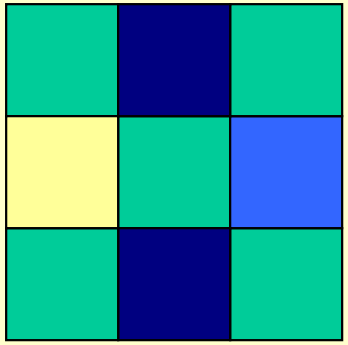
Logical / Physical Representation

- Physical representation of graphical data is how it *actually* appears on devices
- A virtual representation of graphical data may be in a graphics file, or internally in a program
- We may also have a logical representation of the data's structure in our minds
  - These are often not the same!
  - The differences vary from slight to very large
- Converting from a virtual representation to an actual display on a device is called *rendering.*

Pixels

- Smallest logical unit of display on the screen
- Can be monochrome (black and one colour) or coloured

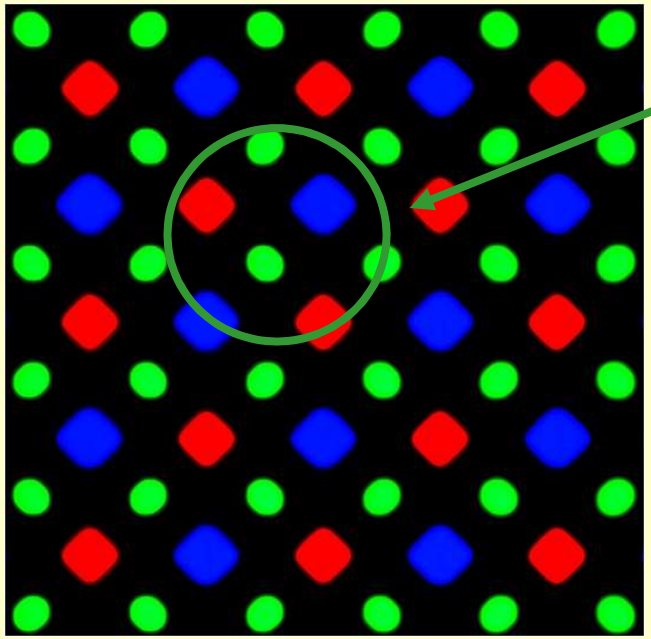
3 x 3 array of coloured pixels



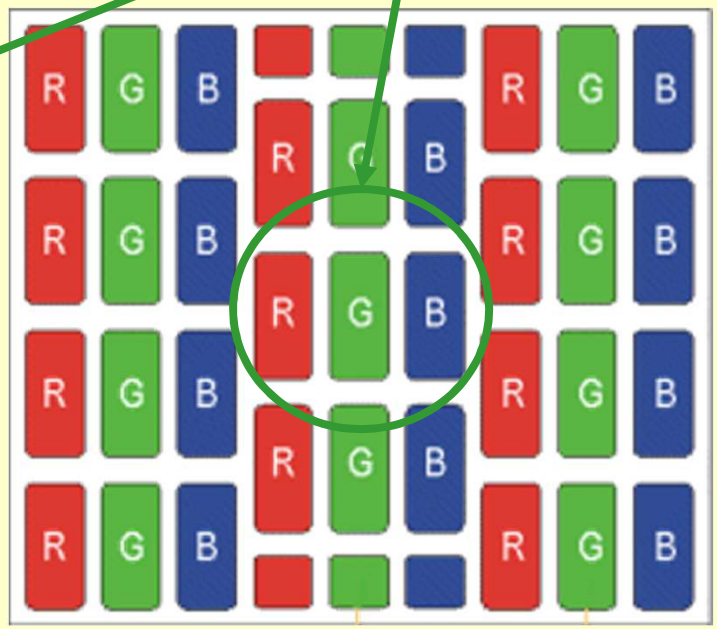
- Arranged (logically!) in a 2D grid

Pixels

- Physical display is different!
- Not necessarily a perfect 2D grid:



OLED



LCD

Colours of Pixels

- Black/white pixels are represented using bits
- Colours are specified using colour code values in some way
- A typical format (RGB) is using 24 bits format
  - (R,G,B) takes up 1 byte for each colour
- A common feature these days is to also have an *alpha channel* , specifying a level of transparency. e.g. in Java 2
  - (R,G,B,α) takes up 4 bytes
  - see *Chapman & Chapman p 135*

Transparency

Colour Terminology

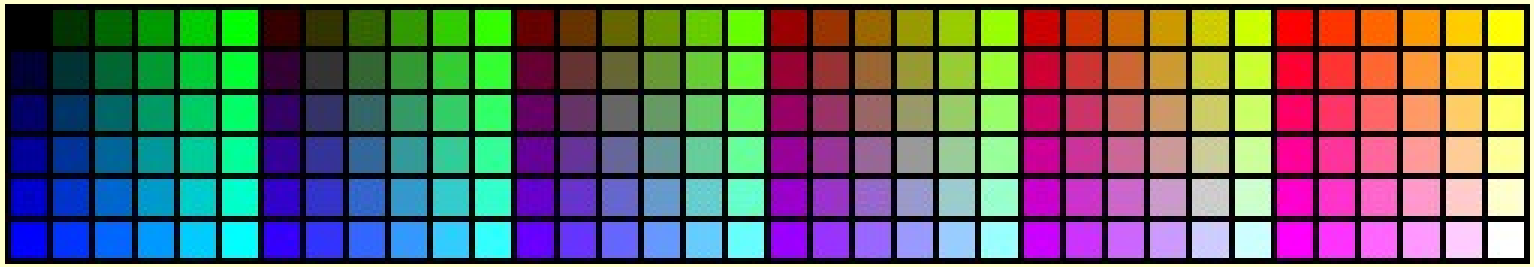
Lots of confusion:

- "Black and white" not good terminology to use
- Black and white photographs are not just black/white, but really greyscale
- "Greyscale" refers to shades of grey, ie where the RGB values are all the same
- "Monochrome" refers not to one colour, but historically to "one colour with black", so "monochrome" really means two colours, usually black and white
- "Monochromatic" in colour blindness refers to greyscale!

Palettes

- A *palette* is a mapping from a small set of numbers, to specifically chosen colours from a wide range
  - 2^{24} typically
- "Indexed images" use palettes (as look-up tables)
- Used in various file formats, monitor displays

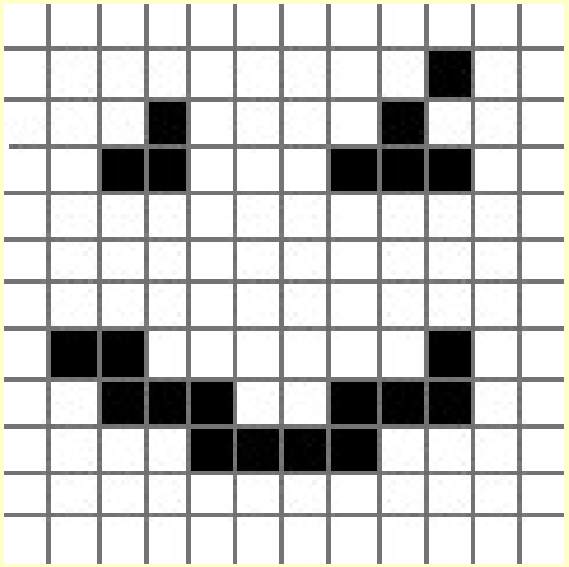
Example (web-safe palette, 216 colours):



One way to represent image data

- Bitmap data is (logically) a 2D array of pixels
- A *bitmap* gives the colours of the picture, pixel-by-pixel (bit-by-bit), in this example:

```
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 1 0 0
0 0 0 1 0 0 0 0 1 0 0 0
0 0 1 1 0 0 0 1 1 1 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 1 1 0 0 0 0 0 0 1 0 0
0 0 1 1 1 0 0 1 1 1 0 0
0 0 0 0 1 1 1 1 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0
```



Bitmaps

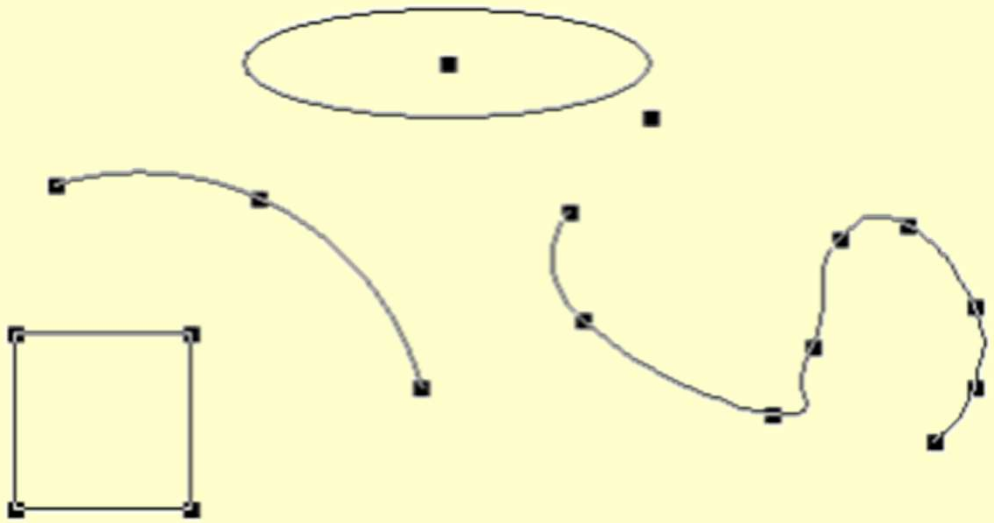
- A bitmap was also known (in ye olden days) as a *raster* (the term is still in use in some circumstances)
- When there used to be just monochrome monitors, bitmaps did indeed have bits in them!
- When colours were introduced, the term *pixelmap* was introduced for coloured images.
- Nowadays, “bitmap” can refer to 2D arrays of bits *or* colours.
- Logically, bitmaps are 2D arrays, although in fact they may be stored by other means
  - Java 2 uses a 1D `int` array

Graphical Data Representation

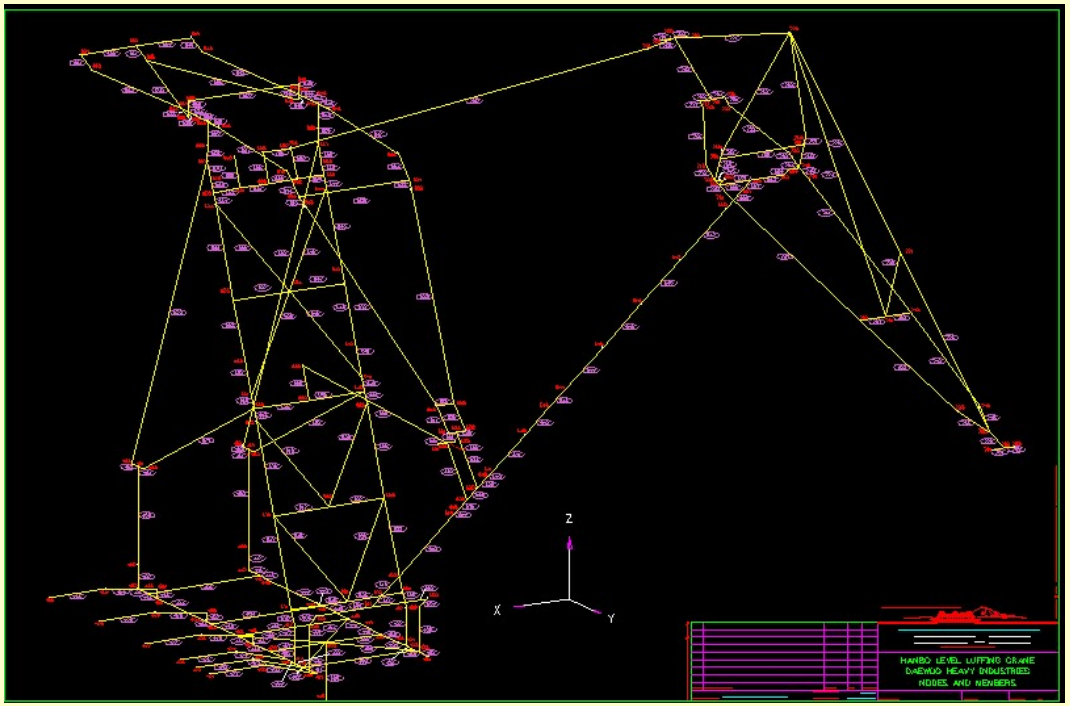
- Bitmaps have a fixed *resolution*
  - amount of detail in an image
- There are other ways of representing image data which do not have a fixed resolution:
  - some are general purpose
  - some are program-specific
  - some are application-specific
- In many state-of-the-art graphics programs, images are represented internally in an application-specific way, then exported to bitmap formats.

Another way to represent image data

- *Vector-based* formats contain descriptions of one or more objects, rather than pixels
- Uses a “draw-then-edit” method of image creation
- Often the objects are mathematically based
  - e.g. line segments, polygons, circles, splines



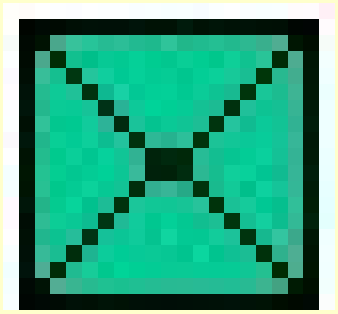
Computer-aided design



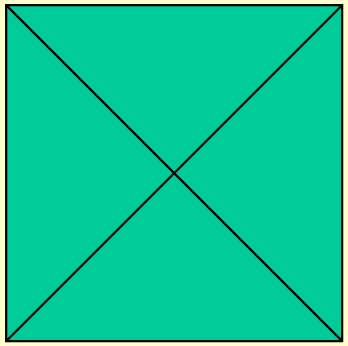
3D Worlds

Bitmap vs Vector

Bitmaps are fixed resolution

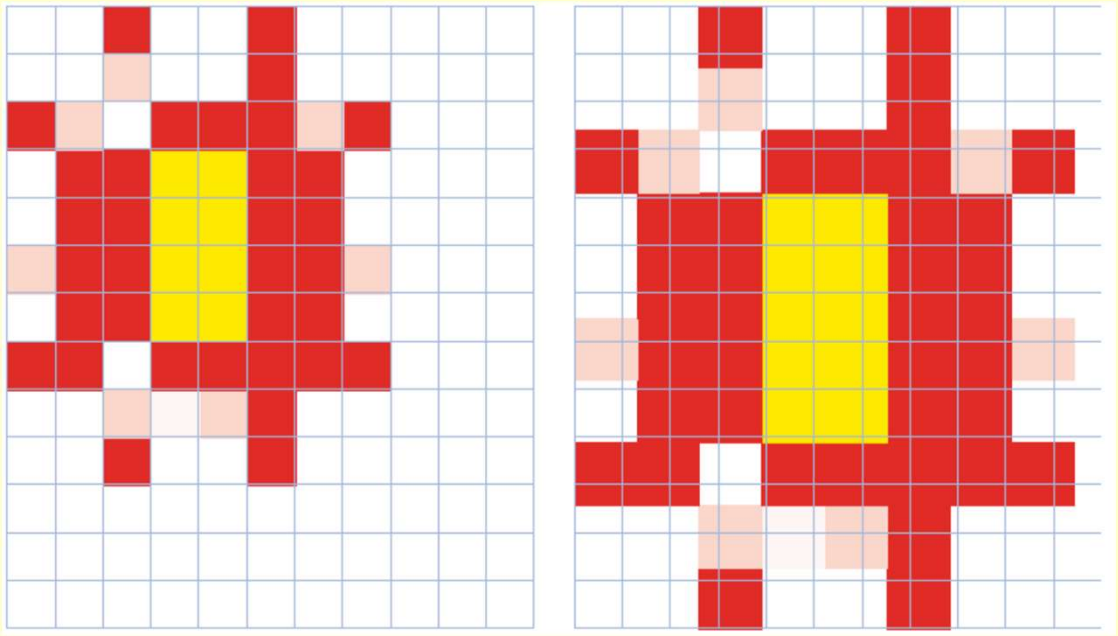


Vector images can be displayed at whatever level of detail is preferred



Scaling Bitmaps

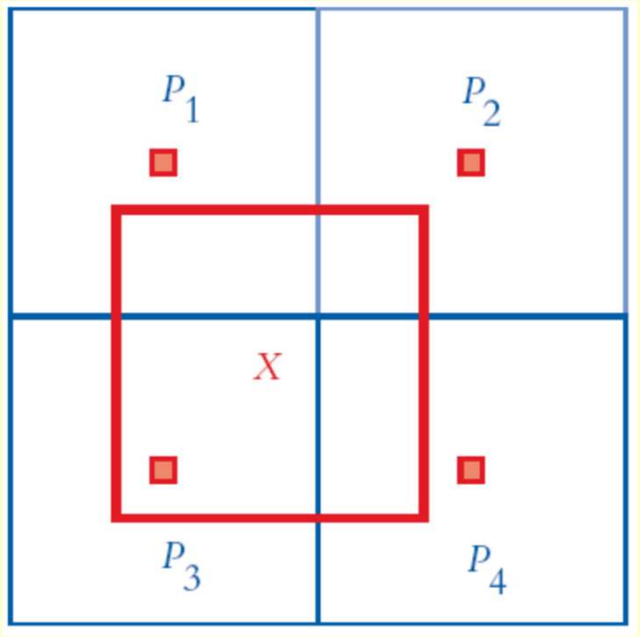
- Resampling
- Increase in size: add new pixels
  - upsampling
- Decrease in size: throw pixels away
  - downsampling



(Chapman & Chapman, Images © MacAvon Media Productions)

Scaling Bitmaps (2)

- How best to calculate new pixel colours?
  - Pixel interpolation
- Nearest neighbour
  - Choose colour of pixel with largest overlap
- Bilinear interpolation
  - Average colours of surrounding pixels
  - Weight by their level of overlap
- More complex mappings
  - Bicubic interpolation



(Image © MacAvon Media Productions)

Scaling Bitmaps (3)

Nearest neighbour

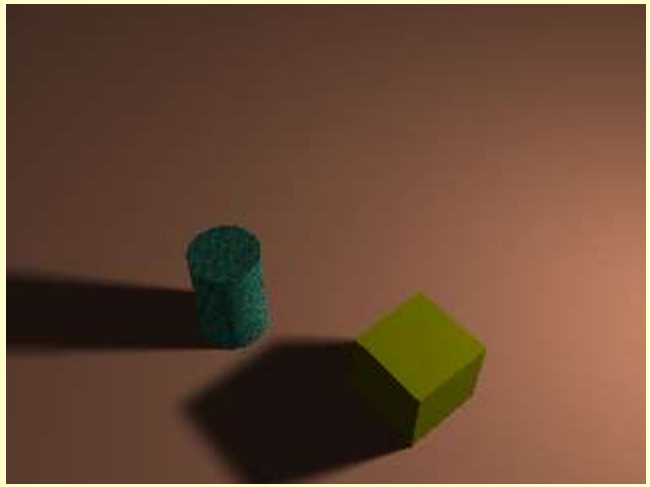
Bilinear interpolation

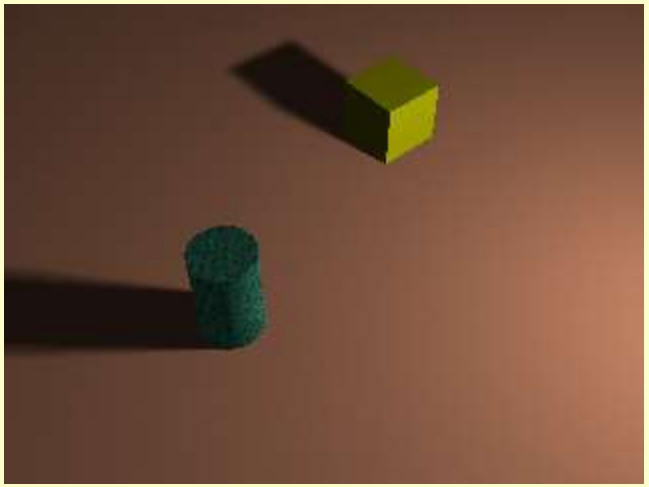
Bicubic interpolation

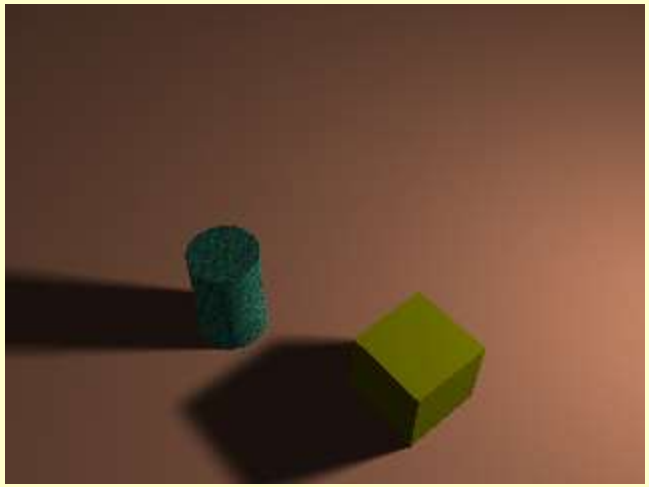
(Image © MacAvon Media Productions)

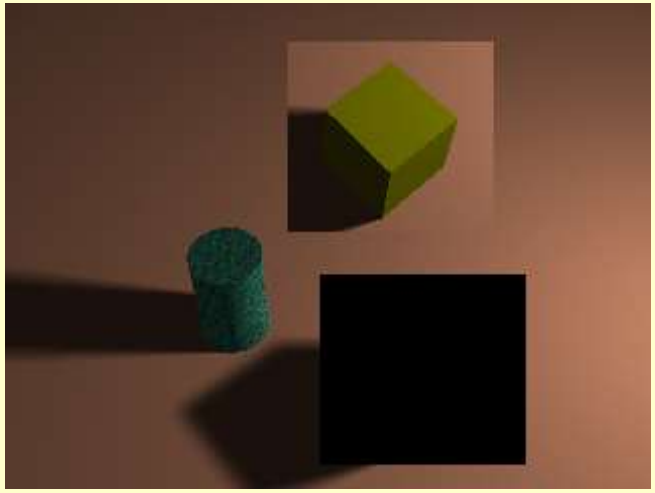
Bitmap vs Vector

Editing a vector file









…and with a bitmap?

Bitmap vs Vector

Further vector advantages:

- Good for storing images composed of line-based or 3D objects (e.g. wire-frame models)
- Easy to convert to bitmap format

Vector disadvantages:

- Not good for storing complex images (such as photographs)
- Appearance of image can vary widely, depending upon the application
- Rendering of the image may take significantly longer than for bitmaps

From Vectors to Bitmaps...

- Historically, vector data was used a lot.
- Pen plotters used pens to draw on paper (an early form of graphics printer)
- These were cheap and produced line-based drawings.
- Storage of high-volume bitmap files was expensive!

- With the advent of cheap storage, and high-resolution output, now most images are bitmap-based.
- Bitmaps are everywhere!
  - Just look at the WWW, with GIFs, JPEGs everywhere!

…and Back Again

- Trends are shifting towards a greater use of vector data - the bitmap trend may not last!
- Size is again an issue
  - big bitmaps take longer to transport over the Internet
- Vector-based formats are better for 3D imaging, and 3D imaging is growing more important
  - fuelled by such concerns as the entertainment industry

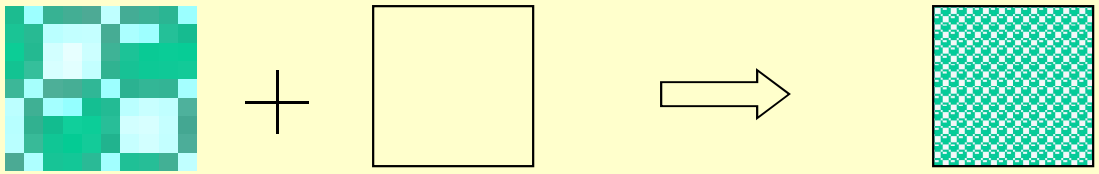
Other Graphics Representations

- Hybrid formats
  - e.g. Metafile formats
- Fractal representation techniques

- Animation formats
- Special purpose 3D formats

Metafile Formats

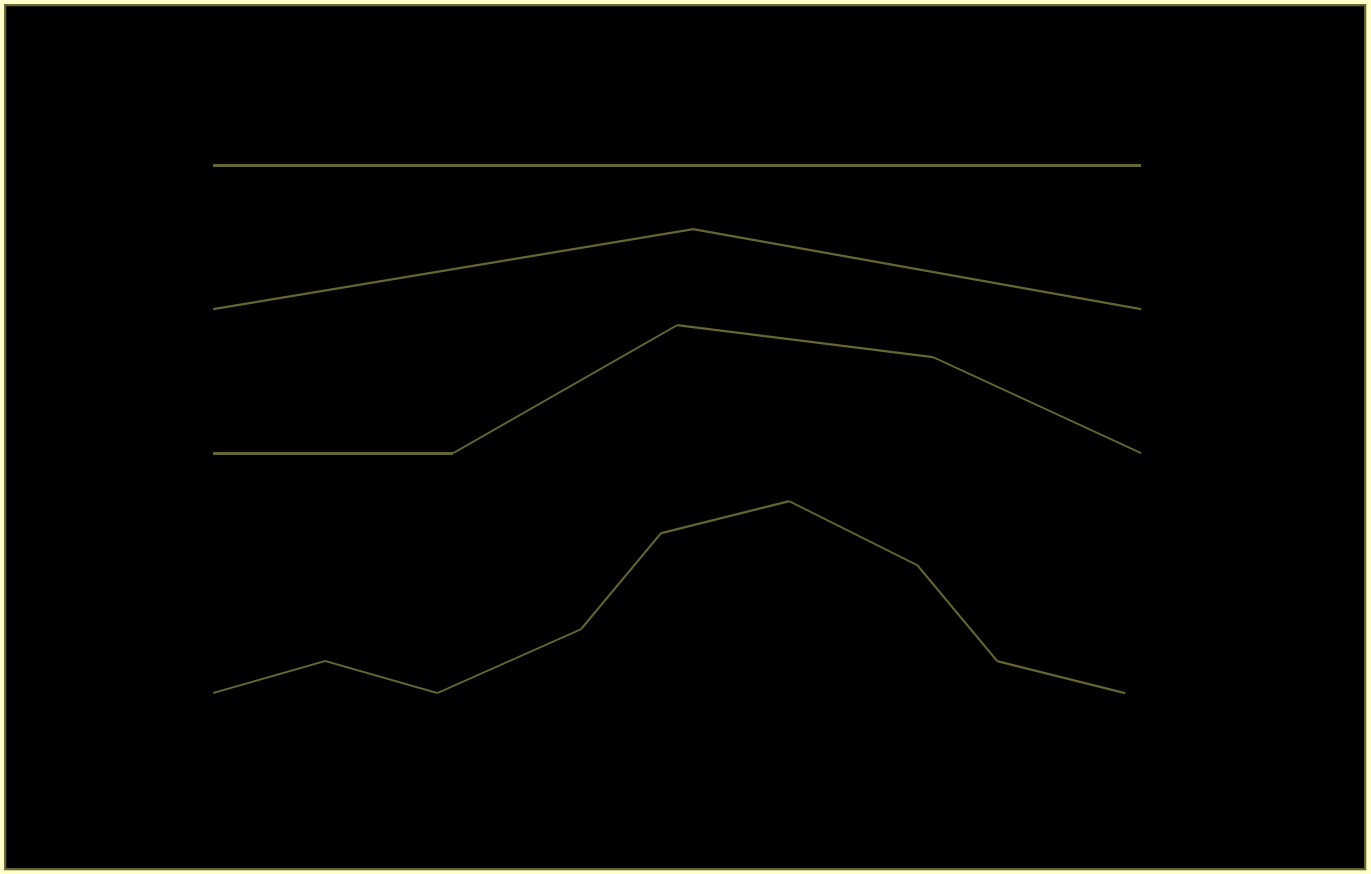
- A metafile can store both vector and bitmap data
- Typically most elements in the file are vectors, with the occasional bitmap
  - e.g. a bitmap stored as a “fill pattern” for a shape



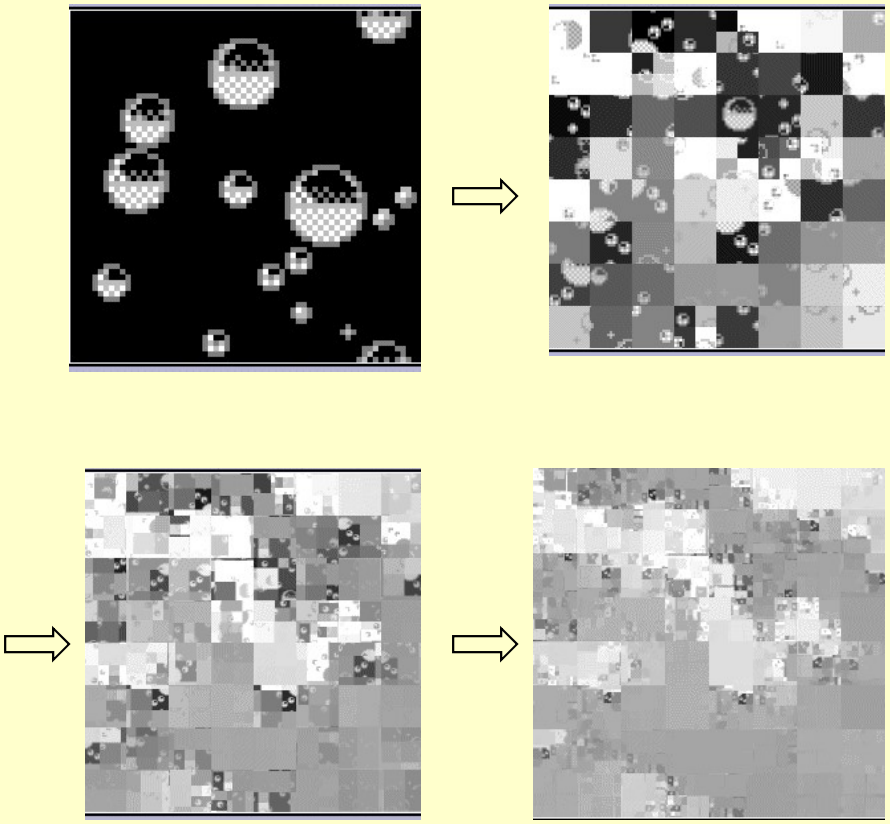
Fractal Image Representation

- An image (or part of an image) is represented by a mathematical formula
- To produce a display of the image on a device, the formula is repeatedly applied to a (maybe) blank "seed" image of the required size
- A resolution-independent way of storing images
- Takes less space than a bitmap
- Many real-world scenes can be described *fractally*

A Fractal Mountain



Fractal Clouds



Bitmap versus Fractals

Original bitmap x2

Fractal version x2

End of Lecture