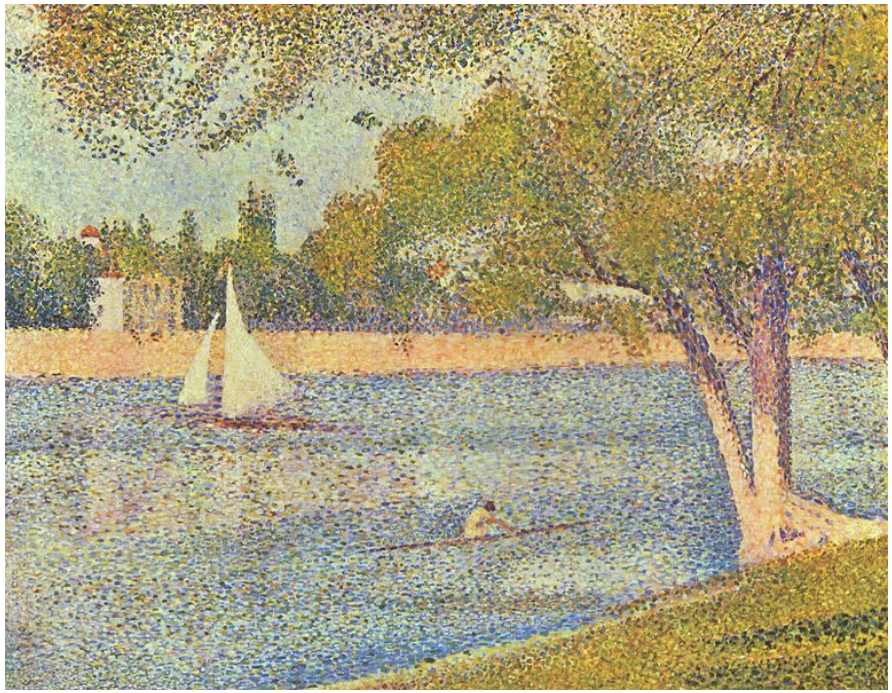
COMPSCI 111/111G
Digital Images and Vector Graphics

Lecture 13 SS 2019



The Seine and La Grande Jatte – Springtime
George Seurat 1888

Learning Outcomes

Students should be able to:

- Describe the differences between bitmap graphics and vector graphics
- Calculate the size in bytes of a bitmap image
- Compare and contrast different compression methods (jpeg, gif and png)

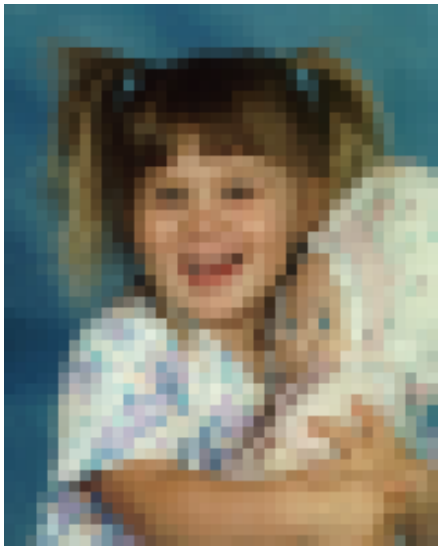
Bitmap Graphics

Storing pictures digitally

- Sample the image (divide into dots)
- Image resolution (number of dots)

200 x 250

40 x 50



20 x 25

http://en.wikipedia.org/wiki/Raster_graphics

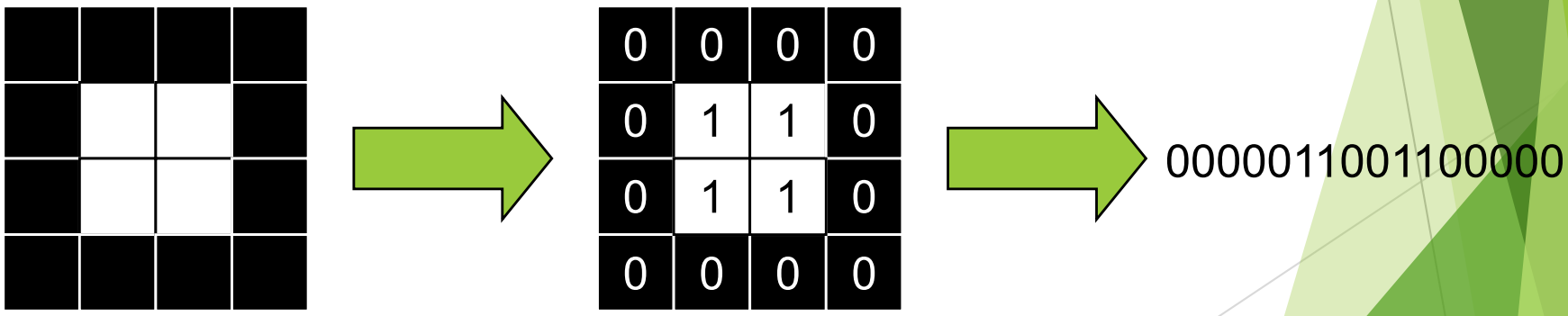
Black and White pictures

Digital Pictures consist of small dots

- Each dot is called a picture element (pixel)

Storing information

- Black and White are only two states
- Use bits to represent pixels (0 = OFF, 1 = ON)
- One to one mapping, so known as Bitmap



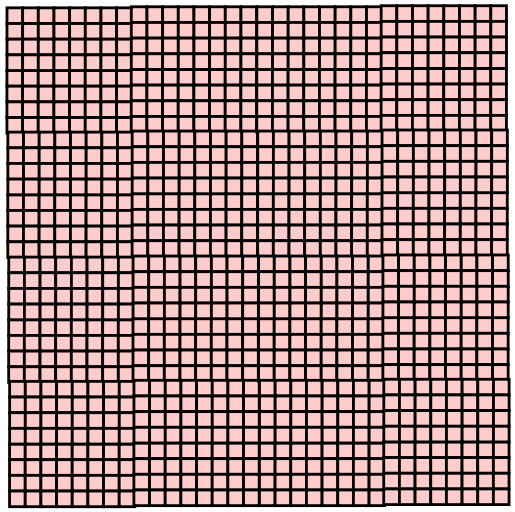
http://en.wikipedia.org/wiki/Pixel

Displaying images

Images are displayed on an output device

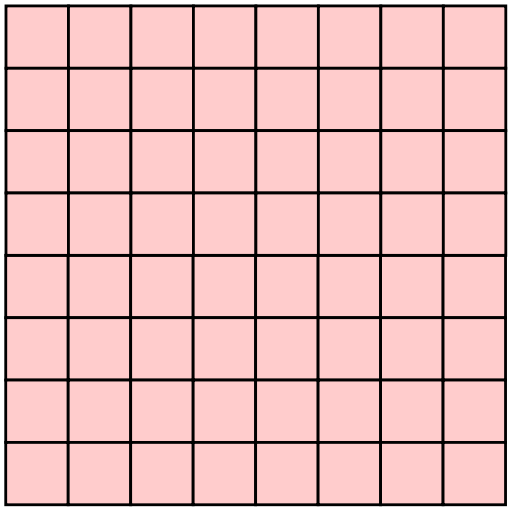
- Screen / Printer
- Physical devices have limitations

Printer



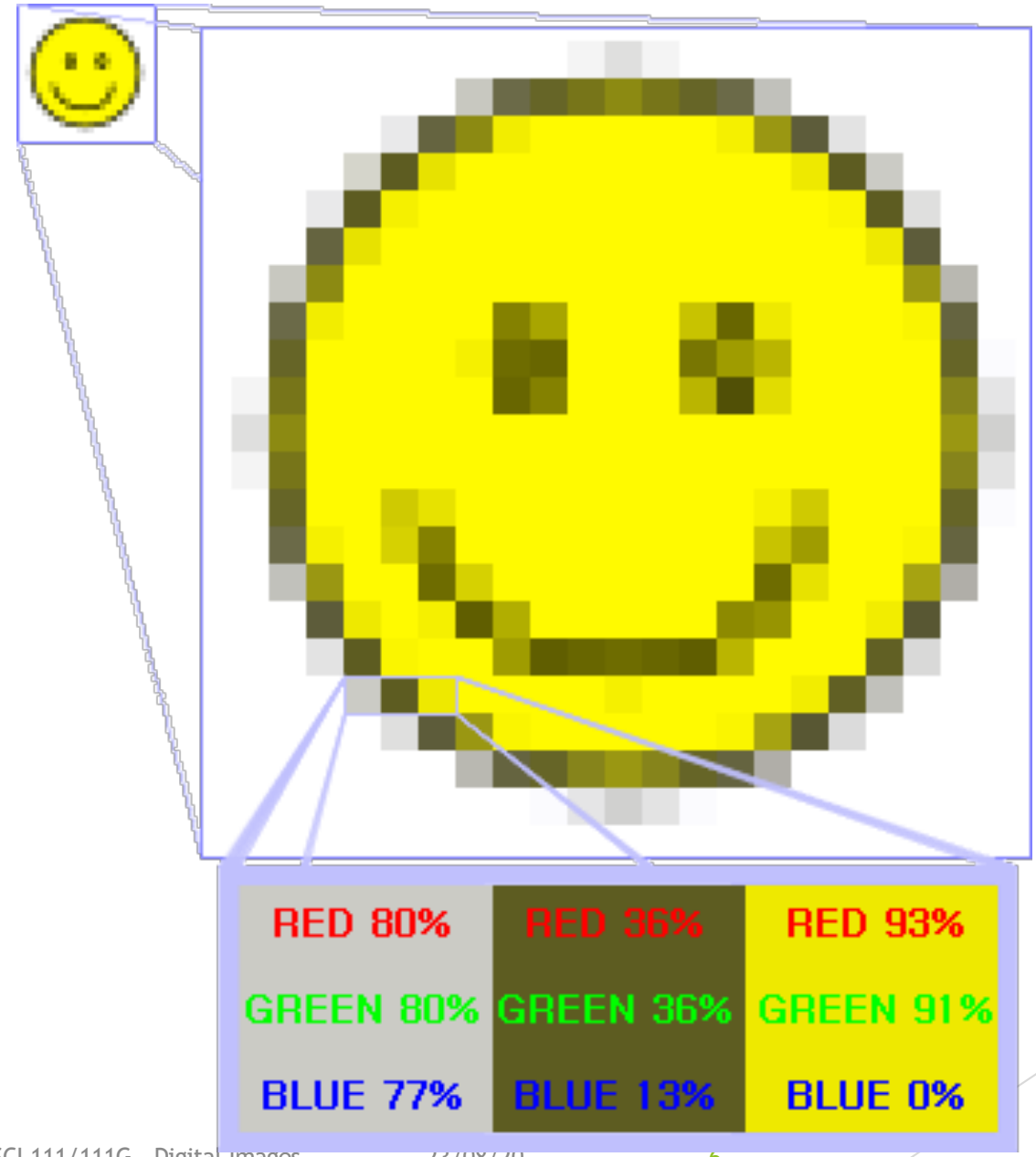
Very small dots

Screen



Large dots

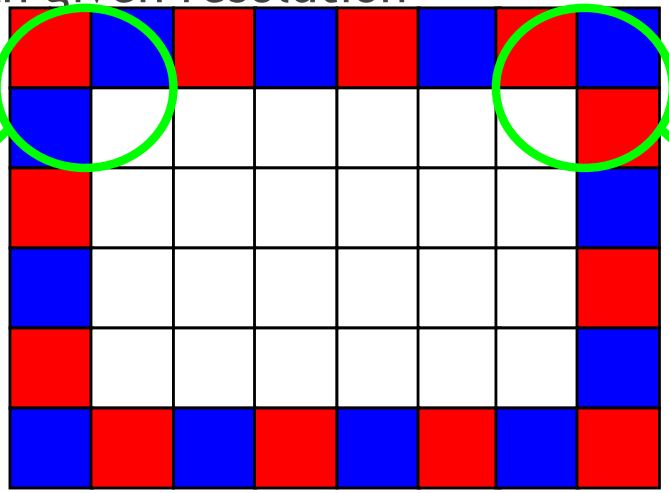
Resizing bitmap images



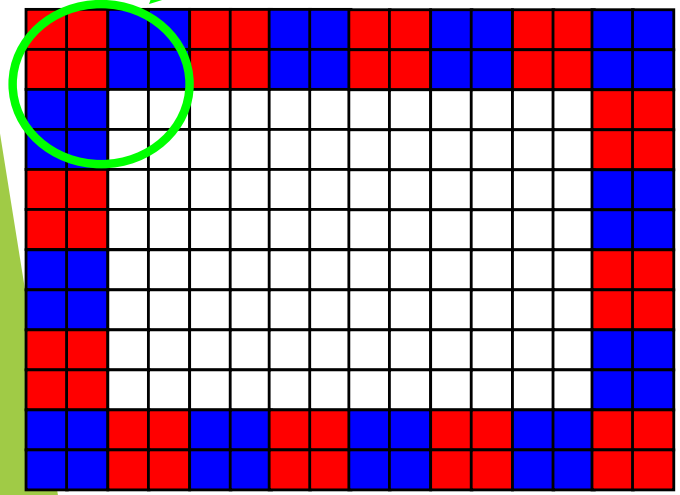
Resizing images

Image information with given resolution

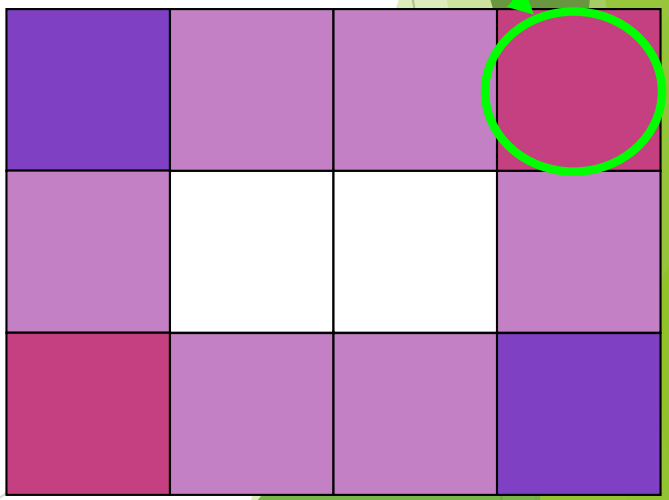
- 8 x 6 pixels



Sampled at higher resolution
16 x 12



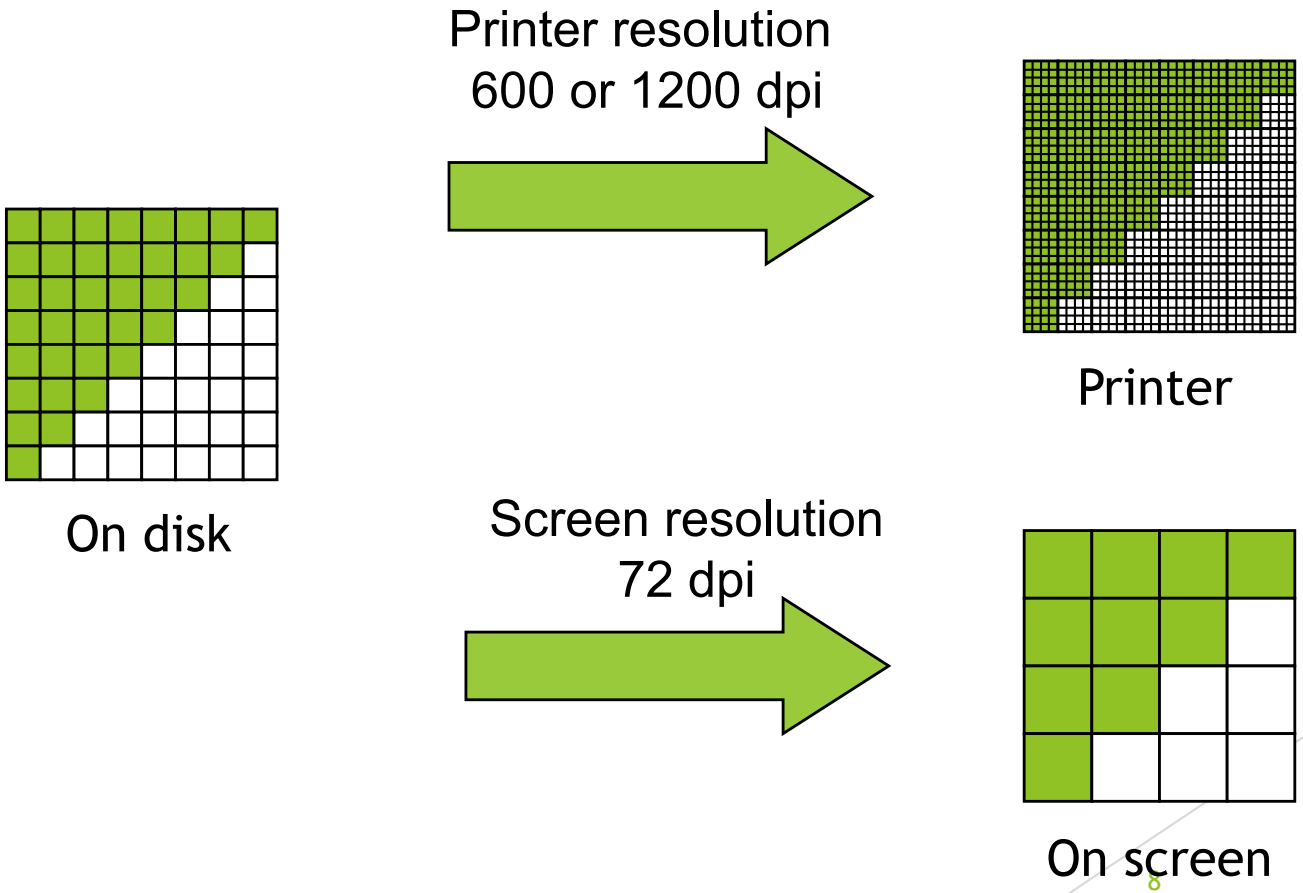
Sampled at lower resolution
4 x 3



Printing Bitmaps

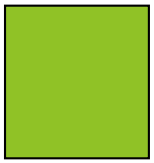
Printer and Screen have different sized dots

- Scale (resample) the bitmap to ensure it looks good on both



Exercises

Imagine you have taken a picture with a 4 megapixel digital camera. For ease of calculation, assume that the picture is square, not rectangular.



4 million pixels

Assume that you are printing this picture out on a printer that has approximately 4000 dots per inch. How many inches across would the picture be when it was printed?

If you viewed this image on a screen that had 1000 dots across, what portion of the image would be visible?

Colour Bitmaps

Colours

- Use more than 1 bit per pixel
- Map the binary number to a colour

1100	0010	1111	1111
1010	0101	0010	1111
1000	0111	0000	1101
0110	1111	1110	1010

Each pixel uses 4 bits

Bits	Colour
0000	Black
0001	Red
0010	Green
0011	Blue
0100	Yellow
...	...

Colour table used for display

How much memory is required?

One binary number used for each pixel

- 1 bit 2 colours
- 2 bits 4 colours
- 4 bits 16 colour
- 8 bits 256 colours
- 16 bits 65536 colours
- 24 bits 16,777,216 colours

How many bits are required for a 16 colour image 100 pixels wide x 8 pixels high?

- 100x8x4 = 3200 bits = 400 bytes

An image using 24 bit colour, 1000 wide x 1000 high (1 Megapixel)?

- 3 MB

Exercises

- How many colours can be represented by 3 bits?
- How many bits are required to represent 128 different colours?
- How much memory would be required to store a black and white image that is 10 pixels high and 5 pixels wide? Show your working.

Exercises

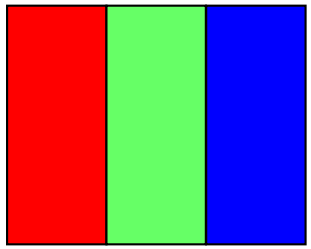
- How much memory (in bytes) would be required to store an image that has 256 different colours and is 3 pixels high and 5 pixels wide? Show your working.

Displays

Screens use a combination of Red, Green and Blue lights

- RGB colour

A single pixel at distance



A single pixel close up

Use one byte (8 bits) for each colour

- 256 different levels of red brightness
- 256 different levels of green brightness
- 256 different levels of blue brightness

Compressing Images

Simply reducing number of colours

Image is 200 pixels wide, 200 pixels high

= 40,000 pixels

Compression Algorithms

Graphics Interchange Format (GIF)

- Lossless method
- 256 colours
- Good for graphics, poor for photos
- Uses an algorithm that was patented

Image Size:	200x100
Original (256 colours):	20KB
GIF (256 colours):	3KB

Image Size:	200x200
Original (256 colours):	40KB
GIF (256 colours):	32KB

http://en.wikipedia.org/wiki/Gif

Compression Algorithms

Portable Network Graphics (PNG)

- Replacement to GIF
- Lossless method
- 16 million colours (24 bit)
- Good for graphics, poor for photos

Image Size: 200x100
Original (256 colours): 20KB
PNG (16M colours): 4KB

Image Size: 200x200
Original (16M colours): 120KB
PNG (16M colours): 68KB

http://en.wikipedia.org/wiki/Png

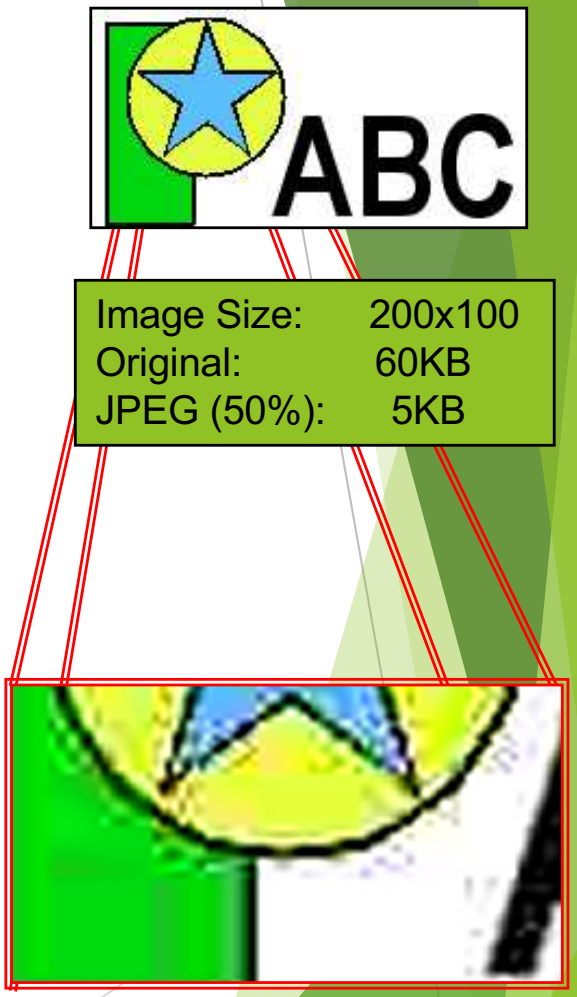
Compression Algorithms - JPEG

Joint Photographic Experts Group (JPEG)

- Lossy method
- 16 Million colours (24 bit)
- Averages nearby colours
- Different degrees of compression
- Good for photos, poor for graphics

Image Size:	200x200
Original:	120KB
JPEG (50%):	6KB

Image Size:	200x200
Original:	120KB
JPEG (99%):	2KB

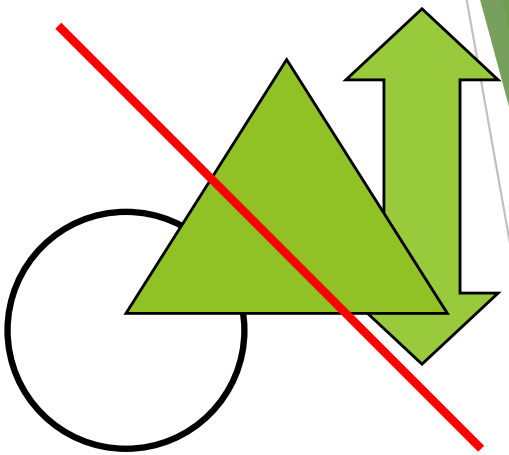


http://en.wikipedia.org/wiki/jpeg

Vector Graphics

Object-oriented graphics

- Objects created independently
- Defined by mathematical formulae



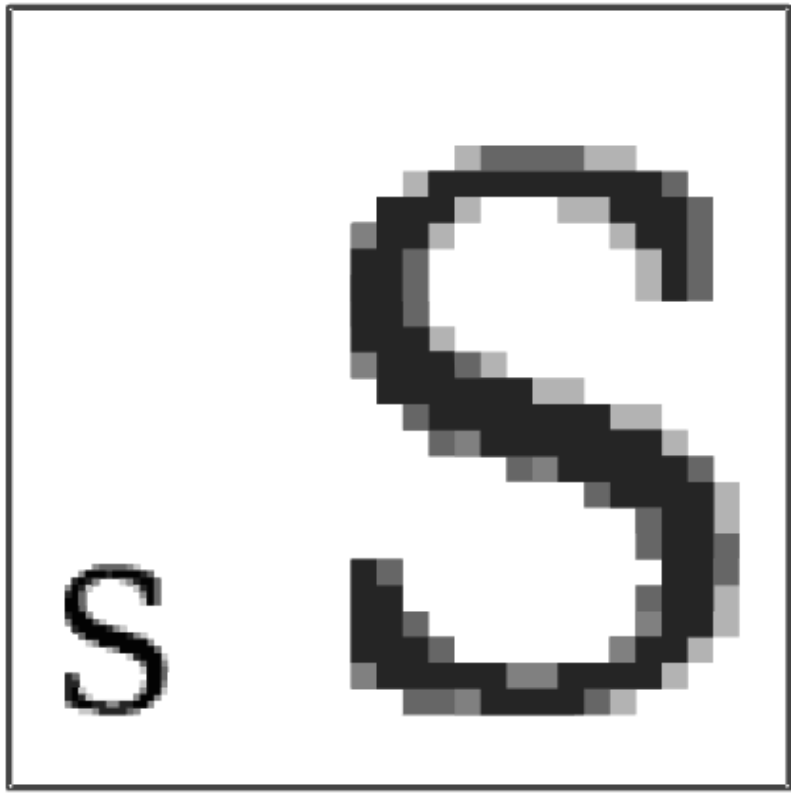
Advantages

- Very small memory requirements
- Memory independent of the image size
- Scale to any size without loss of quality

Object Type:	Square
Height:	100
Width:	100
Position_X:	354
Position_Y:	289
Fill Colour:	Light Blue

http://en.wikipedia.org/wiki/Vector_graphics

Bitmap and Vector Graphics



Bitmap
.gif, .jpg, .png

Vector Graphics
.svg

Scalable Vector Graphics

Format for representing vector graphics images

- Open standard created by W3C
- New, gaining popularity
- XML, text file similar to HTML

```
<?xml version="1.0" encoding="utf-8" standalone="yes"?>
 <!DOCTYPE svg PUBLIC "-//W3C//DTD SVG 1.1//EN"
"http://www.w3.org/Graphics/SVG/1.1/DTD/svg11.dtd">
 <svg xmlns="http://www.w3.org/2000/svg" xmlns:xlink="http://www.w3.org/1999/xlink" version="1.1"
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weight:bold;font-family:"Times New Roman", serif} #P0 {fill:#d4a000;stroke:#000;stroke-width:9} #P1
{fill:url(#tl)} #P2 {fill:url(#bl)} #P3 {fill:url(#br)} #P4 {fill:url(#tr)} ]]> </style> <defs> <linearGradient
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</linearGradient> <linearGradient x1="136.4" y1="136.4" x2="167.5" y2="167.5" id="tl" xlink:href="#lt"
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x2="352.5" y2="352.5" id="br" xlink:href="#dk" gradientUnits="userSpaceOnUse"/> <linearGradient
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gradientUnits="userSpaceOnUse"/> </defs> <path id="P0" d="M260,6.3L 6.3,260L 260,513.7L
513.7,260L 260,6.3z"/> <text y="380" x="200">!</text> <path id="P1" d="M260,12.7L 260,75L 75,260L
12.7,260L 260,12.7z"/> <path id="P2" d="M260,507.3L 260,445L 75,260L 12.7,260L 260,507.3z"/>
<path id="P3" d="M260,507.3L 260,445L 445,260L 507.3,260L 260,507.3z"/> <path id="P4"
d="M260,12.7L 260,75L 445,260L 507.3,260L 260,12.7z"/>
</svg>
```

http://en.wikipedia.org/wiki/Svg

Summary

Bitmap Images

- Pixel width x pixel height = resolution
- Use numbers to encode colour of each pixel (more colours = more bits per pixel)
- Look jagged when enlarged too much
- Take a lot of memory but can be compressed (e.g. JPG)

Vector Images

- Defined by mathematical formulae
- Can be enlarged and still look nice
- Small compared to bitmap images