COMPSCE 111 / 111G
Mastering Cyberspace:
An introduction to practical computing

Digital Images
Vector Graphics
“One picture is worth more than ten thousand words”

• Anonymous
Learning Outcomes

Students should be able to:

– Understand the history of digital images
– 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)
What is a Digital Image?

• A digital image is a representation of a two-dimensional image as a finite set of digital values, called picture elements or pixels.
In What Form is a Digital Image Stored?

• Common image formats include:
  – 1 sample per point (grayscale)
  – 3 samples per point (Red, Green, and Blue)
  – Video (above information plus time)
What is Digital Image and Video Processing?

• Digital image (and video) processing focuses on two major tasks
  – Improvement of pictorial information for human interpretation
  – Processing of image data for storage, transmission and representation for autonomous machine perception

• Some argument about where image processing ends and fields such as image analysis and computer vision start!
What is DIP? (cont…)

• The continuum from image processing to computer vision can be broken up into low-, mid- and high-level processes

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In this course we will stop here
History of Digital Image Processing

• Early 1920s: One of the first applications of digital imaging was in the newspaper industry
  – The Bartlane cable picture transmission service
  – Images were transferred by submarine cable between London and New York
  – Pictures were coded for cable transfer and reconstructed at the receiving end on a telegraph printer
History of DIP (cont…)

• Mid to late 1920s: Improvements to the Bartlane system resulted in higher quality images
  – New reproduction processes based on photographic techniques
  – Increased number of tones in reproduced images

Improved digital image

Early 15 tone digital image
• 1960s: Improvements in computing technology and the onset of the space race led to a surge of work in digital image processing
  – 1964: Computers used to improve the quality of images of the moon taken by the Ranger 7 probe
  – Such techniques were used in other space missions including the Apollo landings

A picture of the moon taken by the Ranger 7 probe minutes before landing
• **1970s:** Digital image processing begins to be used in medical applications
  
  - **1979:** Sir Godfrey N. Hounsfield & Prof. Allan M. Cormack share the Nobel Prize in medicine for the invention of tomography, the technology behind Computerised Axial Tomography (CAT) scans

![Typical head slice CAT image](image_url)
My history with digital images

• Got my first digital camera in 1996
• Casio QV10
• Only 2000 Kilo pixels !!!

• Changed my use of photography
My father – Aug 1996
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

![Diagram of pixel representation]

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

Images are displayed on an output device
- Screen / Printer
- Physical devices have limitations

Printer

Screen

Very small dots

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

Printer resolution
600 or 1200 dpi

Screen resolution
72 dpi

On disk

On screen

Printer
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.

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?

- \(4,000,000 = 2000 \times 2000\)

Therefore the picture would take up 0.5 by 0.5 inches.

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

- You would see \(\frac{1}{2}\) the width and \(\frac{1}{2}\) the height.
- Therefore you would see: \(\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}\) of the image
Colour Bitmaps

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

<table>
<thead>
<tr>
<th>Bits</th>
<th>Colour</th>
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<tr>
<td>0000</td>
<td>Black</td>
</tr>
<tr>
<td>0001</td>
<td>Red</td>
</tr>
<tr>
<td>0010</td>
<td>Green</td>
</tr>
<tr>
<td>0011</td>
<td>Blue</td>
</tr>
<tr>
<td>0100</td>
<td>Yellow</td>
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Each pixel uses 4 bits

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?
- $100 \times 8 \times 4 = 3200$ 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?
  • \(2^3 = 8\) colours

• How many bits are required to represent 128 different colours?
  • \(128 = 2^7\). Therefore 7 bits are required.

• 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.
  • Number of colours = \(2^1\). Therefore 1 bit is required per pixel.
    Number of pixels = \(h \times w = 10 \times 5 = 50\)
    Memory needed = \(50 \times 1 = 50\) bits
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.

• Number of colours = 256 = $2^8$. Therefore 8 bits or 1 byte are required per pixel.
  Number of pixels = h * w = 3 * 5 = 15
  Memory needed = 15 * 1 = 15 bytes
Displays

Screens use a combination of Red, Green and Blue lights

- RGB colour

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: 200x200
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
JPEG (99%): 2KB

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

http://en.wikipedia.org/wiki/Svg
Key Stages in Digital Image Processing

1. Image Acquisition
2. Image Enhancement
3. Image Modelling (Transforms)
4. Image Restoration
5. Image Compression
6. Colour Image Processing
7. Representaion & Description
8. Morphological Processing
9. Segmentation
10. Object Recognition

Real life scene
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