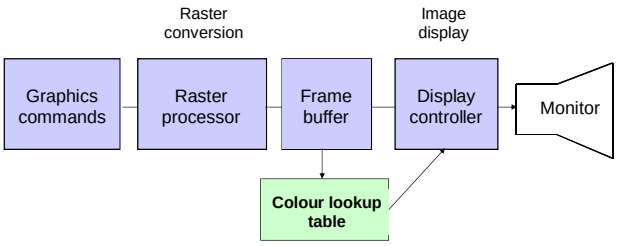
Colour (2)

Colours and their origin
- spectral characteristics
- human visual perception

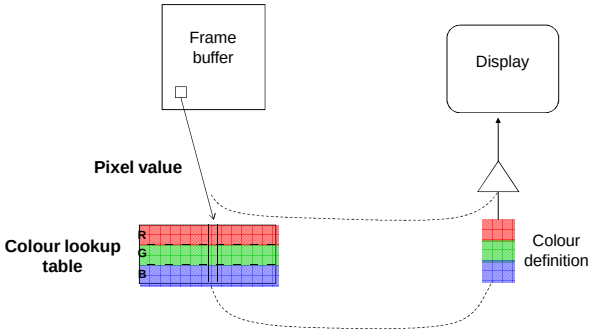
Colour spaces

Raster data
- computer architecture for colour display
- colour models
- image representations
- single and multi-band (multi-channel) images
- colour lookup tables

Computer architecture for colour displays



Colour mapping



Frame buffer

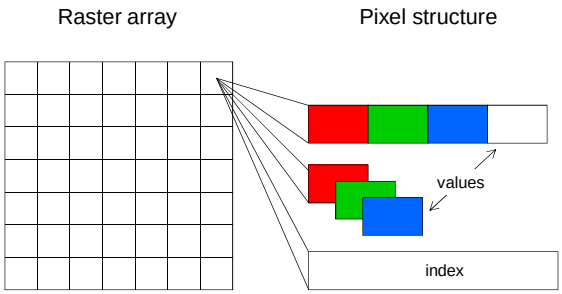
- Frame (display) buffer
  - A specially designated area of memory
  - Direct access by a display processor (but not by an application)
  - Display processor scans the display buffer and passes the contents to a DAC
  - DAC converts values into voltages for individual R, G and B pixel cells
- The colour lookup table is a block of fast RAM

Pixel cells

- Each individual pixel is divided into three cells, or subpixels (R,G and B)
- Each pixel cell receives a voltage from DAC
- Pixel cells generate colour on a display monitor using various methodologies:
  - Phosphors
  - Filters
  - Liquid crystals, etc

Raster data - pixel structure

- Raster data - raster array - a rectangular array of picture elements (pixels)
- Raster array forms a picture
- The structure of a pixel depends on
  - the colour space
  - the colour model

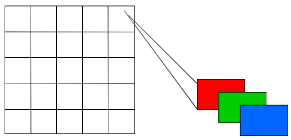


Colour models

A colour model describes how pixels are mapped into colours.

Direct Colour (True Colour)

- Image is an array of **vectors**
  - three integers at each pixel location
- Each vector directly encodes values of the three primaries

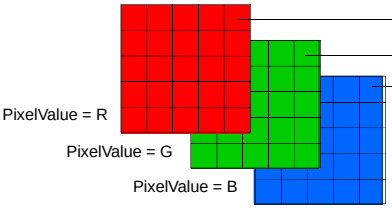


PixelValue(x,y) = [R G B]

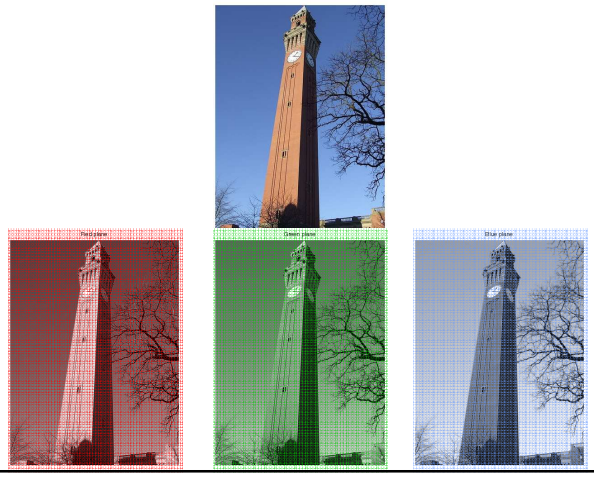
e.g. red: [FF 0 0]
(in hexadecimal notation)

Direct Colour (True Colour)

- Image is represented by three colour planes (channels)
  - three integer arrays, one for each primary
- Each plane directly encodes values of one of the three primaries

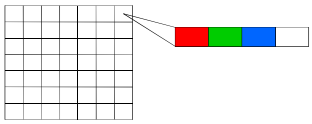


e.g. red
PixelValue(x,y,r) = 255
PixelValue(x,y,g) = 0
PixelValue(x,y,b) = 0



Packed Colour Model (Packed Array)

- Image is an array of **values**, each encoding a colour
- Examples:
  - 4-byte integer
    aaaaaaaa bbbbbbbb gggggggg rrrrrrrr



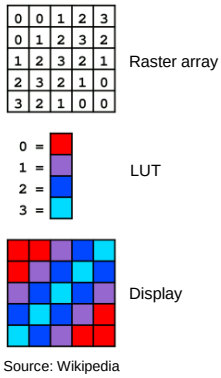
  - 1-byte integer
    rrrgggbb

Indexed Colour Model

- A pixel value (or a value of a pixel component) is an index (a pointer) to a table containing colour definitions

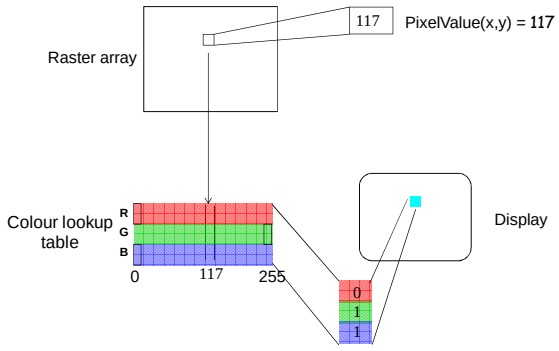
Colour Map

- Synonyms:
  - Colour Lookup Table
  - CLUT
  - LUT
- Each location in a LUT stores a colour definition for a pixel with a given value



Source: Wikipedia

Colour mapping for 1-byte pixels



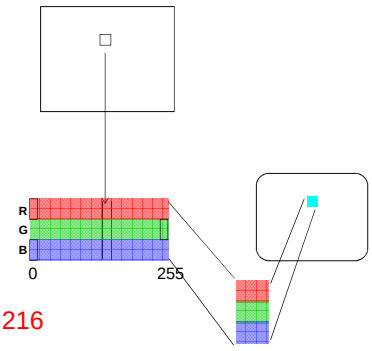
Colour mapping for 1-byte pixels

Number of colours simultaneously available in one image?

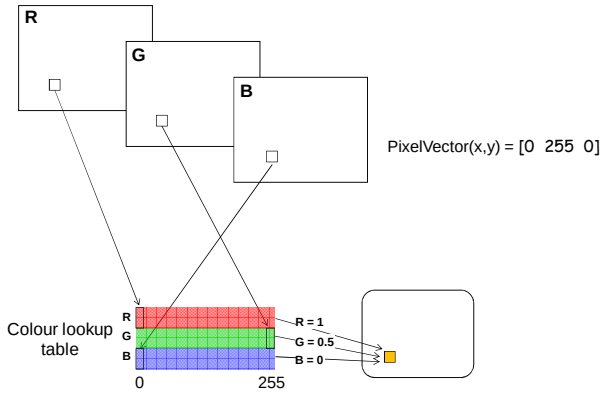
$2^8 = 256$

Gamut (total number of colours available for use)?

$2^{3x8} = 2^{24} = 16,777,216$



Colour mapping for 3-dimensional pixel vectors



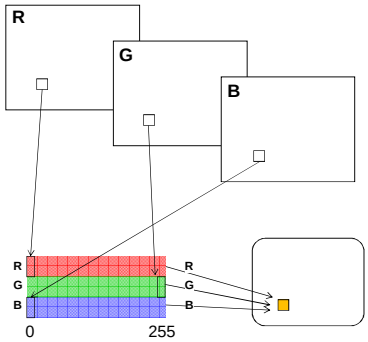
Colour mapping for 3-dimensional pixel vectors

Number of colours simultaneously available in one image?

$2^{24} = 16,777,216$

Gamut (total number of colours available for use)?

$2^{24} = 16,777,216$



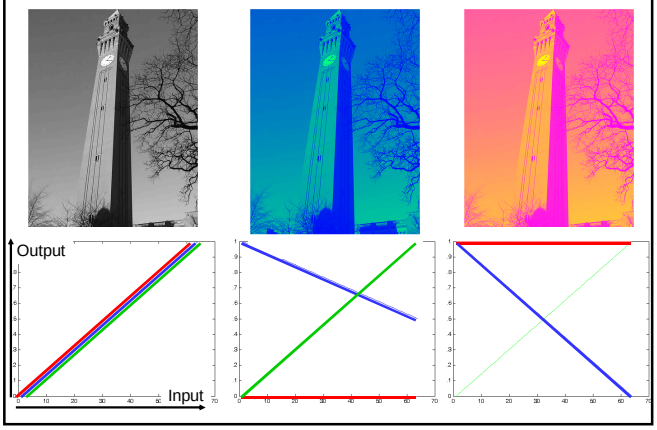
Colour channel / plane

- Colour channel / plane - a component of a colour vector
- RGB: red channel, green channel and blue channel
- A pixel vector can have more than three channels
- Examples
  - alpha channel (often used to describe transparency of a pixel)
  - z channel (in 3D graphics, the depth of the pixel, used in hidden surface removal)

Defining pixel colours

- Changing pixel colours is very easy within the Indexed Colour Model
- A raster array containing pixel values (or pixel vectors) stays unchanged.
- Only colour definitions in the LUT are changing

Colour mapping functions



Homework

- Specify colour definitions for the following colours in the RGB, HSV and CMY colour spaces:
  - Black
  - White
  - Orange
  - Pink
- Define a 64-long colour map specifying rainbow colours
- Define a 32-long colour map specifying red hue of decreasing saturation
- Given a grey-scale image, compute its negative (i.e. black becomes white, white becomes black, dark colours become bright and vice versa).

Next lecture

Computing complete surface colour – class exercise

Following lecture:
Implementing virtual camera