Monash University • Clayton's School of Information Technology

CSE3313 Computer Graphics

Lecture 24: Colour

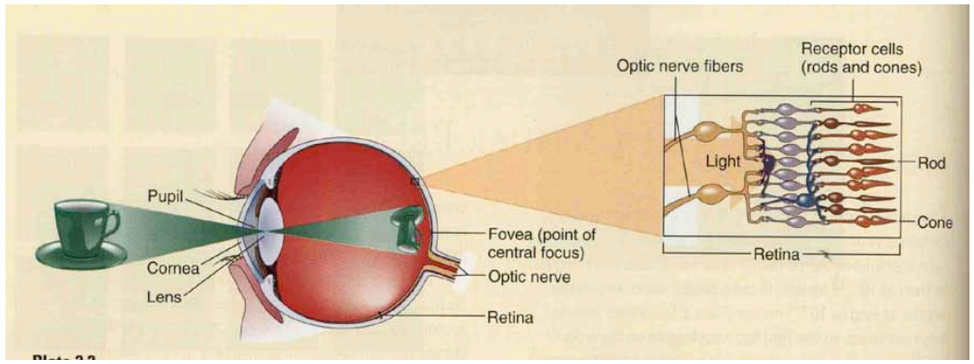
Colour

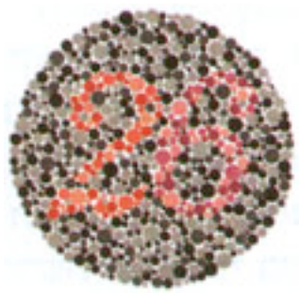
- Colour involves human perception. We cannot guarantee that 2 people will perceive a colour in exactly the same way. Men are know to be more affected by colour blindness than women. Understanding colour involves
  - anatomy
  - physiology
  - psychology
  - physics
- Colour is light in a region of the electromagnetic spectrum that can be perceived by the human visual system (350 – 750 nanometres). Individual frequencies are perceived as having colour, e.g.:
  - 450nm – Blue
  - 530nm – Green
  - 630nm – Red

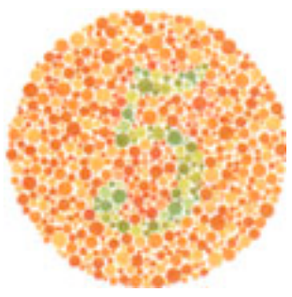
Colour (cont.)

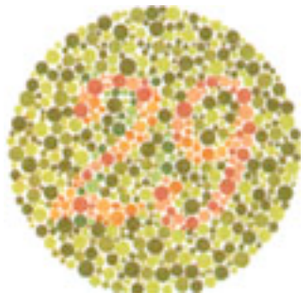
- We can vary intensity of the colour (intensity is a physical quantity) to increase the brightness (a perceptual quantity).

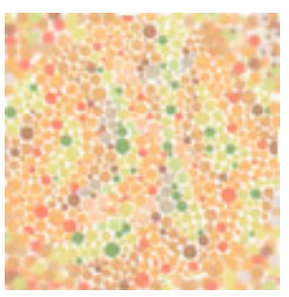
- Humans are less sensitive to the limits of the visible electromagnetic – we tend to see red and blue as being less bright than green or yellow is, even if all colours are the same intensity.









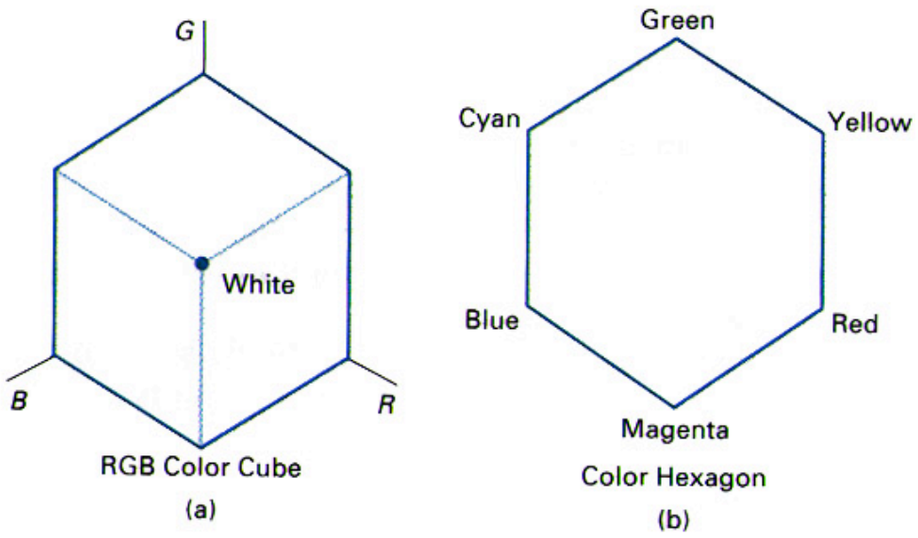


Three-colour Theory

- The eye has three kinds of colour sensors:
  - green
  - blue
  - green–yellow
- We see three tristimulus values. Each value depends on the sensitivity response of the kind of sensor and on the intensity of the colour.
- Any two colours that produce the same tristimulus values are indistinguishable to the human visual system. This leads to *metamers* which have the same perceived colour, but different frequency distributions.

Three-colour Theory (cont.)

- 3 Colour theory is linear:
  - Colour 1 is *(T1, T2, T3)*
  - Colour 2 is *(T'1, T'2, T'3)*
  - Colour 1 + Colour 2 is *(T1 + T'1, T2 + T'2, T3 + T'3)*
- It is convenient to express colour as a vector in 3D space – e.g. as an RGB triplet (Any three linearly independent primaries can be used).
- *Producing colour* – we need 2 or 3 linearly independent primaries.



When the RGB color cube (a) is viewed along the diagonal from white to black, the color-cube outline is a hexagon (b).

Additive & Subtractive Colour

- **Additive colour** – each primary adds light, e.g. a CRT screen.

- **Subtractive colour** – each primary subtracts a part of the incident light. For example, grass looks green when sunlight falls on it because the non-green parts of the incident sunlight are absorbed. In natural scenes, objects appear to have a certain colour because they absorb white light and re-emit the original white light minus some of its components.

- Complementary Colours:

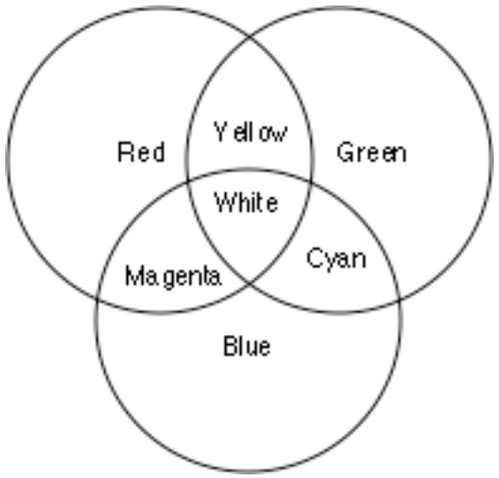
  Red — Cyan

  Green — Magenta

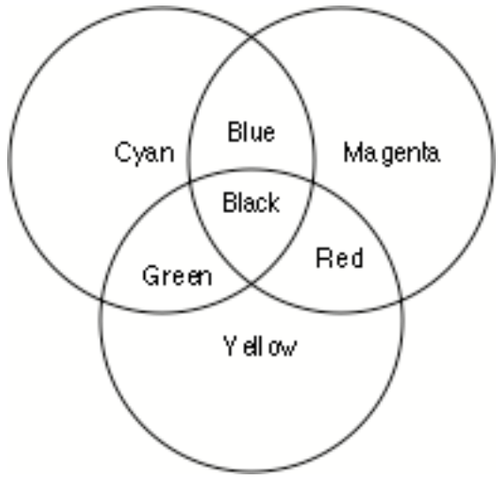
  Blue — Yellow

- Subtractive colour is generally used in printing (coloured inks are layered onto a white surface — CMYK colours).

Additive & Subtractive Colour (cont.)



Additive Colour

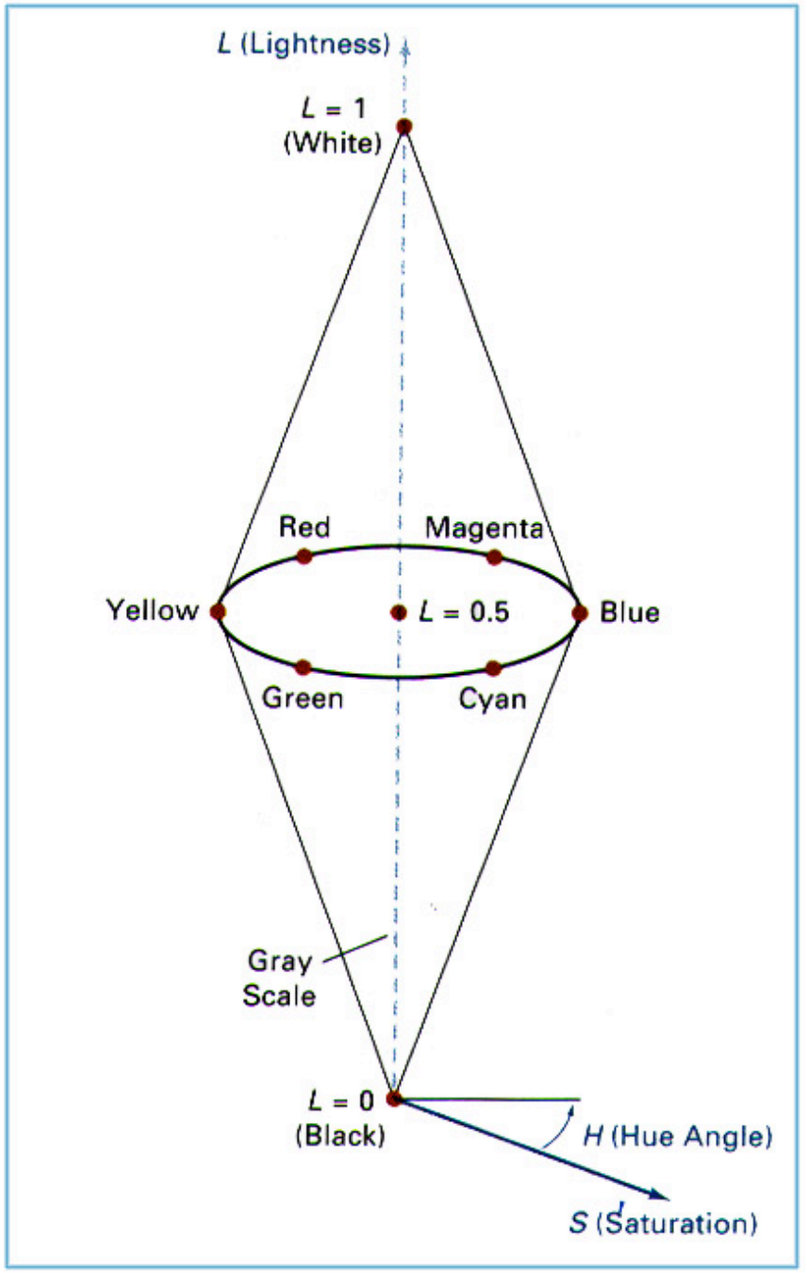


Subtractive Colour

- The *tristimulus basis* can be converted to another via a *transformation matrix*.

The HLS System

- People do not tend to think of colour in terms of Red, Green and Blue (RGB). It is more common for people to think of colour in terms of:
  - Hue, e.g. red, yellow;
  - Lightness, e.g. dark red, light blue;
  - Purity or Saturation, e.g. is it a pure colour to which white has been added.
- The HLS colour system (Hue, Lightness, Saturation) is often used as a convenient way of specifying colour.



The HLS double cone.

Other Colour Systems

- Another way of transforming (R, G, B) is to choose one band to specify the intensity of the colour (*Luminance*) and to use the other two bands to specify the actual colour (*Chrominance*). This system is used in digital television, for example.

- For instance, if we wish to view a colour image on a grey-scale monitor we could extract the luminance band and display that as a grey-scale image.

Original Colour Image