Colour

Learning Objectives

- What are the characteristics of colour?
- What are the examples of colour spaces and systems?
- How are colours applied in data visualisations?

Colour characteristics

Perception

- Physical Detection
  - amplitude, frequencies
- Psychological Perception
  - loudness, pitch of sound
  - brightness, hue of color

Visual Perception

Psychological (Visual) variable	1st order Physical variable	2nd order Physical variable
Brightness	light intensity	wavelength, adaptation of eye
Hue	wavelength	spectrum structure, peripheral light intensity and wavelength
Vividness /Saturation	Spectrum structure	peripheral light
Contrast	Intensity, wavelength, peripheral	

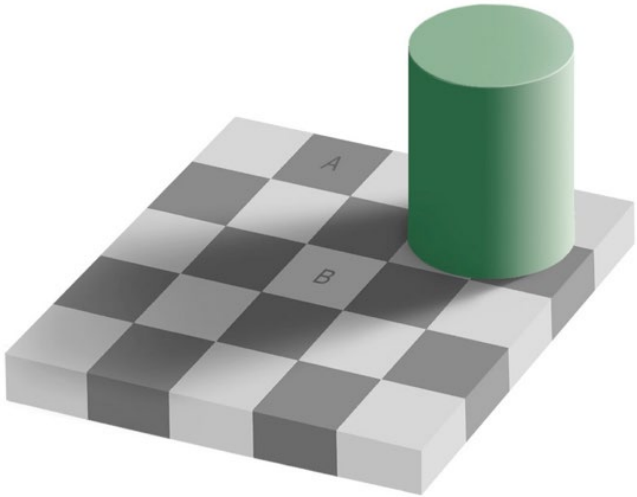
Brightness, Part I

1st order Physical:

- light intensity

2nd order Physical:

- wavelength, adaptation of eye



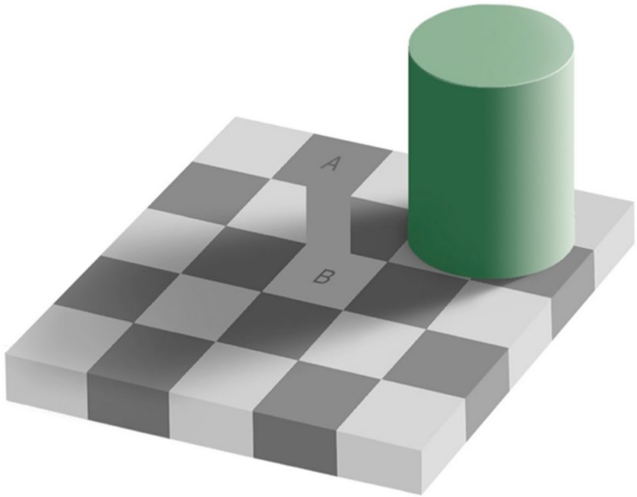
Brightness, Part II

1st order Physical:

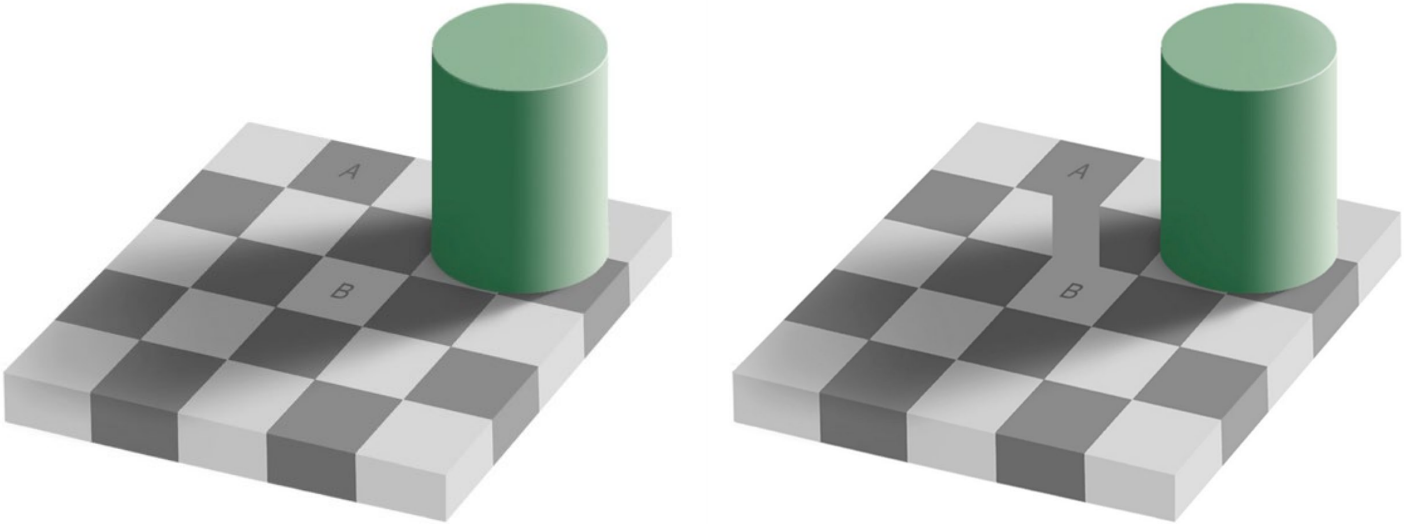
- light intensity

2nd order Physical:

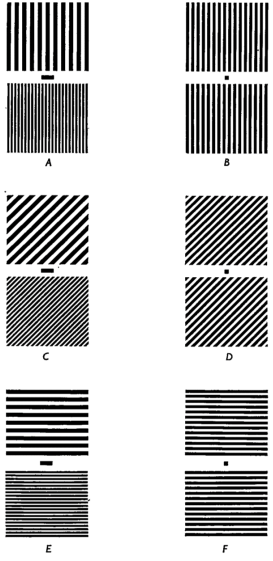
- wavelength, adaptation of eye



Brightness, Part III



Spatial Frequency

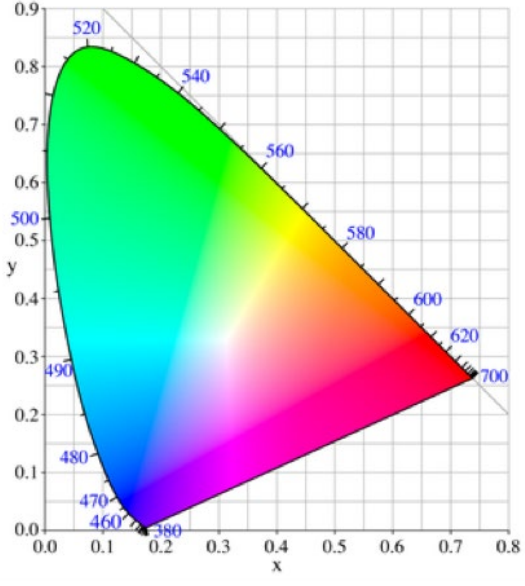


Colour Spaces and Systems

The Commission Internationale de l'Eclairage (CIE) system

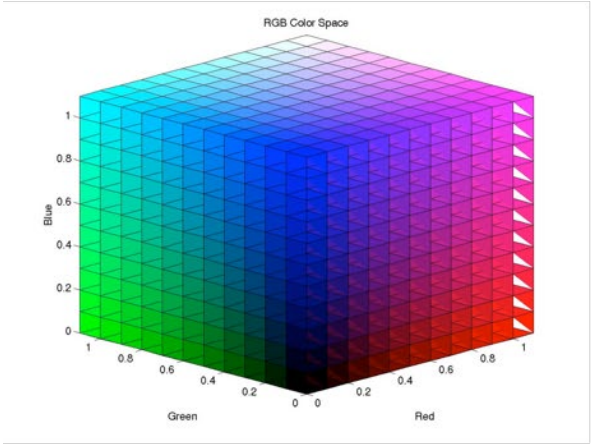
CIE-XYZ

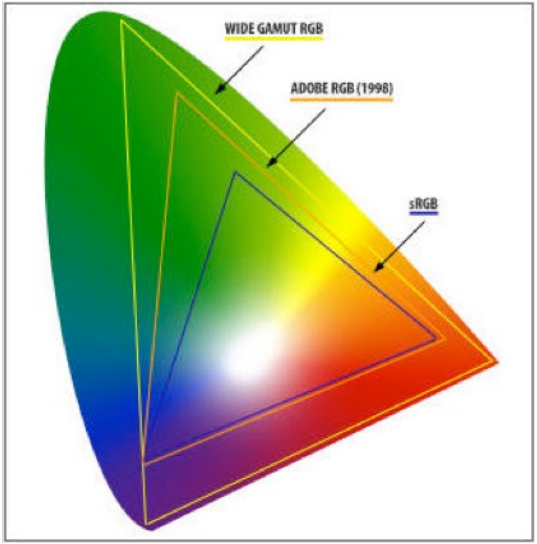
X: non-negative CIE RGB value,
Y: luminance,
Z: equivalent to Blue



$$x = \frac{X}{X+Y+Z}$$
$$y = \frac{Y}{X+Y+Z}$$
$$z = \frac{Z}{X+Y+Z} = 1 - x - y$$

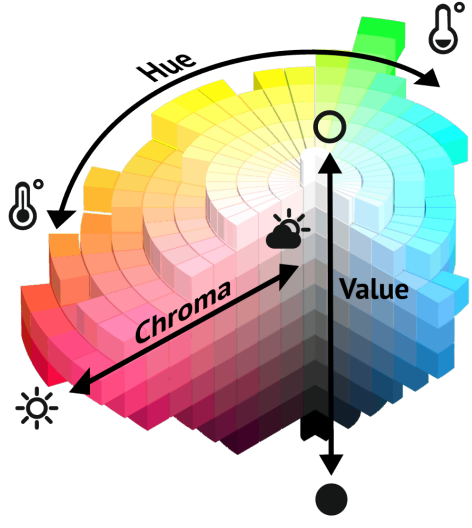
CIE-XYZ and RGB gamut





Recall…
Colour components

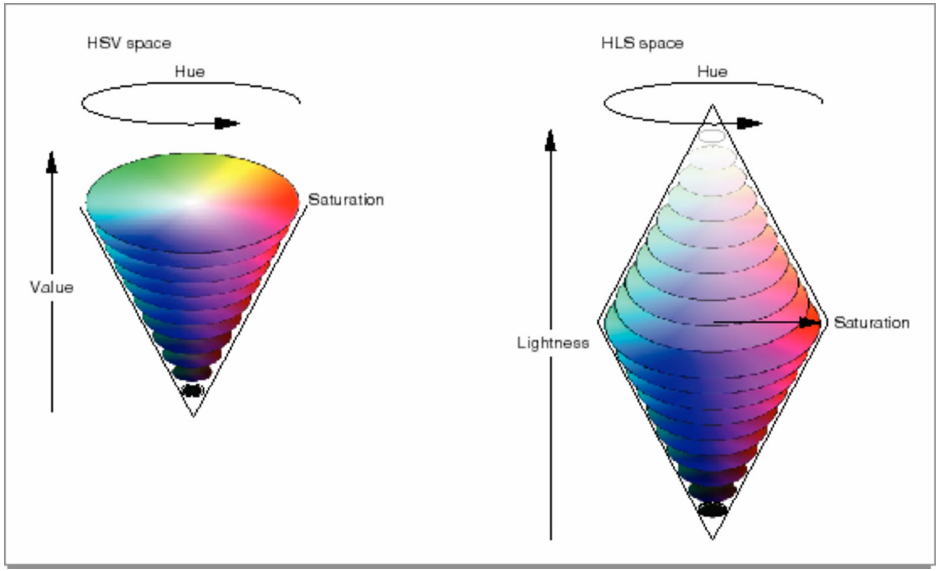
- Hue : wavelength
- Saturation /Chroma : amount of white
- Value /Brightness : light intensity



HSV and HLS colour spaces

Difference between HSV and HLS:

- Max value/brightness in HSV is analogous to shining a white light on a coloured object
- Max lightness in HSL is pure white



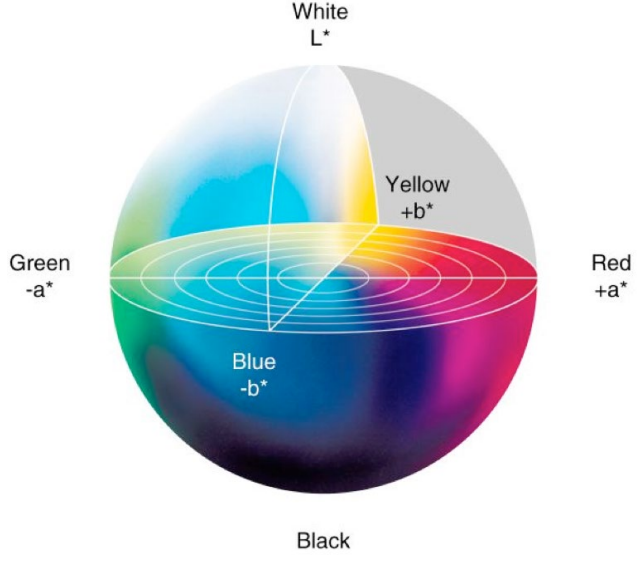
Munsell colour system

perceptual linear color space

- provides a set of standard color chips designed to represent equal perceptual spacing in a three-dimensional mesh
- provide a physical embodiment of a uniform color space

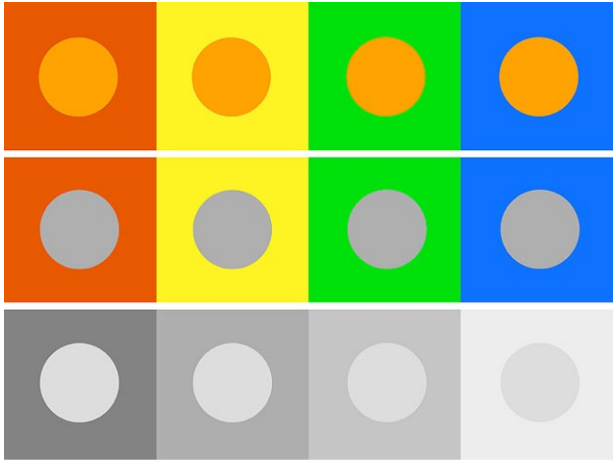
CIELAB colour space

- Based on opponent colour model
- Less uniform in colour axes, but useful for predicting small differences in colour



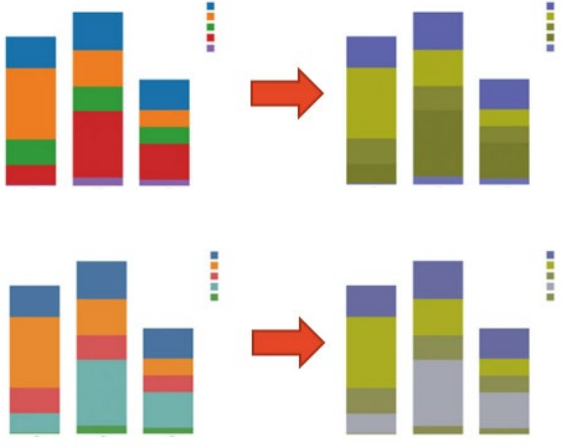
Colour Perception

- Induced Contrast



Colour Perception, cont.

- Colour Blindness



Applications of colour in visualisations

Examples of utilising colour in visualisation

- Colour mapping in 3D visualisation
- Cartography application

Application 1

- Colour mapping in 3D visualisation

Volume Visualisation, Part I

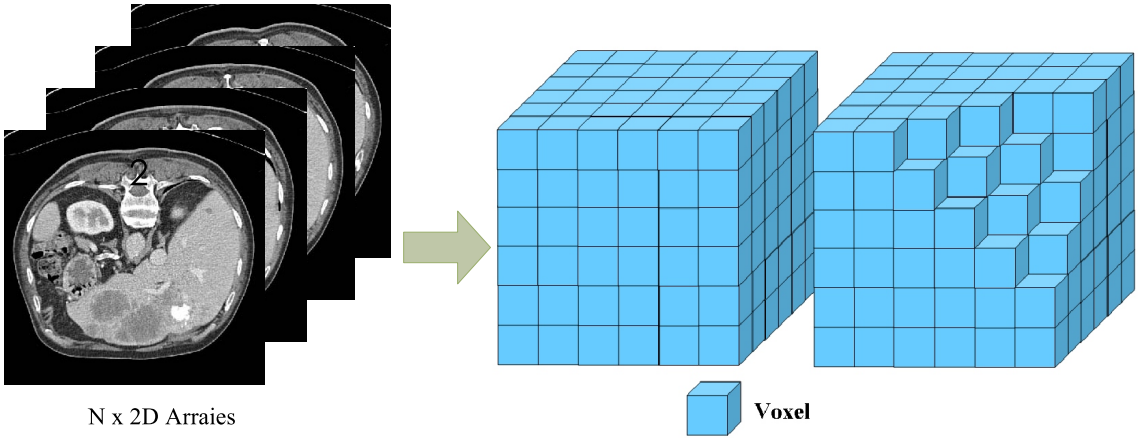


Figure 2.1: Voxels constituting a volumetric object after it has been discretized.

Volume Visualisation, Part II

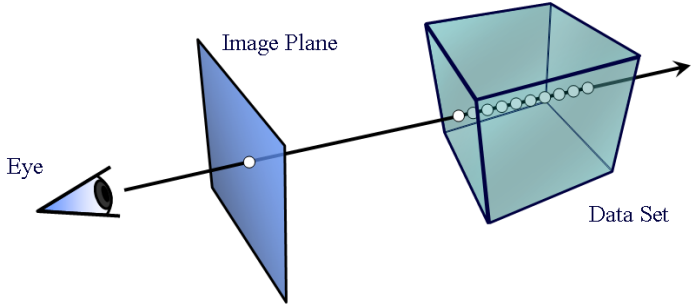


Figure 2.4: A ray casts into voxels of a 3D volume data [40].

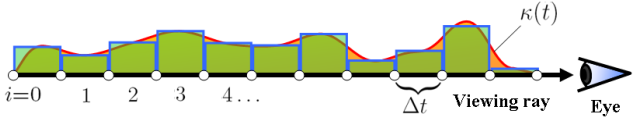


Figure 2.5: A ray is discretized to compute intensity analytically [40].

Volume Visualisation, Part III

- Maximising visibility by utilising colour/opacity

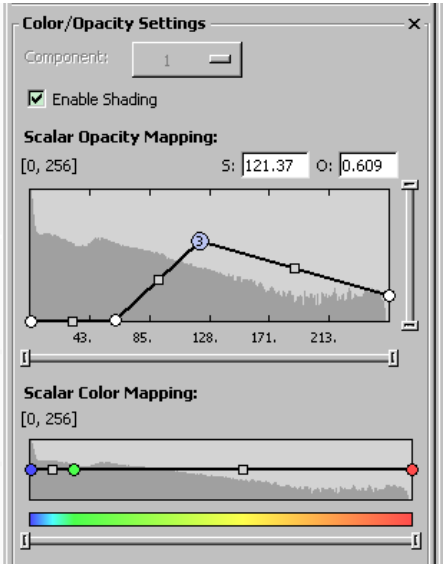


Figure 2.7: A user interface of transfer function specifications [2].

Volume rendered data set, Example I

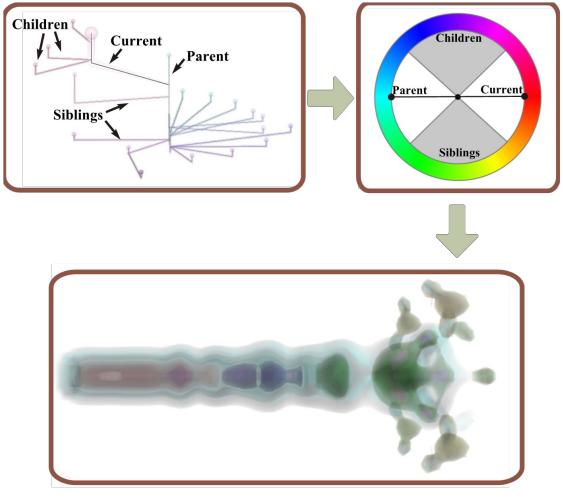


Figure 5.9: Depiction of neighboring relationship of “fuel” data set.

Zhou, J., & Takatsuka, M. (2009). Automatic Transfer Function Generation Using Contour Tree Controlled Residue Flow Model and Color Harmonics. *IEEE Transactions on Visualization and Computer Graphics*, *15*(6), 1481-1488. https://doi.org/10.1109/TVCG.2009.120

Volume rendered data set, Example II

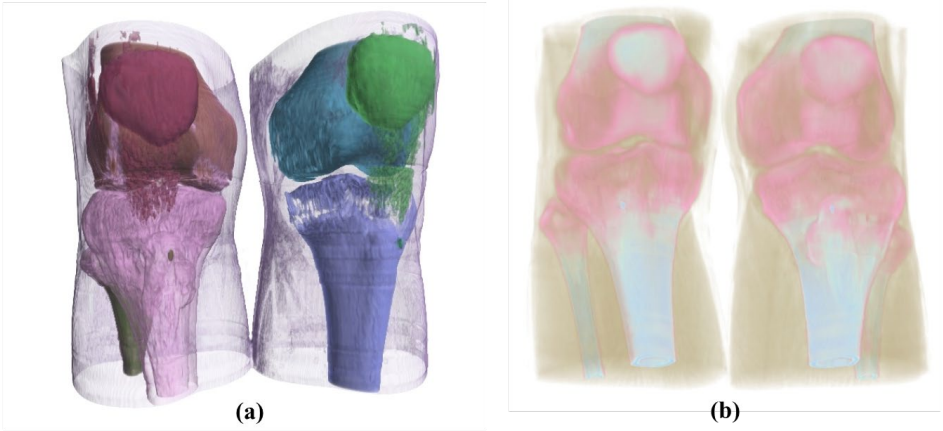


Figure 7.4: Comparison of volume rendered CT knee data set with: (a) our approach, and (b) VolView 3.2.

Zhou, J., & Takatsuka, M. (2009). Automatic Transfer Function Generation Using Contour Tree Controlled Residue Flow Model and Color Harmonics. *IEEE Transactions on Visualization and Computer Graphics*, *15*(6), 1481-1488. https://doi.org/10.1109/TVCG.2009.120

Volume rendered data set, Example III

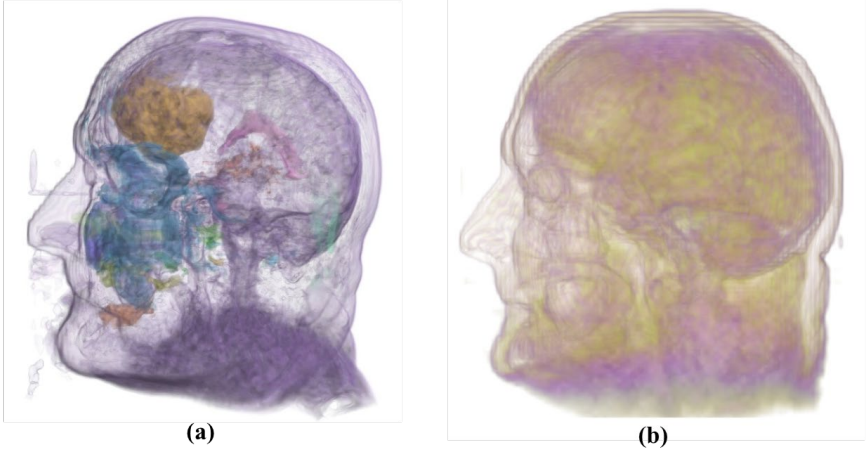


Figure 7.6: Comparison of volume rendered MR tumor head data set with: (a) our approach, and (b) VolView 3.2.

Zhou, J., & Takatsuka, M. (2009). Automatic Transfer Function Generation Using Contour Tree Controlled Residue Flow Model and Color Harmonics. *IEEE Transactions on Visualization and Computer Graphics*, *15*(6), 1481-1488. https://doi.org/10.1109/TVCG.2009.120

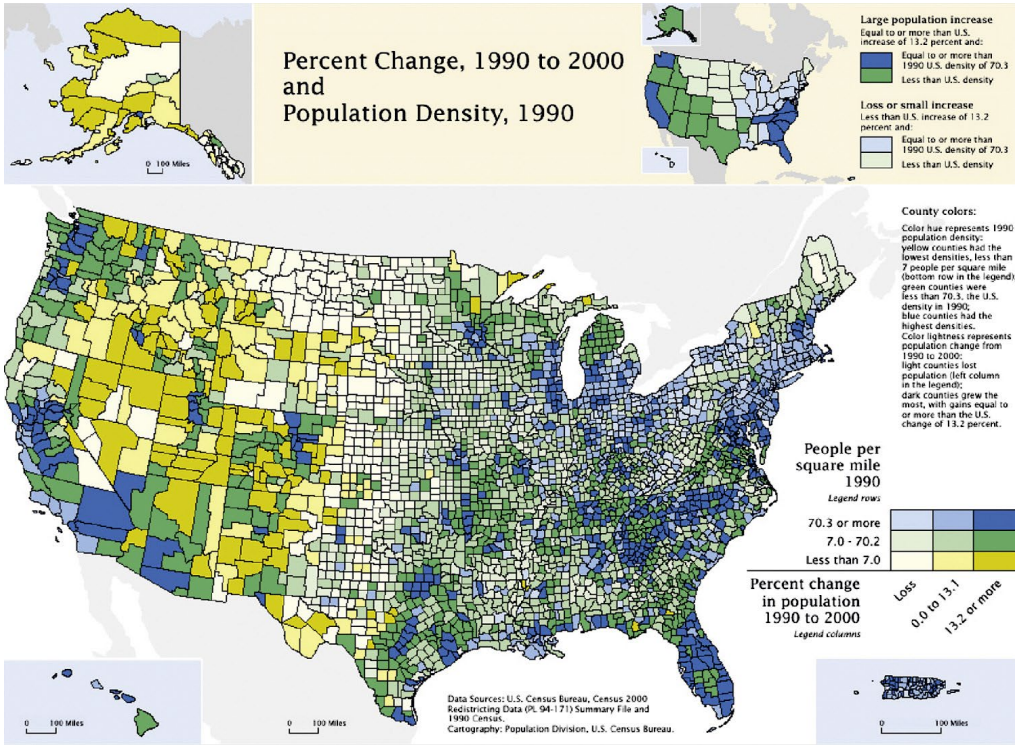
Application 2

- Application in cartography

ColorBrewer by Cynthia Brewer

- online tool for selecting map colour schemes
- colorbrewer2.org

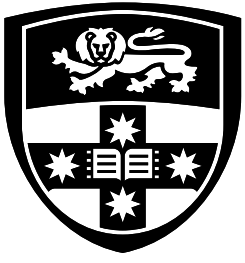
ColorBrewer Example



Ware, C. (2013). *Information Visualization: Perception for Design*. Elsevier Science. https://books.google.com.au/books?id=qFmS95vf6H8C

Summary

- Characteristics of colour
  - Hue
  - Brightness
  - Saturation /Chroma /Vividness
  - Contrast
- Colour spaces and systems
  - RGB, HSV, HLS, Munsell, CIELAB
- Examples of colour applied in data visualisations
  - 3D visualisations
  - Cartography



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