COMP5048 – Week 2

Colour Characteristics

Perception

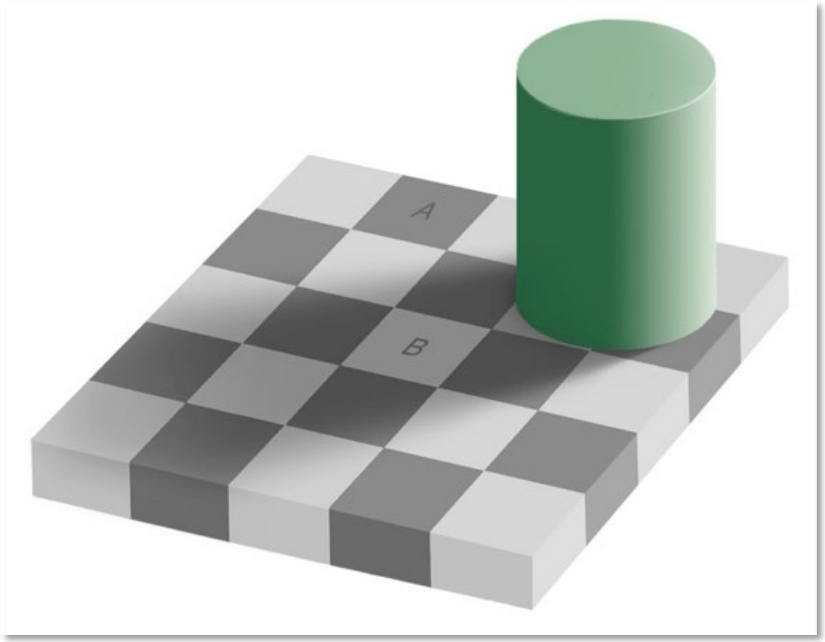
- Physical detection (of light)
  - Amplitude, frequencies
- Psychological perception (of colour)
  - Loudness, pitch of sound
  - Brightness, hue of colour

Visual Perception

Psychological (visual) variable	First-order physical variable	Second-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

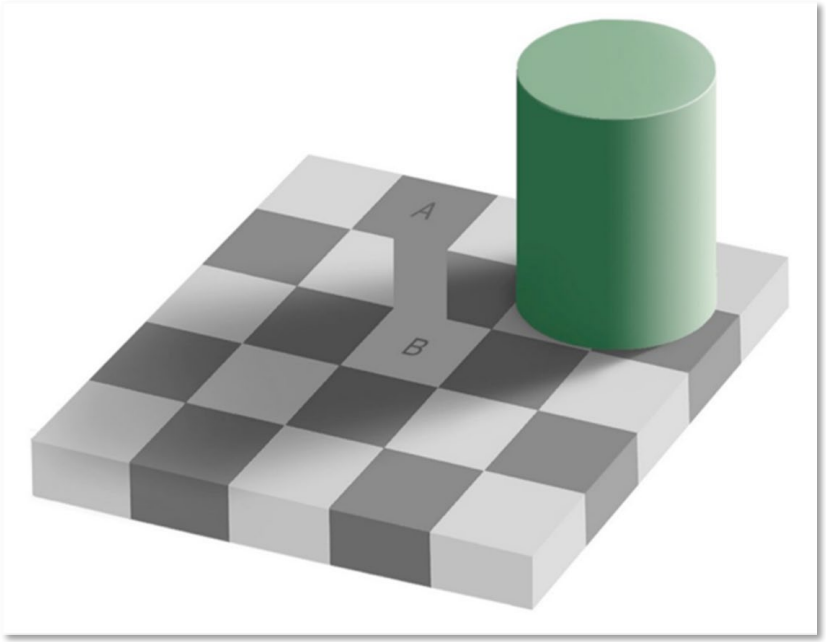
- First-order physical
  - Light intensity
- Second-order physical
  - Wavelength, adaptation of eye



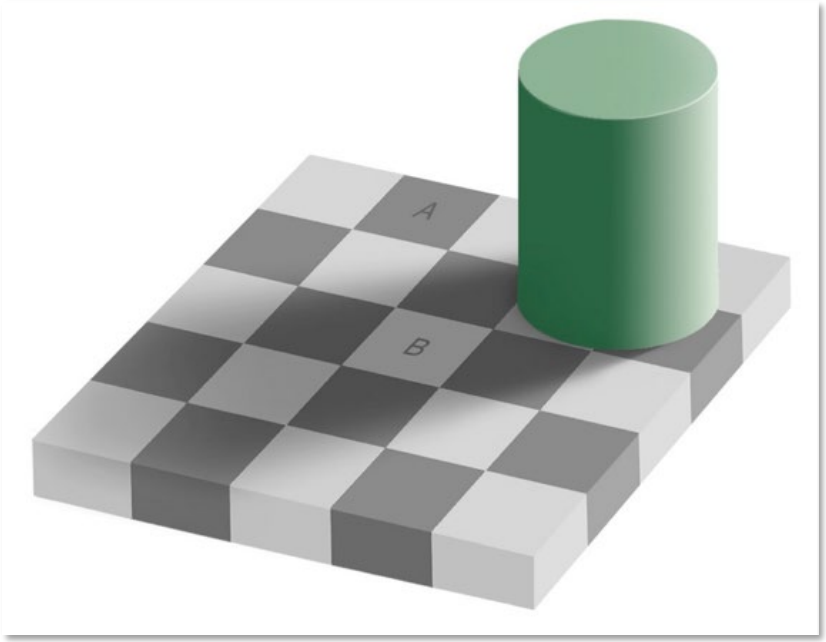
Brightness

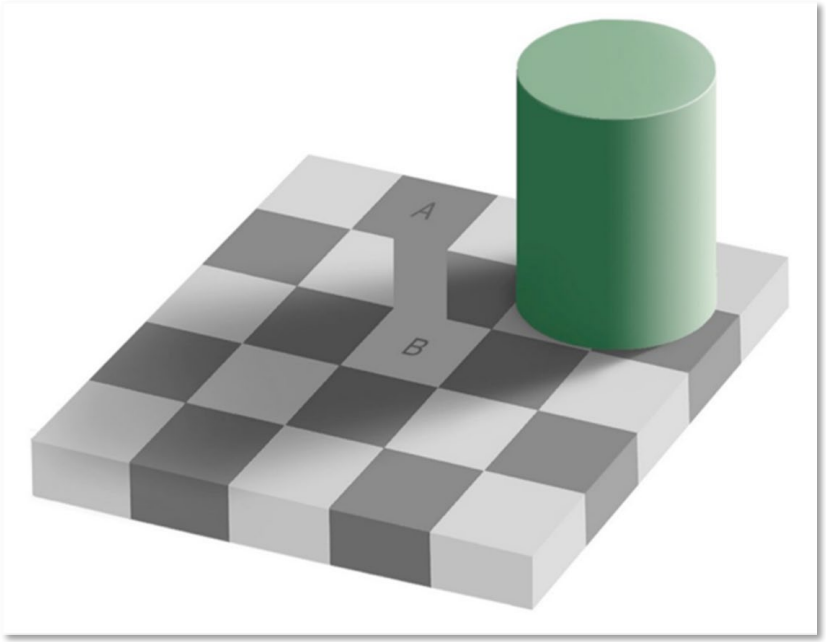
- First-order physical
  - Light intensity
- Second-order physical
  - Wavelength, adaptation of eye

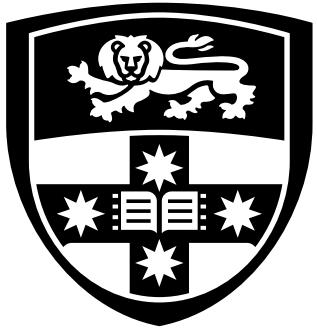
Square A and B have same brightness, but due to the cylinder creating a shadow, we perceive A to be brighter



Brightness (cont.)







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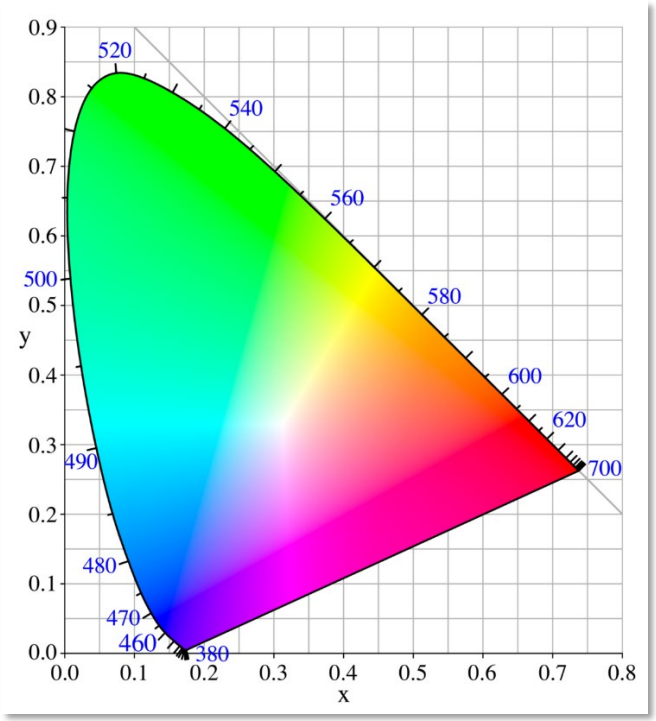
Colour Spaces and Systems

The Commission Internationale de l'Eclairage (CIE) System

CIE-XYZ

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



$$x = \frac{X}{X+Y+Z}$$

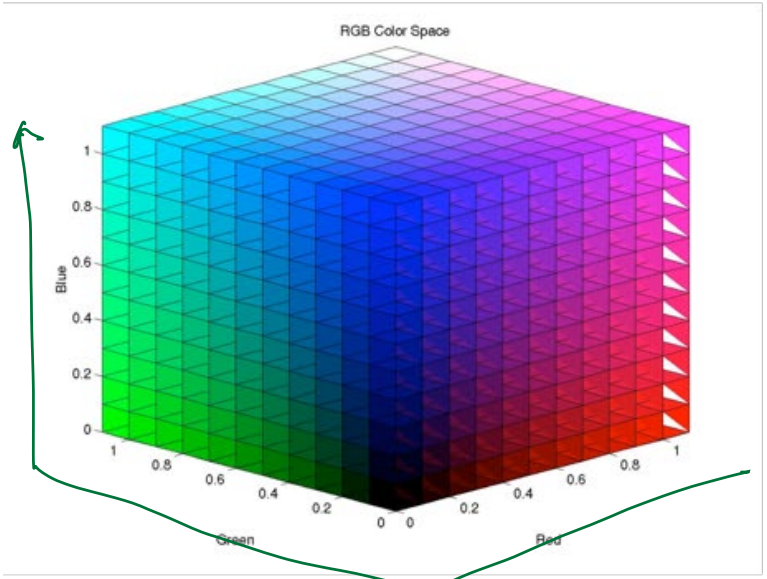
$$y = \frac{Y}{X+Y+Z}$$

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

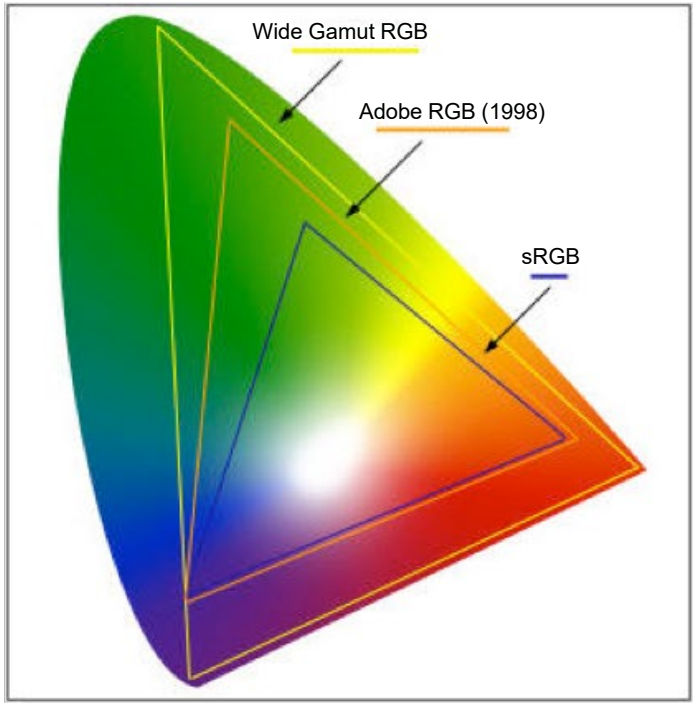
You can specify any colour

CIE-XYZ and RGB Gamut

Linear Space

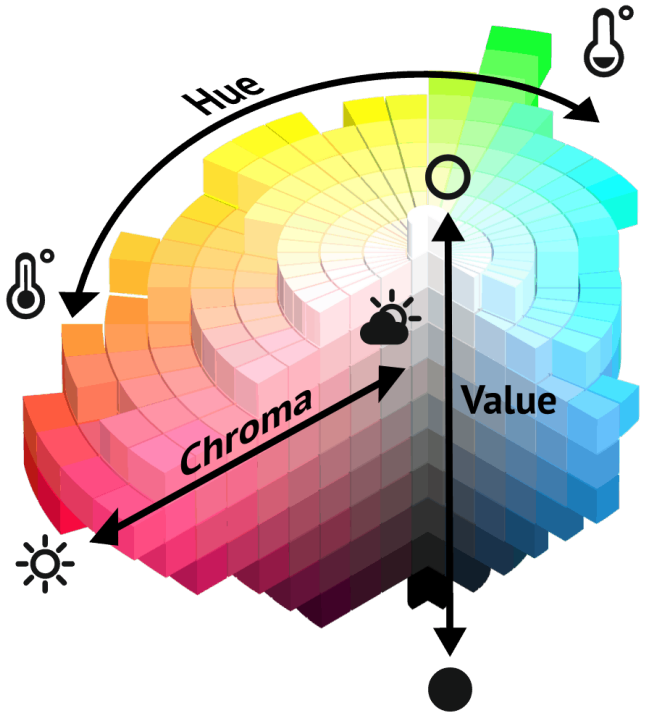


Orthogonal



Recall … Colour Components

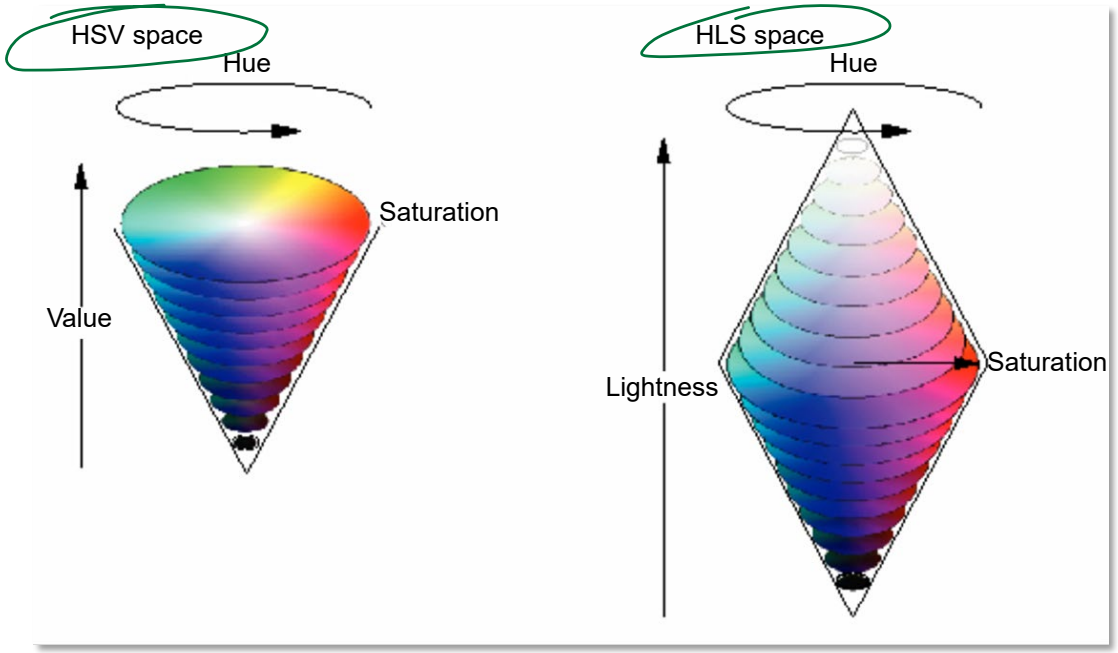
- Hue: wavelength
- Saturation/chroma: amount of white
- Value/brightness: light intensity



HSV and HLS Colour Spaces

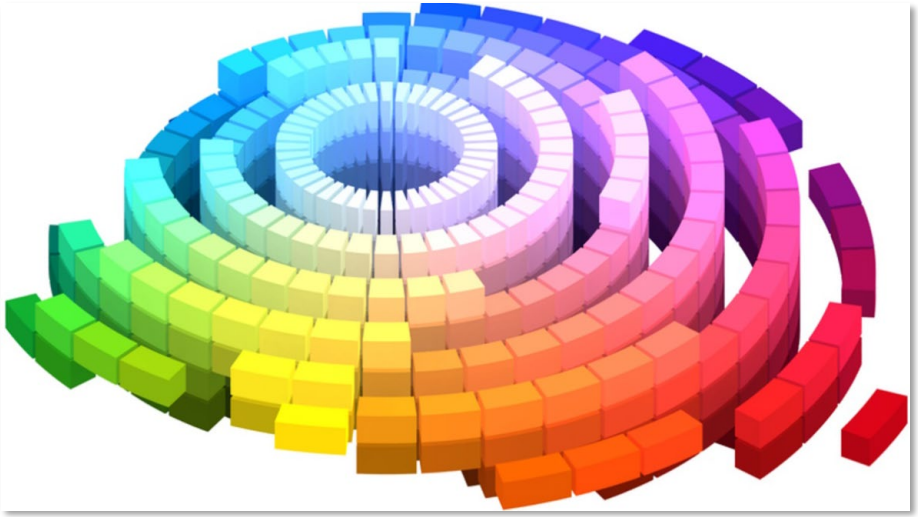
Difference between HSV and HLS

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



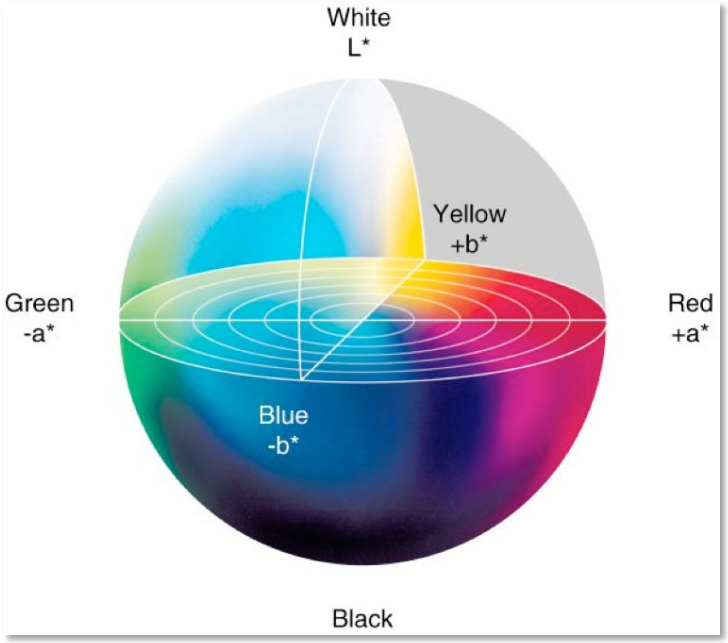
Munsell Colour System (1905 by Albert Munsell)

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



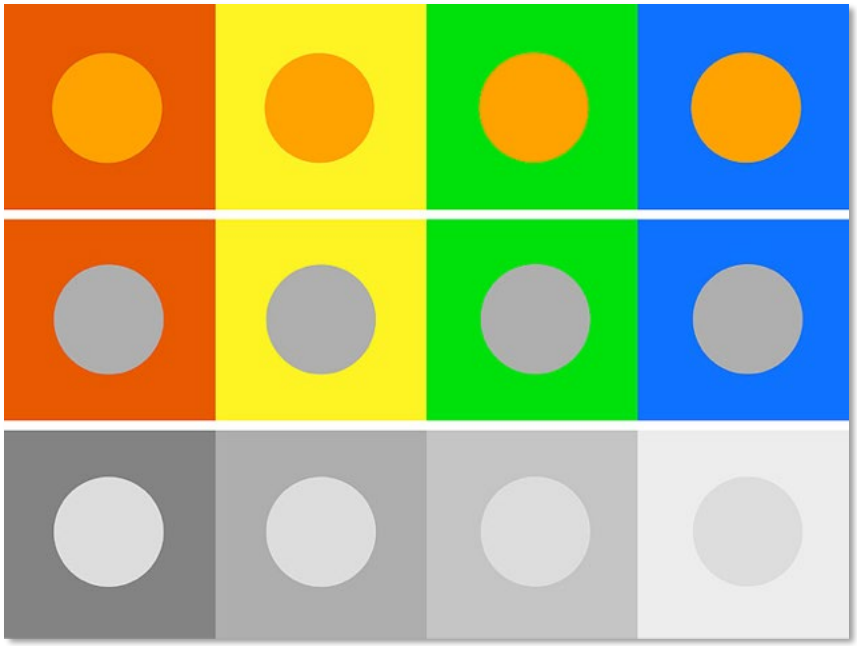
CIELAB Colour Space

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



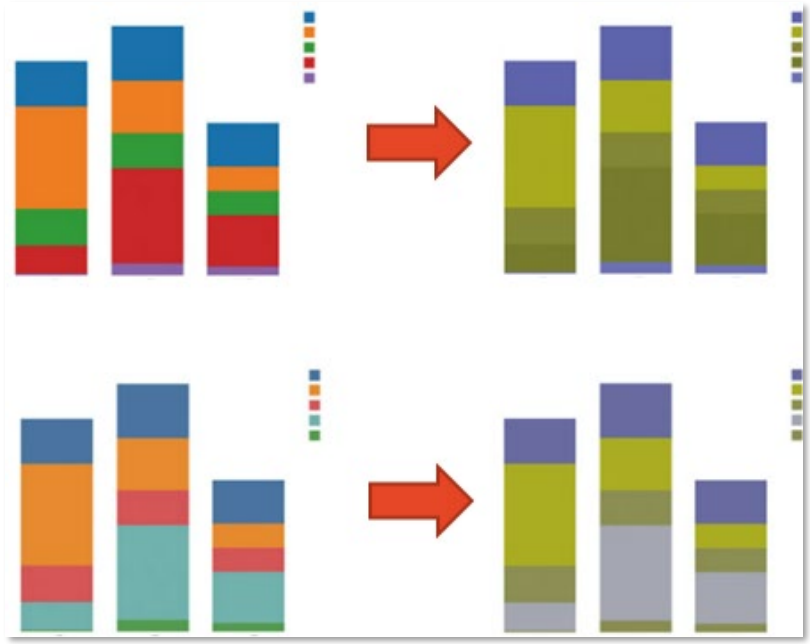
Colour Perception

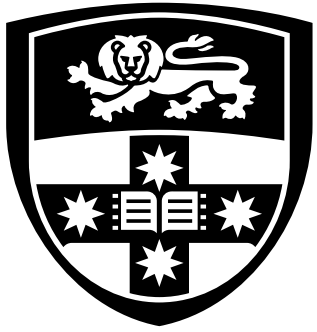
Induced contrast



Colour Perception (cont.)

Colour blindness





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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

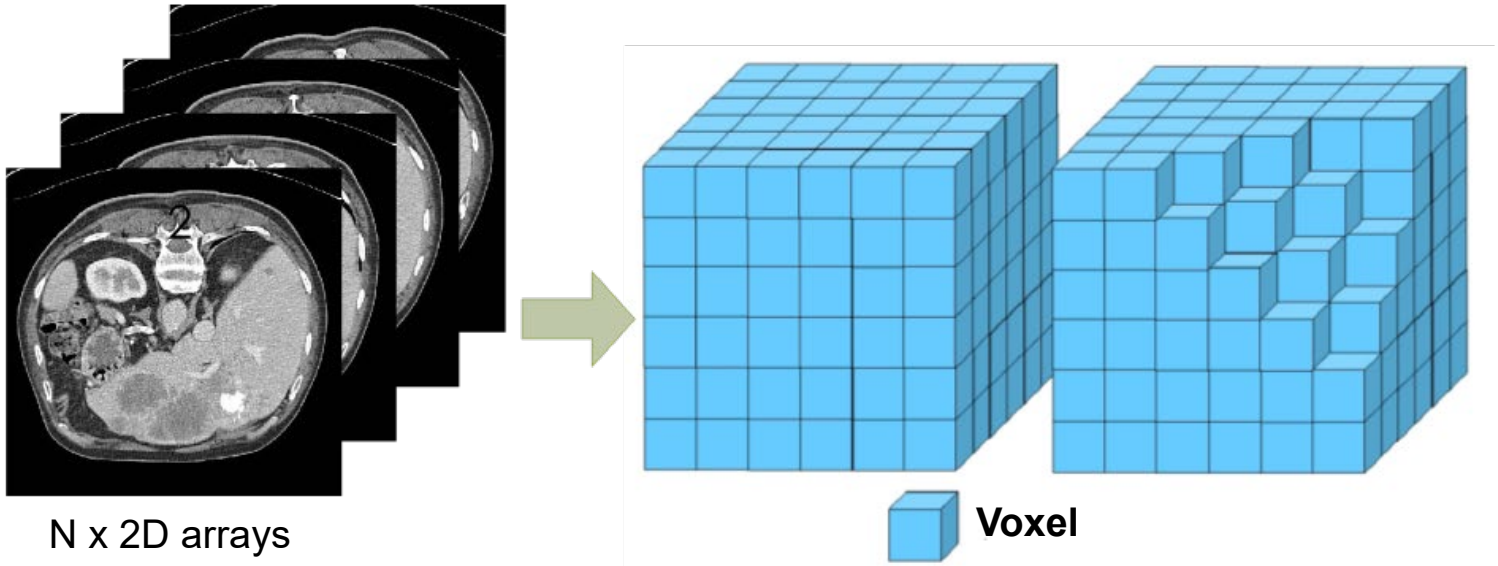


Figure 2.1: Voxels constituting a volumetric object after it has been discretised.

Volume Visualisation, Part II

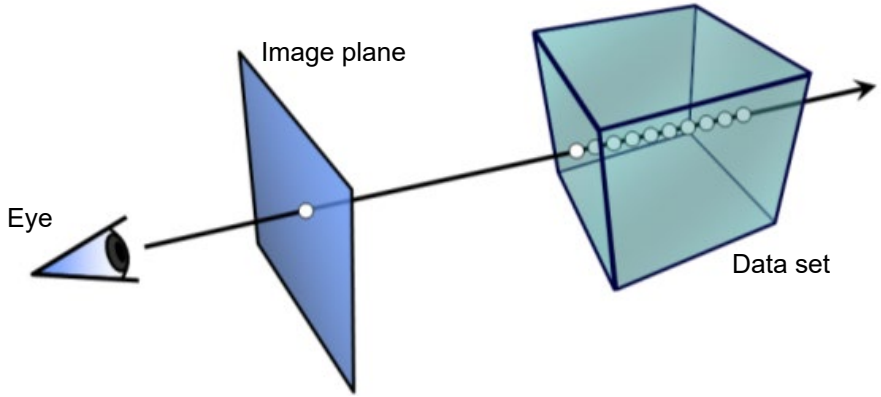


Figure 2.4: A ray casts into voxels of a 3D volume data (40).

Figure 2.5: A ray is discretised to compute intensity analytically (40).

Volume Visualisation, Part III

Maximising visibility by utilising colour/opacity

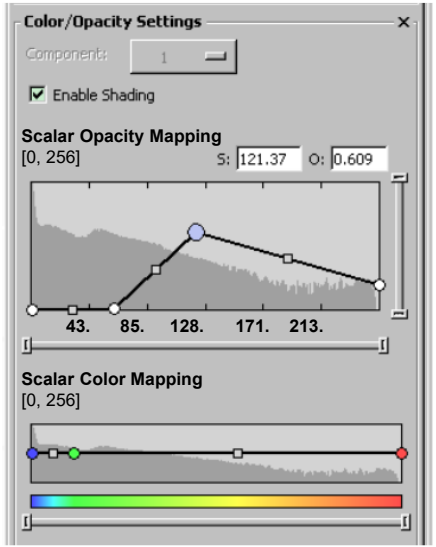


Figure 2.7: A user interface of transfer function specifications (2).

Volume Rendered Data Set, Example I

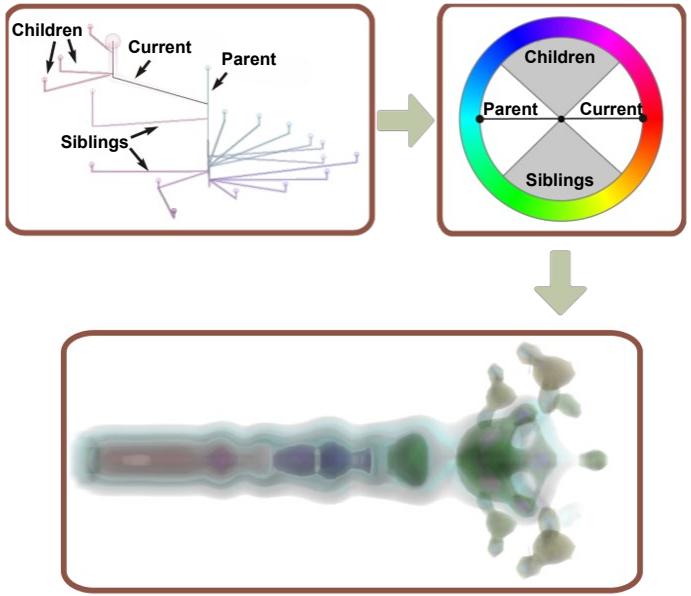


Figure 5.9: Depiction of neighboring relationship of “fuel” data set.

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.

Volume Rendered Data Set, Example II

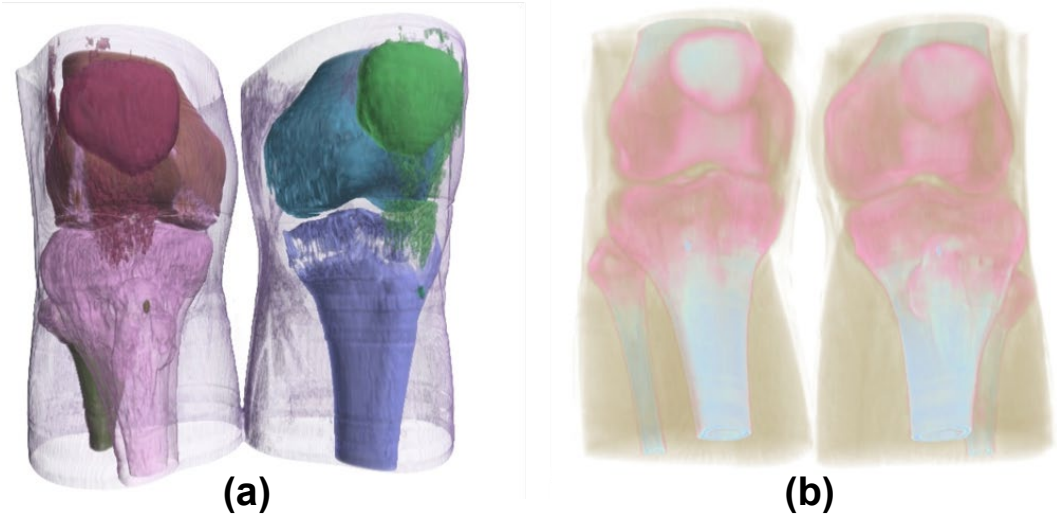


Figure 7.4: Comparison of volume rendered CT knee data set with:
(a) our approach, and (b) VolView 3.2.

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.

Volume Rendered Data Set, Example III

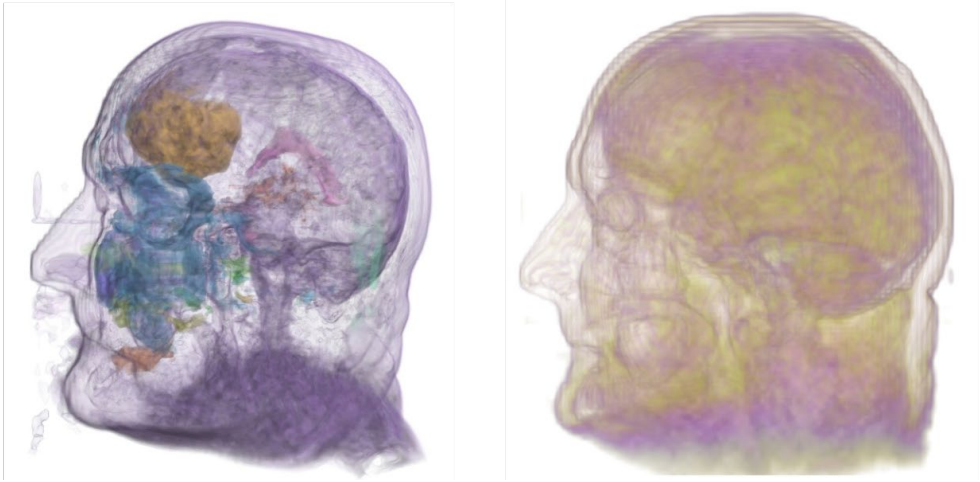
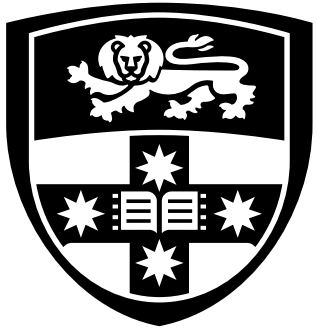


Figure 7.6: Comparison of volume rendered MR tumor head data set with: (a) our approach, and (b) VolView 3.2.

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.



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Application 2

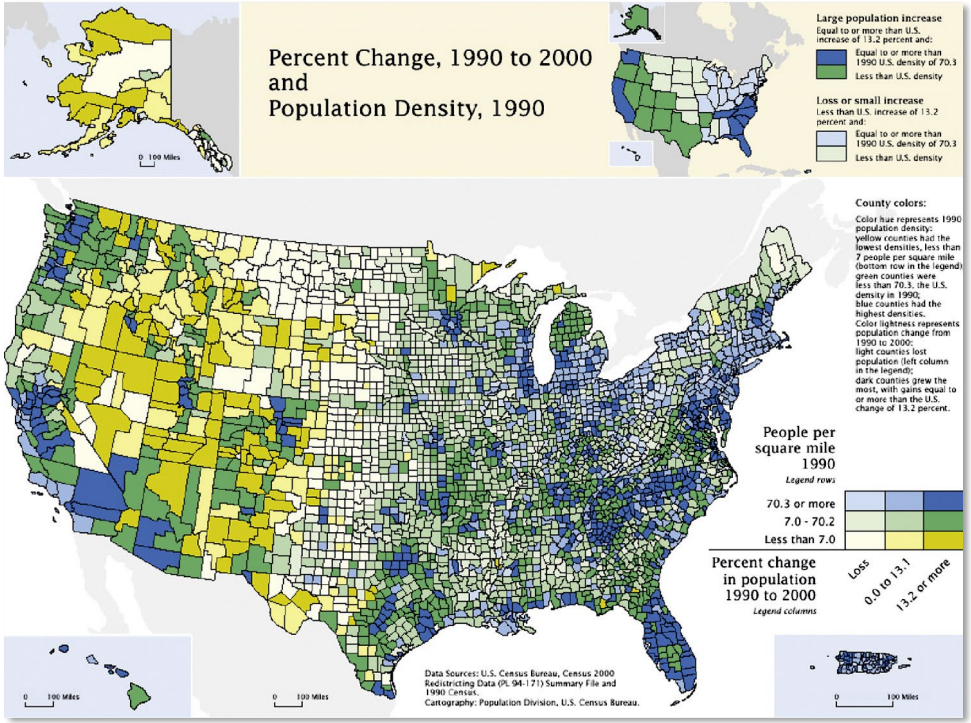
Application in cartography

ColorBrewer by Cynthia Brewer

Online tool for selecting map colour schemes

- Colorbrewer2

Color Brewer Example

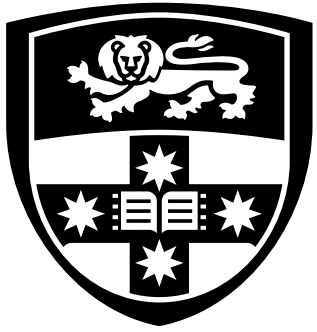


Ware, C. (2013). *Information visualization: Perception for design*. Elsevier Science.

Allows you to pick the best combination based on visualization requirements.

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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Differentiating Data

Quantitative vs Qualitative

Quantitative Data, Part I

- Measures of values or counts
- Expressed as numbers
- Data about numeric variables
- For example, how many, how much, or how often

Quantitative Data, Part II

- Examples

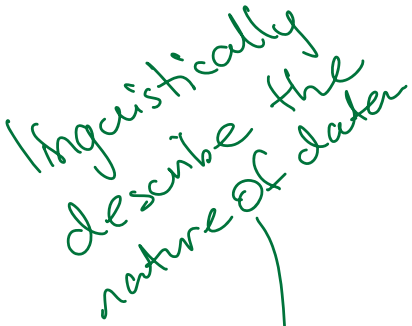
Data unit	Numeric variable means quantitative data	
A person	How many hours do you work?	37.5 hours per week
A house	How many square metres is the house?	200 square metres
A business	How much was the last year's profit?	$300,000
A farm	How many ducks are located on the farm?	100 ducks
A school	How many students are currently enrolled?	5,000 students

Australian Bureau of Statistics. *Statistical language: Quantitative and qualitative data*.

Qualitative Data, Part III

- Measures of “types”
- May be represented by a name, symbol, or a number code
- Data about categorical variables
- For example, what type

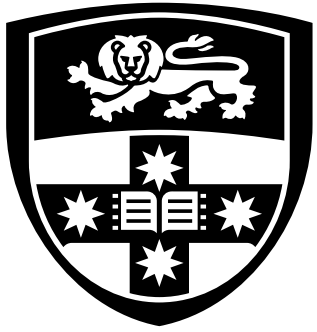
Qualitative Data, Part IV



- Examples

Data unit	Categorical variable means qualitative data	
A person	Do you work part-time or full-time?	Full-time
A house	In which city is the house located?	Sydney
A business	What type of structure is the business?	Joint-venture
A farm	What is the main activity of the farm?	Poultry
A school	Is it a public or private school?	Public

Australian Bureau of Statistics. *Statistical language: Quantitative and qualitative data*.



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Differentiating Data

Structured vs Unstructured

Structured Data

- Organised information in a database
- Can be fit into a spreadsheet
- Easier to handle

Structured Data (cont.)

- Examples
  - Microsoft Excel files (xls, xlsx, xlsm)
  - Text files (csv, txt, tab, tsv)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	price	date_sold	suburb	num_bath	num_bed	num_parki	property_s	type	suburb_po	suburb_me	suburb_sq	suburb_lat	suburb_lng	suburb_ele	cash_rate	property_i	km_from_cbd
2	530000	########	Kincumber	4	4	2	1351	House	7093	29432	9.914	-33.4725	151.4021	24	2	150.9	47.05
3	525000	########	Halekulani	2	4	2	594	House	2538	24752	1.397	-33.2177	151.5524	23	2	150.9	78.54
4	480000	########	Chittaway	2	4	2	468	House	2028	31668	1.116	-33.3268	151.4456	3	2	150.9	63.59
5	452000	########	Leumeah	1	3	1	344	House	9835	32292	4.055	-34.0538	150.8396	81	2	150.9	40.12
6	365500	########	North Avo	0	0	0	1850	Vacant lan	2200	45084	1.497	-33.4561	151.436	18	2	150.9	49.98
7	550000	########	Kincumber	1	3	1	626	House	7093	29432	9.914	-33.4725	151.4021	24	2	150.9	47.05
8	535000	########	Bensville	1	3	1	556	House	2545	36764	4.925	-33.4991	151.3905	27	2	150.9	43.91
9	495000	########	Leumeah	1	3	2	582	House	9835	32292	4.055	-34.0538	150.8396	81	2	150.9	40.12
10	410000	########	Toukley	1	3	3	493	House	4550	25844	3.683	-33.258	151.5432	4	2	150.9	74.11
11	242500	########	Winmalee	0	0	0	1248	Vacant lan	6202	38740	9.058	-33.6797	150.6112	263	2	150.9	59.15
12	6500000	########	Point Clare	1	3	2	742	House	3731	31772	3.336	-33.4402	151.3172	62	2	150.9	48.17
13	890000	########	Picnic Poin	2	4	3	715	House	6160	40560	3.859	-33.973	151.0063	33	2	150.9	22.31
14	533000	########	Whalan	3	4	2	695	House	5973	24180	2.429	-33.7557	150.8036	37	2	150.9	39.53
15	1120500	########	North Roc	2	4	2	904	House	7965	40092	5.462	-33.7757	151.0147	92	2	150.9	20.61
16	830000	########	Winmalee	3	6	2	2109	House	6202	38740	9.058	-33.6797	150.6112	263	2	150.9	59.15
17	675000	########	Bass Hill	3	3	2	263	Townhous	9069	24388	2.929	-33.9003	150.9931	40	2	150.9	20.43
18	500000	########	Kincumber	1	3	1	791	House	7093	29432	9.914	-33.4725	151.4021	24	2	150.9	47.05
19	473000	########	Leumeah	1	3	3	581	House	9835	32292	4.055	-34.0538	150.8396	81	2	150.9	40.12
20	885000	########	Picnic Poin	1	3	2	557	Vacant lan	6160	40560	3.859	-33.973	151.0063	33	2	150.9	22.31
21	625000	########	Chittaway	2	4	2	555	House	2028	31668	1.116	-33.3268	151.4456	3	2	150.9	63.59
22	520000	########	Leumeah	1	3	1	651	House	9835	32292	4.055	-34.0538	150.8396	81	2	150.9	40.12
23	510000	########	Winmalee	1	3	1	993	House	6202	38740	9.058	-33.6797	150.6112	263	2	150.9	59.15
24	610000	########	Chittaway	3	5	8	862	House	2028	31668	1.116	-33.3268	151.4456	3	2	150.9	63.59
25	570000	########	Winmalee	1	3	2	828	House	6202	38740	9.058	-33.6797	150.6112	263	2	150.9	59.15
26	555000	########	Bensville	2	4	0	748	House	2545	36764	4.925	-33.4991	151.3905	27	2	150.9	43.91

domain_properties

Unstructured Data

- Freeform information
- Cannot be fit into a spreadsheet
- More difficult to handle

Unstructured Data (cont.)

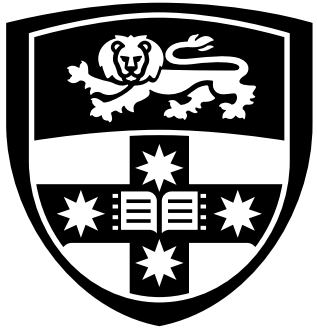
- Examples
  - Videos
  - Audios
  - Images
  - Textual, e.g., emails, text messages
  - Webpages
  - PDFs

Can We Visualise Unstructured Data?

- Machine learning
- Natural language processing

Metadata

- Derived data
- Data that describes other data
- Examples
  - A photo: file name, author, date captured, file size, etc.
  - A book: version, author, publisher details, table of content, etc.
  - An email: subject, from, to, date and time sent, sending and receiving server names and IPs, etc.
  - A spreadsheet: tab names, column names, user comments, etc.



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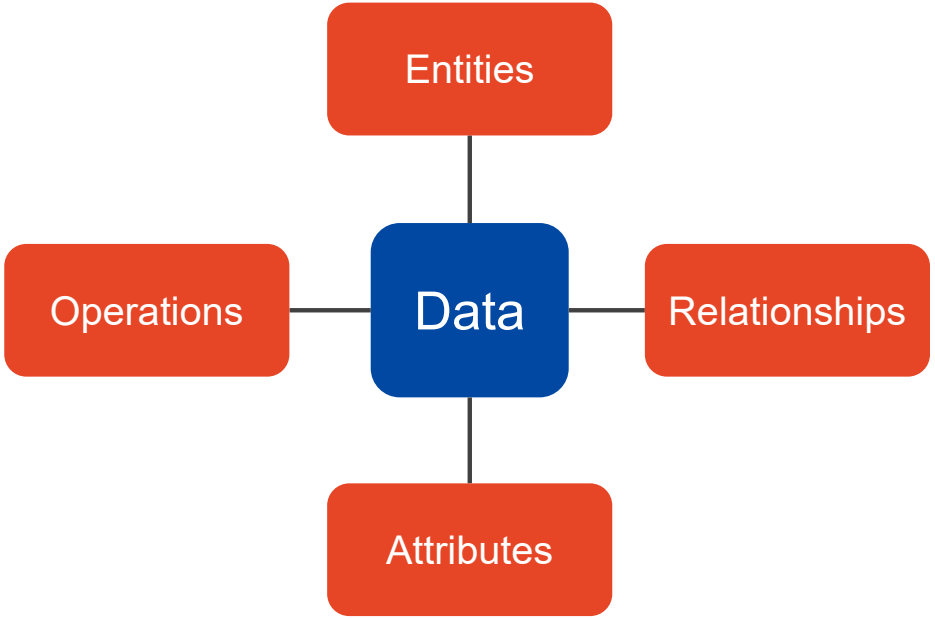
Data Model

Model to Describe Data



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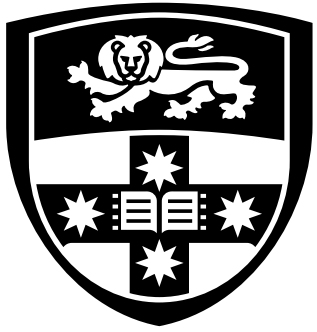

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Data Model

Entities and Relationships

Entities

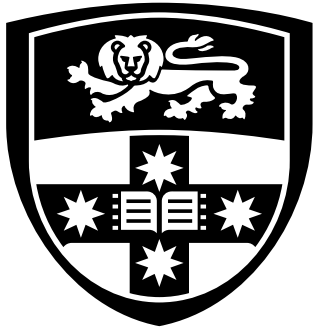
Objects of interest/values

- Can be single
  - People, hurricanes, fish, etc.
- Can be a group
  - A school of fish

Relationships

Structures that relate entities:

- Can be structural and physical
- Can be conceptual
- Can be causal
- Can be temporal



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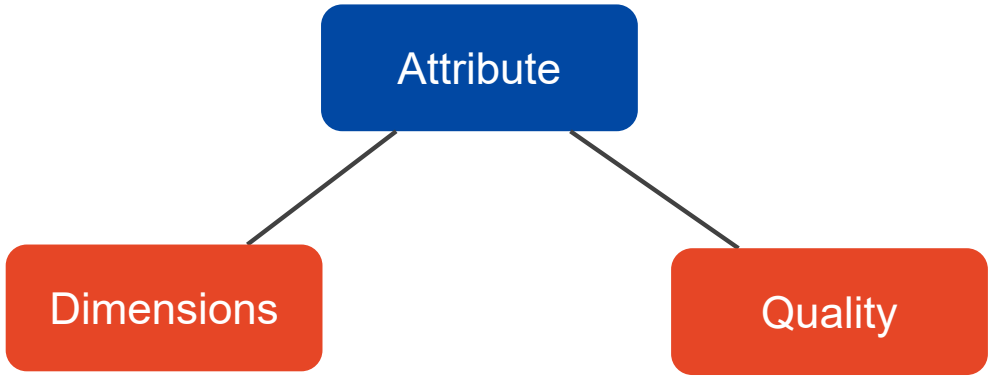
Data Model

Attributes

Attributes of Entities or Relationships

A property of some entity: not independent

- For example
  - Colour of a lychee is an attribute of lychee
  - Temperature of water
  - Duration of a trip



Dimensions of Attribute

- Scalar
  - Weight of person
- Vector
  - Direction of travel
- Tensor
  - Direction plus shear force
  - Stressed object
- Field of scalars/vectors/tensors
  - Gravitational field of earth: 3D vector
  - Gravity strength at earth’s surface: 2D scalar

Quality of Attribute

Four levels of measurement

1. Nominal
    - Labelling purpose
    - Examples?
2. Ordinal
    - Can be ordered in a sequence
    - Examples?

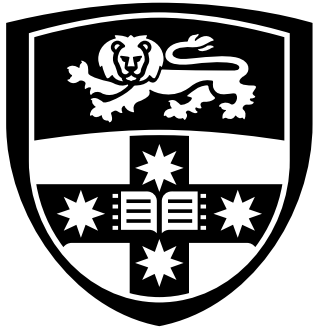
Quality of Attribute (cont.)

Four levels of measurement

3. Interval
   - Able to derive the gap between values
   - Examples?
4. Ratio
   - Full expression of a real number
   - Examples?

Quality of Attribute (Computer Programming)

- Category data
  - Nominal scale
- Integer data
  - Ordinal scale
- Real-number data
  - Interval and ratio scale



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Data Model

Operation

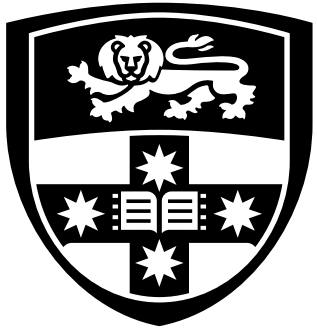
Operations

What about processes that are performed on entities and relationships? They are also considered as data!

- Mathematical operation on numbers (+ − × /)
- Merging lists (two or more into one)
- Inverting a value (creating opposite)
- Bringing an entity/relationship into existence (mean of the set)
- Deleting an entity/relationship (breakups)
- Transforming (froglet to adult frog)
- Forming (pie from apple and pastry)
- Splitting a single entry (disassemble of machine)

Summary

- What are data types?
  - Forms of data for us to visualise
- What are kinds of data we can identify?
  - *Quantitative vs qualitative*
  - *Structured vs unstructured*
  - *Attributes vs relationships*
  - *Nominal, ordinal, interval, and ratio*
  - *Operation*



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