INM433: Session 01

Introduction to Visual Analytics and Visualisation

INM433 Visual Analytics

Welcome to Visual Analytics!

- Taught by
  - Aidan Slingsby
  - Gennady and Natalia Andrienko
- Not much specialised Visual Analytics software
  - We'll use Andrienkos' **V-Analytics**
  - **Tableau/Mondrian/R/Excel** used in a "VA way"
- 100% coursework
  - Groupwork: literature review
  - Individual work: Analysis project

Visual Analytics

What is Visual Analytics?

- The science and practice of **analytical reasoning** by combining **computational analysis** with **interactive visual interfaces**.
  - Let computers do what computers are good at (summarising and searching large amounts of data)
  - Let humans do what humans are best at (interpreting, thinking, reasoning, applying expert knowledge)
- Analytical reasoning
  - Data→Information→Knowledge→Solution/decision

Human vs Computer

Human

- flexible and inventive, can deal with new situations and problems
- solve problems that are hard to formalise
- can cope with incomplete/ inconsistent information
- can recognise things that are hard to compute or formalise

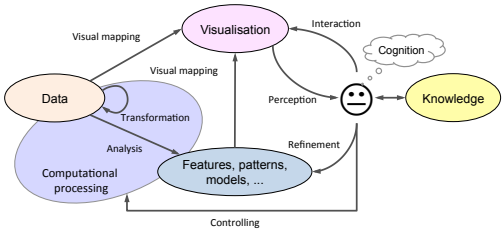
Computer

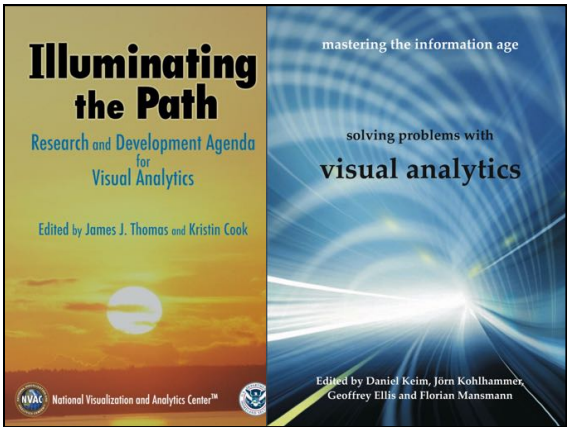
- large amounts of data
- fast search
- fast data processing
- link to other databases/ services
- high quality graphics

Why Visual Analytics?

- Incorporate human reasoning
  - Too much data to simply explore ourselves
    - need a computer to reduce/filter/generalise/identify
    - …but which parameters to use?
  - Want to be aware of potential problems in data
  - Don't know what we're looking for (yet)
  - Want to incorporate "expert knowledge"
  - Want to record and/or understand the process of reasoning

Divide the labour between human and computer





Examples from later in the module

- London Bike Hire scheme
  - Are there distinct bike hiring behaviours? What? Where? Can we manage the scheme better?
- Tweets
  - Can we detect events from tweets? Where? When?
  - Can be characterise neighbourhoods?
- Journeys
  - What are common journeys made

Example

- IBM's entry to Orange's **Data for Development** challenge
  - Participants were given 2.5 billion phone records (cell mast only) for the Ivory Coast
- Suggested bus routes based on mobile phone patterns of communication

http://www.bbc.co.uk/news/technology-22357748

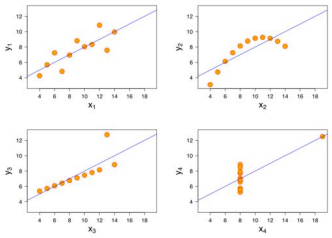
Role of visualisation

Role of visualisation

- **Today is about visualisation**
- Present data in a way that facilitates comparison
  - Compare hundreds of numbers - humans are good as seeing visual patterns
  - See distributions and uncertainties
  - Compare alternative outputs
- As an interactive interface to data:
  - Details on demand
  - Trigger/direct the computational analysis
  - Humans can act on their interpretations

Anscombe's Quartet (1973)

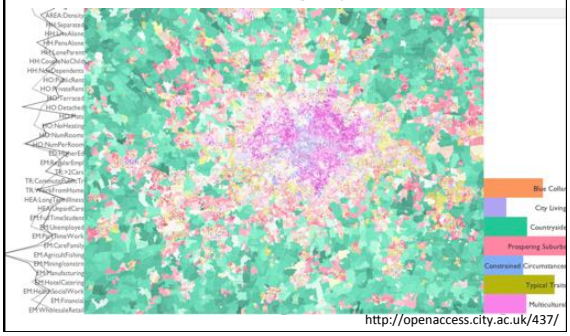
I		II		III		IV	
x	y	x	y	x	y	x	y
10.0	8.04	10.0	9.14	10.0	7.46	8.0	6.58
8.0	6.95	8.0	8.14	8.0	6.77	8.0	5.76
13.0	7.58	13.0	8.74	13.0	12.74	8.0	7.71
9.0	8.81	9.0	8.77	9.0	7.11	8.0	8.84
11.0	8.33	11.0	9.26	11.0	7.81	8.0	8.47
14.0	9.96	14.0	8.10	14.0	8.84	8.0	7.04
6.0	7.24	6.0	6.13	6.0	6.08	8.0	5.25
4.0	4.26	4.0	3.10	4.0	5.39	19.0	12.50
12.0	10.84	12.0	9.13	12.0	8.15	8.0	5.56
7.0	4.82	7.0	7.26	7.0	6.42	8.0	7.91
5.0	5.68	5.0	4.74	5.0	5.73	8.0	6.89



https://en.wikipedia.org/wiki/Anscombe%27s_quartet

(Static) example: transport

(Interactive) example: Geodemographics



http://openaccess.city.ac.uk/437/

(Interactive) example: Geodemographics: Purpose

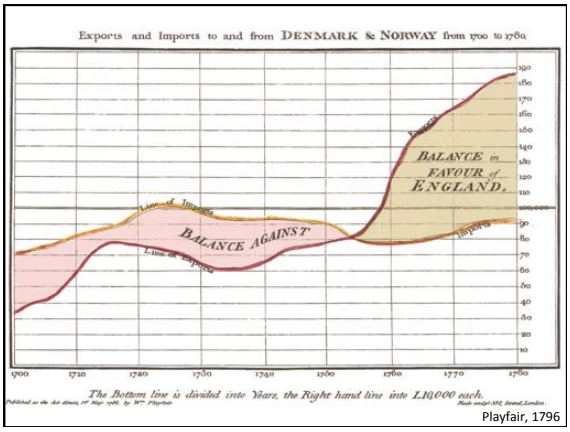
- To explore a population classifier
  - What variables drive the classifier?
  - What's the spatial distribution of the variables?
  - How certain are we that the classifier is a good description?
- To look at the impact on users
  - Does it affect the way that the classifier is used?

http://openaccess.city.ac.uk/437/

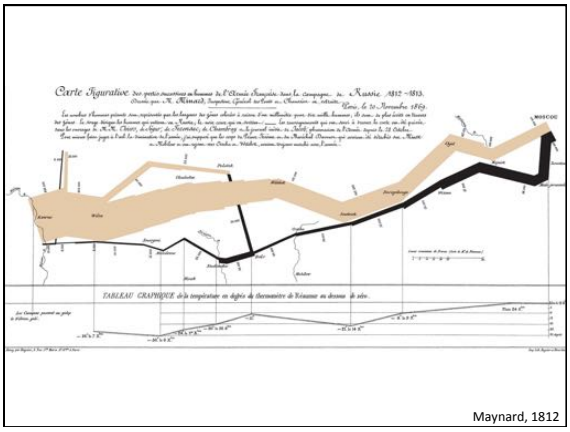
A historical perspective

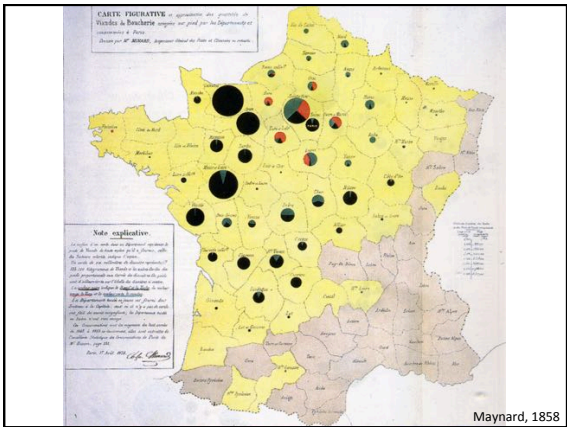
Statistical Graphics

- From the statistics domain
  - Scatter plots
  - histograms,
  - box plots
  - barcharts
  - Realisation that statistics may hide important things
- Exploratory data analysis (Turkey, 1977)
  - Interactive versions from 1970s onwards



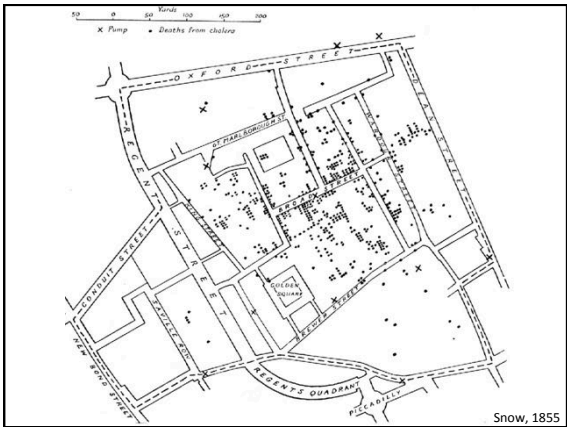
Playfair, 1796


Maynard, 1812


Maynard, 1858

Geographical Information Science (GIS)

- Geographical data storage, visualisation and analysis
  - Facility managements
  - Automated cartography
  - Layers and geographical linking
  - Data representation
  - Spatial analysis
  - (poor temporal handing)
- Recent web-based, mashup developments



Snow, 1855

Information Visualisation

- From computer graphics and human-computer interaction
- Emphasis in novelty in visual encoding and interaction
- Increasingly “spatial” and “temporal”

Visual Analytics

- Incorporation of computational analysis methods
  - particularly for large data
- Emphasis on reasoning and sensemaking in an application domain

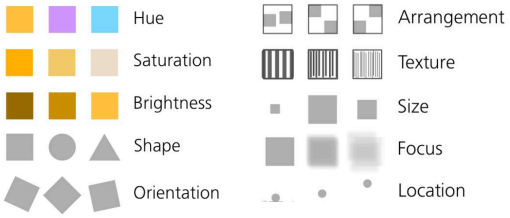
The visualisation display

The visualisation display

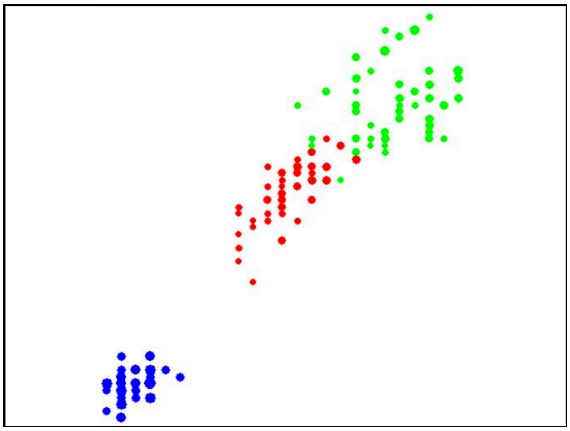
- It's helpful to think of the visualisation display as a **2D space** that contains **marks:**
  - Points, lines, areas, surfaces, volumes
- See:
  - Munzner (2014): *Visualization Analysis and Design*. A K Peters Visualization Series, CRC Press

Visual variables

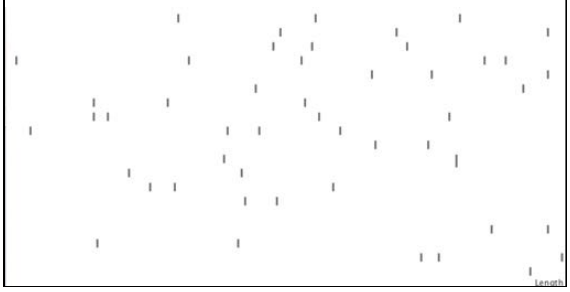
- First proposed by Bertin (1983)
  - also added to by others!



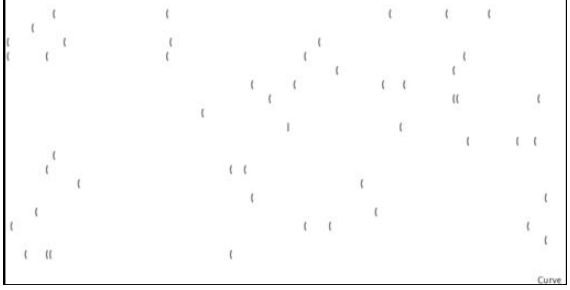
MacEachren, 1995



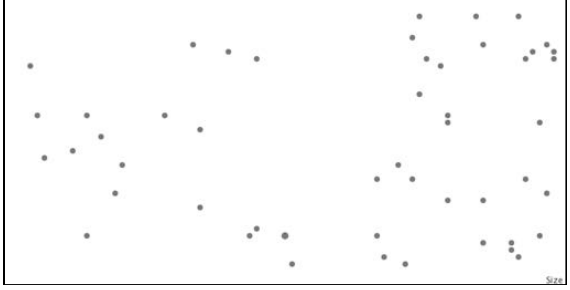
Pre-attentive: length



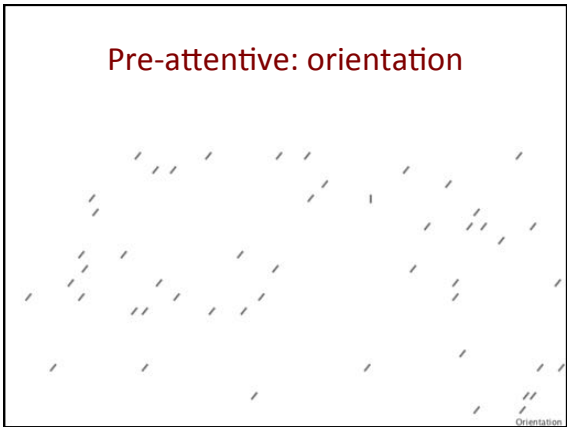
Pre-attentive: curve



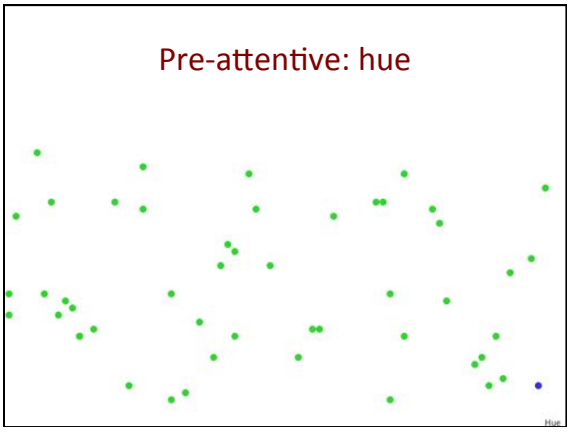
Pre-attentive: size



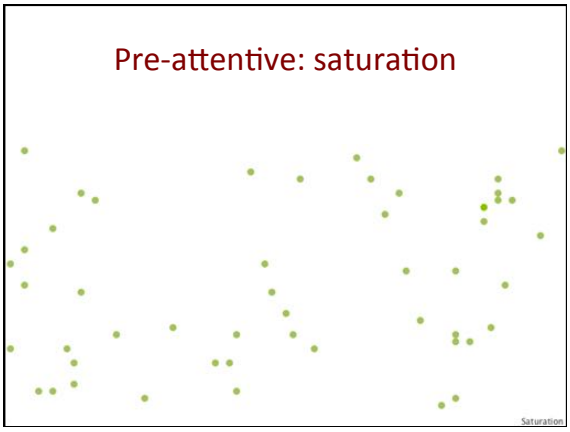
Pre-attentive: orientation



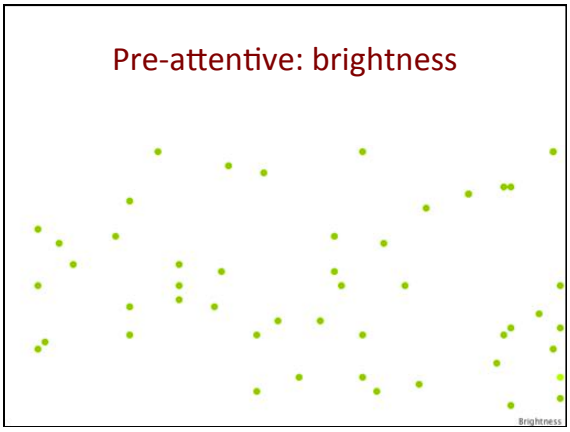
Pre-attentive: hue



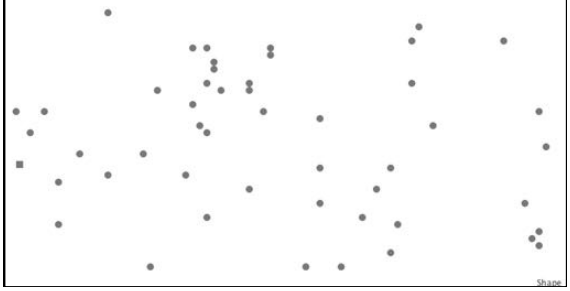
Pre-attentive: saturation



Pre-attentive: brightness



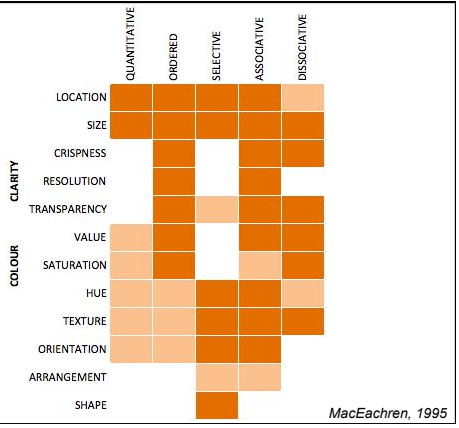
Pre-attentive: shape



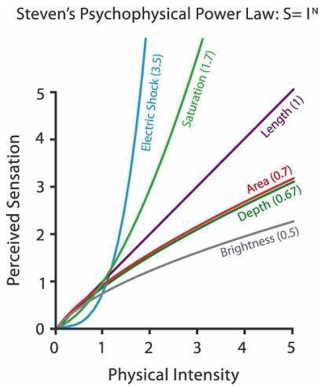
Visual variables not created equal

- Quantitative
  - Allowing **quantity** to be estimated
- Ordered
  - Allowing **order** to be determined
- Selective
  - Allowing **particular things** to be identified
- Associative
  - Allowing **groups of things** to be identified

Bertin, 1983

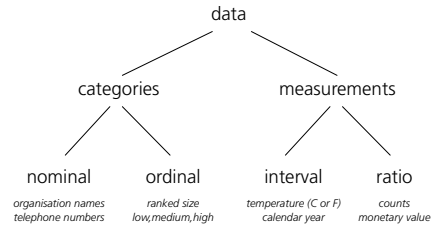


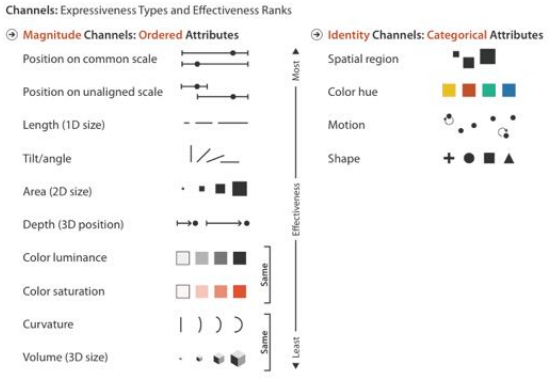
MacEachren, 1995



Stevens, S.S. (1957): On the psychophysical law. *Psychological Review* 64 (3): 153–181

Depends on your data





T. Munzner (2014): *Visualization Analysis and Design*. A K Peters Visualization Series, CRC Press

Use theory to inform design choices

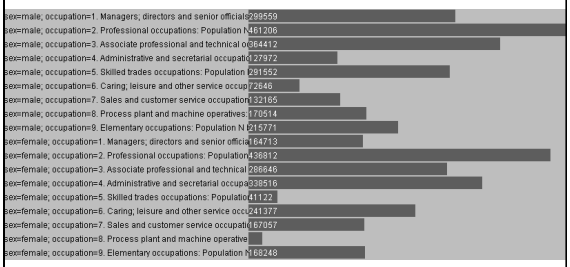
- For example:
  - Position or (aligned) length is the strongest
    - implies quantity/order, so take care with categories
  - Hue and shape good for unordered categories (<8ish)
  - Lightness has a much lower resolution than position
    - can be good for ordered categories.
  - Maps use position to show geography
    - but if geography isn't the main point, are you "wasting" this important visual variable?

Types of display

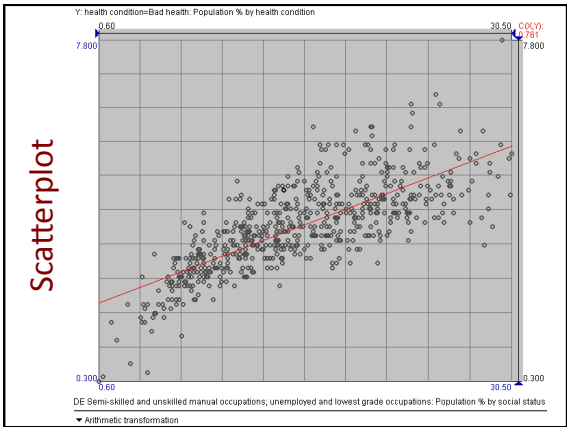
Some common types of display

	Display elements	Data components
Bar graph (bar chart) 	x- or y-position bar size (length)	references numeric attribute
Scatter plot 	marks (dots) x-position y-position	references numeric attribute numeric attribute
Line graph 	x-position y-position	ordered references, especially temporal numeric attribute
Gantt chart 	y-position x-position bar size (length)	temporal objects (events, processes ...) existence time (start, end) duration
Map 	marks (x,y)-position other variables	spatial references (refer to spatial objects) spatial references or spatial attributes attributes

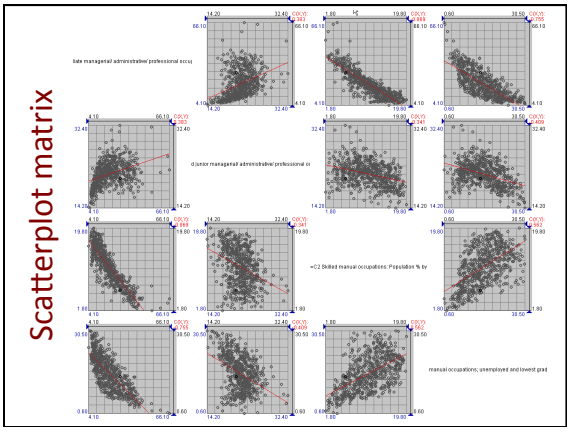
Barchart



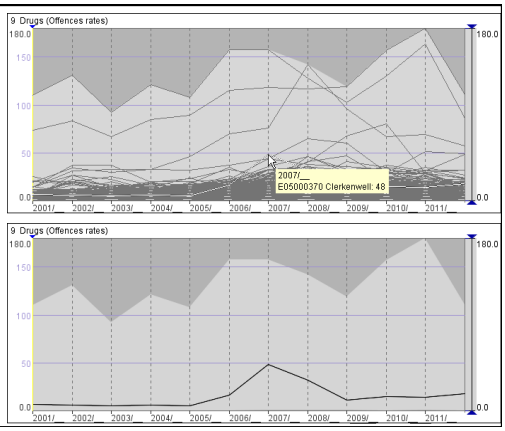
Scatterplot



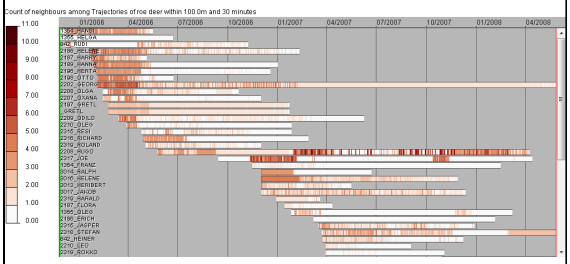
Scatterplot matrix



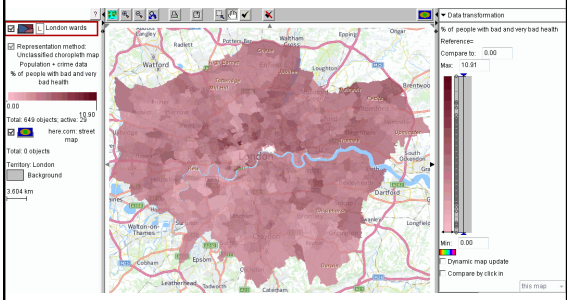
Line graph



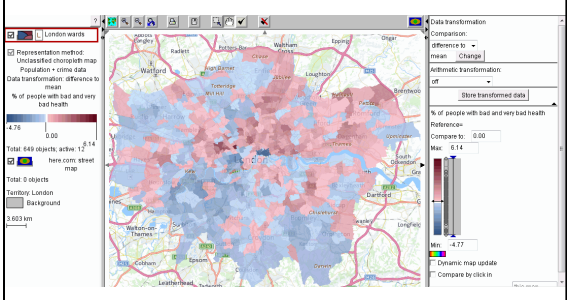
Gantt Chart



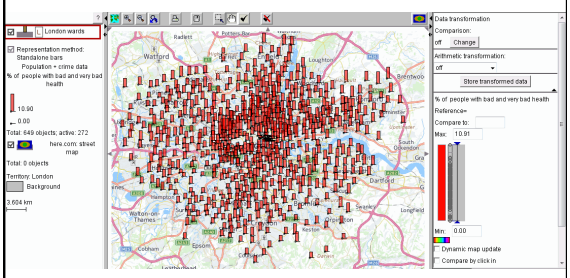
Choropleth map



Choropleth map



Proportional symbol map



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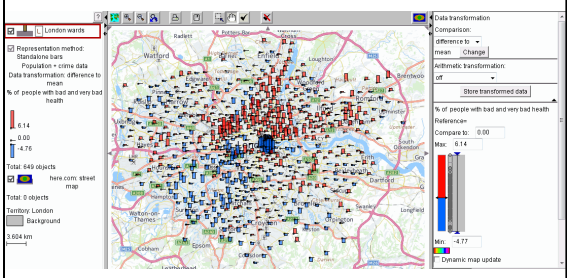

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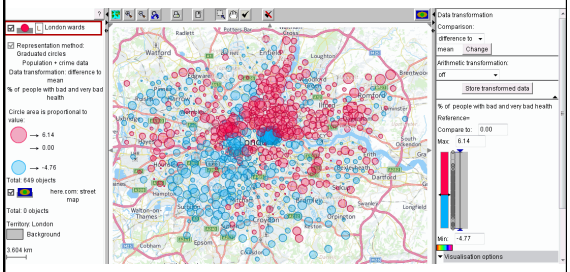
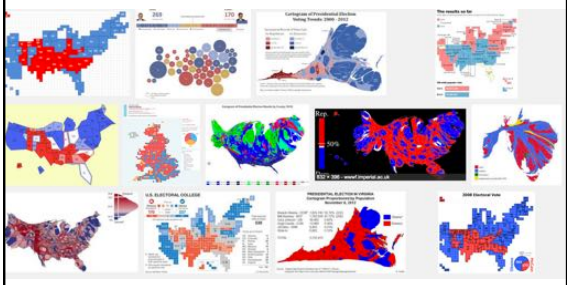


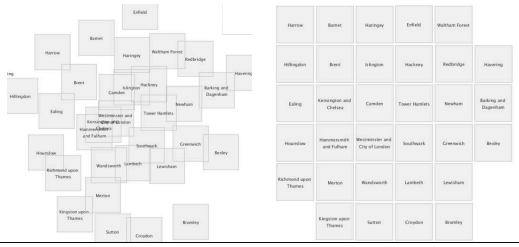
Area cartograms

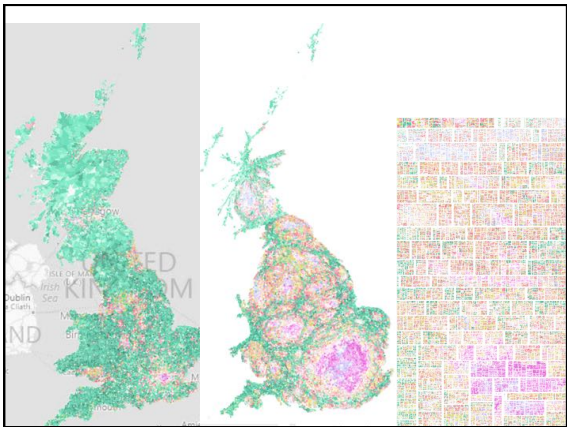
Some results of Google Image search

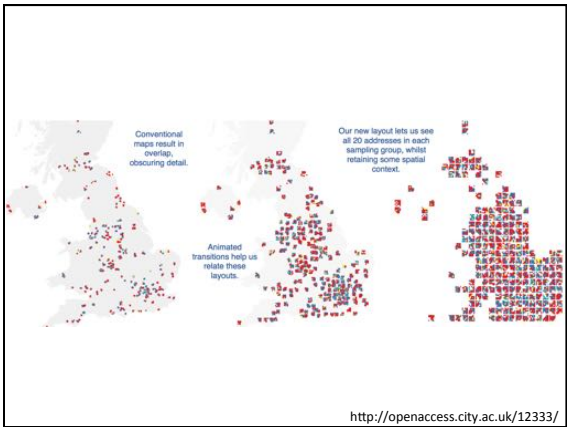


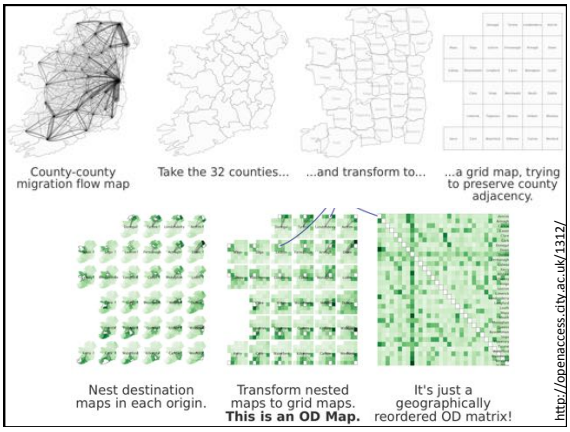
Distorting space

- giCentre often distort geographical space to give space and/or salience to particular places

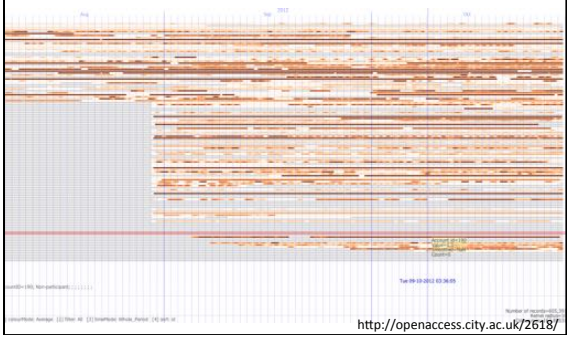








Example: Smart homes

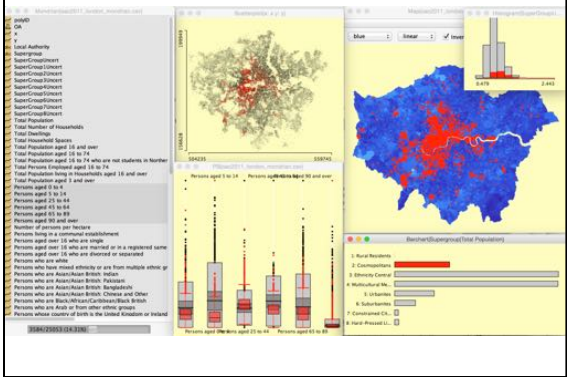


Example: GPS tracking of birds

Mondrian

Mondrian

- Interactive visual exploration software
  - Written by Martin Theus
  - http://www.theusrus.de/Mondrian/
  - Very fast, simple and effective
  - Reads CSV/TSV files



Mondrian

- Simple individual charts… but coordinated!
  - Barchart (& weighted)
  - Histogram (& weighted)
  - Scatterplot
  - Mosiac plot
  - Parallel coordinates
  - Scatter plot matrix (SPLOM)
  - Map

Mondrian: Data

- Standard single CSV or TSV file
  - Comma/tab-separated values
    - Rows = records; columns = attributes
  - Plus an additional `.map` file for choropleth maps
    - Polygons need to be specified in a particular format. Very fiddly. See example datasets and/or ask.

Mondrian: operation

- List of attributes
  - Icon identifies type –click to change
- Select one or more (SHIFT/CTRL for multiple)
  - Can weight by something (e.g. population)
- Use the plot menu to plot simple charts
  - Coordinated: selecting items will select corresponding items
- Calculate: min/max; can also connect to R
- Selection types: see options menu

Tableau

Tableau

- Interactive data visualisation focused on business intelligence
- Perhaps less suited for exploratory visual analysis

Tableau: data

- Tabular data
  - Many types: CSV, database connection, Excel, etc
- Concept of
  - Dimensions: categorical variables for pivoting
  - Measures: quantitative (numerical) variables for mapping to colour/size/etc
- May need to reshape data
  - http://kb.tableau.com/articles/knowledgebase/preparing-excel-files-analysis

Tableau: operation

- Column and row shelves:
  - Broadly, x-position and y-position
- Marks: the shapes that represent data
  - Map to "visual channels": size/colour/label
- Tableau will aggregate data according to what's in the shelves and marks
  - Drag the attribute for disaggregation to marks "detail".

Wrap up

Conclusions

- Visual Analytics is:
  - **analytical reasoning** by combining **computational analysis** with **interactive visual interfaces**
- Visualisation has an important role:
  - Well-designed visualisation present data effectively and facilitating comparison
  - Well-design interactions act as an interface to data, particularly in multiple-linked views
- Mondrian and Tableau enable visualisations/ interactions that can facilitate Visual Analytics

Intended learning outcomes

- Know what Visual Analytics is
- Know the role of interactive visualisation in Visual Analytics
  - Visual variables and when to use
  - Types of visualisation display and when to use
  - Types of interaction
  - Coordinated linked views
- (Practical) how to use Mondrian and Tableau

Reading

- Exploratory Analysis of Spatial and Temporal Data A Systematic Approach.
  - *Chapter 4.3 Visualization in a Nutshell*
  - *Download whole book!* http://0-dx.doi.org.wam.city.ac.uk/10.1007/3-540-31190-4
- **Munzner, T.** Visualization Analysis & Design, CRC Press
  - Chapters 2 and 5.