

Lesson 1: Introduction to Visual Analytics

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What will you learn from this lesson?

- Motivation of Visual Analytics
- What is Visual Analytics
- Learning from the history of visual analytics
- Data Visualisation tools

Motivation of Visual Analytics

The World is full of charts that lie!



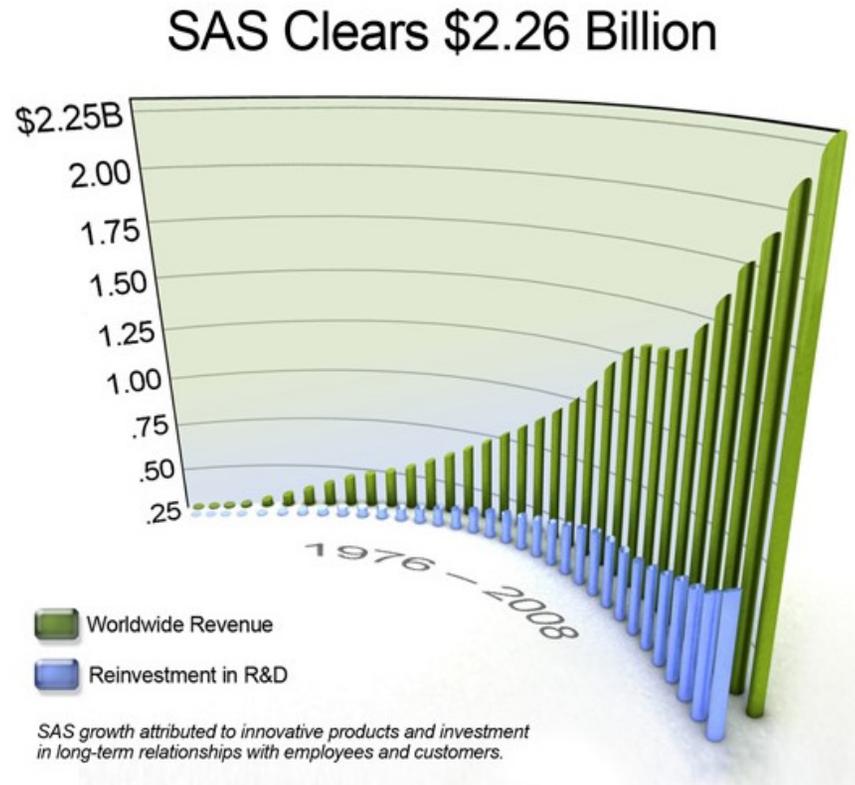
Non-oil domestic exports (Nodx) growth was flat in the second quarter. For the first half this year, Nodx fell 4.5 per cent compared with the same period last year.

Stuttering Nodx performance



Motivation of Visual Analytics

Junk charts are good for advertising but not for understanding.



Motivation of Visual Analytics

Data rich, information poor



Source: <http://omnitele-com.s3.frantic.com/2015/04/big-data-ocean-crop.jpeg>

Motivation of Visual Analytics

The World is buried in data,

Just SHOW me the number

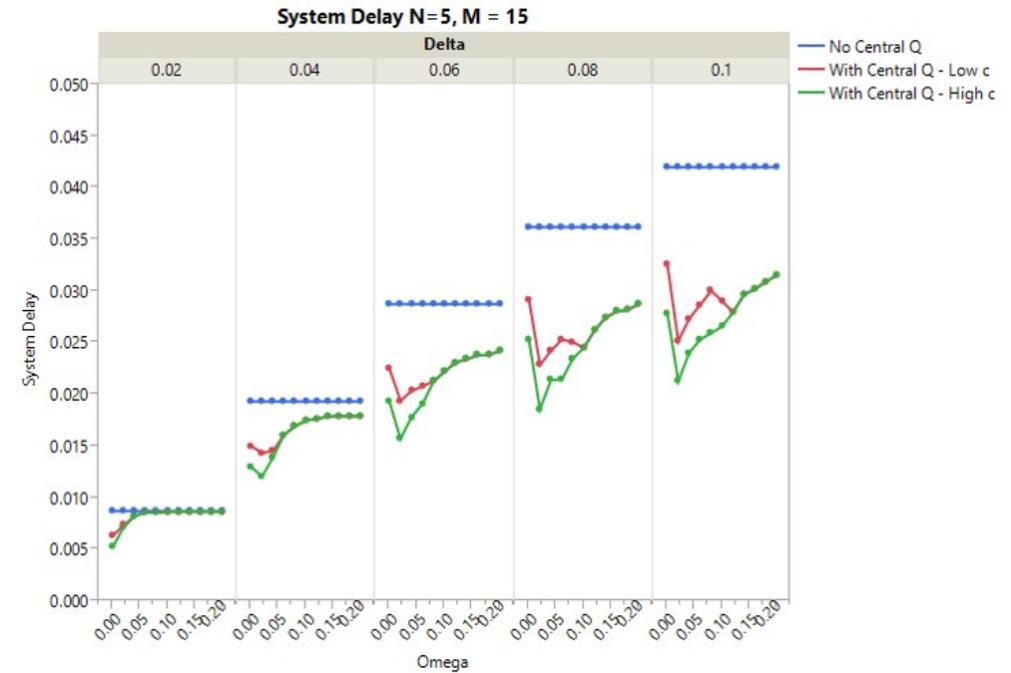
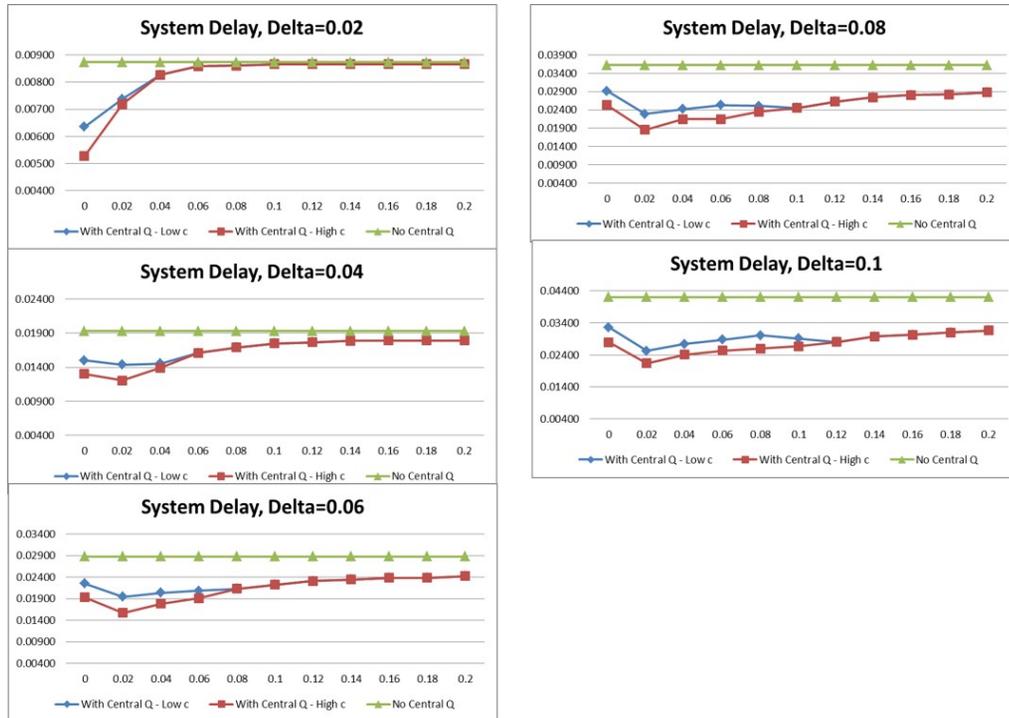


B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD		
1	Country	Exchange	Name	Force	Symbol	ISIN	SEDOL	Class	Industry	Supercat	1Day	1Week	2Week	3Month	1Day	1Week	2Week	3Month	1Day	1Week	2Week	3Month	1Day	1Week	2Week	3Month	1Day	1Week	2Week	3Month
2	AT	ViE	Erxn Gr	EUR	ERXT.VI	AT0000708901	12.75	3E+09	3E+09	Financial	Bank	13.75	13.63	10.27	7.75	11.84	16.2	-0.070	-0.075	-0.063	-0.0894	0.247	0.2607	0.1452	0.1701	0.0763	0.107	-0.2		
3	AT	ViE	Parfumo	EUR	PRFN.VI	AT0000701047	21.21	1E+09	1E+09	Financial	Bank	22.65	25	19.95	14.52	16	15.3	-0.054	-0.056	-0.052	-0.0539	0.0529	0.0601	0.4501	0.5707	0.2256	0.2714	0.06		
4	AT	ViE	reschp	EUR	VOEL.VI	AT0000704340	3.95	1E+09	1E+09	Bank	Bank	10.11	10.47	11.9	12.4	15.22	15.04	-0.024	-0.029	-0.053	-0.0734	-0.12	-0.101	-0.206	-0.72	-0.253	-0.223	-0.3		
5	AT	ViE	Wolfsburg	EUR	WVBY.VI	AT0000705593	5.93	5E+08	1E+08	Industry	Chem	6.95	5.6	5.5	6.57	10.06	11.5	-0.036	-0.033	-0.0338	-0.0222	0.0752	0.1076	-0.037	-0.06	-0.41	-0.583	-0.56		
6	AT	ViE	Intercell	EUR	ICEL.VI	AT0000700796	23.2	3E+08	1E+08	Health	Health	21.22	21.48	21.43	22.92	25.68	21.04	0.933	0.9193	0.8801	0.9563	0.0798	0.9029	0.902	0.954	-0.031	-0.064	0.04		
7	AT	ViE	Andritz	EUR	ANDR.VI	AT0000701176	23.16	3E+08	1E+08	Industry	Indust	21.47	21.51	19.78	24	23.3	18.16	0.0787	0.0784	0.0761	0.0532	0.0709	0.9955	-0.035	0.0045	-0.006	0.0238	0.27		
8	AT	ViE	Vienna	EUR	VIGR.VI	AT0000700833	21.63	3E+08	1E+08	Financial	Insur	22.05	21.3	19.23	19.17	24.6	24.12	-0.019	-0.021	0.0057	-0.0063	0.1065	0.2121	0.1263	0.1743	-0.21	-0.083	-0.8		
9	AT	ViE	ORIX	EUR	ORIX.VI	AT0000701659	25.2	4E+09	3E+09	Bank	Bank	24.23	23.34	21.23	20.72	22.39	19.72	0.075	0.0729	0.071	0.0439	0.101	0.2106	0.2162	0.2444	0.075	0.1661	0.34		
10	AT	ViE	Taliban	EUR	TELA.VI	AT0000705598	11.4	4E+09	1E+09	Telecom	Telecom	10.96	10.43	10.43	9.95	11	10.3	0.0418	0.0414	0.0461	0.0414	0.0611	0.1902	0.1457	0.153	0.0564	0.0733	0.04		
11	AT	ViE	Verbund	EUR	VERB.VI	AT0000706607	28.53	2E+09	3E+09	Utilities	Utilities	28.36	28.92	26.12	25	23.97	32.56	-0.03	-0.035	-0.044	-0.0649	0.0948	0.1862	0.1436	0.1901	-0.046	-0.02	-0.1		
12	AT	ViE	Alpine E	EUR	ATPR.VI	AT0000705884	2.27	5E+08	1E+08	Financial	Real	2.32	2.02	2.15	1.47	2.18	2.58	-0.022	-0.024	0.1238	0.0396	0.0558	0.0298	0.5442	0.6843	0.0433	0.1501	-0		
13	AU	ASX	Bendigo	AUD	BENLX.AU	AU0000701202	6.19	2E+09	1E+09	Financial	Bank	7.92	7.4	6.3	6.84	10	11.1	0.0341	0.0346	0.0366	0.03956	0.3	0.473	0.1974	0.0731	-0.191	-0.035	-0.21		
14	AU	ASX	Sacorp	AUD	SUNLX.AU	AU0000705984	6	3E+09	1E+09	Financial	Bank	6.14	6.17	5.4	5.2	7.5	7.31	-0.023	-0.022	-0.026	0.2437	0.111	0.107	0.1598	0.598	-0.2	0.623	-0.2		
15	AU	ASX	National	AUD	NABLX.AU	AU0000705469	20.1	4E+10	3E+10	Financial	Bank	21.03	19.79	18.35	17.91	18.93	20.86	-0.161	-0.166	0.0971	0.09396	0.0964	0.1112	0.1472	0.2522	0.1618	0.193	-0.6		
16	AU	ASX	Bank of AU	AUD	BOOAL.AU	AU0000701624	6.44	1E+09	1E+09	Financial	Bank	8.3	7.94	7.04	6.84	7.4	8.45	0.0963	0.0714	0.063	0.06666	0.1333	0.0853	0.2339	0.4576	0.1605	0.1635	-0.9		
17	AU	ASX	Australia	AUD	ANZLX.AU	AU0000706558	17.96	3E+10	2E+10	Financial	Bank	16.57	15.25	14.05	13.05	13.27	15.25	-0.048	-0.048	0.0308	0.02607	0.121	0.1433	0.2063	0.352	0.1863	0.373	0.03		
18	AU	ASX	Westpac	AUD	WBCLX.AU	AU0000701846	19.03	6E+10	4E+10	Financial	Bank	18.18	18.26	17.13	16.65	15.64	16.63	-0.003	-0.002	0.0074	0.00033	0.1164	0.223	0.1657	0.2713	0.2206	0.9304	0.11		
19	AU	ASX	Common	AUD	CBAAL.AU	AU0000702503	34.73	2E+10	4E+10	Financial	Bank	37	36.8	31	29.8	26.8	28.3	-0.008	-0.007	-0.01	-0.0064	0.1003	0.2417	0.1854	0.3078	0.291	0.4475	0.22		
20	AU	ASX	Bluestoy	AUD	BBLX.AU	AU0000705323	2.57	2E+09	1E+09	Bank	Bank	2.79	2.79	2.9	2.86	3.33	3.45	-0.019	-0.018	0.0076	0.00929	0.1422	0.2514	0.193	0.2235	-0.272	-0.071	-0.2		
21	AU	ASX	CIR Ltd	AUD	CIRLX.AU	AU0000702964	12	2E+09	1E+09	Bank	Bank	13.35	14.95	11.6	11.0	14.05	13	-0.053	-0.053	0.047	0.04028	0.0295	0.204	0.1963	0.536	-0.193	0.162	-0.1		
22	AU	ASX	Bank Res	AUD	ELU.AU	AU0000705775	4.02	1E+09	1E+09	Bank	Bank	4.45	4.4	4.2	4.28	4.75	4.44	-0.007	-0.007	-0.014	-0.009	-0.04666	-0.067	-0.037	-0.022	0.0267	-0.06			
23	AU	ASX	Dechra	AUD	DETLX.AU	AU0000702312	2.25	2E+09	1E+09	Bank	Bank	2.34	2.35	1.805	1.6	2.43	2.33	-0.055	-0.054	0.0328	0.0264	0.2445	0.1102	0.25	0.1102	0.074	0.0107	-0.07		
24	AU	ASX	Aluma	AUD	ALVAL.AU	AU0000705498	1.29	2E+09	1E+09	Bank	Bank	1.24	1.21	1	1.05	1.14	1.05	0.0237	0.0229	0.0279	0.05031	0.29	0.3454	0.0711	0.1393	0.1228	0.2268			
25	AU	ASX	Newcor	AUD	NMCLX.AU	AU0000706101	32.73	2E+10	1E+10	Bank	Bank	33.54	33.66	31.7	30	31	33.08	-0.024	-0.024	-0.028	-0.034	0.0322	0.1519	0.091	0.2327	0.055	0.2248	-0.1		
26	AU	ASX	BHP Bill	AUD	BHPAL.AU	AU0000704436	31.91	1E+11	7E+10	Bank	Bank	34.63	33.32	30.6	28.6	28.6	30.5	-0.085	-0.082	-0.081	-0.082	-0.0438	0.0264	0.0919	0.1873	0.0462	0.1431	0.071		
27	AU	ASX	Libb	AUD	LIBLX.AU	AU0000703936	3.29	4E+09	3E+09	Bank	Bank	3.63	3.4	2.97	2.77	3.17	3.15	-0.03	-0.029	-0.035	-0.0416	0.0444	0.0507	0.0602	0.523	0.0473	0.2907	0.006		
28	AU	ASX	Equinox	AUD	EQNLX.AU	AU0000706626	2.55	3E+09	2E+09	Bank	Bank	2.6	2.5	2.91	2.84	1.79	1.65	-0.019	-0.019	0.0038	0.0144	0.0203	0.1503	-0.044	0.06	0.1407	0.1741	0.25		
29	AU	ASX	Pitkin	AUD	PDKLX.AU	AU0000706646	3.4	2E+09	1E+09	Bank	Bank	3.51	3.41	3.36	3.75	3.4	2.75	-0.011	-0.017	-0.02	-0.0283	0.0763	0.1303	0.2184	0.1957	0.0166	0.1934	0.44		
30	AU	ASX	Rio Tinto	AUD	RIOAL.AU	AU0000702010	58.57	2E+10	1E+10	Bank	Bank	58.88	59.59	50.75	46.6	48.6	48.6	-0.005	-0.005	0.1195	0.11225	0.1747	0.1766	0.2218	0.3002	0.2421	0.4664	0.526		
31	AU	ASX	Indecon	AUD	PLAX.AU	AU0000701304	2.12	3E+09	1E+09	Bank	Bank	2.2	2.15	2.33	2.36	2.63	2.4	-0.036	-0.036	-0.014	-0.0204	-0.113	-0.048	-0.028	0.0566	-0.206	-0.114	-0.1		
32	AU	ASX	Orica	AUD	ORIAL.AU	AU0000704500	14.73	3E+09	4E+09	Financial	Bank	15.14	14.75	13.93	13.89	15.54	13.8	-0.023	-0.023	0.0007	-0.0038	0.0572	0.1102	0.1001	0.055	0.0823	0.1535	0.07		
33	AU	ASX	Leighton	AUD	LEIAL.AU	AU0000701227	19.3	1E+10	2E+09	Industry	Chem	20.19	11.25	19.44	18.03	19.16	20.23	-0.043	-0.042	0.0206	-0.0079	0.0603	0.0543	0.0919	0.0784	0.1896	0.2592	-0.21		
34	AU	ASX	Boral	AUD	BORAL.AU	AU0000702870	5.11	1E+10	1E+09	Industry	Chem	5.68	5.41	4.96	4.82	5.9	5.85	-0.019	-0.019	0.0051	0.0176	0.0202	0.2267	0.2343	0.1056	0.1057	-0.02			
35	AU	ASX	James	AUD	JMLX.AU	AU0000704197	4.2	2E+09	1E+09	Industry	Chem	4.07	4.05	3.75	3.25	3.76	4.45	0.0444	0.0435	0.037	0.03023	0.12	0.1722	0.2823	0.3752	0.0784	0.1707	-0.07		
36	AU	ASX	Lead	AUD	LICLX.AU	AU0000701204	6.43	3E+09	2E+09	Industry	Chem	6.43	6.25	5.82	5.06	6.79	7.03	0.003	0.003	0.0394	0.00974	0.181	0.1721	0.2826	0.3643	-0.044	0.1543	-0.0		
37	AU	ASX	Dowcor	AUD	DOVAL.AU	AU00007045573	4.45	1E+09	1E+09	Industry	Chem	4.61	4.69	4.16	3.87	4.56	5.33	-0.003	-0.003	0.0397	0.02026	0.0129	0.121	0.1438	0.2231	0.25	0.5858	0.16		
38	AU	ASX	United	AUD	UNLX.AU	AU0000704881	3.19	2E+09	1E+09	Industry	Chem	3.27	3.33	3.75	3.7	4.02	9	-0.005	-0.005	0.1419	0.1414	0.224	0.2825	0.2073	0.2054	0.1446	0.2507	0.14		
39	AU	ASX	Purpure	AUD	PPTLX.AU	AU0000706233	26.84	1E+09	1E+09	Financial	Bank	27.64	27.02	25.5	23.96	30.12	34.9	-0.025	-0.025	-0.014	-0.0207	0.0595	0.1104	0.1214	0.1937	-0.123	-0.042	-0.26		
40	AU	ASX	ASX Ltd	AUD	ASXLX.AU	AU0000702870	29.35	1E+10	3E+09	Financial	Bank	30.05	29.44	29	28.11	31.68	31.85	-0.023	-0.023	-0.005	-0.0099	0.0202	0.0507	0.1217	0.153	0.091	0.1102	-0.8		
41	AU	ASX	AMP	AUD	AMPLX.AU	AU0000703893	4.7	1E+09	1E+09	Financial	Bank	4.95	4.45	4.14	4.88	4.27	5.07	-0.001	-0.001	0.0562	0.04321	0.1053	0.217	-0.039	0.030	-0.108	0.0305	-0.1		
42	AU	ASX	Macquarie	AUD	MACLX.AU	AU0000702077	27.05	8E+09	1E+09	Financial	Bank	25.44	23.3	20.04	17.83	24.94	28.8	0.0425	0.043	0.1566	0.1296	0.1498	0.1497	0.1416	0.1435	0.0401	0.1572	-0.0		
43	AU	ASX	Comput	AUD	CPUAL.AU	AU0000704042	8.78	4E+09	1E+09	Financial	Bank	8.75	8.54	7.3	7.13	7.25	8.9	0.0004	0.00039	0.0281	0.0241	0.114	0.161	0.2314	0.3004	0.211	0.3232	0.9		
44	AU	ASX	Goodes	AUD	GFFLX.AU	AU0000701091	1.045	1E+09	1E+09	Consumer	Food	1.03	1.07	0.96	1.05	1.03	1.05	0.0146	0.015	-0.023	-0.0231	0.0885	0.1441	-0.116	-0.062	-0.319	-0.256	-0.18		
45	AU	ASX	Fortis	AUD	FGLX.AU	AU0000704426	5.06	1E+10	1E+09	Consumer	Food	5.1																		

Motivation of Visual Analytics

Spreadsheet: A great hammer but lousy screwdriver

Visual analytics come to the rescue



Motivation of Visual Analytics

When statistics failed!

SALESFORCE A	SALES_REVENUE A	SALESFORCE B	SALES_REVENUE B	SALESFORCE C	SALES_REVENUE C	SALESFORCE D	SALES_REVENUE D
10	8.04	10	9.14	10	7.46	8	6.58
8	6.95	8	8.14	8	6.77	8	5.76
13	7.58	13	8.74	13	12.74	8	7.71
9	8.81	9	8.77	9	7.11	8	8.84
11	8.33	11	9.26	11	7.81	8	8.47
14	9.96	14	8.1	14	8.84	8	7.04
6	7.24	6	6.13	6	6.08	8	5.25
4	4.26	4	3.1	4	5.39	19	12.5
12	10.84	12	9.11	12	8.15	8	5.56
7	4.82	7	7.26	7	6.42	8	7.91
5	5.68	5	4.74	5	5.73	8	6.89

Summary Statistics		Summary Statistics	
Mean	9	Mean	7.4990909
Std Dev	3.3166248	Std Dev	2.0300614
Std Err Mean	1	Std Err Mean	0.6120865
Upper 95% Mean	11.228139	Upper 95% Mean	8.8629047
Lower 95% Mean	6.7718611	Lower 95% Mean	6.1352771
N	11	N	11

Linear Fit	
SALES_REVENUE = 3.0000909 + 0.5000909*SALESFORCE	
Summary of Fit	
RSquare	0.666542
RSquare Adj	0.629492
Root Mean Square Error	1.236603
Mean of Response	7.500909
Observations (or Sum Wgts)	11

I just can't make sense of this data.



Have you tried looking at the pictures?



fresh spectrum

Data analysis without data visualisation is no data analysis

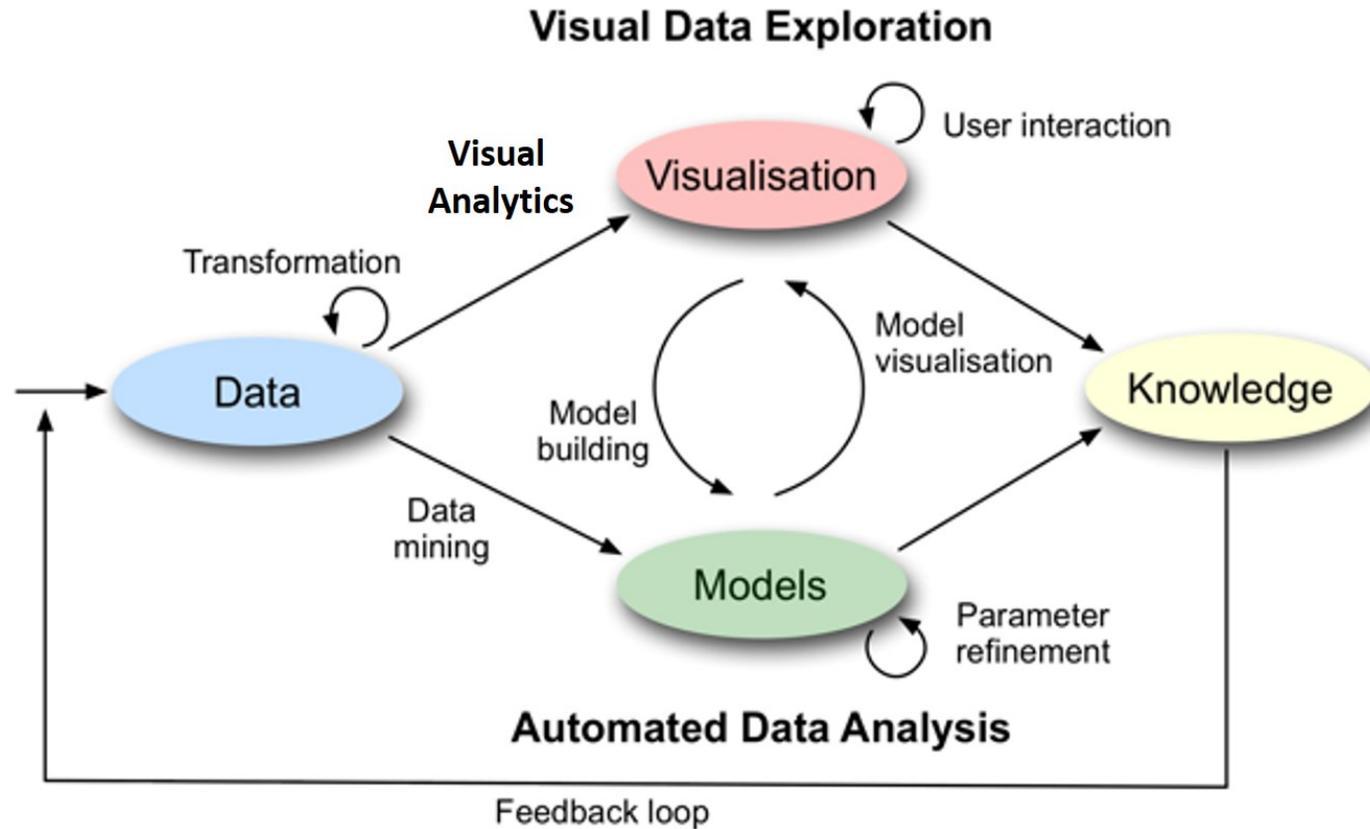
Motivation of Visual Analytics

Analytical graphics reveal the truth



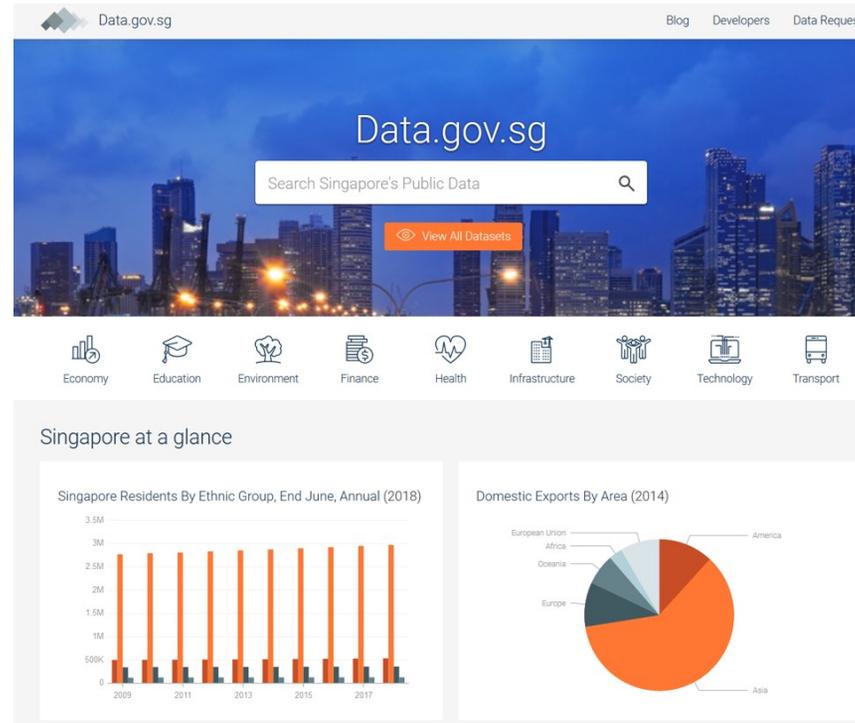
Motivation of Visual Analytics

Is there a place for Visual Analytics in knowledge discovery?



Motivation of Visual Analytics

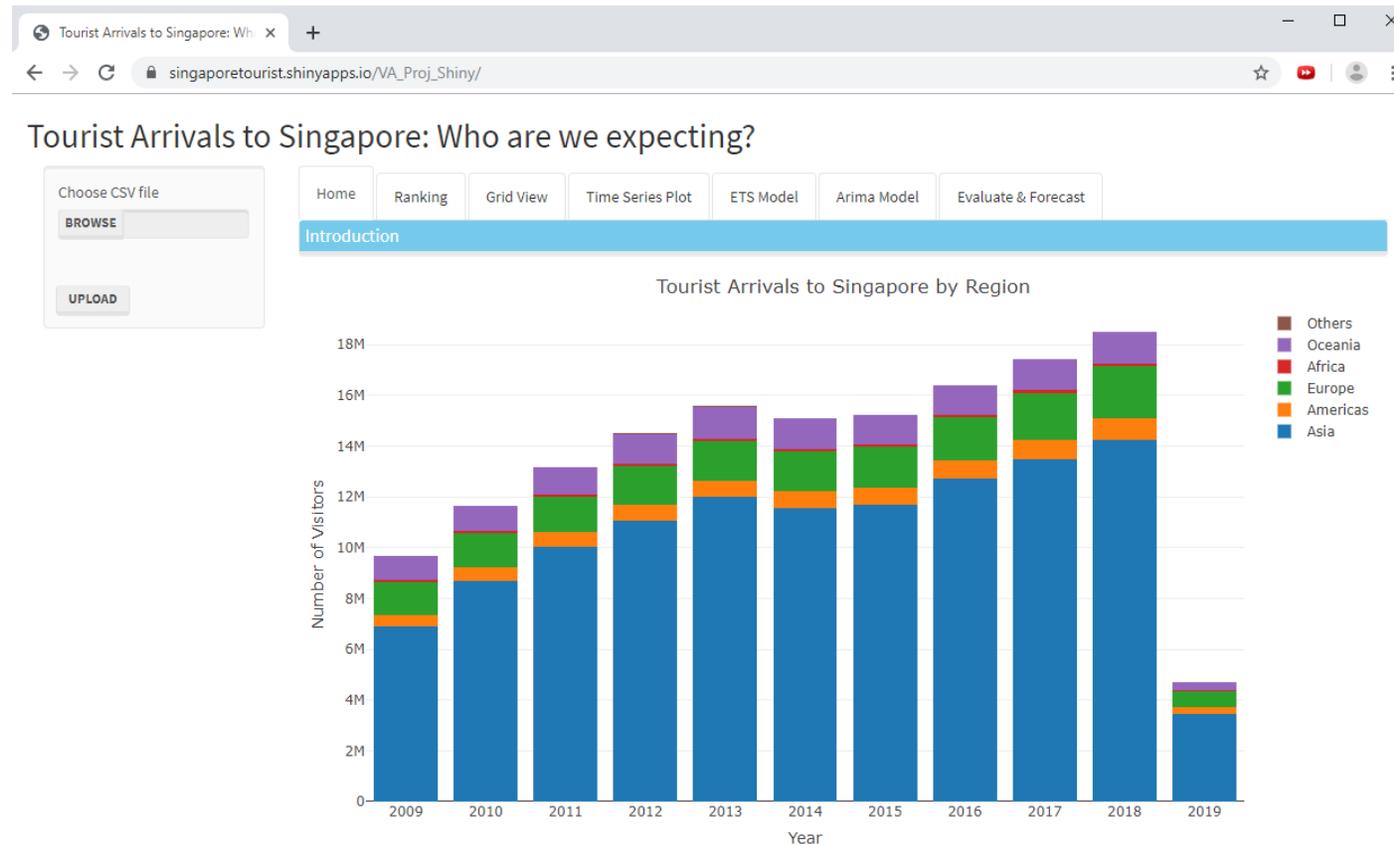
Open data need to be unlocked!



Visit the link at <https://data.gov.sg>

Motivation of Visual Analytics

Democratising Data and Analytics with Visually-driven Web Apps



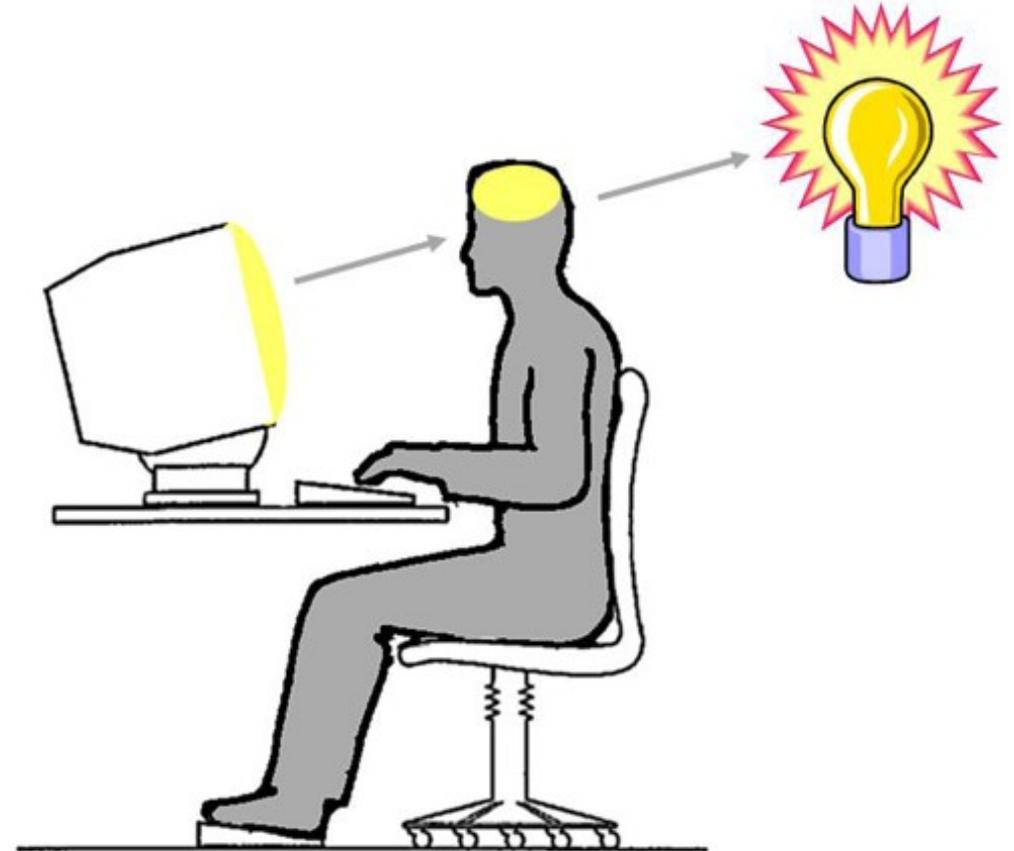
Visit the link at https://singaporetourist.shinyapps.io/VA_Proj_Shiny/

What is Visual Analytics?

Visual Analytics is the craft of **analytical reasoning** supported by:

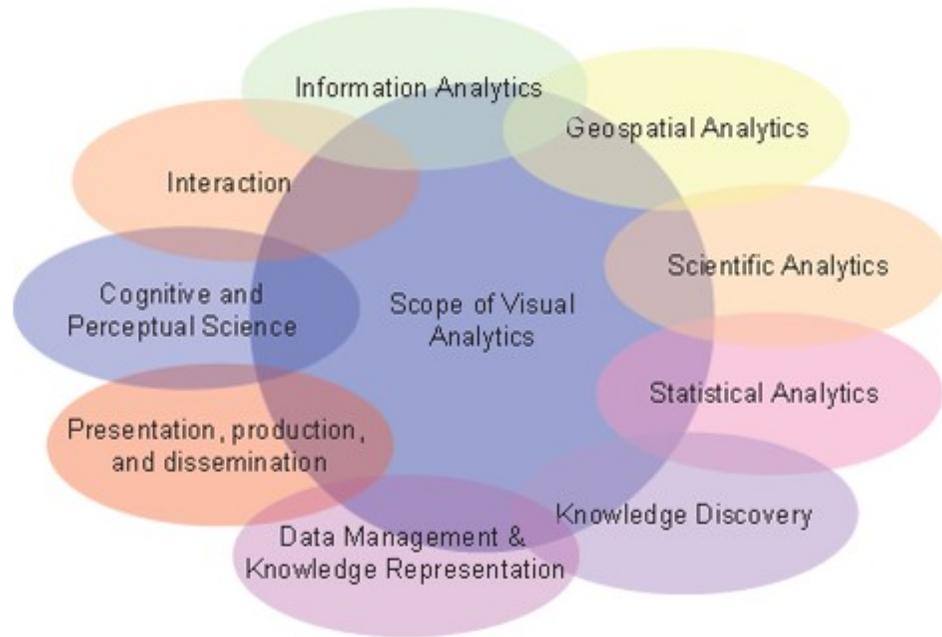
- Data Science and Analytics
- Data Visualisation
- Human-Computing-Interaction (HCI)
- Interface Design
- Visual Storytelling

The marriage of data analytics and visualizations



What is Visual Analytics?

Science of Visual Analytics



Aims of Visual Analytics

*Detecting the expected,
discovering the unexpected*

What is Visual Analytics?

Visual Data Sense-making

Visual Analytics' greatest strength is its use for **sense-making**.

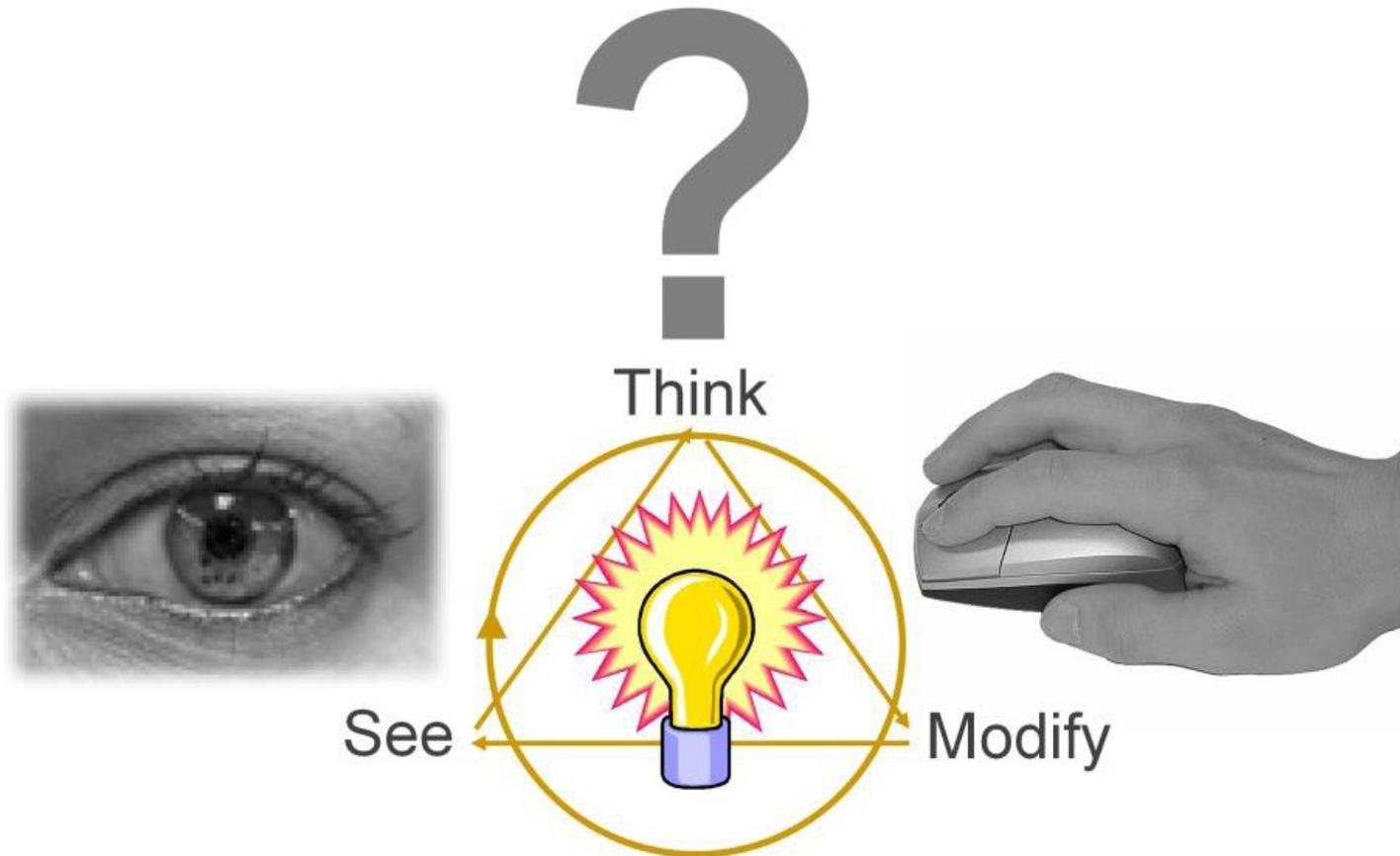
*When you have eliminated
the impossible, whatever
remains, however
improbable, must be the
truth.*

- Sherlock Holmes



What is Visual Analytics?

Visual Analytics Framework



What is Visual Analytics?

Visual Analytics require a shift of mindset

VISUAL THINKING

Exploration

Analysis

VISUAL COMMUNICATION

Synthesis

Presentation

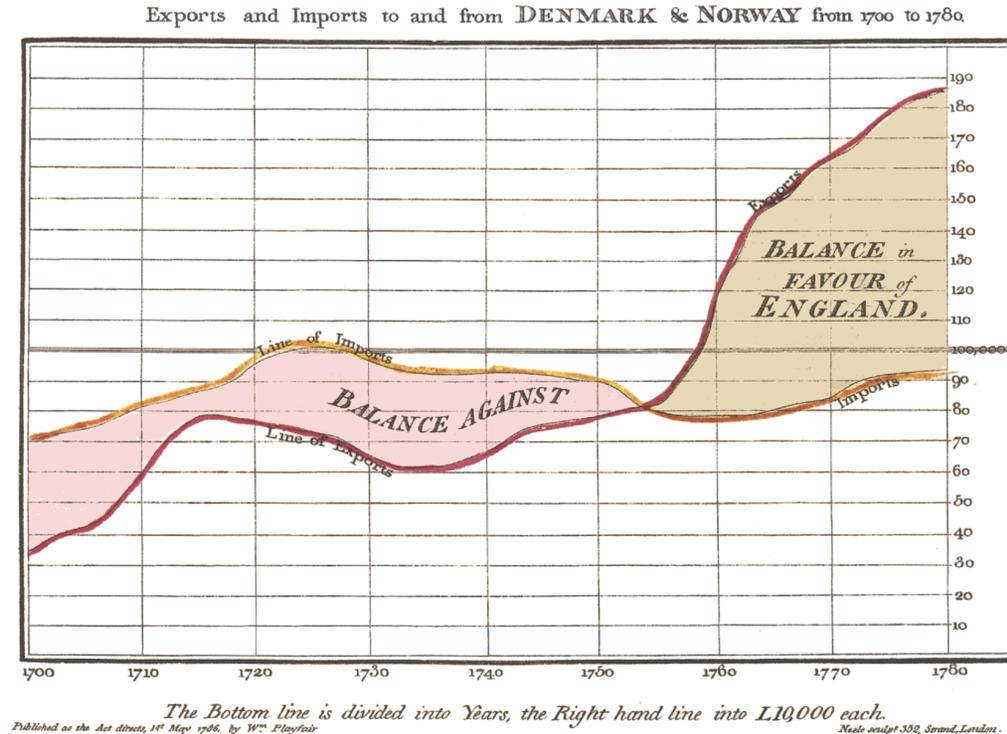
PRIVATE REALM

PUBLIC REALM

What is Visual Analytics?

Learning from the history of Visual Analytics

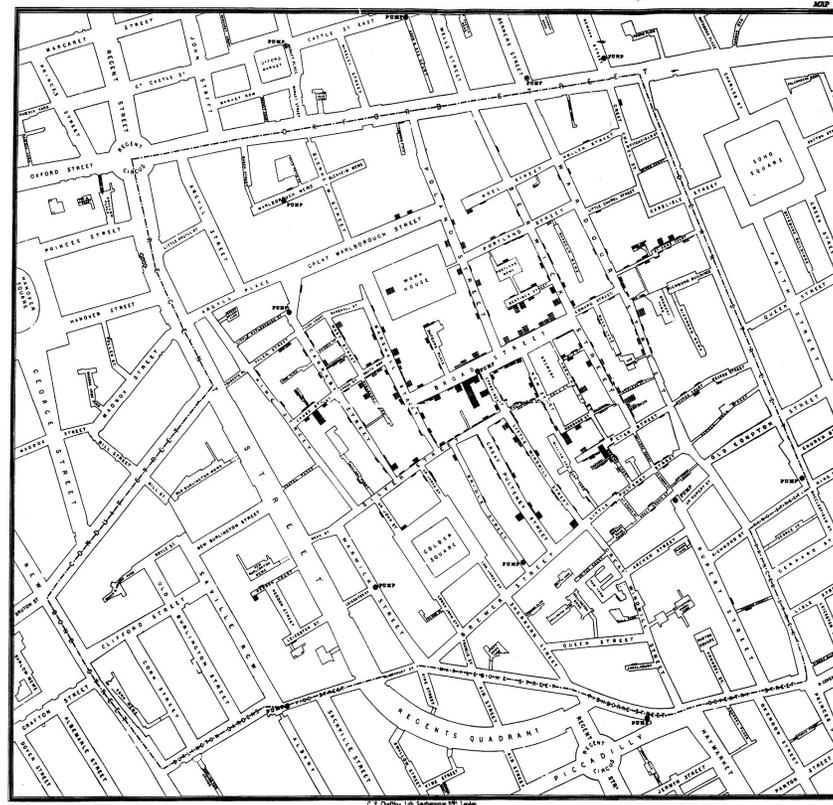
Commercial and Political Atlas by William Playfair (22 September 1759 – 11 February 1823)



What is Visual Analytics?

Learning from the history of Visual Analytics

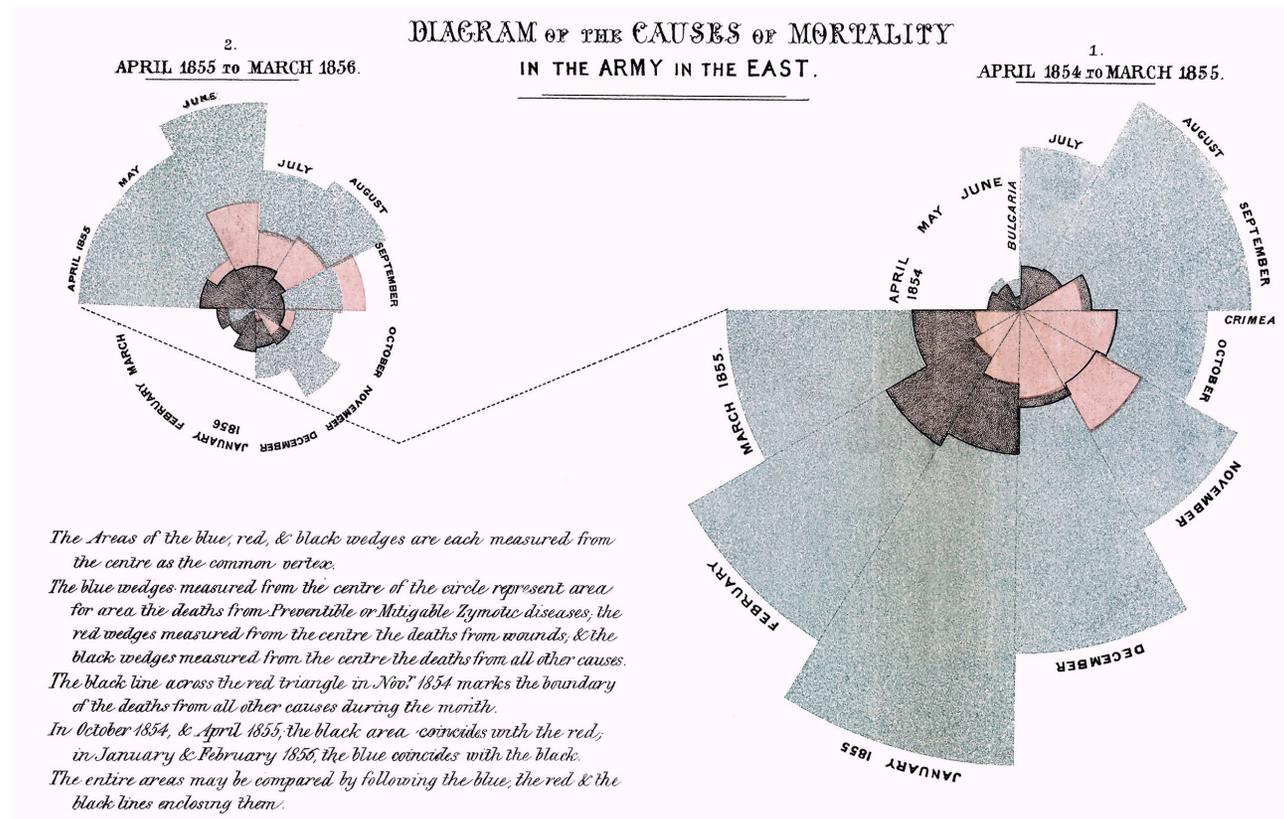
Cholera and the Pump on Broad Street(John Snow, 1854).



What is Visual Analytics?

Learning from the history of Visual Analytics

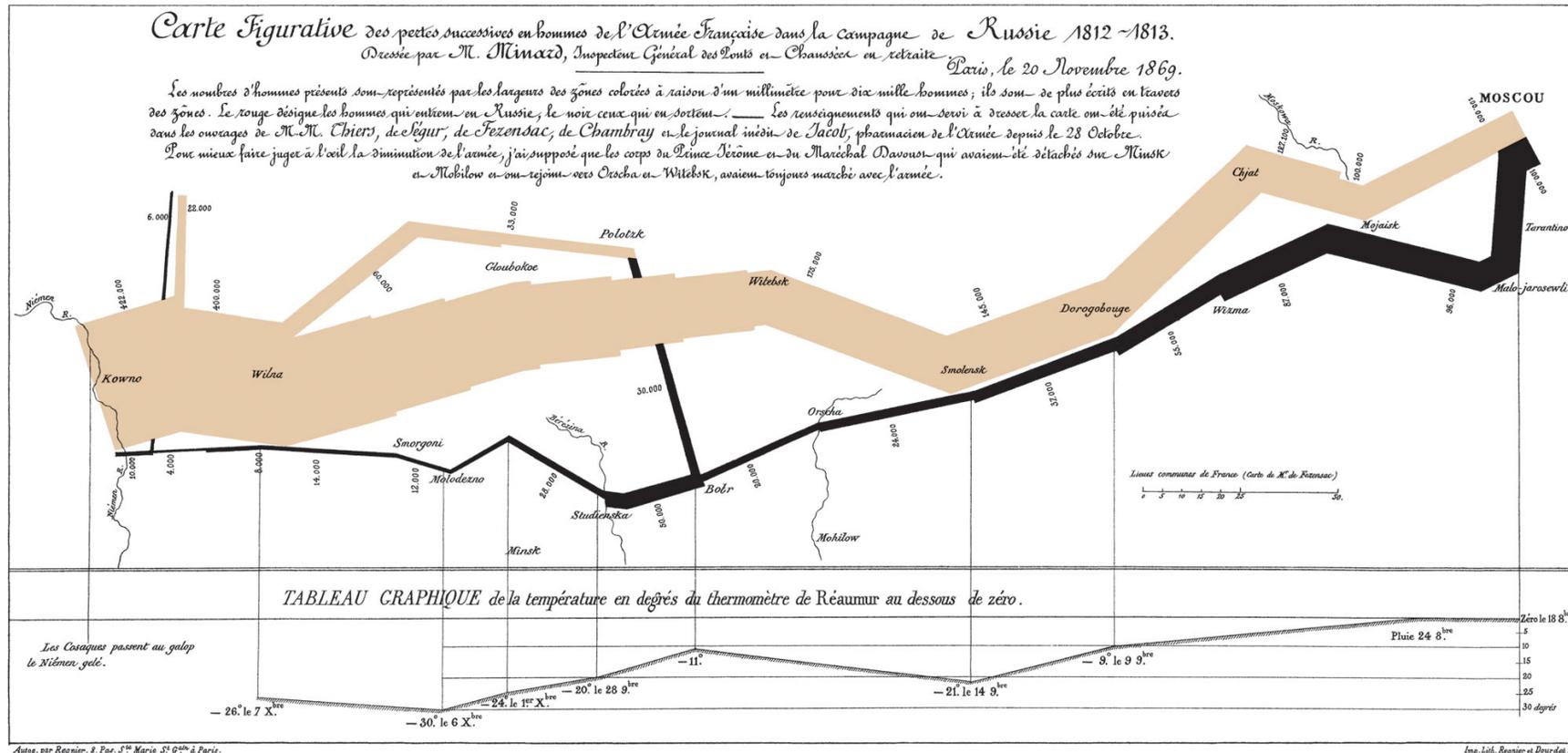
Florence Nightingale: The compassionate statistician (12 May 1820 – 13 August 1910)



What is Visual Analytics?

Learning from the history of Visual Analytics

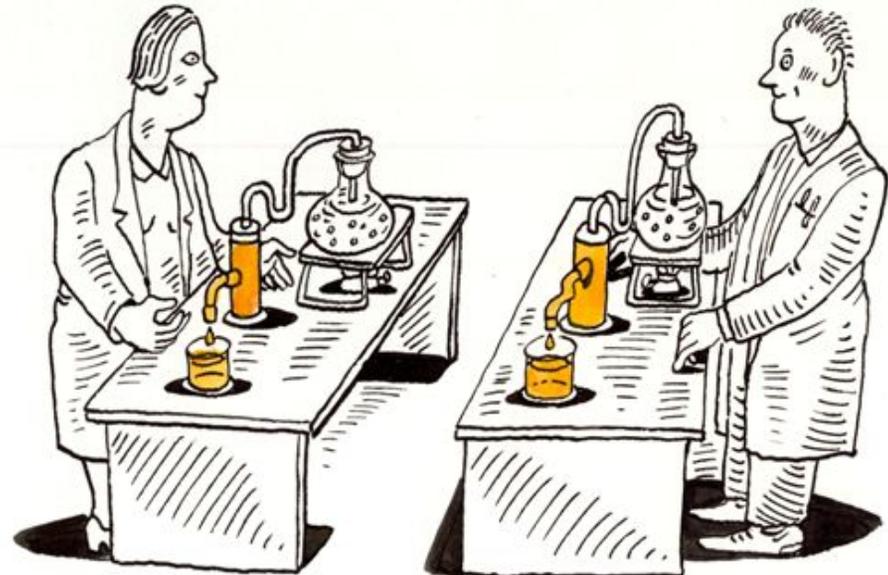
Plot of Napoleon's ill-fated Russian campaign of 1812-1813 (Charles Joseph Minard, 1861)



What is Visual Analytics?

Visual Analytics must be Reprducible

- For every result, keep track of how it was produced.
 - Avoid manual data manipulation steps.
 - Archive the exact versions of all external programmes used.
 - Version control all custom scripts.
 - Record all intermediate results, when possible in standard formats.
 - For analysis that include randomness, note underlying random seeds.
 - Always store raw data behind plots.
 - Generate hierarchical analysis output, allowing layers of increasing detail to be inspected.
- Connect textual statements to underlying results.
 - Provide public access to scripts, runs, and results.



Data Visualisation Toolkits

- Commercial-off-the-shelf
 - Visual analytics toolkit such as Tableau, JMP, PowerBI, Qlik Sense/View & TIBCO SpotFire.
 - Specialised data visualisation applications such as TreeMap from Macrofocus (<https://www.macrofocus.com/>)
- Open source
 - Specialised data visualisation applications such as Gephi (<https://gephi.org/>)
 - Data visualisation API library such as ggplot2, plotly, and D3.js (<https://d3js.org/>)

COS Data Visualisation Toolkit

Magic Quadrant for BI and Analytics Platforms



COS Data Visualisation Toolkit

Data Visualisation Centric



Sense™



SAS® VISUAL ANALYTICS

BI Centric



QlikView

MicroStrategy

ORACLE®
BUSINESS INTELLIGENCE



SAP Lumira®
Ignite Creative Ideas

Tableau: A data visualisation tool for everyone

- Theory to practice
 - The Grammar of Graphics
- Science to product
 - VisQL
 - Show Me
 - Polaris



Breakthrough
Technology



Programmable Data Visualisation Library

- Javascript
 - D3.js (<https://d3js.org/>)
- Python
 - Matplotlib (<http://matplotlib.org/>)
 - Bokeh (<http://bokeh.pydata.org/en/latest/>)
 - Plotly (<https://plot.ly/python/>)
- R, Base Graphics
 - lattice (<https://cran.r-project.org/web/packages/lattice/index.html>)
 - ggplot (<https://ggplot2.tidyverse.org/>)
 - plotly R (<https://plot.ly/r/>)
 - R Shiny (<https://shiny.rstudio.com/>)

Data Visualisation Toolkit for Data Journalism

- Flourish
- Datawrapper

Highly recommended blogs

- Perceptual Edge (<https://www.perceptualedge.com/>)
- Junk Charts (http://junkcharts.typepad.com/junk_charts/)
- The Functional Art (<http://www.thefunctionalart.com/>)