Information Visualization

James EAGAN

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Includes slides adapted from John Stasko (Georgia Tech), Petra Isenberg & Jean-Daniel Fekete (INRIA), Chris North (Virginia Tech), Tamara Munzner (UBC)

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Who am I?

James EAGAN

MAÎTRE DE CONFÉRENCES EN INTERACTION HOMME-MACHINE

Associate Professor at Télécom Paris
Adjunct Researcher at LTCI

2008 — Georgia Tech
M.S., Ph.D. Computer Science

2000 — Lawrence University
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Research

Human-Computer Interaction

Information Visualization

Multi-surface Interaction

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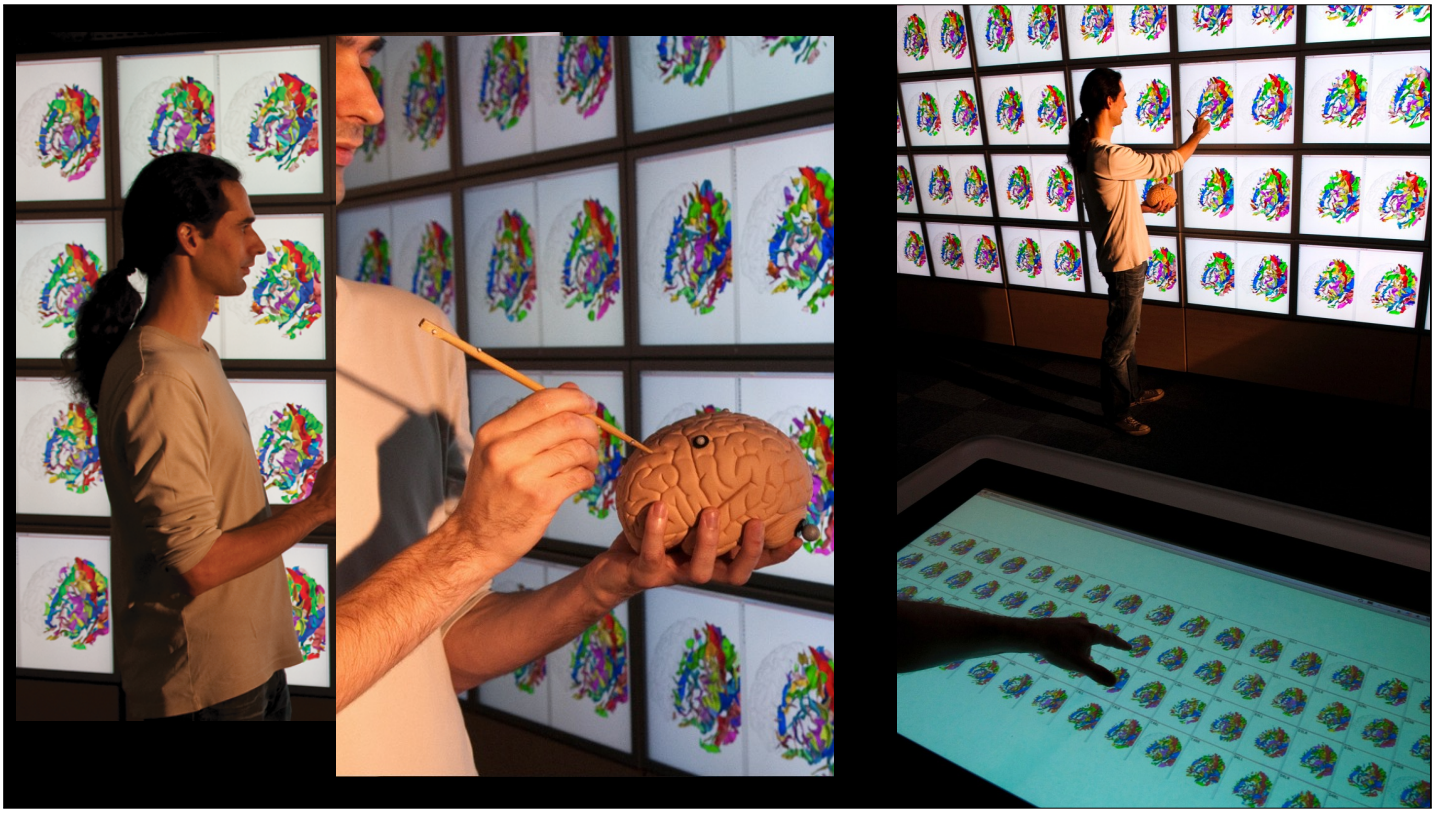

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Data Exploration

- Society is more complex
  - There is simply more “stuff”
- Computers, internet, and web give people access to an incredible amount of data
  - news, sports, financial, sales, demographics, etc.
  - pollution, computer logs, weather, photos, videos, etc.

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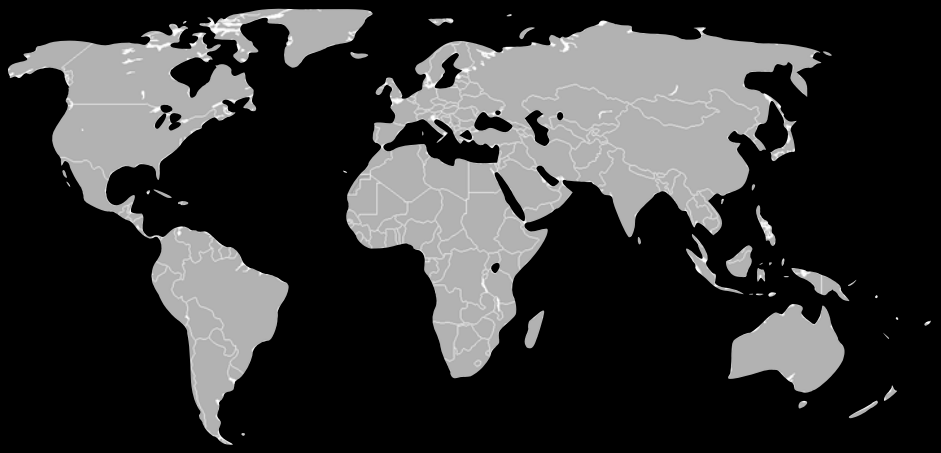
How much data?

- Between 1 and 2 exabytes of unique info produced per year
  - 1000000000000000000 (10^{18}) bytes
  - 250 meg for every man, woman and child
  - Printed documents only .003% of total

Peter Lyman and Hal Varian, 2000
Cal-Berkeley, Info Mgmt & Systems
`www.sims.berkeley.edu/how-much-info`

8

2008



800 exabytes per year

[The Diverse and Exploding Digital Universe, IDC, 2008]

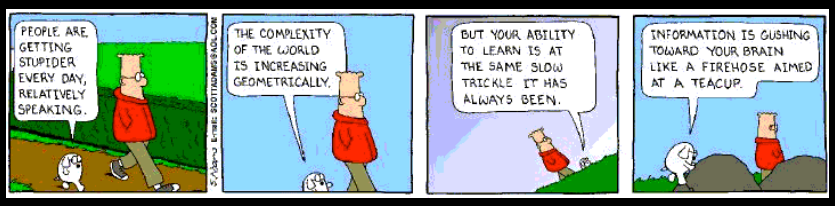
2017

900 zetabytes per year

[10 Key Marketing Trends for 2017, IBM, 2017]

Data Overload

- How can we make use of the data?
  - How do we make sense of the data?
  - How do we harness this data in decision-making processes?
  - How do we avoid being overwhelmed?



The need is there

"The ability to take data—to be able to understand it, to process it, to extract value from it, to visualize it, to communicate it's going to be a hugely important skill in the next decades."

— Hal Varian, chief economist, Google

[The McKinsey Quarterly, January 2009]

The Challenge

- Transform the data into information (understanding, insight) thus making it useful to people

Human Vision

- Highest bandwidth sense
- Fast, parallel
- Pattern recognition
- Pre-attentive
- Extends memory and cognitive capacity

(Multiplication test)

- People think visually

Impressive. Lets use it!

[Courtesy of Chris North, Virginia Tech]

Example

Questions: Which state has the highest income?
Is there a relationship between income and education?
Are there any outliers?

Table - StateData ()

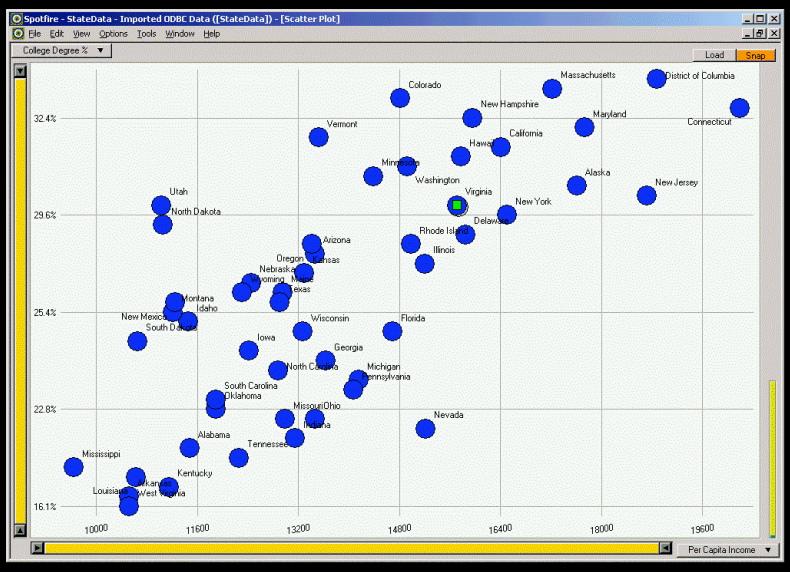
Load | Snap

State	College Degree %	Per Capita Income
Alabama	20.6%	11486
Alaska	30.3%	17610
Arizona	27.1%	13461
Arkansas	17.0%	10520
California	31.3%	16409
Colorado	33.9%	14821
Connecticut	33.8%	20189
Delaware	27.9%	15854
District of Columbia	36.4%	18881
Florida	24.9%	14698
Georgia	24.3%	13631
Hawaii	31.2%	15770
Idaho	25.2%	11457
Illinois	26.8%	15201
Indiana	20.9%	13149
Iowa	24.5%	12422
Kansas	26.5%	13300
Kentucky	17.7%	11153
Louisiana	19.4%	10635
Maine	25.7%	12957
Maryland	31.7%	17730
Massachusetts	34.5%	17224
Michigan	24.1%	14154
Minnesota	30.4%	14389
Mississippi	19.9%	9648
Missouri	22.3%	12989
Montana	25.4%	11213
Nebraska	26.0%	12452
Nevada	21.5%	15214
New Hampshire	32.4%	15959
New Jersey	30.1%	18714
New Mexico	25.5%	11246
New York	29.6%	16501
North Carolina	24.2%	12885
North Dakota	28.1%	11051
Ohio	22.3%	13461
Oklahoma	22.8%	11893
Oregon	27.5%	13418
Pennsylvania	23.2%	14068
Rhode Island	27.5%	14981
South Carolina	23.0%	11897
South Dakota	24.6%	10661
Tennessee	20.1%	12255
Texas	25.5%	12904
Utah	30.0%	11029
Vermont	31.5%	13527
Virginia	30.0%	15713
Washington	30.9%	14923
West Virginia	16.1%	10520
Wisconsin	24.9%	13276
Wyoming	25.7%	12311

[Courtesy of Chris North, Virginia Tech]

Visualize the Data

College Degree %



Per Capita Income

[Courtesy of Chris North, Virginia Tech]

Even Tougher?

- What if you could only see one state's data at a time? (e.g. U.S. Census Bureau's website)
- What if I read the data to you?

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

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Anscombe's Quartet

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

Mean of x	9.0
Variance of x	11.0
Mean of y	7.5
Variance of y	4.12
Correlation between x and y	0.816
Linear regression line	$y = 3 + 0.5x$

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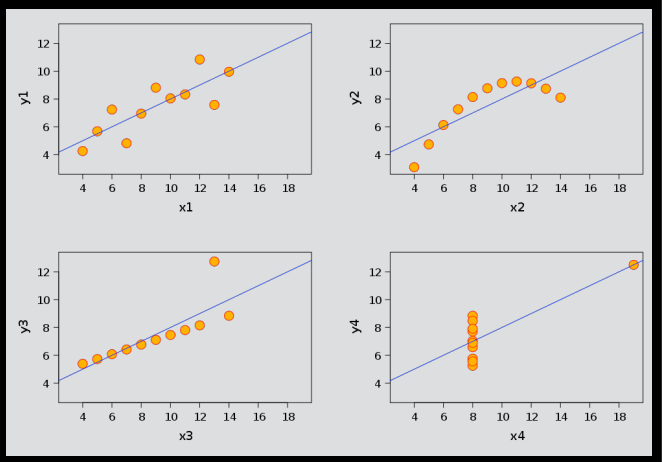
Anscombe's Quartet

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



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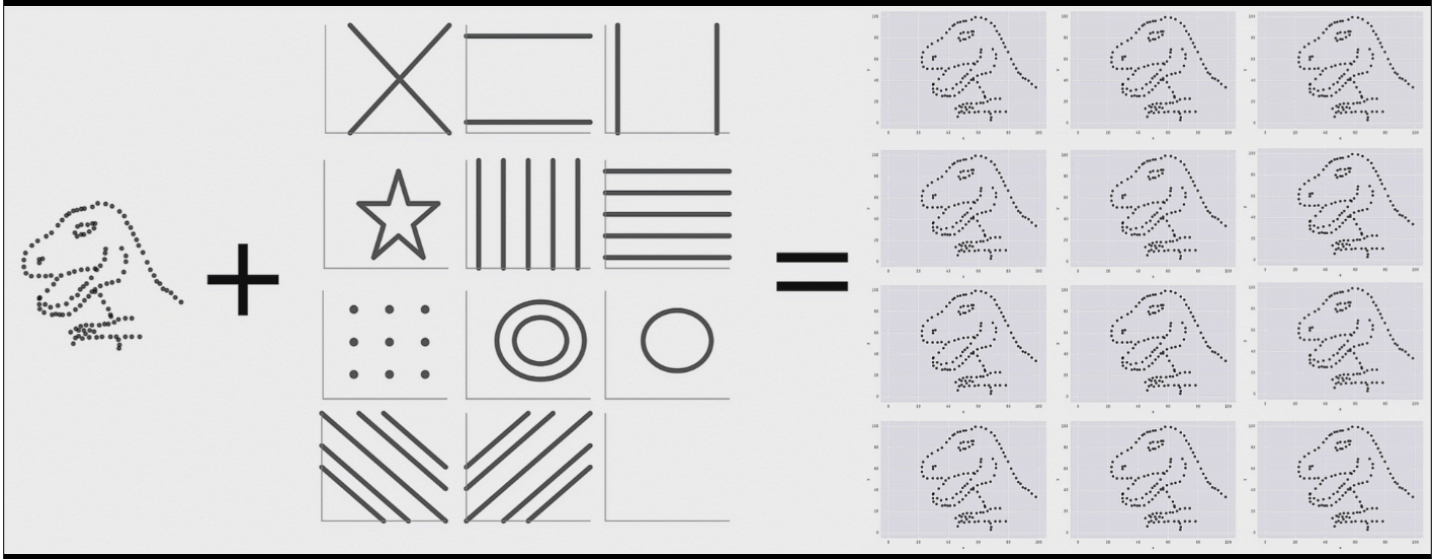

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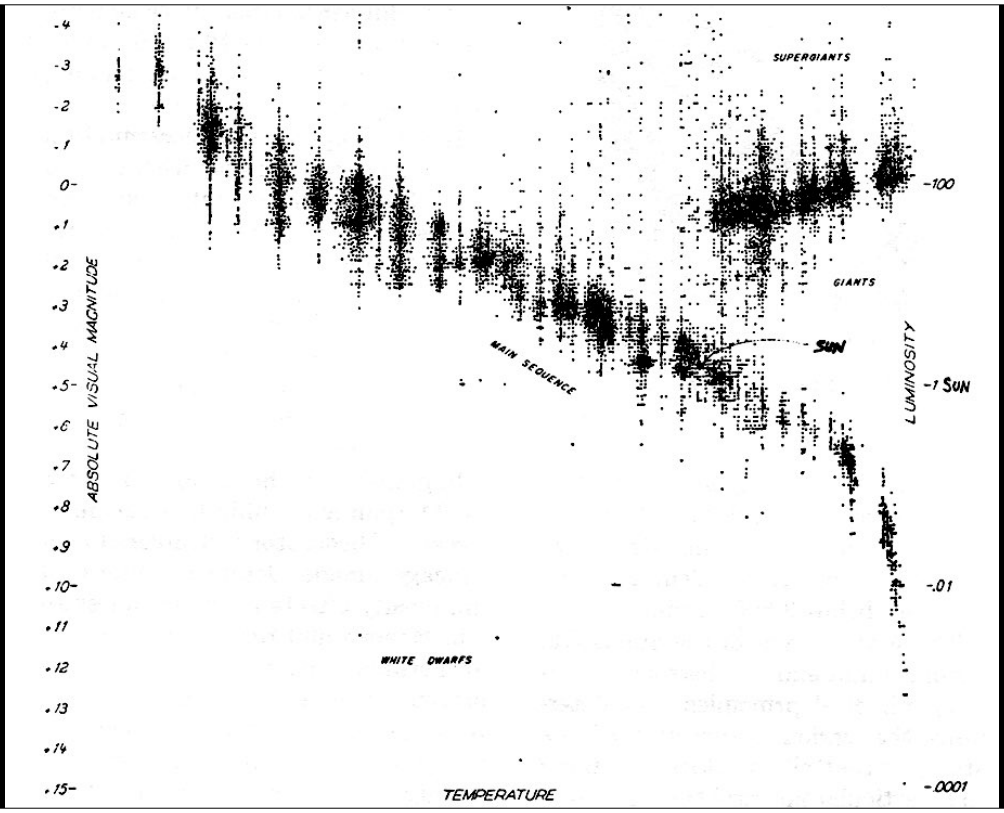
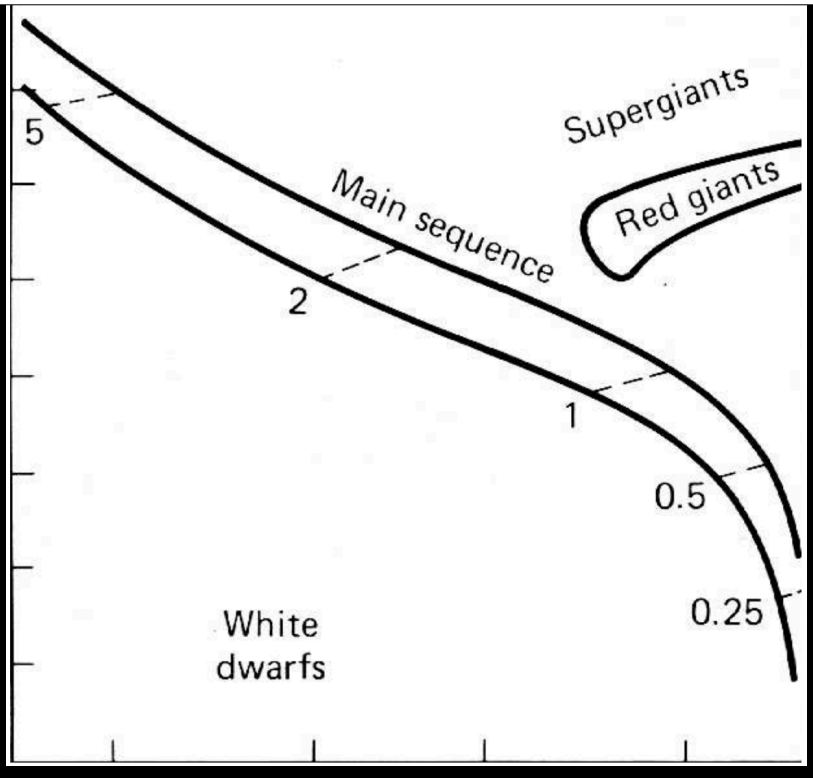

SUPERGIANTS
GIANTS
MAIN SEQUENCE
SUN
WHITE DWARFS
ABSOLUTE VISUAL MAGNITUDE
LUMINOSITY
TEMPERATURE
-4
-3
-2
-1
0-
+1
+2
+3
+4
+5-
+6
+7
+8
+9
+10-
+11
+12
+13
+14
+15-
-100
-1 SUN
-.01
-.0001

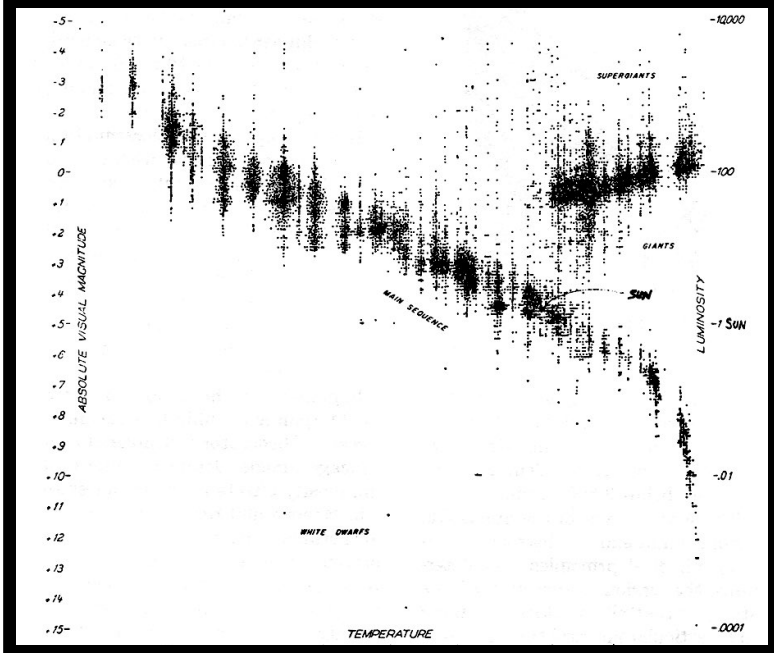
23

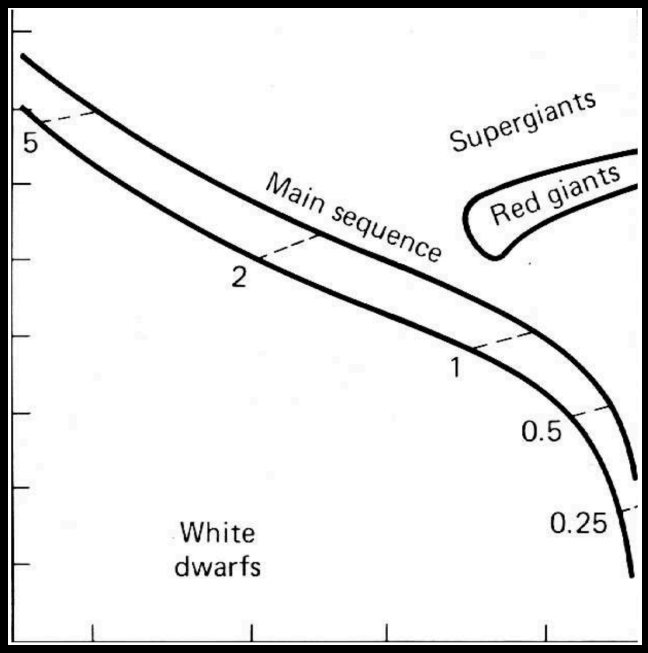
23


5
2
1
0.5
0.25
Supergiants
Red giants
Main sequence
White
dwarfs

24

24





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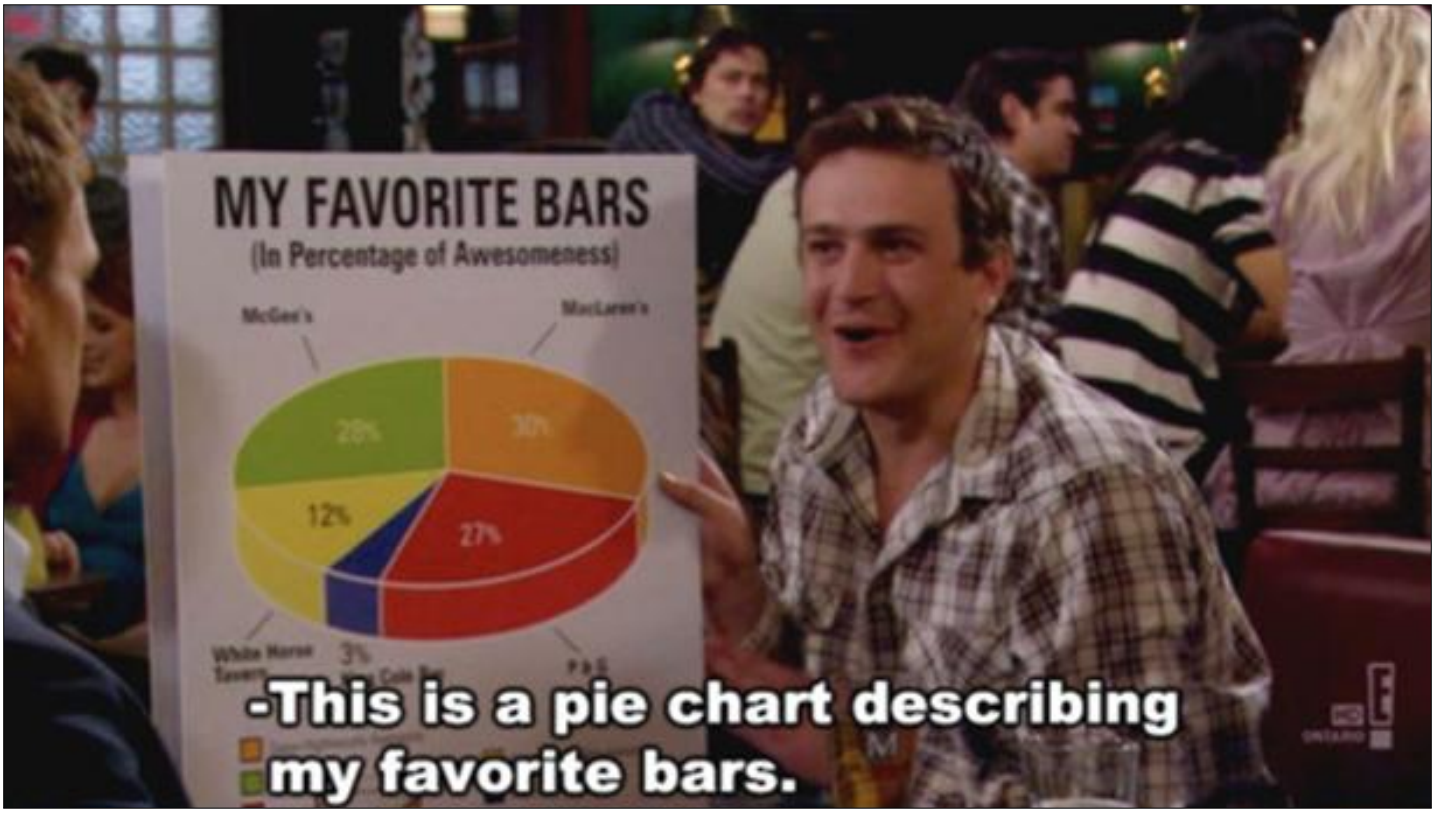
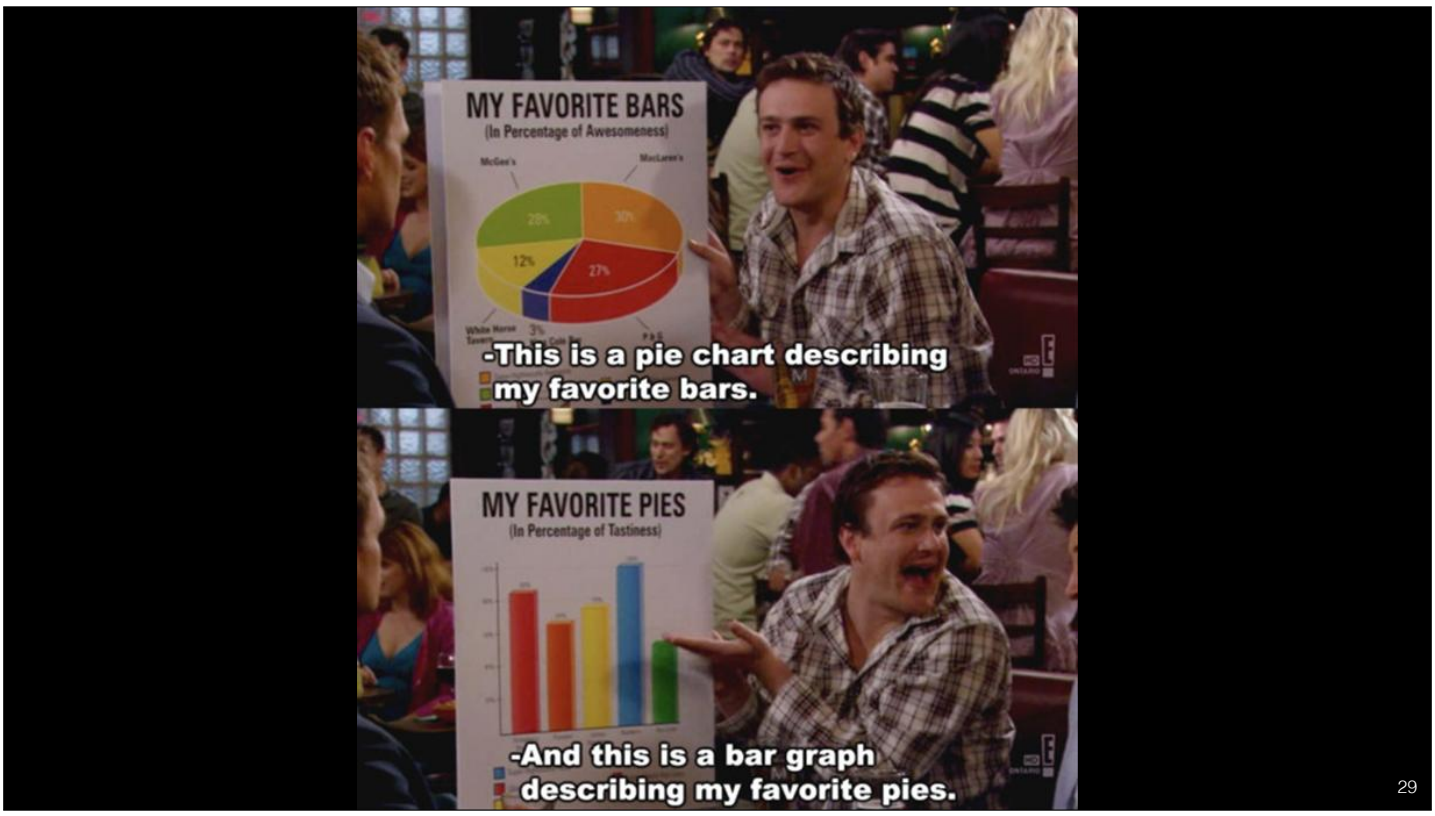
Illustrates Our Approach

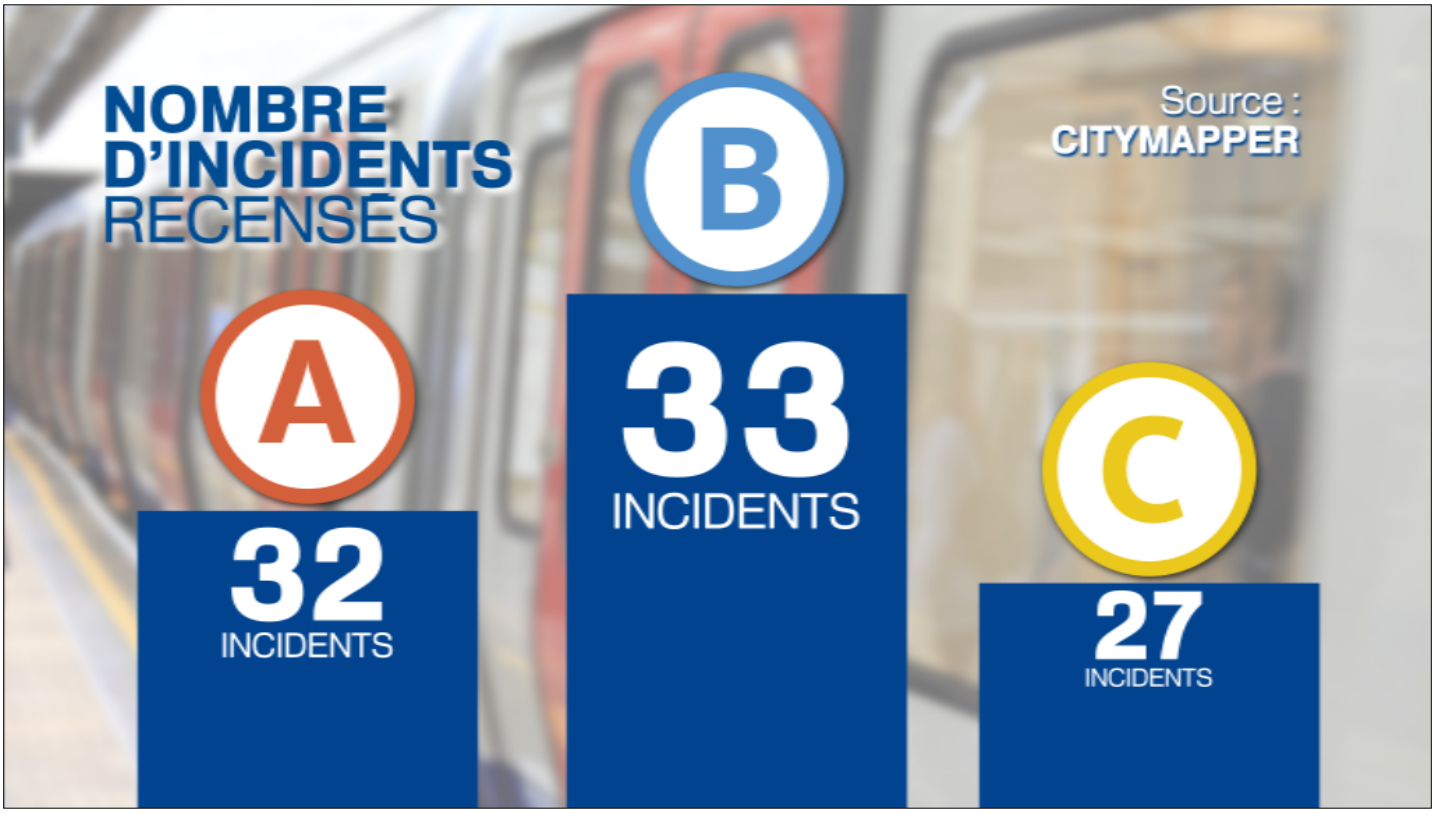
- Provide tools that present data in a way to help people understand and gain insight from it
- Clichés
  - “Seeing is believing”
  - “A picture is worth a thousand words”

Teasers

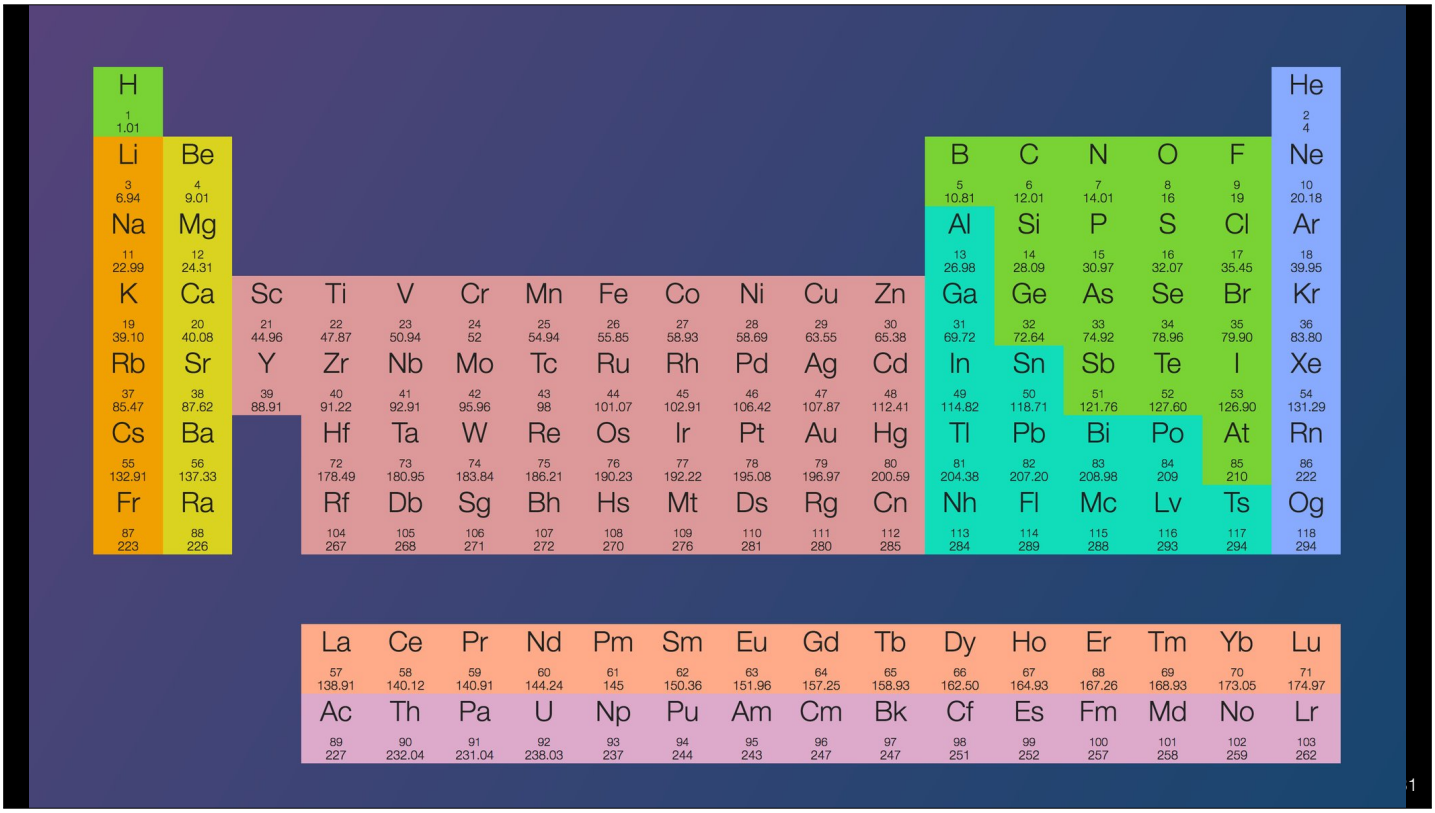

MY FAVORITE BARS
(In Percentage of Awesomeness)
28%
30%
12%
27%
3%
-This is a pie chart describing
my favorite bars.


MY FAVORITE BARS
(In Percentage of Awesomeness)
-This is a pie chart describing my favorite bars.
MY FAVORITE PIES
(In Percentage of Tastiness)
-And this is a bar graph describing my favorite pies.
29

29


NOMBRE D'INCIDENTS RECENSÉS
Source : CITYMAPPER
A
32
INCIDENTS
B
33
INCIDENTS
C
27
INCIDENTS

30


H 1 1.01
He 2 4
Li 3 6.94
Be 4 9.01
B 5 10.81
C 6 12.01
N 7 14.01
O 8 16
F 9 19
Ne 10 20.18
Na 11 22.99
Mg 12 24.31
Al 13 26.98
Si 14 28.09
P 15 30.97
S 16 32.07
Cl 17 35.45
Ar 18 39.95
K 19 39.10
Ca 20 40.08
Sc 21 44.96
Ti 22 47.87
V 23 50.94
Cr 24 52
Mn 25 54.94
Fe 26 55.85
Co 27 58.93
Ni 28 58.69
Cu 29 63.55
Zn 30 65.38
Ga 31 69.72
Ge 32 72.64
As 33 74.92
Se 34 78.96
Br 35 79.90
Kr 36 83.80
Rb 37 85.47
Sr 38 87.62
Y 39 88.91
Zr 40 91.22
Nb 41 92.91
Mo 42 95.96
Tc 43 98
Ru 44 101.07
Rh 45 102.91
Pd 46 106.42
Ag 47 107.87
Cd 48 112.41
In 49 114.82
Sn 50 118.71
Sb 51 121.76
Te 52 127.60
I 53 126.90
Xe 54 131.29
Cs 55 132.91
Ba 56 137.33
Hf 72 178.49
Ta 73 180.95
W 74 183.84
Re 75 186.21
Os 76 190.23
Ir 77 192.22
Pt 78 195.08
Au 79 196.97
Hg 80 200.59
Tl 81 204.38
Pb 82 207.20
Bi 83 208.98
Po 84 209
At 85 210
Rn 86 222
Fr 87 223
Ra 88 226
Rf 104 267
Db 105 268
Sg 106 271
Bh 107 272
Hs 108 270
Mt 109 276
Ds 110 281
Rg 111 280
Cn 112 285
Nh 113 284
Fl 114 289
Mc 115 288
Lv 116 293
Ts 117 294
Og 118 294
La 57 138.91
Ce 58 140.12
Pr 59 140.91
Nd 60 144.24
Pm 61 145
Sm 62 150.36
Eu 63 151.96
Gd 64 157.25
Tb 65 158.93
Dy 66 162.50
Ho 67 164.93
Er 68 167.26
Tm 69 168.93
Yb 70 173.05
Lu 71 174.97
Ac 89 227
Th 90 232.04
Pa 91 231.04
U 92 238.03
Np 93 237
Pu 94 244
Am 95 243
Cm 96 247
Bk 97 247
Cf 98 251
Es 99 252
Fm 100 257
Md 101 258
No 102 259
Lr 103 262

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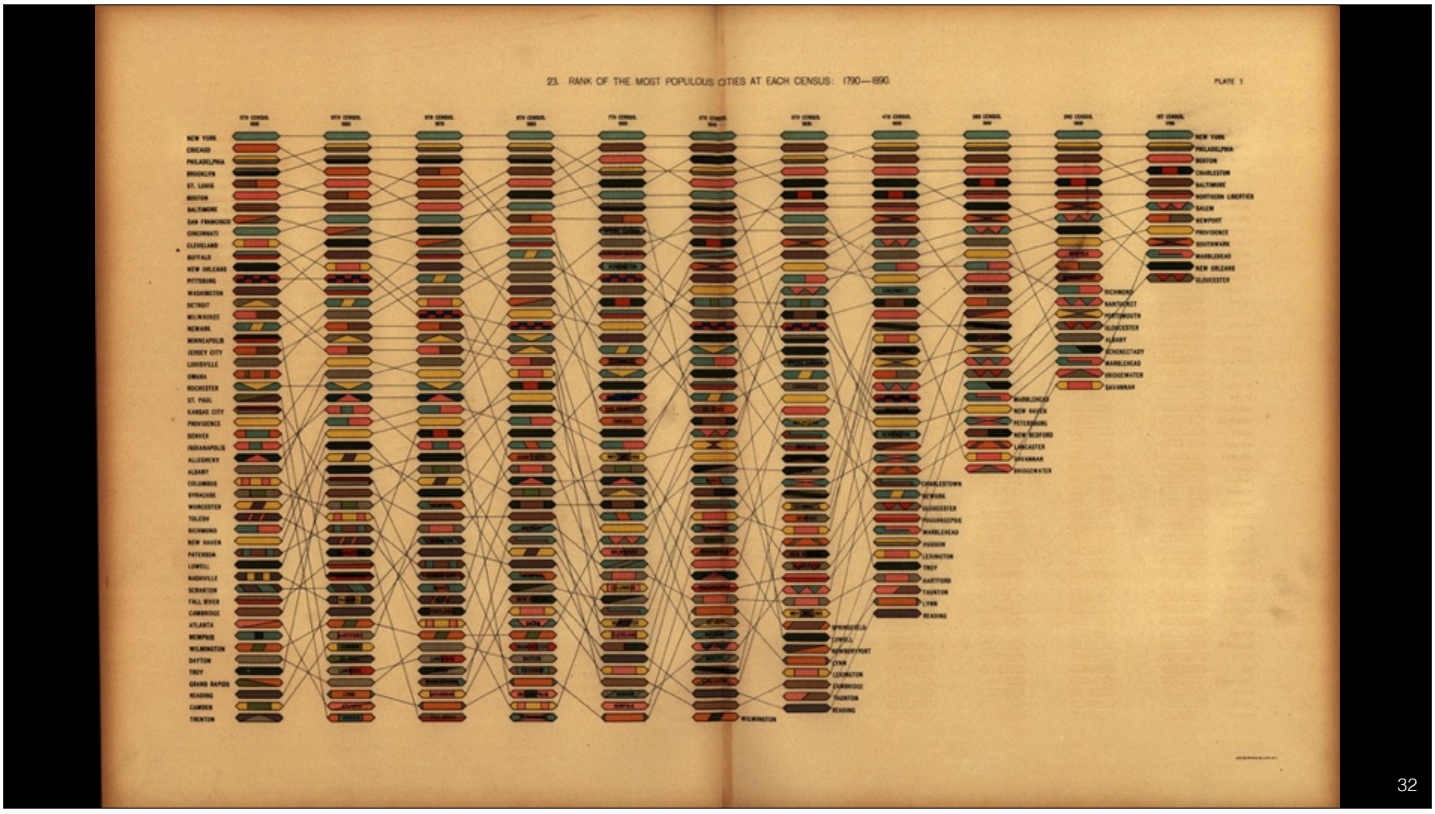
23. RANK OF THE MOST POPULOUS CITIES AT EACH CENSUS: 1790—1890.
PLATE I
32

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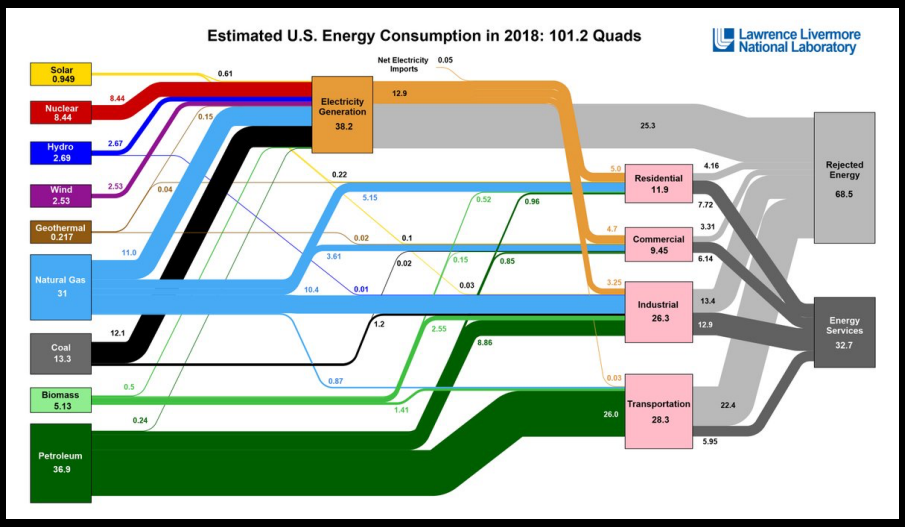
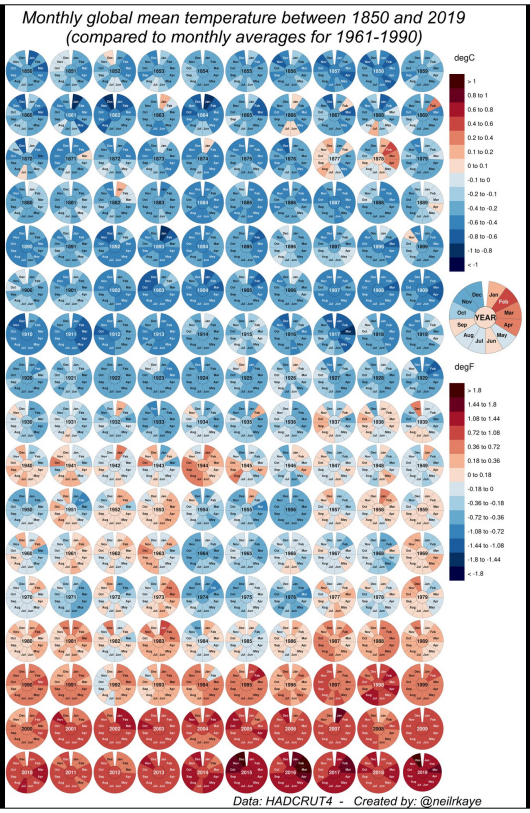


[LLNL, via @carlzimmer]



[Source: @joelEastwood]

Class overview

[www.telecom-paris.fr/~eagan/class/igr204]

Class overview

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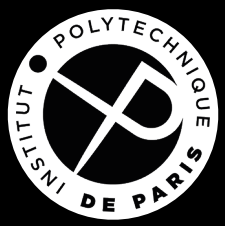

Dernière mise à jour : avril 2020.

Goal: Insight

- Often thought of as process of making a graphic or an image
- Really is a cognitive process
  - Form a mental image of something
  - Internalize an understanding
- “The purpose of visualization is insight, not pictures”
- Insight: discovery, decision making, explanation

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Insight

- Prediction rules
  - Will this loan be repaid?
  - What features let us identify fraudulent phone activity?
- Categories
  - Customer profile segmentation
- Patterns
- Causality
  - Smoking can cause cancer

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Information Visualization

- Provide tools that present data in a way to help people understand and gain insight from it
- Clichés
  - “Seeing is believing”
  - “A picture is worth a thousand words”

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Main Idea

- Visuals help us think
  - Provide a frame of reference, a temporary storage area
- External cognition
  - Role of external world in thinking and reason

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Information Visualization

- What is “visualization”?
  - The use of computer-supported, interactive visual representations of data to amplify cognition.
  - From [Card, Mackinlay, Shneiderman ’98]

Information Visualization

- What is “visualization”?
  - The use of computer-supported, interactive visual representations of data to amplify cognition.
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Three Subfields

- Scientific Visualization
- Information Visualization
- Visual Analytics

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Scientific Visualization

- Primarily relates to and represents something physical or geometric
- Examples
  - Air flow over a wing
  - Stresses on a girder
  - Movement of clouds

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Information Visualization

- Components:
  - Taking items without a direct physical correspondence and mapping them to a 2-D or 3-D physical space.
  - Giving information a visual representation that is useful for analysis and decision-making

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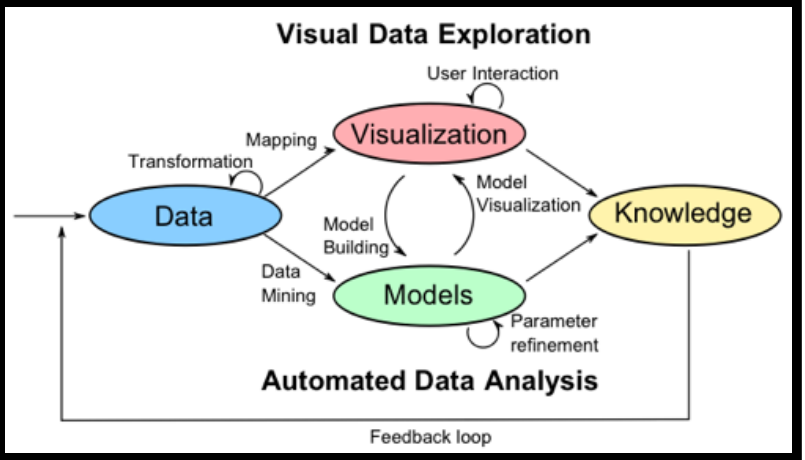
Visual Analytics

- Marry InfoVis with Data Mining
- Human in control



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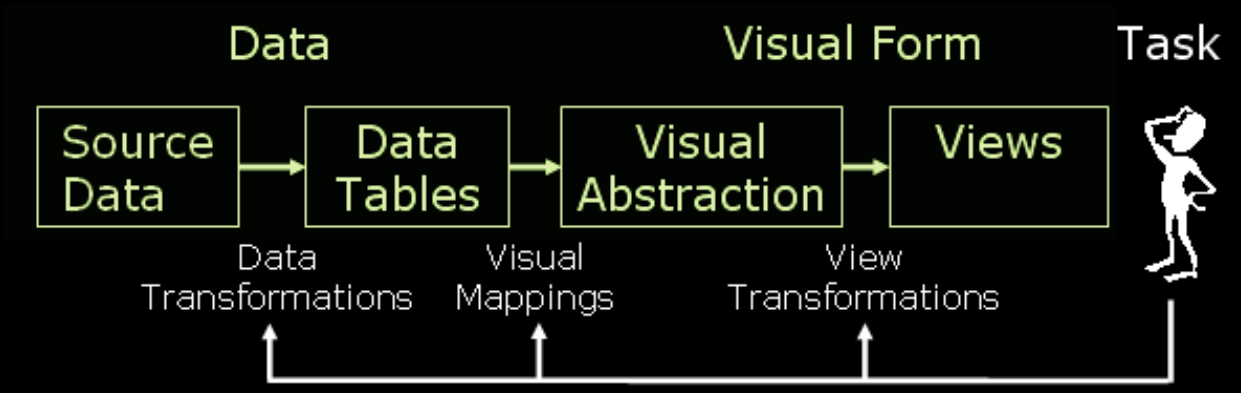
Two Key Attributes

- Scale
  - Challenge often arises when data sets become very large
- **Interactivity**
  - Want to show multiple different perspectives on the data

Data → Visualisation

InfoVis Pipeline



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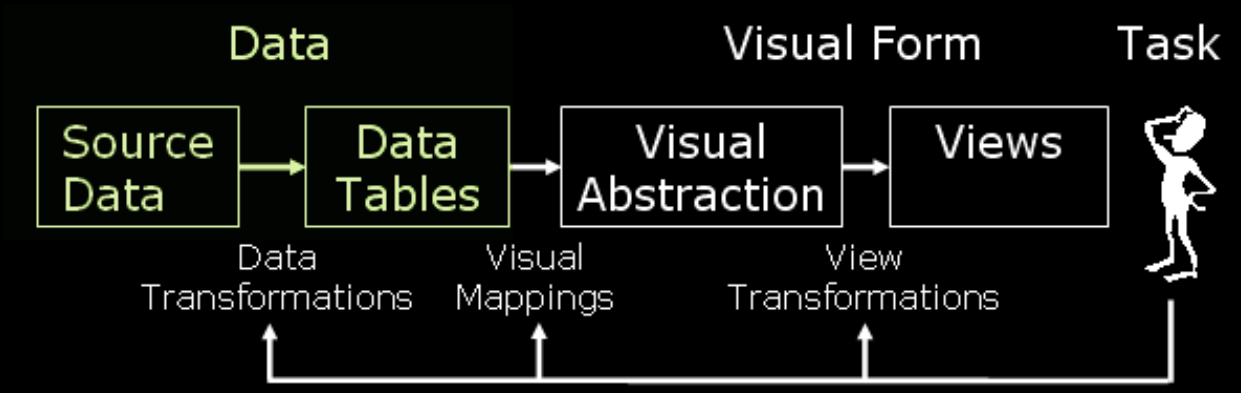
InfoVis Pipeline



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Data Sets

- Data comes in many different forms
- Typically, not in the way you want it

- How is stored (in the raw)?

Example

- Cars
  - make
  - model
  - year
  - miles per gallon
  - cost
  - number of cylinders
  - weights
  - ...

Data Tables

- Often, we take raw data and transform it into a form that is more workable
- Main idea:
  - Individual items are called cases
  - Cases have variables (attributes)

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Data Table Format

Dimensions

	$Variable_1$	$Variable_2$	$Variable_3$	$Variable_4$	…
$Case_1$	$Value_{1,1}$	$Value_{1,2}$	$Value_{1,3}$	$Value_{1,4}$	
$Case_2$	$Value_{2,1}$	$Value_{2,2}$	$Value_{2,3}$	$Value_{2,4}$	
$Case_3$	$Value_{3,1}$	$Value_{3,2}$	$Value_{3,3}$	$Value_{3,4}$	
$Case_4$	$Value_{4,1}$	$Value_{4,2}$	$Value_{4,3}$	$Value_{4,4}$	
⋮					

Think of as a function:

$f(case_i) = \langle value_{i,1}, value_{i,2}, \ldots, value_{i,n} \rangle$

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Data Table Example

People in Class

	Hair	Age	GPA	ID	...
Marie	brown	23	12,3	901-12-3456	
Jean	black	17	14,6	901-12-4567	
Henri	blond	47	10,2	901-12-5678	
Bob	red	29	11,8	901-12-6789	
⋮					

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Variable Types

- Three main types of variables
  - Qualitative
    - N-Nominal (equal or not equal to other values)
      - Example: gender
    - O-Ordinal (obeys < relation, ordered set)
      - Example: fr,so,jr,sr
  - Q-Quantitative (can do math on them)
    - Can be *absolute* or *relative*
    - Example: age, temperature

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Metadata

- Descriptive information about the data
  - Might be something as simple as the type of a variable, or could be more complex
  - For times when the table itself just isn't enough
  - Example:
    - if car motor is electric, then L/100km is meaningless.
    - number of home runs ≤ number of at-bats
    - data collected on *date* by *person.*

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How do we show the data?

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À suivre…

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