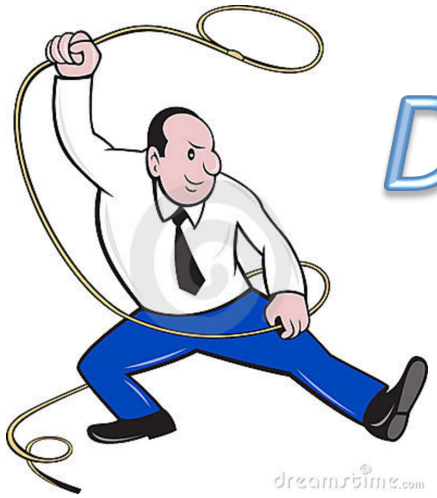


Data Wrangling

John Meehan

Jeff Rasley

Working with raw data sucks.

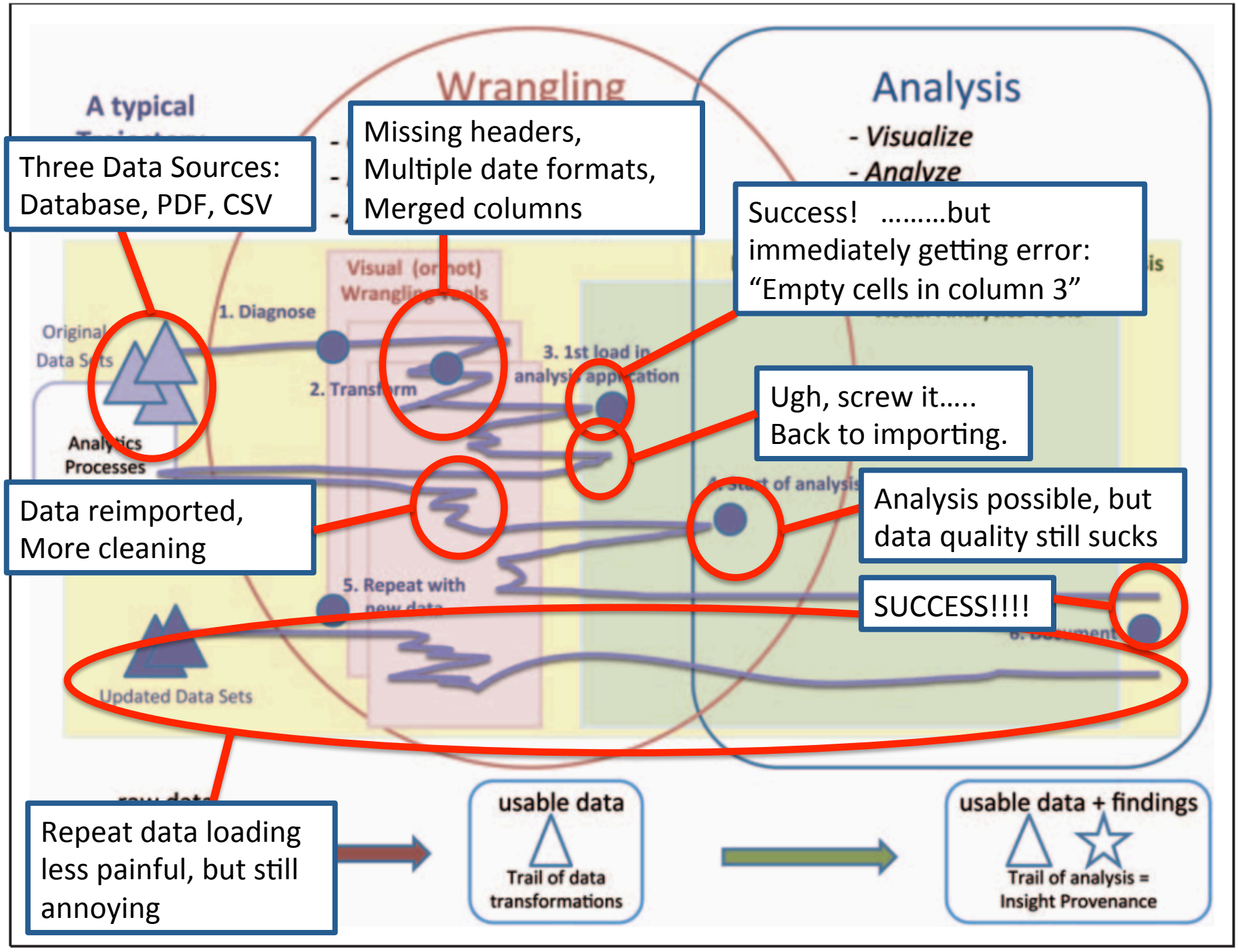
- Data comes in all shapes and sizes
  - CSV files, PDFs, stone tablets, .jpg…
- Different files have different formatting
  - Spaces instead of NULLs, extra rows
- “Dirty” data
  - Unwanted anomalies
  - Duplicates

Current Tools

- Focus on specific problems
  - Resolving entities
  - Removing duplicates
  - Schema matching
- Most systems are non-interactive
  - Inaccessible to general audience
- A lot of people just use Excel or regular expressions…

Data Wrangling

- Goal: extract and standardize the raw data
  - Combine multiple data sources
  - Clean data anomalies
- Combine automation with interactive visualizations to aid in cleaning
- Improve efficiency and scale of data importing
- Lower the threshold for broader audiences


Wrangling
Analysis
- Visualize
- Analyze
Three Data Sources:
Database, PDF, CSV
Missing headers,
Multiple date formats,
Merged columns
Success! ……but
immediately getting error:
"Empty cells in column 3"
Ugh, screw it…..
Back to importing.
Data reimported,
More cleaning
Analysis possible, but
data quality still sucks
SUCCESS!!!!
Repeat data loading
less painful, but still
annoying
usable data
Trail of data
transformations
usable data + findings
Trail of analysis =
Insight Provenance

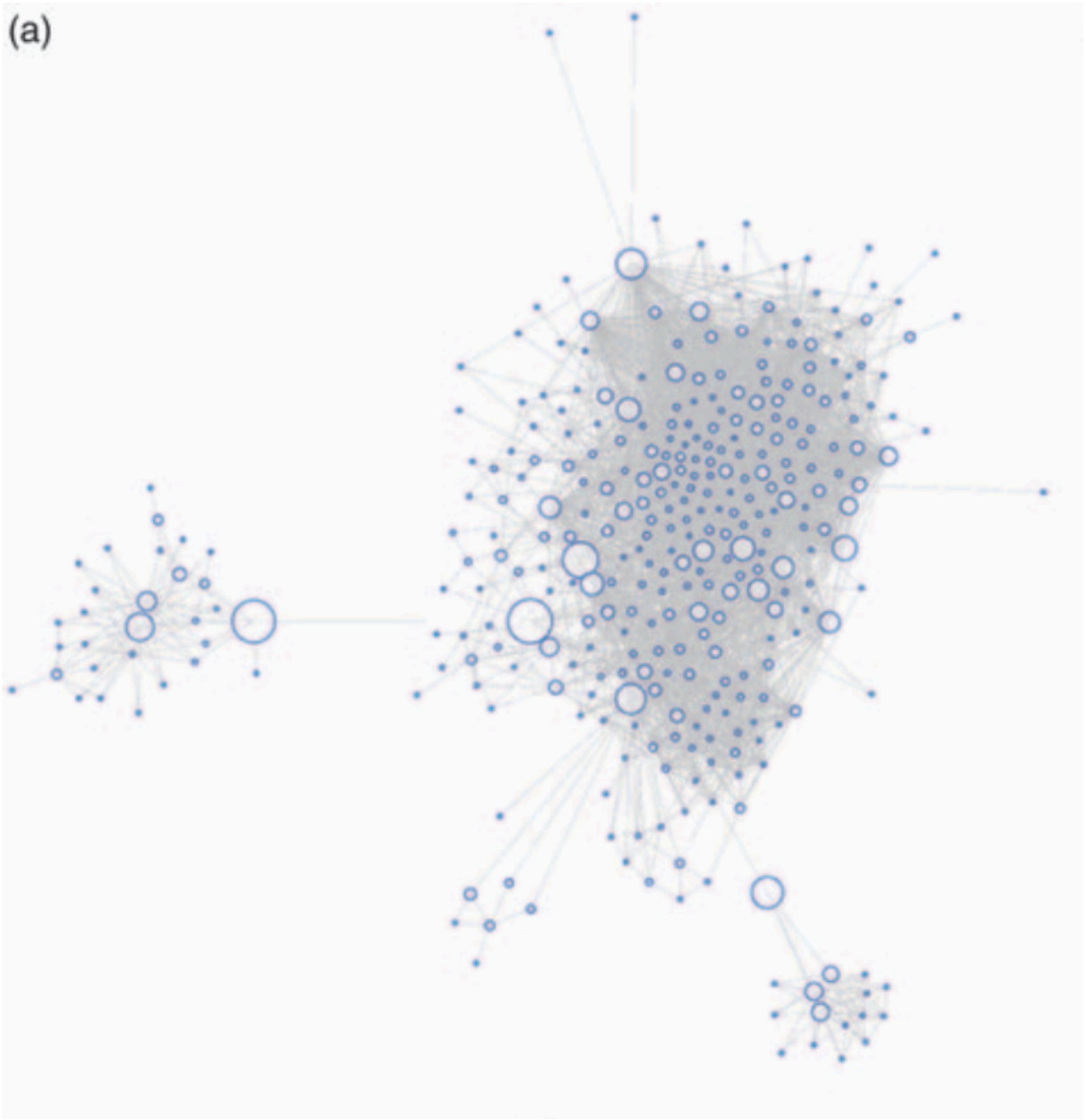
Types of Data Problems

- Missing data
- Incorrect data
- Inconsistent representations of the same data
- About 75% of data problems require human intervention
- Cleaning data vs overly-sanitizing data

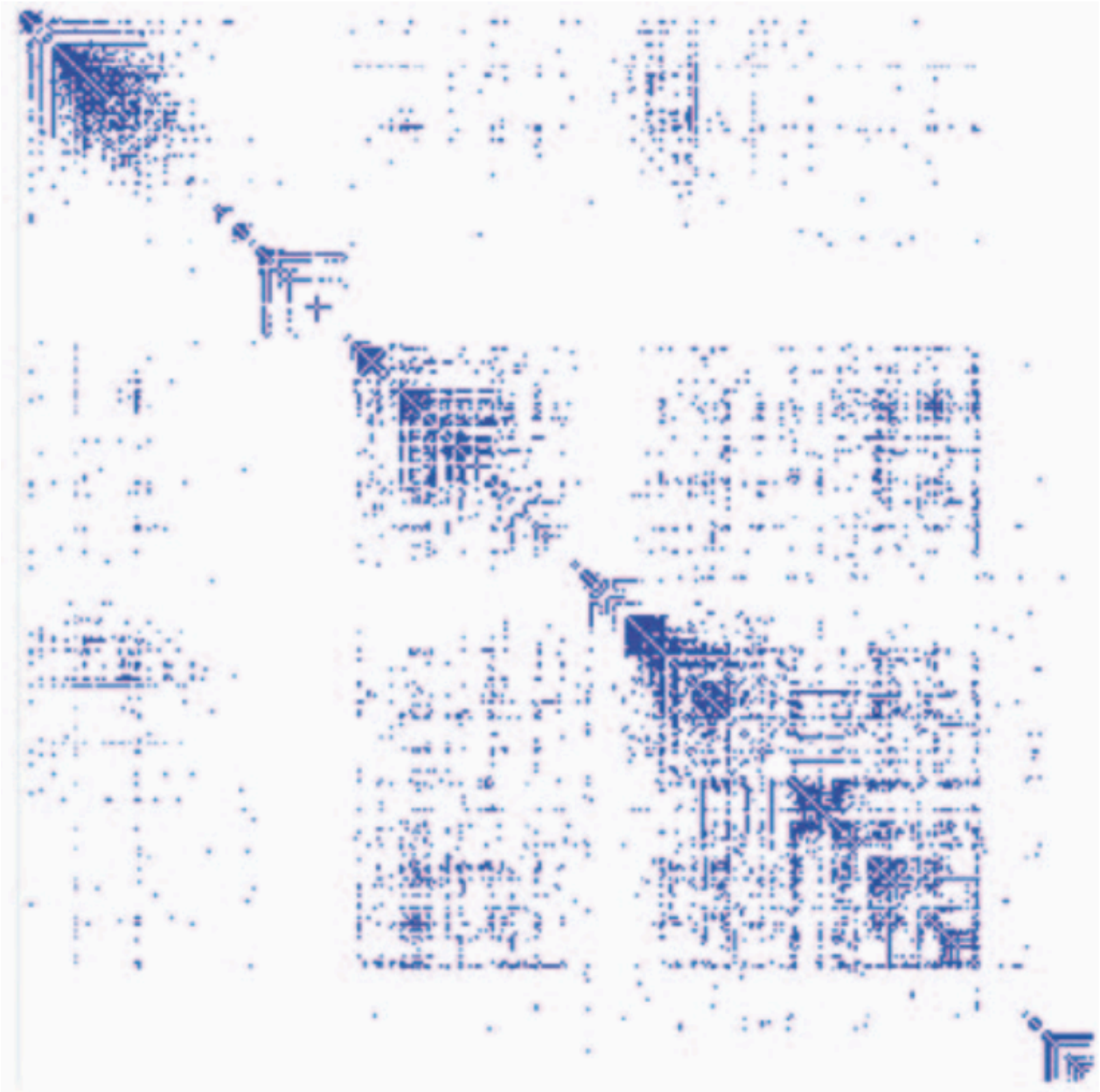
Diagnosing data problems

- Visualizations can convey “raw” data
- Different visual representations highlight different types of data issues
  - Outliers often stand out in a plot
  - Missing data will cause gap or zero value
- Becomes increasingly difficult as data gets larger
  - Visual design coupled with interaction
  - Sampling

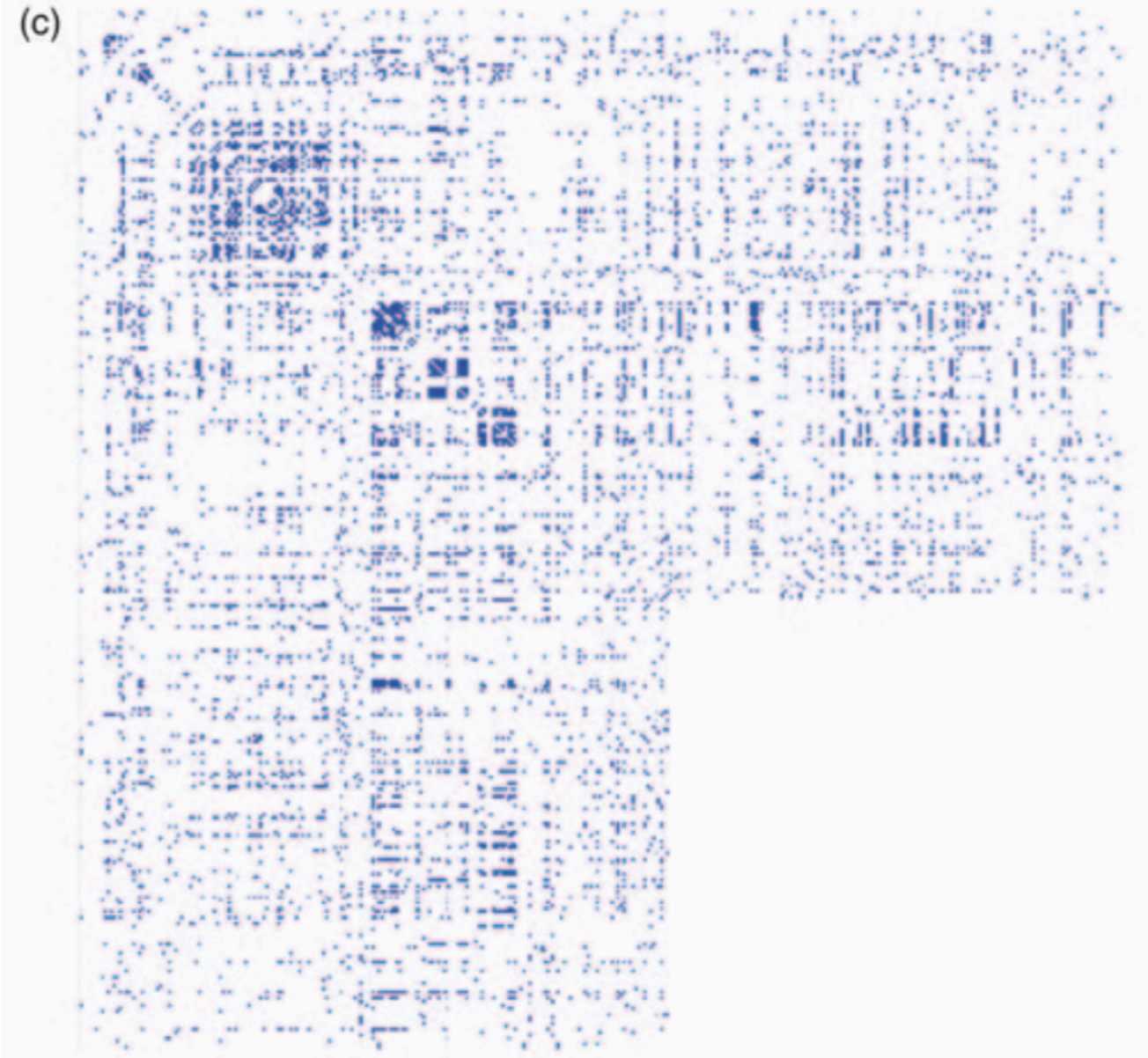
Node-Link Diagram

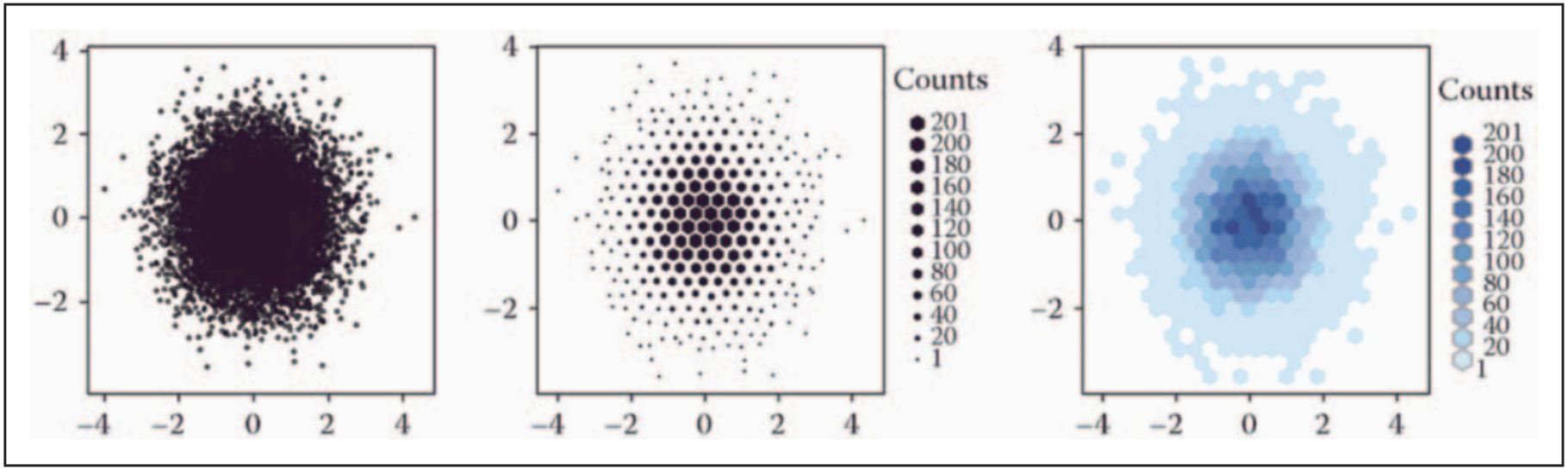


Matrix View



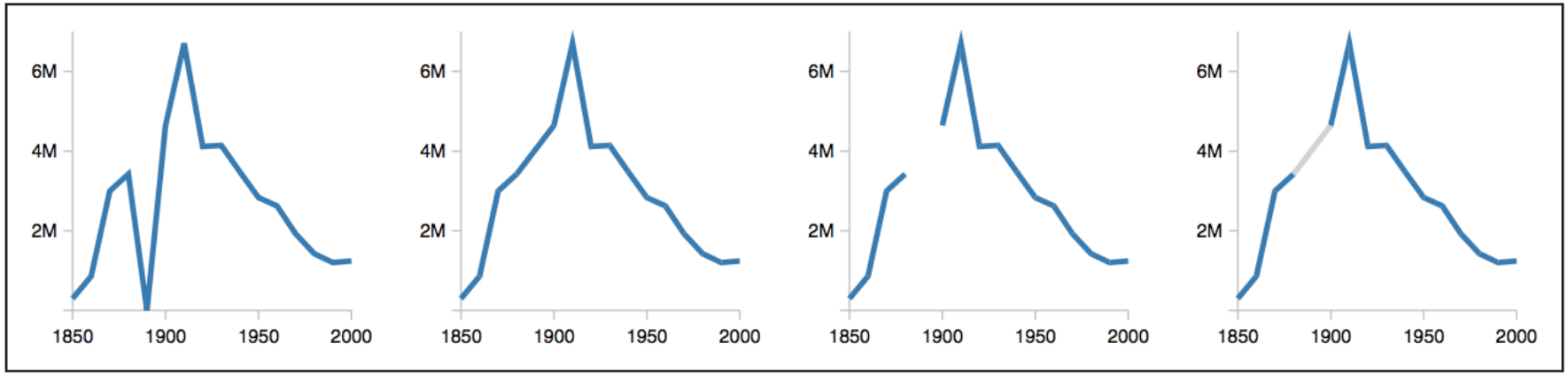
Sorted Matrix View




4
2
0
−2
−4 −2 0 2 4
Counts
201
200
180
160
140
120
100
80
60
40
20
1

Visualizing Missing Data

- Set values to zero?
- Interpolate based on existing data?
- Omit missing data?



Visualizing Uncertain Data

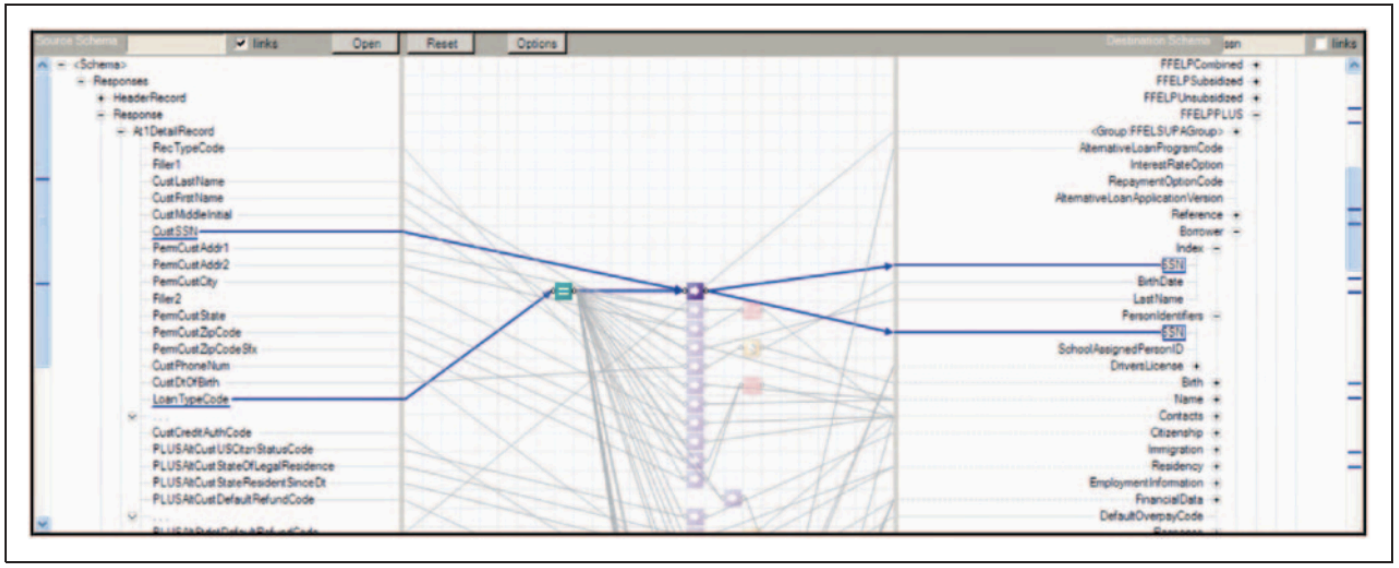
- Can arise from:
  - Measurement errors
  - Missing data
  - Sampling
- Visualization must
  - Consider all components of uncertainty
  - Depict multiple kinds of uncertainty
  - Interact with uncertainty depictions

Transforming Data

- Splitting columns, converting into meaningful records
- Typical methods: regular expressions, programming by demonstration
  - Prone to errors, tedious
- Interactive tools simplify the process
  - Guide user through setting automated constraints
  - Generates scripts for the user

Transforming Data (cont)

- Data formatting, extraction, and conversion
- Correcting erroneous values
- Integrating multiple data sets



Editing and Auditing Transformations

- Data Provenance
  - Maintaining the data history
  - Track the lineage of a specific item's origins
- Used for the modification, reuse, and understanding of a transformation
- What transformation language should be used?
  - Extend existing languages?

Wrangling in the Cloud

- Allows the sharing of data transformations
- Mining records of wrangling
  - Better automatic suggestions
- User-defined data types
- Feedback from downstream analysts
  - Crowdsourcing the final result
  - Allow users to annotate or correct the data

Checkpoint-Conclusion

- Data wrangling is often a second-class citizen
- Common problems, very time-consuming
  - Manual approach is no longer a viable option
- Future work: extend visual approaches into the data wrangling phase
- Plenty of research directions

Secure Data Analytics

- Private/sensitive data
  - SSN, Medical, Classified, etc.
- Cloud-base analysis currently doesn't work
- Local analysis is key
- Research area?

Potter's Wheel: An Interactive Data Cleaning System

- Vijayshankar Raman and Joseph Hellerstein (VLDB '01)
- Provide a graphical interactive tool to support various data transformations with suggestions

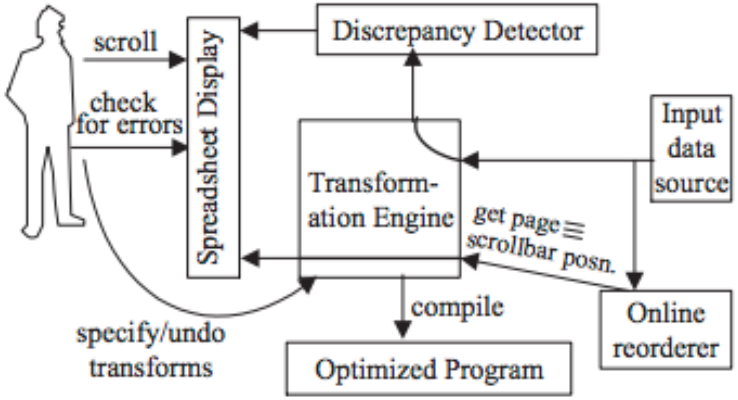


Figure 2: Potter's Wheel Architecture

Transformations

Transform	Definition		
Format	$\phi(R, i, f)$	$=$	$\{(a_1, \ldots, a_{i-1}, a_{i+1}, \ldots, a_n, f(a_i)) \mid (a_1, \ldots, a_n) \in R\}$
Add	$\alpha(R, x)$	$=$	$\{(a_1, \ldots, a_n, x) \mid (a_1, \ldots, a_n) \in R\}$
Drop	$\pi(R, i)$	$=$	$\{(a_1, \ldots, a_{i-1}, a_{i+1}, \ldots, a_n) \mid (a_1, \ldots, a_n) \in R\}$
Copy	$\kappa((a_1, \ldots, a_n), i)$	$=$	$\{(a_1, \ldots, a_n, a_i) \mid (a_1, \ldots, a_n) \in R\}$
Merge	$\mu((a_1, \ldots, a_n), i, j, \text{glue})$	$=$	$\{(a_1, \ldots, a_{i-1}, a_{i+1}, \ldots, a_{j-1}, a_{j+1}, \ldots, a_n, a_i \oplus \text{glue} \oplus a_j) \mid (a_1, \ldots, a_n) \in R\}$
Split	$\omega((a_1, \ldots, a_n), i, \text{splitter})$	$=$	$\{(a_1, \ldots, a_{i-1}, a_{i+1}, \ldots, a_n, \text{left}(a_i, \text{splitter}), \text{right}(a_i, \text{splitter})) \mid (a_1, \ldots, a_n) \in R\}$
Divide	$\delta((a_1, \ldots, a_n), i, \text{pred})$	$=$	$\{(a_1, \ldots, a_{i-1}, a_{i+1}, \ldots, a_n, a_i, \text{null}) \mid (a_1, \ldots, a_n) \in R \wedge \text{pred}(a_i)\} \cup$ $\{(a_1, \ldots, a_{i-1}, a_{i+1}, \ldots, a_n, \text{null}, a_i) \mid (a_1, \ldots, a_n) \in R \wedge \neg\text{pred}(a_i)\}$
Fold	$\lambda(R, i_1, i_2, \ldots i_k)$	$=$	$\{(a_1, \ldots, a_{i_1-1}, a_{i_1+1}, \ldots, a_{i_2-1}, a_{i_2+1}, \ldots, a_{i_k-1}, a_{i_k+1}, \ldots, a_n, a_{i_l}) \mid (a_1, \ldots, a_n) \in R \wedge 1 \leq l \leq k\}$
Select	$\sigma(R, \text{pred})$	$=$	$\{(a_1, \ldots, a_n) \mid (a_1, \ldots, a_n) \in R \wedge \text{pred}((a_1, \ldots, a_n))\}$

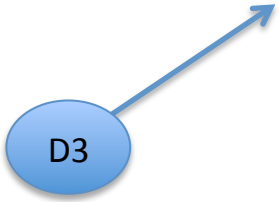
Notation: R is a relation with n columns. i, j are column indices and a_i represents the value of a column in a row. x and glue are values. f is a function mapping values to values. $x \oplus y$ concatenates x and y. splitter is a position in a string or a regular expression, left$(x,$ splitter$)$ is the left part of x after splitting by splitter. pred is a function returning a boolean.

Download!

- Potter's Wheel A-B-C: An Interactive Tool for Data Analysis, Cleansing, and Transformation
  - http://control.cs.berkeley.edu/abc/
- (But you probably don't want to, last release was Oct 10, 2000)

Data Wrangler

- Wrangler: Interactive Visual Specification of Data Transformation Scripts (CHI '11)
  - Sean Kandel, Andreas Paepcke, Joseph Hellerstein, Jeffrey Heer (Stanford Vis Group + Berkeley)



$4.3M in Series A funding! (1/12)

What's new?

- Similar goals as Potter's Wheel
- Improved UI for the web
- Python & JavaScript libraries
- Additional transformations such as fill

Demo

(~10min)

	Year	Property_crime_rate
0	Reported crime in Alabama	
1		
2	2004	4029.3
3	2005	3900
4	2006	3937
5	2007	3974.9
6	2008	4081.9
7		
8	Reported crime in Alaska	
9		
10	2004	3370.9
11	2005	3615
12	2006	3582

7 Command-Line Tools for Data Science

- http://jeroenjanssens.com/2013/09/19/seven-command-line-tools-for-data-science.html