Visualization through Textualization

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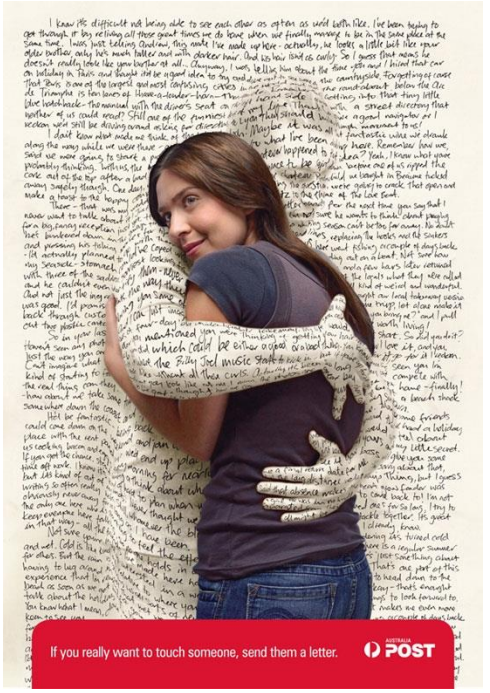
Motivation

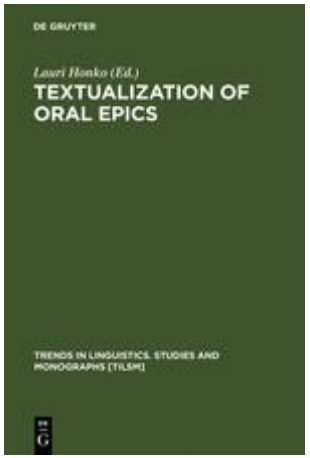
- Gap exist between what users want and what information visualization can provide
  - Visual metaphors unfamiliar to novice users
  - Cluttered views
  - Complicated interactions
- Interactive visual exploration of large, complex datasets can only be performed by a small number of visualization experts and domain experts collaborating with them

Power of Text

- Text is an intelligent tool
  - Text is used to refer to something that carries its interpretation within itself
  - it can render abundant information with its placement, font, color, feeling, and style
- Text helps people convey information and form opinions promptly



Textualization



- “to put into text ” of oral epics, blogs, emotions …
- Textualization: externalizing and refining associated contextual information of the original data
- A variety of abstract data can be processed and analyzed in semantic-rich forms

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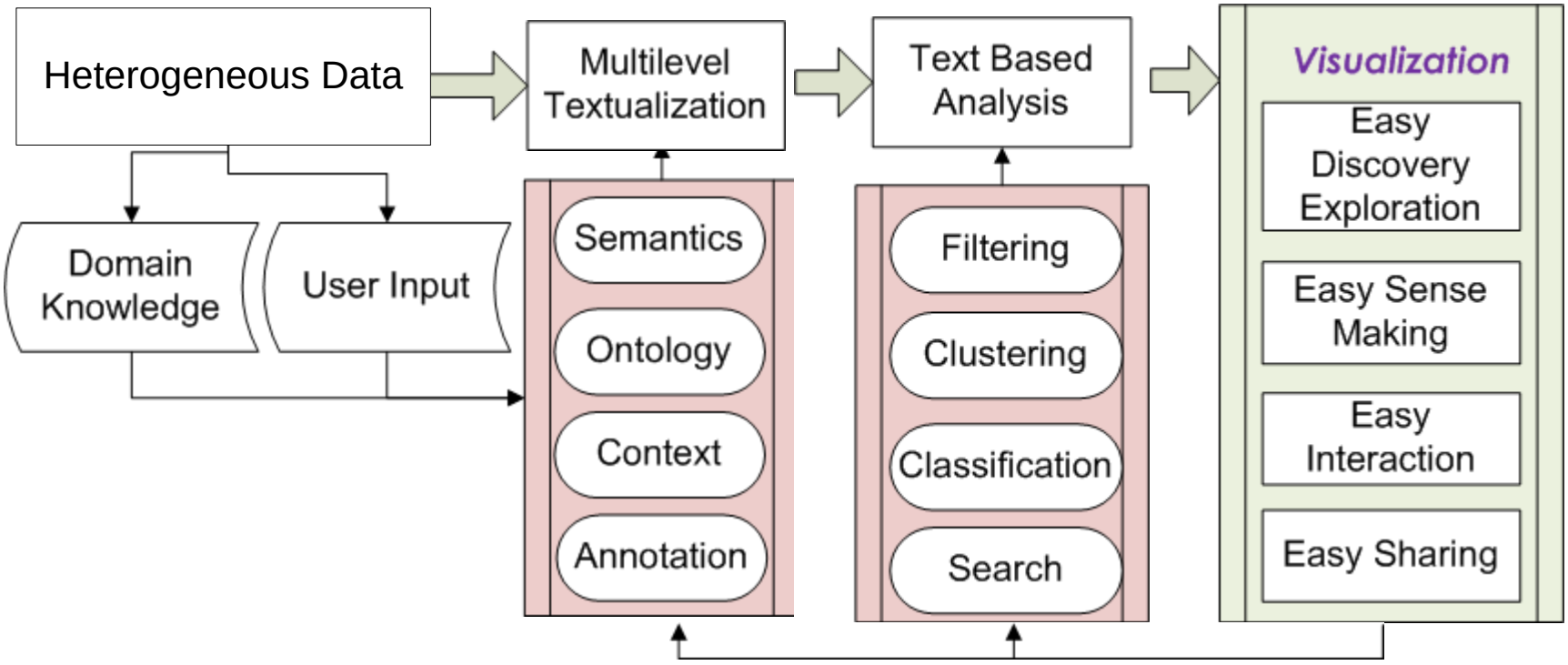
Visualization through Textualization

- Develop visualization techniques to fully utilize the power of text
  - Expose semantics and contextual information associated with the original data
  - Discover patterns and trends of the data with text mining techniques
  - Explore discoveries with interactive visualization

Our Scheme



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Stage 1: Data processing

- A multilevel textualization scheme to manifest the contextual and semantic information of the original data
  - Semantic transformation: convert data values into textual descriptions from domain knowledge
  - User Input: incorporate users' input of annotation, tagging, comments
  - Domain ontology: use the vocabulary to denote given data with its types, implicit properties, and interrelationships

Multilevel Textualization: An example

- Taxi trajectory data: two GPS samples

T1

	T1	T2
DATE/TIME	06/17/12 08:19:11	06/17/12 20:59:33
STATUS	1	0
SPEED	50KM/H	2KM/H
LATITUDE	22.533	22.649
LONGITUDE	114.044	113.814

T2

	Level 1 Street Address	Level 2 Point of Interest	Level 3 Semantics	Level 4 Annotation
T1	Xinsha Road, Futian District, Shenzhen	Shenzhen Golf Club, Sports/ Entertainment	Morning, Slow Motion, Local Road, Passenger Occupied	*Safe Place, Residential, Food/Shopping*, 9 Holes, New Driver
T2	Konggang 7 Road, Bao'an District, Shenzhen	Shenzhen Airport, Transportation	Evening, Creeping Forward, Airport Waiting, Empty	*Long Wait, Metro/Shuttle/ Ferry*, Extra Charge, Experienced Driver

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Challenge: Handling Different Data Types

- *How can we handle different types of data with the textualization scheme?*
- *How can we preserve the data features and relationships?*

Geospatial data

- A variety of “georeferenced” information
  - demographic (e.g. census and real estate)
  - environmental (e.g. weather and climatological records)
  - geology (e.g. land features)
- Geospatial-temporal data
  - severe weather systems
  - population movement of plant and animal species
  - epidemics of flu
  - human and vehicle mobility trajectories
- Map geospatial positions to a meaningful text representation

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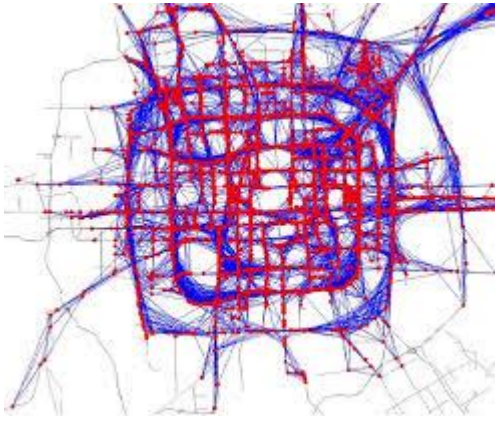
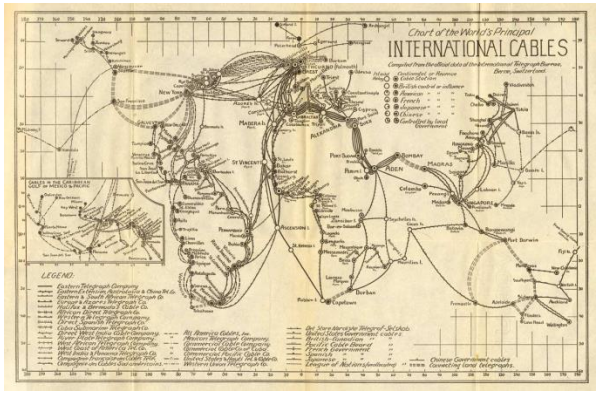
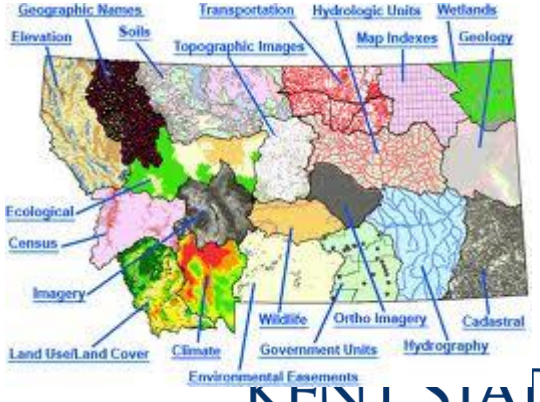
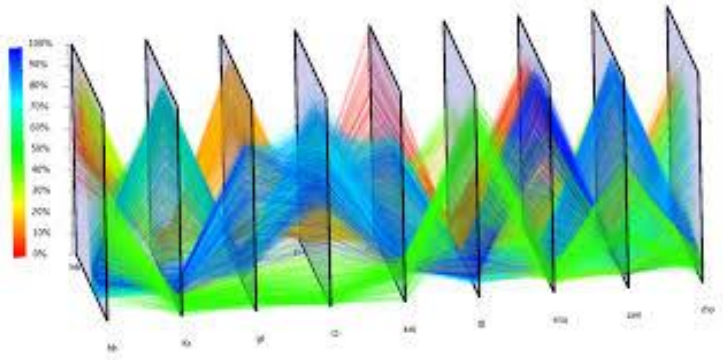


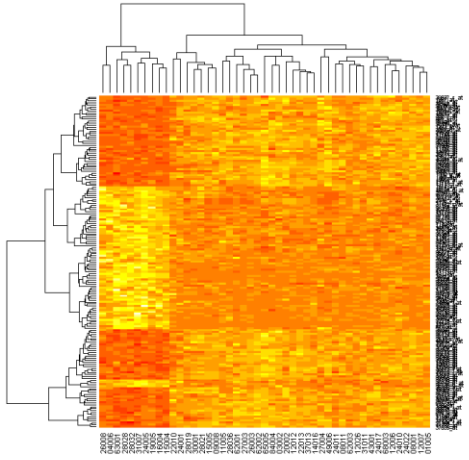




Tabular and Relational Data

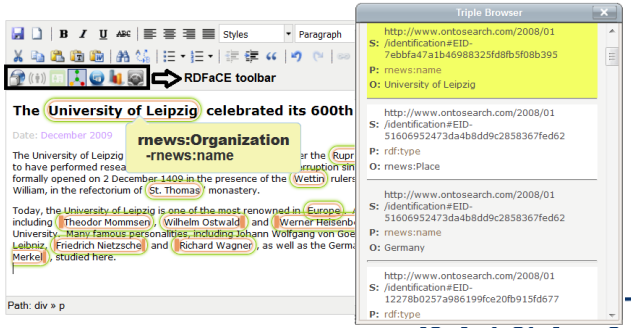
- A fundamental type incorporates numeric, ordinal, categorical, and textual variables, as well as unstructured metadata
  - Each data record can be turned into a document
  - A value in the record is converted into a keyword
- Relational datasets may contain a set of tables
  - Tables can be processed through controlled denormalization





Challenge: Interactively Incorporating User Input

- *How can we employ user input for a large dataset?*
- *How can we design an effective interface for users?*
- Users tag or comment over instance data, then apply to remaining data
- Systems developed in semantic web and information extraction
  - Mostly dedicated to unstructured text
- A good visual interface needed



Challenge: Organizing Data

- *How can we store and organize data?*
- *How can we make the organization efficient for text analysis and interactive visualization?*
- To support:
  - fast query and retrieval by text
  - query and retrieval by original data items
  - fast computation promoting interactive visualization

Stage 2: Text Data Processing

- A set of techniques in natural language processing, statistical, and machine learning that extract and analyze the information of textual data
  - Filtering
  - Clustering
  - Classification
  - Query and Search

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Studying Textualized Data

- Find information patterns from textualized data
  - Utilize the term (keyword) vector model to represent data items and datasets
- Fast computing and easy user interaction

Visualization

- Significant discoveries can be expressed using intuitive visualizations and textual explanations written in natural language
- Challenge 1: Expand existing text visualization techniques
- Challenge 2: Combine text visualization with abstract data visualization

Case study: Explore Taxi Trajectory with Semantic Transformation

- Convert each trajectory as a *document* consisting of the taxi-traversed streets
- Enable analysis of massive taxi datasets as document corpora with text mining tools
- Use LDA Topic modeling to infer hidden patterns of moving taxi populations
- Visualization based on the *taxi topics*

Shenzhen Data

- Daily trajectories of 21,360 taxis in Shenzhen
  - A big city in southern China bordering with Hong Kong
  - Fifteen million residents in a condensed area
  - taxis are a major means of passenger transportation
- Each taxi reports nearly three thousand GPS sample positions per day
- Each sample consists of taxi plate, time, status, speed, direction, and latitude and longitude
- A total of 59,087,230 samples recorded in one day.

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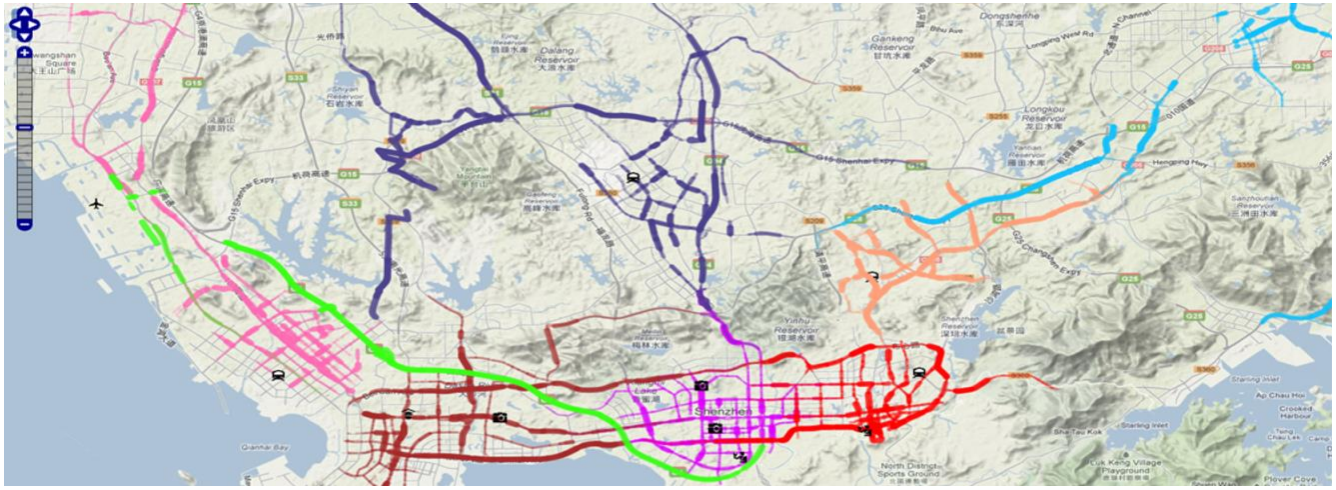
Taxi Topic

- Reveal typical traveling patterns of city cabs



- The topics approximate the city's functional regions
  - A large portion of taxis can accomplish their movement inside a district
- Topics are more than geometrical divisions
  - An airport highway (Green) is an important component of several topics, connecting different regions

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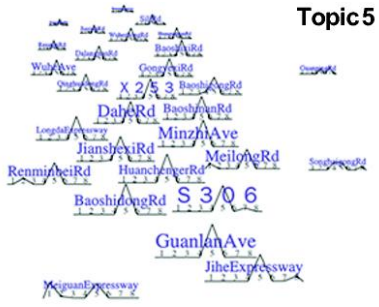
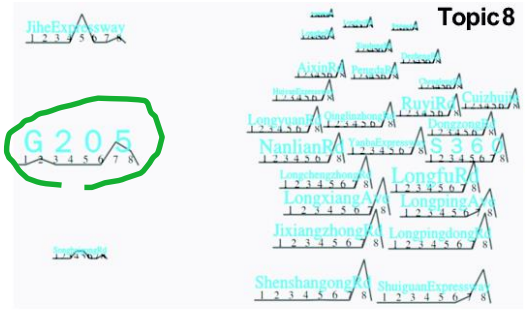
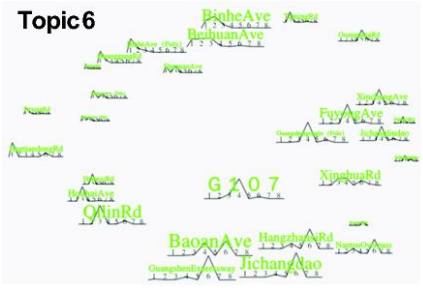
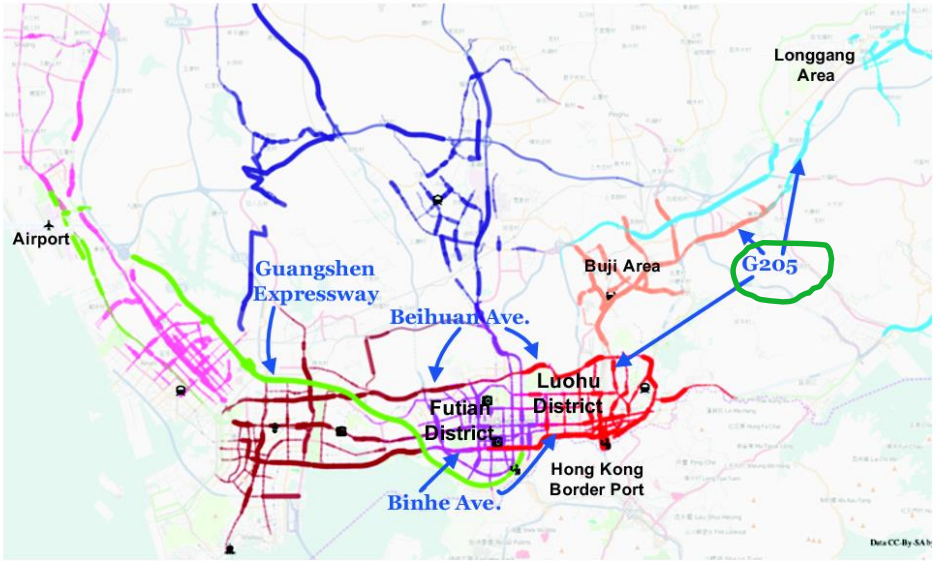
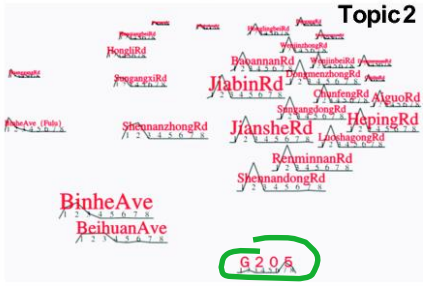
Eight Topics

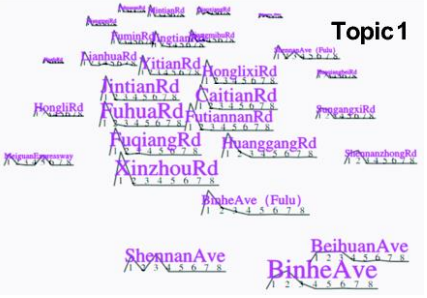












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PCP-based Analysis of Topic 2

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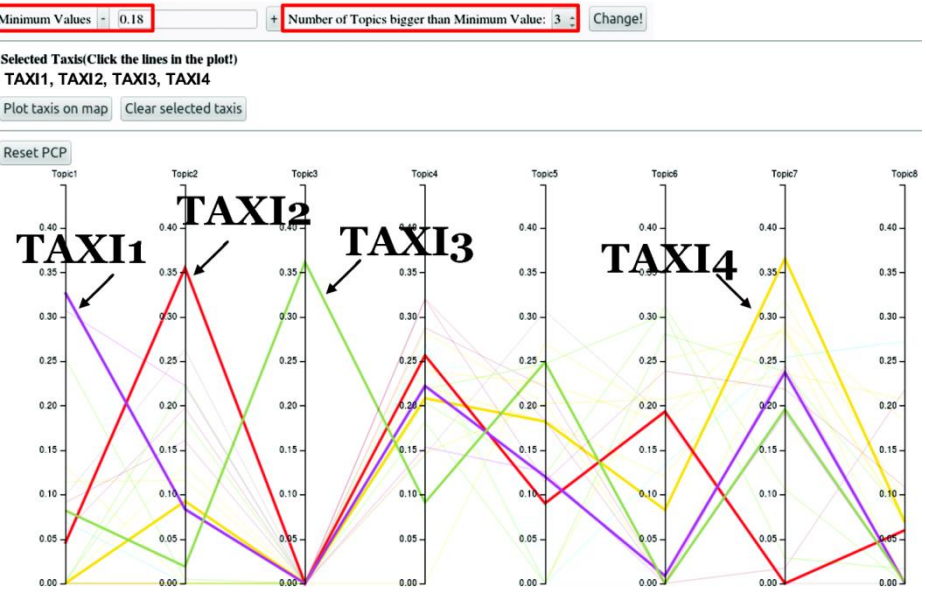
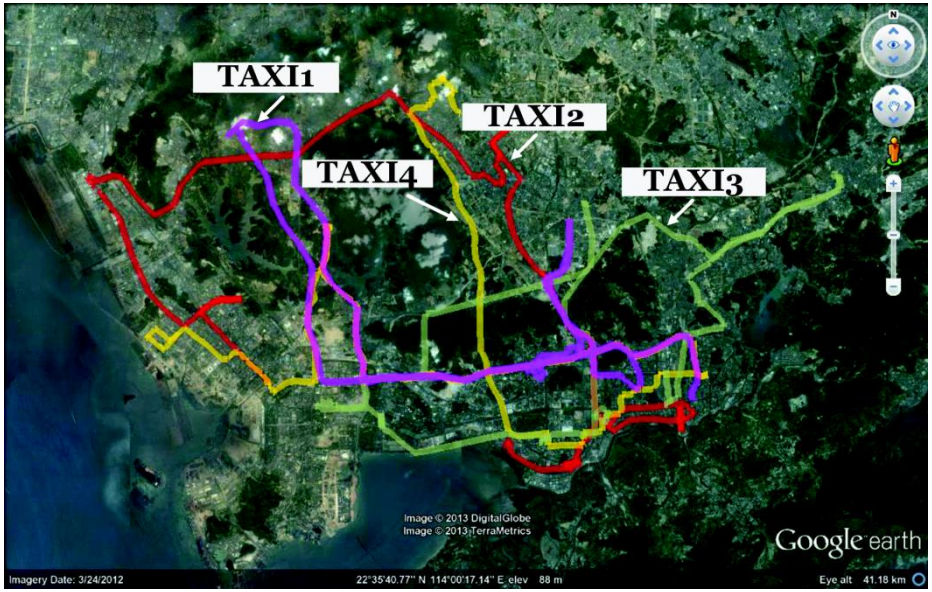
Topics and Trajectories





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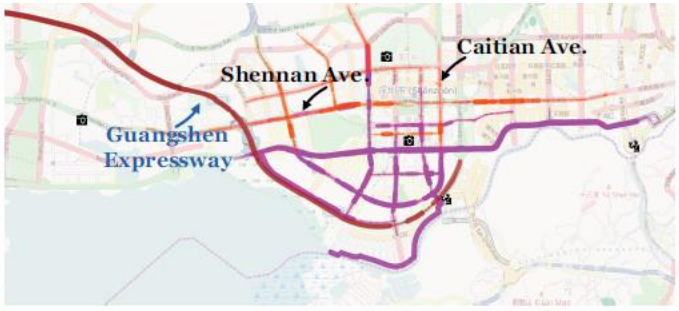
Visualize Street Changes



(b) Topic2: 3pm-6pm

(c) Topic2: 6pm-9pm

- Visualizing disappearing (brown) and emerging (orange) streets

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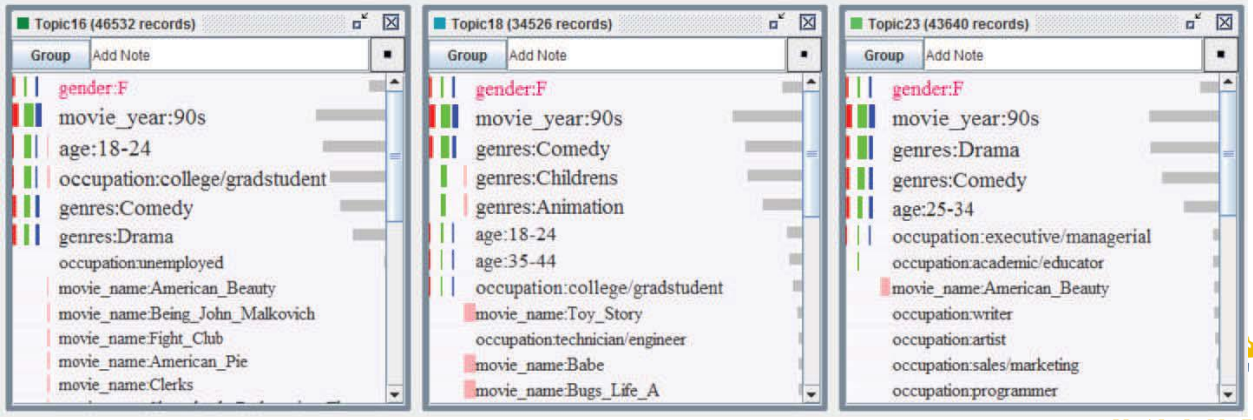
Case Study: Explore Categorical Datasets as Documents

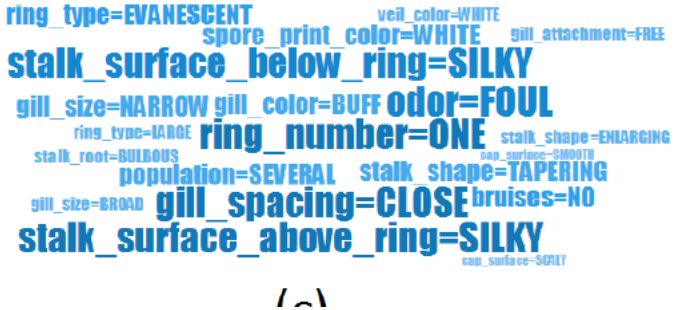
- Map each record in a categorical dataset to a document represented by a bag of categories
- Convert a categorical dataset into a document corpus
- Apply text-based cluster analysis (LDA) to discover subspace clusters of textual category values
- Use associate rule mining discovers optimal risk rules describing multivariate relationships in the textualized topical subspaces

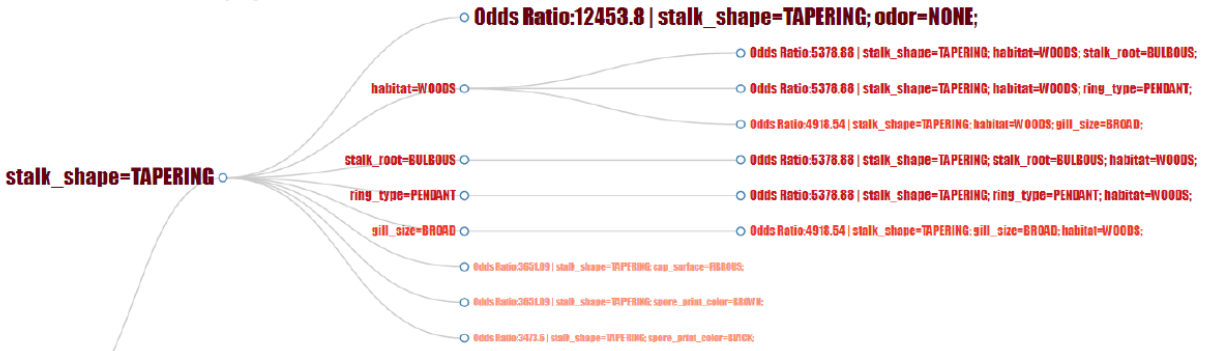
MovieLens dataset

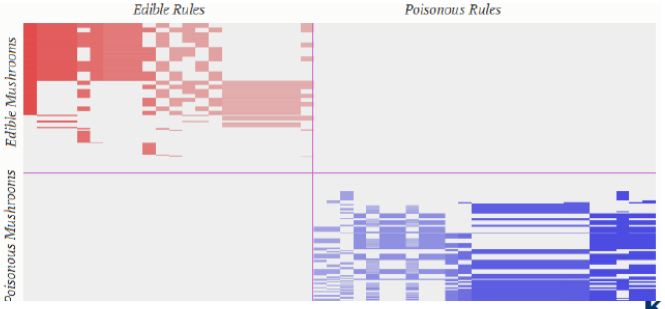
- 1,000,209 data items representing rankings from 6,040 users for 3,883 movies
- Use word clouds, word tree, and fingerprinting, are then used to visualize the rules and data items for interactive knowledge discovery
- Topic Cards: https://www.youtube.com/watch?v=W2Kt7WKIMTI



Mushroom Data







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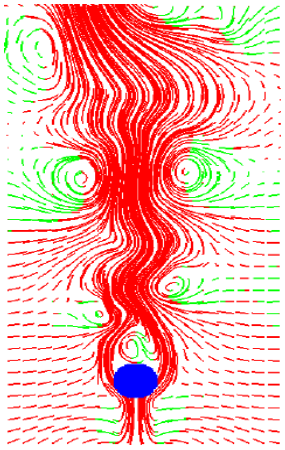
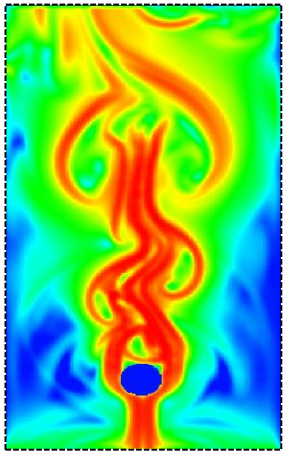
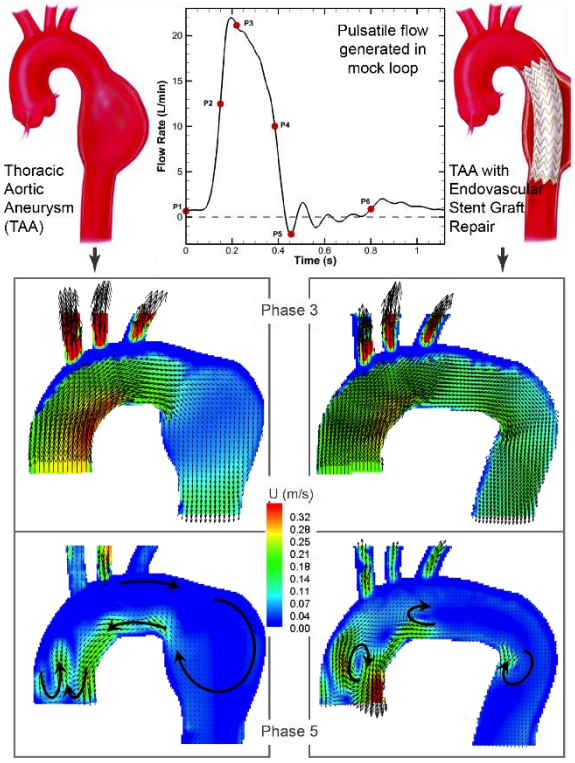
Working on Evaluation

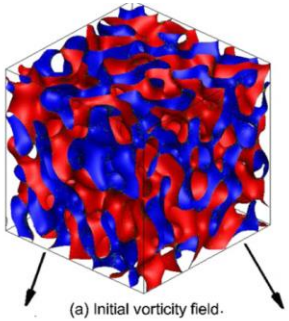
- The effectiveness and efficiency of algorithms of textualization methodology?
- Compare them with other visualizations?
- User study over different applications

Use in More Visualization Tasks?

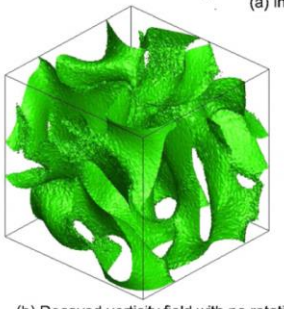




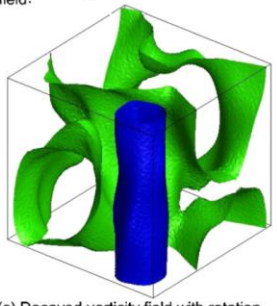




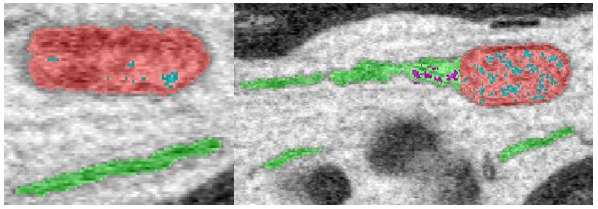
(a) Initial vorticity field.



(b) Decayed vorticity field with no rotation.



(c) Decayed vorticity field with rotation.



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Conclusion

- Text can be of interest in abstract data analysis and visualization
- Text analysis tools are enabled
- Text visualization to be compactly integrated with existing visualizations
- Specific approaches for different data types and applications

Thanks!

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