Geospatial Visual Analytics:

Introduction to Visual Analytics

Fraunhofer IAIS
Institut Intelligente Analyse- und Informationssysteme

Gennady Andrienko & Natalia Andrienko
http://geoanalytics.net

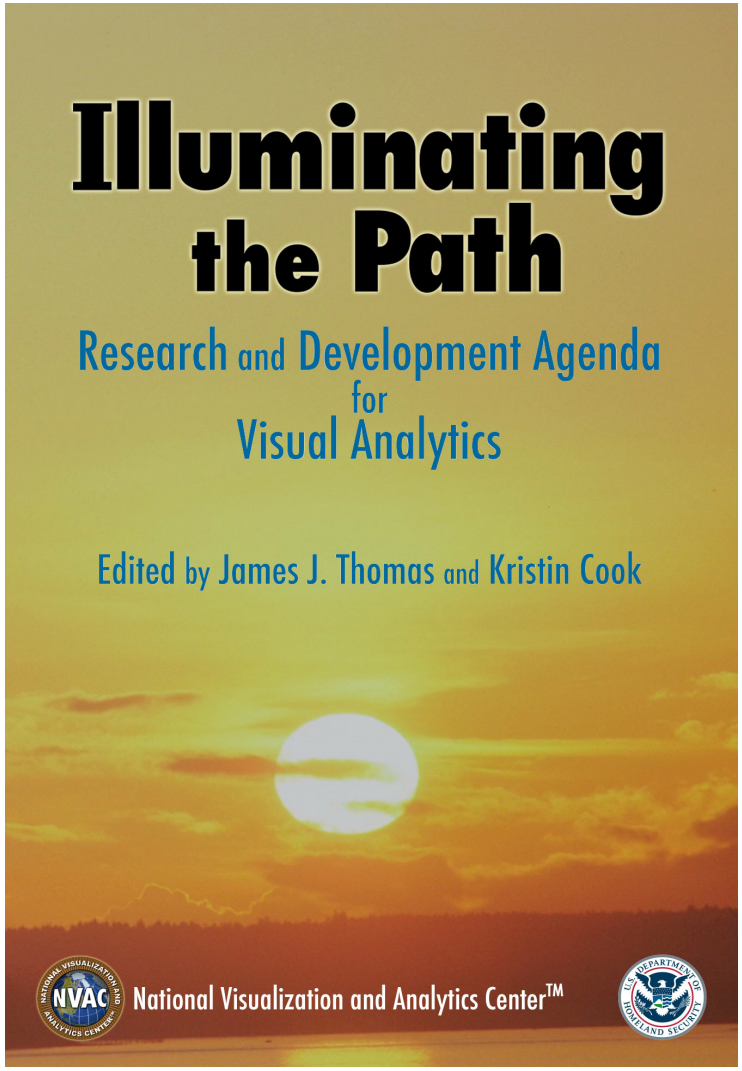
What Is Visual Analytics

Visual Analytics is the science of analytical reasoning facilitated by interactive visual interfaces.

People use visual analytics tools and techniques to

- Synthesize information and derive insight from massive, dynamic, ambiguous, and often conflicting data
- Detect the expected and discover the unexpected
- Provide timely, defensible, and understandable assessments
- Communicate assessment effectively for action

The book (IEEE Computer Society 2005) is available at http://nvac.pnl.gov/ *in PDF form*



Emergence of Visual Analytics

Initially driven by the USA Homeland Security…

…but now has a much broader scope and impact

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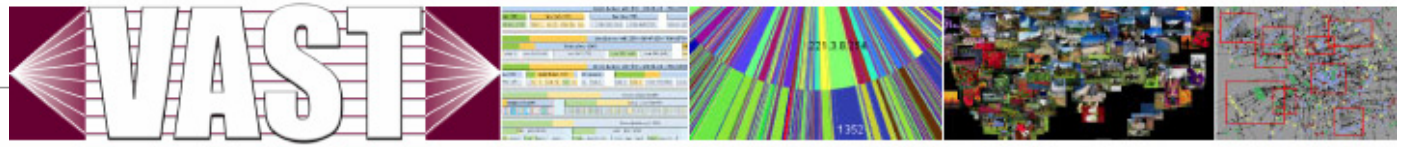
Conferences, symposia, workshops

EU Workshop on Visual Analytics
18. January 2007

Downloads

Agenda

- Agenda



IEEE Symposium on Visual Analytics Science and Technology 2007 • October 30 to November 1, 2007

GIScience 2006 Visualization, Analytics & Spatial Decision Support

Call for papers for the Workshop on Visualization, Analytics & Spatial Decision Support at the GIScience conference (September 20, 2006, Münster) and for a special issue of the International Journal of Geographical Information Science

Research programs and projects

National Science Foundation
WHERE DISCOVERIES BEGIN

HOME | FUNDING | AWARDS | DISCOVERIES | NEWS | PUBLICATIONS | STATISTICS

Funding

Division of Computing and Communication Foundations
Foundations of Data and Visual Analytics (FODAVA)

DFG Priority Program

Scalable Visual Analytics: Interactive Visual Analysis Systems of Complex Information Spaces

University courses and seminars

Visualization and MultiMedia Lab
Department of Informatics, University of Zürich

VMML visualization and multimedia lab university of zürich

HOME | PEOPLE | RESEARCH | TEACHING | PUBLICATIONS | LINKS

vmml:/teaching/seminar

Organisation
Voraussetzung

Seminar in Visualization and Visual Analytics (V-Nr. 43

TECHNISCHE UNIVERSITÄT DARMSTADT

Courses and Lectures
Comment: Visual Analytics: Inte

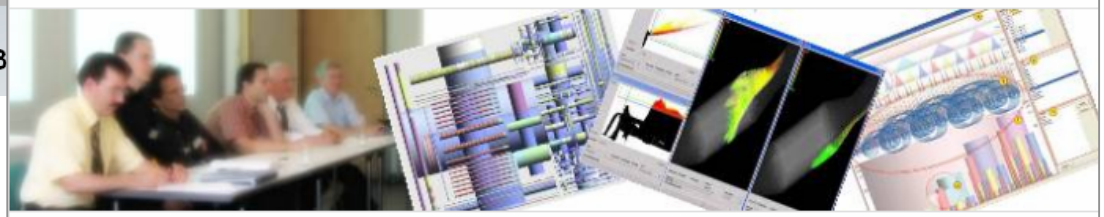
Visual Analytics

Department of Computer Science
UNC Charlotte

ITCS 4122 (Undergraduate)
ITCS 5122 (Graduate)

Fraunhofer

VisMaster: Visual Analytics - Mastering the Information Age



VisMaster
Visual Analytics - Mastering the Information Age

What is VisMaster?

Visual Analytics - Mastering the Information Age

VisMaster is a European Coordination Action Project focused on the research discipline of Visual Analytics: One of the most important challenges of the emerging Information Age is to

Current affairs

News

Events

Kontakt »

Data Explosion

- The human society faces **overwhelming and rapidly growing amounts** of data and information from **numerous sources.**
  In order to make right and timely decisions, people need to **make sense** of the data.
- Some examples of data types
  - Textual data: documents, news, Web, email, …
  - Databases: corporate, government, scientific, …
  - Image data: satellite, aerial
  - Sensor data: environment, medicine, manufacturing, traffic, …
  - Video data: security observation, traffic monitoring, …
- Data of **multiple types** coming from **multiple heterogeneous sources** must often be analysed in concert to gain insights
- Among the **massive amounts** of data, relevant information content may be **hidden in a few nuggets**
- The information may be **disparate**, **incomplete**, **inconsistent**, **time-varying**

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Grand Challenge: Enable Profound Insights

- In order to make right and timely decisions, people need to **make sense** of complex data.
  Complexities: huge amounts, high dimensionality, time variance, multiple sources, diversity of types, heterogeneous quality, incompleteness, uncertainty, inconsistency

➢ A **grand challenge** is to support the analyst in

- distilling the relevant nuggets of information from disparate information streams
- understanding the connections among relevant information
- gaining insight from data

Why Visual Analytics?

- Visualize: “to **make perceptible** to the mind or imagination”
  - Random House Webster’s College Dictionary
- “Visualization is the process of representing abstract business or scientific data as images that can **aid in understanding the meaning** of the data.”
  - Whatis?com computer dictionary, http://whatis.techtarget.com/whome/
- “Visualization offers a method for **seeing the unseen**.”
  - B. McCormick, T. DeFanti, and M. Brown. Definition of Visualization. ACM SIGGRAPH Computer Graphics, 21(6), November 1987, p.3
- “An estimated 50 percent of the brain's neurons are associated with vision. Visualization <…> aims to put that neurological machinery to work.”
  - Ibid.

➢ Visual analytics is called upon to **extend the perceptual and cognitive abilities** of humans, to provide them with the capability to truly understand complex information

Scalability Challenge

- Current technologies (in particular, current visualization techniques) cannot support the **scale and complexity** of the growing analytical challenge.
- New techniques and underlying scientific foundations are needed to deal with the scale of the problems the humans are facing.
- Major scale issues that must be addressed:
  - **Information scalability**: the capability to extract relevant information from massive data streams
  - **Visual scalability**: the capability to effectively display massive data sets
  - **Display scalability**: effective use of everything from wall-sized to phone-sized displays
  - **Human scalability**: scale from single users to collaborative environments
  - **Software scalability**: the capability of a software system to interactively manipulate large data sets

Technology and Human Abilities

- The basic computer technology performance doubles every 18 months; graphics technologies every 12 months
- However, basic human skills and abilities do not change significantly; there are fundamental limits, which are being asymptotically approached

⇒ Large-scale problems have to be reduced to a scale that humans can comprehend and act on

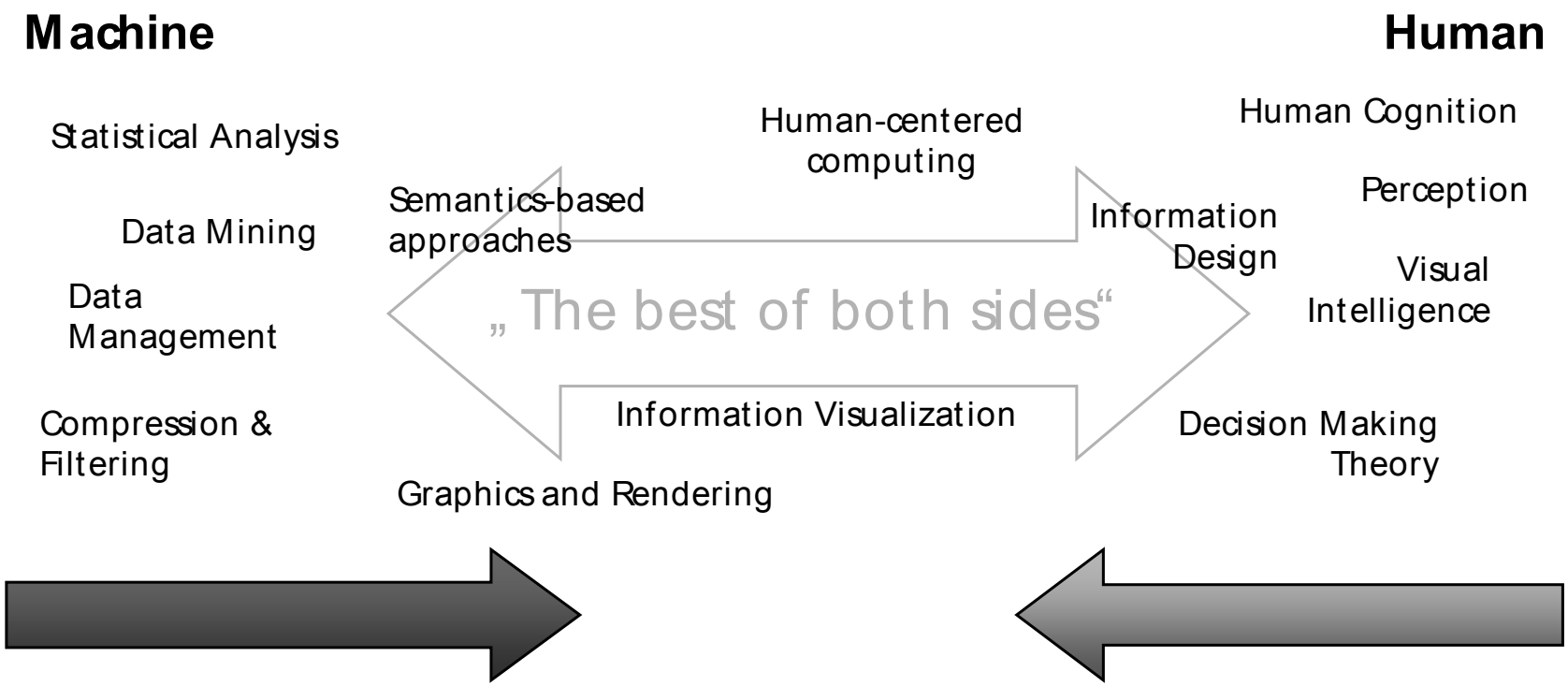
⇒ The advances in the computer technology by themselves do not resolve the scalability issues

⇒ **Principally new** solutions are needed

The Need for Visual Analytics

- Visual analytics must develop new solutions
  - enabling analysts to focus their **full perceptual and cognitive capabilities** on their analytical processes
  - while allowing them to **apply advanced computational capabilities** to augment their discovery process

Visual analytics integrates scientific disciplines to improve the division of labour between human and machine



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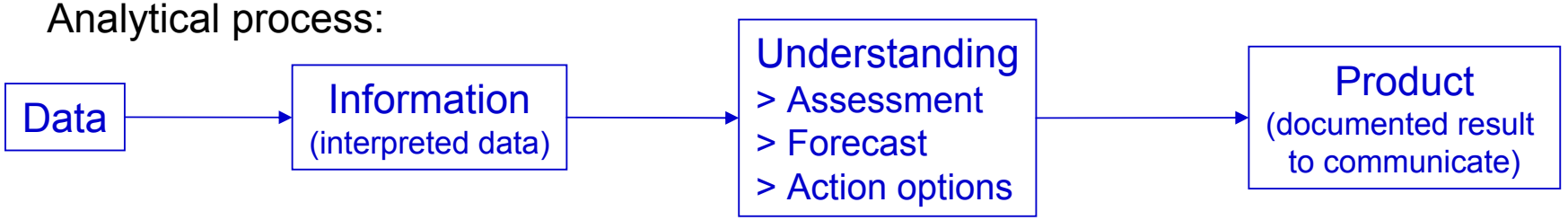
Components of Visual Analytics

- **Analytical reasoning**
  - How to maximise human capacity to perceive, understand, and reason about complex and dynamic data and situations?
- **Visual representations and interaction techniques**
  - How to augment cognitive reasoning with perceptual reasoning through visual representations and interaction?
- **Data representations and transformations**
  - How to transform data into a representation that is appropriate to the analytical task and effectively conveys the important content?
- **Production, presentation, and dissemination**
  - How to convey analytical results in meaningful ways to various audiences?

What Is Visual Analytics *(a recapitulation)*

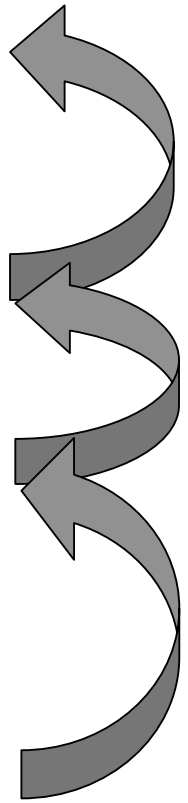
- The science of **analytical reasoning facilitated by interactive visual interfaces**
- Given: *massive, heterogeneous, dynamic, ambiguous, conflicting data*
- Required:
  - *Synthesise information and derive insight*
  - *Detect the expected and discover the unexpected*
  - *Provide timely, defensible, and understandable assessments*
  - *Communicate assessments effectively for action*
- Analytical process:



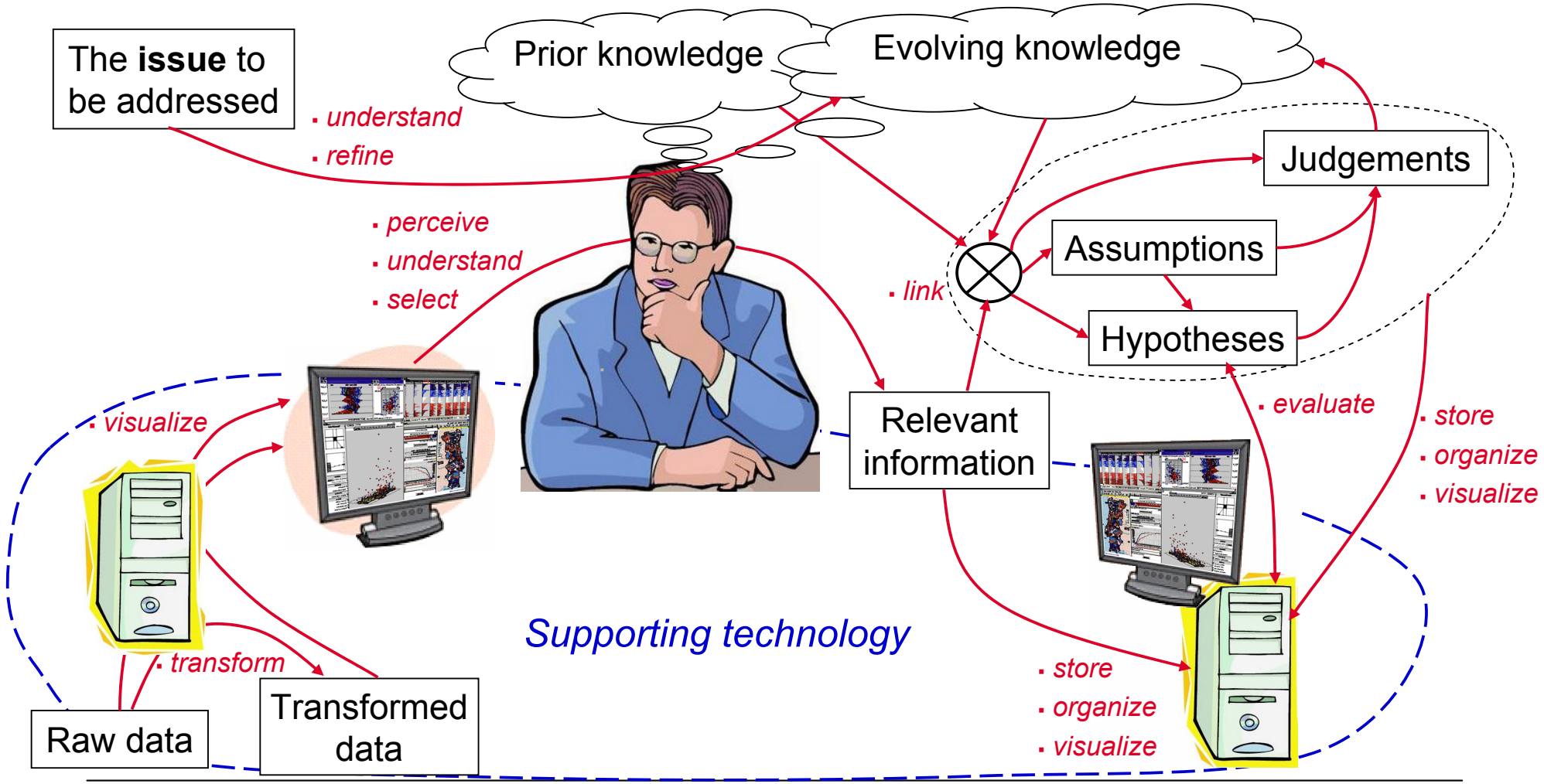
➢ **Interactive visual interfaces** enable analysts
  - to utilize their perceptual and cognitive capabilities fully and effectively
  - to complement and augment their abilities with advanced computational methods

Steps in the Analytical Process

- Plan the process
- Gather relevant information and become familiar with it
- Incorporate the relevant information with the existing knowledge
- Generate candidate explanations (hypotheses)
- Evaluate the hypotheses in light of evidence and assumptions
- Develop a judgement about the most likely explanations or outcomes
- Try to find other possible explanations that were not previously considered
- Draw conclusions
- Create a report or presentation of the results; explain why
- Collaboratively review the results and the arguments (with colleagues and/or external experts)
- Share the results with customers or other audience



Analytical Discourse



Supporting Technology

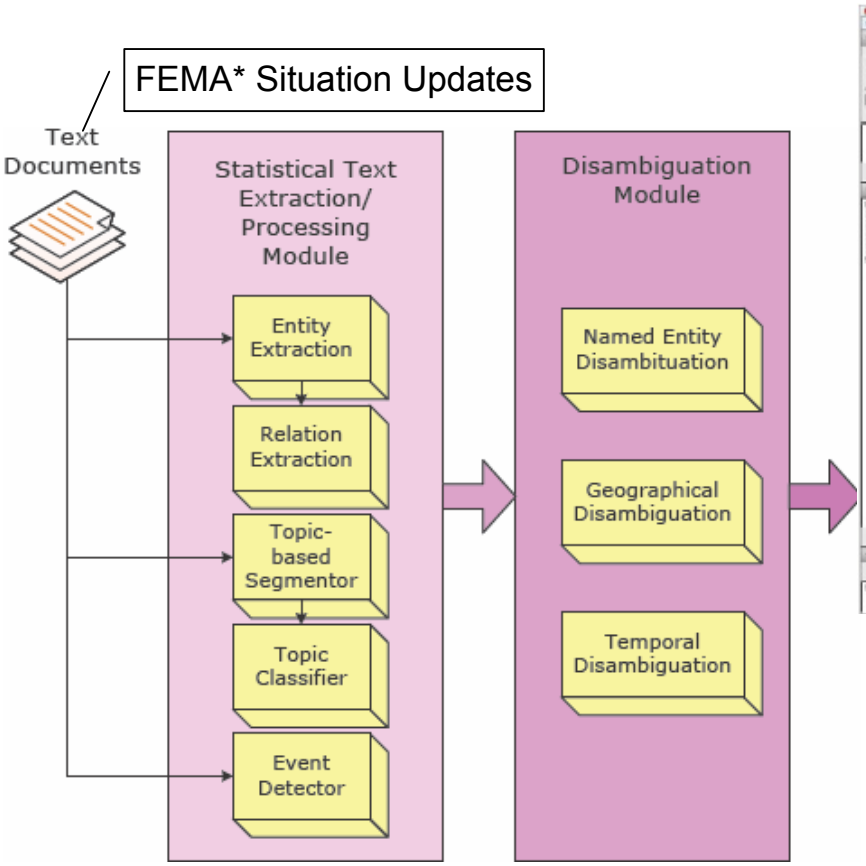
- Data pre-processing and computer-adapted representation
  - e.g. extraction of structured data from images, video, texts
- Data transformations
  - e.g. aggregation; clustering; dimensionality reduction; interpolation; smoothing
- Automatic extraction of potentially interesting features and patterns (relations, regularities, anomalies, trends)

Visualization of data (original and derived)

- Techniques for hypotheses testing (statistics)
- Annotation support
- Support for workspaces and workflows
- Support for collaborative analyses

Visualization of derived knowledge, argumentation, and analysis process

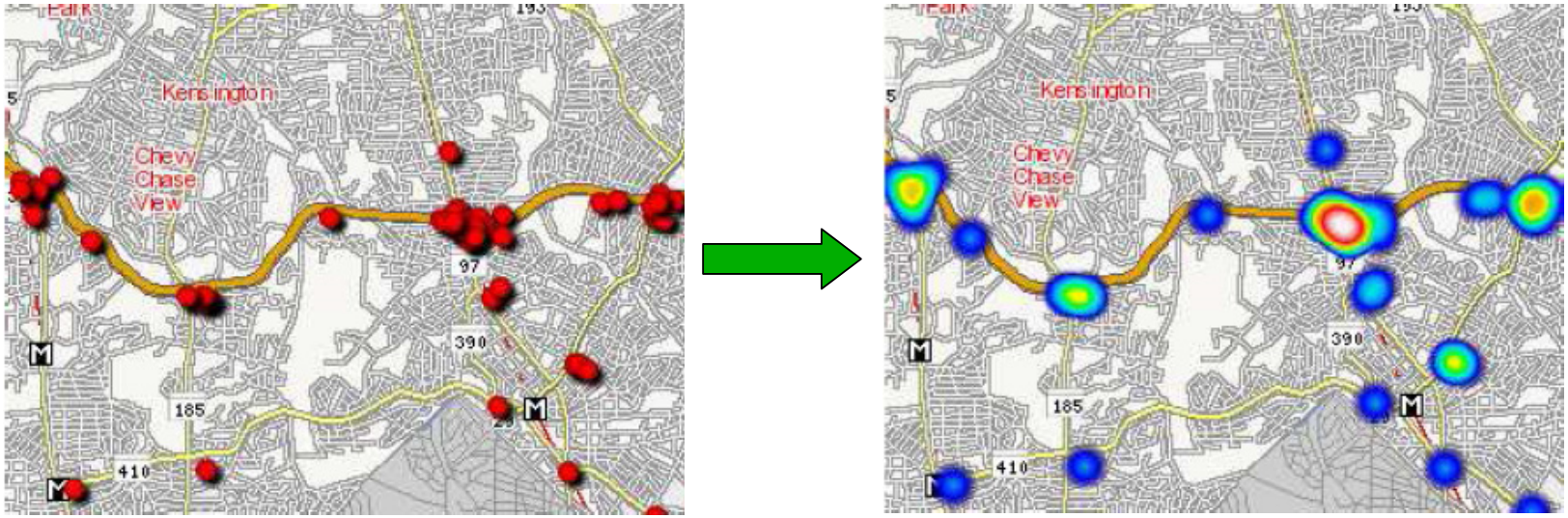
Example of Data Pre-processing (Text Processing)



** Federal Emergency Management Agency*

Chi-Chun Pan, Prasenjit Mitra
Pennsylvania State University

Example of Data Transformation: Aggregation, Smoothing

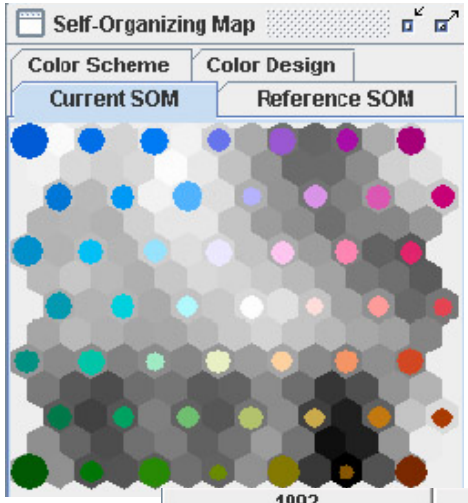


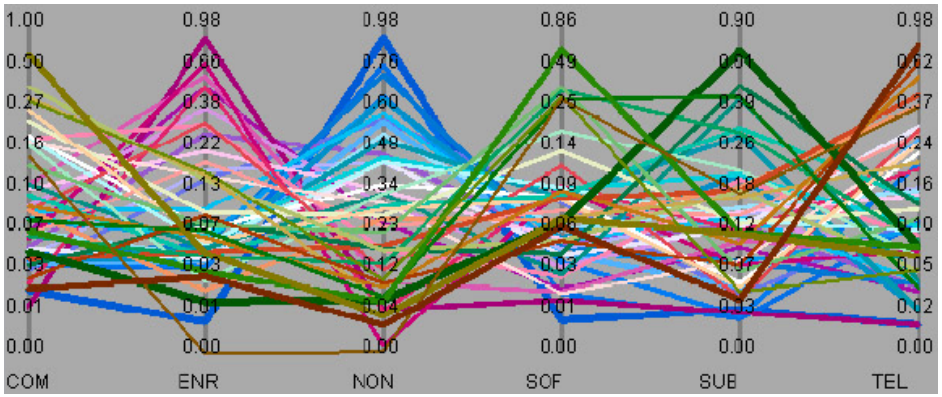
Events (traffic accidents)

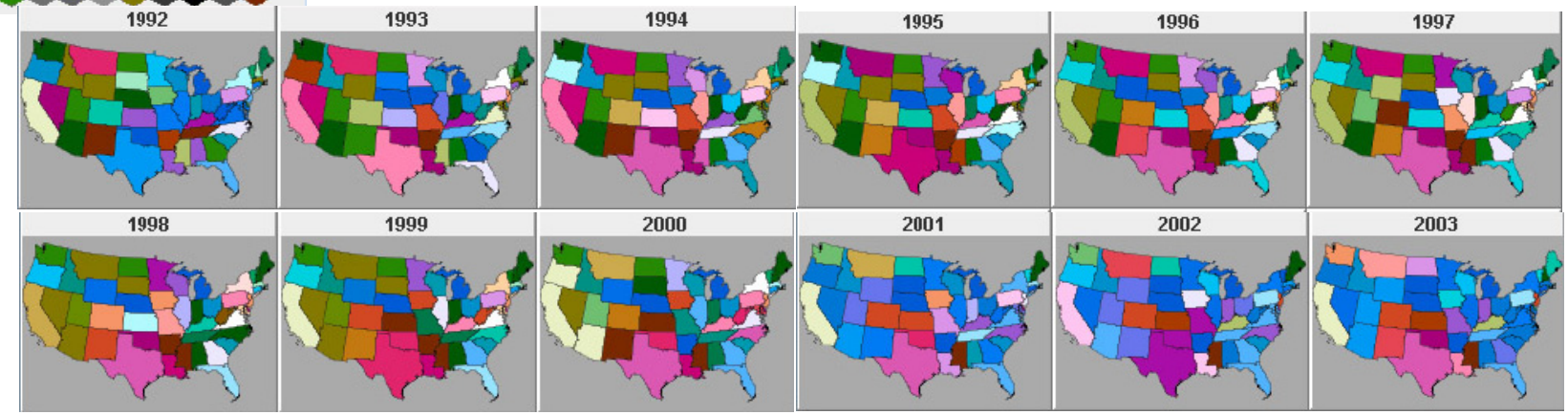
Densities of events

Darya Filippova, Joonghoon Lee, Andreea Olea, Michael VanDaniker, Krist Wongsuphasawat
University of Maryland, College Park

Example of Data Transformation: Clustering, Classification



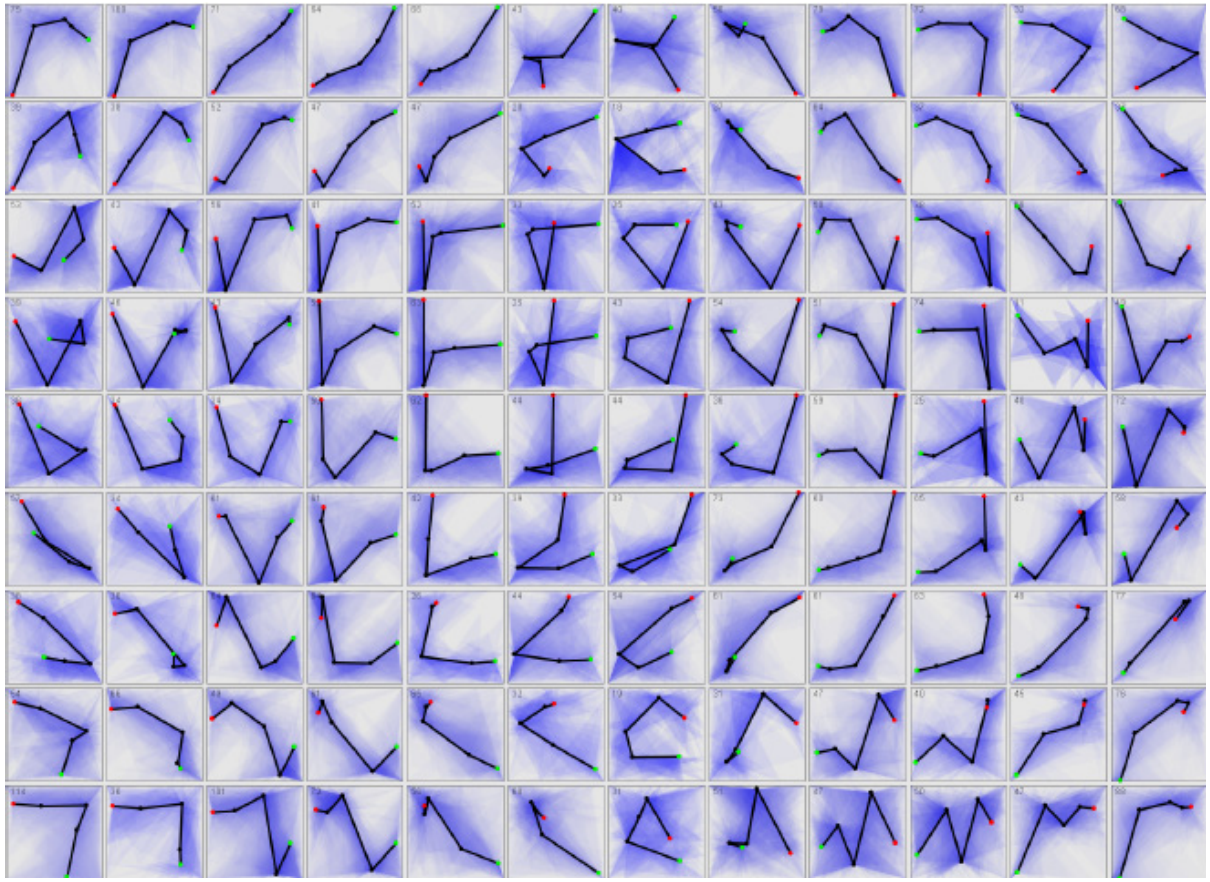




Diansheng Guo, Jin Chen, Alan M. MacEachren, Ke Liao
University of South Carolina; Pennsylvania State University

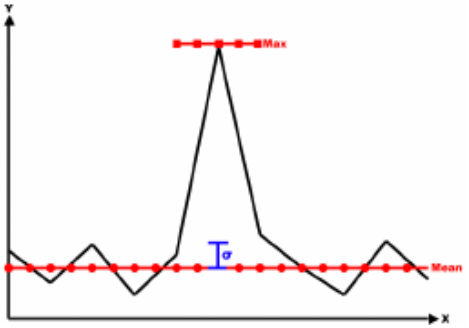
Example of Data Transformation: Clustering, Dimensionality Reduction

Time series of 2 variables clustered using SOM (Self-Organizing Map)

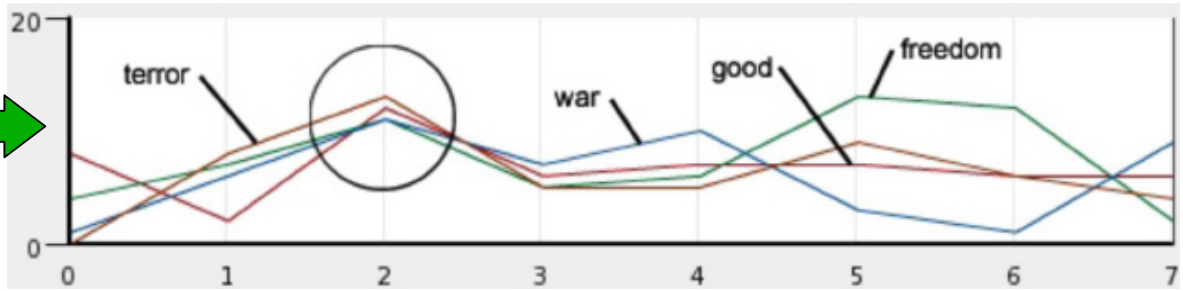


Tobias Schreck, Tatiana Tekušová,
Jörn Kohlhammer, Dieter Fellner
Technische Universität Darmstadt
Fraunhofer IGD Darmstadt

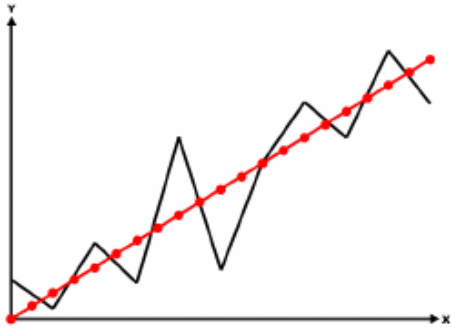
Example of Feature Extraction



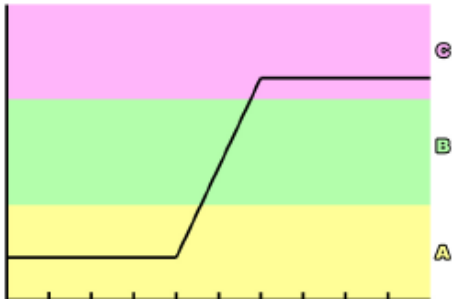
Spike



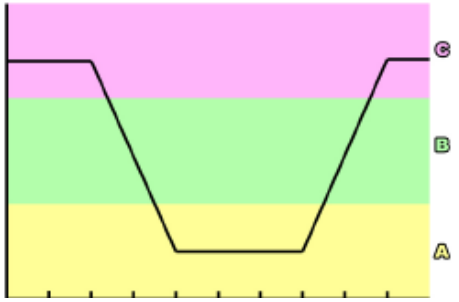
Search for certain types of features in time series data



Increasing slope



Rise

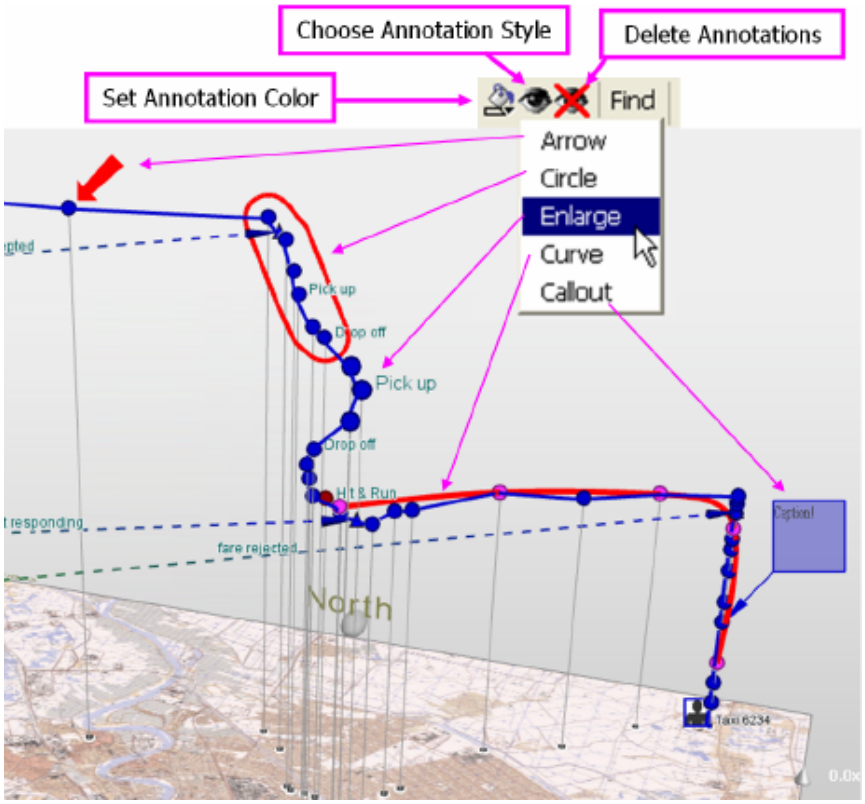


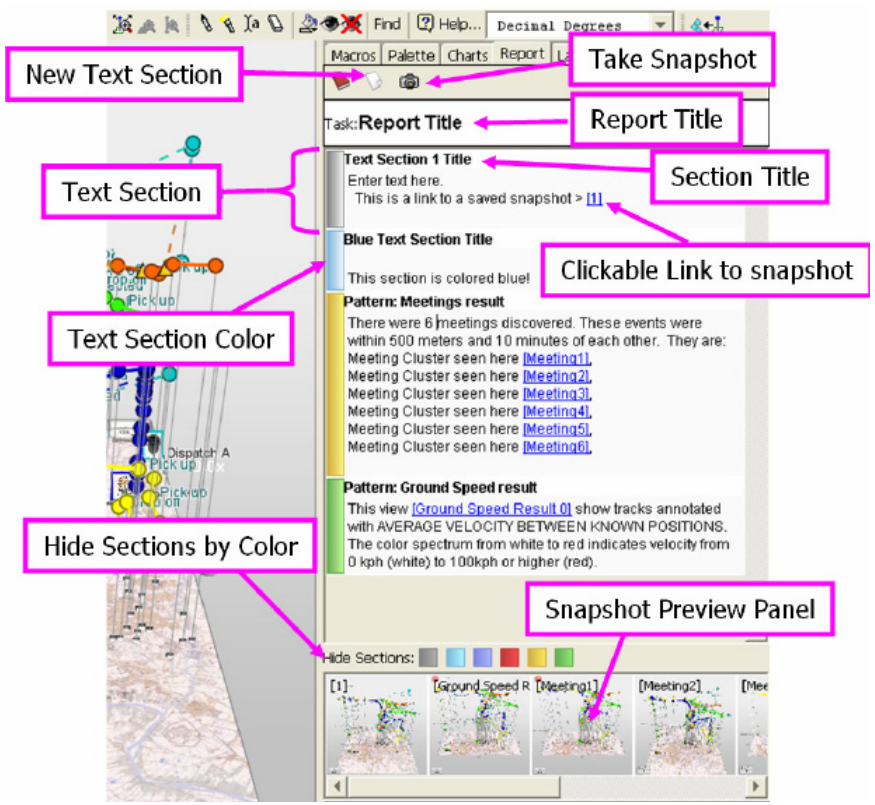
Valley

...

Machon Gregory, Anthony Don, Elena Zheleva, Sureyya Tarkan, Catherine Plaisant, Ben Shneiderman
University of Maryland, College Park

Example of Annotation Support

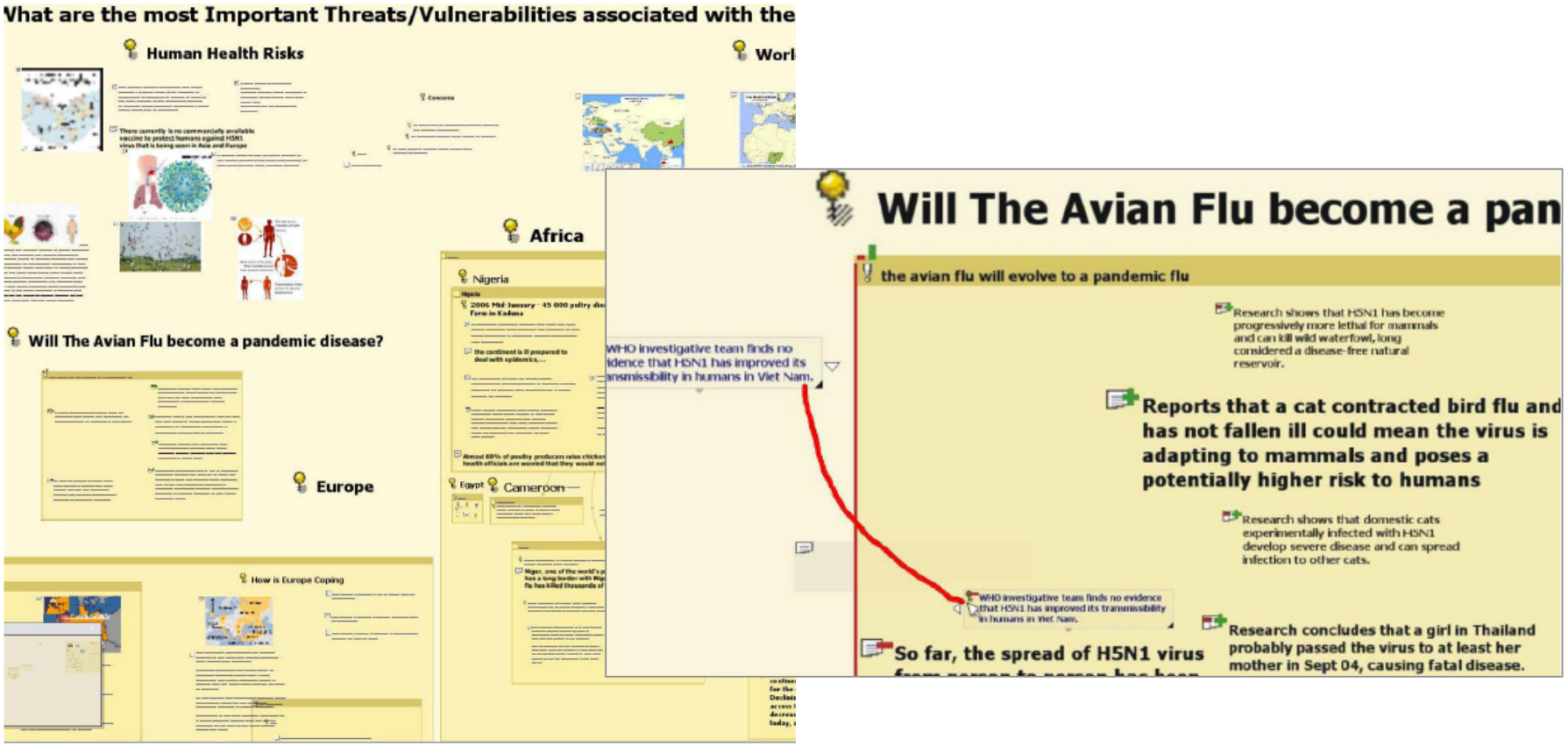




Ryan Eccles, Thomas Kapler, Robert Harper, William Wright
Oculus Info Inc.

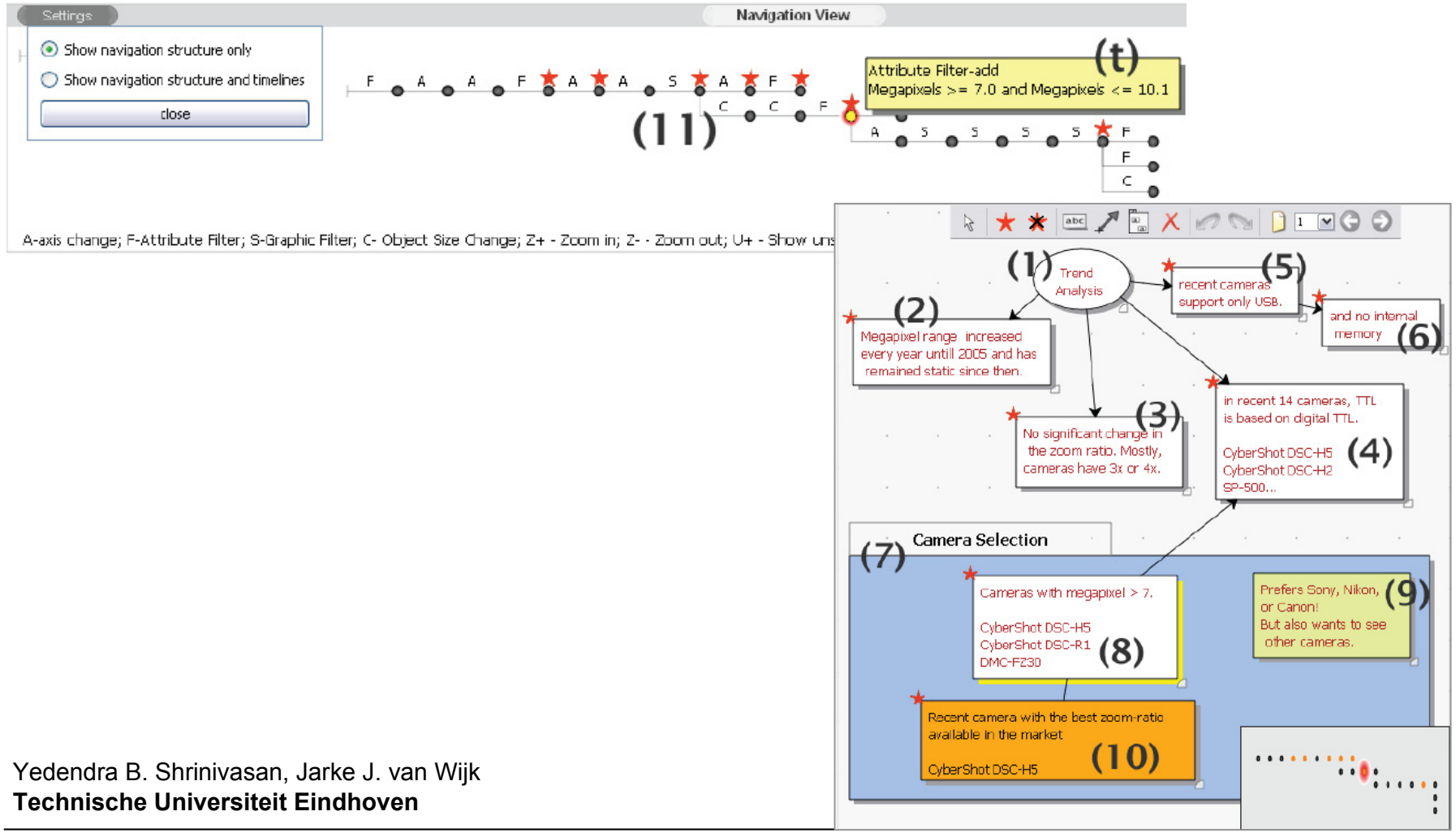
Example of Workspace Support

Relevant Information, Hypotheses, Evidence, Arguments, …



Pascale Proulx, Sumeet Tandon, Adam Bodnar, David Schroh, Robert Harper, William Wright
Oculus Info Inc.

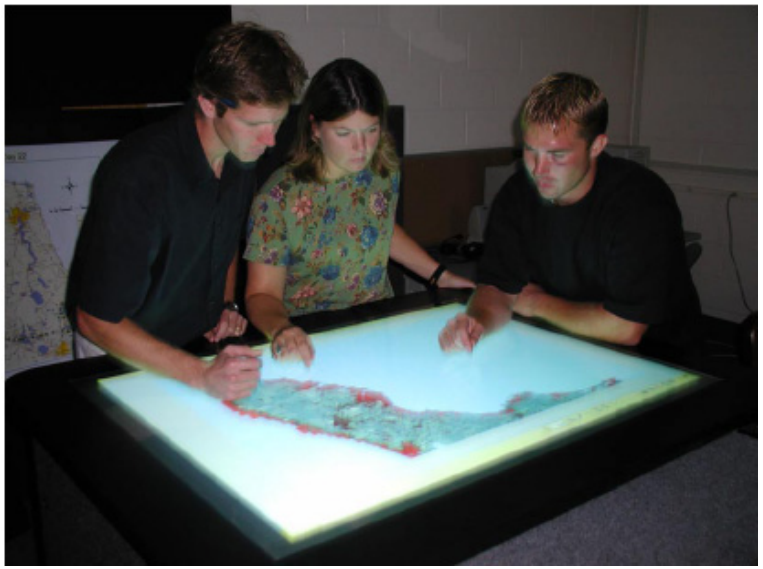
Example of Workflow and Workspace Support

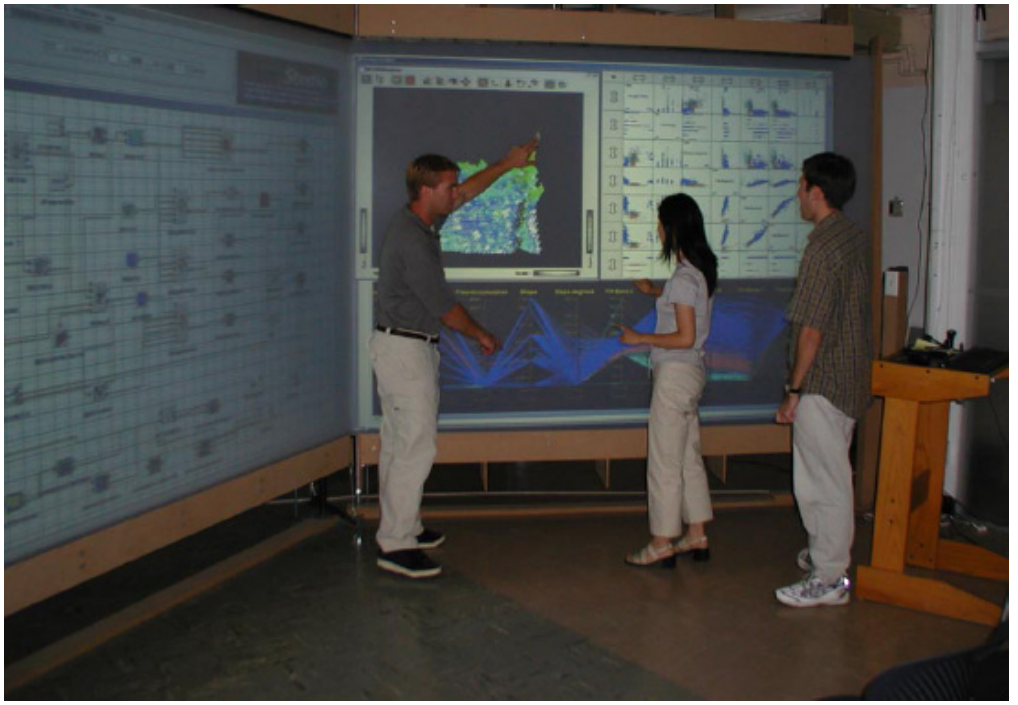


Yedendra B. Shrinivasan, Jarke J. van Wijk
Technische Universiteit Eindhoven

Examples of Support for Collaborative Analyses

(synchronous, co-located collaboration)

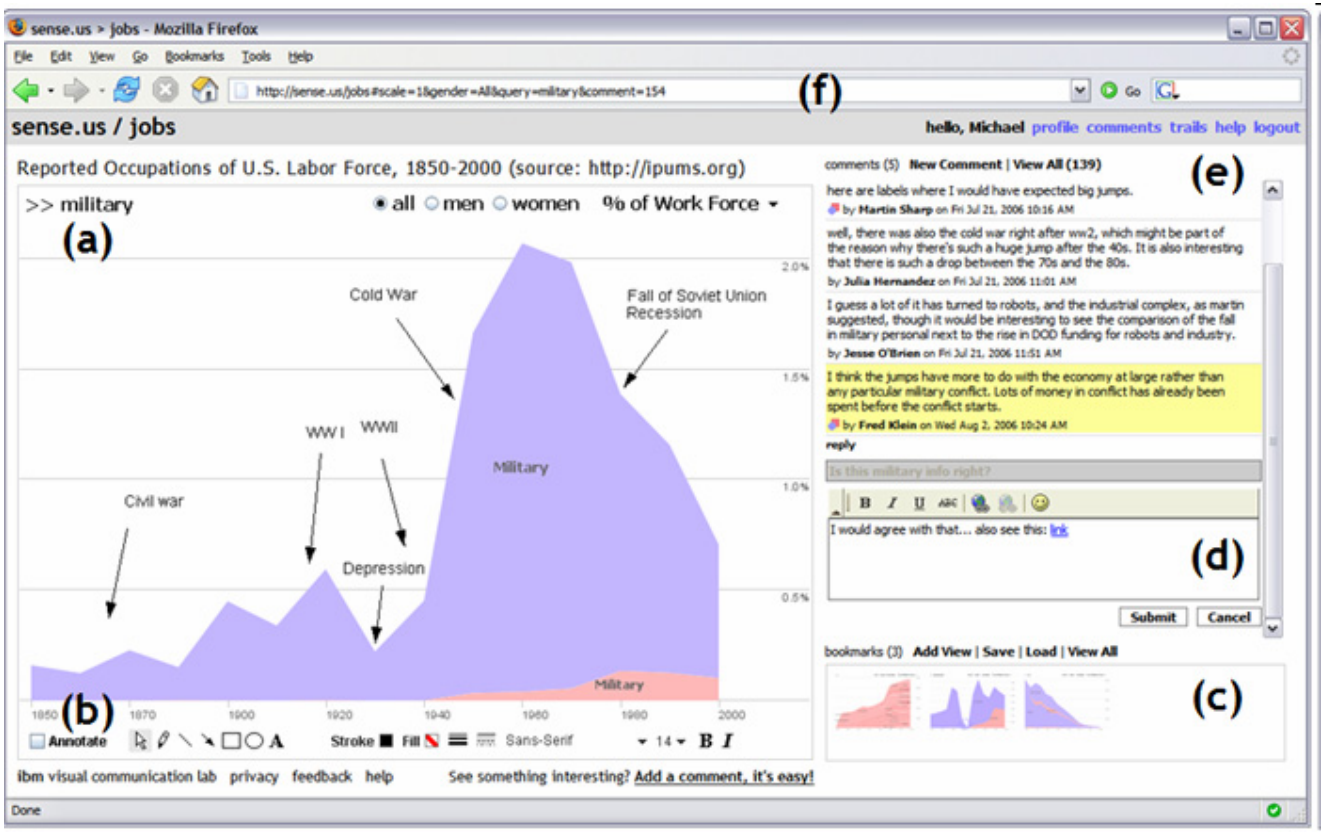




Alan M. MacEachren, Isaac Brewer
Pennsylvania State University

Example of Support for Collaborative Analyses

(asynchronous, distributed collaboration)



sense.us

Jeffrey Heer, Fernanda B. Viégas, Martin Wattenberg
University of California, Berkeley

Conclusion

- Visual Analytics science and technology is meant to help people to make sense from complex data
- Complexities: massive amounts, high dimensionality, heterogeneity, multiple facets, time variance, incompleteness, uncertainty, inconsistency
- Visual Analytics combines interactive visual interfaces with algorithmic methods for data pre-processing, transformation, and feature/pattern extraction
- Visual Analytics also includes interactive visual tools supporting reasoning, knowledge synthesis, and knowledge management
- Interactive visual interfaces help analysts to utilize their perceptual and cognitive capabilities fully and effectively
- Computer technologies compensate for the natural limitations in human skills and abilities and augment the discovery process
- The ultimate goal is to enable a synergistic collaboration of human and computer where each side can utilize its intrinsic capabilities in the best possible way