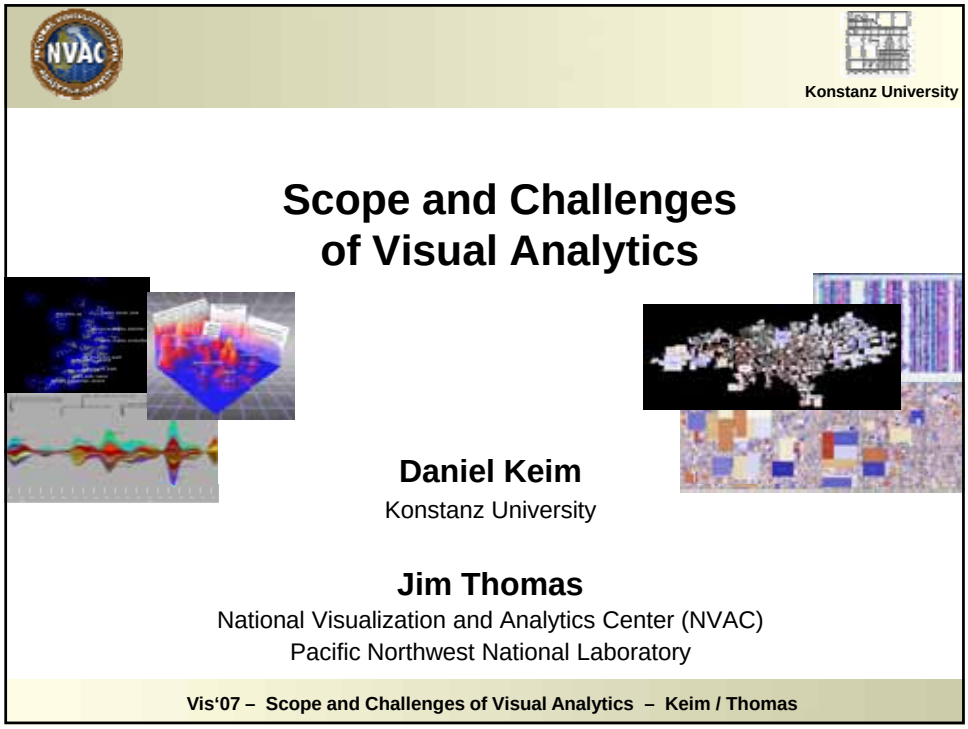

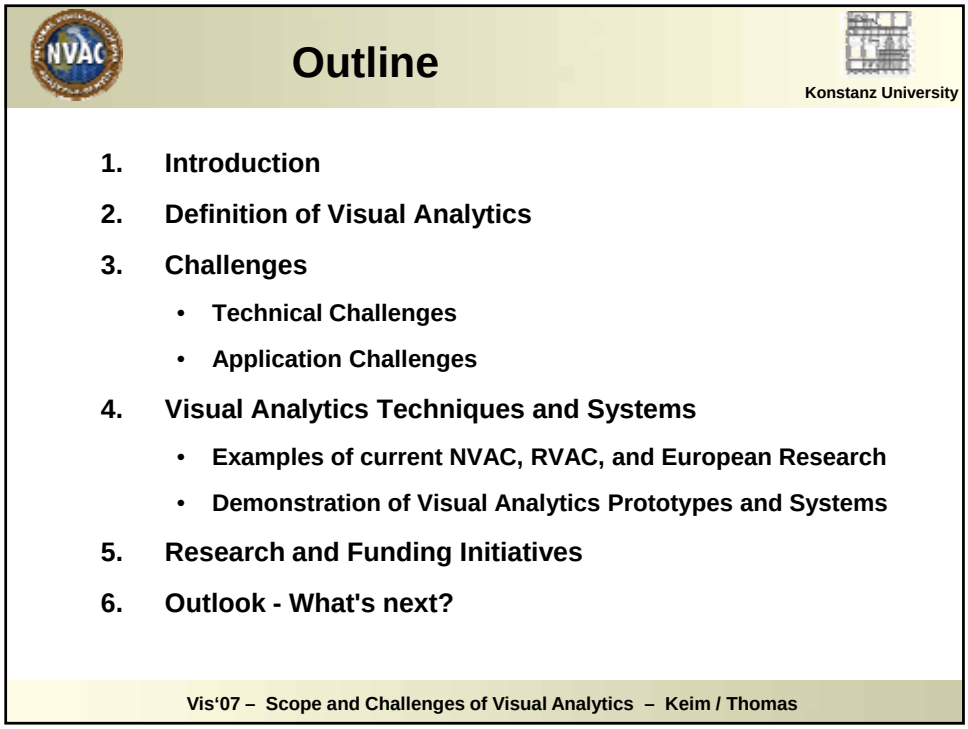

Challenge of the Information Age

Konstanz University

- 100 million FedEx transactions per day
- 150 million VISA credit card transactions per day
- 300 million long distance calls in AT&T's network per day
- 50 billion e-mails worldwide per day
- 600 billion IP packets per day DE-CIX backbone

Challenge of the Information Age

Konstanz University

- Scale of Things to Come:
  - Information:
    - In 2002, recorded media and electronic information flows generated about 22 exabytes (10^{18} *) of information
    - In 2006, the amount of digital information created, captured, and replicated was 161 EB
    - In 2010, the amount of information added annually to the digital universe will be about 988 EB (almost 1 ZB)

*10^{18} = 1,000,000,000,000,000,000

Vis'07 – Scope and Challenges of Visual Analytics – Keim / Thomas

Challenge of the Information Age

Konstanz University

- Scale of Things to Come:
  - Information
  - Drivers of Digital Universe:
    - 70% of the Universe is being produced by individuals
    - Organizations (businesses, agencies, governments, universities) produce 30%
      - Wal-Mart has a database of 0.5 PB; it captures 30,000,000 transactions/day
    - The growth is uneven
      - Today the United States accounts for 41% of the Universe; by 2010, the Asia Pacific region will be growing 40% faster than any of the other regions

Challenge of the Information Age

Konstanz University

- Scale of Things to Come:
  - Information
  - Drivers of Digital Universe
  - Kinds of Data:
    - About 2 GB of digital information is being produced per person per year
    - 95% of the Digital Universe's information is unstructured
      - 25% of the digital information produced by 2010 will be images
    - By 2010, the number of e-mailboxes will reach 2 billion
      - The users will send 28 trillion e-mails/year, totaling about 6 EB of data

Vis'07 – Scope and Challenges of Visual Analytics – Keim / Thomas

Challenge of the Information Age

Konstanz University

- Scale of Things to Come (information, drivers, kinds)

- Today's interaction designed for point and click on individual items, groups(folders), and lists
- Today's interaction assumes user knows subject, concepts within information spaces, and can articulate what they want
- Today's interaction assumes data and interconnecting relationships are static in meaning over time
- Today's interaction is one way initiated
- Today's interaction (WIMP) designed over 30 years ago.

Selected Examples Demonstrating Need

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- Information Logistics (Data Sciences)
  (Data capture->ingest @ massive rates)
  - Adaptive Middleware/Data Concierge and Universal Parsing Agent

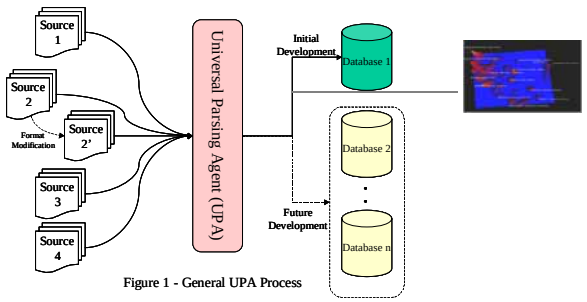

Figure 1 - General UPA Process

Examples Demonstrating Need

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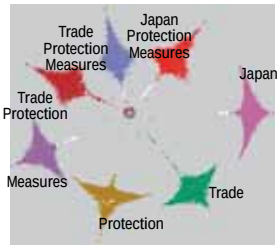
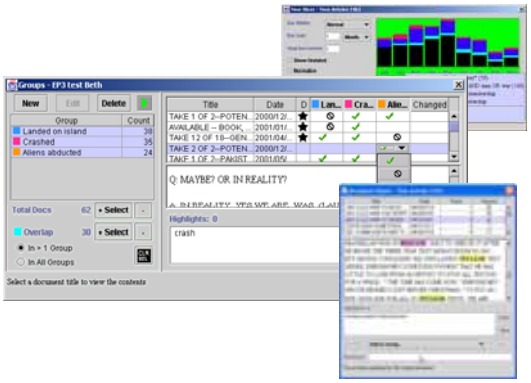
- Towards Predictive Analytics - *discovery of the unexpected* through Hypothesis/Scenario-based Analytics *(hypothesis testing – IN-SPIRE)*
  - Human Information Discourse

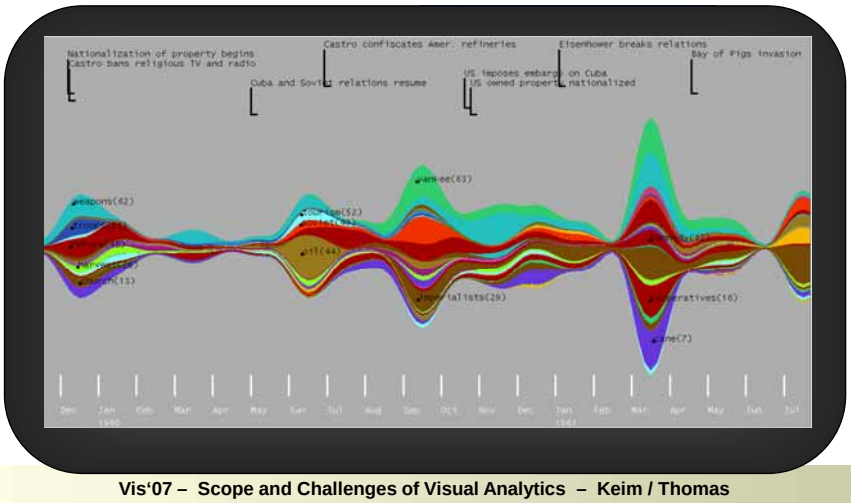




Examples Demonstrating Need

Konstanz University

- Changing Nature of Information Structure: Temporal, dynamically changing relationships, determination of intent
  (DC Sniper & ThemeRiver)



Examples Demonstrating Need

Konstanz University

- Information Logistics (Data Sciences)
- Towards Predictive Analytics
- Changing Nature of Information structure
- Information synthesis while preserving security and privacy
  - Data Signatures that are semantic and scale

Examples Demonstrating Need

Konstanz University

- Walk up useable
- Immersion into my context space
- Look at "old" information from new perspectives with new experimental data
- Capture analytical process for new uses within different situation
- Real time temporal analytics
- Visual communication to tell a story

"Discovery consists of seeing what everybody has seen and thinking what nobody has thought."
~Albert von Szent-Gyorgyi (1893 - 1986)

Vis'07 – Scope and Challenges of Visual Analytics – Keim / Thomas

Critical Thinking*

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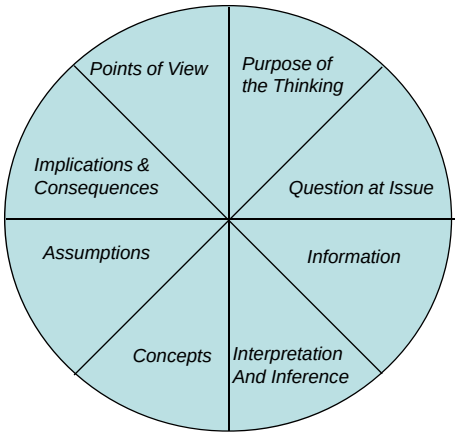
"…the quality of our life and that of what we produce, make, or build depends precisely on the quality of our thoughts."

Elements of thought:



* Foundations of Critical Thinking www.criticalthinking.org

Example Heuer's Central Ideas

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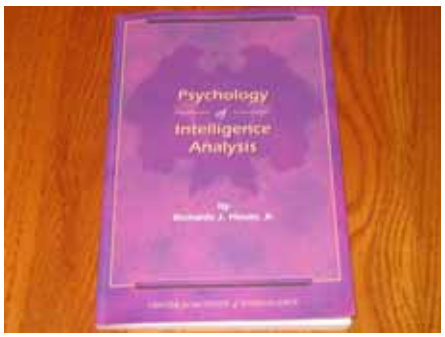

- "Tools and techniques that gear the analyst's mind to apply higher levels of critical thinking can substantially improve analysis… structuring information, challenging assumptions, and exploring alternative interpretations."

New Requirements Summary

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- Volume of data, orders of magnitude larger and different levels of abstraction
- Complexity of information spaces into very high dimensions, 200 the norm
- Information often out of context, incomplete, fuzzy
- Information in all media types: text, imagery, video, voice, web, sensor data
- Time and temporal dynamics fundamentally change the approach
- Spatial, yet non-spatial abstract data
- Multiple ontologies, languages, cultures

For many applications:
we now turn to data-intensive visual analytics

Outline

Konstanz University

1. **Introduction**
2. **Definition of Visual Analytics**
   - Definition of Visual Analytics
   - Scope of Visual Analytics
   - Framework for Visual Analytics
   - Visual Analytics Pipeline
   - Why now? Video conversation
3. **Challenges**
4. **Visual Analytics Techniques and Systems**
5. **Research and Funding Initiatives**
6. **Outlook - What's next?**

Visual Analytics Definition

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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 beginning of knowledge is the discovery of something we do not understand."
~Frank Herbert (1920 - 1986)

Research Areas Related to Visual Analytics

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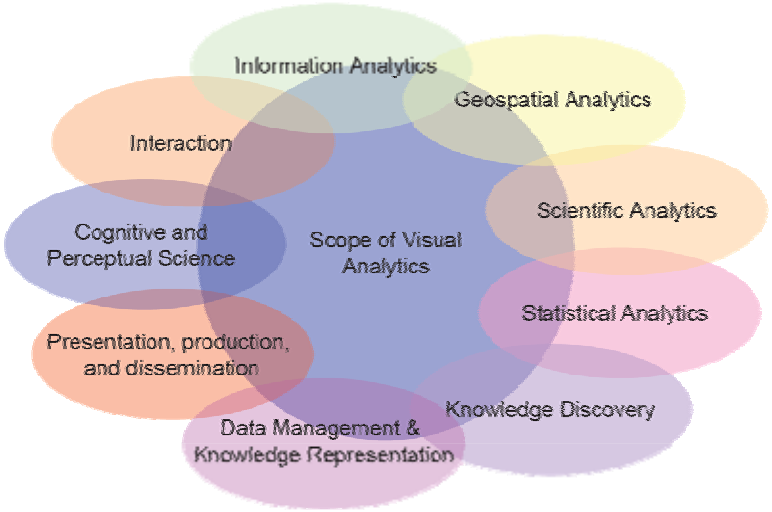

Abilities of Humans and Computers

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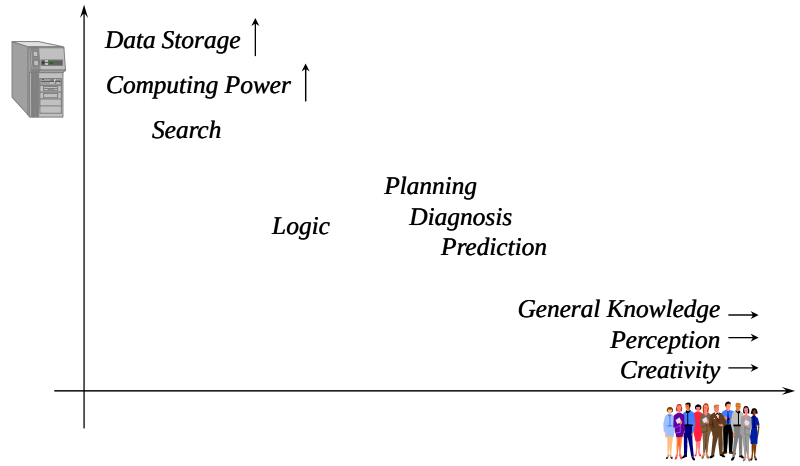

Why is the topic highly relevant today?

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- Very Large Data Collections are available in Databases and Data Warehouses
- On the Basis of the Data Complex Decisions have to made in a timely fashion
- Pure Visualization Methods (Information Visualisation) do not work for Billions of Data Records
- Full Automatic Knowledge Discovery Approaches only work for well-defined and clearly specifiable problems.
- Especially for adversarial situations:
  Fraud, Viruses, SPAM, Attacks, Competition, …

What is new ?

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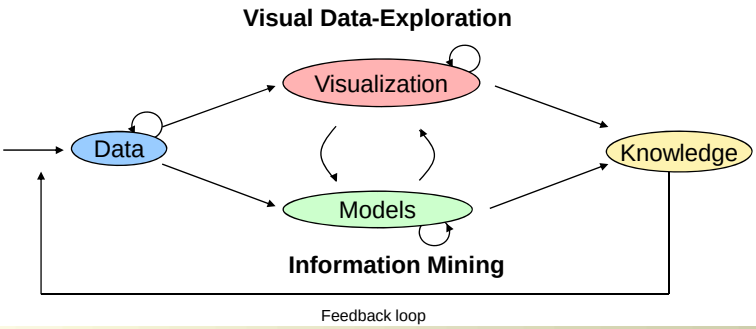
What do we have?

- Automatic Knowledge Discovery & Information Mining
- Interactive Visual Data-Exploration

What do we need?

Tight Integration of Visual and Automatic Data Analysis Methods with Database Technology for a Scalable Interactive Decision Support



The Good News

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- We seldom need all information on any topic
- We can learn new knowledge from others
- We can share with others in microseconds
- We can, if approved within security and privacy policies, have access to landscapes of information
- However, this volume of information poses challenges and opportunities; *scale changes everything*

Information Technology will either enable or limit success, failure is not an option

Outline

Konstanz University

1. **Introduction**
2. **Definition of Visual Analytics**
3. **Challenges**
   - **3.1 Technical Challenges**
   - – Integration of Visualization with
     - Automated Analysis (Machine Learning & KDD)
     - Databases and Data Stream Technology
     - Statistical Analysis
     - Perception Research ...
   - – Scalability
   - – Illuminating the Path: the R&D Agenda for Visual Analytics
   - **3.2 Application Challenges**
4. **Visual Analytics Techniques and Systems**
5. **Research and Funding Initiatives**
6. **Outlook - What's next?**

Technical Challenges

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Real-time Analysis of

- very large, complex, dynamic information
- from many diverse data sources
- in diverse formats and resolutions
- in uncertain, potentially life-threatening, and time-critical situations.

"Discovery consists of seeing what everybody has seen and thinking what nobody has thought."
~Albert von Szent-Gyorgyi (1893 - 1986)

Technical Challenge: Scalability

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Scalability w.r.t.

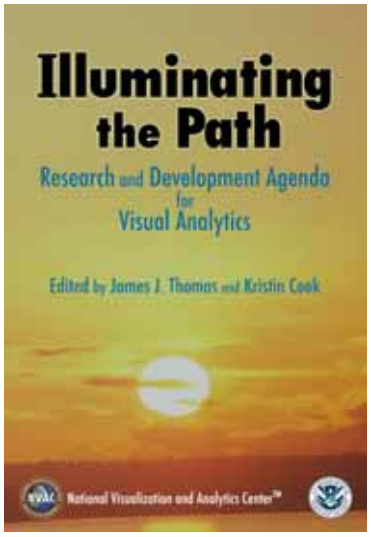
- Amount of Data and Dimensionality
- Number of Data Sources and Heterogeneity
- Data Quality and Data Resolution
- Dynamicity and Novelty
- Data Representation and Visual Resolution
- User Interface and Interaction
- Display Devices

> "All truths are easy to understand once they are discovered; the point is to discover them."
> ~ Galileo Galile (1564-1642)

Available now:

Konstanz University

- Available at http://nvac.pnl.gov/ in PDF form
- Special thanks to IEEE Technical Committee on Visualization and Graphics



Overview of the R&D Agenda

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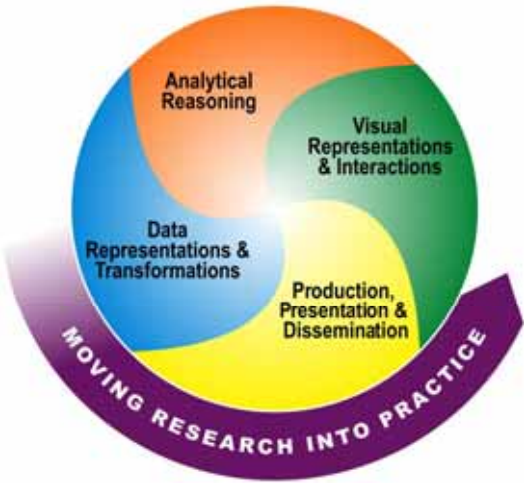
- Challenges
- Science of Analytical Reasoning
- Science of Visual Representations and Interactions
- Data Representations and Transformations
- Production, Presentation, and Dissemination
- Moving Research Into Practice
- Positioning for an Enduring Success



Analytical Reasoning

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- Towards an analytic discourse
- Sense-making methods as a theoretical basis
- Perception and cognition
- Collaborative visual analytics

Recommendations: Analytical Reasoning

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- Build upon *theoretical foundations of reasoning,* sense-making, cognition, and perception, to create visually enabled tools to support collaborative analytic reasoning about complex and dynamic problems.
- Conduct research to address the challenges and *seize the opportunities posed by the scale* of the analytic problem. The issues of scale are manifested in many ways, including the complexity and urgency of the analytical task, the massive volume of diverse and dynamic data involved in the analysis, and challenges of collaborating among groups of people involved in the analysis, prevention, and response efforts.

Visual Representations & Interaction Techniques

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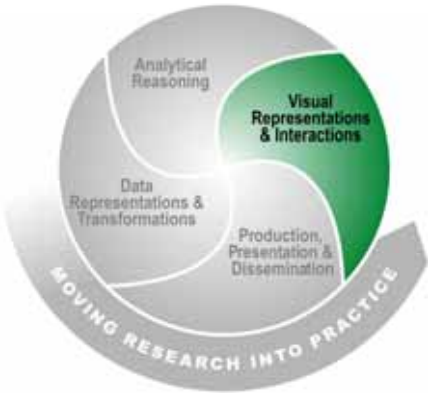
- Principles for depicting information
- Science of interaction
  Support human-information discourse
- New visual paradigms
  Support understanding and reasoning
- Novel systems and approaches
  for generating visualizations



Recommendations: Visual Representations and Interactions

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- *Create a science of visual representations* based on cognitive and perceptual principles that can be deployed through engineered reusable components. Visual representation principles must address all types of data, address scale and information complexity, enable knowledge discovery through information synthesis, and facilitate analytical reasoning.
- Develop a new *suite of visual paradigms* that support the analytical reasoning process.
- Develop a new *science of interactions* that supports the analytical reasoning process. This interaction science must provide a taxonomy of interaction techniques ranging from the low-level interactions to more complex interaction techniques and must address the challenge to scale across different types of display environments and analytical tasks.

Data Representations & Transformations

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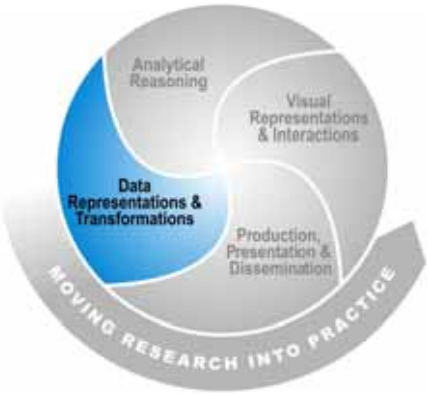
- Transforming data into tractable forms
  - Hold the key knowledge
  - Support visualization and discourse
  - Support synthesis
  - Support mixed-initiative systems



Recommendations: Data Representations and Transformations

Konstanz University

- Invest in development of both *theory and practice for transforming data into new scalable representations* that faithfully represent the content of the underlying data.
- *Create methods to synthesize information* of different types and from different sources into a seamless data representation so that analysts may be able to focus on the meaning of the data.
- Develop *methods and principles for representing data quality, reliability, and certainty* measures throughout the data transformation and analysis process.

Production, Presentation & Dissemination

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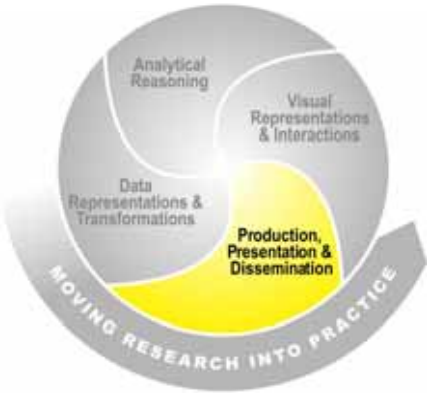
- Connection between analytic reasoning and a tangible, timely, useful product



Recommendations: Production, Presentation, and Dissemination

Konstanz University

- Develop methodology and tools that enable the *capture of the analytic assessment, decision recommendations, and first responder actions* into information packages. These packages can be tailored for each intended receiver and situation and can be expanded in detail to show supporting evidence as needed.
- Invest in *technologies that enable analysts to communicate what they know through the use of appropriate visual metaphor* and accepted principles of reasoning and graphic representation. Create techniques that enable effective use of limited, mobile forms of technologies to support situation assessment by first responders. Support the need for effective public alerts with the production of a basic handbook for common methods for communicating risks.
- *Create visual analytics data structures, intermediate representations, and outputs that support seamless integration of tools* so that data requests and acquisition, visual analysis, note-taking, presentation composition, and dissemination all take place within a cohesive environment that supports around-the-clock operation and provides robust privacy and security control.

Moving Research into Practice

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- Goal: Accelerate the transition of successful research into practice.
- Evaluation
- Security and privacy
- Interoperability
- Concerted and sustained support for insertion into practical use

Recommendations: Moving Research into Practice

Konstanz University

- Develop an *infrastructure to facilitate evaluation of new visual analytics technologies*.
- Create and use a *common security and privacy infrastructure*, with support for incorporating privacy-supporting technologies such as data minimization and data anonymization.
- Use a *common component-based software development approach* for visual analytics software to facilitate evaluation of research results in integrated prototypes and deployment of promising components in diverse operational environments.
- Identify and *publicize best practices for inserting visual analytics technologies into operational environments*.

Recommendations: Positioning for Enduring Success

Konstanz University

- Develop programs to *support education of the research community* about the drivers for visual analytics research.
- Form *university-led centers of excellence* as well as partnerships with government, industry, national laboratories, and selected international research entities to bring together the best talents to accomplish the visual analytics research and development agenda.
- Establish *special partnerships* with the Corporate Information Office (CIO) organizations that support mission agencies to facilitate technology insertion within their operational environments.
- Provide ongoing *support for collaborations, internships, staff exchanges, educational material development*, and other efforts that help build interest in the missions of homeland security, science, health,...

Outline

Konstanz University

1. **Introduction**
2. **Definition of Visual Analytics**
3. **Challenges**
   - **3.1 Technical Challenges**
   - **3.2 Application Challenges**
     - Visual Engineering Analytics
     - Visual Software Analytics
     - Visual Environmental Monitoring (Climate & Weather)
     - Visual Personal Information Management
     - Visual Physics / Astronomy Analytics
     - Visual Analytics in Biology & Medicine / Visual Health Analytics
     - Visual Mobile / Traffic Analytics
     - Visual Business Analytics
     - Visual Security Analytics (Homeland, Network, ...)
     - Visual Disaster / Emergency Management
4. **Visual Analytics Techniques and Systems**
5. **Research and Funding Initiatives**
6. **Outlook - What's next?**

Application Areas

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- Public & Personal Information Management
- Safety & Security
- Socio-demographic applications
- Environmental protection
- Biology, Medicine & Health Care
- Engineering
- Financial Industry
- Many more in examples to follow

Public & Personal Information Management

Konstanz University

- Many facets, affecting our everyday life through digital information devices (PDAs, mobile phones, laptop computers,...)
- Large Volumes of complex data types (Text, Video, Images,...)
- "Information Fragmentation". Different devices and applications often come with their separate ways of storing and organizing information.
- Challenge:
  - Enhance human capabilities to cope with information overload: Support the user to efficiently analyse, search and identify important and decision-relevant personal information
  - Having the right information in the right place, in the right form, and of sufficient completeness and quality
  - manage information across tools and over time

Public & Personal Information Management (2)

Konstanz University

Example: Email communication

• Users increasingly suffer from overload and interruptions

Challenges:

• Pressure to Respond Quickly

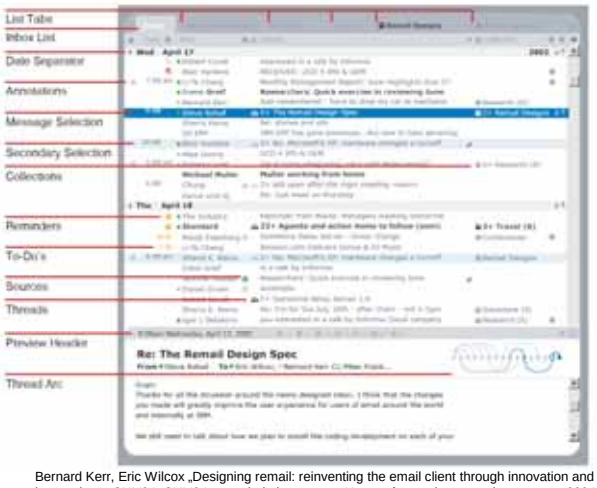
• Keeping Track of Email

Value of a VA-Tools must be assessed over time and in a broader context of a person's various PIM activities

e.g. IBM Remail Project:

• Concepts like "Thread Arcs",

"Correspondents Map", and "Message Map" support the user to efficiently analyse his personal email communication.



Bernard Kerr, Eric Wilcox „Designing remail: reinventing the email client through innovation and integration" , CHI '04: CHI '04 extended abstracts on Human factors in computing systems 2004

http://www.research.ibm.com/remail/

Vis'07 – Scope and Challenges of Visual Analytics – Keim / Thomas

Safety & Security

Konstanz University

- Important research topic and is strongly supported by the U.S. government
- Application field in this sector is wide, ranging from terrorism informatics over border protection to network security
- **Challenges**:
  - Getting all the information together (temporal, spatial) and linking numerous incidents to find correlations
  - Decisions have to be based on various kinds of independent information sources with varying degress of confidence

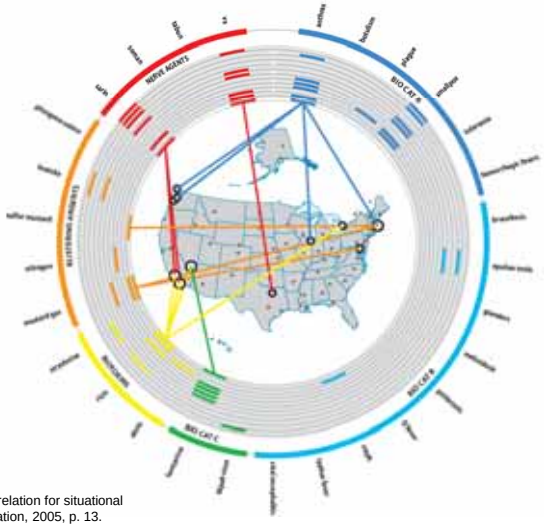
Safety & Security (2)

Konstanz University

Example: **VisAware**

Built upon the w3 premise: Every incident has at least the three attributes: What, When, and Where

The location attribute is placed on a map, the time attribute indicated on concentric circles around this map, and the classification of the incidentis mapped to the angle around the circle. For each incident, the attributes are linked through lines.



Y. Livnat, J. Agutter, S. Moon, and S. Foresti, "Visual correlation for situational awareness." in IEEE Symposium on Information Visualization, 2005, p. 13.

Socio-demographic applications

Konstanz University

- Form the basis of informed and defensible political decisions
- Chain of effects between political decisions and their demographic effects can not be approached by simple theories
- Challenges:
  - Integrate perspectives from Visual Analytics and GIS
  - Reason about space and time, Prediction models
  - Synthesize different types of information from different sources into unifid representations (census data, geo-related data, State Statistics,...)

Socio-demographic applications (2)

Konstanz University

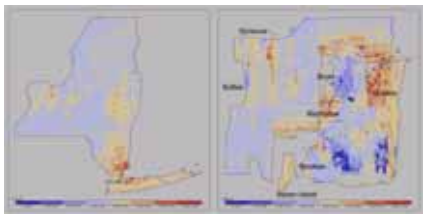
• Classical Thematic maps are often not sufficient to identify complex space time patterns

Thematic / Choropleth map

Improvise: Exploring spacial and temporal aspects

C. Weaver, D. Fyfe, A. Robinson, D. W. Holdsworth, Donna J. Peuquet and A. M. MacEachren. "Visual Analysis of Historic Hotel Visitation Patterns". Proc. IEEE VAST 2006, Baltimore, MD, October 2006.

• Recently, tools like Improvise or the Pixelmap technique have been succesfully applied in the context of socio-demographic applications



Pixelmaps (Sips et al)

Environmental protection

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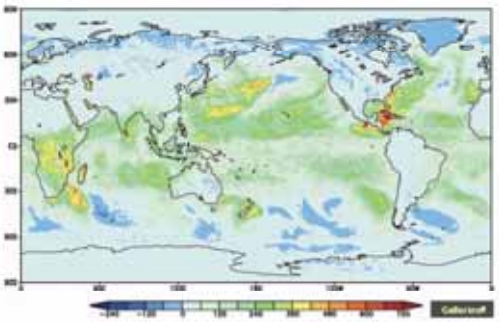
- Monitoring environmental data (e.g. climate and weather) results in huge amounts of data collected from sensor data or from satellites in short time intervals, easily accumulating to terabytes / day
- Applications often do not only visualize snapshots of a current situation, but also have to generate sequences of previous developments and forecasts which can cover all possible time intervals, from daily weather forecasts to complex visualizations of climate changes that can expand to thousands of years
- **Challenges**:
  - Interpret these massive amounts of data to gain insight into the dependencies of climate factors and climate change scenarios
  - Complex Analysis Szenarios over Space and Time
  - Visual Analytics of factors that have an impact on the environment (air quality, ozon level, global warming,...=

Environmental protection (2)

Konstanz University

- Important Applications are the Visualization of weather forecasts, the global warming, melting of the poles, the stratospheric ozone depletion, hurricane warnings or oceanography
- Global Simulations, like computed by on of the largest computers, the Earth Simulator are typically very complex, involving thousands of parameters



The figure shows evaporation from the land and ocean surface to the atmosphere in terms of latent heat flux in a CFES simulation. CFES is our atmosphere-ocean-land-sea ice coupled model. In yellow to red areas, heat is taken away from the ocean and land by evaporation. Earth Simulation Center (ESC) Atmosphere and Ocean Simulation Research Group

Biology, Medicine & Health Care

Konstanz University

- Wide variety of applications:
- Well studied areas like 3D Visualization and reconstruction (computer tomographie, ultrasound imaging)
- Emerging areas like bioinformatics provide new **Challenges**:
  - sequencing scientists face unprecedented volumes of data (Human Genome Project ~ 3 billion base pairs per human)
  - Proteomics (studies of the proteins in a cell), Metabolomics (systematic study of unique chemical fingerprints that specific cellular processes leave behind) or combinatorial chemistry have to consider millions of compounds

Biology, Medicine & Health Care (2)

Konstanz University

New analysis methods are needed in

Molecular Medicine

- *Improved diagnosis of disease, Drug design,...*

Energy and Environmental Applications

- *microbial genomics research to develop environmental monitoring techniques*

Risk Assessment

Agriculture, Livestock Breeding, and Bioprocessing

Image provided by U.S. Department of Energy Genome Programs
http://genomics.energy.gov

Engineering

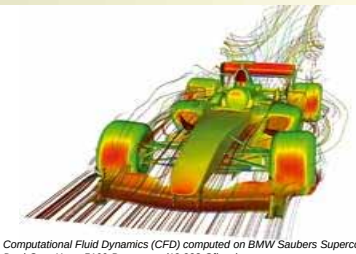
Konstanz University

- Covers whole range from engineering to construction
- Analysis methods are crucial to speed up development time for products/materials/tools and to reduce productions costs
- Effective management of feedback from tests and applications, customers and employees is an key issue
- Challenges:
  - Representation of the very complex systems (thousands of parameters / sensors)
  - Identification of critial process parameters and their interplay
  - Analytical scale, interplay between complexity and urgency
  - Support strategic business decision making

Engineering (2)

Konstanz University

- Simulations highly depend on Visual Analytics techniques, e.g. in automotive industry:
  - flow visualization automotive essential to optimize air resistance of vehicles, the flows inside catalytic converters or diesel particle filters
  - Crash test simulations
- Visual Analytics methods are able to improve existing simulation systems in order to reduce costs, get insight into critical process parameters



Computational Fluid Dynamics (CFD) computed on BMW Saubers Supercomputer with 512 Dual-Core-Xeon-5160-Prozessos (12.228 Gflops).
http://www.testticker.de/praxis/home_computing/article20061228010.aspx

Crash test simulation: Computed deformation. Source: FröhlicFE-Programs

Financial Industry

Konstanz University

- Growing field of application for Visual Analytics (e.g. in Stock market Analysis)
- Complexity of business decisions: ranging from market and costumer analysis, process optimisation and logisticsreal time data streams
- Challenges:
  - Business decision support on a broad scale, where the crucial aspect is the coupling of information from heterogeneous sources
  - Time related data
  - Often real time or streaming data → time critical response situations

Financial Industry (2)

Konstanz University

Charting techniques (Line charts) are widely used in financial analysis, but:

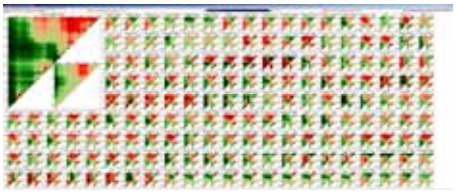
• Price charts do not allow the easy perception of relative movement in terms of growth rates over multiple intervals, which is a key feature of any price-related time series

• typically thousands of assets in the market → Overview visualizations using line charts difficult

• Need to visualize impact factors (sales volume, press release,...) on asset prizes

Visual Analytics techniques allow to observe multiple assets over time

Map of the market, Findex,...



Smartmoney's Map of the market
http://www.smartmoney.com/marketmap/

The Homeland Security Challenge

Konstanz University

- Diverse, multiple threats
- Complex, interrelated vulnerabilities
- Low tolerance for false alarms
- Scale and diversity of information needed
- Privacy assurance
- Deception






The Challenge: U.S. Ports of Entry

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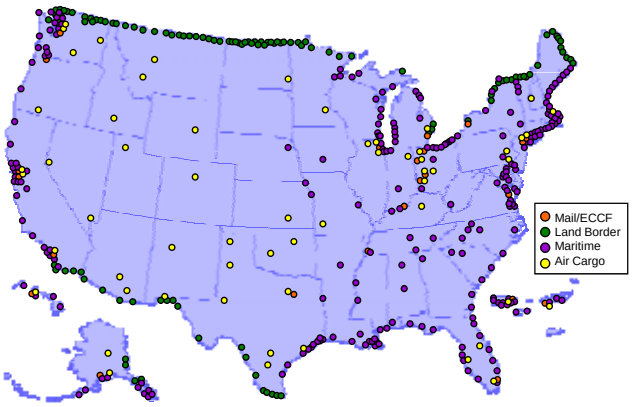

- 307 Ports of Entry representing 621 border sites to protect
- 332,622 vehicles per day
- 57,006 trucks/containers per day
- 2,459 aircraft per day
- 580 vessels per day

Border Security Examples

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Systems Biology: Data Sources for Multi-Scale Analysis

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Organism

Time & Space

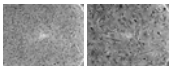
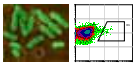
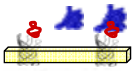
Cells

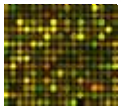
Signaling Networks

Gene Networks

Molecules

Atoms




lux Signaling

Flow Cytometry

Bacterial Display for Rapid Peptide Ligand Isolation

Localization Assay (ChIP)

Gene Expression MicroArrays

Protein MicroArrays

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Konstanz University

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Example concepts for Text Visual Analytics

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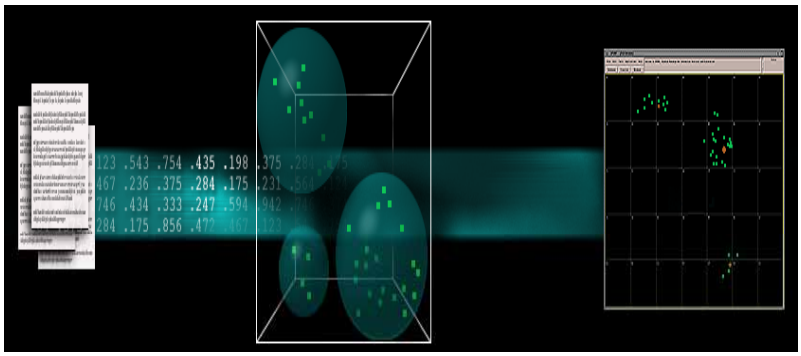
Create data signature

Synthesize into high dimensional discovery space

Visual discourse for discovery



Visual Abstractions

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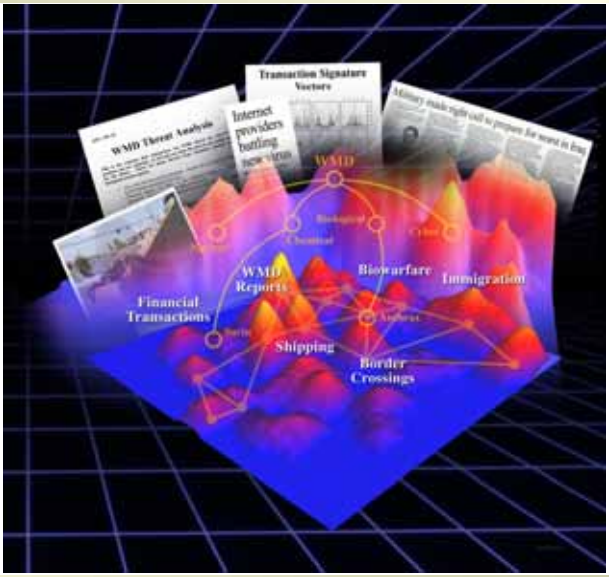
- Full summary of your collections



IN-SPIRE: Enterprise Deployed Visual Text Analytics: Current Text Visualizations

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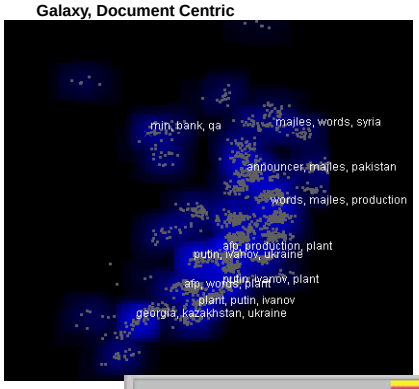
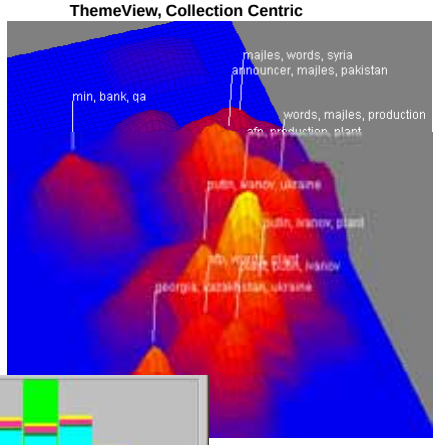
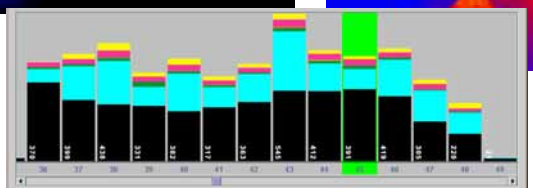
Galaxy, Document Centric



ThemeView, Collection Centric





Time Slicer, Temporal

IN-SPIRE: Document Viewer - Source Data Always Available

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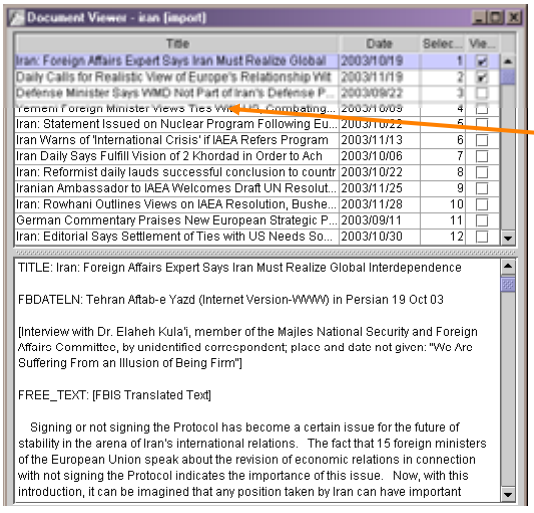

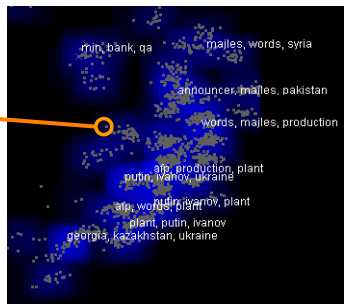

IN-SPIRE: Analyst Control over Focus / Discourse Dynamic Perspective

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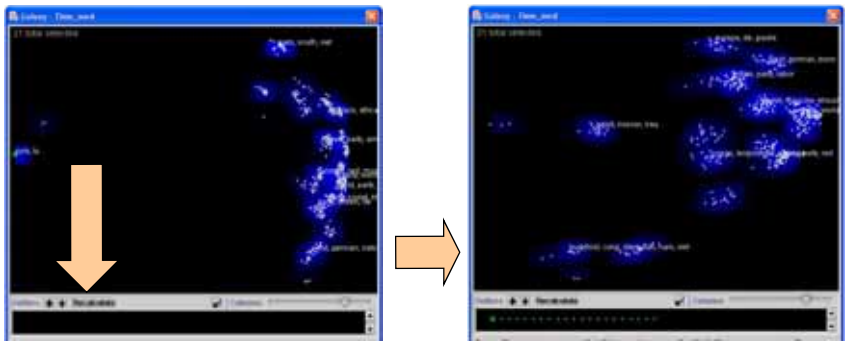
To temporarily move aside less interesting documents, users select and move them to an isolation area, and the system reveal more depth of meaning about the remainder.



Same Principle is Applied to "Themes", Can Remove Less Interesting Themes to Change Perspective.

IN-SPIRE: Live Data Streams Dynamic Data, Enduring Issues

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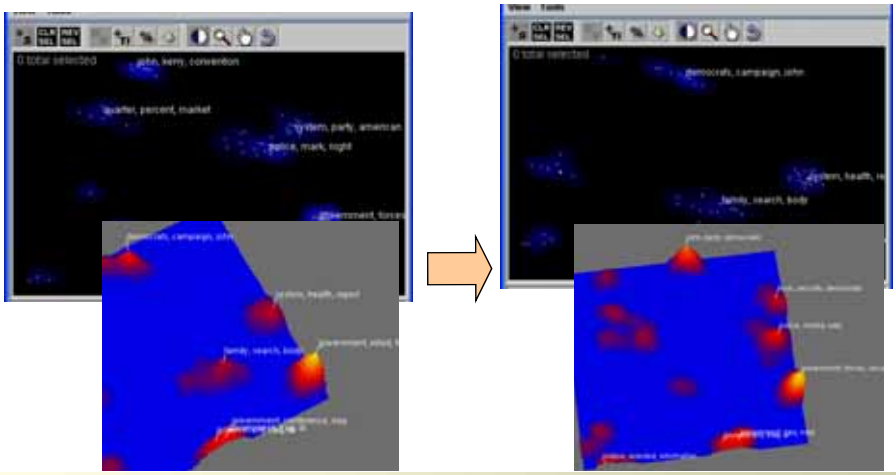
Data can be added to the dataset, including near real-time feeds for watch applications.



IN-SPIRE: Hypothesis Assessment over Time

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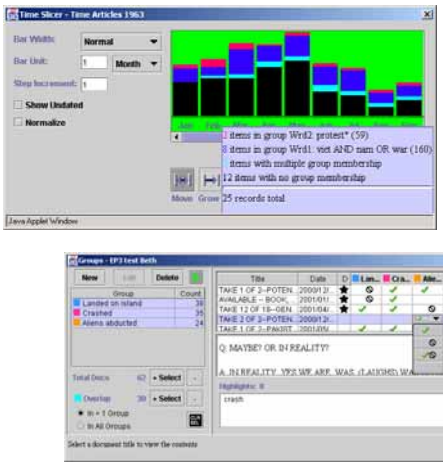
Structuring Evidence and Reasoning
ACH Implementation



IN-SPIRE: Improved Evidence Handling

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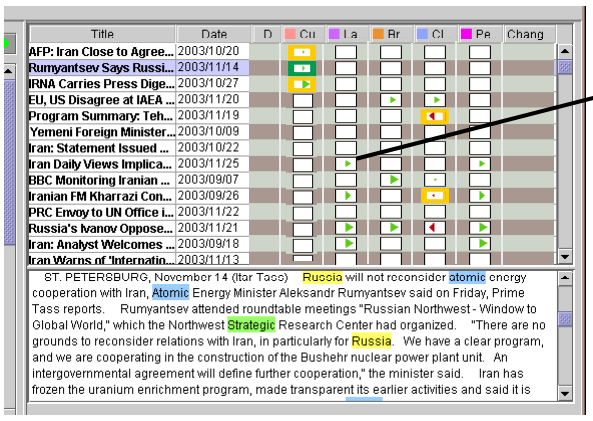
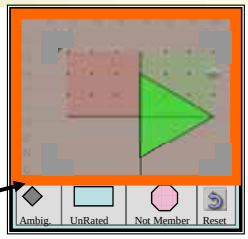
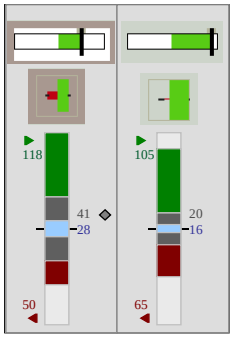
Ratings of Argument, Strength, Confidence
Summaries of Evidence
Driving External Models & Stores







IN-SPIRE: Correlation Understanding

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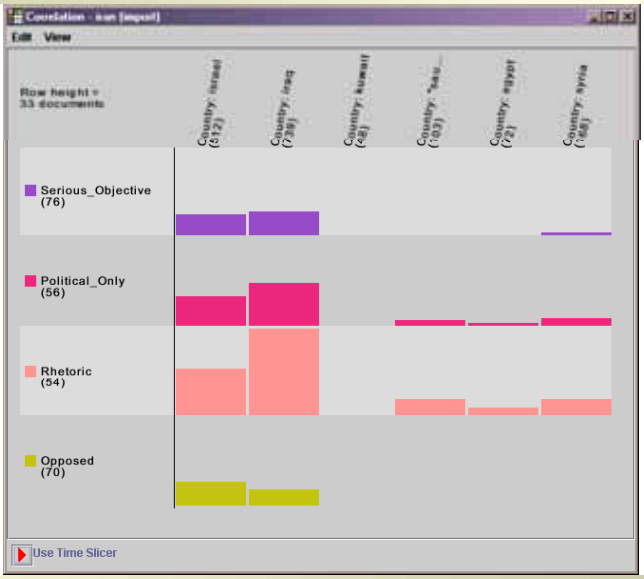
Topics
Vs
Evidence Groups
Vs
Sources
Vs
Actors
Vs
Timing
…

With Details by Evidence Argument



IN-SPIRE: Queries, Retrieval Interaction

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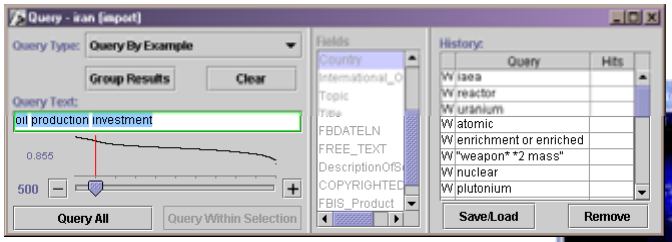
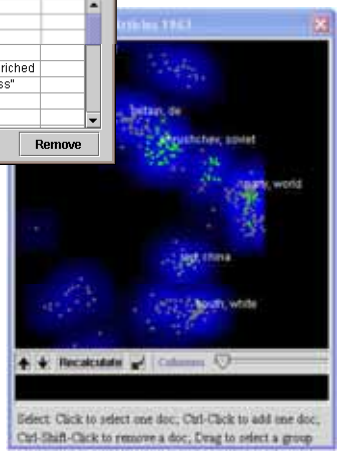


Boolean Queries,
Phrase Queries,
Query By Example (Shown Here),

In Work - Time Queries, Evidence
Proposed - Natural Language Question/Answer

Linked to Correlation, Steering, TimeSlice..
in Discourse



IN-SPIRE: Repeatable Retrieval/Triage Strategies

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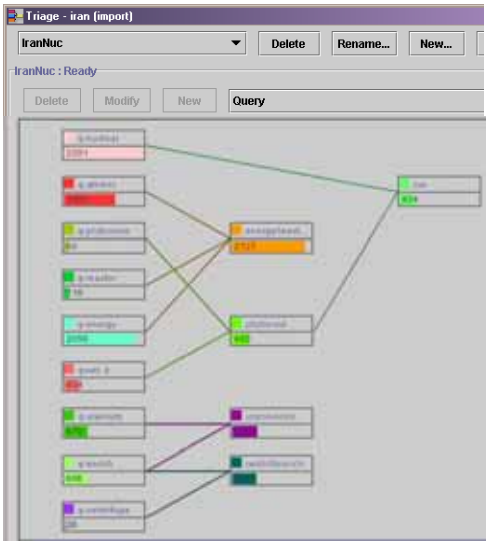
User Defines How They
- Isolate/Retrieve and Prioritize Documents.
- How They Structure The Information For Review.

Interactive Inspection and Testing

Repeated Over New Data Automatically.

Supports Work Flow in Broader Applications



IN-SPIRE: Summary

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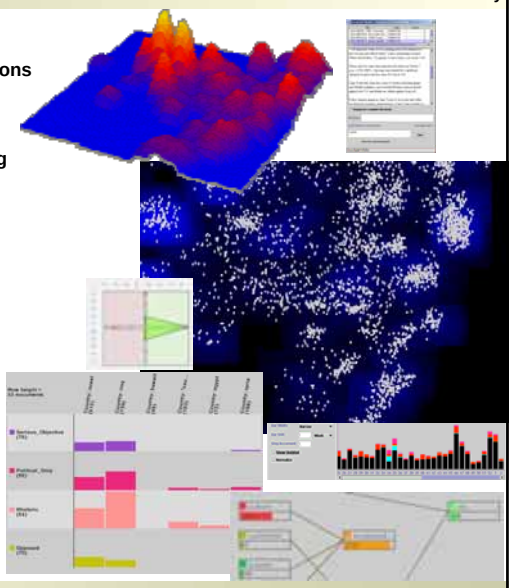
Knowledge Signatures - Steerable Vector Space Visualizations - Family of Interrelated Visualizations
Interaction and Discourse -
- **Retrieval**
- **Structuring**
- **Evidence and Hypothesis Reasoning**
- **Multiple Languages**
- **Support for Repeating Activity**

Engineering / Deployment Suitability -
- **Windows Platform**
- **Approvals to Operate**
- **Client/Server Lightweight System**
- **Full Auditing, etc.**
- **No Data Caching**
- **Freedom for Questionable Infrastructure**

Also Operates Stand-Alone



Integrating Chemical and Biological Data

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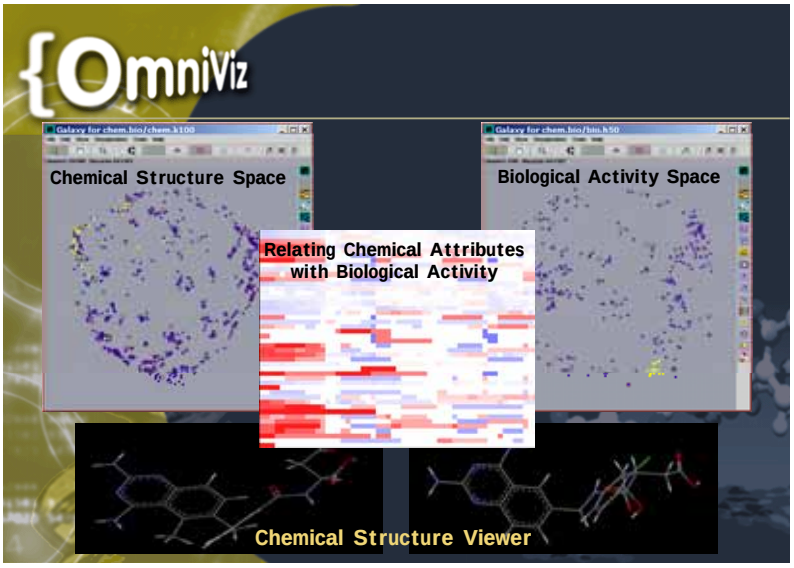

Uses Today

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- Scientific Research
- Regulatory and Legal Communities
- Intelligence Analysis
- DOE and DOD
- Capability analysis - resumes
- Medical and Pharmaceutical Communities
- National Security and Law Enforcement
- Information Assurance, web analytics
- Technology Scanning, Asset and Intellectual Property Management

Tools to date only illustrate the possibility of a new science

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Visual Classification

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attr.1	attr.2	...	class
0.3	23.3	...	Y
2.4	2.0	...	N
⋮	⋮	⋮	⋮

→

attr. 1	class
0.2	Y
0.3	Y
0.3	Y
0.5	N
1.1	Y
⋮	⋮

attr. 2	class
0.5	N
1.3	Y
2.0	N
2.5	Y
5.1	N
⋮	⋮

…

- Each attribute is sorted and visualized separately
- Each attribute value is mapped onto a unique pixel
- The color of a pixel is determined by the class label of the object
- The order is reflected by the arrangement of the pixels

Visual Classification

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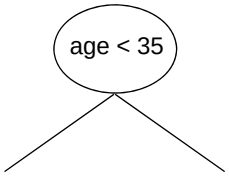
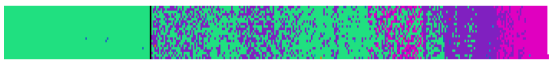
- A New Visualization of a Decision Tree

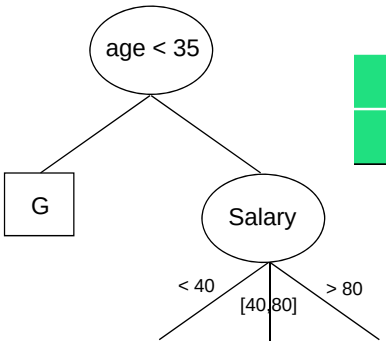


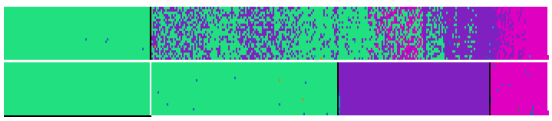


Visual Classification

Konstanz University

- A New Visualization of a Decision Tree





Vis'07 – Scope and Challenges of Visual Analytics – Keim / Thomas

Visual Classification

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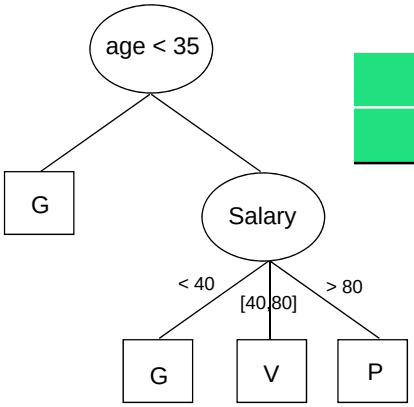

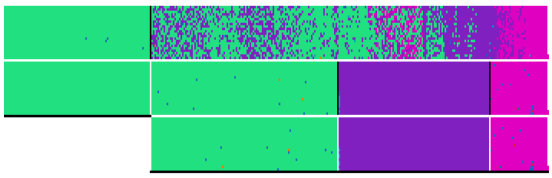

Visual Classification

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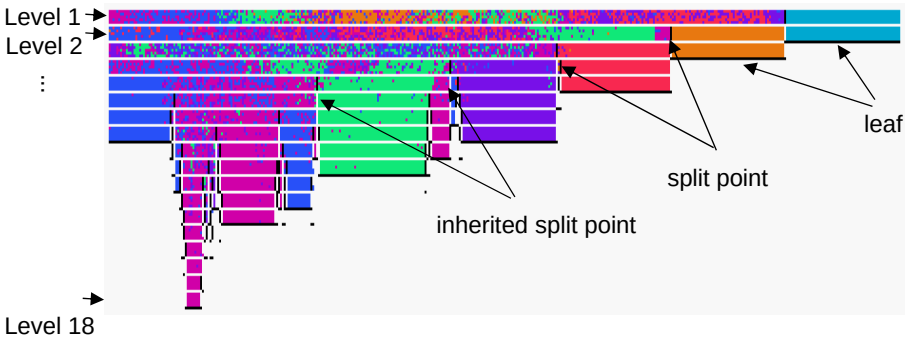
- Decision Tree Visualization for the Segment Dataset



SouthEastern RVAC:UNC Charlotte

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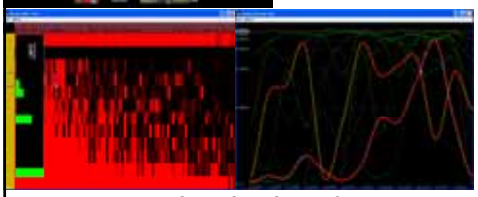
Visual Image Content Browser
Analyzes any number of images of unknown content. Provides a highly interactive visual interface for exploration. NVAC is evaluating and will use. Available to all RVACs and partners.

Video Exploration Visual Interface

Explores hundreds or more broadcast channels over time to automatically analyze news.



Transaction Visual Interface

Used to explore wireless bank transactions to find money laundering. Able to do complex investigations over time. Work with Bank of America and NVAC.

SouthEastern RVAC: Georgia Tech

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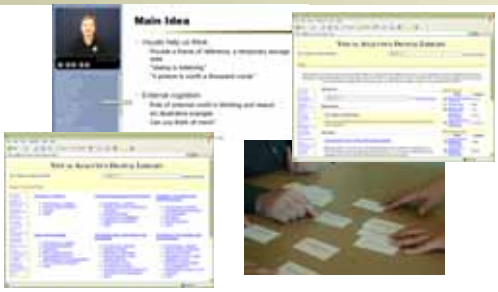
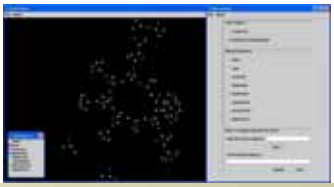


Visual Analytics Digital Library
A central repository for educational materials about visual analytics. Organized along a visual analytics taxonomy.
URL: `http://vadl.cc.gatech.edu`

STAB System
Making predictive hypotheses about future events based on past situations.

Intelligence Report Visualizer
Visualizing intelligence reports and their important constituents in order to help analysts explore the reports more flexibly.



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Visual Network Analysis

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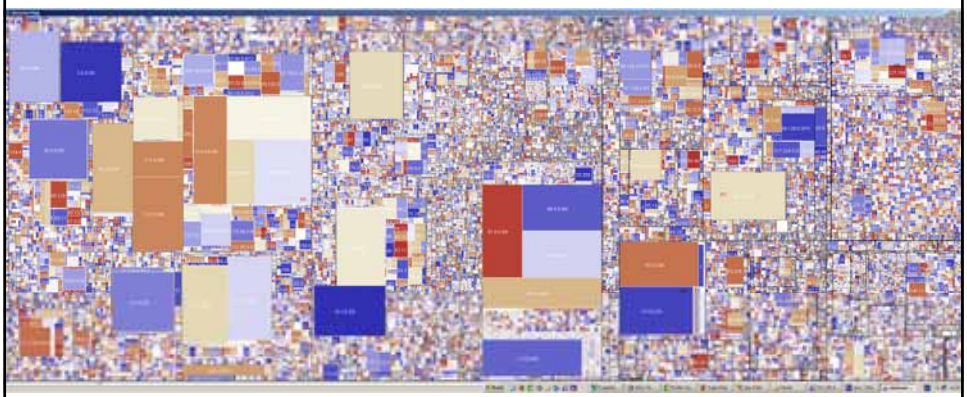
IP Space Visualization



Visual Network Analysis (2)

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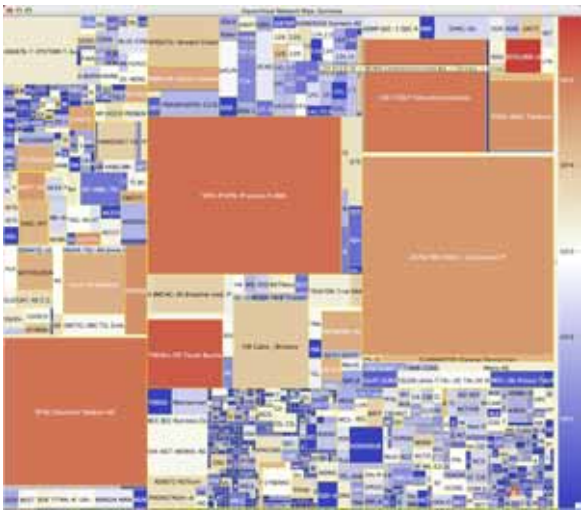

Hierarchy:

- Continents
- Countries
- Autonomous Systems
- Networks

data: rzstat3 date: 29 Nov 2005 measure: outgoing connections

Visual Network Analysis (3)

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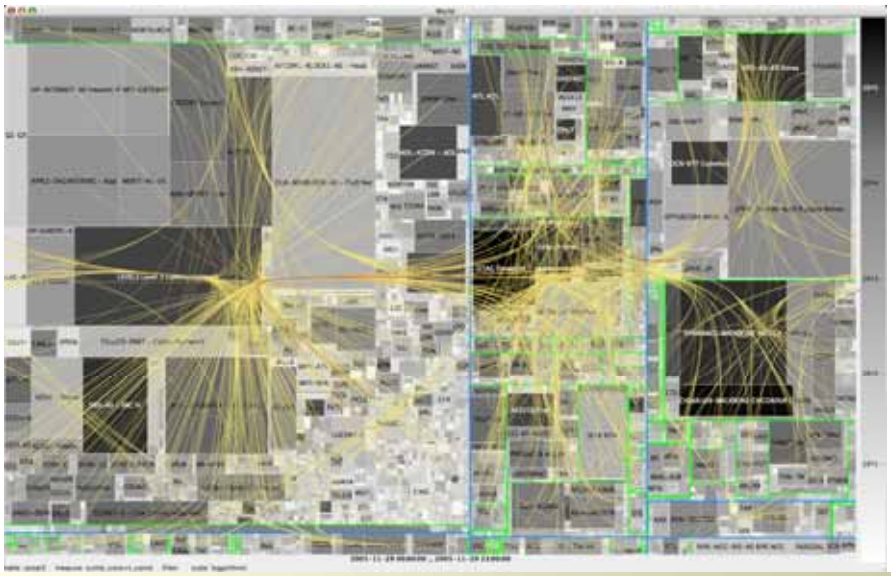

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NorthEastern RVAC:

Exploring connections between conceptual knowledge, geography, and disease cases

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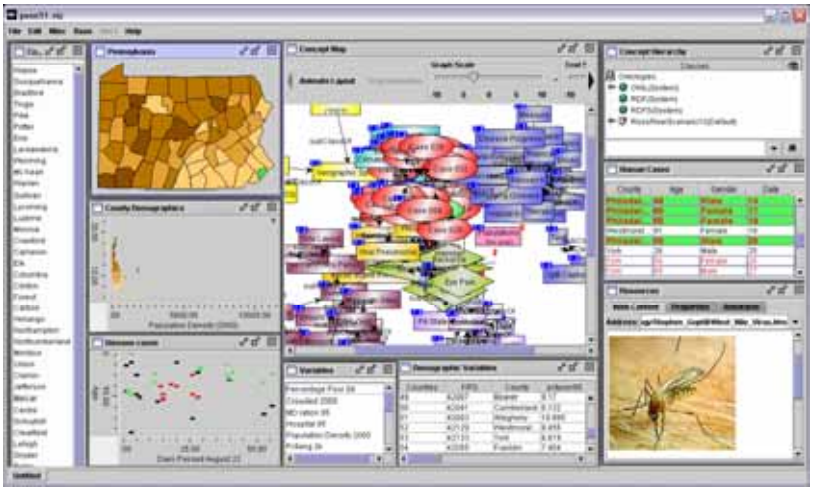
Investigating new outbreaks of vector-borne disease (highly coordinated visual representations, existing knowledge is used to find new resources)



First Responder Command and Control

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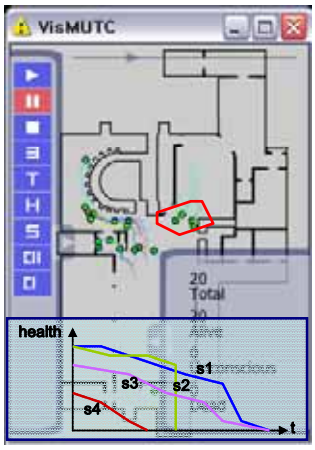
Muscatatuck Urban Training Center
Mobile and EOC Visual Analytics



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   - **Examples of current NVAC, RVAC, and European Research**
     - **Visual (Unstructured) Text Analysis**
     - Visual Classification Analysis
     - Visual Network Analysis
     - Visual Environmental Analysis
     - **Visual Security Analysis** ←
     - Visual Social Analysis
     - Visual Geo-Spatial Analysis
   - **Demonstration of Visual Analytics Prototypes**
5. **Research and Funding Initiatives**
6. **Outlook - What's next?**

Outline

Konstanz University

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Interactive Graph Analytics

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An integrated problem-solving environment providing novel interactive visualization of graphs with up to 1 million nodes, feature extraction techniques, and topological and semantic analysis.

- **Real-time scalable algorithms provide visualization support to most any application with graph data.**
- **Feature extraction and clustering can be used to provide different perspectives for semantic graphs in domains such as power grid analysis to environmental sensor analysis.**

Power Grid Partners

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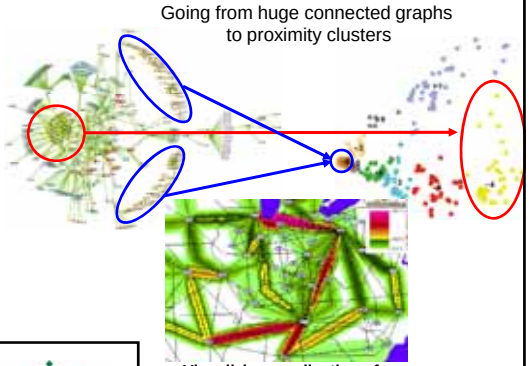
Going from huge connected graphs to proximity clusters



Visualizing a collection of transmission system lines

Interactive Graph Analytics

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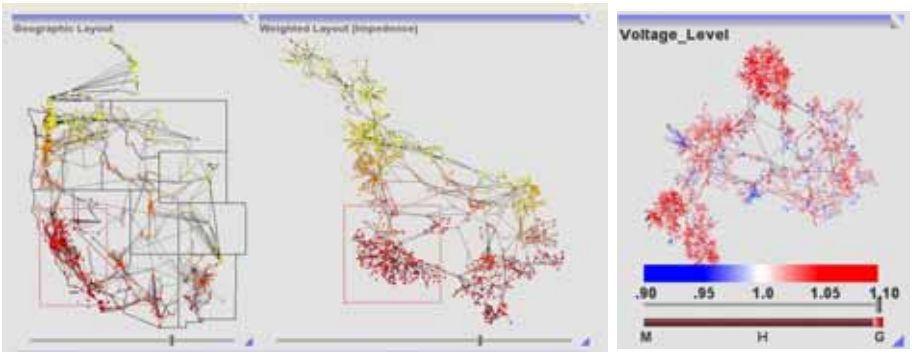

Stanford: Transactional Analytics

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Goals:

- *Transforming* events into transactions
- *Linking* transactions into behaviors
- *Modeling* participant behavior patterns
- *Identifying* unusual patterns
- *Searching* for their agents

Challenges:

- Massive amounts of streaming data
- Couple classification and visualization

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Presidential Election Results

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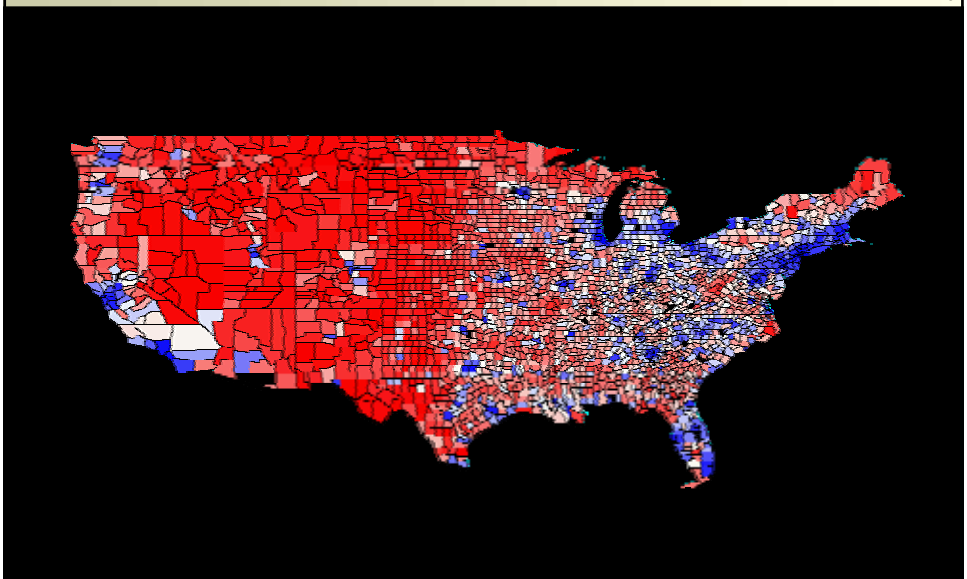

Presidential Election Results

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PARVAC: Pacific Rim Visualization and Analytics Center

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JITC3

(Just-In-Time C3)

Purpose - To develop a flexible, portable command post for deployment with emergency response personnel which optimizes situational awareness and responder flow during an emerging event.

Approach - Develop a cohesive geo-spatial representation of an urban environment that can be navigated and manipulated using Augmented Reality. The ARToolkit's intuitive, tangible interface is used to create location-specific perspectives, including both exocentric and egocentric viewpoints.

An international R&D collaboration involving researchers in the Washington, Hawaii, Alaska, Canada, New Zealand and Australia, led by the University of Washington HIT Lab (Tom Furness, PI)

RimSim

Purpose - To develop a reality-based simulation game as a platform for studying distributed cognition and collaborative analysis of geospatial events typical of cities around the Pacific Rim.

Approach - In parallel to requirements gathering and game development, a focus on assessing the quality of a game session through a visual analytics support tool helps RimSim developers verify game data needs, interface needs, and game objectives. The assessment tool builds upon the Improvise platform developed by researchers at the Penn State RVAC.

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   - German Research Program on Scalable Visual Analytics
   - European FP7 FET-Open Initiative
   - US Visual Analytics Initiatives (NVAC, RVAC, NSF, NIH, ...)
   - Canada Visual Analytics Initiatives
   - Australian Research Initiative on Visual Analytics
6. **Outlook - What's next?**

EU Perspective on Visual Analytics

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- Utilise strong European background in many aspects that define Visual Analytics
- Achieve a broad leadership in this area
  - Solicit the EU and member states to launch dedicated research programmes/challenges in the area of Visual Analytics
  - Organise workshops, conferences and targeted events bringing together the VA communities
  - Have specific industry events to attract industrial interest around the latest research and technology advances in the area

EU Perspective on Visual Analytics

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- Visual Analytics is important Research Area with High Potential

  Solutions to Important Problems
  - with high Societal Relevance and
  - many Industrial Applications
- EU Competences

  Leading Research Groups and Industries in Relevant Research Areas
  - Information Visualization
  - Knowledge Discovery
  - Geo-Spatial Analysis
  - Databases
  - Interaction

EU Perspective on Visual Analytics

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- Broad Focus
  - Visual Network Analytics (FP7 – ICT Challenge 1)
  - Visual Engineering Analytics (FP7 – ICT Challenge 3)
  - Visual Content Analytics (FP7- ICT Challenge 4)
  - Visual Health Analytics (FP7 – ICT Challenge 5)
  - Visual Demographics and Social Analytics (FP7 – ICT Challenge 7)
  - Visual Bio-molecular Analytics (FP7 – Non ICT)
  - Visual Business Analytics (FP7 – ???)
- Synergy with US Visual Analytics Program

Visualization and Analytics Centers

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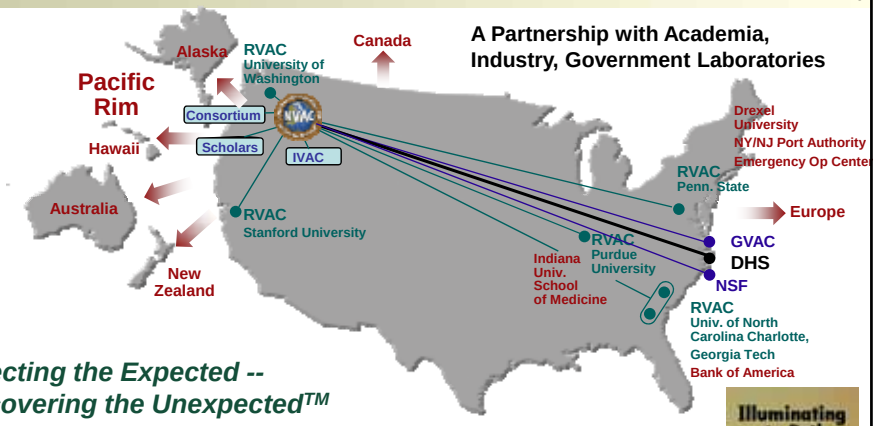
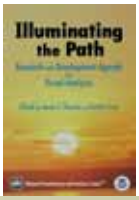


Detecting the Expected -- Discovering the Unexpected™



Jim Thomas

Director, U.S. Department of Homeland Security National Visualization and Analytics Center
Pacific Northwest National Laboratory Fellow
http://NVAC.pnl.gov

Visual Analytics Applies to Many DHS Mission Needs

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"The important thing in science is not so much to obtain new facts as to discover new ways of thinking about them."

~Sir William Bragg (1862 - 1942)

Capabilities Desired

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- **Reduce the threat of terrorism through the invention, development, evaluation, and deployment of technology to analyze masses of data in different formats and types, from different sources, with highly varying degrees of confidence levels, within time frames required for rapid decision making.**
- **Better understand the risks and vulnerabilities of our critical infrastructures, trade, ports, and immigration by combining sensor, computational and visual analytics technologies for in-the-field and strategic decision making.**
- **Enable rapid visual communication technology for response teams for clear understanding of the situation assessment and alternate options for response with geospatial, and multi-jurisdictional situations for WME and natural disasters.**
- **Ensure effective information communication methods and technologies throughout DHS missions of analysis, risk, levels of alerts, and response, in unwrappable levels of assessment with evidence and communication styles aimed within audience-centric applications for rapid understanding and action.**
- **Provide an enduring talent base of educated professionals supporting future developments requiring visual communication of integrated information and operational support missions.**

"All truths are easy to understand once they are discovered; the point is to discover them."
~ Galileo Galile (1564-1642)

Partners and Leaders

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PARTNERS

The NVAC partners, with government, industry, academia and national laboratories to leverage and enhance the vast resources and expertise to develop and deploy new visual analytics tools and capabilities to prevent terrorism.

Tony Bartoletti
Lawrence Livermore National Laboratory
Mark Billinghurst
Human Interface Technology Laboratory, New Zealand
Stuart Card
Palo Alto Research Center
Daniel Carr
George Mason University
Nancy Chinchor
Advanced Technologies and Programs, U.S. Government
John Dill
Simon Fraser University
Rae Earnshaw
University of Bradford
David Ebert
Purdue University
Stephen Eick
University of Illinois at Chicago and SSS Research
Robert Grossman
University of Illinois at Chicago and Government
Charles Hansen
University of Utah
Kenneth Joy
University of California - Davis
David Kasik
Boeing Corporation
David Laidlaw
Brown University
Sharon Laskowski
National Institute of Standards and Technology
Alan MacEachren
Penn State University
Catherine Plaisant
University of Maryland
William Ribarsky
University of North Carolina, Charlotte
John Stasko
Georgia Institute of Technology
Maureen Stone
StoneSoup Consulting
Matthew Ward
Worcester Polytechnic Institute
David White
Sandia National Laboratory
David Woods
Ohio State University
William Wright
Oculus Info Inc.

The Assessment Wall

Konstanz University

Developed an interactive information visualization system that provides an up-to-date overview and helps users intuitively find documents of interest on a large touch display.

- **A walk-up usable interface that provide anyone instant analytical capability.**
- **Designed for team collaboration and discussion of analytical tasks.**
- **Simple interface design to provide rapid analytical results is ideal for command room style utility.**

Scalable Reasoning System

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A free-form visual environment and knowledge base scaling across mobile devices and desktop interfaces that integrates methods for organizing data, reasoning with information, and disseminating knowledge.

- **Uses light-weight interaction and visualization techniques to support use by any analyst.**
- **Designed for real-time collaborative tasks and sharing of knowledge across distributed teams.**
- **Assists in vetting of knowledge products through dissemination of the evidence and analysis that contributed to a product.**

PENNSTATE PURDUE UNIVERSITY ARJIS

Narrative Scenarios

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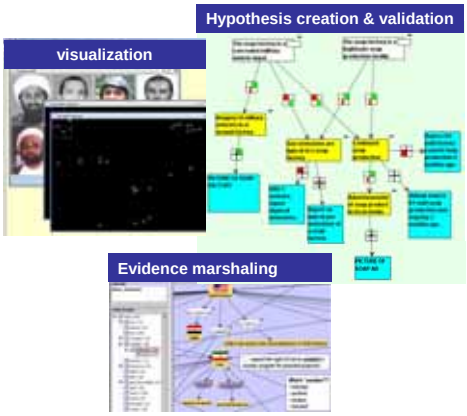
Developing a Visual Interactive Environment for Predictive Analytics that supports the analysis of competing hypotheses by facilitating evidence marshaling, hypothesis testing, and intelligence dissemination

- **Designed for use by dedicated analysts but with a simplified interface to facility rapid analysis.**
- **Applicable to most domains but directly intended for those using analysis of competing hypotheses and similar techniques.**



PURDUE UNIVERSITY UNCCHARLOTTE

Threat Stream Generator

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Creating the science for developing realistic, synthetic data sets, based on scenarios, with known ground truth for testing and evaluation of analytical tools and techniques

- **The data sets and evaluation methods can be applied to a wide range of analytical tasks to determine the value of tools and techniques.**
- **Development of better testing methodologies will result in more rapid and superior tool development.**

UNCCHARLOTTE Georgia Institute of Technology

ICAHST Others

"Of all of the data generators that I have seen/heard about in my time at the ICAHST, PNNL's seems to be the one that simulates the real world the most effectively."

- ICAHST Testing Manager

Example Products

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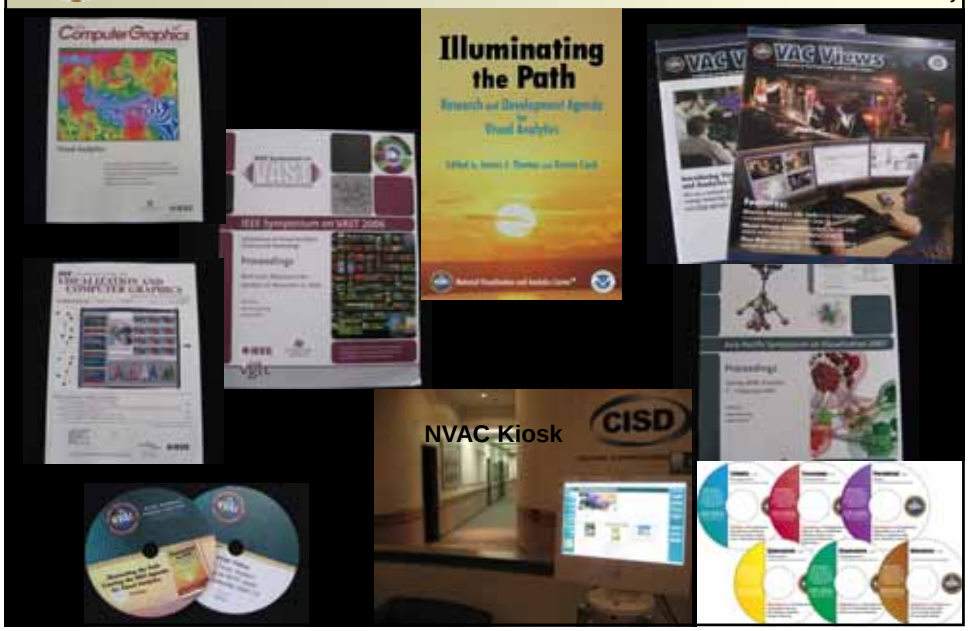

Other countries starting programs in Visual Analytics

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- Canada: Brian Fisher, John Dill
- Australia: Peter Eades
- Germany: Daniel Keim
- UK: private company

→ Panel discussion later during IEEE VAST

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   - **Technical Challenges**
   - **Application Challenges**
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Call for Action

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- Visual analytics is a grand challenge in science
- Progress measured by
  - New visual analytic techniques are being transitioned into analytical use
  - A vibrant and growing community of practice for visual analytics researchers and engineers
- Implemented through partnerships:
  - Academia
  - Industry
  - Other government agencies
  - National laboratories
  - International partnerships

Conclusions

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- Visual Analytics is an opportunity worth considering
- Collaboration between academia, industry, national laboratories, and government (national and international) is key
- For each of you:

The best is yet to come…