

Visual Analytics - Introduction

Eduard Gröller

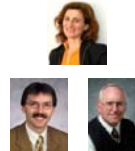
Institute of Computer Graphics and Algorithms
Vienna University of Technology

Outline

- Introduction to visual analytics
- Definition of visual analytics
- Technical challenges and agenda
- Application areas

- Some slides courtesy of

- ◆ Silvia Miksch
- ◆ Daniel Keim / Jim Thomas



Eduard Gröller

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Motivation: Main Problems

Data Unmanageable – Loss of Overview

Missing Integration of
Various (Heterogeneous)
Information Sources

Various
Interdisciplinary Methods

Missing Involvement of
Users and their Tasks



Danube University Krems
Department of Information und Knowledge Engineering (Silvia Miksch et al.)



Challenge of the Information Age

- 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



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

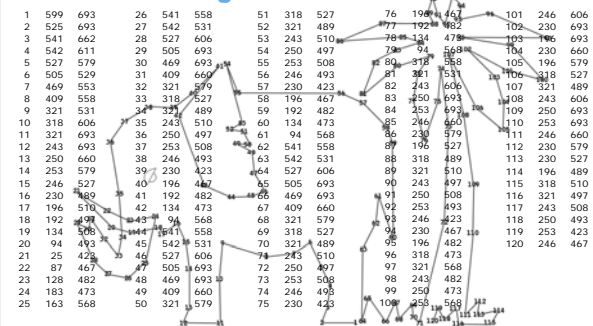
New Requirements Summary

- 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

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

Visualization for Problem Solving



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Analytical Methods

Screen Resolution: 1024 * 768 = **786.432**
 Measurements of Water Level in LA Every Year: **5.256.000**
 Number of Cellular Phones in Austria (2005): **8.160.000**
 Transmitted Emails Every Hours (World-Wide): **35.388.000**

Whole Data often not Presentable

1. Applying Analytical Methods (*Data Reduction*)
2. Visualization of Most Important Data and Information

Analytical Methods

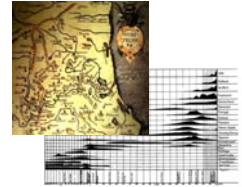
Statistics, Machine Learning & Data Mining



Interactions

Past

Only passive Observations
 Representation not Changeable
 „one fits all“



Today

Active Examination with Visualizations
 Dynamically Adaptable and Modifiable
 → Different Users, Tasks and Aims

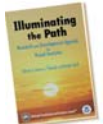


Visual Analytics – What is it?

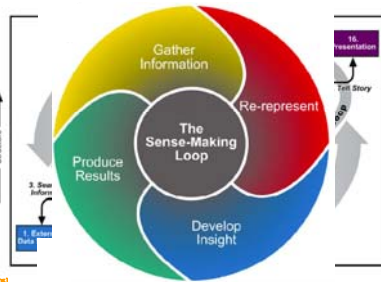
James Thomas & Kristin A. Cook:

NVAC (National Visualization and Analytics Center), Seattle, USA

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



[Thomas & Cook 2006]



Visual Analytics Definition

Konstanz University

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

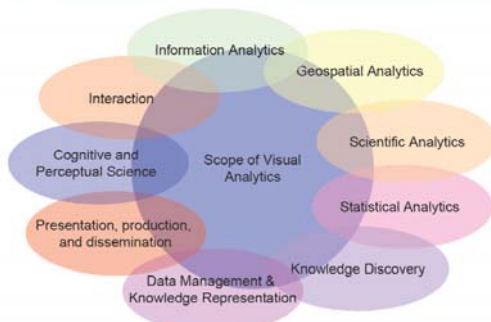
People use visual analytics tools and techniques to

- 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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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 be 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 ?

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

Visual Data-Exploration

Feedback loop

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

Technical Challenges

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)

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Technical Challenge: Scalability

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 Galilei (1564-1642)

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Visual Analytics Agenda

[Thomas & Cook 2006]

The Science of Analytical Reasoning
“... enable users to obtain **deep insights** that directly support assessment, planning, and decision making.”

Visual Representations & Interaction Technologies
“... take advantage of human eye's broad bandwidth pathway into the mind to allow users to **see, explore, and understand large amount of information** at once.”

Data Representations & Transformations
“... **covert** all types of conflicting and dynamic data in ways that support visualization and analysis.”

Production, Presentation, & Dissemination
“... **communicate** information in the appropriate context to a **variety of audience**.”

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Department of Information und Knowledge Engineering [Silvia Miksch et al.]

Application Areas

Economic & Business Data

- Business Intelligence
- Market Analysis

Medicine & Biotechnology

- Patients' Data Management
- Epidemiology
- Genetics

Security & Risk Management

- Disaster Management
- Computer Networks
- Transportation
- Reducing Crime and Terror Rate
- Fraud Detection

Environment & Climate Research

etc.

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Department of Information und Knowledge Engineering [Silvia Miksch et al.]

Visual Steering to Support Decision Making in Visdom

Jürgen Waser

http://www.cg.tuwien.ac.at/research/publications/2011/waser_2011_VSD/

visdom

vrvis

Flood emergency assistance

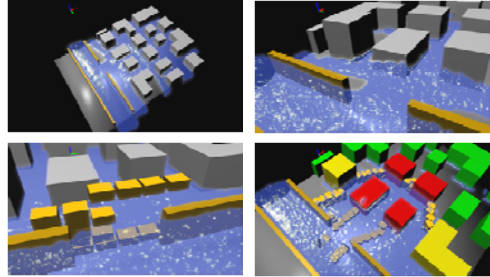
- New Orleans 2005: 17th canal levee breach



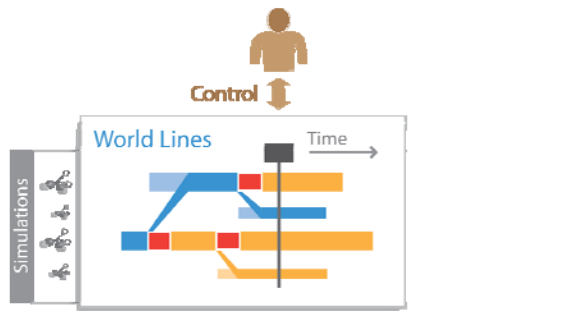
Image courtesy of USACE, US Army Corps of Engineers

Flood emergency assistance

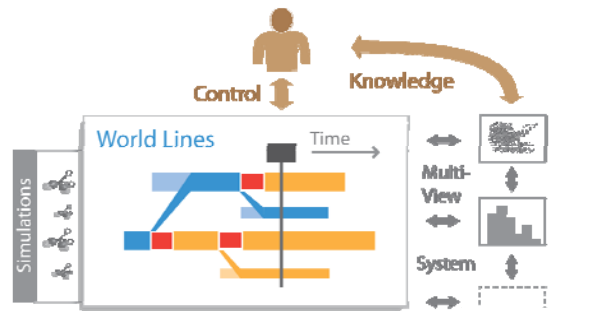
- Testing sandbag configurations in a virtual environment



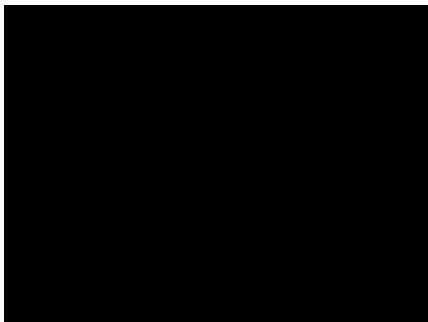
Solution: World Lines



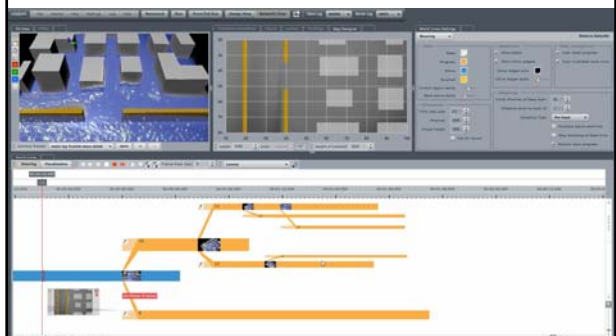
Solution: World Lines



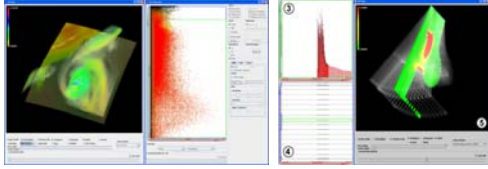
Video



Worldlines – Multiple Linked Views



SimVis: Interactive Visual Analysis of Large & Complex Simulation Data



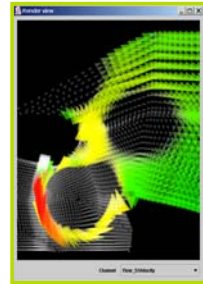
Dr. Helmut Doleisch
VRVis Research Center

<http://www.VRVis.at/>

vrvis

Motivation

- large data sets from simulation
- goal: support **exploration** and **analysis** of results
 - analyze n-dim. data **interactively**
 - use **3D visualization**
 - overview, zoom and filter, detail on demand** (Shneidermans' information seeking mantra)
- challenge:
 - occlusion
 - interactive data handling



Helmut Doleisch <http://www.simvis.at/> SimVis: Interactive Visual Analysis of Large & Complex Simulation Data

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Interactive Data Handling

- sample data set size:
 - 540 million data items
 - currently working to expand to billions

cells	timesteps	attributes	cells * timesteps	cells * timesteps * attributes
704.900	20	16	14.098.000	225.568.000
150.124	600	6	90.074.400	540.446.400
7.680.000	288	15	2.211.840.000	33.177.600.000

Helmut Doleisch <http://www.simvis.at/> SimVis: Interactive Visual Analysis of Large & Complex Simulation Data

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SimVis

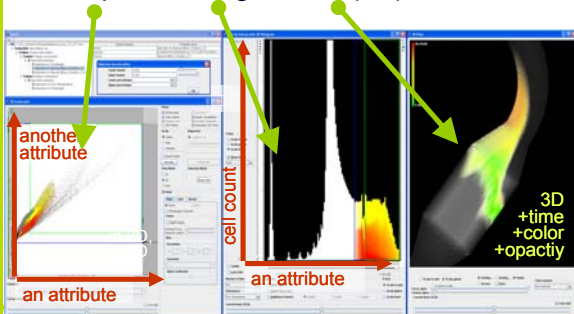
- VRVis' solution for these challenges
- Feature-based visualization framework
- SimVis key features:
 - Multiple, linked views
 - Interactive feature specification
 - Focus+Context visualization
 - Smooth feature boundaries
 - Explicit feature representation
 - On-the-fly attribute derivation

Helmut Doleisch <http://www.simvis.at/> SimVis: Interactive Visual Analysis of Large & Complex Simulation Data

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SimVis: Multiple Views

- Scatterplots, histogram, 3D(4D) view, etc.

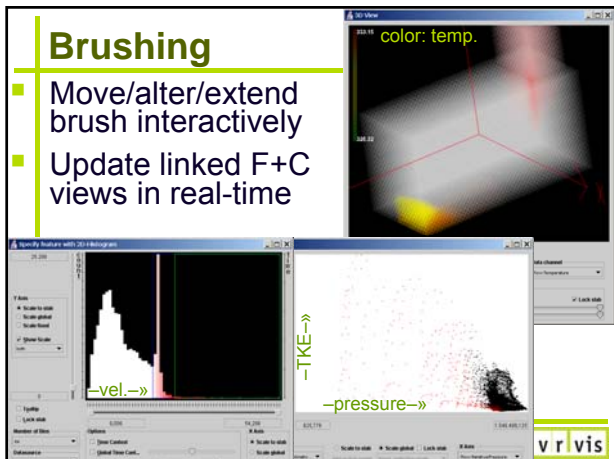


Helmut Doleisch <http://www.simvis.at/> SimVis: Interactive Visual Analysis of Large & Complex Simulation Data

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Brushing

- Move/alter/extend brush interactively
- Update linked F+C views in real-time



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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...