

An Introduction to Information Visualization Techniques for Exploring Large Database

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Time Series Data Visualization

Class 7

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Time Series Data

- Fundamental chronological component to the data set
- Random sample of 4000 graphics from 15 of world's newspapers and magazines from '74-'80 found that 75% of graphics published were time series

– Tufte

From John Stasko's class slides

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Datasets

- Each data case is likely an event of some kind
- One of the variables can be the date and time of the event
- Examples: sunspot activity, baseball games, medicines taken, cities visited, stock prices, newswires, network resource measures

Partially From John Stasko's class slides

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Discussion

Visualize these dataset:

■ Dataset 1:

- Time 1, sunshine intensity
- Time 2, sunshine intensity
- Time m, sunshine intensity

■ Dataset 2:

- Day 1, 5 news articles about Clinton, 7 news articles about oil, and 2 news about Iraq
- Day 2, ...
- Day m,...

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Discussion

■ Dataset 3:

- Lisa was born in Worcester in 2002
- She went to Austin in 2004
- She moved to Charlotte in 2005
- She will visit China in 2006

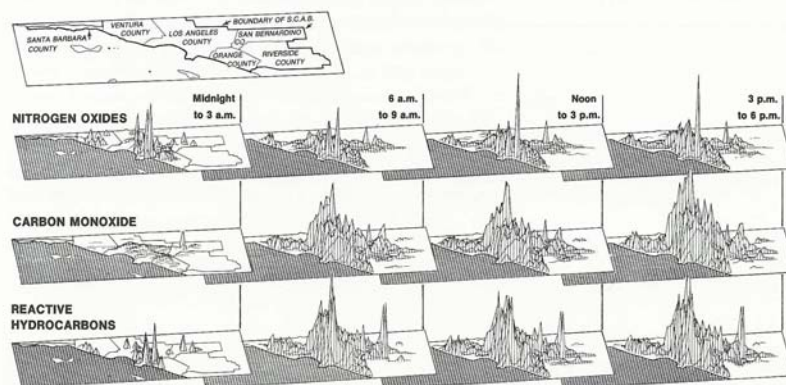
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Time Series Visualization Approaches

- Small Multiples
- Time-Series Plot
 - Treat time as a explicit dimension in the display
- Static State Replacement
 - Treat time as a dimension hidden from the display
 - Divide time into period (timeframe)
 - Generate a visualization for each timeframe
 - Replace a display of one timeframe using that of another timeframe
 - Animations, trails

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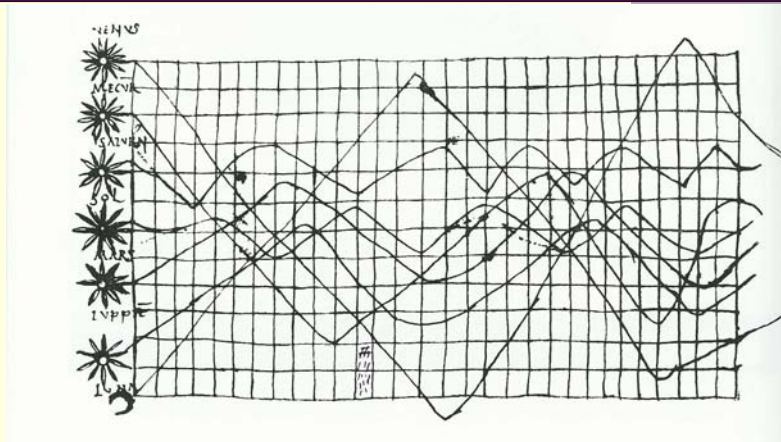
Small Multiples



Three air pollutants in six counties in southern California
Los Angeles Times, 1979

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Time Series Plot

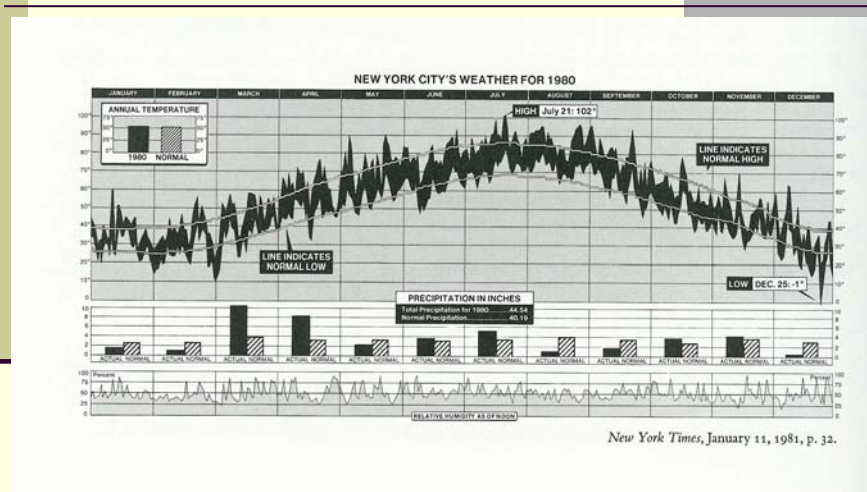


Inclinations of the planetary orbits as a function of time

Part of a text of monastery schools, tenth century

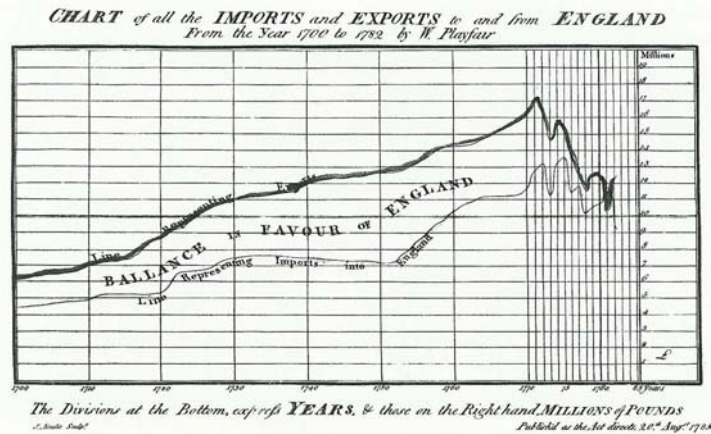
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Time Series Plot

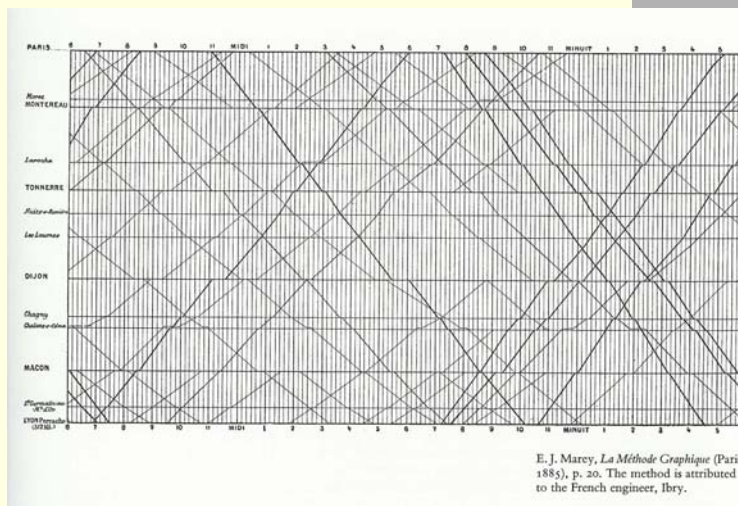


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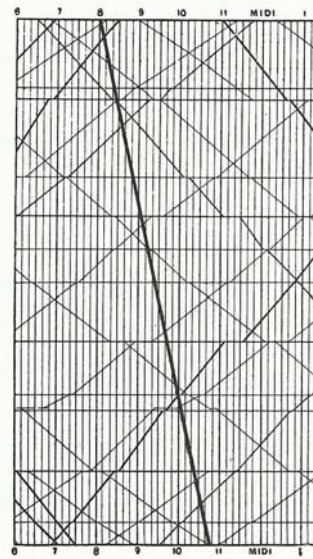
Time Series Plot



Time Series Plot



Time Series Plot



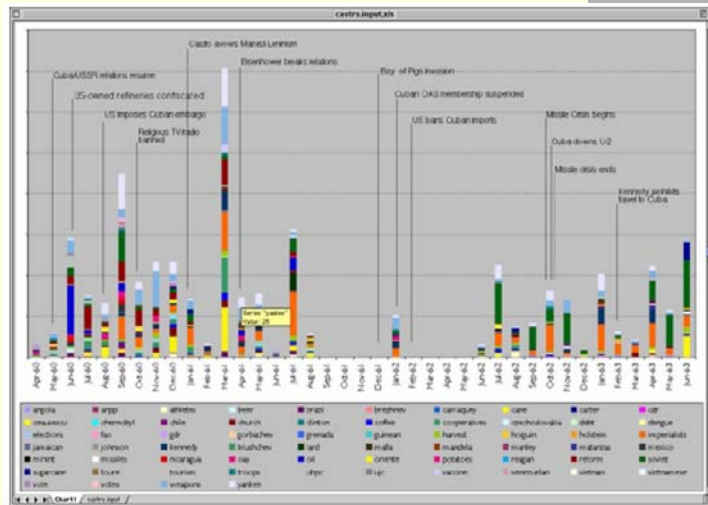
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Paper: ThemeRiver: Visualizing Theme Changes Over Time [Havre et al. Infovis 00]

- Background: a user is less interested in document themselves than in theme changes within the whole collection over time
- ThemeRiver provide users with a macro-view of thematic changes

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A histogram depicting thematic changes



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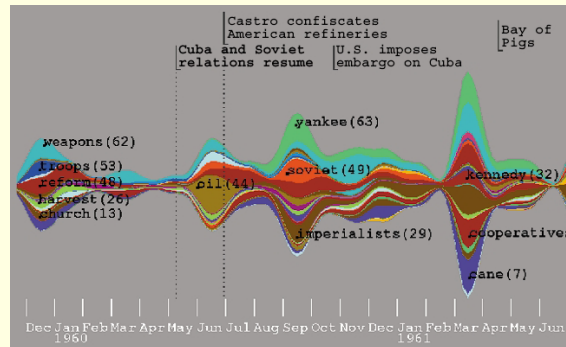
Problem

- The position of a particular theme within the bars may vary considerably
- Users are required to integrate the themes across time
- Improvement : the river and currents metaphor -> ThemeRiver

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ThemeRiver

- The river flows from left to right through time
- Colored currents flowing with the river narrow or widen to depict the strength of individual topics



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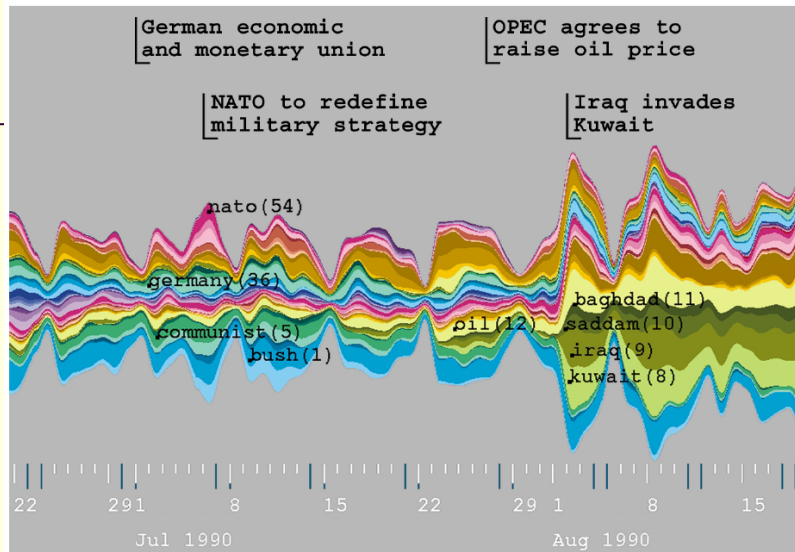


Figure 3: AP data from July - August 1990. A wide current in the river indicates heavy use of a topic, while changes in color distribution correlate to changes in themes.

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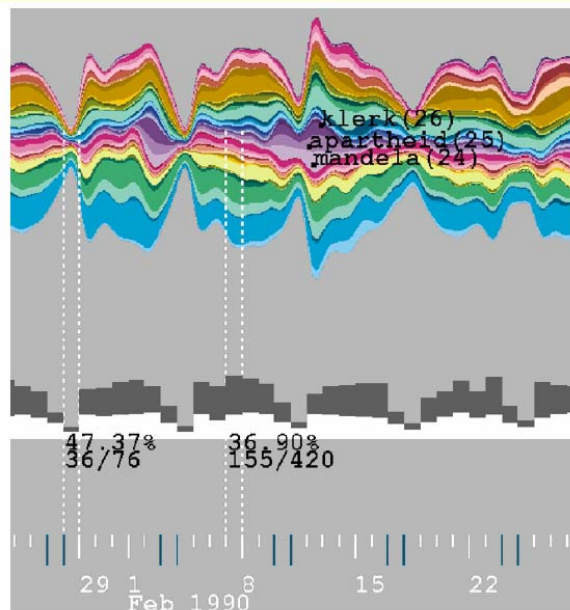


Figure 5: The addition of a histogram to Theme-River™ reveals that news is light on Sundays,

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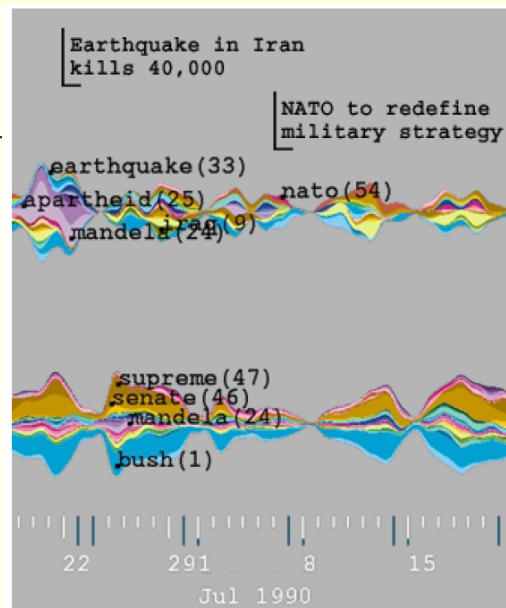
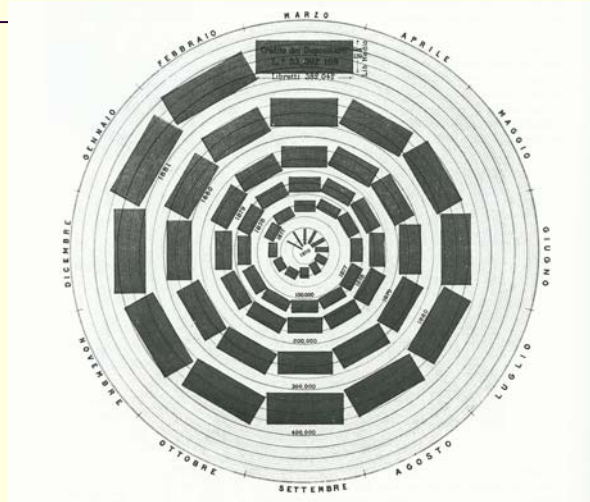


Figure 6: Parallel rivers let users compare AP data from Washington, D.C. and New York from the same time period.

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Spiral Graphs



History of Italian post office

A. Gabaglio, 1888

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Paper: Visualizing Time-Series on Spirals [weber et al. Infovis 01]

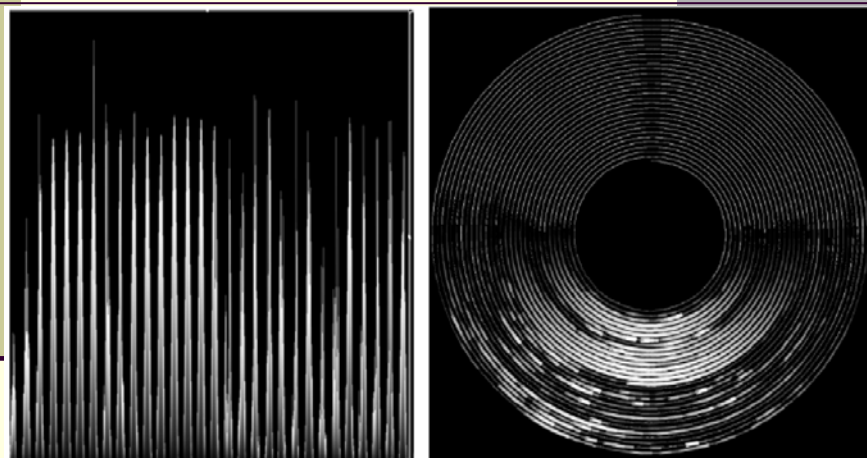


Figure 1: Two visualizations of sunshine intensity using about the same screen real estate and the same color coding scheme. In the spiral visualization it is much easier to compare days, to spot cloudy time periods, or to see events like sunrise and sunset.

Features

- Scale to large data sets
- Support identification of periodic structures in the data
- Compare multiple datasets
- Use Archimedes' spiral: $r = a\theta$
 - A ray emanating from the origin crosses two consecutive arcs of the spiral in a constant distance $2\pi a$ (equal distance between adjacent periods)

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Periodic Pattern Identification

- Spectrum analysis
- Animation

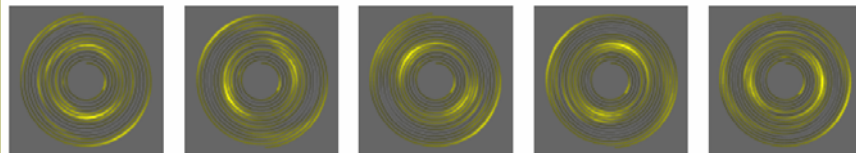


Figure 3: Visualizations of the same data with continuously changing cycle length. The period in the data can be found visually, i.e. the visual system is used to detect periodic patterns in the data exploiting the spatial layout on the spiral. In this example, the visual system detects a significant structure in the middle image, which unveils the corresponding periodicity in the data.

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Multiple Spirals

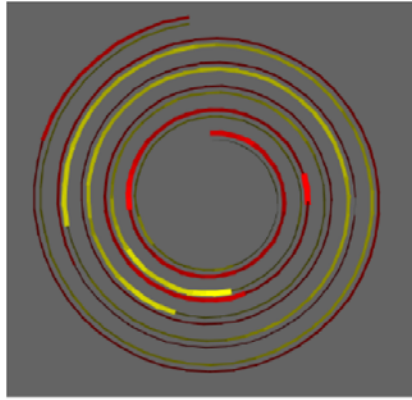


Figure 4: Comparing different data sets on a multi-spiral. Here, comparative reading can be combined with matching the periodicity of the data.

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Scales & Legends

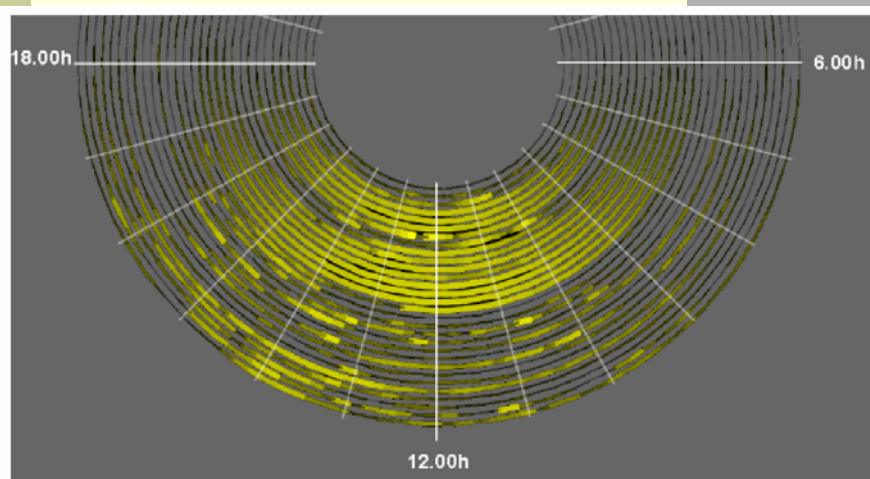


Figure 5: A possible way to add informative scales to the parametric dimensions of a spiral.

3D Overview and Selection

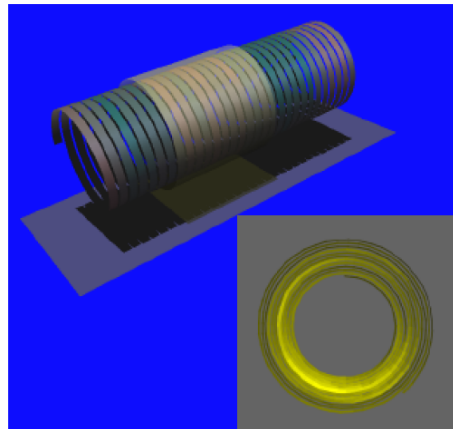


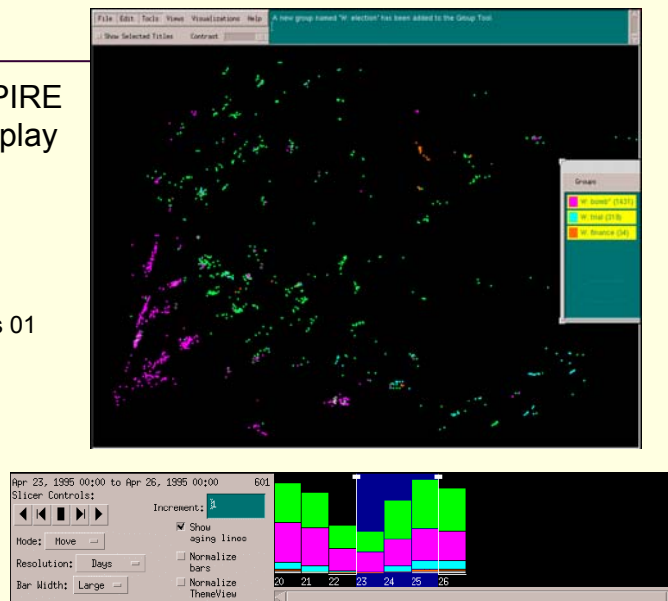
Figure 6: Using a helix in 3D to support intuitive browsing through a large data set.

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Static State Replacement

- Example: SPIRE Galaxies display

Nowell et al. Infovis 01

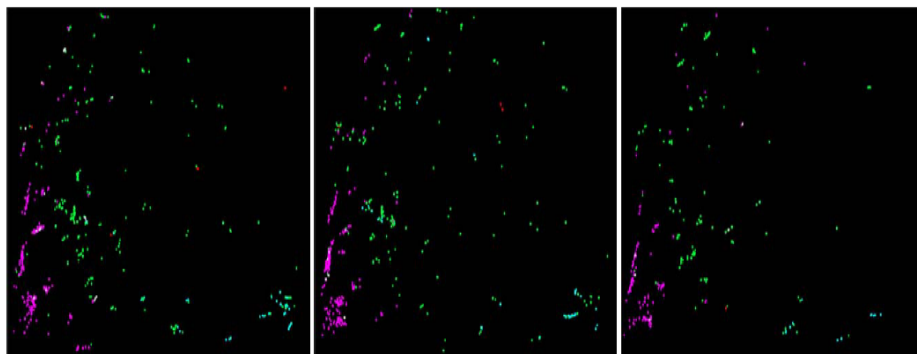


Problem: Change Blindness

- Phenomenon – people do not notice changes in visible elements of a scene
- Possible reasons:
 - Overwriting
 - Old scene is wholly replaced by the new one
 - First impressions
 - Accurately encode details of first scene and fail to encode the details of the changed scene
 - Nothing is stored
 - No need to develop any mental representation of the scene
 - Nothing is compared
 - Need to focus on changed items to recognition of changes
 - Feature combination
 - New scene and old scene are combined together

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Change Blindness

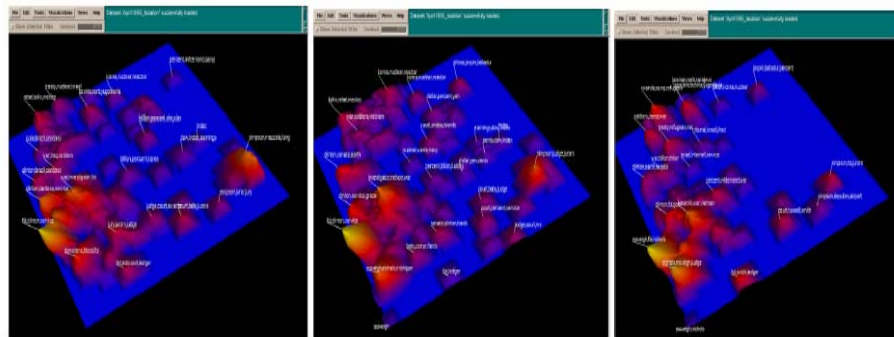


Galaxies slices depicting days 1-3

Nowell et al. Infovis 01

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Change Blindness



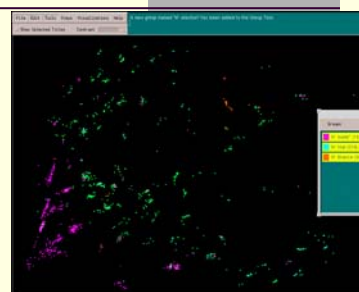
Themeview slices depicting days 1-3

Nowell et al. Infovis 01

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Paper: Change Blindness in Information Visualization: A Case Study [Nowell et al. Infovis01]

- Portraying document age in Galaxies Visualization
- Requirements:
 - Relative age should be apparent
 - Newest documents to be seen pre-attentively
 - Other document ages to be intuitively ordered



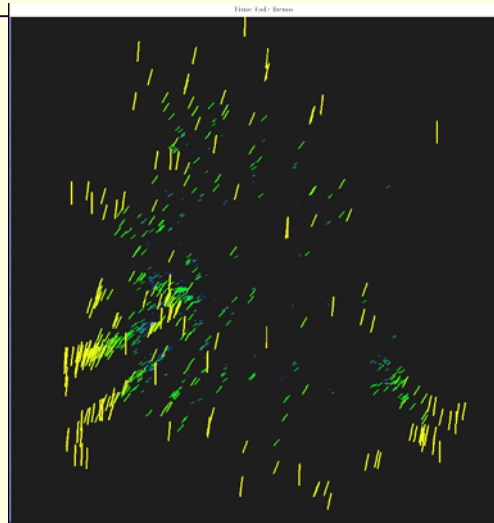
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Paper: Change Blindness in Information Visualization: A Case Study [Nowell et al. Infovis01]

- Check pre-attentive features:
 - Spatial layout
 - Size
 - Shapes
 - Angles
 - Line length
 - Color progression (such as yellow to green to blue)
 - Bright to dim progression
 - Perspective depth
 - Left to right spatial progression

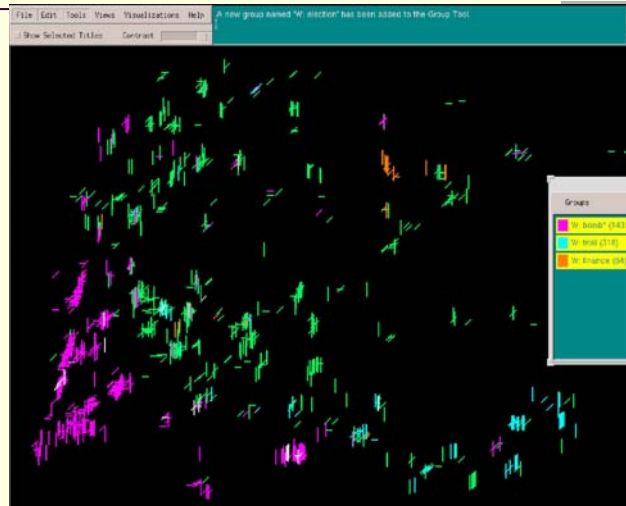
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Perspective depth, line and length encoding



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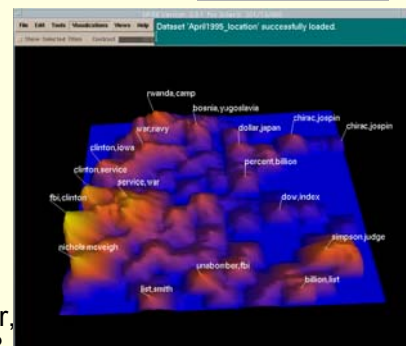
Line angle and length solution



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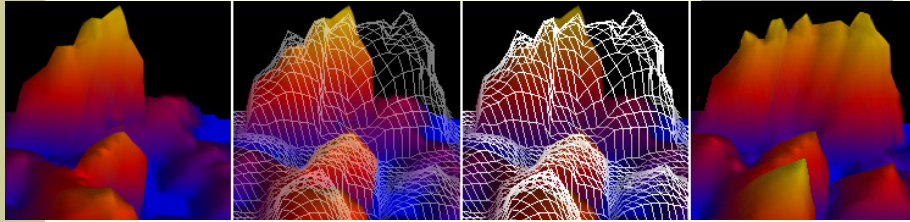
Paper: Change Blindness in Information Visualization: A Case Study [Nowell et al. Infovis01]

- Candidate solutions for ThemeView
 - Morphing
 - What come before, what will eventually appear?
 - Does not help users remember the changes
 - Cross-fading
 - Which part will get brighter, which part will fade away?
 - Using a wireframe in combination with changes in color and translucency



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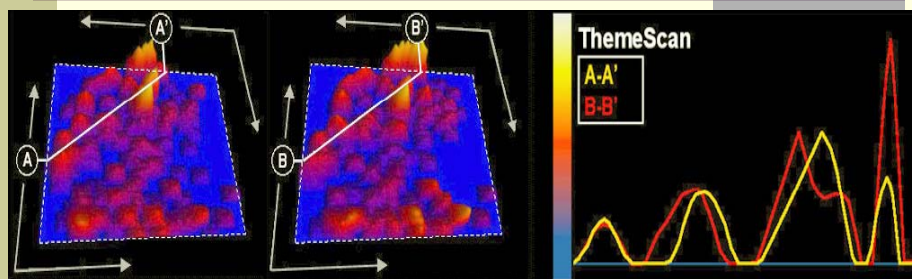
Wireframe Solution



Moving from one time slice to another with a wireframe and variable translucency.

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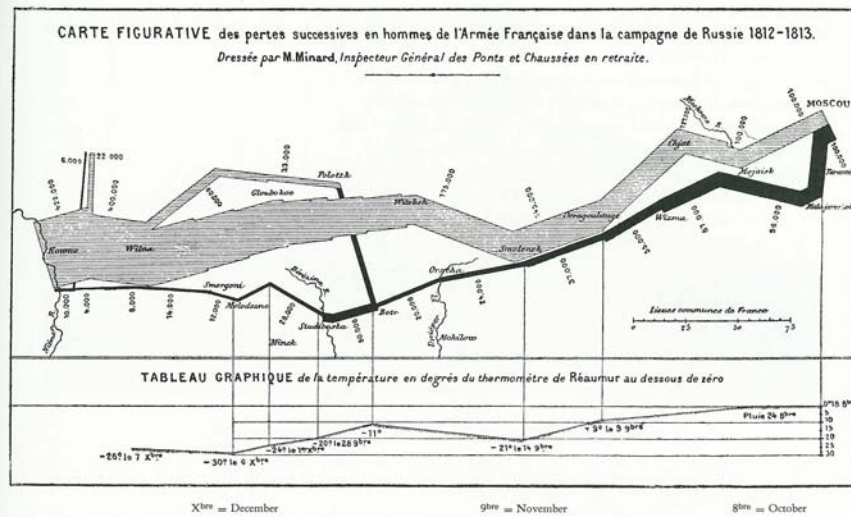
Theme Scan Solution



ThemeScan visualization of changes between time slices

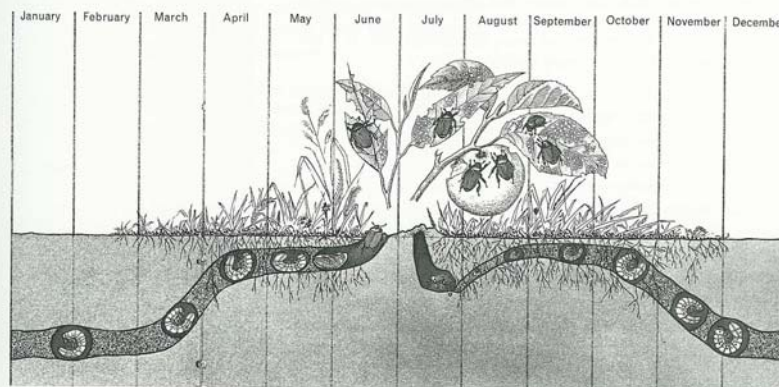
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Space and Time



Napoleon's army in Russia, author: Charles Minard (1781-1870)

Space and Time



Life circle of Japanese Beetles L. Newman, Man and Insects, 1965

Paper: GeoTime Information

Visualization [Kapler and Wright Infovis 04]

- A combined temporal-spatial space (X, Y, T coordinate space)
- Represent place by 2D plane (or maybe 3D topography)
- Use 3rd dimension to encode time

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Paper: GeoTime Information

Visualization [Kapler and Wright Infovis 04]

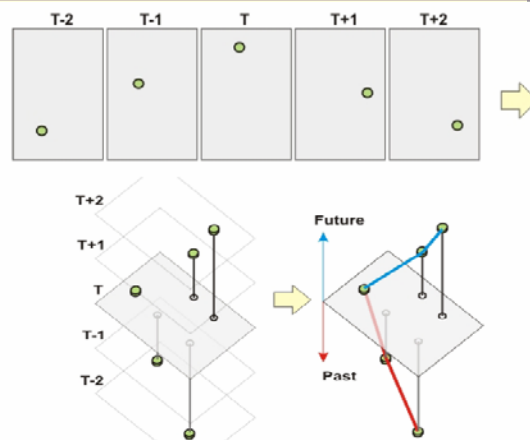


Figure 1: Individual frames of movement are translated into a continuous spatiotemporal representation.

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Timelines

■ 3-D Z axis timelines

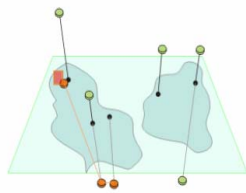


Figure 3: Diagram showing how 3-D Timelines pass through terrain locations. 3-D Timelines are locked in terrain space and are affected by changes in perspective.

■ 3-D viewer facing timelines

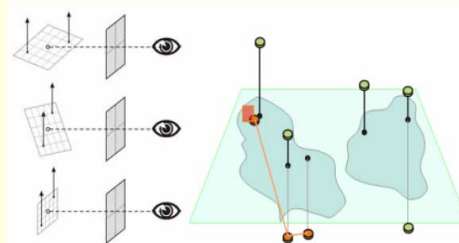


Figure 4: Viewer facing timelines rotate to face the viewpoint no matter how the terrain is rotated in 3-D.

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Example

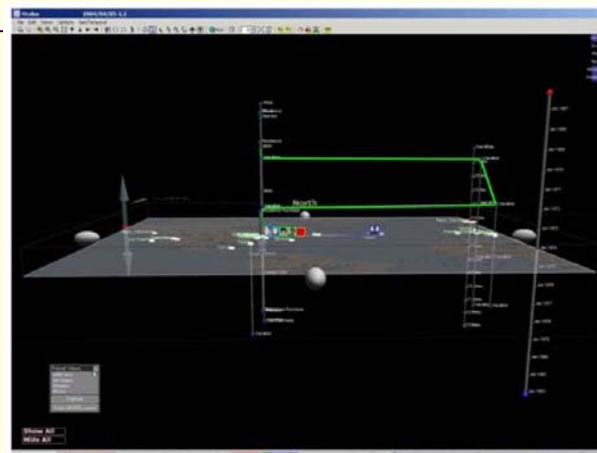


Figure 6: Screenshot of GeoTime with time slider at bottom and moveable time scale at right. The green line traces one entity's movement in time and geography.

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Example

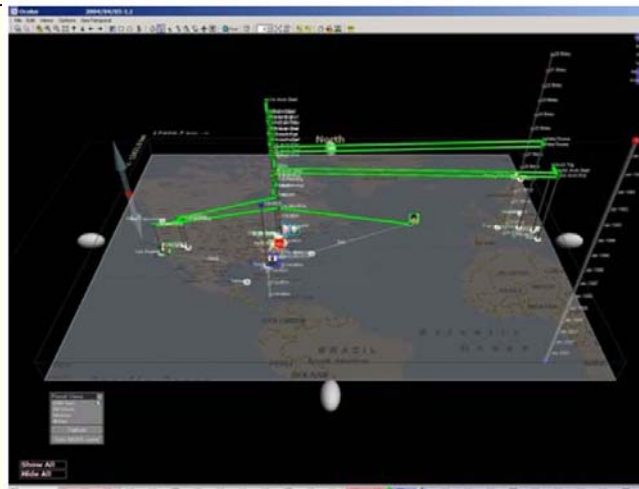
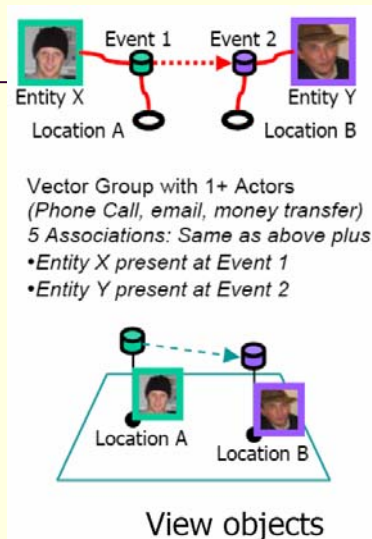


Figure 7: Screenshot of GeoTime with overhead view and time slider advanced forward in time from Figure 6.

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Information Model

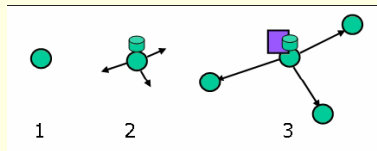
- Entities
 - People or things
- Locations
 - Geospatial or conceptual
- Events
 - Occurrences or discovered facts



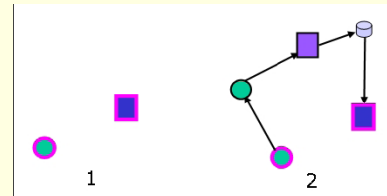
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Association Analysis

Expanding search



Connection search



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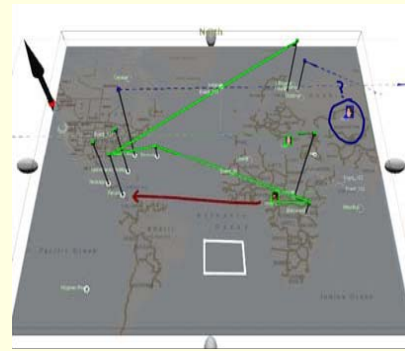
Other Interactions

Animation of entity movements

Drilling down



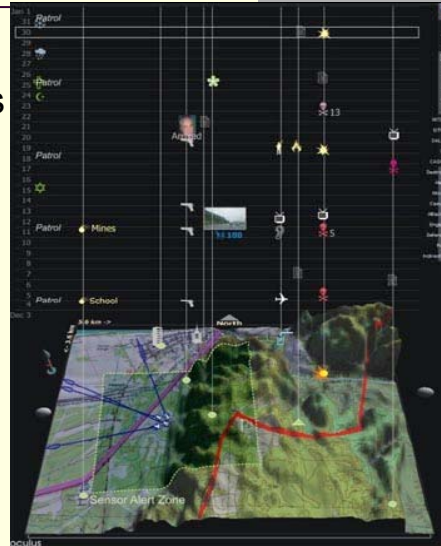
Annotations



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Alternative View

- Afghanistan in 2002
- Events in three weeks
 - Shootings
 - Bombings
 - Fires
 - Mines
 - Kidnaps
 - Thefts
 - assaults



Paper: Time-Varying Data Visualization Using Information Flocking Boids [Moore Infovis04]

- Motivation: users are interested in how data values evolve in time, or in the context of the whole dataset, rather than exact data values
- Example: stock price
 - A company performing significantly better than the day before
 - A company performing significantly better than the day before

Flocking Boids

- Boids (bird-objects) within a flock
 - Boids at the edge of a herd are easier to be selected
 - Boids attempt to move as close to the center of the herd as possible
 - Boids view the world from their own perspective rather than from a global one

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Behavior Animation

- Each individual member contains its own set of rules and the future state of a member only depends on its neighbors
- Rules:
 - Collision Avoidance
 - Velocity Matching (move with about the same speed as neighbors)
 - Data similarity (Stay close to boids experienced similar data value evolution during current timeframe)
 - Data Dissimilarity (Stay away from boids experienced dissimilar data value evolution)
 - Flock Centering (move toward the center as the boid perceives it)

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Example

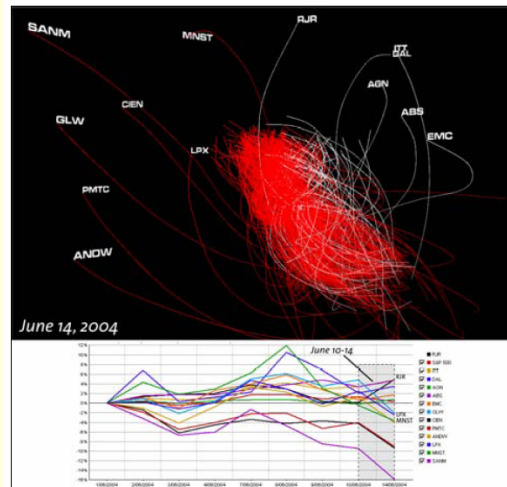


Figure 2. Individual birds separating from the main flock.

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Shape

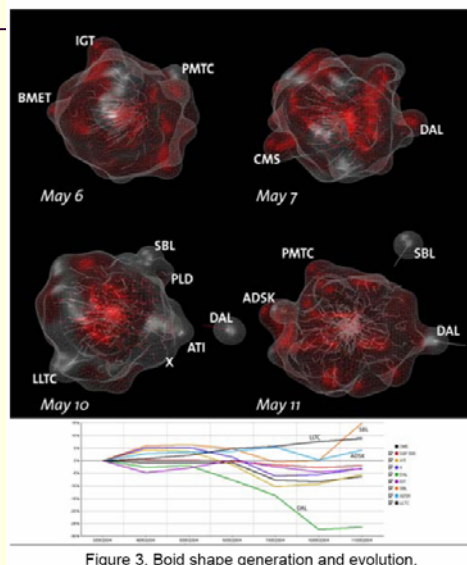


Figure 3. Bold shape generation and evolution.

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References

- E. Tufte. The Visual Display of Quantitative Information, 1983
- Papers referred