visualization of **time-oriented data**

visualization techniques

Wolfgang Aigner

aigner@ifs.tuwien.ac.at
http://ieg.ifs.tuwien.ac.at/~aigner/

Version 2.4
7.1.2011

Section A:

questions & application areas

Questions 1/4

1. When are the doors going to be installed and what is done afterwards?
2. Was arthritis diagnosed while a period of tabacco consume? (DEMO)
3. When did "Olson" write the Technical Report for the "DELTA" project?
4. What do I have to do tomorrow?
5. When do I have to leave the office in order to catch my bus? (DEMO)
6. Are 7 days really 7 days?
7. For how long do I need to apply the therapy at minimum?
8. Until when can corticosteroids be given?
9. Can "Controlled Ventilation" and "Crisis Management" overlap temporally?
10. Who logged into my server at 3pm yesterday?

Questions 2/4

11. At what time did Fidel Castro talk most about "oil"? (MOVIE)
12. What kind of food do chimpanzees prefer in winter?
13. Do the stocks of "Microsoft" and "Sun Microsystems" have a similar price history?
14. Is the my software project likely to fail?
15. What parts of my software project are stable?
16. How does Beethoven's "Bagatelle" sound and look like? (MOVIE)
17. Which stocks increased in a similar way during the year? (DEMO)
18. Who are the main contributors in an online environment?
19. Which meeting is going to happen on August, 17?
20. How did the prices of various MP3 players change over the last months?

Questions 3/4

21. How is time represented in paintings?
22. How did the ozone concentration in Los Angeles change over the last decade?
23. Can the same pattern of value increase be found in other sessions of dialysis? (MOVIE)
24. How did various authors conribute to the wikipedia entry on "Islam" over time?
25. How did the blood pressure of Jane Doe evolve over the last hours? (MOVIE)
26. What did Isaac Newton do in 1667 and where did he do it?
27. How do the top 100 news topics during the last day look like?
28. What were the main events in my life so far? (MOVIE)
29. How does an hour worth of "Simpsons" look like in one picture? (MOVIE)
30. Which parts of my website were visited during the last hours? (MOVIE)

Questions 4/4

31. When did Philipp Glass write his fastest songs? (Online-DEMO)
32. Who are my main e-mail communication partners?
33. How does the history of photography look like?
34. Are there any critical portions in my project plan? (DEMO)
35. How is Mary's course of therapy? (DEMO)
36. What treatment step should be performed next?
37. Are there differences in the trends of sold items on different weekdays?
38. What are the patterns of deployed police forces in a city?

Applications 1/3

1. project plans (2 (DEMO))
2. juvenile justice records, patient records (DEMO)
3. document/file collections
4. personal and/or corporate time management (2)
5. time management (DEMO)
6. events on different granularities
7. medical treatment planning (2, 3, 4)
8. network intrusion detection

Applications 2/3

9. document collections (MOVIE)
10. chimpanzees food consumption
11. internet movie database
12. stock prices
13. software evolution (2)
14. music visualization (MOVIE)
15. stock prices (DEMO)
16. microarray data (DEMO)
17. discussion group activity
18. visual arts

Applications 3/3

19. ozone concentration in Los Angeles
20. medical data (MOVIE) (2 (MOVIE), 3 (DEMO), 4)
21. Wikipedia document evolution
22. historical events (2)
23. news
24. personal history (MOVIE)
25. webpage hit evolution (MOVIE)
26. music collection (Online-DEMO)
31. e-mail history
32. retail (sold items)
33. police unit deployment

Section B:

time & arts

Renaissance

[Masaccio and Masolino, **Scenes from the Life of St. Peter**, c.1426-7, Brancacci Chapel, Florence]

Multiple appearences of the same person within a single scene

Cubism

The first documented occurrence of the fourth dimension being used in art appeared in 1910 in Paris.

Origin: mathematics + physics (n-dimensional spaces)

At this point, the fourth dimension was thought as time.

Person walking down stairs -->

Fourth dimension in the painting by picturing different stages of the person's descent

[Marcel Duchamp, **Nude Descending a Staircase**, 1912]

Cubism

New ideas about the fourth dimension into the static domain of pictures.

Overlays many different observations.

Emphasizes process of looking and recording over time.

[Picasso, **Portrait of Vollard**, 1910]

Comics

Visual story telling over time.

Many interesting techniques / paradigms.

If you want to know more, start here: [Scott McCloud, **Understanding Comics**, 1994]

Section C:

visualization techniques

TimeSearcher

[Hochheiser, 2002; Hochheiser and Shneiderman, 2002]

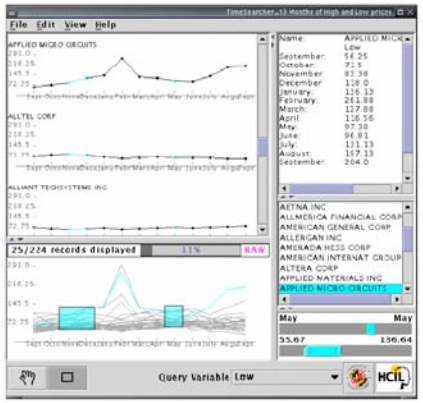


Figure 2: TimeSearcher with graph display and highlight in query window.

http://www.cs.umd.edu/hcil/timesearcher/

visualization tool for time-series data

timebox query model

- rectangular regions that specify constraints over time series data sets
- x-axis extent: time period of interest
- y-axis extent: constraint on the range of values

combinations of multiple timeboxes

data + query envelope

DEMO

Interactive Parallel Bar Charts (IPBC)

[Chittaro et al., 2002]

basic vis technique: bar charts

bar charts only suitable for 1 time series; more --> 3D

analysis of medical data

occlusions can be removed by flattening occluding elements --> matrix visualization

tide mode (highlighting areas)

smooth transitions

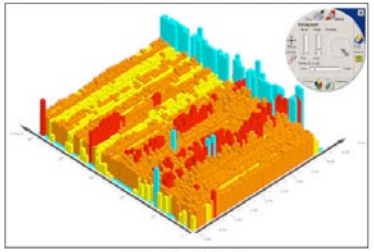


Fig. 1. A Parallel Bar Chart.

Midgaard 1/2

[Bade et al., 2004]

visualization of medical intensive care data

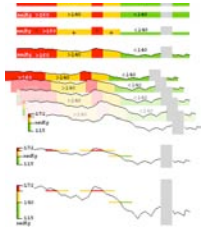
qualitative scales

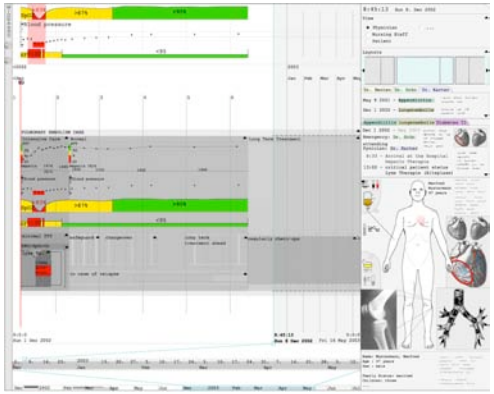
quantitative scales

qualitative / quantitative hybrids

semantic zoom

smoothly integrated





Midgaard 2/2

different granularities

vis of measurement deviation, trustability of data points, and missing data

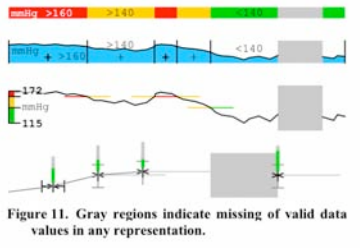


Figure 11. Gray regions indicate missing of valid data values in any representation.

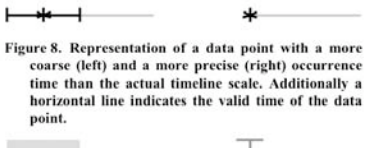


Figure 8. Representation of a data point with a more coarse (left) and a more precise (right) occurrence time than the actual timeline scale. Additionally a horizontal line indicates the valid time of the data point.

Figure 9. Visualization of measurement deviation by extending the representations as shown in Figure 8.

Figure 10. Trustability of data points represented by a green filled bar. (extending Figure 8).

TimeWheel / Zeitrad 1/2

[Tominski et al., 2003]

Time axis in the center

Variable axis arranged circularly

Lines connecting time and feature values

Similar to parallel coordinates

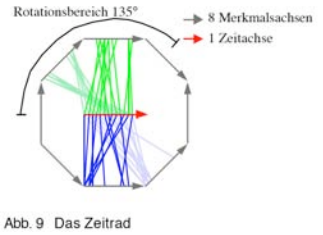
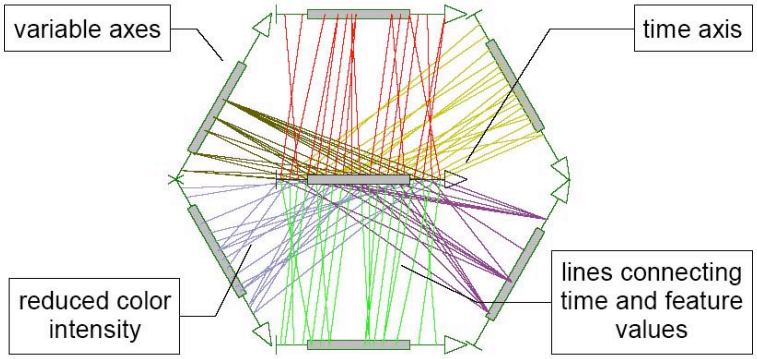


Abb. 9 Das Zeitrad

Variables parallel to time axis (upper and lower) can be explored most effectively

Focus + Context by shortening of rotated axis and color fading

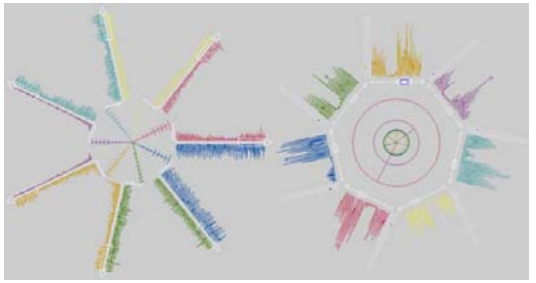
TimeWheel / Zeitrad *2/2*



User interaction:

Rotation of variable axes
(moving axes of interest into a position parallel to the time axis)

MultiCombs [Müller and Schumann, 2003]



Axis based technique

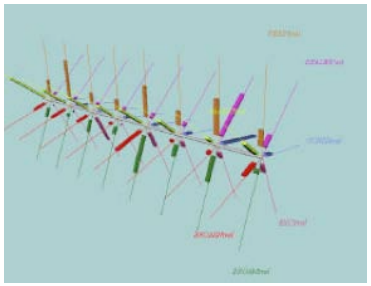
Multiple parameters on multiple time axis, circularly arranged

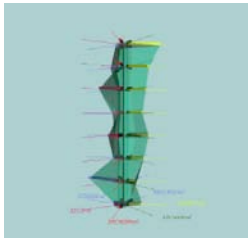
Outward from the center of star-shaped

Aggregated view of "past" values in the center

Temporal Star

[Noirhomme-Fraiture, 2002]





radial bar graph --> 3D over time

visualizing an object at different epochs

central axis represents time

transparent veil to enhance evolution

not suited for nominal data

Serial Periodic Data *1/6*

[Carlis and Konstan, 1998]

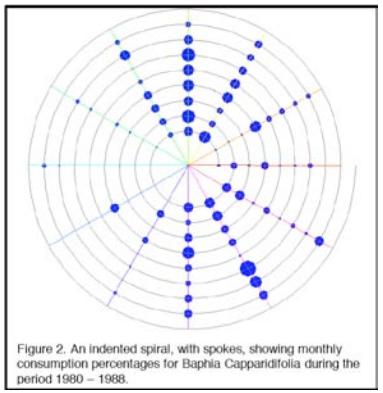


Figure 2. An indented spiral, with spokes, showing monthly consumption percentages for Baphia Capparidifolia during the period 1980 – 1988.

Visualize both, **serial** + **periodic** properties to reveal certain patterns

- Time continues serially, but weeks, month, and years are periods that reoccur

Map time onto a **spiral** + **spokes** for orientation

Data values are mapped to **blots** on spiral

- **Area** of blot proportional to value

Serial Periodic Data *2/6*

informations-visualisierung

<u>Pure</u>
serial periodic data

Periods with constant durations

<u>Event-anchored</u>
serial periodic data

Periods with different durations

Start of a new period is indicated by an event

Examples:

- Multi day racing data
- Project based time tracking

Serial Periodic Data *3/6*

informations-visualisierung

Figure 3. A spiral display of monthly consumption percentages for all 112 foods during the period 1980 – 1988.

Extension to 3D:

Z-axis for different sets of data
- No quantitative meaning of z-axis

Color coding of data sets

Lidless, hollow "cans"
- Instead of blots
- Prevent occlusion

Volume of can is proportional to data value

Pro: good overview

Cons:
- Occlusion
- Clutter
- Z-position meaningless
- Double mapping (z-pos + color)

Serial Periodic Data *4/6*

informations-visualisierung

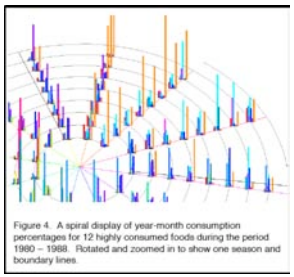


Figure 4. A spiral display of year-month consumption percentages for 12 highly consumed foods during the period 1980 – 1988. Rotated and zoomed in to show one season and boundary lines.

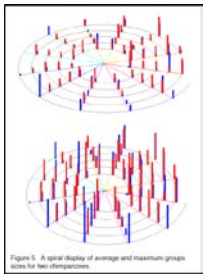


Figure 5. A spiral display of average and maximum groups sizes for two chimpanzees.

User control:
- Rotation, zoom, pan, tilt

Annotation features:
- Align different spirals vertically
- Definition of data derived border lines

Display of several data sets simultaneously
- Using bar charts
- Color coded

Multiple, linked spirals

Serial Periodic Data *5/6*

informations-visualisierung

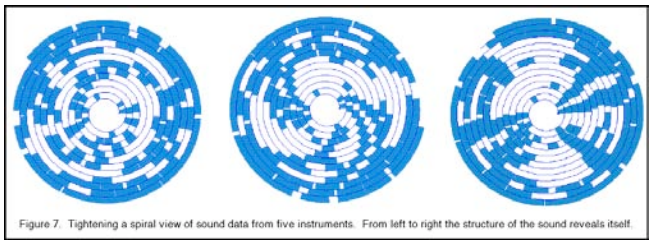


Figure 7. Tightening a spiral view of sound data from five instruments. From left to right the structure of the sound reveals itself.

Interval data
- Only duration of element

Periodicity unknown
- Animation

Serial Periodic Data *6/6*

informations-visualisierung

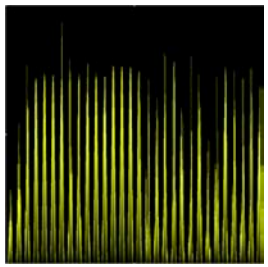
User experience findings:

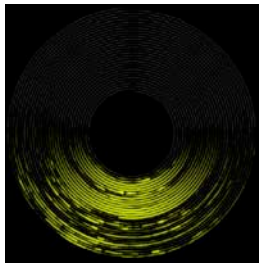
+ Users quickly accept the notion of serial periodic data on a spiral
+ Users react to the spiral displays
  When they saw patterns, they tried to explain them by telling stories
+ Users want more
  Visualization sparked interest for further investigation
- Tool not self explanatory
  Trained operator needed

Spiral Graph *1/3*

[Weber et al., 2001]

informations-visualisierung





Main intension: detection of periodic behavior

Mapping data onto a spiral

Mapping of data values to
– color and
– thickness of line

Nominal + ordinal + quantitative data

1 cycle = period length

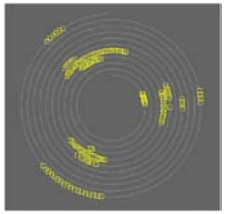


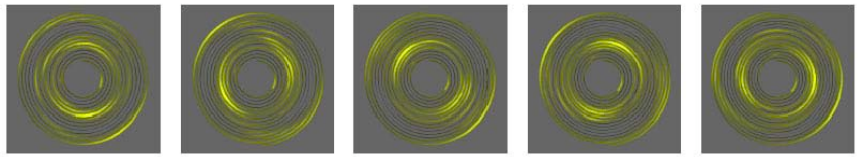
Figure 2:Nominal time-series data presented on a Spiral. The periodic behaviour of the underlying process is revealed.

Spiral Graph *2/3*

informations-visualisierung

Two possibilities to detect periodic behavior:

1. **Computational**:
   Compute frequencies with higher amplitudes via *Fourier Transformation*
2. **Visually**:
   Utilize the visual system of a human observer to discover structures
   Spiral is **animated** by continously changing the cycle length
   Periodic behavior becomes immediately apparent (changing from unstructured to structured)
   User can stop animation when period is spotted



Spiral Graph *3/3*

informations-visualisierung

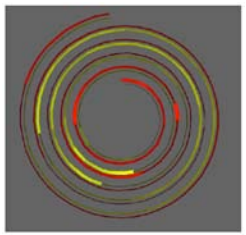


Figure 4:Stock prices of Microsoft (yellow) and Sun Microsystems (red) in five years on parallel spirals.

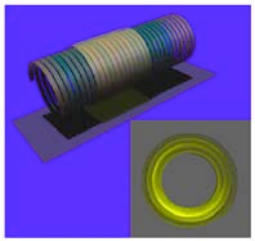


Figure 6:Using a helix in 3D to support intuitive browsing through a large data set.

Extensions:

Multi Spirals

Compare a data set with cyclic patterns in other data.

Rendering intertwined Spiral Graphs.

3D extension

Problem: space

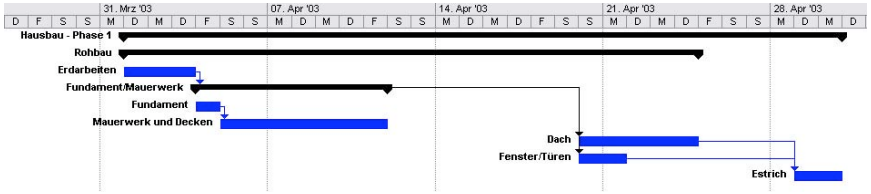
→ mapping onto a helix.

Brushing integrated.

Selected region is displayed in 2D spiral.

3D helix best used for navigation only.

GANTT charts *1/2*



Project management, project planning

Tasks and their temporal attributes (location, duration)

Milestones

Past + present + future

Hierarchical decomposition

GANTT charts *2/2*

Pros:

Well known representation

Collapsable hierarchical decompostion

Easy to comprehend

Hundreds of tools available (i.e. MS Project)

Cons:

No uncertainty

Space consumption (diagonal layout)

LifeLines *1/2*

[Plaisant et al., 1996, Plaisant et al., 1998]

Based on Time Lines

Facets

Visualizing personal histories and patient information

Horizontal bars showing temporal location and duration of data elements

Past + Present

http://www.cs.umd.edu/hcil/lifelines/latestdemo/kaiser.html **DEMO**

LifeLines *2/2*

Pros:

Simple and easy to comprehend

Better layout than GANTT

Use of vertical dimension

Interactive time scale (zoom, pan)

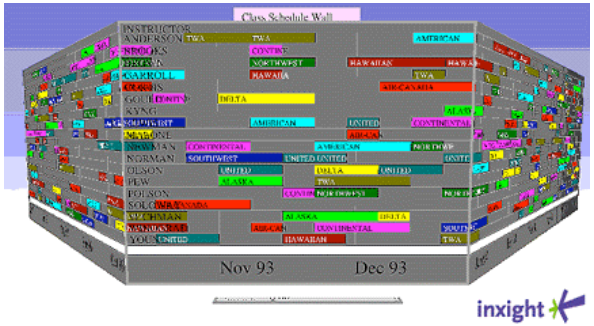
Cons:

No hierarchical decomposition (only Facets)

(Just past and present)

Perspective Wall

informations-visualisierung



[Mackinlay et al., 1991]

Large collections of documents

Focus + Context of elements over time

Intuitive 3D metaphor for distorting 2D layout

Color coding

Smooth transitions, 3D interactive animation

Dynamic Timelines

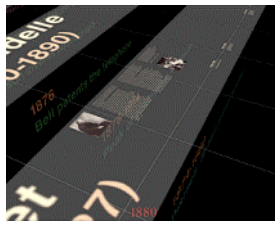
informations-visualisierung

[Kullberg, 1995; Kullberg, 1996]

3D presentation of **historical information**
- history of photography

seamless micro and macro readings
- semantic zoom
- translucency
- animated visual transition

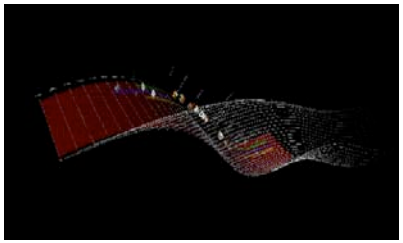
F+C by selective transparency (queries)

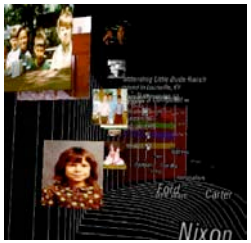


Timeline Cinematic Temporal Ride

informations-visualisierung

[Elise Co, 1997]





3D representation

timelines are created from date, image and text data

subjective reshaping and repositioning

animation / ride along an individual timeline

http://acg.media.mit.edu/projects/timelines/

The Historical Event Markup and Linking Project (HEML)

informations-visualisierung

http://www.heml.org/

Event	Date	Location
Newton is born	AD 1643 January 4	Woolsthorpe
Newton studies at Trinity College	AD 1661 June 5 -- AD 1668	Cambridge
Newton lays the foundations of calculus	AD 1665 June 1 -- AD 1667	Woolsthorpe
Newton publishes 'Philosophiae naturalis principia mathematica'	[AD 1687 -- AD 1687]	Cambridge
Newton dies	AD 1727 March 31	London

marking up web documents

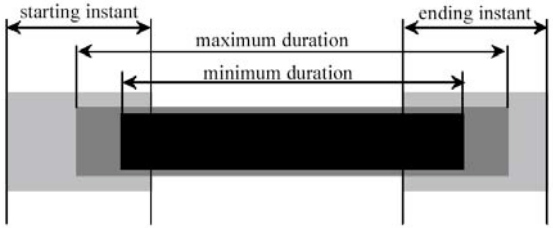
different representations
- **table**
- **timeline**
- **map**
- **animated map**

XML-Schema for historical events
- participants, dates, location, keywords, evidence (ref)

web service
- use of open technologies
- XSLT, SVG, Servlets, ...

Temporal Objects *1/2*

[Combi et al., 1999]



Depict data with different granularites
- Starting instant (earliest start, latest start)
- Ending instant (earliest end, latest end)
- Maximum duration
- Minimum duration

Based on LifeLines

Two encapsulated bars with caps at each end

Temporal Objects *2/2*

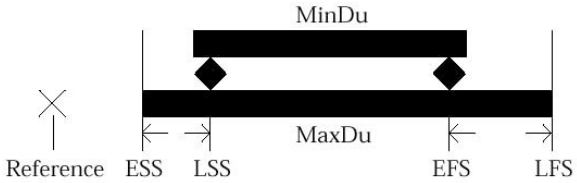
Pros:
- Simple representation for complex time attributes
- Different granularities
- Easy to comprehend

Cons:
- Only presentation, no interaction
- No direct manipulation

Time Annotation Glyph *1/2*

[Kosara and Miksch, 1999]

Definition:
[[ESS, LSS], [EFS, LFS], [MinDu, MaxDu], Reference]

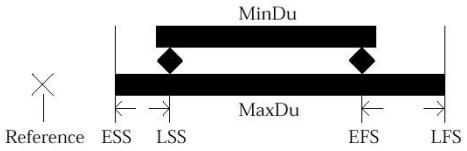


For representation of future planning data (uncertainty / indeterminacy)

Characteristics:
- Time points are relative (Reference point)
- Notion for temporal granularity
- Notion for missing values / incomplete specifications
- Metaphor of bar lying on diamonds (preventing invalid constellations)
- User interaction / can be manipulated

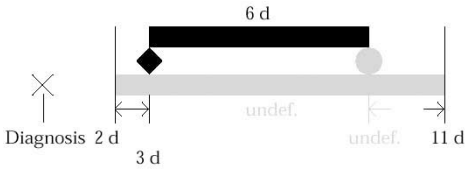
Time Annotation Glyph *2/2*

Definition:
[[ESS, LSS], [EFS, LFS], [MinDu, MaxDu], Reference]



MinDu and LFS defined to higher precision than time axis

Example: [[2 d, 3 d], [_, 11 d], [6 d, _], Diagnosis]



MinDu and LFS defined to lower precision than time axis

Paint Strips

[Chittaro and Combi, 2001]

Metaphor of **paint rollers**

Paint roller at the end of a line = line can expand

Wall = expansion limit

Smaller set of temporal attributes as “Temporal Objects” and “Time Glyph”

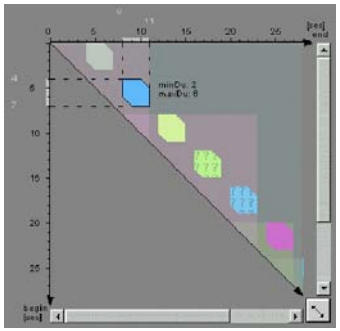
Combination of strips (rope)

Starting and finishing interval can’t be defined independently from duration

SOPOs *1/2*

[Messner, 2000]

Rit’s Set of Possible Occurences



2D technique

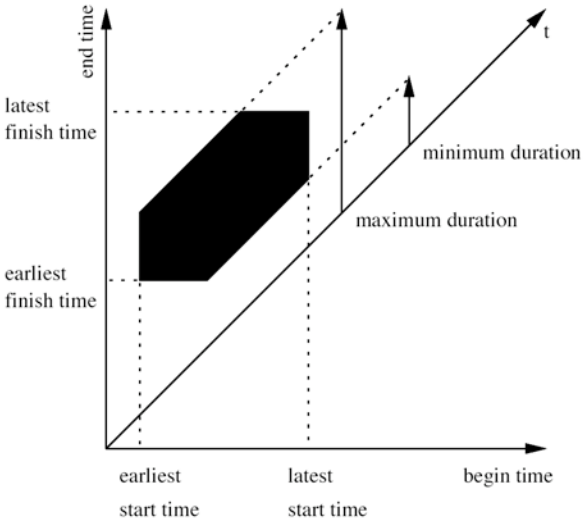
Area depicts set of valid (start, end) tuples

Designed for easy graphical propagation of temporal constraints

Cons:

- Representation more complicated than LifeLine based ones
- Space consumption

SOPOs *2/2*



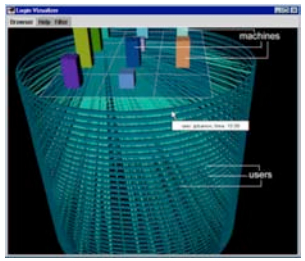
Start interval: x-axis

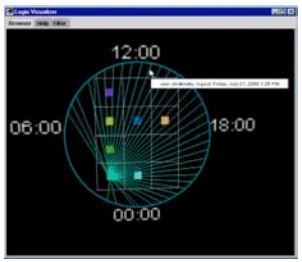
End interval: y-axis

Minimum duration, maximum duration: constraining borders parallel to 45° time flow axis

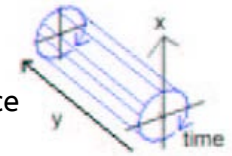
Intrusion Detection

[Muniandy, 2001]





Visualization of user access to machines over time.



Mapping:

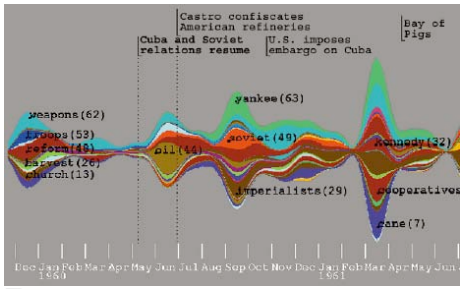
- Time: circumference
- User: cylinder slice
- Machines: cubes on top
- Access: connection lines

Annotations via tool tips (mouse hovering)

ThemeRiver™ 1/3

[Havre et al., 2000]

informations-visualisierung



MOVIE

Visualize thematic variations over time.

Across a large collection of documents.

River Metaphor: the "river" flows through time.

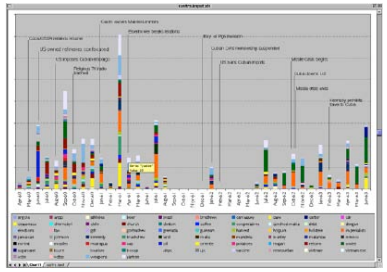
Changing width to depict changes.

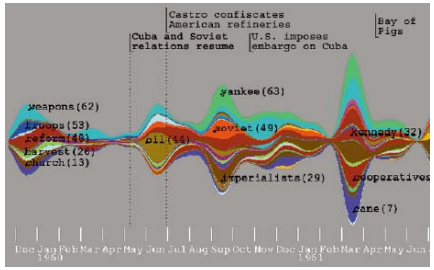
Themes or topics are colored "currents".

ThemeRiver™ 2/3

informations-visualisierung

Histogram vs. ThemeRiver™:





Discrete values

Exact values

Hard to follow a single current

Continuous flow

Interpolation, approximation

Easy to follow a single current (**curving continous lines**)

ThemeRiver™ 3/3

informations-visualisierung

User interaction:

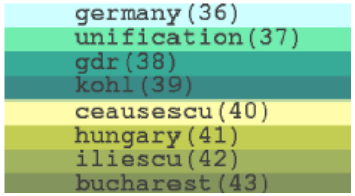
- Hide or display
  - topic + event labels
  - time + event grid lines
  - raw data points
- Choose alternate algorithms for line drawing
- Pan + Zoom

Color relations

- Related themes are associated to the same color family

Improvements:

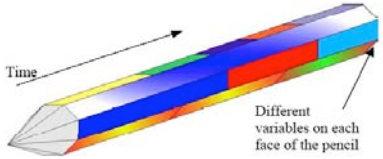
- Parallel rivers
- Display of numeric values (on demand)
- Total number of documents
- Access documents directly
- User defined ordering

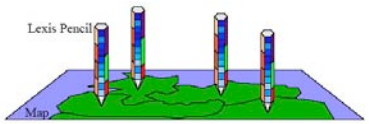


Lexis Pencil

[Francis and Pritchard, 1997]

informations-visualisierung





Pencil-like geometric objects

Mapping time-dependent variables onto faces of the pencil

Heterogeneous data

Can be located in 3D space to show the spatial context

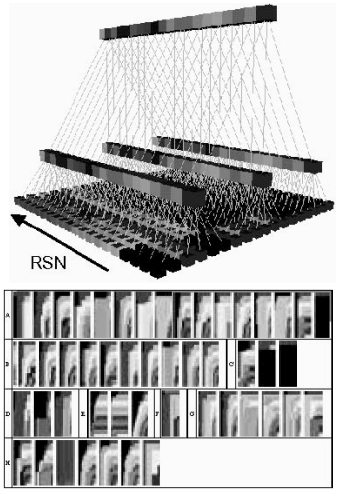
- Tip allows exact positioning
- Problem: Occlusion

Focus + Context

- On pencil: by radial arrangement
- In 3D space: enlarging pencil in focus

Software Evolution Analysis

[Jazayeri et al., 1999]



Analyzing evolution of SW-systems / product families

3D visualization

Colors encode versions

Changes of parts over time

Hierarchical decomposition

Pattern analysis

Not as information rich as Time-wheel

PeopleGarden 1/2

[Xiong and Donath, 1999]

Figure 8. A PeopleGarden showing messages from a message board with 1200 postings over a 2-month period. Height of flower denotes amount of time a user has been at the board.

on-line environment user visualization

flower metaphor for individuals

garden metaphor for environment

visualization of social network / behavior

PeopleGarden 2/2

[Xiong and Donath, 1999]

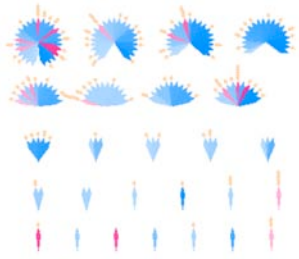


Figure 9. A PeopleGarden sorted by amount of postings. Magenta denotes initial postings, and blue replies. (See http://graphics.lcs.mit.edu/~becca/papers/pgarden for colored picture.)

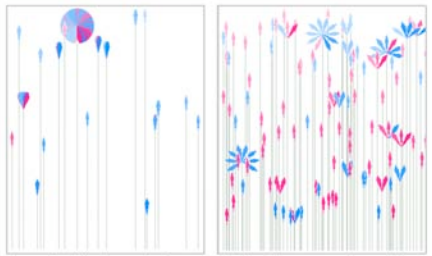


Figure 2. What can data portraits like the ones above tell us about discussion groups? A group with a dominating voice vs. a more democratic group.

time of posting --> ordering, saturation

amount of response --> circles on top of petals

whether a post starts a **new conversation** --> color

how long a user is on the board --> flower height

history flow 1/2

[Viegas and Wattenberg, 2003; Viegas et al., 2004]

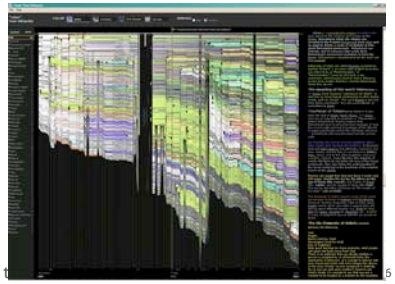
Wiki web visualization (Wikipedia)

evolution of entries

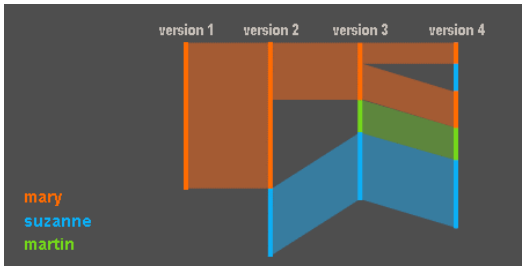
finding collaboration patterns

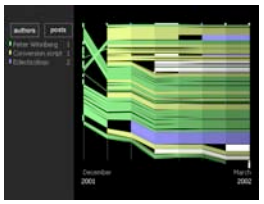
- revealed complex patterns of cooperation and conflict
- i.e. “self healing” - malicious edits were typically repaired within 2 minutes

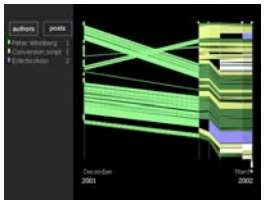
show relationships between multiple document versions



history flow 2/2







vertical revision lines
- length is proportional to text length

different colors for authors (original author)

gaps in connections clearly highlight deletions and insertions

“space by occurence” vs. “space by date”

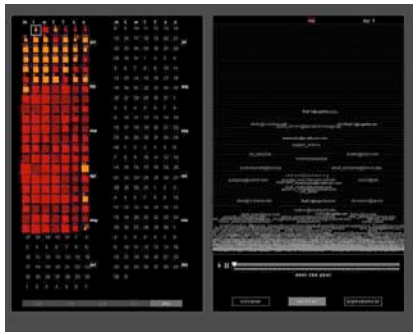
PostHistory 1/2

[Viegas et al., 2004]

visualizing **email activities**
- dyadic email relationships (people)
- time

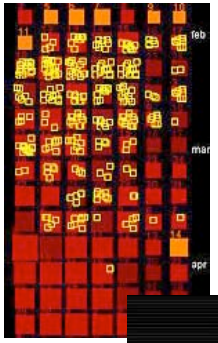
uncover email patterns
- social networks
- email exchange rhythms
- the role of time in these patterns

mail traffic vs. content

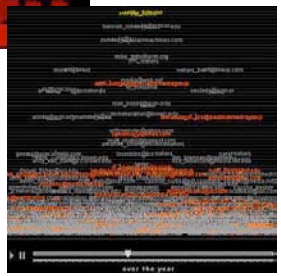


aggregates
- Daily email averages (send / receive)
- Daily "quality" of emails (directly / copy / mailing list)
- Frequency of email exchanges with contacts
- Comparative frequency of email exchanges with contacts

PostHistory 2/2



calendar panel
- intensity of email exchanges over time
- each square represents a single day
- row --> week; one year at a time
- amount of received emails --> size of square
- personal or directed (mailing-list) --> color (average is calculated)



contacts panel
- names of the people who have sent messages to the user
- different layouts

interaction by highlighting and animation through time

Anemone

[Fry, 1997]

organic information design

evolution of webpage usage (visited pages)

branches are created when visited for the first time

branches that are visited often, grow

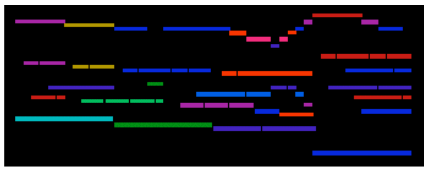
pages that aren’t visited slowly fade away

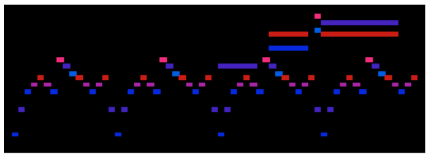
user interaction

http://acg.media.mit.edu/people/fry/anemone/

Music Animation Machine (M.A.M.) *1/2*

[Malinowski]





Visualization of music

Dynamic representation

Relate audio to visual structure

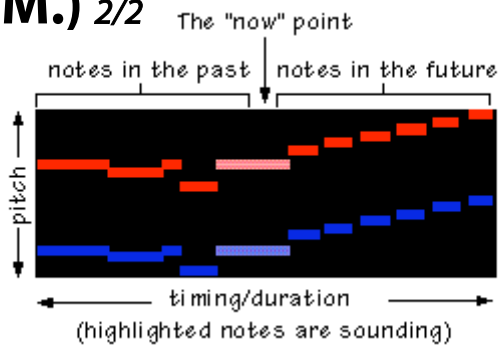
Simple representation for music

extremely complex system

Complex patterns

Online:
http://www.well.com/user/smalin/mam.html

Music Animation Machine (M.A.M.) *2/2*



Each note is represented by a colored bar

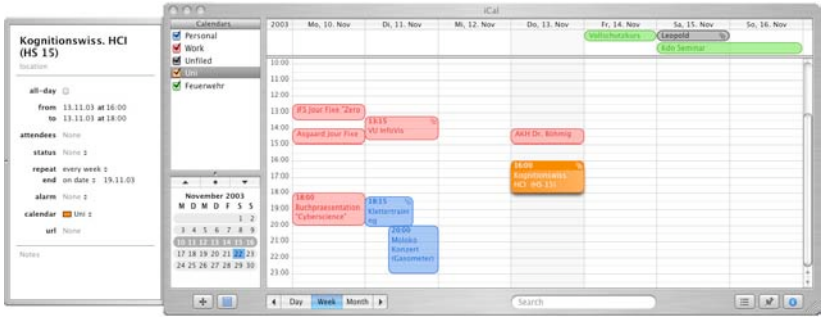
Each bar lights up as its note sounds

The length of each bar corresponds exactly to the duration of its note as performed

The vertical position of the bar corresponds to the pitch

The horizontal position indicates the note's timing

Calendar Tools



Past + present + future

Calendar scale

Events over time, repeating events

Icons, Reminder

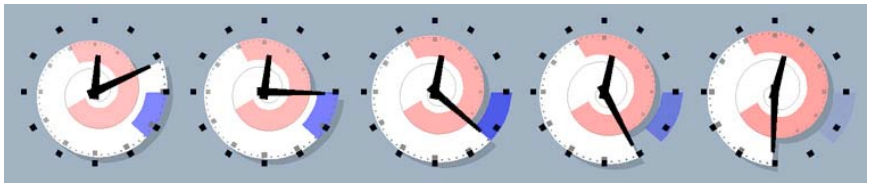
Very well known (MS Outlook, iCal, …)

Interactive Techniques:

- Overview + Detail
- Zoom
- Filter
- Details on Demand
- Multiple Views
- Focus + Context

SpiraClock *1/2*

[Dragicevic and Huot, 2002]

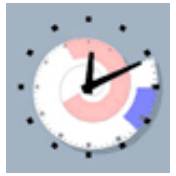


Visualization technique for nearby events.

Intention: fill gap between static calendar and pop-up reminders.

Continuous and non-intrusive feedback.

Analog clock with white spiral inside representing near future.



SpiraClock *2/2*

Interaction:

- Change time by moving hands.
- Adjust number of spiral revolutions (visibility of future events)

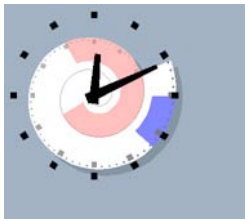
Range: 1 hour - several days

Not suited for all kinds of events

- *i.e. conference, 20. - 25. October*

Java applets and applications:

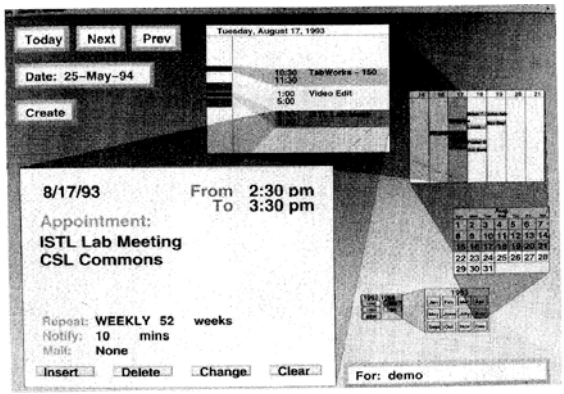
- http://www.emn.fr/spiraclock
  - Bus schedule, MS Outlook and vCal import



DEMO

Spiral Calendar

[Mackinlay et al., 1994]



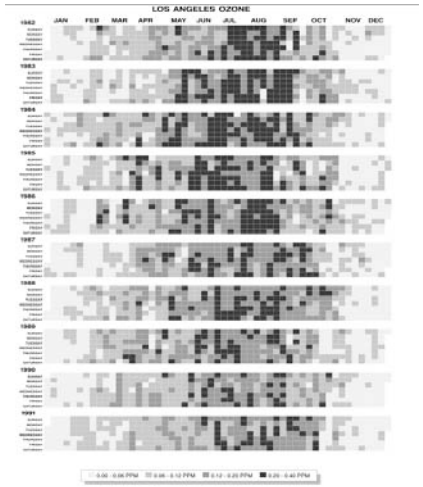
individual schedule

3D spiral layout

behaviour: clicking, animation

animated transitions

TileMap / Matrix Vis.



visualization of **quantitative histories**

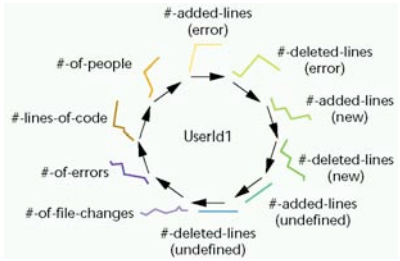
- histories whose values are numbers

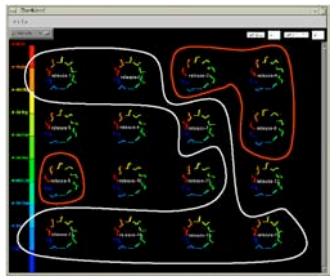
each square represents one day

good for displaying data with a seasonal pattern

Time-wheel *1/3*

[Chuah and Eick, 1997]





Visualization of **software projects** over time

Multiple time-series placed in a circle

Data attributes are color coded

Global trends

Helps to examine different trends within one object

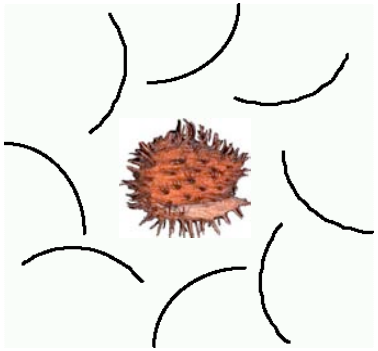
Easy recognition of two trends:

- Increasing trend
- Tapering trend

Time-wheel *2/3*

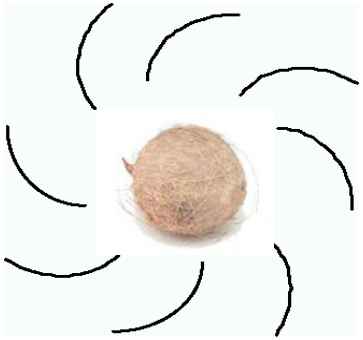
informations-visualisierung

Increasing trend



„Prickly fruit“

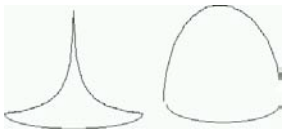
Tapering trend



„Hairy fruit“

Time-wheel *3/3*

informations-visualisierung



Extension to 3D:

Encodes the same attributes as the Time-wheel

Uses height dimension to encode time

Variables are encoded as slices of a base circle

Pro: Easier to identify overall trends

Cons:

- Occlusion
- Perspective

10x10

[J. Harris, 2004]

http://www.tenbyten.org/10x10.html

informations-visualisierung

100 words and pictures that define the time

RSS news feeds are scanned + linguistic analysis --> top 100 words

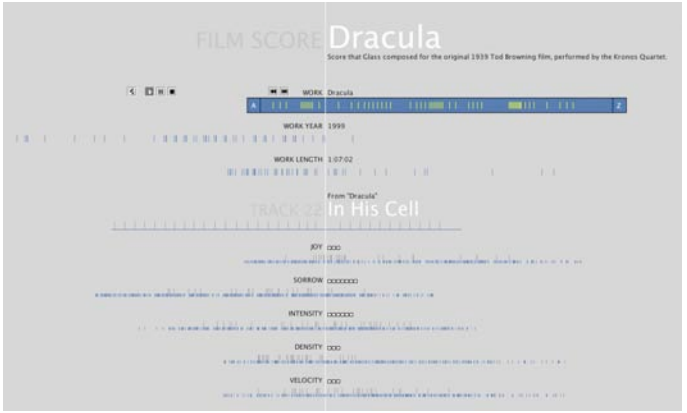
fisheye menu for selecting words

Glass Engine

http://www.philipglass.com/glassengine/#

[IBM T.J. Watson Research Center]

informations-visualisierung

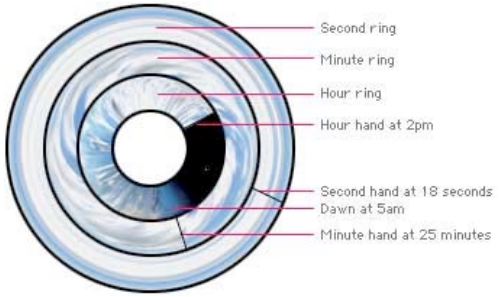


music of Philipp Glass

navigation along various attributes

Last Clock

[Cooper and Ängeslevä, 2002]



"Last' is a clock that is a record of its own history"

video input data

different zoom levels / display of
- last minute
- last hour
- last 12 hours

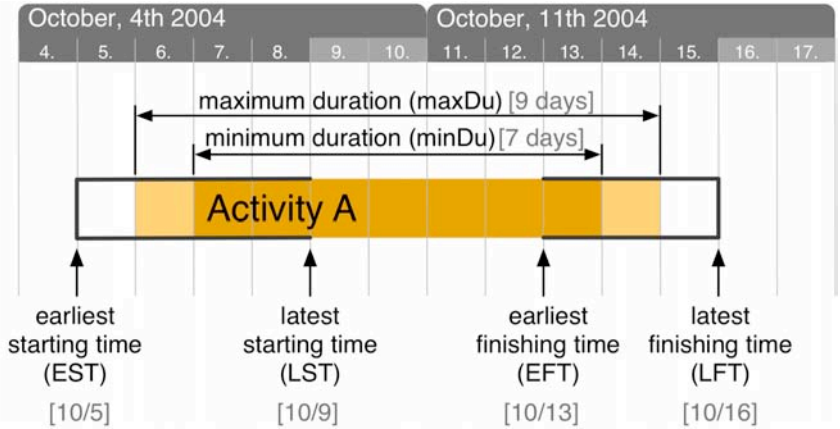
http://www.edleader.co.uk/last/

PlanningLines 1/2

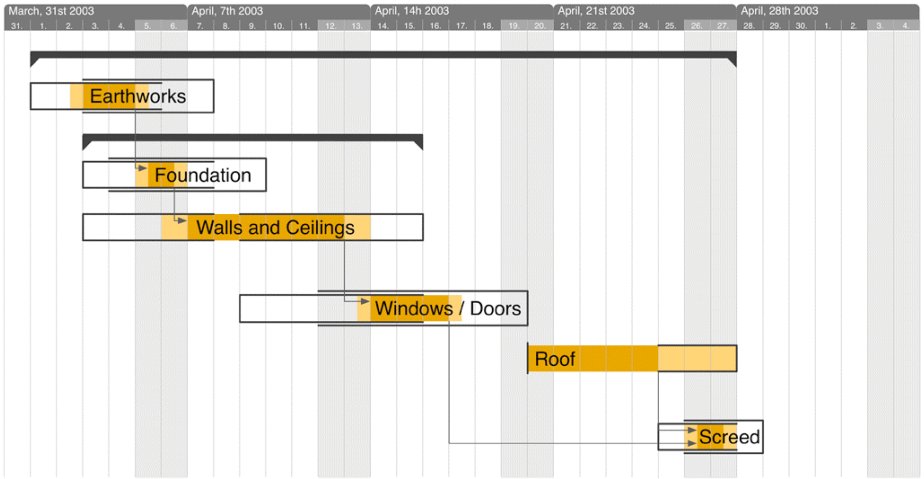
[Aigner et al., 2005]

Begin and end are intervals rather than instants

Complex set of attributes presented „at a glance"



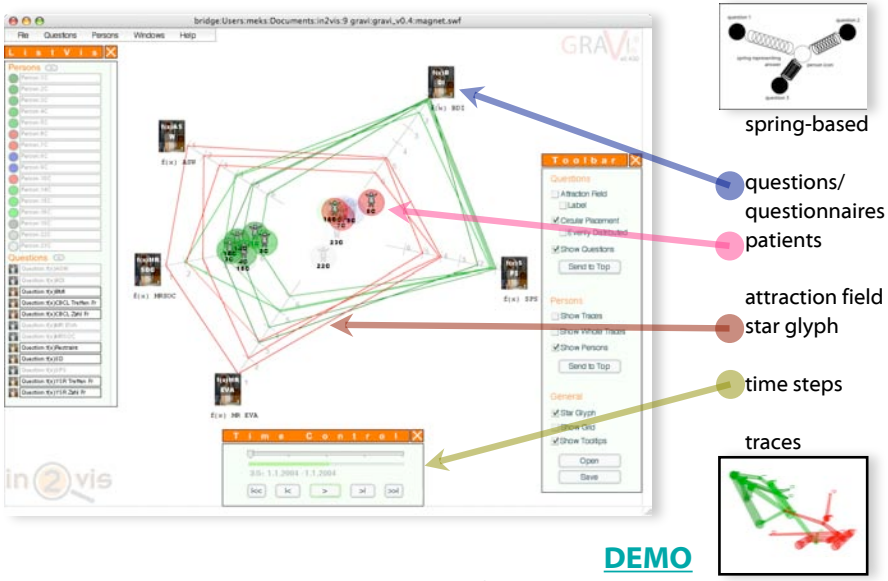
PlanningLines 2/2



DEMO

GRAVI++

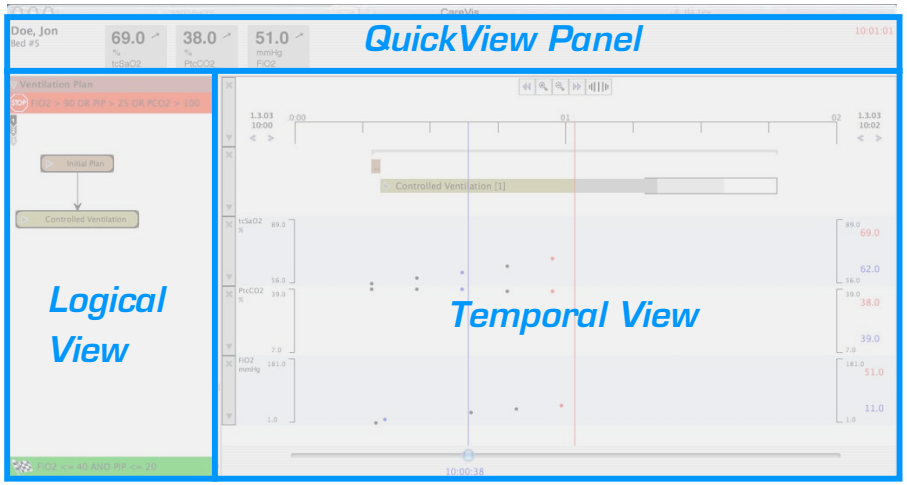
[Hinum et al., 2005]



DEMO

CareVis

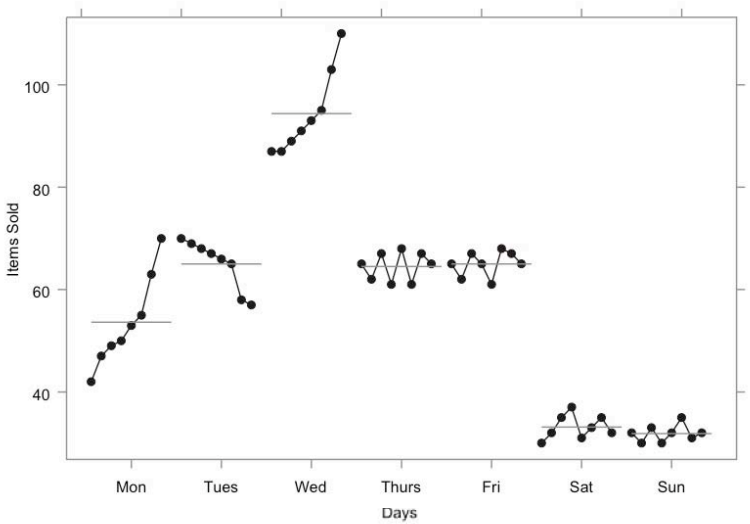
[Aigner et al., 2004]



integrated visualization of computerized protocols and temporal patient data

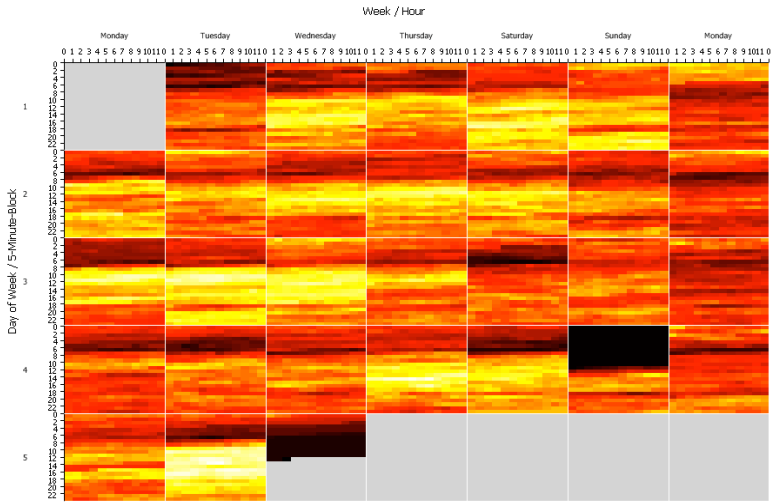
Cycle-Plot

[Cleveland, 1994]



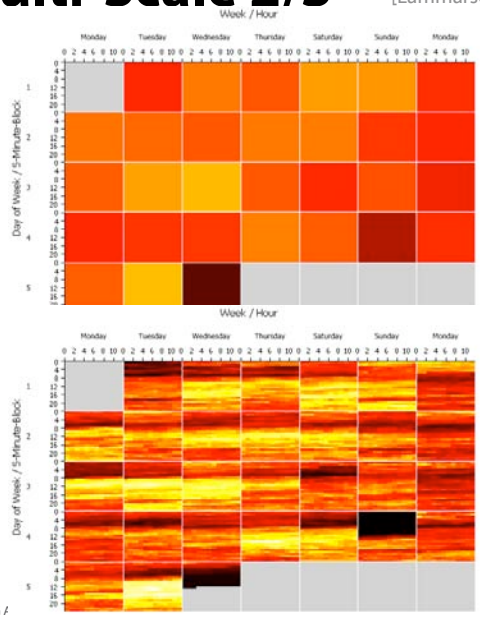
Multi Scale 1/3

[Lammarsch, 2008]



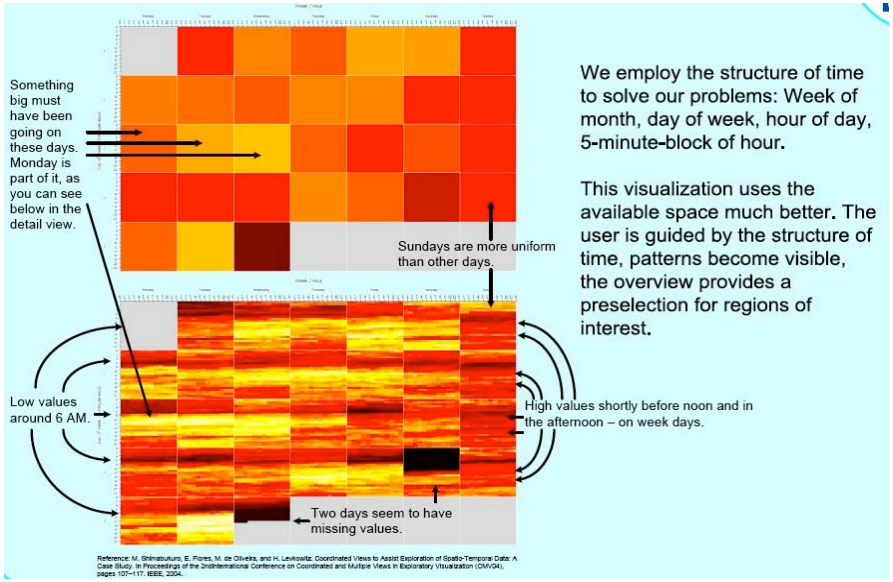
Multi-Scale 2/3

[Lammarsch, 2008]



Multi-Scale 3/3

[Lammarsch, 2008]



We employ the structure of time to solve our problems: Week of month, day of week, hour of day, 5-minute-block of hour.

This visualization uses the available space much better. The user is guided by the structure of time, patterns become visible, the overview provides a preselection for regions of interest.

Reference: M. Shimabukuro, E. Flores, M. de Oliveira, and H. Levkowitz, Coordinated Views to Assist Exploration of Spatio-Temporal Data: A Case Study. In Proceedings of the 2ndInternational Conference on Coordinated and Multiple Views in Exploratory Visualization (CMV04), pages 107–117. IEEE, 2004.