Part 3

Icon-based Techniques

Chernoff-Faces,
Stick Figures, ...

Icon-Based Technique

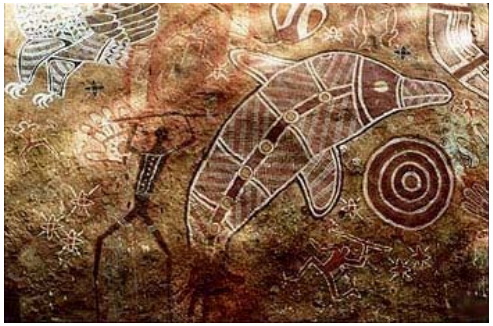
Basic Idea

Visualization of Data Values as Features of Icons (Glyphs)

ISOTYPE	[Neurath 1945]
Chernoff-Faces	[Chernoff 1973; Tufte 1993]
Stick Figures	[Pickett, et al. 1988/90]
Shape Coding	[Bedderson 1994]
Color Icons	[Levkowitz 1991]
Pixel-based Techniques	[Keim, et al. 1996, ff]
Mosaic Metaphor	[Nocke, et al. 2005]
AsbruView	[Kosara, et al. 2001]
SopoView	[Messner, et al. 2000]
VIE-VISU	[Horn, et al. 1998]
TimeWheel & InfoBug	[Chuah & Eick 1998]

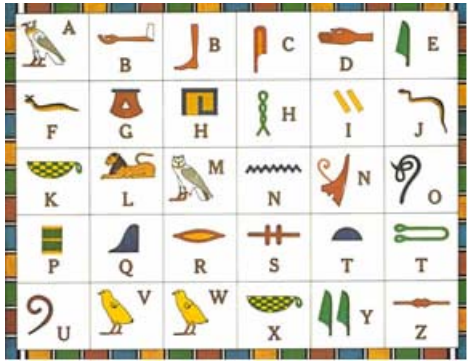
Cave-Painting ("Höhlenmalerei")

Lascaux (France)



Australia

Egyptian Hieroglyphs



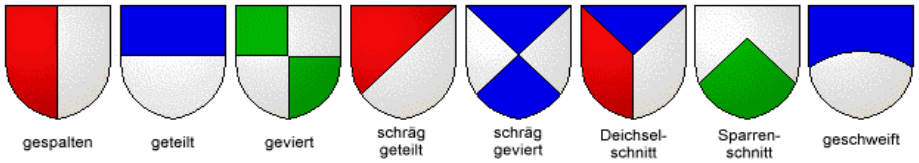
Scottish Tartan ...

Scottish Tartan from
MacCrae-Clans

Irish Tartan
from Dublin

Heraldry

Meaning and Sense of Heraldic
Figures/Arms



Traffic Signs and Warnings

Definitions - Concepts

Symbols

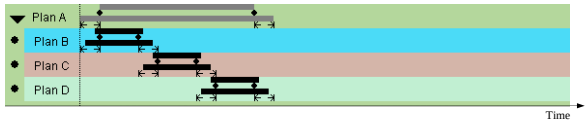
Meaning as a Whole

Glyphs

Graphical Objects,
Whose Features Reflect Values

Healthy

Graphical Primitives



Icons

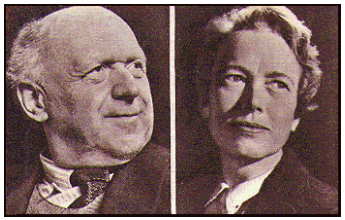
Synonym to Glyph

Information Graphics

Otto u. Marie Neurath

Otto: 1882-1945

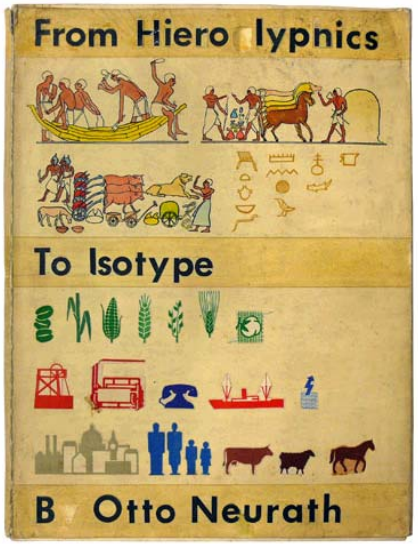
Marie: 1898–1986

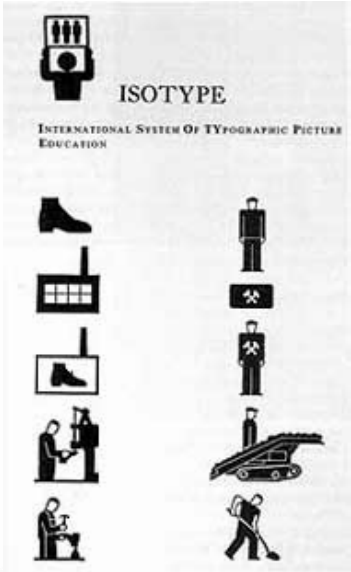


ISOTYPE:

International **S**ystem **o**f **T**ypographic **P**icture **E**ducation

ISOTYPE

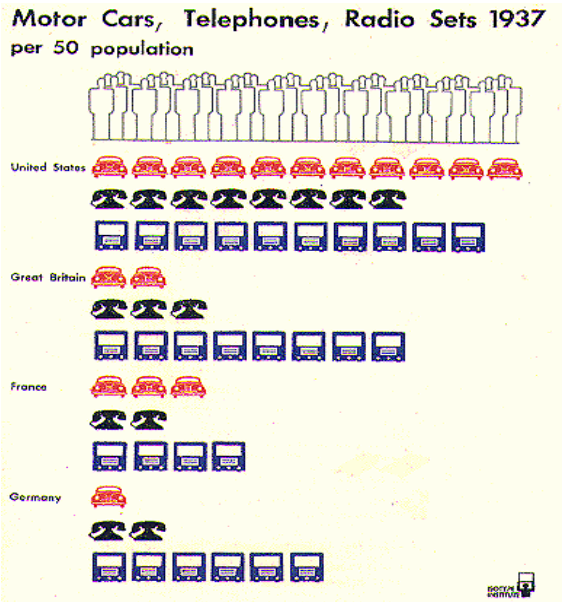




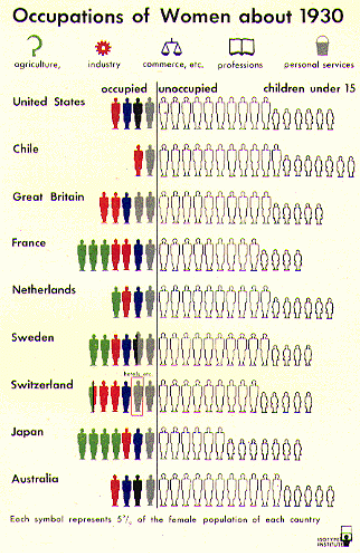
From hieroglyphics to Isotype

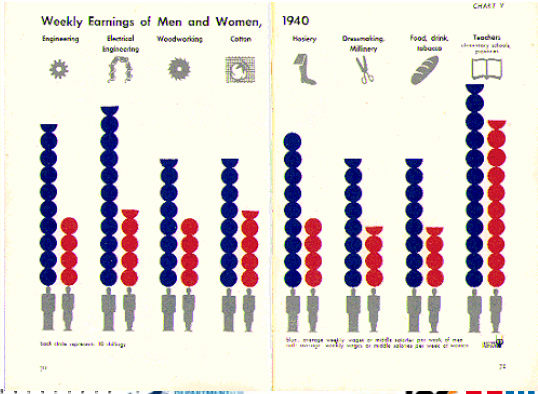
cover design / mock-up, Otto Neurath / Isotype Institute, c.1944, (I.C. 3.2/87)

ISOTYPE

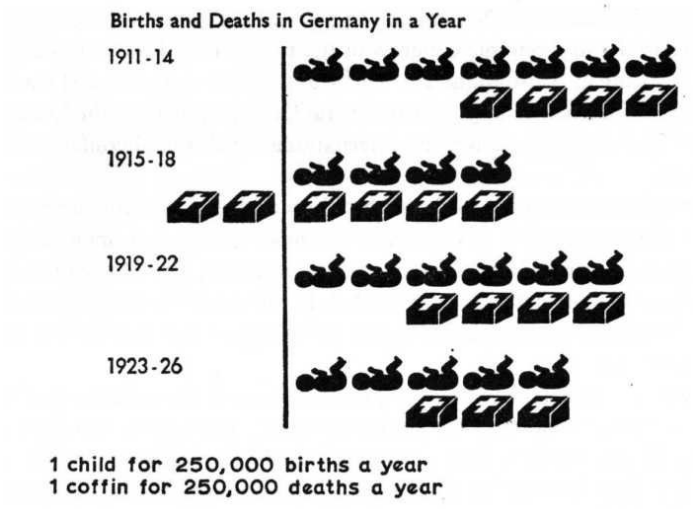


ISOTYPE





ISOTYPE



Book ...

Frank **Hartmann** und
Erwin K. **Bauer**
Bildersprache:
Otto Neurath
Visualisierungen

facultas.wuv
Universitätsverlag
Wien, 2002/2006, 168 p.
ISBN 3-85114-704-9

[Glyphs] Chernoff Faces

[Chernoff 1973; Tufte 1993]

Idea

Data Set → Attributes/Properties of a Face
Schematically Simplified Version
Easy to Comprehend

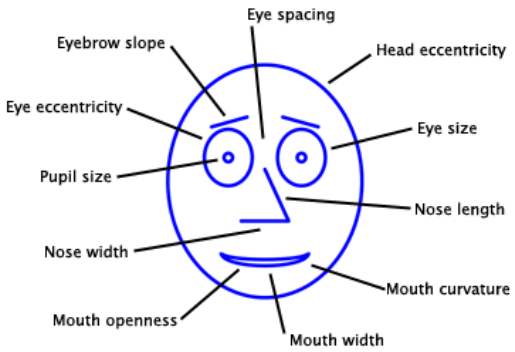
Fitting

Explorative Data Analyses
Glyphs / Icons
Multivariate Data

[Glyphs] Chernoff Faces

10 Parameters (Properties of a Face)

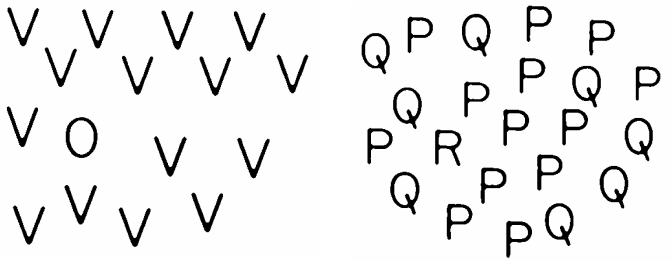
Head Eccentricity
Eye Eccentricity
Pupil Size
Eyebrow Slope
Nose Size
Mouth Vertical Offset
Eye Spacing
Eye Size
Mouth Width
Mouth Openness



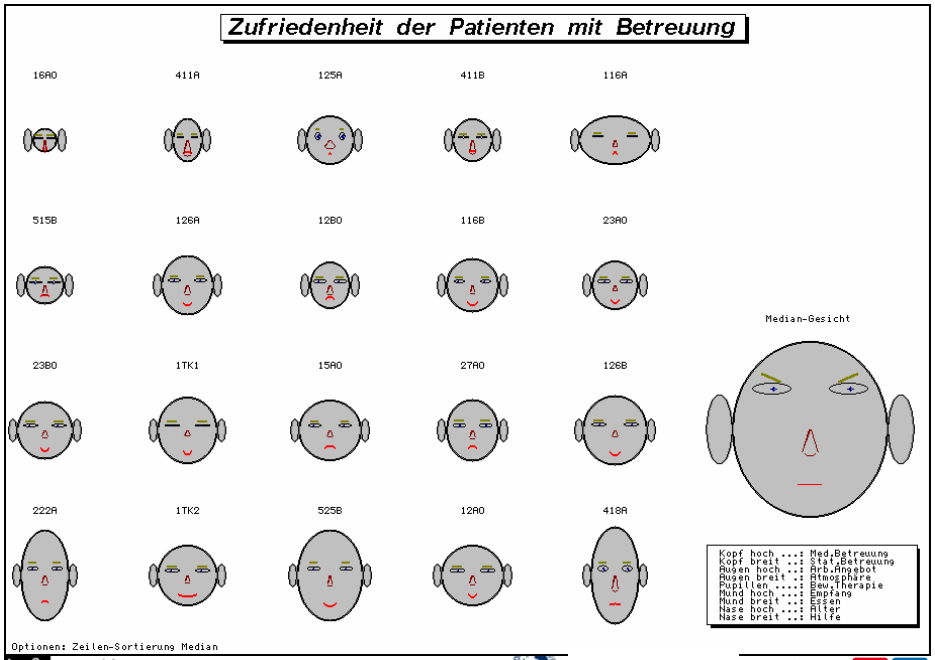
Background

Education - Psychology

Preattentivity



Gestalt - Perception

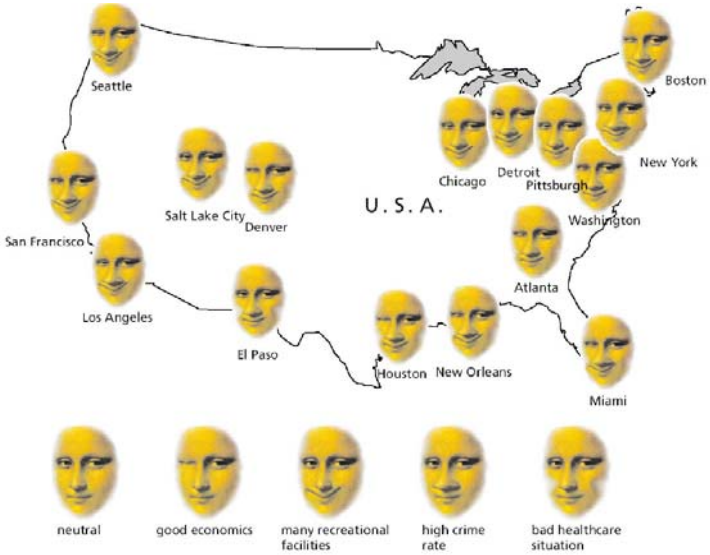


[VGSPS, 2002]

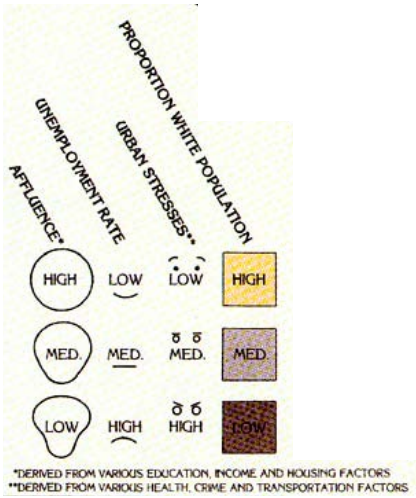
Example

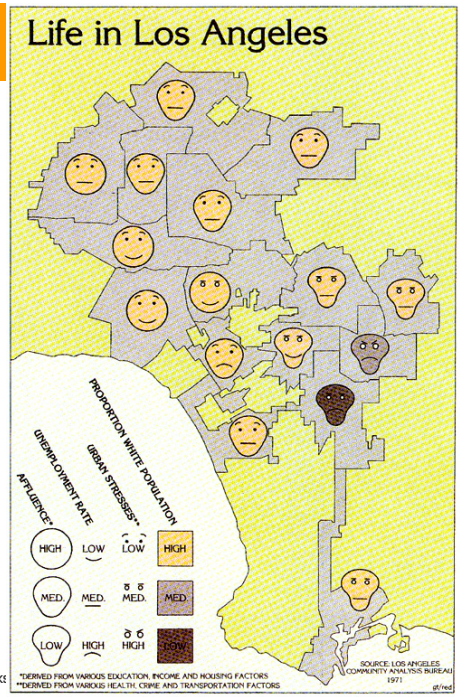
[Müller & Alexa, 1998]

Mona Lisa

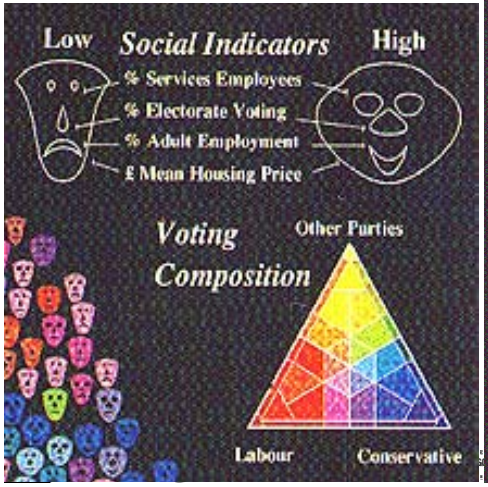


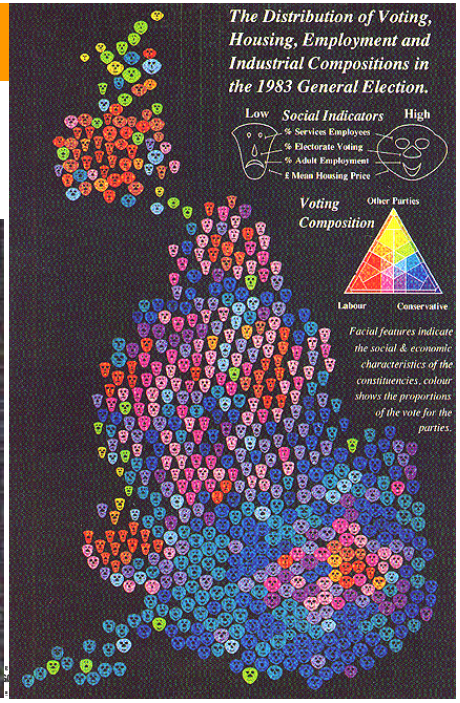
Example



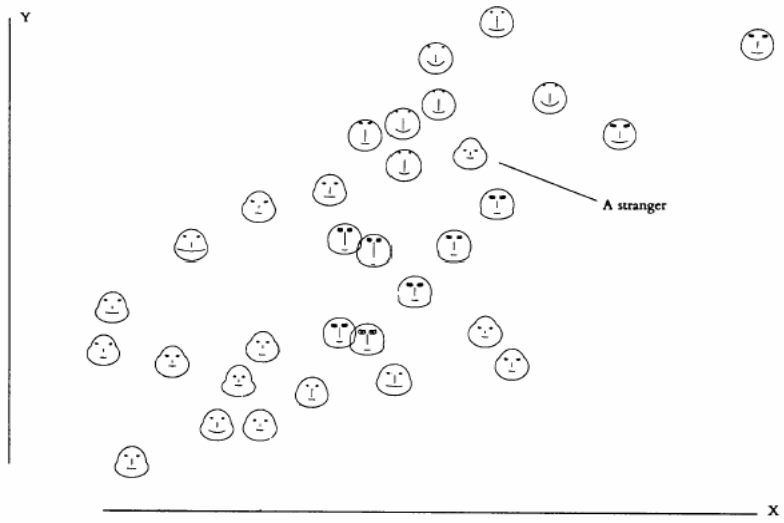


Example

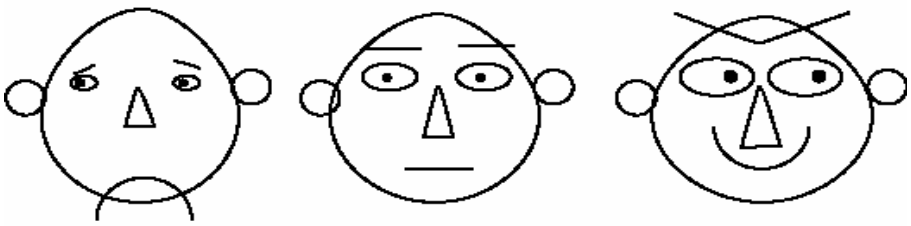




Another Example



Classification

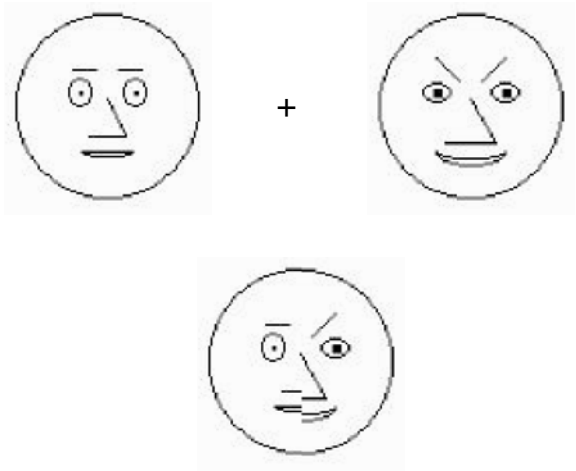


Distressed Neutral Healthy

A template for failure classification: alternative outcomes from the assignment of financial variables to facial characteristics

Data Reduction

[Morris, et al. 1999]



Efficiency - Preattentivity

[Morris, et al. 1999]

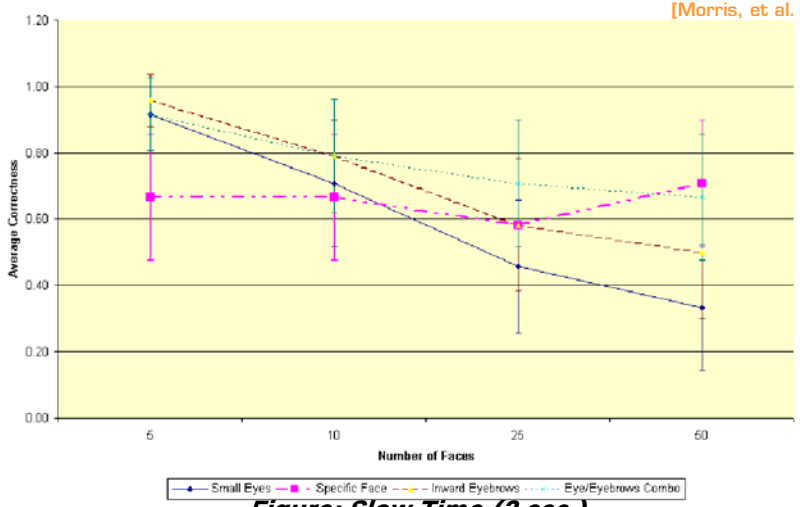


Figure: Slow Time (2 sec.)

0,4 - 2 sec. : Needed to Recognize Object => ***Not Preattentive***

Conclusion

Decision Support

Benefits are Relative

Problems Exist - Improvements

Loss the Real values

Experienced vs. Inexperienced

Training Needed

Efficiency ?

Preattentivity ?

Stick Figures

[Pickett, et al. 1988/90]

Multidim. Data (=multivar.)

2-dim. / 4 "Arms Figures"

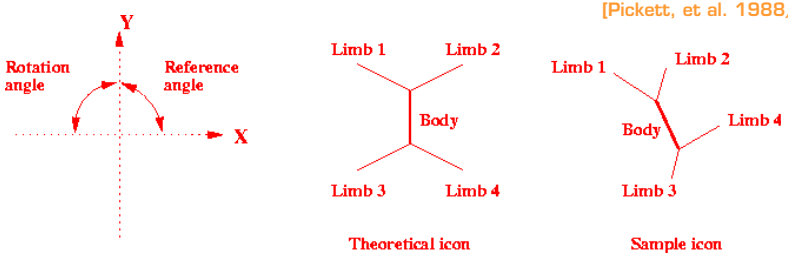
Two Attributes of the Data are Mapped to the Display Axes

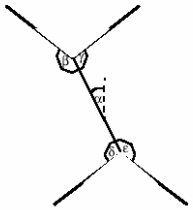
Remaining Attributes are Mapped to the Angle and/or Length of the Limbs

Texture Patterns in the Visualization Show Certain Data Characteristics

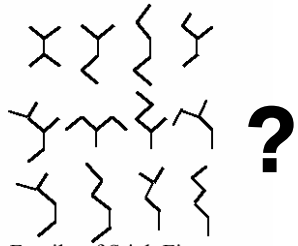
Stick-Figure Family

[Pickett, et al. 1988/90]





Stick Figure Icon



A Family of Stick Figures

Main Principle

[Pickett, et al. 1988/90]

Texture

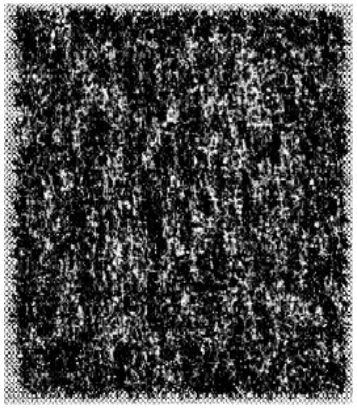
Easy to interpret and distinguish of textures

Color Coding

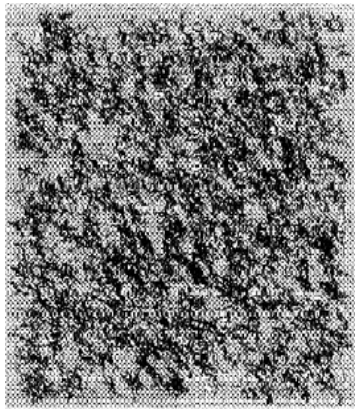
Geometric Coding

Preprocessing of Data

[Pickett, et al. 1988/90]



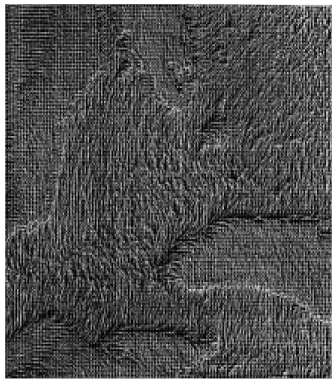
100% of the Data



10% of the Data

Images: Weather Satellites

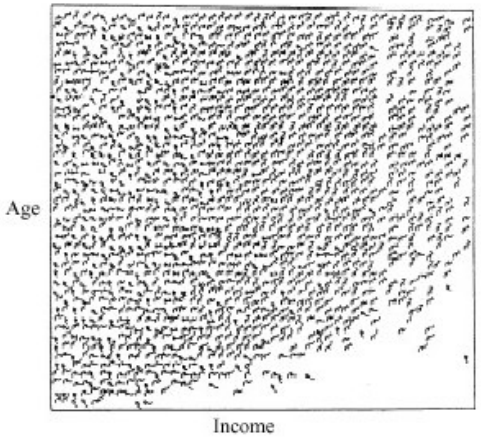
[Pickett, et al. 1988/90]

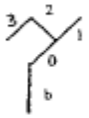


5-dim. Image from Great Lake Region

Census Data

[Pickett, et al. 1988/90]



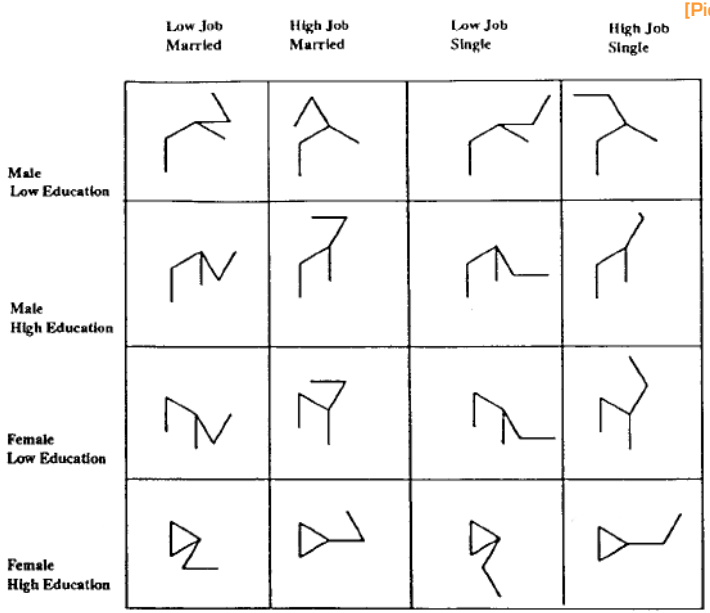


Icon Feature	Data Field
b	reference
0	Sex
1	Education
2	Occupation
3	Marital Status

Figure 6: Stick Figure Visualization of Census Data

Census Data

[Pickett, et al. 1988/90]



Shape Coding (1/2)

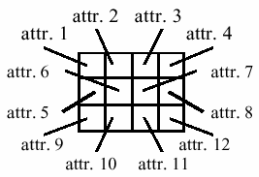
[Bedderson 1994]

Basic Idea

Data are Visualized Using Small Arrays of Fields

Each Field Represents One Value

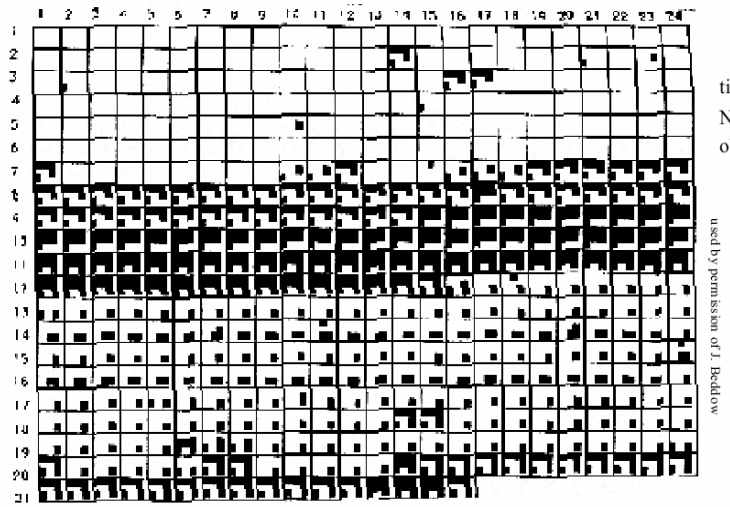
Arrangement of Attribute Fields (e.g., 12-dim. data)



Arrays are arranged line-by-line according to a given sorting (e.g., the time attribute for time-series data)

Shape Coding (2/2)

[Bedderson 1994; Keim 2001]



time series of NASA earth observation data

used by permission of J. Beddow

Color Icons (1/2)

[Levkowitz 1991]

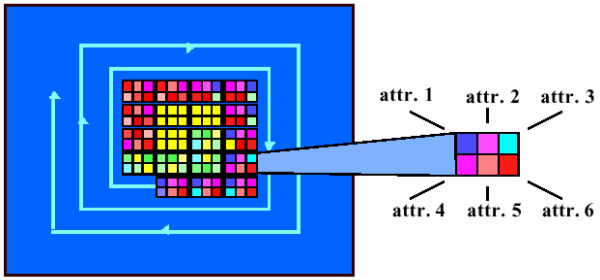
Basic Idea

Visualization of the Data Using Color Icons

Color Icons are Arrays of Color Fields Representing the Attribute Values

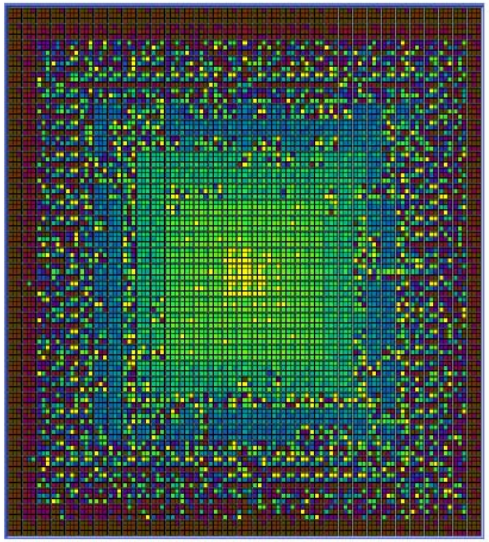
Arrangement is Query Dependent (e.g., spiral)

schematic representation of 6-dim. data



Color Icons (2/2)

[Levkowitz 1991]



random data containing several clusters

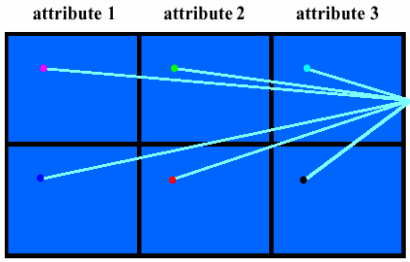
Pixel-Based Techniques

[Keim, 2001]

Basic Idea

- Each Attribute Value is Represented by One Color Pixel
  - Value Ranges of the Attributes are Mapped to a Fixed Color Map
- Attribute Values for Each Attribute are Presented in Separate Subwindows

visualization of six-dim. data



attribute values of a data item

[Pixel-Based ...] Overview

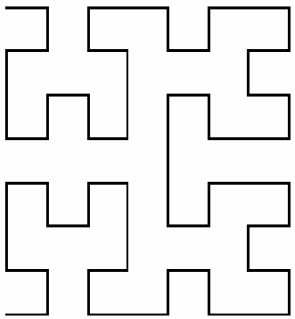
[Keim, el al 1996, 2001 ff]

Query-Independent Techniques
- Simple Techniques
- Space-Filling Techniques
- Recursive Pattern Techniques
- …

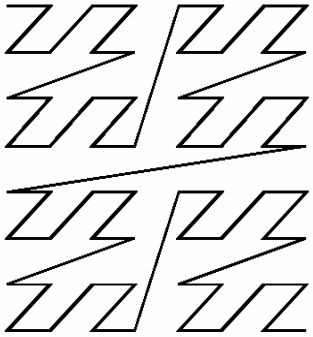
Query-Dependent Techniques
- Spiral Techniques
- Axes Techniques
- Circle Segments
- …

Query-Independent Techniques

Space-Filling Curve Arrangement



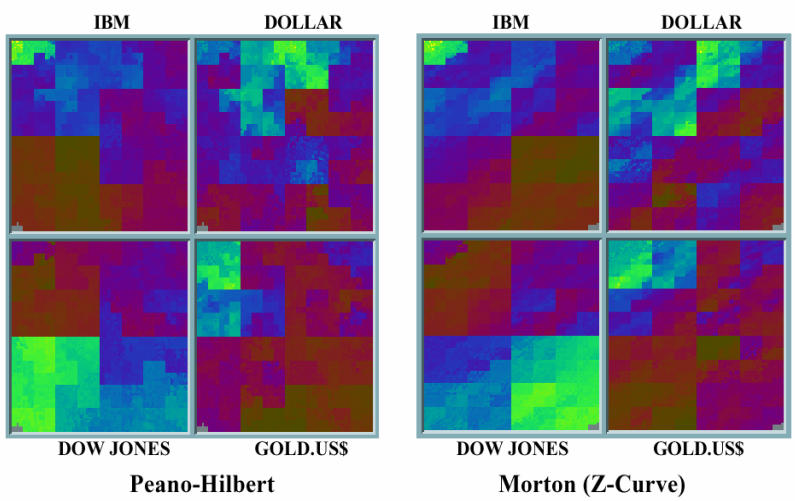
Peano-Hilbert



Morton (Z-Curve)

Query-Independent Techniques

Space-Filling Curve Arrangement

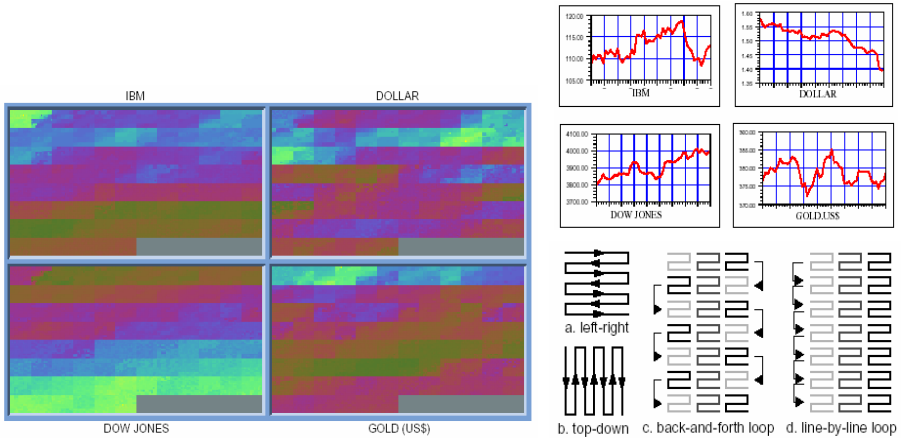


Peano-Hilbert

Morton (Z-Curve)

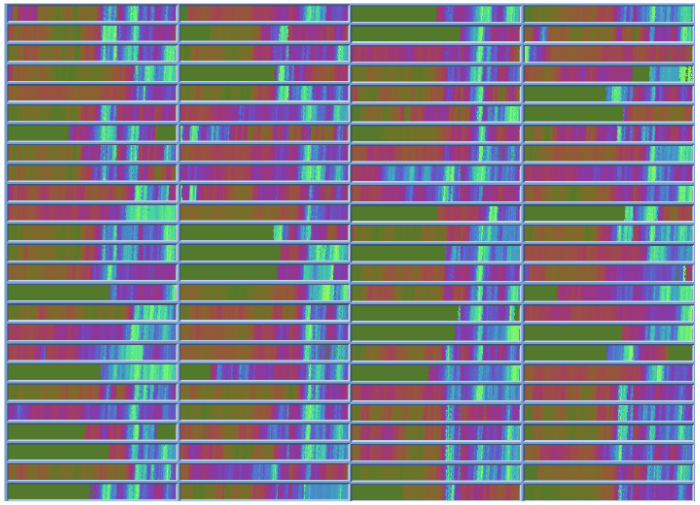
Query-Independent Techniques

Recursive Pattern Techniques



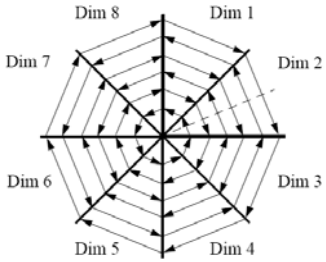
Query-Independent Techniques

Recursive Pattern: FAZ-Index (Jan. '74 - Apr. '95)

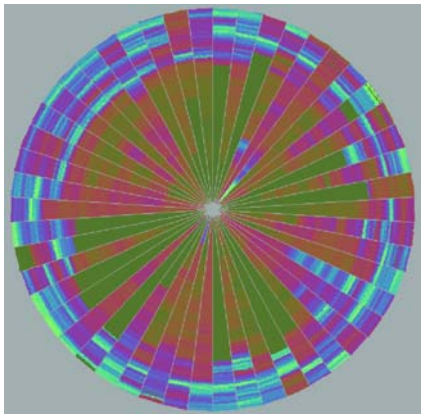


time series of
of the 100 stocks
in the Frankfurt
Stock Index

Query-Dependent Techniques



Arrangement of 8-dim. Data



Circle Segments visualizing
50 Stocks from Jan. '74 to Apr. '95
(over 265,000 data values)

[Nocke, et al. 2005]

Icon-based Visualization using Mosaic Metaphors

Thomas Nocke, Stefan Schlechtweg, Heidi Schumann: Icon-based Visualization using Mosaic Metaphors. Proceedings IEEE Symosium Information Visualization (IV'05), London, 2005.

Approach

[Nocke, et al. 2005]

Cartography Methaphor

Replace Abstract Icons by Methaphor Icons

Image Mosaics

- Created from other Smaller Images which together Portray a Larger Subject
- Steps
  - Choose Images Which are to be Used As Mosaic Tiles
  - Choose a Tiling Grid
  - Find an Arrangement for the Mosaic Tiles in the Grid
  - Possibly Perform a Color Correction on the Tiles to Match the Target Image
- Global View & Small Details

Application Maize Harvest Data Set

[Nocke, et al. 2005]

Input

- Numerical,
- Multi-Variate Data

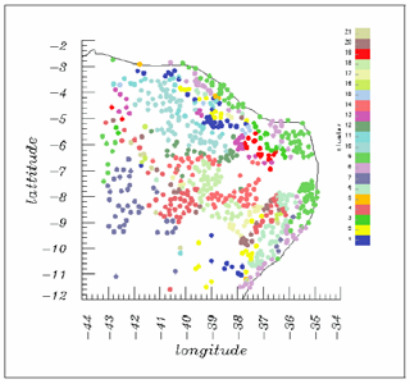


Figure 1. Visualization of clusters representing the risk of a drought for maize cultivation during the year 1983 in the semi-arid Northeast of Brazil based on regional climate model results.

Mosaic Pattern

[Nocke, et al. 2005]

Figure 2. The three base icons displaying maize conditions: good (left), middle (center) and bad (right) conditions

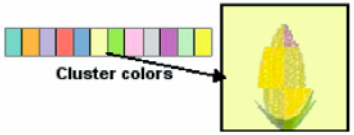


Figure 4. Metaphor-based icon representing six parameters with the background color identifying the cluster

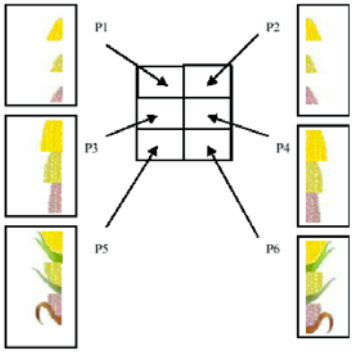


Figure 3. Construction of a metaphor-based icon, representing six parameters

Layout Types

[Nocke, et al. 2005]

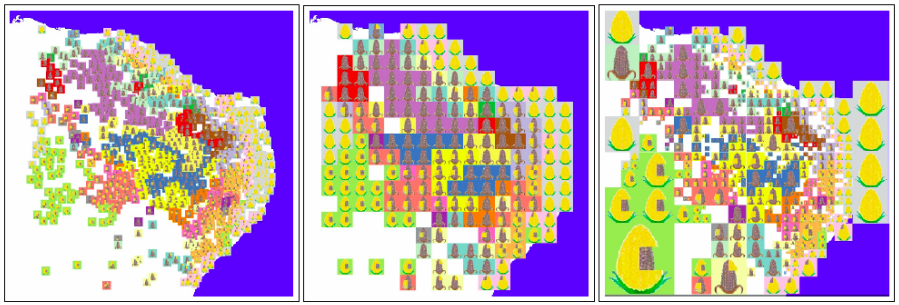


Figure 5. Three layout types of Image Mosaics: scattered(left), regular (center) and quadtree-based multi-resolution (right) layout

+ Underlying Distribution
- Overlapping of Icons

+ Quick Overview
- No Underlying Distribution

+ Quick Overview
- Extension of Icons in "Undefined" Regions

[Nocke, et al. 2005]

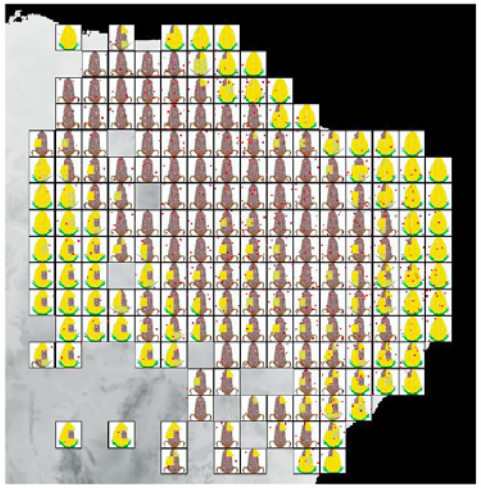


Figure 6. Mosaic image in regular layout with stations faded in (red dots)

[Nocke, et al. 2005]

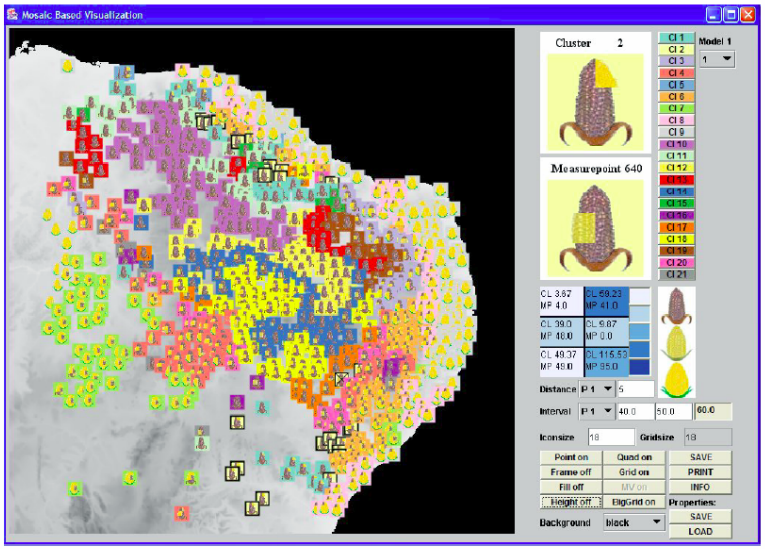


Figure 7. The mosaic framework: Image Mosaic map (left) and parameter control and legends (right); a certain measurement station and all the stations of the same cluster have been selected

Mosaic Metaphors: *Conclusion*

[Nocke, et al. 2005]

Acquire Information at all Levels of Details

Good Overview of the Whole Data Set

Regional Distribution

Detail Information about Station Parameters

Easy to Understand, but some Learning Effort

First Tests

Climate Researcher: New Insights

Asgaard

Designing Task-Specific Problem-Solving Methods to Support the Design and Execution of Time-Oriented Skeletal Plans

Silvia Miksch, et al.

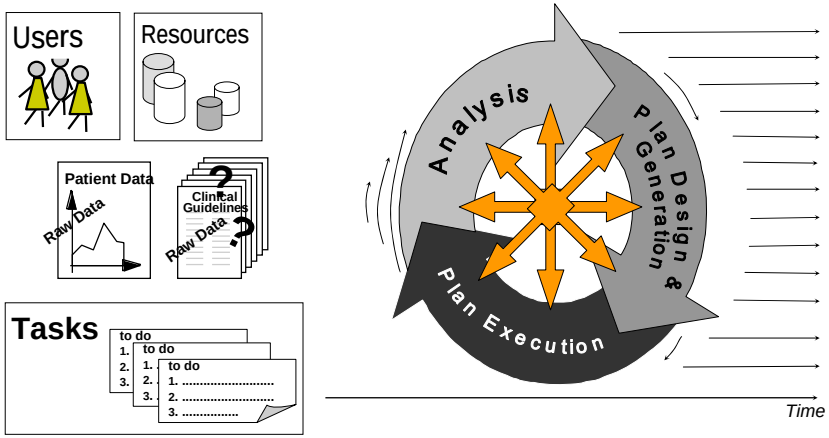
Yuval Shahar, et al. — Israel

Peter Johnson, et al. — UK

AsbruView - SopoView

Plan Management

Living Processes and Plans

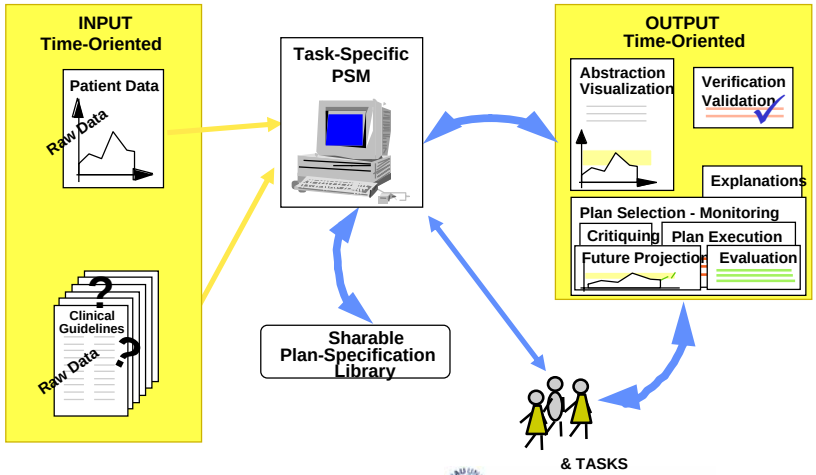


Fully Intertwined and Interactive Tasks

Asgaard / Asbru Project

[Miksch, et al. 1998]

Designing Task-Specific Problem-Solving Methods to Support the Design and the Execution of Time-Oriented Skeletal Plans



Medical Therapy Planning

[Miksch, et al. 1998]

Clinical Protocols

Current Representations of Protocols

- Free Text
- Flow-Charts
- Tables

Used for

- Communication
- Quality Assessment

Asbru's Key Features

[Miksch, et al. 1998]

Hierarchical Decomposition of Plans

Temporal Annotations & Uncertainty

Knowledge Roles

- Preferences
- Intentions
- Conditions
- Effects
- Plan Layouts

I-RDS Example in Asbru 6.5

[Miksch, et al. 1998]

```
(PLAN controlled-ventilation
(PREFERENCES (SELECT-METHOD BEST-FIT))
(INTENTION:INTERMEDIATE-STATE (MAINTAIN STATE(BG) NORMAL controlled-ventilation *))
(INTENTION:INTERMEDIATE-ACTION (MAINTAIN STATE(RESPIRATOR-SETTING) LOW controlled-ventilation *))
(SETUP-PRECONDITIONS (PIP (<= 30) I-RDS *now*)
                                    (BG available I-RDS [[_, _], [_, _],[1 MIN,_](ACTIVATED initial-phase#1)]))
(ACTIVATED-CONDITIONS AUTOMATIC)
(ABORT-CONDITIONS ACTIVATED
        (OR (PIP (> 30) controlled-ventilation [[_, _], [_, _], [30 SEC, _], *self*])
            (RATE(BG) TOO-STEEP controlled-ventilation [[_, _], [_, _], [180 MIN,_], *self*])))
        (SAMPLING-FREQUENCY 10 SEC))
(COMPLETE-CONDITIONS
        (FiO2 (<= 50) controlled-ventilation [[_, _], [_, _], [180 MIN, _], *self*])
        (PIP (<= 23) controlled-ventilation [[_, _], [_, _], [180 MIN, _], *self*])
        (f (<= 60) controlled-ventilation [[_, _], [_, _], [180 MIN, _], *self*])
        (patient (NOT DYSPNEIC) controlled-ventilation [[_, _], [_, _], [180 MIN, ], *self*]))
        (STATE(BG) (OR NORMAL ABOVE-NORMAL) controlled-ventilation [[_, _], [_, _], [180 MIN,_], *self*])
(SAMPLING-FREQUENCY 10 MIN))
(DO-ALL-SEQUENTIALLY
        (one-of-increase-decrease-ventilation)
        (observing)))
```


I-RDS Example in Asbru 7.1d

[Miksch, et al. 1998]

```
<?xml version="1.0" encoding="UTF-8" ?>
<!DOCTYPE plan-library (View Source for full doctype...)>
- <plan-library>
- <domain-defs>
- <domain name="i-rds">
- <record-def name="patient">
<field-def name="name" type="STRING" />
<field-def name="sex" type="maleorfemale" />
</record-def>
- <qual-scale-def name="rate-change">
<qual-entry entry="normal" />
<qual-entry entry="too-steep" />
</qual-scale-def>
- <qual-scale-def name="bg_state">
<qual-entry entry="normal" />
<qual-entry entry="strange" />
<qual-entry entry="critical" />
</qual-scale-def>
- <qual-scale-def name="respirator-setting">
<qual-entry entry="low" />
<qual-entry entry="normal" />
<qual-entry entry="high" />
</qual-scale-def>
- <qual-scale-def name="malea[illegible]
<qual-entry entry="mala[illegible]
<qual-entry entry="[illegible]
- <qual-scale-[illegible]
- <qu[illegible]-nam[illegible]facecolor">
<qual-[illegible]ntry[illegible]t_dypneic" />
<qual-e[illegible]ntry="dyspneic" />
</qual-scale-def>
- <unit-def name="frequency" roun[illegible]="nearest">
- <compound-[illegible]
<numerator />
- <denominator>
<unit-class name="time" exponent="1" />
</denominator>
</compound-def>
</unit-def>
- <unit-def name="flow-unit" rounding="nearest">
- <compound-def>
- <numerator>
<unit-class exponent="1" name="amount" />
</numerator>
<denominator />
</compound-def>
</unit-def>
- <parameter-def na[illegible]="bg" r[illegible]="yes"
type="bg_state">
- <qual-[illegible]arameter-def [illegible]state">
- <limits>
<con[illegible]t-re[illegible]me="[illegible]ntrolled-ventilation" />
<limit-[illegible]ry v[illegible] />
<limit-e[illegible] value="5" />
<lim[illegible]-entry value="7" />
<limit-entry value="9" />
<numerical-constant unit="[illegible]0" />
</limits>
<raw-data-[illegible]f [illegible]="manual"
</qual-par[illegible]ter-[illegible]
<nu[illegible]ical-[illegible]stant unit="s" value="10" />
<para[illegible]ter-def>
- <parameter-def name="respirator-setting" required="no"
type="respirator-setting">
- <qual-parameter-def scale="respirator-setting">
- <limits>
<context-ref name="i-rds" />
<limit-entry value="low" />
<limit-entry value="normal" />
<limit-entry value="high" />
<numerical-constant unit="s" value="10" />
</limits>
- <spread-def>
<numerical-constant unit="[illegible]" value="10" />
<numerical-constant u[illegible]="s" value="10" />
<raw-data-de[illegible] mode="[illegible]matic" />
</spre[illegible]def>
- <qual-p[illegible]meter-de[illegible]
<nu[illegible]rical-[illegible]stant unit="s" value="10" />
</par[illegible]ter-def>
- <parameter-def name="pip" requ[illegible]="
type="pressure">
<raw-data-def mod[illegible]tom[illegible] />
<[illegible]umerical-[illegible]ant u[illegible]="s" v[illegible]="10" />
</parameter
- <parameter-d[illegible]="f[illegible]quired="yes"
type="frequency">
<raw-d[illegible]-def mode="automatic" />
<[illegible]umerical-constant unit="s" value="30" />
</parameter-def>
- <parameter-def name="FiO2" required="yes" type="flow-
unit">
<raw-data-def mode="automatic" />
<numerical-constant unit="s" value="10" />
</parameter-def>
- <parameter-def name="facecolor" required="yes"
type="facecolor">
<raw-data-def mode="manual" />
<numerical-constant unit="h" value="1" />
</parameter-def>
</domain>
</domain-defs>
<value-defs />
- <plans>
- <group name="controlled-ventilation">
- --
```

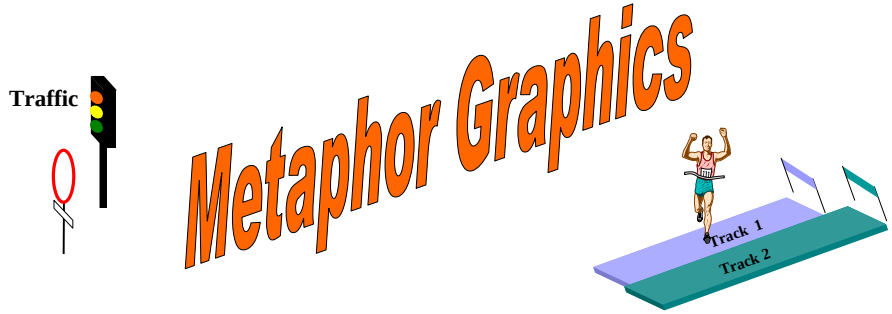
Impossible to use for Domain Experts

AsbruView

[Kosara, et al. 2001]

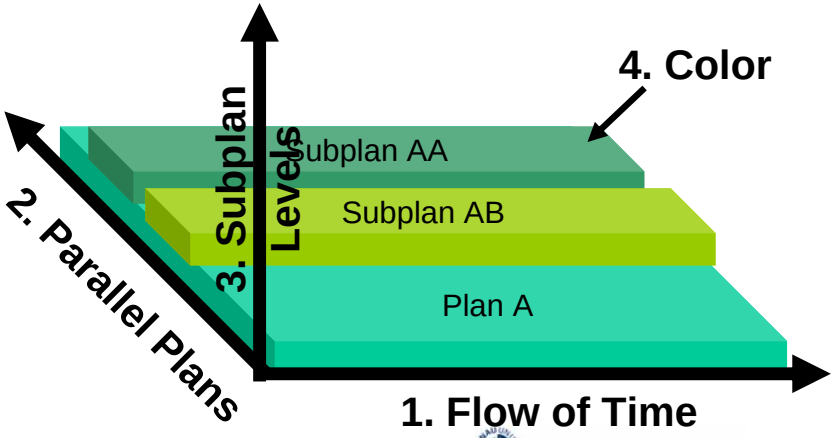
Interface to the

Plan-Representation Language Asbru



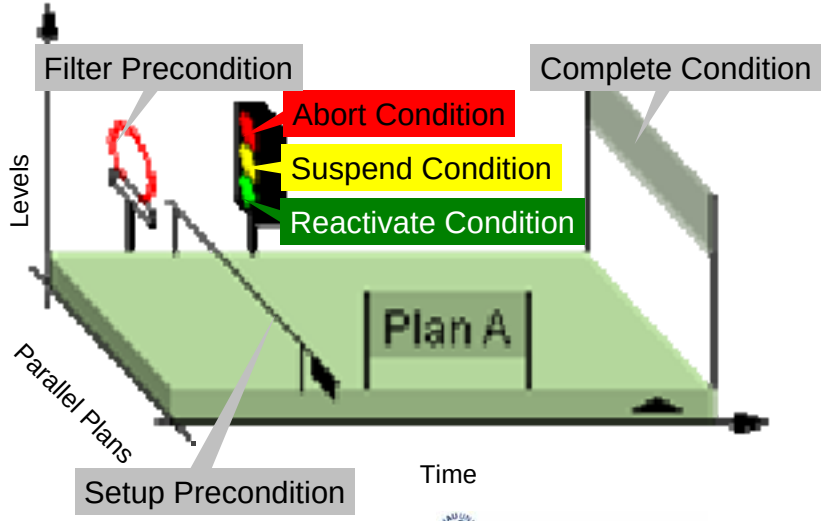
AsbruView's Dimensions

[Kosara, et al. 2001]



Anatomy of a Plan

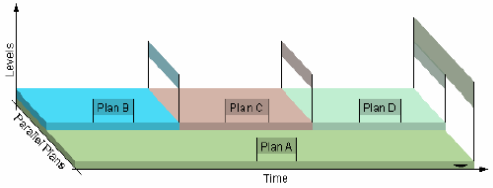
[Kosara, et al. 2001]



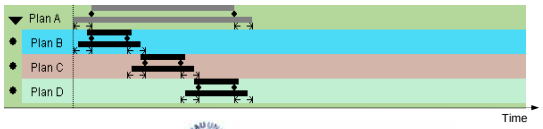
Sequential Plans

[Kosara, et al. 2001]

Topological View



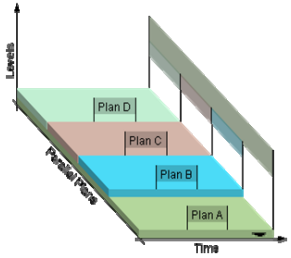
Temporal View



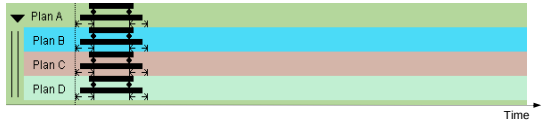
Parallel Plans

[Kosara, et al. 2001]

Topological View



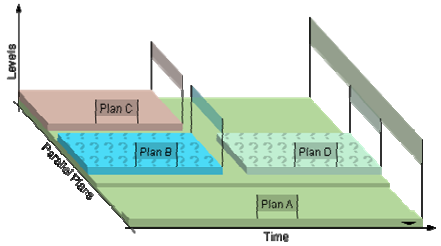
Temporal View



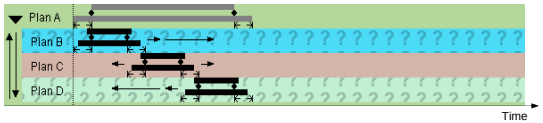
Any-Order Plans - Some

[Kosara, et al. 2001]

Topological View



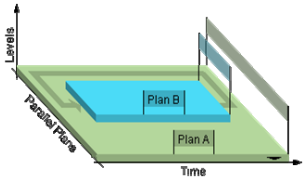
Temporal View



Cyclical Plans

[Kosara, et al. 2001]

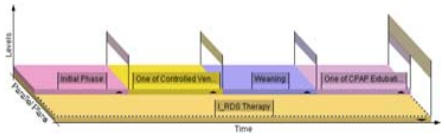
Topological View

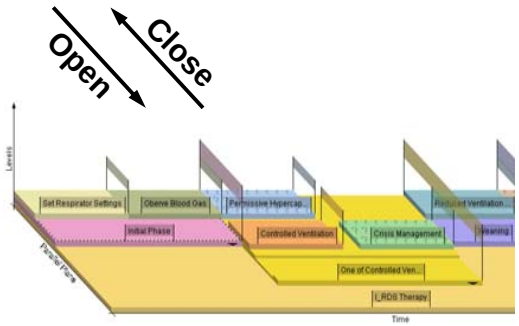


Temporal View

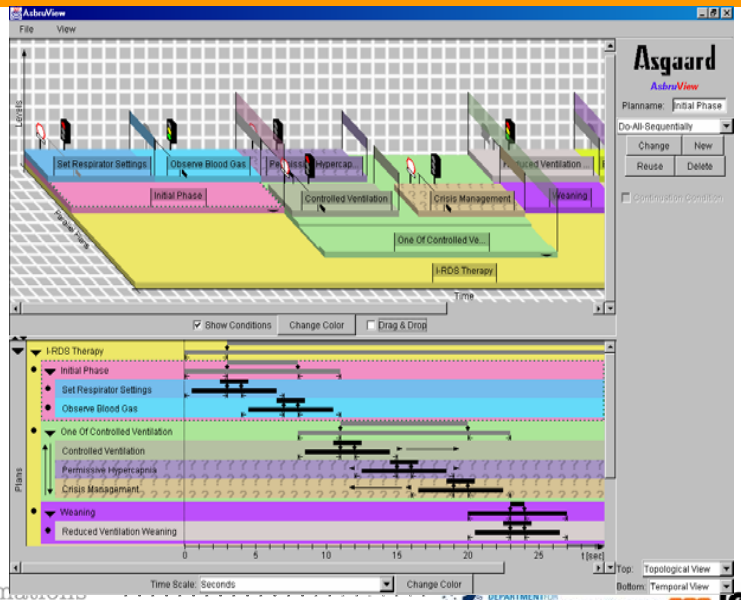
Level of Detail

[Kosara, et al. 2001]

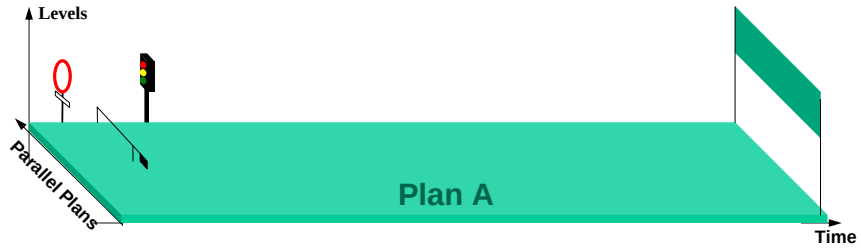


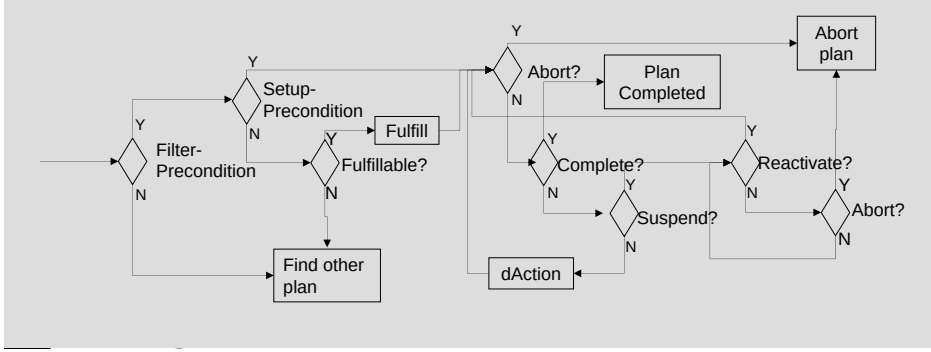


AsbruView



AsbruView vs. Flow-Charts





Evaluation

[Kosara, et al. 2001]

Metaphors

Colors

Two Views

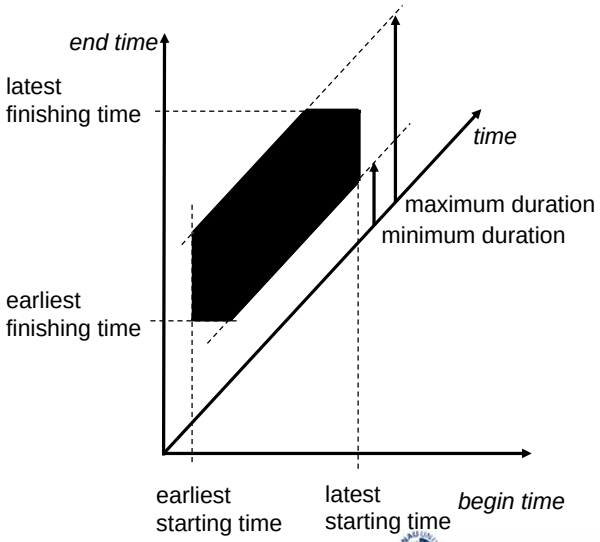
Time Annotations

Speed

(Plan Placement)

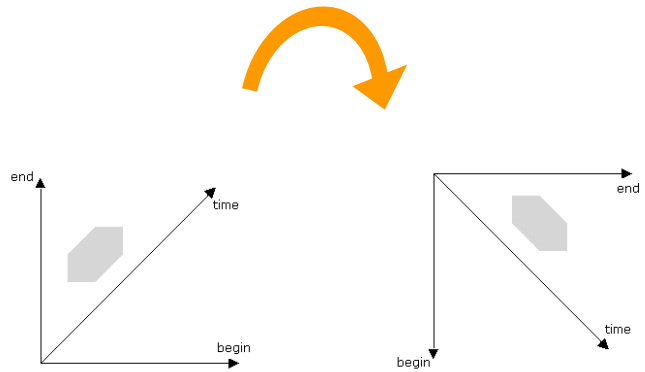
SOPOs

[Rit, 1986; Messner, et al. 2000]



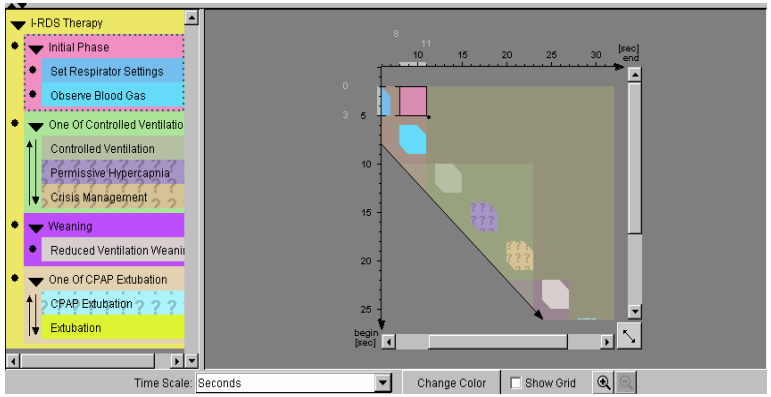
SOPO: Set of Possible Occurrences

[Rit, 1986; Messner, et al. 2000]



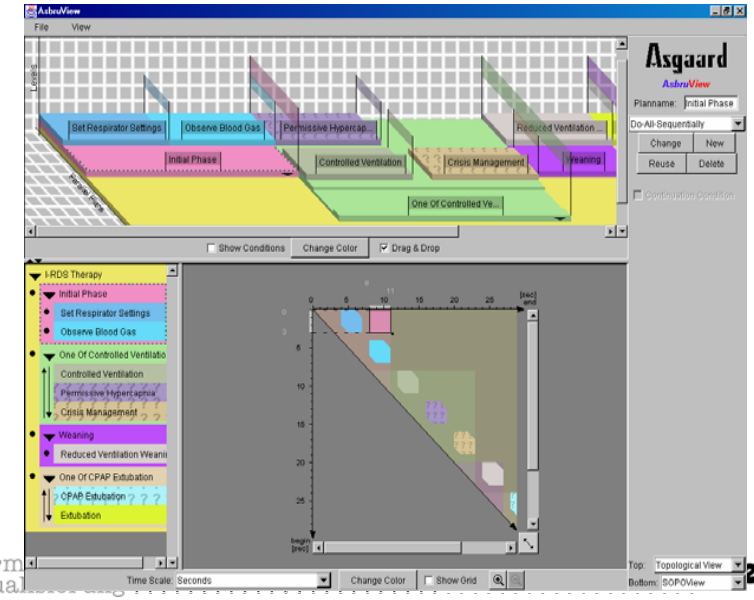
AsbruView - SopoView

[Messner, et al. 2000]



AsbruView - SopoView

[Messner, et al. 2000]



SOPOs

[Messner, et al. 2000]

SOPO = Set of Possible Occurrences

Pro

- Temporal Uncertainty
- Evaluated in Small User Study

Con

- Hard to Understand (not Intuitive)
- No Hierarchical Decomposition (Unmodified)
- No Facets (Very Difficult)

Vie-Visu

[Horn, et al. 1998]

Metaphor Graphics to Visualize ICU Data Over Time

Werner Horn
Austrian Research Institute for Artificial Intelligence
and Department of Medical Cybernetics and AI

Christian Popow, Lukas Unterasinger
NICU, Department of Pediatrics
University of Vienna

Data Visualization

[Horn, et al. 1998]

Electronic Patient Records in Data Rich Environments (ICUs)

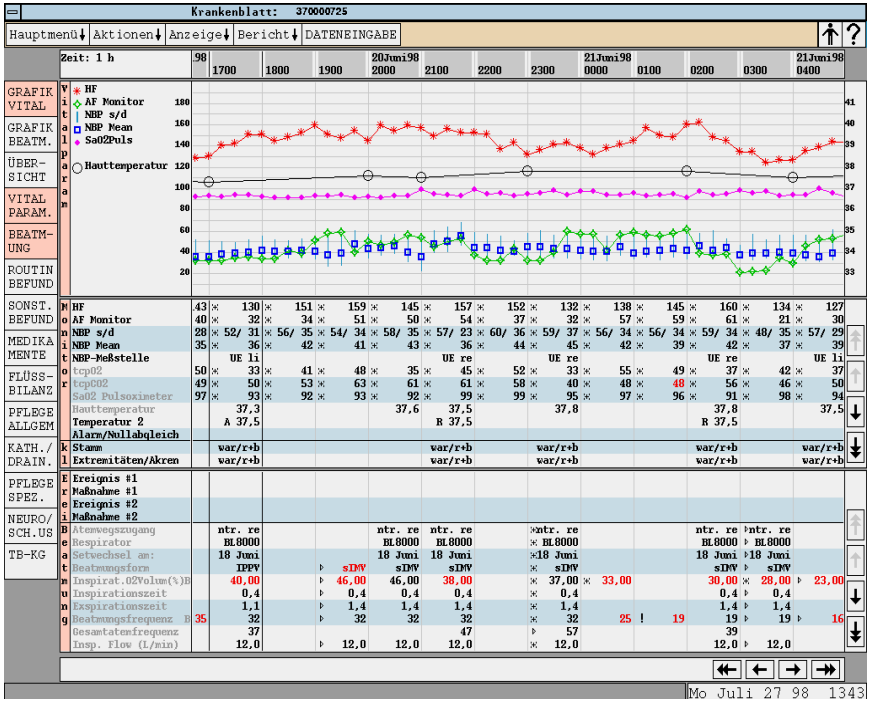
e.g., HP CareVue®

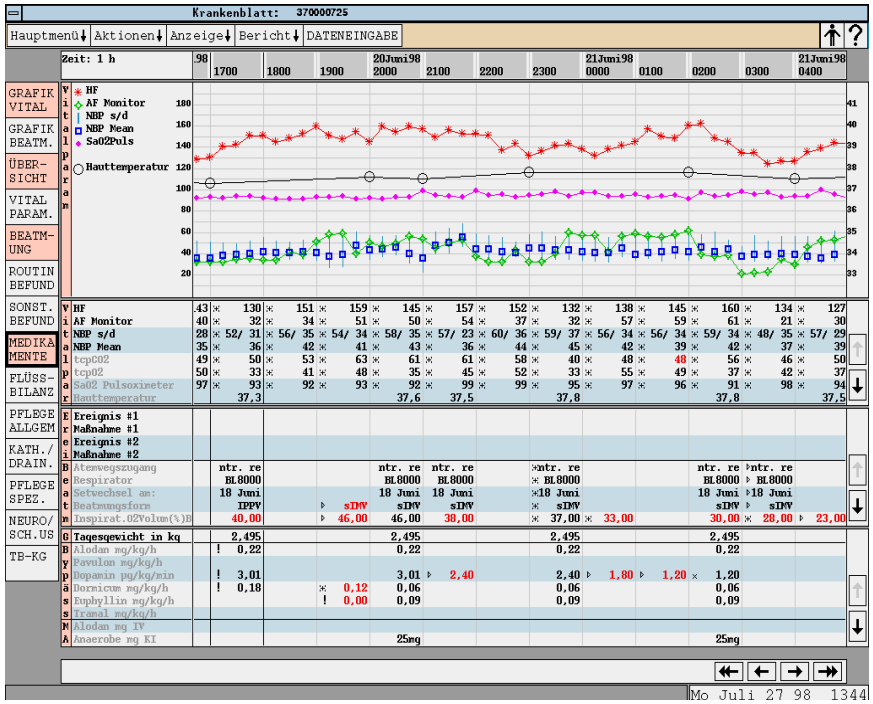
X-Y Plots

Spreadsheet Tables

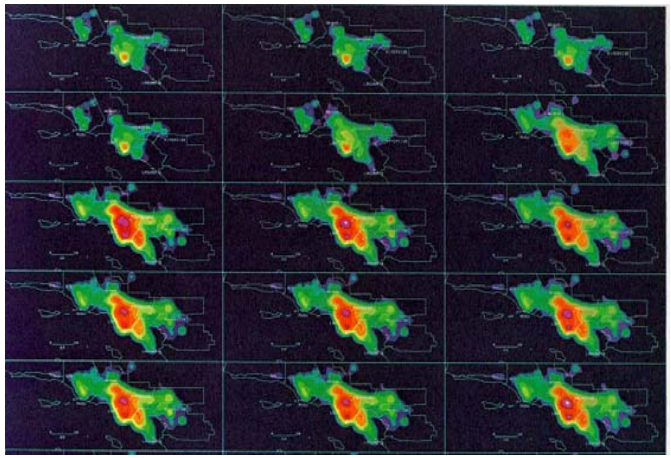
Good for Problem Investigation in Great Detail

Bad for an Overall Assessment of the Situation of the Patient





Metaphor Graphics – Small Multiples



(E.R.Tufte, The Visual Display of Quantitative Information, Graphics Press, Cheshire, CT, 1983)

Multiples in Space and Time

Multiple images reveal repetition and change, pattern, and surprise - the defining elements of *information.*

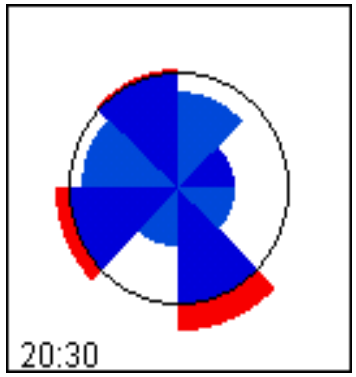
Multiples directly depict comparisons, the essence of statistical thinking.

Edward Tufte:
Visual Explanations, Graphics Press, Cheshire, CT, 1997

VIE-VISU - a first design

[Horn, et al. 1998]

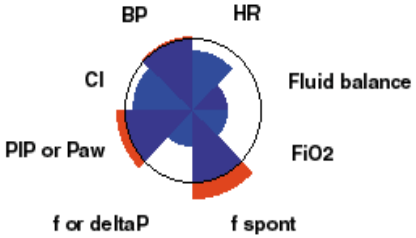
Growing and Shrinking circles



VIE-VISU - a first design

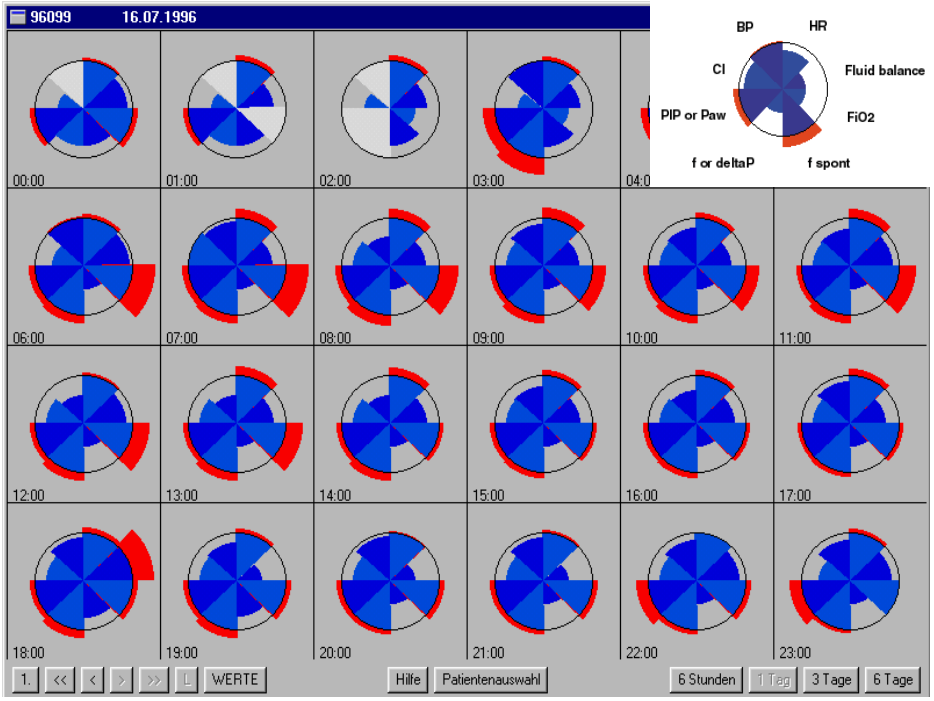
[Horn, et al. 1998]

8 Variables (reduced from 12)



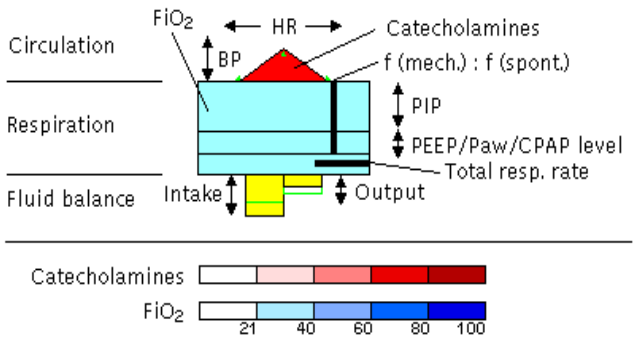
24 Multiples on One Display: 24 hours

Selectable Resolution: 6h, 24h, 3d, 6d

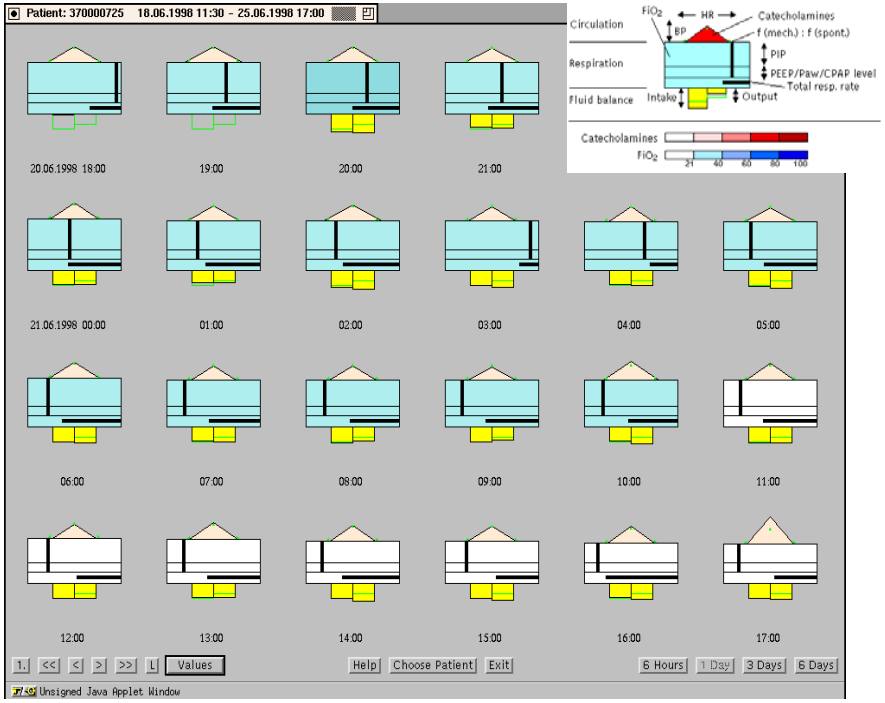


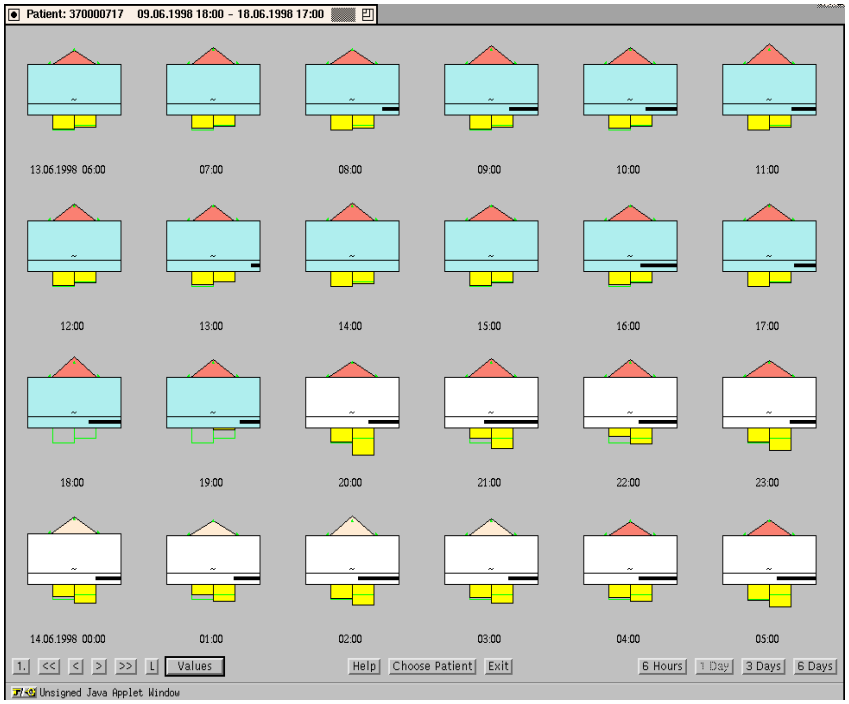
Structured Metaphor Graphics

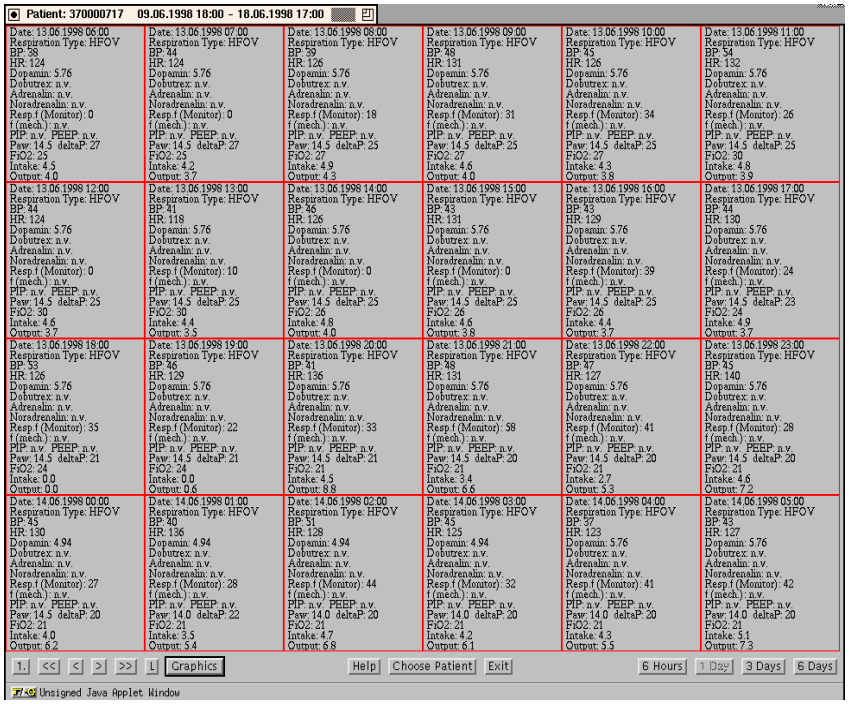
[Horn, et al. 1998]

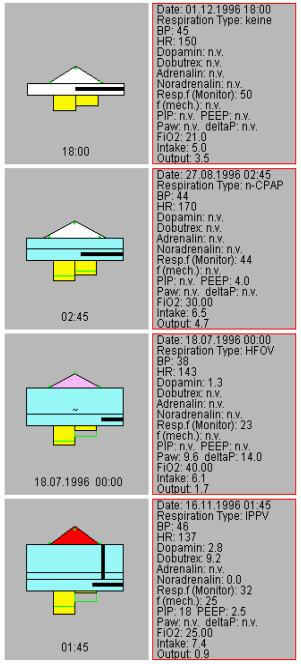


informations-visualisierung SILVIA MIKSCH DEPARTMENT FÜR INFORMATION UND KNOWLEDGE ENGINEERING ieg TU WIEN









Normal

CPAP ventilation

HFOV ventilation

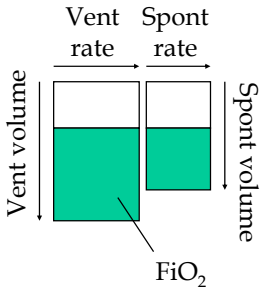
IPPV ventilation

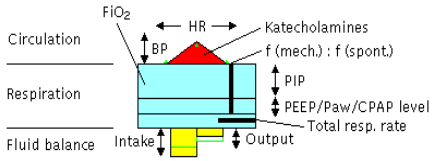
Discussion

[Horn, et al. 1998]

Uniform vs. structured objects

Cole vs. VIE-VISU





W.G.Cole, J.G.Stewart:
Metaphor Graphics to Support Integrated Decision Making with Respiratory Data,
Int.J.Clin.Mon.Comp., 10, 91-100, 1993.

Discussion

[Horn, et al. 1998]

Uniform vs. structured objects

Aberdeen polygons vs. VIE-VISU

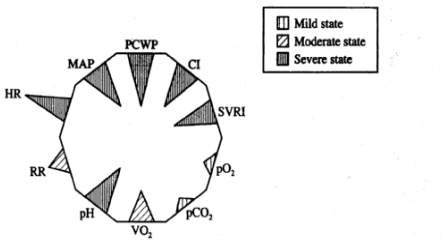


Figure 2. Example of an Aberdeen polygon representing late septic shock. The parameter values are identical to those used in figure 1.

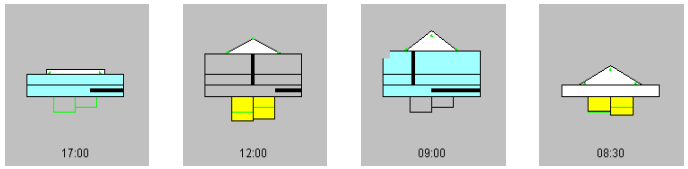
Discussion

[Horn, et al. 1998]

Uniform vs. structured objects

Cole vs. VIE-VISU

How to deal with missing values?



Discussion

[Horn, et al. 1998]

Uniform vs. Structured Objects

- Cole vs. VIE-VISU

How to deal with missing values?

What is the representative value for a given interval?

- Median
- Extreme

Conclusion

[Horn, et al. 1998]

Multiples Promote to Focus on Stability and Change

Access to the Complex without Complicating the Simple

Open Questions

- Easy Learnability
- Long Remembering periods
- Good Decision Support
  (Finding Patterns in a Mass of Data)

[Chuah/Eick 1998]

Glyphs for Software Management Data

Mei C. Chuah, Stephen G. Eick: Information Rich Glyphs for Software Management Data, *IEEE Computer Graphics and Applications*, 18(4), pp. 24–29, 1998.

Domain

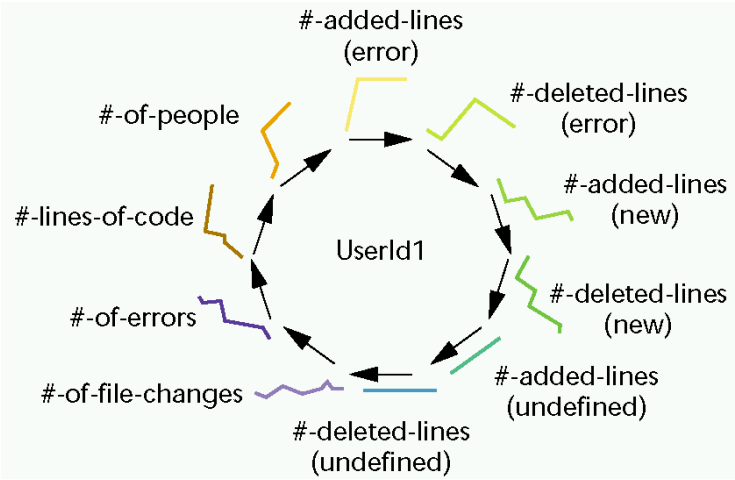
[Chuah/Eick 1998]

Software Project Management

- Large Software Systems
- Enormous Amounts of Code
- Great Number of Involved People
- Team Oriented
- Complex Task
- Many Different Influences
- Big Amount of Management Data

Timewheel Glyph

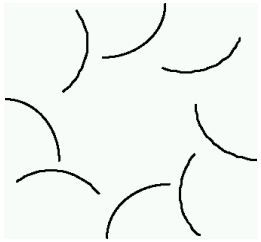
[Chuah/Eick 1998]



Timewheel Glyph

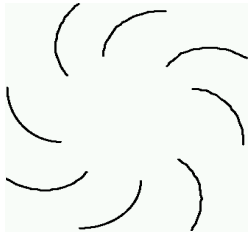
[Chuah/Eick 1998]

Increasing Trend



„Prickly fruit“

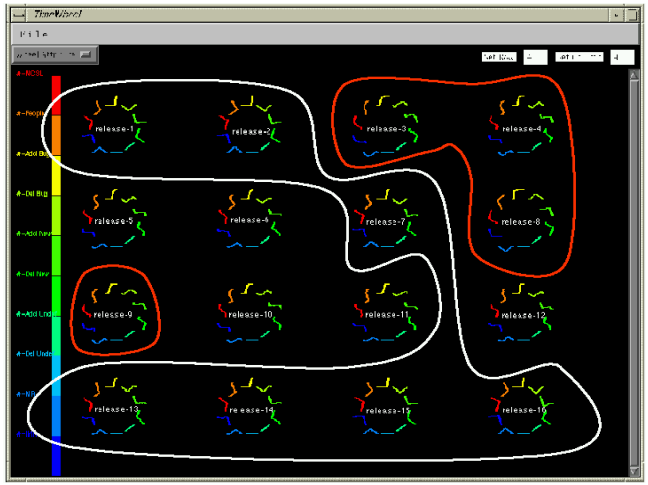
Tapering Trend



„Hairy fruit“

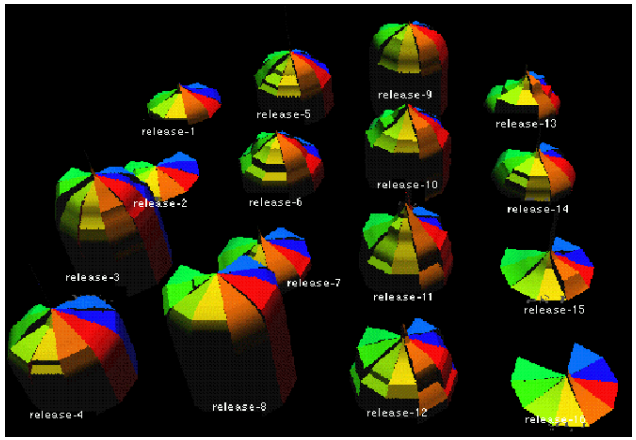
Timewheel Interface

[Chuah/Eick 1998]



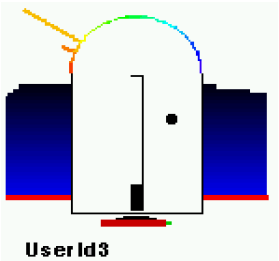
3D Wheel Glyph

[Chuah/Eick 1998]



Infobug Glyph

[Chuah/Eick 1998]



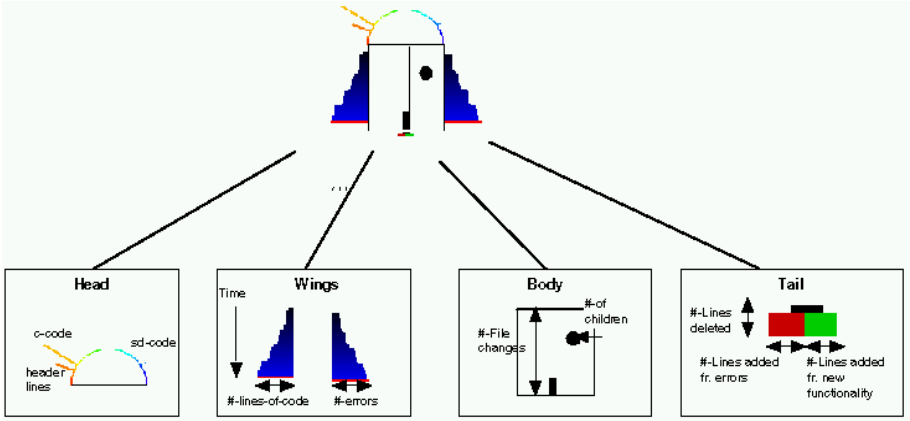
Looks Like an Insect

Represents four Classes of Software Data:

- Code Lines, Errors (Wings)
- Types of Code (Head)
- Changes, Component Size (Body)
- Lines Added and Deleted (Tail)

Infobug Glyph

[Chuah/Eick 1998]

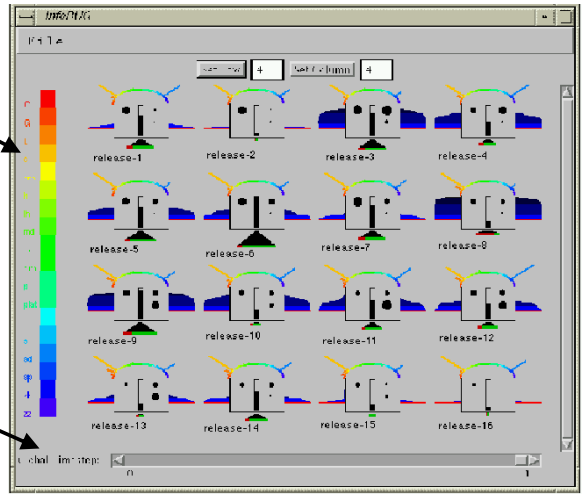


Infobug Interface

[Chuah/Eick 1998]

File types

Time scale



Advantages - Shortcomings

[Chuah/Eick 1998]

+ Large Datasets on Little Space
+ Entities Shown as Objects
+ Easy to Recognize Patterns
+ Easy to Obtain Trends / Overall Information
+ Interactive
+ Combinable with Other Methods
+ Information Rich Glyphs
+ Easy to Analyze and Compare

- Learning Required (not Intuitive Understandable)
- Focuses on the Past
- No Additional Information Includable (Risk for Project, Reasons for Certain Patterns, ...)

[Icon-Based ...] Conclusion

Benefits

- Easy to Tell Multidimensional Differences
- Find Complex Patterns (in Time Series Data)
- Can be based on Metaphor(s)

Limitations

- Individual Values Hard to Read
- Require Legend(s) – Reference Representation(s)
- Limited Number of Dimensions
- Dimensions/Directions not Equal