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; Tuft 1993]
- Stick Figures [Pickett, et al. 1988/90]
- Shape Coding [Bedderson 1994]
- Color Icons [Levkowitz 1991]
- 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”)

Lascoux (France)

Egyptian Hieroglyphs
Scottish Tartan ...

Irish Tartan from Dublin

Scottish Tartan from MacCrae-Clans

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

Icons
Synonym to Glyph
Information Graphics

Otto u. Marie Neurath

Otto: 1882–1945
Marie: 1898–1986

ISOTYPE: International System of Typographic Picture Education

ISOTYPE

Motor Cars, Telephones, Radio Sets 1937 per 50 population

ISOTYPE

Occupations of Women about 1930

ISOTYPE

Weekly earnings of Men and Women, Occupations

1940

ISOTYPE

From Hieroglyphics to Isotype

cover design / mock-up, Otto Neurath / Isotype Institute, c.1944, (I.C. 3.2/57)
Chernoff Faces

Idea

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

Fitting

- Explorative Data Analyses
- Glyphs / Icons
- Multivariate Data

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

Example

[Müller & Alexa, 1998]

Mona Lisa

Example

Life in Los Angeles
Example

The Distribution of Voting, Housing, Employment and Industrial Compositions in the 1983 General Election.

- Low Social Indicators
- Low Electorate Voting
- High Adult Employment
- High Mean Housing Price

Voting Composition

Other Parties

Labour
Conservative

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**

Figure: Slow Time (2 sec.)

0.4 - 2 sec.: Needed to Recognize Object => Not Preattentive

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**Conclusion**

**Decision Support**

**Benefits are Relative**

**Problems Exist - Improvements**

- Loss the Real values
- Experienced vs. Inexperienced

**Training Needed**

**Efficiency?**

**Preattentivity?**

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**Stick Figures**

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

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**Stick-Figure Family**

[Pickett, et al. 1988/90]
Main Principle

Texture
Easy to interpret and distinguish of textures

Color Coding

Geometric Coding

Preprocessing of Data

100% of the Data
10% of the Data

Images: Weather Satellites

5-dim. Image from Great Lake Region

Census Data

Figure 6: Stick Figure Visualization of Census Data
**Census Data**

- **Basic Idea**: Data are visualized using small arrays of fields. Each field represents one value. Arrangement of attribute fields (e.g., 12-dim. data).

**Shape Coding** (1/2)

- **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)**.

**Color Icons** (1/2)

- **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).
**Color Icons**

(2/2)

**Pixel-Based Techniques**

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

**Overview**

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)**

**Recursive Pattern Techniques**

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

Query-Independent Techniques

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

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

Query-Dependent Techniques

- Arrangement of 8-dim. Data
**Approach**

**Cartography Metaphor**

Replace Abstract Icons by Metaphor 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**

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**Application Maize Harvest Data Set**

**Input**

Numerical, Multi-Variate Data

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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.

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

**Figure 3.** Construction of a metaphor-based icon representing six parameters with the background color identifying the cluster.

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

- **Underlying Distribution**
- **Quick Overview**
- **Extension of Icons in "Undefined" Regions**

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

### Mosaic Metaphors: Conclusion

- **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

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

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.
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.
Peter Johnson, et al.

AsbruView - SopoView

Plan Management
Living Processes and Plans

Users

Resources

Tasks
to do
1. ..............
2. ..............
3. ................
to do
1. ..............
2. ..............
3. ................
to do
1. ..............
2. ..............
3. ................

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

Medical Therapy Planning

Clinical Protocols
Current Representations of Protocols
Free Text
Flow-Charts
Tables

Used for
Communication
Quality Assessment
Asbru's Key Features

Hierarchical Decomposition of Plans
Temporal Annotations & Uncertainty
Knowledge Roles
  Preferences
  Intentions
  Conditions
  Effects
  Plan Layouts

I-RDS Example in Asbru 6.5

(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*])))
(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-SEQUENTIAL
  (one-of-increase-decrease-ventilation)
  (observing)))

I-RDS Example in Asbru 7.1d

AsbruView

Interface to the Plan-Representation Language Asbru

Metaphor Graphics

Impossible to use for Domain Experts
**AsbruView's Dimensions**

1. **Flow of Time**
2. **Parallel Plans**
   - Subplan AA
   - Subplan AB
   - Plan A
3. **Levels**
4. **Color**

**Anatomy of a Plan**

- **Abort Condition**
- **Suspend Condition**
- **Reactivate Condition**
- **Filter Precondition**
- **Complete Condition**
- **Setup Precondition**

**Sequential Plans**

- **Topological View**
- **Temporal View**

**Parallel Plans**

- **Topological View**
- **Temporal View**

[Kosara, et al. 2001]
Any-Order Plans - Some

Topological View

Temporal View

Kosara, et al. 2001

Cyclical Plans

Topological View

Temporal View

Kosara, et al. 2001

Level of Detail

Close

Open

Kosara, et al. 2001

AsbruView

Kosara, et al. 2001
AsbruView vs. Flow-Charts

Evaluation

Metaphors
Colors
Two Views
Time Annotations

Speed
(Plan Placement)

SOP0s

SOPO: Set of Possible Occurrences

[Asbru, et al. 2001]

[SILVIA MIKSCH]

View vs. Flow-Charts

Plan vs.

Parallel Plans

Plan A

Filter-
Precondition

Setup-
Precondition

Find other plan

Fulfill

Fulfillable?

N

Y

Y

N

Abort?

Y

N

Abort plan

Plan Completed

Complete?

Y

N

Reactivate?

Y

N

Suspend?

Y

N

Abort?

Y

N

Suspend?

Y

N

Abort?

Y

N

SOP0s

SOPO: Set of Possible Occurrences

[Asbru, et al. 2001]

[SILVIA MIKSCH]

begin time

end time

earliest starting time

latest finishing time

minimum duration

maximum duration

[SILVIA MIKSCH]
**AsbruView - SopoView**

[Messner, et al. 2000]

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**SOPOs**

**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)

[Messner, et al. 2000]

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**Vie-Visu**

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

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

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:

VIE-VISU - a first design

Growing and Shrinking circles

8 Variables (reduced from 12)

24 Multiples on One Display: 24 hours
Selectable Resolution: 6h, 24h, 3d, 6d

[Horn, et al. 1998]
Structured Metaphor Graphics

[Horn, et al. 1998]
Normal

CPAP ventilation

HFOV ventilation

IPPV ventilation

Discussion

Uniform vs. structured objects

Cole vs. VIE-VISU


How to deal with missing values?
**Discussion**

**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

- [Horn, et al. 1998](#)

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**Conclusion**

**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)

- [Horn, et al. 1998](#)

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**Domain**

**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

- [Chuah/Eick 1998](#)

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**Glyphs for Software Management Data**


- [Chuah/Eick 1998](#)
**Timewheel Glyph**

- #-added-lines (error)
- #-deleted-lines (error)
- #-lines-of-code
- #-of-people
- #-of-errors
- #-of-file-changes
- #-added-lines (new)
- #-deleted-lines (new)
- #-added-lines (undefined)
- #-deleted-lines (undefined)

**Timewheel Interface**

**3D Wheel Glyph**

Increasing Trend

- „Prickly fruit“

Tapering Trend

- „Hairy fruit“
Infobug Glyph

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)

Advantages - Shortcomings

+ 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, ...)

Infobug Interface

File types
Time scale
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/Direcions not Equal