

# Vorlesung Advanced Topics in HCI (Mensch-Maschine-Interaktion 2)

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WS2003/2004

<http://www.medien.informatik.uni-muenchen.de/>

## Chapter 2: Information Visualization

### Table of Content

- Information & representation
- What is information visualization
- Perception basics
- Standard techniques
- Principles and Taxonomy
- Options for visualization & Examples

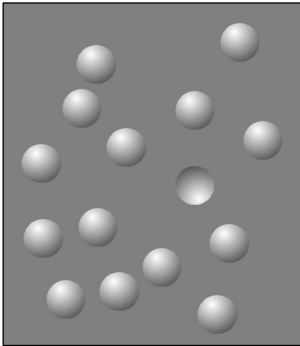
*“Graphical excellence is that which gives to the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space.”*

-- Edward R. Tufte

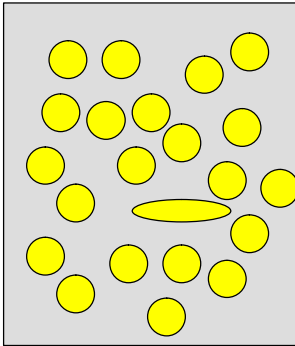
## Preattentive Processing (Pop Out)

- Time required to find target independent of number of overall number
  
- Form:
  - line orientation, length, width
  - spatial orientation, added marks, numerosity (4)
- Colour:
  - hue, intensity
  
- Motion:
  - flicker, direction of motion
- Spatial Position:
  - stereoscopic depth, convex/concave shape, shadows

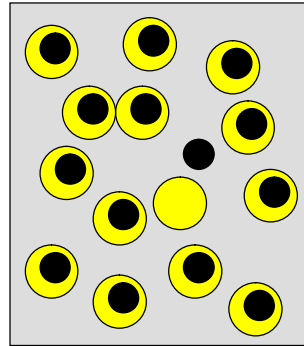
## Examples (pop-out)



Shading

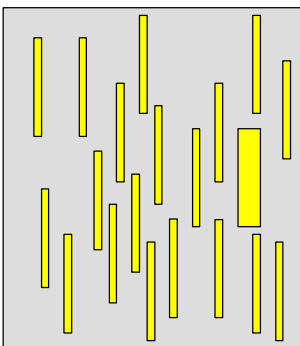


Shape

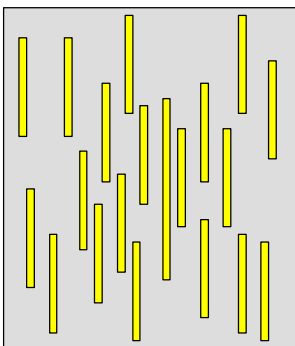


Enclosure

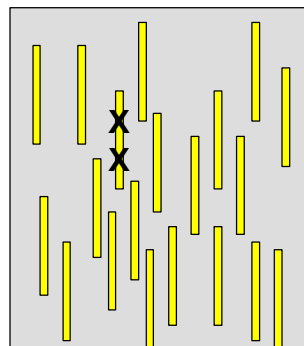
## Examples (pop-out)



width



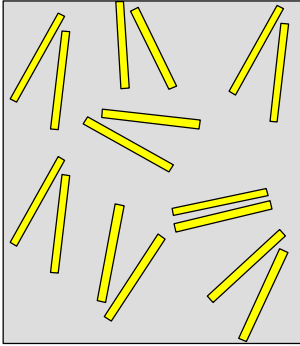
length



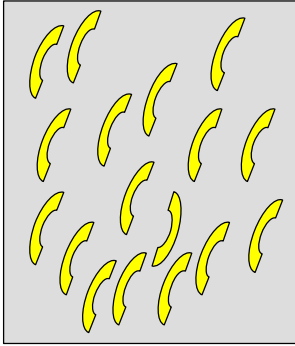
marked

Hiding features  
due to placement

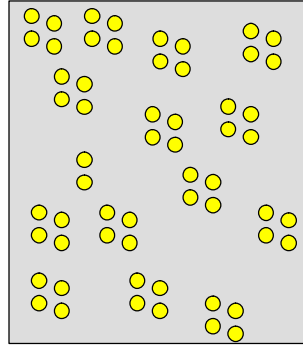
# Examples (pop-out)



angle

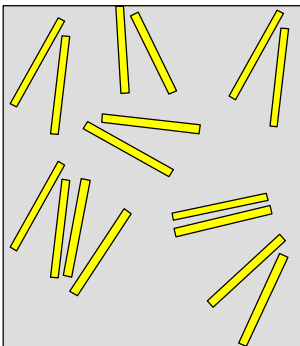


curve

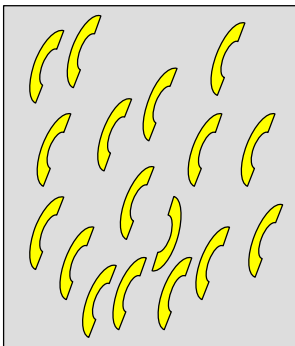


Clusters/count

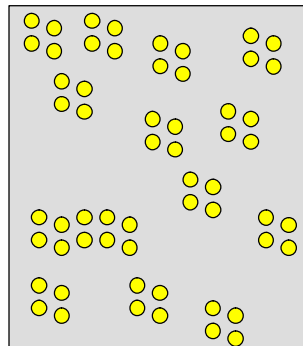
# Examples (pop-out)



angle



curve



Clusters/count

Hiding features  
due to placement

Hiding features  
due to placement

## Accuracy Ranking of Quantitative Perceptual Tasks static features

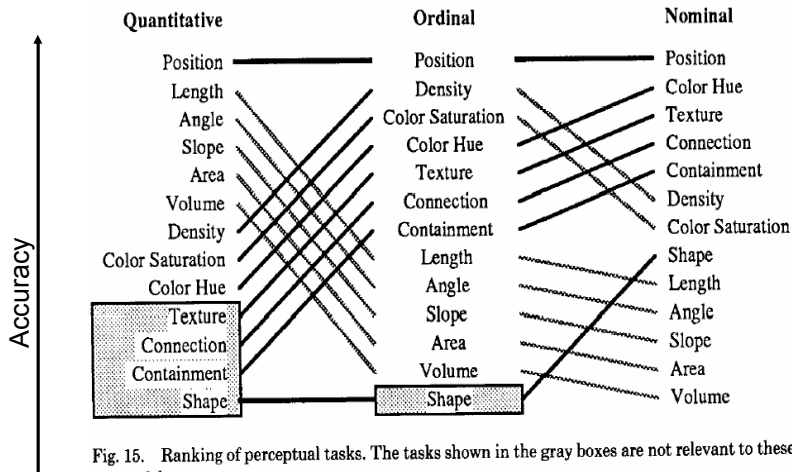


Fig. 15. Ranking of perceptual tasks. The tasks shown in the gray boxes are not relevant to these types of data.

Mackinlay 88

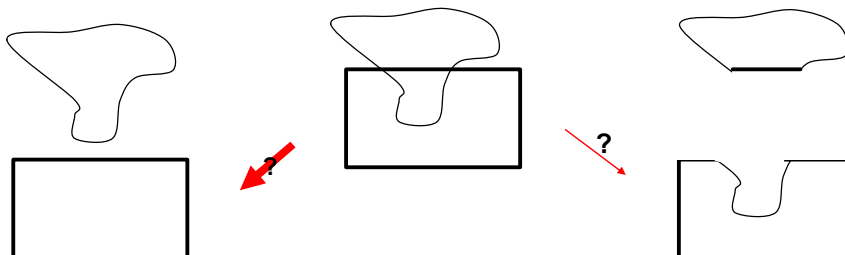
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## Continuity

- Experience tells that visual elements are more likely to be continuous
- Implied connection
- connections are used to show relations



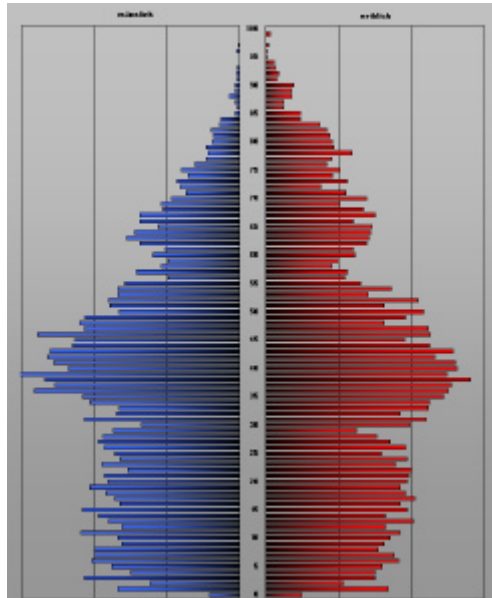
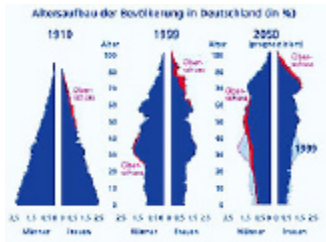
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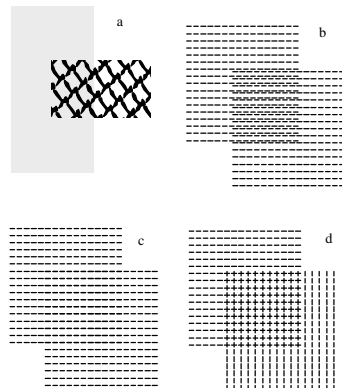
# Symmetry

- Symmetrical to emphasizes relationship



# Figure, Background Transparency, Overlap

- What is foreground and what is background?
- Transparency is perceived only when good continuity and color correspondence exists.
- visual interference in overlapping textures



# Concepts & Principles

## Tufte – Principles of Graphical Excellence

- Graphical excellence
  - the well-designed presentation of interesting data – a matter of substance, of statistics, and of design
  - consists of complex ideas communicated with clarity, precision and efficiency
  - is that which gives to the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space
  - **requires telling the truth about the data.**

Hearst, 2003

# Tufte Principle

Maximize the data-ink ratio  
(Avoid “chart junk”)

$$\text{Data-ink ratio} = \frac{\text{data ink}}{\text{total ink used in graphic}}$$

Hearst, 2003

# Tufte's Graphical Integrity

- Some lapses intentional, some not

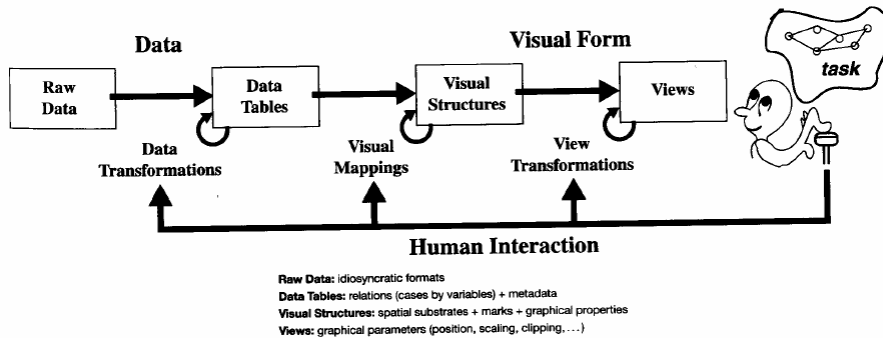
$$\text{Lie Factor} = \frac{\text{size of effect in graph}}{\text{size of effect in data}}$$

- Misleading uses of area
- Misleading uses of perspective
- Leaving out important context
- Lack of taste and aesthetics

Hearst, 2003

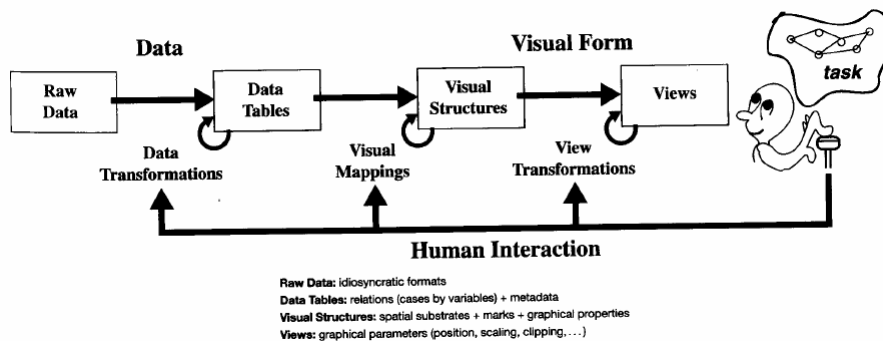


# Visualization Reference Model



(Storey, 2004)

# Visualization Reference Model Human Interaction



- Raw Data → Data Table  
filtering
- Data Table → Visual Structure  
pick mappings
- Visual Structure → Views  
probes, viewpoints, distortions

(Storey, 2004)

# Visualization Reference Model Overview

DATA TABLES	VISUAL STRUCTURES	VIEWS	HUMAN INTERACTION	TASKS	LEVEL
Cases Variables Values Metadata	Spatial Substrate Marks Graphical properties	Location Probes Viewpoint Controls Distortion	Data Tables Visual Structures Views	Forage for Data Problem Solving Search for Schema Instantiate Schema Author, Decide, or Act	Infosphere Workspace Visual Knowledge Tools Visual Objects

## Specific Techniques

Spatial (Scientific) Geographic Documents Time Database Hierarchies Networks World Wide Web	Position: NOQ Marks: PLAV Properties: Connection, Enclosure, Retinal, Time Axes: Composition Alignment Folding Recursion Overloading	Brushing Zooming Overview + Detail Focus + Context	Dynamic Queries Direct Manipulation Magic Lens	Overview Zoom Filter Details-on-Demand Browse Search Read Fact Read Comparison Read Pattern Manipulate Create	Delete Reorder Cluster Class Promote Average Abstract Instantiate Extract Compose Organize
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(Storey, 2004)

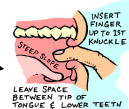
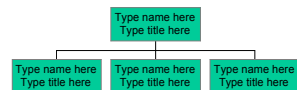
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# Basic Types of Symbolic Displays (Kosslyn 89)

- Graphs
- Charts
- Maps
- Diagrams



From Hearst, 2003

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# Basic Types of Data

- **Nominal (qualitative)**
  - (no inherent order)
  - city names, types of diseases, ...
- **Ordinal (qualitative)**
  - (ordered, but not at measurable intervals)
  - first, second, third, ...
  - cold, warm, hot
- **Nominal/Interval (quantitative)**
  - list of integers or reals

Hearst, 2003

# Data Types - Overview

- **Generic**
  - **entity, relationship,**
  - **Attribute to entity or relationship**
  - **operation**
- **Specific**
  - **1-D Linear** Document Lens, SeeSoft, Info Mural, Value Bars
  - **2-D Map** GIS, ArcView, PageMaker, Medical imagery
  - **3-D World** CAD, Medical, Molecules, Architecture
  - **Multi-Dim** Parallel Coordinates, Spotfire, XGobi, Visage, Influence Explorer, TableLens, DEVise
  - **Temporal** Perspective Wall, LifeLines, Lifestreams, Project Managers, DataSpiral
  - **Tree** Cone/Cam/Hyperbolic, TreeBrowser, Treemap
  - **Network** Netmap, netViz, SeeNet, Butterfly, Multi-trees

**Shneiderman, 2003**

# Information Visualization Mantra

...

**Overview, zoom & filter, details-on-demand**

**Overview, zoom & filter, details-on-demand**

**Overview, zoom & filter, details-on-demand**

**Overview, zoom & filter, details-on-demand**

**Overview, zoom & filter, details-on-demand**

**Overview, zoom & filter, details-on-demand**

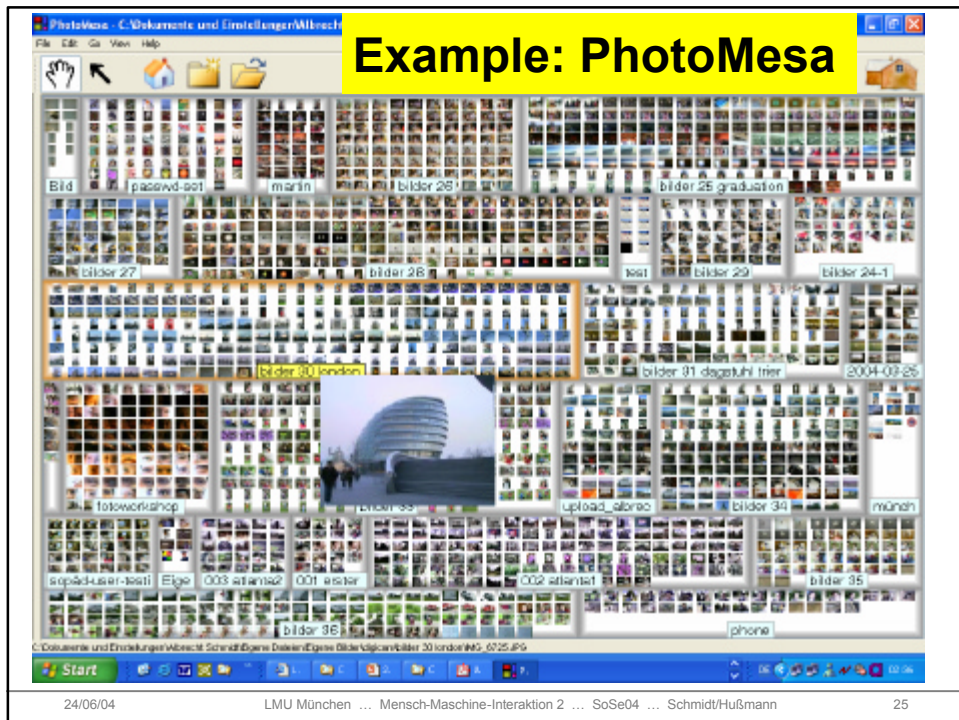
...

*Shneiderman, 2003*

# Information Visualization Tasks

- **Overview** Gain an overview of the entire collection
- **Zoom** Zoom in on items of interest
- **Filter** Filter out uninteresting items
- **Details-on-demand** Select an item or group and get details when needed
- **Relate** View relationships among items
- **History** Keep a history of actions to support undo, replay, and progressive refinement
- **Extract** Allow extraction of sub-collections and of the query parameters

*Shneiderman, 2003*



## Information Visualization: Design Guidelines

### Direct manipulation strategies

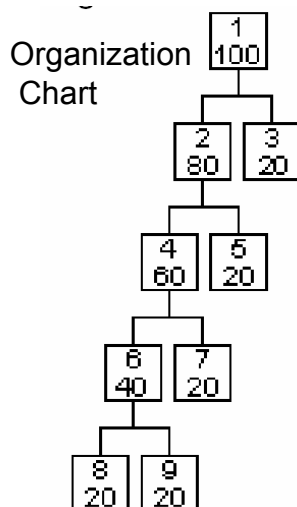
- Visual presentation of query components
- Visual presentation of results
- Rapid, incremental and reversible actions
- Selection by pointing (not typing)
- Immediate and continuous feedback
- Reduces errors
- Encourages exploration

*Shneiderman, 2003*

# Basic Visualization Techniques

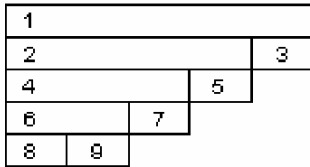
- Finding appropriate visualization for data structures
- Example: trees / graphs

# Alternative Tree Visualization

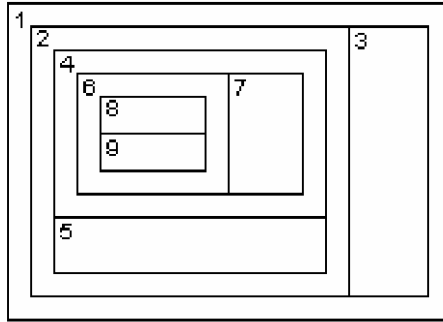


# Alternative Tree Visualization

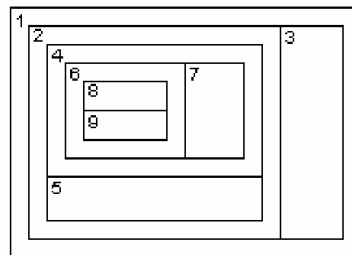
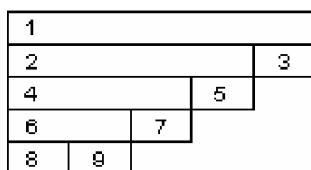
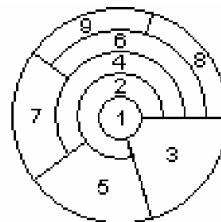
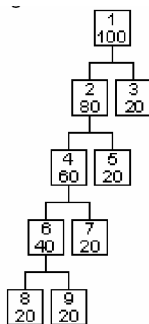
Icicle Plot



Tree Map



# Comparing Visualizations



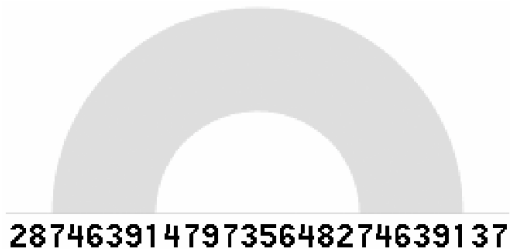
# Typical Tasks for viewing Trees

- Determine the type of tree, e.g.
  - Binary
  - N-ary
  - Balanced
  - Unbalanced
- Find relations, e.g.
  - Deepest common ancestor
- Size of the tree, e.g.
  - How many levels
  - How many leaves
- Details about leaves, e.g.
  - Largest leaf
- Different representation may be better for a given task, e.g.
  - To find out if a tree is balanced or how many levels exist the Icicle Plot is good

More details see:  
Barlow et al. "A Comparison of 2-D Visualizations of Hierarchies" INFOVIS'01  
<http://www.sims.berkeley.edu/courses/is247/s02/readings/barlow.pdf>

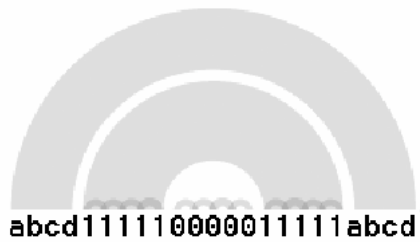
# Arc Diagrams

- Visualization method
  - For representing complex patterns of repetition in string data.
  - Arc diagrams scale efficiently for strings that contain many instances of the same subsequence.
  - idea of visualizing only a subset of all possible pairs of matching substrings.
  - highlight just the subsequences essential to understanding the string's structure

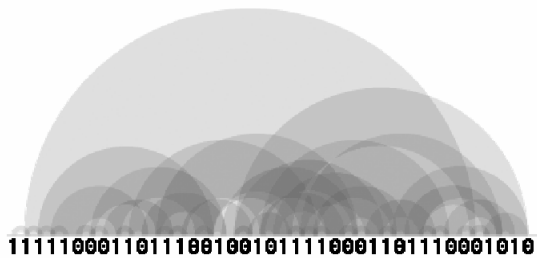




# Arc Diagrams - Basics

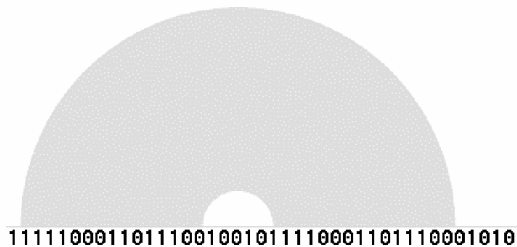


# Arc Diagram – Level of Detail

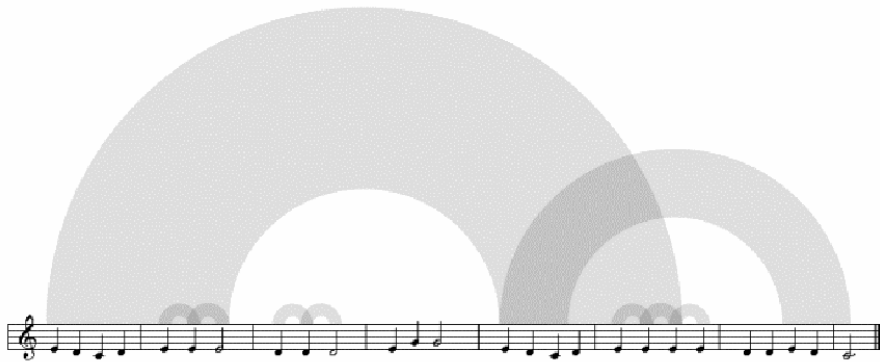


Applied to

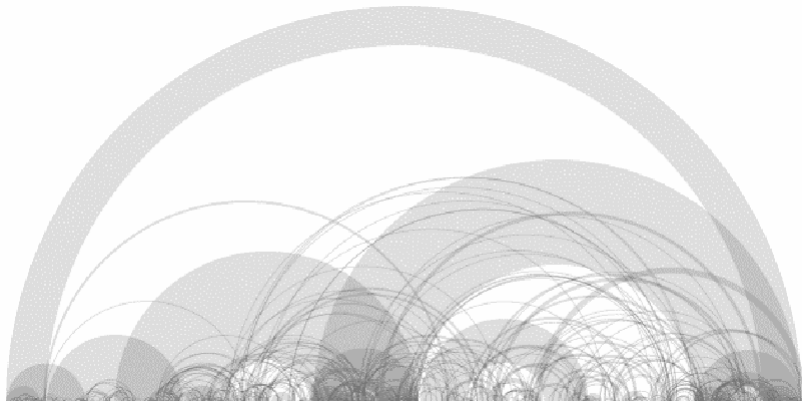
- Music
- DNA
- Web pages
- Byte code



# Arc Diagram applied to Music



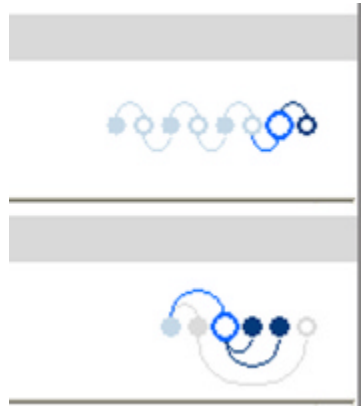
# Arc Diagram applied to Music “für Elise”



- More details  
Martin Wattenberg. Arc Diagrams: Visualizing Structure in Strings  
IBM Watson Research Center, Technical report 2002-11  
<http://domino.research.ibm.com/cambridge/research.nsf/0/e2a83c4986332d4785256ca7006cb621?OpenDocument>

# Thread Arcs

- Thread Arcs combine the chronology of messages with the branching tree structure of a conversational thread
- Benefits
  - Chronology.
  - Relationships
  - Stability:
  - Compactness:
  - Attribute Highlighting:
  - Scale:
  - Interpretation/Sense

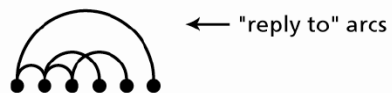
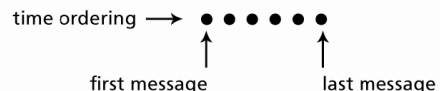


- <http://www.research.ibm.com/remail/threadarcs.html>

# Thread Arcs for Emails

## ▪ Visualization

- linear layout of message nodes connected by relationship arcs.
- each circular node represents a message in the thread.
- *chronology* of the thread is encoded by the position
- The width of a Thread Arc is a linear function of the size of the thread
- *compact visualization* if height is constrain



The relationship between messages are clearer when arcs are draw above and below nodes (B).

# Pseudo code for drawing a thread arc

## To make a Thread Arc

```

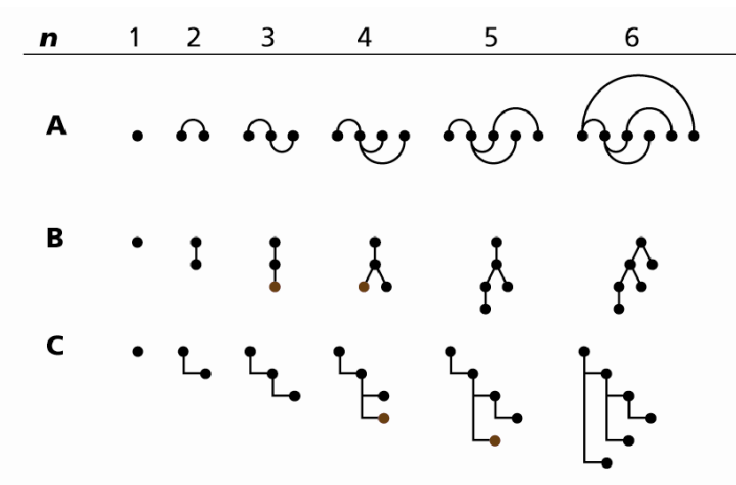
sort all messages chronologically
find the generation depth of each message

for each message
  if the message is the root message then
    place the node at the starting position
    don't draw an arc
  else
    place the message to the right of the last message
    if the message generation depth is odd then
      draw an arc above the line to the message's parent
    else
      draw an arc below the line to the message's parent
next message
  
```

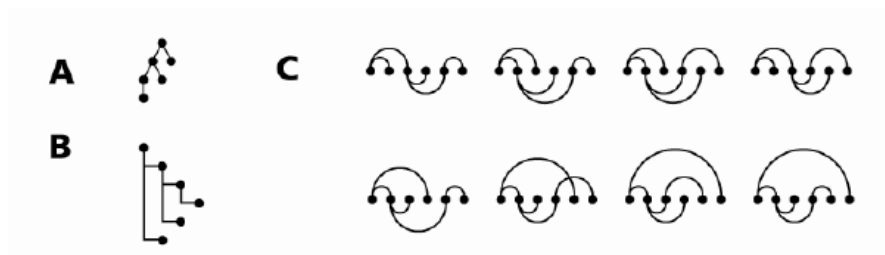
# Possible Thread Arcs that can be built with 2 to 5 messages.

<i>n</i>	2	3	4	5
<b>t</b>	1	2	6	24

# Stability of Thread Arcs



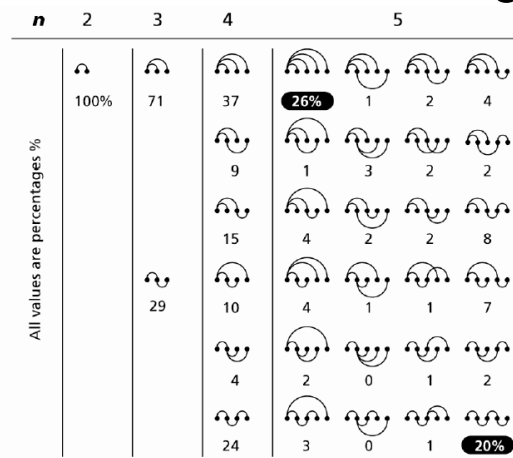
# Chronological Information in the Thread Arcs



# Example Email Client using Thread Arcs



# Distribution of distinctive Thread Arcs of 2 to 5 messages



More details: <http://www.research.ibm.com/real/publications.html>

# Techniques

- Focus & Context
- Zoom & Pan

# Background

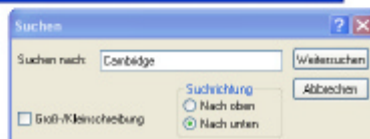
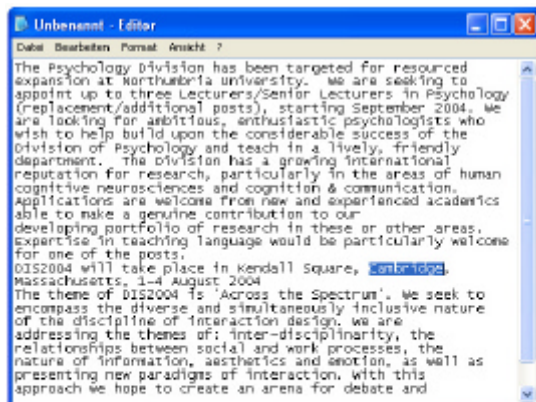
- Useful Field of View (UFOV)
  - expands searchlight metaphor
  - size of region from which we can rapidly take information
  - maintains constant number of targets
- Tunnel Vision and Stress
  - UFOV narrows as cognitive load/stress goes up
- Role of Motion in Attracting Attention
  - UFOV larger for movement detection

# Depth of Field

- Guiding user attention by blurring less relevant parts of an image
- Keeping the context
- Semantic Depth of field = blurring objects based on their relevance

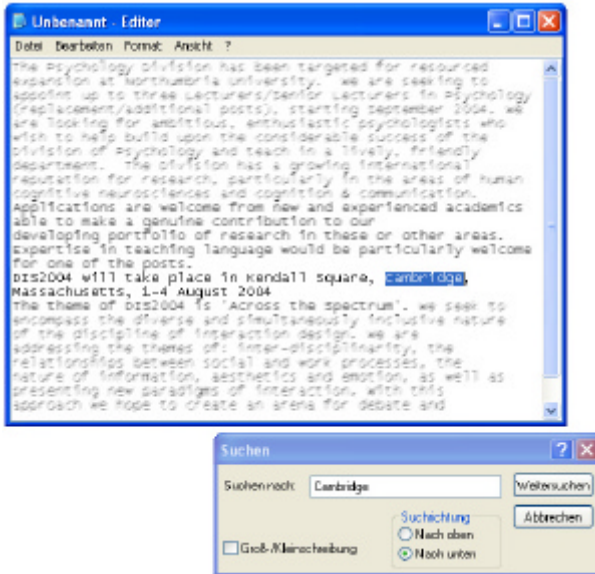


# Semantic Depth of Field - Example





# Semantic Depth of Field - Example



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# References

- A Review and Taxonomy of Distortion-Oriented Presentation Techniques, Leung & Apperley, 1994
- Barlow et al. "A Comparison of 2-D Visualizations of Hierarchies" INFOVIS'01 <http://www.sims.berkeley.edu/courses/is247/s02/readings/barlow.pdf>
- Martin Wattenberg. Arc Diagrams: Visualizing Structure in Strings IBM Watson Research Center, Technical report 2002-11 <http://domino.research.ibm.com/cambridge/research.nsf/0/e2a83c4986332d4785256ca7006cb621?OpenDocument>
- Thread Arcs <http://www.research.ibm.com/remail/threadarcs.html>
- Focus+Context Taken Literally, Robert Kosara, Silvia Miksch, Helwig Hauser, 2000
- Marti Hearst, <http://bailando.sims.berkeley.edu/talks/chi03-tutorial.ppt>
- Storey, [http://www.cs.uvic.ca/~mstorey/teaching/infovis/course\\_notes/introduction.pdf](http://www.cs.uvic.ca/~mstorey/teaching/infovis/course_notes/introduction.pdf)
- Shneiderman, <http://www.cs.ubc.ca/~tmm/courses/cpsc533c-03-spr/readings/shneiderman96eyes.pdf>

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