Overview

A) Hierarchical visualization techniques

B) Visualizing hierarchical data

Figure 1. Classification of visual data exploration techniques.

[Keim, 2001]
Part A

hierarchical visualization techniques
Problem

Data
multivariate data (e.g., Movie DB, Car dataset)

Presentation space
display dimensionality constrained to 2D or 3D

Task
meaningful representation of all variables within a single plot

How?
Example

4 variables:
longitude
latitude
ore grade
depth
Dimensional Stacking

[LeBlance et al. 1990]

visualization of oil mining data with longitude and latitude mapped to the outer x-, y- axes and ore grade and depth mapped to the inner x-, y- axes

used by permission of M. Ward, Worcester Polytechnic Institute
Dimensional Stacking

Partitioning of the n-dim. attribute space in 2-dim. subspace, which are “stacked” into each other

Partitioning of the attribute value ranges into classes

Important attributes should be used on the outer levels

Adequate especially for data with ordinal attributes of low cardinality
Dimensional Stacking

**Given**

Given variables $V_1 - V_m$

Power of the Domain: Cardinalities $K_1 - K_m$

**Process**

2 Variables $V_i, V_k \rightarrow K_i * K_k$ Grid
Dimensional Stacking

Recursive Repetition with a Grid with Additional Pairs of Variables

Dummy-Variable: 2n-1 Variables

[LeBlance et al. 1990]
Example

Variable: $V_1 - V_6$

Numbers of Cardinality:

- $K_1 = 4$
- $K_2 = 2$
- $K_3 = 2$
- $K_4 = 3$
- $K_5 = 3$
- $K_6 = 2$

[LeBlance et al. 1990]
Example

Variables: $V_1 - V_6$
Cardinalities: $K_1 = 4, K_2 = 2, K_3 = 2, K_4 = 3, K_5 = 3, K_6 = 2$
Pairs $P_1 (V_1, V_3), P_2 (V_4, V_5), P_3 (V_2, V_6)$
Example - Combination: 4, 2, 3, 2, 2, 2
Worlds-within-Worlds

Partitioning of the n-dim. Space into 3-dim. Subspace

Nested 3-dim coordinates

3-dim coordinate = one property

Selected points --> new coordinates’ system

[Feiner & Besherss 1990]
Worlds-within-Worlds

[Feiner & Besherss 1990]
Part B
visualizing hierarchical data
Visualization Design

Data

Representation & Interaction

Task

Appropriateness

User

Efficiency

Effectiveness
Basic Data Characteristics

network / graph
items (nodes) that have relationships (links)
no inherent hierarchical structure

hierarchical / tree
parent - child relationships
every node has at most one parent
exactly one root node
mostly non-leaf nodes are containers only
Basic Data Characteristics

Topology
   Nodes
   Edges

Node attributes

Edge attributes

Node measures (derived)

Edge measures (derived)

Network measures (derived)

Size / number of elements?
Hierarchical data are **very common**

Hierarchies are one of the most prevalent **organizing principles** for coping with information

**application examples**

- organizations, org-charts, taxonomies, table of contents, sitemaps, file system, genealogies, ...
Tasks

*What are the tasks the users want to perform? What are users’ goals?*

- reducing complexity
- categorization - hierarchies (expand/collapse)
- overview of topology
- distribution
- examine relationships
- examine paths
- examine elements
- identify
- locate
- distinguish
- relate
- compare

**specific**

**general**
Illustrating example

Data: file system

Problem/task: disk is full --> free some space

How?

Tool?

Visualization?

Visual Encodings

indentation
representation of hierarchy level via indentation
focus on linear structure

connection
node-link diagrams
convention: root mostly on top, leaves on bottom
aspect ratio

containment
summed values
propagation through hierarchy
space-filling graphs

adjacency matrices
graph as table
nodes as rows/columns
edges as table cells

Images 1 and 2:
Demo application: Hierarchical Visualization System (HVS) [Andrews, 2005]

Acedemic prototype

Graz University of Technology, Institute for Information Systems and Computer Media (IICM)

Lead by Prof. Keith Andrews

Extensible InfoVis toolkit for visualizing hierarchically structured data

Visualizations provided:
- Tree View
- Information Pyramids
- Hyperbolic Tree
- Magic Eye
- InfoLens
- TreeMaps
- Sunburst
Node-link diagrams

Graph drawing
huge area
lots of theory and algorithms

Good layout is important for effective presentation of inherent structure

basic layouts
linear
tree
radial
force directed
spring
gravity
magnetic

Links - Gestalt law - line smoothness

Images:
- Jeffrey Heer, Tree Visualization, SIMS 247: Information Visualization and Presentation, 2005.
- Max Baker, Netdisco, http://netdisco.net/
Interaction

why?

aspect ratio
large information space
do not fit onto display space
Problem: large structures that don't fit on a single view/screen

expand / collapse
navigate
focus + context

see upcoming lecture for details
visualization techniques
Indented Lists

representation of hierarchy
level via indentation

focus on linear structure
SpaceTree / DOI Tree

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

http://prefuse.org/gallery/treeview/

[Plaisant et al., 2002]

[Heer and Card, 2004]
Cone Trees

[Robertson, Mackinlay, Card 1991]

Figure 5: A Standard 2D Tree

Figure 9: A 3D Cone Tree.
Cone Trees vs. Cam Trees

Vertical (Cone Tree) vs. Horizontal (Cam Tree)

Shadows provide 2D structure
Cone Trees

Important: Interaction!

Figure 1: Layout of a simple Cone Tree, before and after selection.

Figure 2: Layout of a simple Cam Tree, before and after selection.

Figure 4: Result of a Search Operation.

[Robertson, Mackinlay, Card 1991]
Starlight – File System

[Pacific Northwest National Laboratory – USA]
Balloon Trees

Flattened cone trees

[Herman, Melancon, and Marshall, 2000]
Hyperbolic Trees

Nodes are placed on hyperbolic geometry (inside of a sphere)

Projection into 2D

F+C

[Munzner, 1998]
Magic Eye

Modified spherical projection

Tree level background coloring

[Andrews, 2005]
InfoLens

Spherical projection + 2-way fisheye projection

[Andrews, 2005]
FAS.research

Social Network Analysis

http://www.fas.at/
Containment

[Shneiderman 1992; Johnson, 1993]
InfoCube

3 D Visualization of Hierarchical Data Using Transparent Boxes

[Rekimoto & Green 1993]
Application example: Clustering search engine

Clusty

Indented list

http://clusty.com
Application example: Clustering search engine

Grokker

Containment hierarchy

http://www.grokker.com
Venn-Diagram → Treemaps

Nested Treemap

Treemap:

[Shneiderman 1992; Johnson, 1993]
Example: File Structure to Tree

File System:
3 Folders
6 Files

1) Root -> whole Screen
Example: File Structure to Tree

File System:
3 Folders
6 Files

2) Cutting - according to the size (30% and 70% of the space)

Root
Dir 1
File 1 1 MB
File 2 2 MB
Dir 2
File 3 2 MB
Dir 2-1
File 4 3 MB
File 5 1 MB
File 6 1 MB
Example: File Structure to Tree

File System:
- 3 Folders
- 6 Files

3) Iteration: folder and subfolder
Example: File Structure to Tree

File System:
3 Folders
6 Files

One Solution

---

<table>
<thead>
<tr>
<th>File 1</th>
<th>File 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>File 2</td>
<td>File 4</td>
</tr>
</tbody>
</table>

---

Diagram with file structure:

- **Root**
  - **Dir 1**
    - File 1: 1 MB
    - File 2: 2 MB
  - **Dir 2**
    - File 3: 2 MB
    - **Dir 2-1**
      - File 4: 3 MB
      - File 5: 1 MB
      - File 6: 1 MB

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Demo (HVS)
Treemap: View Large Trees with Node Values

+ Space filling
+ Space limited
+ Color coding
+ Size coding
- Requires learning

TreeViz (Mac, Johnson, 1992)
NBA-Tree (Sun, Turo, 1993)
Winsurfer (Teittinen, 1996)
Diskmapper (Windows, Micrologic)
Treemap3 (Windows, UMd, 2001)

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

(Shneiderman, ACM Trans. on Graphics, 1992)
Finance Analysis
Gainers (bright green)

http://www.smartmoney.com/marketmap
Finance Analysis
Losers (bright red)

http://www.smartmoney.com/marketmap
http://www.hivegroup.com/
Treemap: Product catalogs
Treemap: Newsmap

http://newsmap.jp
TreeMaps Summary

Turning a tree into a planar space-filling map

Capacity to see tens of thousands of nodes in a fixed space and find large areas or duplicate directories is very powerful

Treemap algorithms

- BinaryTree
- Ordered
- SliceAndDice
- Squarified
- Strip

Beamtree

Map of the market [Wattenberg, smartmoney.com]
Icicle Trees

Tree levels side by side horizontal / vertical

Subdivision by size

Sunburst Tree

Radial version of icicle trees

Interaction facilities to navigate / zoom

Sunburst Tree: Focus + Context

Selected element is redrawn and expanded in outer semi-circle

[Andrews, 2005]
Information Pyramids

3D visualization

Hierarchy via containment

Faces used for labeling

Interactive rotate, zoom, pan, tilt

[Andrews, 2005]
Botanical Visualization of Huge Hierarchies

[Kleiber, van de Wetering & van Wijk, 2001]

Node and link diagram

Holton’s “Strang Modell”

Figure 10. Complete hard disk with $\alpha = 45$ and $\beta = 360/\varphi$. 
Botanical Visualization

[Kleiberg, van de Wetering & van Wijk, 2001]

Alternative 3D Visualization to Big Hierarchies

Branches Clash Seldom, Even Though no Particular Algorithm is Included

Adapted Phi-Balls are Appropriate for Big Files
Summary

Hierarchical visualization techniques
Re-usage of display dimensions

Visualization of hierarchical data
Hierarchical / tree data
  Parent/child relationships
  Widespread and common data structure

Representations
  Indented lists
  Node-Link diagrams
  Containment diagrams
  Adjacency matrices
Useful Stuff

Treemap

HCIL Treemap Browser <http://www.cs.umd.edu/hcil/treemap>
Map of the Market <http://www.smartmoney.com/marketmap>
Newsmap <http://newsmap.jp>
The Hive Group <http://www.hivegroup.com>
HyperTree Java Library <http://hypertree.sourceforge.net/>

SpaceTree <http://www.cs.umd.edu/hcil/spacetree>

Tree Visualizer <http://www.randelshofer.ch/ooop/treeviz/index.html>

VisualComplexity.com <http://www.visualcomplexity.com>

ManyEyes <http://www.many-eyes.com>

Search Engines / Clustering

Clusty <http://clusty.com>
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