The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations

Author：Ben Shneiderman

Reporter：Du Yanhan, Xu Youxiang

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1 Author(s) B. Shneiderman View All Authors

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Authors

B. Shneiderman
Dept. of Comput. Sci., Maryland Univ., College Park, MD, USA

Introduction

- Visual language researchers and user-interface designers are inventing powerful information visualization methods, while offering smoother integration of technology with task.
- Exploring information collections becomes increasingly difficult as the volume grows. A page of information is easy to explore, but when the information becomes the size of a book, or library, or even larger, it may be difficult to locate known items or to browse to gain an overview,
- Designers are just discovering how to use the rapid and high resolution color displays to present large amounts of information in orderly and user-controlled ways.

Introduction

- A picture is often cited to be worth a thousand words and, for some (but not all) tasks, it is clear that a visual presentation-such as a map or photograph-is dramatically easier to use than is a textual description or a spoken report. As computer speed and display resolution increase, information visualization and graphical interfaces are likely to have an expanding role.

Visual Information Seeking Mantra

- As computer speed and display resolution increase, information visualization and graphical interfaces are likely to have an expanding role.
- Visual displays become even more attractive to provide orientation or context, to enable selection of regions, and to provide dynamic feedback for identifying changes (for example, a weather map). Abstract information visualization has the power to reveal patterns, clusters, gaps, or outliers in statistical data, stock-market trades, computer directories, or document collections.

Task by Data Type Taxonomy

- "To sort out the prototypes and guide researchers to new opportunities, I propose a type by task taxonomy (TTT) of information visualizations. I assume that users are viewing collections of items, where items have multiple attributes."

1-dimensional

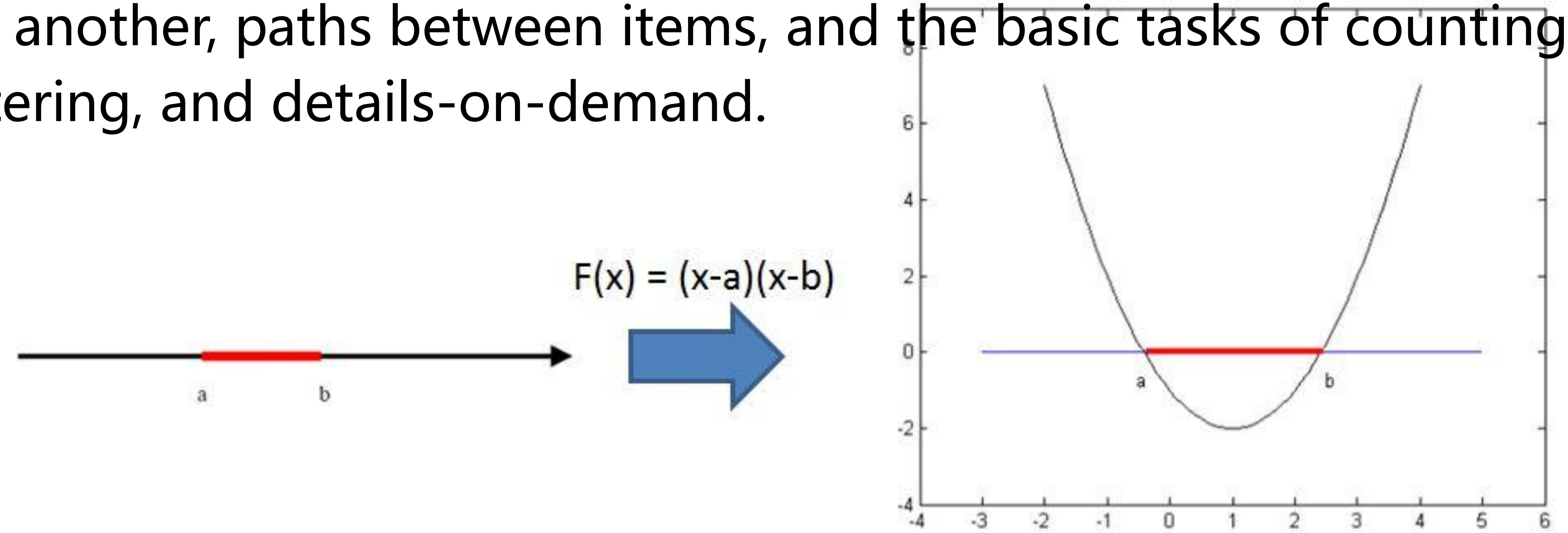
- Interface design issues include what fonts, color, size to use and what overview, scrolling, or selection methods can be used. User problems might be to find the number of items, see items having certain attributes (show only lines of a document that are section titles, lines of a program that were changed from the previous version, or people in a list who are older than 21 years), or see an item with all its attributes.

1-dimensional（example)

- the selected issue of a scientific journal had detiails about each article, the older and newer issues of the journal were to the left and right on the bookshelf with decreasing space
- the attribute values of each thousands of item in a fixed-sized space using a scrollbar-like display called value bars。

2-dimensional

- planar or map data include geographic maps, floorplans, or newspaper layouts.
- User problems are to find adjacent items, containment of one item by another, paths between items, and the basic tasks of counting, filtering, and details-on-demand.



2-dimensional（example)

- Information visualization researchers have used spatial displays of document collections organized proximally by term co-occurrences.

3-dimensional

- real-world objects such as molecules, the human body, and buildings have items with volume and some potentially complex relationship with other items.
- In 3-dimensional applications users must cope with understanding their position and orientation when viewing the objects, plus the serious problems of occlusion.
- Solutions to some of these problems are proposed in many prototypes with techniques such as overviews, landmarks, perspective, stereo display, transparency, and color coding.

3-dimensional（example）

- Navigating high resolution images of the human body is the challenge in the National Library of Medicine's Visible Human project
- Some applications have attempted to present 3-dimensional versions of trees，networks, or elaborate desktops.

Temporal

- time lines are widely used and vital enough for medical records, project management, or historical presentations to create a data type that is separate from 1-dimensional data。
- The distinction in temporal data is that items have a start and finish time and that items may overlap. Frequent tasks include finding all events before, after, or during some time period or moment, plus the basic tasks

Temporal (example)

- LifeLines shows a youth history keyed to the needs of the Maryland Department of Juvenile Justice, but is intended to present medical patient histories as a compact overview with selectable items to get details-on-demand.
- Temporal data visualizations appear in systems for editing video data or composing animations such as Macromedia Director.

Multi-dimensional

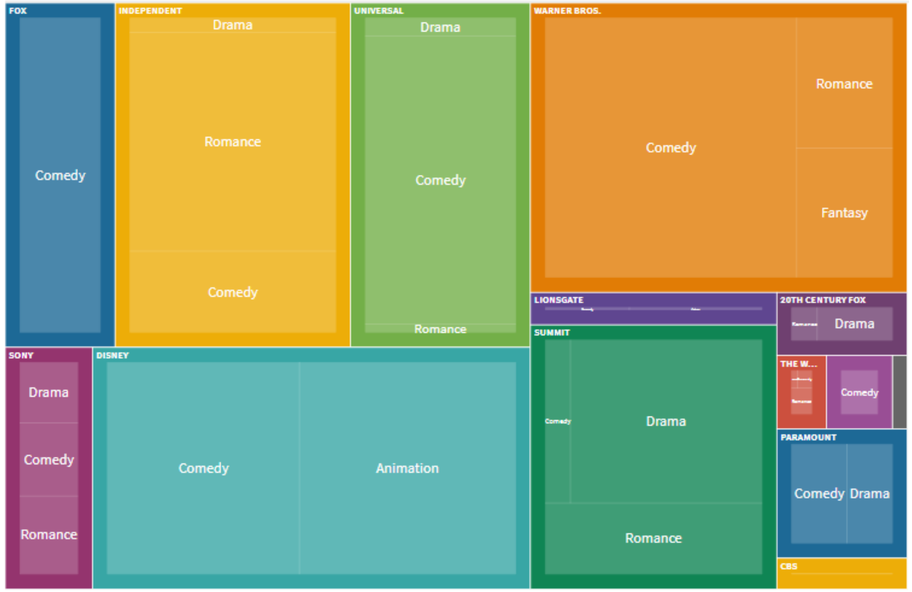
- most relational and statistical databases are conveniently manipulated as multidimensional data in which items with n attributes become points in a n-dimensional space.
- The interface representation can be 2-dimensional scattergrams with each additional dimension controlled by a slider
- Multi-dimensional data can be represented by a 3-dimensional scattergram but disorientation (especially if the users point of view is inside the cluster of points) and conclusion (especially if close points are represented as being larger) can be problems.

Tree

- tree structures are collections of items with each item having a link to one parent item (except the root).
- Items and the links between parent and child can have multiple attributes.
- While it is possible to have similar items at leaves and internal nodes, it is also common to find different items at each level in a tree。
- Interface representations of trees can use an outline style of indented labels used in tables of contents, a node and link diagram, or a treemap, in which child items are rectangles nested inside parent rectangles.

Tree-example

- The treemap approach was successfully applied to computer directories, sales data, business decision-making (Asahi et al., 1995), and web browsing (Mitchell et al., 1995; Mukherjea et al., 1995), but users take 10-20 minutes to accommodate to complex treemaps.

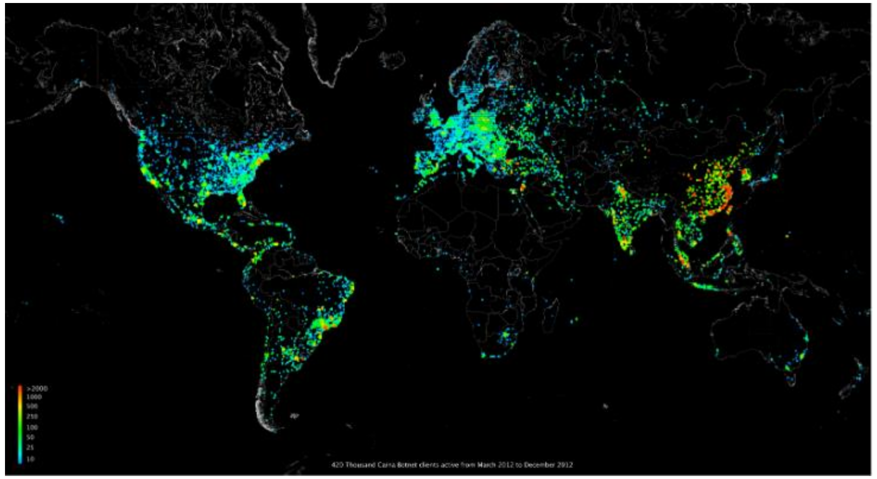


Network

- sometimes relationships among items cannot be conveniently captured with a tree structure and it is useful to have items linked to an arbitrary number of other items. While many special cases of networks exist (acyclic, lattices, rooted vs. un-rooted, directed vs. undirected) it seems convenient to consider them all as one data type.
- Network visualization is an old but still imperfect art because of the complexity of relationships and user tasks.

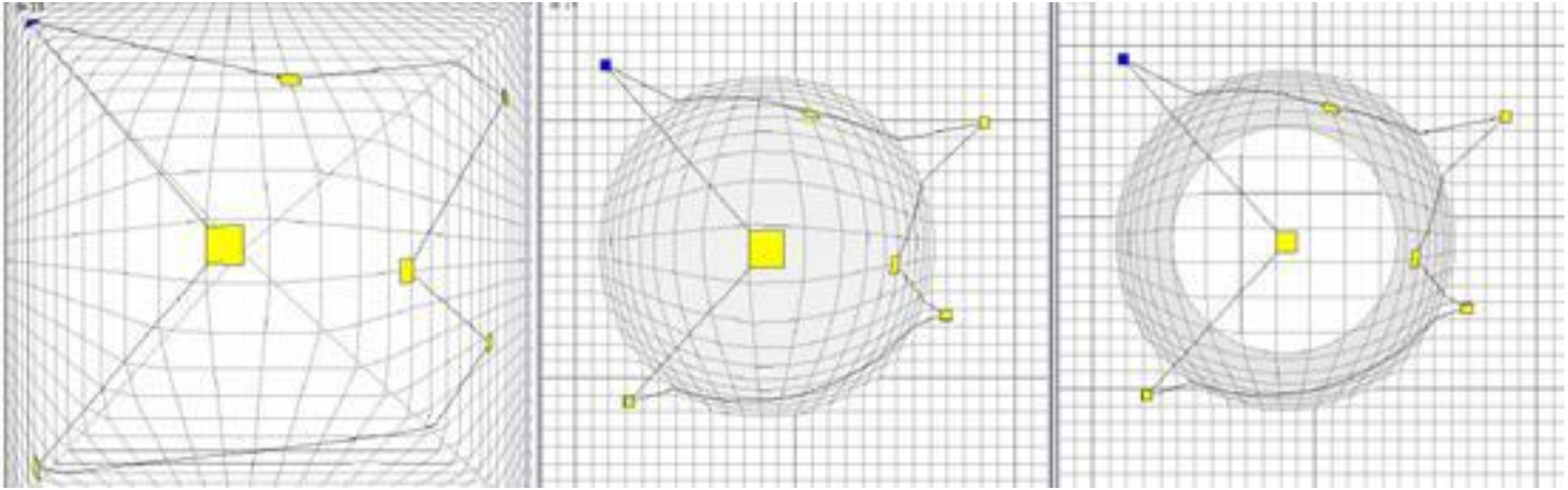
Network-example

- Commercial packages can handle small networks or simple strategies such as Netmap's layout of nodes on a circle with links criss-crossing the central area.
- An ambitious 3-dimensional approach was an impressive early accomplishment (Fairchild et al., 1988), and new interest in this topic has been spawned by attempts to visualize the World Wide Web (Andrews, 1995; Hendley et al., 1995).



Overview: Gain an overview of the entire collection.

Fisheye strategy



Overview strategies include zoomed out views of each data type to see the entire collection plus an adjoining detail view

Zoom: Zoom in on items of interest.

trees are important special cases. Interface representations of trees can use an outline style of indented labels used in tables of contents (Chimera and Shneiderman, 1993), a node and link diagram, or a treemap, in which child items are rectangles nested inside parent rectangles.

Examples: Tree-structured data has long been displayed with indented outlines (Egan et al., 1989) or with connecting lines as in many computer-directory file managers. Attempts to show large tree structures as node and link diagrams in compact forms include the 3-dimensional cone and cam trees (Robertson et al., 1993; Carriere and Kazman, 1995), dynamic pruning in the TreeBrowser (Kumar et al., 1995), and the appealingly animated hyperbolic trees (Lamping et al., 1995). A novel space-filling mosaic approach shows an arbitrary sized tree in a fixed rectangular space (Shneiderman, 1992; Johnson and Shneiderman, 1991). The treemap approach was successfully applied to computer directories, sales data, business decision-making (Asahi et al., 1995), and web browsing (Mitchell et al., 1995; Mukherjea et al., 1995), but users take 10-20 minutes to accommodate to complex treemaps.

Network: sometimes relationships among items cannot be conveniently captured with a tree structure and it is useful to have items linked to an arbitrary number of other items. While many special cases of networks exist (acyclic, lattices, rooted vs. un-rooted, directed vs. undirected) it seems convenient to consider them all as one data type. In addition to the basic tasks applied to items and links, network users often want to know about shortest or least costly paths connecting two items or traversing the entire network. Interface representations include a node and link diagram, and a square matrix of the items with the value of a link attribute in the row and column representing a link.

Examples: Network visualization is an old but still imperfect art because of the complexity of relationships and user tasks. Commercial packages can handle small networks or simple strategies such as Netmap's layout of nodes on a circle with links criss-crossing the central area. An ambitious 3-dimensional approach was an impressive early accomplishment (Fairchild et al., 1988), and new

looking at the tasks and data types in depth.

Overview: Gain an overview of the entire collection. Overview strategies include zoomed out views of each data type to see the entire collection plus an adjoining detail view. The overview contains a movable field-of-view box to control the contents of the detail view, allowing zoom factors of 3 to 30. Replication of this strategy with intermediate views enables users to reach larger zoom factors. Another popular approach is the fisheye strategy (Furnas, 1986) which has been applied most commonly for network browsing (Sarkar and Brown, 1994; Bartram et al., 1995). The fisheye distortion magnifies one or more areas of the display, but zoom factors in prototypes are limited to about 5. Although query language facilities made it difficult to gain an overview of a collection, information visualization interfaces support some overview strategy, or should. Adequate overview strategies are a useful criteria to look for. Along with an overview plus detail (also called context plus focus) view there is a need for navigation tools to pan or scroll through the collection.

Zoom: Zoom in on items of interest. Users typically have an interest in some portion of a collection, and they need tools to enable them to control the zoom focus and the zoom factor. Smooth zooming helps users preserve their sense of position and context. Zooming could be on one dimension at a time by moving the zoombar controls or by adjusting the size of the field-of -view box. A very satisfying way to zoom in is by pointing to a location and issuing a zooming command, usually by clicking on a mouse button for as long as the user wishes (Bederson and Hollan, 1993). Zooming in one dimension has proven useful in starfield displays (Jog and Shneiderman, 1995).

Filter: filter out uninteresting items. Dynamic queries applied to the items in the collection is one of the key ideas in information visualization (Ahlberg et al., 1992; Williamson and Shneiderman, 1992). By allowing users to control the contents of the display, users can quickly focus on their interests by eliminating unwanted items. Sliders, buttons, or other control widgets coupled to rapid display

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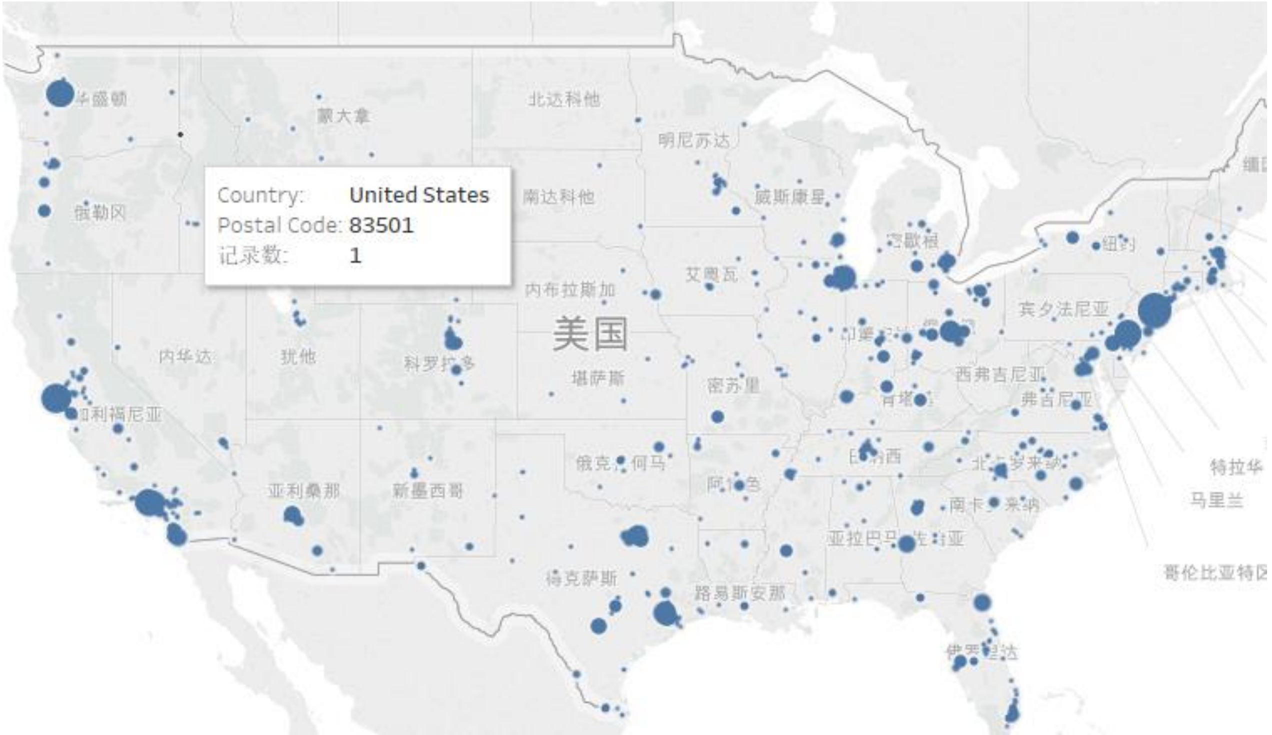
Details-on-demand:

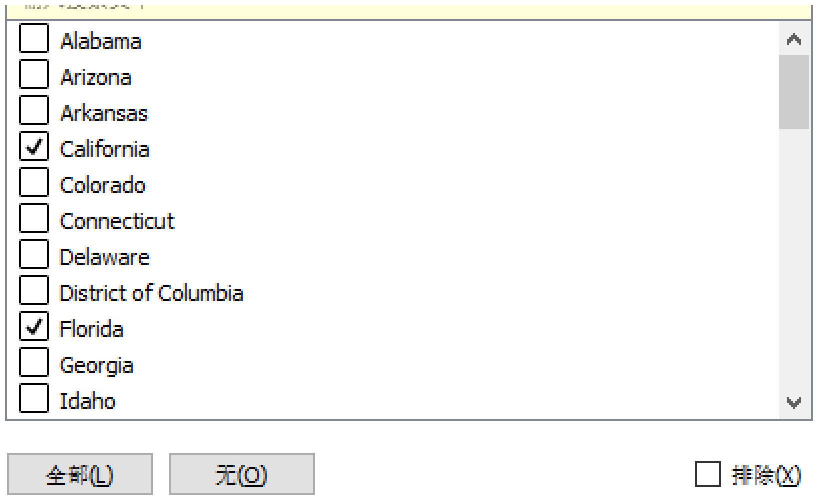
Select an item or group and get details when needed.



Relate: View relationships among items.

- 2 4 8 16 32
- 3 6 9 12 15

Advanced Filtering



Summary

- This article defines seven types data.
- Dimensional , temporal , network , tree
- And give us a way to looking data:
- Overview first , zoom and filter ,then details-on-demand
- This approach can help novices and intermittent users to specify complex Boolean expressions.


Thank for your attention.