INFORMATION VISUALIZATION

Definitions

Information visualization is a rapidly developing and distinctive field with less than 20 years of history. It has quickly become a multidisciplinary research area that overlaps into a number of subject domains, including digital libraries, human-computer interaction, hypertext, the Web and the Internet, and information retrieval.

The literature of these areas illustrates that information visualization is the latest stream in a long-established trend of modern user interface design. Many librarians say information visualization is at a crossroads, waiting for that killer application that will put it on the map of information organizations and their users.

To understand what information visualization is, workable definitions of the various levels of the field of visualization itself are required. Here are some definitions, moving from general to specific, focusing on information visualization itself:[1]

External cognition	Use of the *external world* to accomplish cognition.
Information design	Design of *external representations* to amplify cognition.
Data graphics	Use of *abstract, nonrepresentational* visual representations of data to amplify cognition.
Visualization	Use of *computer-based, interactive* visual representations of data to amplify cognition.
Scientific visualization	Use of interactive visual representations of *scientific* data, typically *physically based*, to amplify cognition.
Information visualization	Use of interactive visual representation of *abstract, nonphysically based* data to amplify cognition.

Almost all the literature agrees on this definition of information visualization:

> Information visualization is the use of computer-supported, interactive, visual representations of abstract data to amplify cognition.[2]

Although this definition is understandable to most computer and information professionals, simpler and easier ways of defining information visualization are required for those in information organizations.

Here are some other ways of defining information visualization:

- The process of analyzing and transforming nonspatial data into an effective visual form
- A highly efficient way for the mind to directly perceive data and discover knowledge and insight from it
- The visual appearance of data objects and their relationships
- The transformation of abstract data to a visual representation, which is rapidly understood by the user.

For the purpose of this report, information visualization is simply the process of transforming data into a visual representation. It is the process of transforming data into a 3D visual representation.

Although this report does not intend to examine other visualization areas closely related to information visualization, know that extensive research and whole subgenres of visualization exist that are related to the topic of information visualization. These areas include:

- **Data visualization:** The graphical representation of information, with the goal of providing the viewer with a qualitative understanding of the information contents. Information may be data, processes, relations, or concepts.

  Graphical presentation means manipulation of graphical entities (points, lines, images, text, shapes) and attributes (color, shape, size, position). Understanding involves detection, comparison, and measurement, is enhanced by interactive techniques, and views information from multiple views and with multiple techniques.

- **Geographic visualization:** The graphical representation of geographical and spatial information. Spatial metaphors are important in information visualization and also are one of the most fundamental design models of virtual environments. In the design of virtual or digital libraries, geographic visualization works hand in hand with information visualization, especially in 3D and other multiD environments.

- **Scientific visualization:** The graphical representation of scientific information. This field is the basis for current research in information visualization, and has the most extensive literature associated with it. It dates back to the 1987 National Science Foundation (NSF) report *Visualization in Scientific Computing*.

- **Software visualization:** A branch of scientific visualization that addresses software objects (algorithms, parallel processes, programs, and so on). The use of computer animation and graphics help illustrate and present computer processes, algorithms, and programs.

  For practical purposes, software visualization systems are used in teaching to help students understand how algorithms work, and in program development to graphically illustrate how programmers can better understand their code.

History

The origins of visualization date back to the 18^{th} century. As an organized subfield, however, the NSF report *Visualization in Scientific Computing* is generally considered the defining document.[3]

In the sciences, information visualization was conceived as a method to handle large datasets of scientific information and to enhance the ability to see relationships and phenomena in the data.

Attempts to represent things such as the human body, the chemical periodic table, and other scientific structures graphically beyond 1D and 2D were the focus of early computer scientists.

Representing hypertext networks in a map-like form was an early foray in graphic experimentation as well. A more formal infrastructure began to emerge academically with the establishment of the annual IEEE Information Visualization Symposium initiated in 1995. This symposium quickly became the research forum for the discipline.

A number of research grants began to focus on this area in the late 1990s, as well as the annual IEEE Information Visualization conference in London. Only lately have some peer-reviewed journals been established in this field to help organize, coordinate, and assist in defining the research agenda of the new discipline.[4]

Conceptualizing data types in information visualization

Although this report primarily discusses 3D applications and techniques of information visualization, librarians should understand technically and structurally how computer scientists and information organizations will view information in the future.

The human perceptual system can assimilate color, motion, proximity, shape, and size quickly. A good information visualization software product or system not only assists in the perception of information more easily, but it also should allow users to assimilate that information quicker, as well as allow for more information to be assimilated than was possible before.

Specialists in information visualization have attempted to categorize the various dimensional aspects of their field, and they basically agree on seven to eight data types as the foundational approach to the understanding of information visualization:[5]

- Temporal
- One-dimensional (1D)
- Two-dimensional (2D)
- Three-dimensional (3D)
- Multi-dimensional (MultiD)
- Trees
- Network
- Workspace

Temporal information visualization has two basic qualities: temporal events can be either overlapping or simultaneous, and that multiple scales of precision (from seconds to centuries) are necessary for measurements.

Tasks for which temporal information visualization are useful include finding temporal inconsistencies or undesired relationships between and among disparate events or data, creating and viewing historical timelines, hypothetical strategic planning of events related to a time sequence (like timelines in multimedia authoring programs such as Macromedia's Director and Flash), and the viewing and manipulation of related and unrelated data and events. Examples include animations, timelines of various sorts, and video manipulation and representation.

See www.otal.umd.edu/Olive/Temporal.html to view projects, products, citations, videos, and other online examples of temporal information visualization, as of 1998.

One-dimensional (1D) information visualization is text-based information. It is simple, linear data. Figures, tables, and text presented on this type of page are one-dimensional information visualization.

One-dimensional space is limited to only relative length of information, and color, as objects for manipulation, see www.otal.umd.edu/Olive/1-D.html.

Most information professionals work with this type of visualization most often, especially before 1995 and the mass marketing of the Web and the introduction of Internet browsers.[6] Tasks in one-dimensional space include being able to sort and arrange long lists in changeable order sets, viewing summary data of large datasets to find similarities and discrepancies, and to filter out unwanted data.

Two-dimensional (2D) information visualization combines two primary attributes represented in a space. Placing these two attributes on an x-axis and y-axis allows for representation in a visual space environment.

Types of tasks that can be done in this environment include geographic information services (GIS), computer chip design, photo and image layout and browsing, tracking systems, semantic zooming capabilities, and newspaper layout.

When considered from the computer modeling viewpoint, all visualization is displayed on a 2D surface. Confusion between temporal or network visualization often occurs when this point is not understood. In fact, most 3D information visualization software programs and environments available are presented in a 2D surface.

Information about the 2D environment, www.otal.umd.edu/Olive/2-D.html

The next step is to move forward with 3D environments in the corporate and information world that can take advantage of the true nature of 3D without sacrificing staff and monetary resources. Geographic information has always had a head start in using 2D, and 3D with a 2D surface, in the presentation and manipulation of latitude and longitudinal information

Three-dimensional (3D) information visualization is the focus of this report. 3D information visualization goes beyond 2D by incorporating volume. The use of computer modeling, and technologies such as QuickTimeVR and the Virtual Reality Modeling Language (VRML; now known as X3D), have greatly assisted researchers experimenting in this area.

The most visible and impressive website is the Visible Human Project, available at www.nlm.nih.gov/research/visible.

Although current technology in the marketplace specializes on 3D information in a 2D space (and these software products and projects are mentioned in this report), that killer application and current experimentation will eventually make this area a critical focal point for information organizations. Scientific information visualization has been presenting information in 3D for some time now.

Information about the 3D environment, www.otal.umd.edu/Olive/3-D.html.

Some major experimentation is taking place in what is known as immersive virtual reality equipment. 3D information visualization also can be subdivided into: the scientific and architectural 3D visualization, which attempts to help the researcher see unexplored or inner parts of an object not usually available in a 2D environment; artificial or synthetic worlds or workspaces, where a virtual world is available for the user to traverse, communicate, and collaborate within; the use of 3D to simulate 3D objects such as system trees, networks, and GIS systems (some of these have also been placed in the 1D and Workspace sections); and the placing of 2D objects into a 3D space. Each of these subdivisions will be examined further.

See www.otal.umd.edu/Olive/Multi-D.html for a long list of citations and experiments in this area in the late 1990s.

Multidimensional information visualization (multiD) is data that has more than three attributes, each of which is fairly equal in the visual context of the data and is primarily nonspatial. Stock market statistics, real estate home listings, books in a library, a movie database—these datasets work well in multiD.

Tree structures—or hierarchies—are data with multiple nodes, each of which has a single parent node, or root node. These nodes can have siblings (items that have the same parent node) and children (items that have it as the parent node). These structures are common; examples include computer data storage systems, genealogical trees, and business organizational structures.

Some of the tasks that tree structure visualization can assist with are:

- Discovering attributes (especially the size) of nodes and trees
- Finding the most recent common ancestor between two nodes
- Finding numerous types of relationships among nodes (both global and item level)
- Finding the path to a particular node from the root of the hierarchy

MultiD information can be presented in 3D as well. Cone trees, hyperbolic tree structures, and tree maps are some common ways to present this information.

See www.inf.ethz.ch/personal/lombardo/archives/da/node9.html for examples of cone trees, and www.inf.ethz.ch/personal/lombardo/archives/da/node10.html for an example of a hyperbolic tree structure. See www.otal.umd.edu/Olive/Tree.html for more information.

Network visualization goes back to the 1960s, when the large computer systems in government and academia were beginning to be constructed.

Items/nodes have relationships/links to an arbitrary number of other items and include the following:

- Multiple parent nodes (unlike hierarchical visualization nodes, which have a unique parent node)
- No apparent or inherent hierarchical structure, where multiple paths exist between two nodes, and where multiple attributes are between the items and the relationships

This complexity is represented by network visualization.

The World Wide Web, digital libraries, GIS, software, even grocery shopping are examples of complex and numerous relationships and nodes where network visualization can be used to assist users in organizing and visualizing the overall structure.

Some tasks that network visualization can help accomplish are finding both short and long paths to certain information, editing the network structure to make it more understandable to the viewer, managing traffic both locally and nationally, finding relationships between and among nodes, examining program performance of a certain system or product, and managing huge multiconglomerate networks of information.

See www.otal.umd.edu/Olive/Network.html for interesting software and projects in this area.

Finally, workspace visualization is a more recent phenomenon, especially with the Windows environment now found with Microsoft products. Attempting to provide more windows within a screen space size and attempting to organize the work environment to address new information are two of the main research areas in this field.

Some tasks that workspace visualization tries to assist users with are:

- Organizing and interacting with information efficiently
- Viewing and interacting with computer screen layouts in a more consistent way
- Rapidly accessing and integrating new information
- Allowing geographically disparate users to work together and collaborate in real time
- Creating new information through synthesis and collation of both old and new information resources

Workspace visualization information, www.otal.umd.edu/Olive/Workspace.html.

Many pros and cons exist to using 3D. Given the option of 1D, 2D, or 3D, librarians should consider many challenges for implementation.

One-dimensional visual structures are used when space is at a premium. Two-dimensional visual structures are most common, because they have an effective record and history for the presentation of abstract data. Although three-dimensional visual structures are visually exciting, they have greater implementation challenges.

Significant processing power is required in 3D, along with many more parameters including texturing, rendering, font display, and at least six degrees of freedom of movement. Design challenges for 3D include a ground plane to provide the illusion of 3D, lighting and shadows, and occlusion.

These challenges are why the presentation of information in visual format, thus far, has basically been in 2D. With the expanded capabilities and processing power of computers and the Internet today, however; more experimentation and presentation of information in 3D will soon be available.

Representing information in 3D

Visual user interfaces (VUIs) will be the major component of most 3D information visualization systems in the future, and they will be the means by which users will be able to take a more active role in the overall visualization process.

VUIs will become the graphical user interfaces (GUIs) of the 3D environment; that is, not only will 3D information visualization systems have modules related to the screen design, but they will also need to have a method for the user to interact with the application and the data.

Previous experiences with GUIs will become important in the creation of 3D information visualization systems. Some sets of criteria and functionalities that need to remain in the forefront are:

- Immediate, continuous feedback from the system to the user
- Close connection to the data through zooming and probing features
- Multidimensional approaches to displaying and manipulating multiple attributes
- A picture-centric user interface that is easy to use and understand
- Rapid prototyping and features for novices in programming both data and visualization of data
- Control of the underlying data model through manipulation of visual results, which supports iterative, efficient investigation of data
- Different views of the same information to support interactive visual correlation
- Interactive control of level of detail and resolution
- Ability to combine visual queries with visual data mining to form “What if …” questions; incorporation of a tool that can accomplish this task

Along with these criteria, users access and manipulate data and information at various levels of application. Most experts generally agree on four levels in 3D information visualization environments. These levels are (from highest to lowest):

- **Infosphere:** All the information outside the user’s immediate sphere of knowledge and outside the user’s immediate environment. Examples include information on the Internet or databases maintained online through a remote server.

- **Information workspace:** A staging area for integration of information from the level above (the infosphere) and the levels indicated below. Organized around tasks, the metaphor of a workbench or a computer desktop is a good analogy of this level.

  The user takes whatever information acquired from above and below, analyzes and manipulates it, and makes decisions regarding one or several tasks that he or she wishes to do with the information. The purpose of this level for the user is for decision making and information gathering related to his or her own choices and requirements.
- **Visual knowledge tools:** These software and hardware tools assist the user in viewing, manipulating, and creating 3D visualizations of information. Here users can determine the relationships in a particular set of data that they are interested in and can move them upward to the next level along with other datasets and visualized information.
- **Visually enhanced objects:** Information objects and datasets that have been enhanced by the use of 3D information visualization techniques.[7]

These four levels are usually called Infosphere, Workspace, Tools, and Objects. When Microsoft first brought out the Windows/Office products in the 1980s, it directly addressed the Workspace issue needed for the mass marketing of computers and manipulation of information in the GUI environment.

For 3D information visualization to have the same effect, it is in the Tools area that this revolution needs to take place. Only then can the lower level of Objects in 3D (for production and manipulation of information) as well as the upper level of Workspace in 3D (for organization and decision-making of multiple 3D objects and information packages) be combined to interactively provide users with the same power and ability available in the video game market. These Tools must be affordable, easy to use, easy to understand, and able to work with the current processing ability of most computers.

One interesting website that illustrates and provides graphic representations of cyperspaces such as the Internet, the World Wide Web, and other digital landscapes is An Atlas of Cyberspaces. This website divides various types of cyberspaces and digital landscapes into topics such as geographic, historical, weather maps, MUDs and virtual worlds, conceptual, artistic, surfmaps, website maps, information maps, information landscapes, information spaces, cables and satellites, census, topology, traceroutes, wireless, and ISP maps.

An Atlas of Cyberspaces, www.cybergeography.org/atlas/atlas.html

Most of these representations of information are 3D using 2D tools, but they still show the broad range of application and presentation of information in a 3D environment. This website is a good place to begin the exploration of 3D information visualization and is mentioned again in Chapter 3.

3D information visualization presentation techniques

Representing information in 3D visualization spaces is a challenge to convey in a nontechnical way. The best approach is to provide short definitions of each presentation technique, along with a website that visually illustrates what this method of visualization looks like:

- **Benediktine space:** The attributes of the information or object can be mapped onto intrinsic and extrinsic spatial dimensions. Intrinsic dimensions can include object attributes such as color, shape, size, texture, etc. Extrinsic dimensions specify points within a space.

- **Cityscapes:** This method attempts to take the spatial attributes of buildings or entire cities, and present them in 3D.
- **Cluster maps:** A way of virtually associating measurements of data with a map location. It is usually associated with geographically or spatially related information in the 3D environment. It can provide graphic representation of large, multiple objects not able to be viewed simultaneously or even realistically.
- **Concept mapping:** Graphical representations of knowledge comprised of concepts and the relationships among them. When placed in 3D, they can:
  - — Serve as navigational aids for hypermedia
  - — Graphically organize instructional materials for individual courses or entire curricula
  - — Teach critical thinking and can consolidate educational experience
  - — Improve affective conditions for learning
  - — Scaffold understanding
  - — Aid or provide an alternative to traditional writing.

  The June 2004 issue of *Syllabus* (v. 17, no. 11) has an informative article on this topic. When concept maps and the ideas they represent are connected to the digital resources themselves, they are called *content maps*.
- **Fish-eye views:** Attempts to present information in the narrow, tunnel-visioned approach that a fish might see in.
- **Graphs:** Presentation of graphical structures in a 3D environment.
- **Landscapes:** Presentation of real and imagined landscapes in a 3D environment.
- **Networks:** Presentation of networks in the 3D environment (computer systems, nodes, communication systems, and so on).
- **Perspective walls:** A technique for viewing large, linearly structured information, focusing on a particular area while still maintaining some degree of context or location.
- **Rooms:** Presentation of real or imagined rooms in the 3D environment. Often used in virtual collaboration environments.
- **Sphere visualization:** Presentation of spherical structures in 3D to view opposite or hidden dimensions and information that is not visibly apparent.
- **Topic maps:** Provide bridges between information management and knowledge representation. Are usually large collections of information resources.
- **Trees** (cones, cams, and hyperbolic): These types of 3D presentations usually start with one point or node of information, and then cascade downward or upward in various ways to show relations and similarities among disparate and common information being mapped.

An interesting master's thesis graphically displays 3D examples of many types of presentations in this environment (and also includes some highly technical explanations and calculations). It contains a hyperlinked table of contents for quick navigation and accessibility to the information.

For example, see www.inf.ethz.ch/personal/lombardo/archives/da/node7.html

For example, see www.ercim.org/publication/Ercim_News/enw38/jung.html

For example of a 3D representation of the universe, see www.hep.upenn.edu/~max/sdss/release.html.

Fish-eye views, www.absint.com/aisee/manual/windows/node54.html.

Graphs, www.originlab.com/index.aspx?s=9&lm=+153.

Landscapes, www.micromouse.ca/landscapes.html.

Networks, www.opnet.com/products/modules/3d_network_visualizer.html.

Perspective walls, www.inf.ethz.ch/personal/lombardo/archives/da/node6.html.

Rooms, www.trianglesun.com.au/emerald/3drooms.html.

Sphere visualization, www.cs.uvic.ca/~mstorey/vissoft2003/submissions/rilling2.pdf.

Topic maps, www.gca.org/papers/xmleurope2000/papers/s29-03.html and www.topicmap.com/topicmap/resources.html

Trees, see http://graphics.stanford.edu/papers/munzner_thesis/html/node8.html, http://davis.wpi.edu/~matt/courses/trees/, www.vrvis.at/vis/resources/DA-NSahling/node12.html, and www.cosc.canterbury.ac.nz/~andy/2d3d.html.

Look at the master's thesis website section on State of the Art in Information Visualization and its subsequent chapter divisions, along with the section on Information Visualization with 3D Scatterplots.

An explanation of the focus-plus-context (F+C) technique, which is often used to move 2D information into a 3D environment, also is available under the 3D Information Visualization section.

Master's thesis presenting technology examples, www.vrvis.at/vis/resources/DA-NSahling

3D information visualization in the Web environment

One new area of research in 3D information visualization is its application in what is referred to as the Semantic Web, or the second generation of the Web. Librarians should understand that information visualization and the Semantic Web are both similar and different in their approaches to information.

Although information visualization produces graphical representations of abstract information for users, the Semantic Web relies on a universal descriptive framework of resources accessed by software agents.

Information visualization focuses on the meaning and semantics conveyed by visual-spatial models to the user, where the Semantic Web uses machine-readable (not machine-understandable), formal, and cognitive-like approaches.

Will these two fields of research be able to work alongside each other? Research indicates that much practical and theoretical work remains to be done to see whether these two areas can be synchronized and work harmoniously with each other.[8]

The majority of research, experimentation, and programming in 3D information visualization is being done in two major programming languages, both written in the eXtensible Markup Language (XML) environment.

The first is the Virtual Reality Modeling Language (VRML), now known as eXtensible 3D (X3D). VRML was first developed by the Web3D Consortium, and Version 1.0 was released in May 1995.

Web3D Consortium, www.web3d.org

X3D, www.web3d.org/x3d

VRML is a language designed to allow users to build and design 3D simulations and virtual worlds on the Internet. Originally, it was based on an existing language called Open Inventor, developed by Silicon Graphics Inc., that supported various types of lighting, surface materials, and three-dimensional objects, such as would be needed in a virtual reality system.

VRML 2.0, issued in August 1996, officially became an international standard under the name VRML97 in December 1997. Version 3.0 has taken on a life of its own within the Web3D Consortium, incorporating the powerful capabilities of XML, such that VRML is now commonly known as X3D.

Although the X3D specification is only a part of VRML 3.0, X3D provides the behavior and geometry capabilities of XML along with new interactive and graphical objects, applications, viewers, and utilities.

X3D is an open standards XML-enabled 3D file format assisting in real-time communication of 3D data. It is being used in scientific visualization, architecture and CAD systems, medicine, training simulation, multimedia, as well as educational and entertainment-related environments.

According to the X3D website, the features of X3D include XML-integrated services, extensibility, well-specified standards, evolutionary capabilities, real-time interactive 3D data structures, broadcast-ready applications, and lightweight components.

X3D supports 3D graphics (such as polygonal and parametric geometry), 2D graphics, physical stimulation (such as geospatial datasets and humanoid animation), networking capabilities, spatialized audio and video, user-defined object creation and manipulation, desktop user visual interfaces, and dynamic scripting.

In contrast to VRML97, which requires an entire feature set for compliance, X3D has been developed to support subsets of the specification (known as profiles), composed of modular blocks of functionality (called components).

For a description of these profiles, and a visual graphic showing how they interact, see www.web3d.org/x3d/overview.html.

The four baseline X3D profiles are named Interchange, Interactive, Immersive, and Full. Some applications, viewers, and utilities available for working in X3D follow.

The second programming language is Scalable Vector Graphics (SVG). It is a new language designed to describe 2D graphics in XML.

SVG, www.w3.org/TR/SVG

Drafted in 1999 by the World Wide Web Consortium (W3C), SVG 1.0 became a Web standard of the W3C in September 2001. SVG is completely based on XML, which allows users to incorporate XML technologies such as the Resource Description Framework (RDF), the Document Object Model (DOM), the Synchronized Multimedia Integration Language (SMIL), the eXtensible Stylesheet Language (XSL), Cascading Style Sheets (CSS), as well as the XPointer and XLink capabilities of XML.

SVG allows for three types of graphic objects: text, images, and vector graphic shapes. SVG drawings can be interactive, dynamic, and animated. Its modularization is part of its strength as a 3D programming language.

Advantages of an XML-based graphics format include the ability to use XML-enabled software on the images, that it is an open standard, it is entirely text-based so text within graphics is searchable, it supports scripting interactivity, and it is resolution and media independent.

All these advantages make SVG the programming language of choice for 2D visualizations on the Semantic Web. The integration of RDF metadata is a bonus for digital libraries, in that SVG graphics and drawings are searchable and understandable to both humans and computers. Moving SVG into the 3D realm may be the next logical evolution for this programming language.

Notes

[1]*Readings in Information Visualization: Using Vision To Think*. Ed. S. Card, J. Mackinlay, and B. Shneiderman. San Francisco: Morgan Kaufmann, 1999. p. 6. See Table 1.1, from which this information is quoted.

[2]Ibid.

[3]B. H. McCormick and T. A. DeFanti, *Visualization in Scientific Computing*. National Science Foundation (NSF) report. 1987.

[4]The best reference book for the history of visualization (although dated), with historical texts and readings, is *Readings in Information Visualization: Using Vision To Think*. Ed. S. Card, J. Mackinlay, and B. Shneiderman. San Francisco: Morgan Kaufmann, 1999. It is organized around the seven data types of information visualization, described in the footnote below.

[5]Information for this section is taken from Gary Geisler, "Making Information More Accessible: A Survey of Information Visualization Applications and Techniques." (last updated Jan. 31, 1998). Although dated, it is available at www.ils.unc.edu/~geisg/info/infovis/paper.html. Geisler lists seven data types. A more user-friendly (and visually appealing presentation of these data types) is available at Olive: on-line library of

information visualization environments. www.otal.umd.edu/Olive/ (last updated Sept. 28, 1997), also dated. The Olive project lists eight data types.

[6]For an interesting early attempt to present one-dimensional information visually in new ways, see D. Small, "Navigating Large Bodies of Text." MIT Media Lab (v. 35, no. 3&4), 1996. Available at www.research.ibm.com/journal/sj/mit/sectiond/small.html. Small discusses the Virtual Shakespeare Project and how users are able to manipulate one-dimensional text in various ways.

[7]See Chapter 6, "Infosphere, Workspace, Tools, Objects" in Card et. al for more specific information and reference articles related to these four levels.

[8]The most up-to-date book on this topic is Vladimir Geroimenko and Chaomei Chen, *Visualizing the Semantic Web: XML-based Internet and Information Visualization* (London: Springer 2003).