visualizing technical information
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Baywood
2003

Chapter 6

Information Visualization

WHAT IS INFORMATION VISUALIZATION?

Information visualization is the name given to a wide range of dynamic visualizations of data. As opposed to the genres we have previously discussed, information visualization takes us into a much more interactive approach to the technical visual genre. The key point to first make is that our focus in this chapter will be information visualization that shows abstract data. This is an important point because many peoples' association of visualization is of physical entities displayed on computer screens. For example, members of the public may be familiar with visualization techniques such as the medical imaging machines that produce digitized views of the human body simply because they encounter it in hospitals. But graph-like visualizations of commodities markets and documents stored on systems still have a more specialized audience. Our discussion then starts off with a distinction between scientific and information forms of visualization.

The key difference between information visualization and scientific visualization is that scientific visualization usually represents actual physical entities while information visualization represents abstract data. According to David Carr, "Information visualization is the presentation of abstract data in a graphical form so that the user may use his visual perception to evaluate and analyze the data" [1]. The key in this statement is that the purpose is to evaluate and analyze the data, not present it. Thus, the question may be asked: In a book which has thus far concentrated on presentation technical visual genres, why examine an analytically based genre? For example, the graphs, charts, diagrams, tables, and illustrations that we have examined have primarily been used as presentation tools. Certainly these devices are also used as analytical tools, but the primary focus of the analysis thus far has been to examine how these genres communicate. Thus, what relationship can an examination of this kind of analytical tool have to the presentation graphics we have been looking at? The answer is that the ultimate answer may not lie in information visualization as it currently exists but, instead, information isualization is a medium that can possibly move us into the next generation f technical visual genres. It is its developing capacity as an interactive genre ıat holds the most promise for answering some of the critiques that I have resented in previous chapters. As we will see in this chapter, "Until recently, ıe term visualization meant constructing a visual image in the mind. But now has come to mean something more like a graphical representation of data or ɔncepts" [2, p. 1].

Vhy Would an Interactive Genre ›e So Valuable?

What information visualization offers us is a dynamic, interactive approach › data, which, while designed for analysis, has the potential to make communi-ation, if presented on-line or in person, far more responsive to questions and ueries about the information. The promise of this newly developing genre is that s placement on the dynamic Internet and computer-based Intranets could signal a ıore interactive and thus more empowered medium for users. As we will see in ıis chapter, with information visualizations, readers have more power to decide here to look in the data, how to envision it, and how to understand its facets. f course, all of this depends on how well the visualization product is designed ı the first place, the integrity of its database and whether and how often it is ɔdated. But still, as we look at this last and developing genre, we may agree with pence who writes that visualization's value is its window to the insight and ıderstanding that we as humans experience cognitively [3, p. 1]. Of course, for ›aders who have read this book from the beginning, such a statement holds a nge of negativity as its focus, like other technical visual genres, is cognitive ıther than contextual.

We may also find in this genre the same objectivist stance that has been :oblematic for so many of the traditional genres. But we will also see that the ı-line presentation of the information visualization genre can create a far more :teractive approach both to the design and reading of a graph. Take, for example, simple bar chart that is presented in paper form. This chart may be read as ırt of a larger paper-based text or as a static on-line graph. In this situation, the ›ader is heavily dependent on the text that surrounds the graph, both in labels ıd titles, as well as in paragraphs before and after its presentation. However, we look into the future and see the Internet as a more dominant means of ɔmmunicating information, we can speculate that information visualization will great part displace static presentations as the primary medium for all of the chnical visual genres. Taking this leap, however, does not mean that we will l move to completely paperless presentations of information graphics. Paper ›oductions of text and graphics will most likely continue, but the dynamic atures and capabilities of the Internet, as evidenced through information visual-ation, are too important to ignore.

Thus far, one of the promises of information visualization research has been to enhance human cognitive limitations via advancements in visualization techniques. Visualizations of complex relationships could bolster the abilities of both information workers and more typical consumers of personal computing, allowing them to more quickly handle the ever-increasing amounts of information available to them.

What Distinguishes Information Visualization from Other Genres?

When discussing information visualization, it is first important to distinguish the kind of information that is typically displayed in an information visualization vs. the kind of information that is typically displayed in a traditional graph, chart, diagram, or table display. A key determiner of the information visualization genre is the fact that it is typically used for larger sets of data than are usually presented in graphs, charts, and diagrams. The second qualifier that distinguishes information visualization is that the forum in which it is presented is on-line rather than on paper. Of course, still images from this visualization can still be used as presentation graphics, but its dominant use is on-line and analytical. The third qualifier to distinguish it from other genres is that it is a dynamic, not a static medium. Users can zoom in on certain parts, ask questions or see smaller aspects such as graphs of subsets of information or raw data tables—experiences that are not possible with traditional static genres. Next, a key distinction to understanding information visualization is that, unlike database querying and reporting, interactive visualized inquiry is nonlinear so that "users select the data and graph that they want to display; then they proceed through a process of incrementally selecting subsets, adding dimension through perceptual cues such as color coding and sizing of data points, drilling down for detail, zooming out again to relate micro and macro views, transforming data into new variables, reorganizing data structures and relationships, and animating data relationships to see parts in relation to the whole or to see changes over time" [4, p. 492]. Finally, information visualization, as it currently exists, is primarily an analytical medium, whereas the static technical visual genres are often presentation-based genres, though they, too, can be used for analysis.

When we look at these three qualifiers, we can see information visualization has key differences from the previous genres we have looked at, although it is closely tied to current genres. At the same time, however, we have to be careful when we so clearly divide the domain of information visualization from the traditional genres that provide visualizations of data. For example, the third qualifier that I mentioned above is that information visualization is dynamic whereas traditional genres are static. However, we are all aware that the traditional genres of the graph and chart are becoming less static as they are more and more capable of being created in tools which have animation options that can mimic some of the visual effects of information visualization.

For example, in an oral PowerPoint presentation, the presenter can design a slide show that allows users to see him zooming in on a static graph, making certain aspects appear to move or visually highlight certain aspects of it at designated times. We could say, then, that these computer-generated and computer-presented displays of traditional genres are dynamic in a sense. That is, they do move; they can change and alter appearance. However, the difference between this kind of animated display and the dynamic displays of information visualization is who is in charge of the visual changes and what you can do. In a PowerPoint slide of a graph, the designer can choose to use pre-set animation options created by the software designers to make changes and movement in the graph, but the graph and data itself does not fundamentally change. On the other hand, in information visualization, as we will see, the user has considerable control over what is seen and how it is displayed.

This control is evidenced when users of information visualization programs choose to zoom in on data, to decide what subsets of data to look at, and to make other kinds of user-centered graphic decision-making. At the same time, it would be naive to make the claim that the user is in full charge. Obviously, the control is shared both by the user and by the designer of the visualization program who presets options. In addition, someone had to originally create the database and choose what went in and what was left out. Thus, the choices that are then left up to the user are in some ways controlled by the designer of the visualization and the database. Still, the user has the control to manipulate the data, whereas users of animated graphs and charts in PowerPoint displays do not.

The Promise of Information Visualization Technology

The genre's ability to allow selective manipulation may also address some of the problems seen in traditional genres. For example, Tufte and others have often criticized the use of three-dimensional displays of data, especially when showing complex information, since it is hard to compare heights against slanted and distorted 3-D shapes and then compare them to the point on the axis to which they are supposed to be aligned. Of course, the ease with which such displays can be generated in today's computer software programs makes them likely to be used by graph designers. But this addition of a third dimension does not change the basic data and its intended display. In information visualization, however, a user's options are not cosmetic. The user does not simply change how the visualized data is shown; the user zooms in on certain subsets of the data, queries for specific answers, and searches for specific information. Alternatively, while an Excel designer can change the degree of angle that the third dimension shows on a graph, he or she does not learn more about the information by doing this. However, in information visualization, users can move from an initial three-dimensional display of complex data to a two-dimensional presentation that reveals new information. In this way, the information visualization "allows selected bars associated with a user-drawn reference line to be projected onto a two-dimensional presentation that allows comparisons to be made" [3, p. 25]. In this latter situation, a user's option allows a different view of the data that helps answer particular questions, whereas an Excel user of a static bar graph is only given the chance to make cosmetic changes to the basic graph.

Information visualization is capable of doing this because it allows the user to interact with the visualization by manipulating controls that change the view or focus. This can be done is a variety of ways. First, the user can make a dynamic query, which simply means that the user can specify the kind of information he or she wants. Readers may be familiar with this technique if they have used a library's on-line searching mechanisms to find a book. Thus, a library user would make the choice to narrow down a search to a certain person, publication date, and/or author. According to Card, Mackinlay, and Shneiderman, the dynamic query aspect of information visualization can, first, enable a direct walk to a desired place, as in the library search or on a Web page where we link to new pages [5, p. 233]. Second, the user can ask for details on demand. In turn, the visualization can expand a small subset of objects to reveal more of their variables [5, p. 233]. Third, users can enact what is called an "attribute walk" where he or she can select a case and then search for other cases with the same attributes [5, p. 233]. Fourth, a user can use the brushing technique to manipulate a range slider (a sliding bar on a scale that can be moved) [5, p. 233]. Fifth, users can directly manipulate the visualization to modify views by adjusting the parameters so that multi-dimensional views can be made of the data [5, p. 233]. All of these techniques are designed to facilitate the perceptual abilities of human beings. The main goal of this newly developing genre is, then, to use research results on perception to allow users to discover, decide, and explain information rather than to present information [5, p. 6].

HOW IS INFORMATION VISUALIZATION DEVELOPING?

In this chapter I make the claim that information visualization is a new and developing genre despite the fact that familiar genres such as tree charts are frequently used in the visualizations. I make this claim because this new genre was born not on paper but on the screen. Unlike the other genres discussed in this book, information visualization has, then, a different starting point—one which rests on a very different foundation, and one that is dynamic rather than static. To be sure, this new genre borrows heavily from the traditional paper-based genres like the table, the map, and the graph. However, unlike traditional static paper-based graphs and charts, it is a type of visual genre that was born on and is exclusive to a computer environment. It is not like the traditional charts and graphs which have simply been transferred from their paper-based medium to a new medium, as is the case with computer-based graph programs. Instead, it owes its distinction to the capabilities (and shortfalls) of on-screen and on-line visualizations of information. Because of this dynamic and different medium, information visualization is capable of doing far more than traditional paper-based technical visual genres.

If we accept the premise that information visualization is a developing new genre, we'll have an exciting opportunity to see how "the emergence of certain patterns . . . give (it) generic qualities" [6, p. 22]. Such a study also helps us to realize the dependence this newly developing genre has on its predecessors. As Bahktin wrote about the evolution of speech genres, "During the process of their (the genres) formation, they absorb and digest various primary (simple) genres that have taken form . . ." [7, p. 62]. The same phenomenon is taking place within the developing information visualization genre. It is borrowing forms already in place such as tree maps and developing new kinds of forms such as the fisheye lens, all the time manipulating them to fit the unique dynamic characteristics of an on-line forum.

In addition to the genre-defining characteristic of borrowing from its predecessors, we may also examine other characteristics of new genres to decide if this is a truly new genre. As I stated in the first chapter, a particular genre has "certain stable thematic, compositional and stylistic types of utterances" [7, p. 62]. If this is true, can we say at this point that information visualization envelops these characteristics? This is an important question because Thomas G. West argues that although "the acceptance of visualization seems really old hat," it may also be "another unintentional head fake" [8, p. 14]. What West means by this is that its existence is questionable due to its use as a market-driven economic boon when, in fact, the technological revolution it is supposed to have chartered has not yet unfolded [8, p. 14]. Is this then a stable genre when the technology is still being developed? This is a good question because as good as information visualization is, it is still limited in most part to those companies that have the economic means to develop it, although some programs can be available to users as add-ons to such spreadsheet programs like Excel. Thus, currently we might say that this is a genre used only by certain people—a certain privileged few? We can explore this question by examining what is occurring in the genre's early development that either mirrors previous developments in the traditional genres or that springs up as entirely new problems. What benefits are seen to the new genre by its proponents? What is the theory behind the genre and, more importantly, how does the theoretical foundation impact readers?

When examining a developing genre, we focus in on users and then directly on to the learning curve attached to it. The main factor we need to consider is the role of conventions. According to West, "Whether the visualization is directly or indirectly useful, convention is still a strikingly powerful barrier for

many" [8, p. 14]. Thus, while bar and line charts and tables may be well-known conventions, other visualization-specific formats such as complex histograms and new kinds of spatial arrangements not based on familiar icons may prove to be barriers for novice users. "What can traditional accountants or stockbrokers make of numbers that are shown as clouds in space, or complex, pulsing histograms? Or, what of traditional physicians who are happy with imaging that extends the microscope or x-ray machine—but have remarkable difficulties with sophisticated information visualization techniques that are truly novel?" [8, p. 14]. Of course, most companies that use information visualization at this time are using their own information, aided by a developer, and these companies then go on to train their employees in its use. The question seems to be: Will information visualization become a more widespread tool or will its influence in certain sectors affect how users may expect previously static-based technical genres to operate?

In addition to learning new conventional forms in information visualization, there are other problems. For example, meeting the storage space of large databases and lacking portability to the average user limits the number of people who have access to the genre. On the other hand, information visualization software that is available on-line may, in the future, not need such large-capacity computers. We also have to consider whether technical visual genres that use much smaller sets of data can actually be improved by information visualization techniques or whether their interactive features will only complicate what could be a simpler task.

Another problem area that we need to examine is whether the same kind of theoretical issues that have appeared in medical and scientific forms of visualization will also appear in the information visualization area. Medical and scientific forms of visualization, for example, have created many positive advances in our understanding. An expectant mother can see on a screen the fetus developing within her body. However, when we consider, for example, the impact of the woman seeing her baby on the monitor during an ultrasound, we may realize some of the problems that this attractive medium can have because of the distancing that is taking place in the visualization. Thus, in this truly out-of-body experience, the mother often finds herself not only removed from the life inside of her but also often ignored during the ultrasound while medical professionals discuss among themselves what they see [9]. Although this example of visualization is quite different than the kind of data visualization we are discussing in this chapter, it does provide a cautionary note since any kind of visualization of information can result in a product which places the user at some steps removed from the actual creation and experience of data. Do we, for example, trust a multi-dimensional, colored, and interactive visualization of a dataset more than a static presentation of its parts? How do we discuss its attributes? That is, at what point do we rely on technical terminology, technical manipulation, and perhaps ineffective assessments of the visualized data because of its persuasive mode and forum? Not that this is always a negative thing. For example, seeing a visualization f a mass of country-wide phone networks helps the user to understand ow a company's practices are impacting traffic and efficiency in various ɜgions. If the software is designed well, the user can learn more about the large ataset by zeroing in on smaller aspects to help him or her understand what ; happening.

;arly Development

Visualizing information is not, of course, a new phenomenon. As we have ɜen in previous chapters, there is a long history of both realistic and abstract isualizations of information. What is different about computer-based information isualization is its ability to be dynamic and interactive. It is a new genre that xists solely on the computer medium and, therefore, it takes advantage of the ıedium's capabilities. According to Card, Mackinlay, and Shneiderman, inforıation visualization is defined as "the use of computer-supported, interactive, isual representations of abstract data to amplify cognition" [5, p. 7]. Robert pence writes that information visualization, unlike scientific visualization ·hich displays physical entities, concerns itself with "abstract concepts such ; price, stress, baseball scores, (and) currency fluctuations" [3, p. 4] while Colin /are refers to visualization today as "a graphical representation of data or ɔncepts" [2, p. 1].

Its roots, of course, lie in earlier statistical visualizations of data from Playfair ı Tufte. Also influential has been the work of John Tukey and William Cleveland ·ho both created statistical visualizations that allowed increased insight into ata, particularly data with many variables [5, p. 7]. Cleveland writes that data isualization is as revolutionary today as was Descartes' Cartesian coordinates. Its ɪpacity to allow direct manipulation by the user causes the display to change in ·al time, thus vastly changing the static domain of technical visual genres. When ıe National Science Foundation announced the new initiative, it mostly centered n visualizations of physical objects [5, p. 8]. This was followed by advances in ;aphic hardware that improved user interfaces and resulted in new techniques ıch as dynamic queries and treemaps [5, p. 8].

WHAT CATEGORIES OF INFORMATION VISUALIZATION EXIST?

As stated earlier, information visualization is primarily an analytical tool, though it can also be used for presentation. Within this framework there are a ımber of different techniques that are used to visualize data. Basically, the ırrent types of information visualization on the market offer tools that allow users ı have access to a certain amount of data so they can: 1) focus in on some aspect of ıe visual information while still retaining a view of the context (with such chniques as fisheye lens, magic lenses, zoom and pan, table lens); and 2) connect

large amounts of information (networks, net maps, tree structures, browsers). According to Card, Mackinlay, and Shneiderman, "the fundamental strategy of visualization is to convert data to a visual form that exploits human skills in perception and interactive manipulation" [5, p. 35]. As a result, space is a primary vehicle for visualizations of abstract data because our interpretation of positions in space is our best perceptual skill. Thus, categories of spatial visualization have developed that allow data to be arranged to show spatial relationships of data through trees, networks, multi-dimensional views, and orthogonal views. These tools offer the user a dynamic view of the information and facilitate user interaction. Users visualize this information through view transformation techniques called fisheye lens, net maps, and tree structures, all familiar visual metaphors. "View transformations exploit time to extract more information from the visualization than would be possible statically" [5, p. 31]. These transformations can take three kinds of common view transformations: location probes, viewpoint controls, and distortions [5].

Location Probes

A magic lens, developed by Xerox Corporation, is a kind of location probe that works much like a magnifying glass and is a probe that gives the user an alternate view of a region in the visual structure [5, p. 31]. The user could, for example, move the lens from its resting point on a display of a text to focus in on, instead, a particular part of the text so that more information could be viewed. As Spence writes, the magic lens concept is such a good idea because of its attractive metaphor—a magnifying glass (see Figure 1) [3, p. 124].

Such a technique can be useful not only for textual displays but also for focusing on maps to learn more about the particular place the user is interested in.

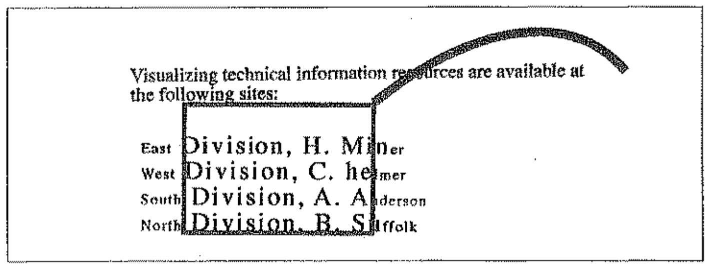

Figure 1. Example of a magnifying lens.

Viewpoint Controls

Controlling a viewpoint is a critical need for information visualization users. Instead of being at the mercy of default settings, users have the option of controlling what they see. According to Ware, "Some data visualization environments show information in such a way that it looks like a 3D landscape, not just a flat map" [2, p. 343]. The advantages of presenting a view in three dimensions is so "we can harness our real-world spatial interpretation and navigation skills" to navigate through data [2, p. 344]. With viewpoint controls, users can direct the focus of the visualization. One kind of viewpoint control is the data visualization slider, seen in Figure 2.

Distortions

Another type of transformation that users can employ is distortion. With this technique the user can modify a visual structure to create "focus + context" views [5, p. 31]. Other views offer an overview that lets you focus in on details, such as the hyperbolic tree in which the visual metaphor of a tree is expanded and somewhat abstracted. The idea is to focus in on information in one part of the tree while retaining an overall textual view. Then the user can take this further by purposely distorting space to give the user the sense of looking through a virtual camera that stretches and squeezes the tree or geometric shape in view [9, p. 381]. The technical name for this kind of space is "hyperbolic," which simply means that the space expands exponentially. Thus, "dragging part of a tree visualization to the center of the display gives it the maximum magnification. Parts of the visualization further away from this point get progressively smaller" [9, p. 381]. In other words, parallel lines diverge away from each other so that the circumference of a circle grows exponentially with its radius, resulting in more space being available with increasing distance [9, p. 384]. A generic example of this can be seen in Figure 3, which shows a tree-based organization chart displayed by uniformly embedding the tree on a hyperbolic.

According to its developers, Lamping and Rao, this kind of view helps facilitate an understanding of hierarchy while also being able to display a much

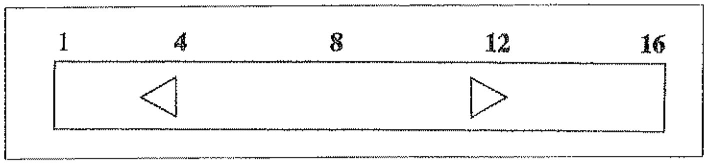

Figure 2. Example of data visualization slider.

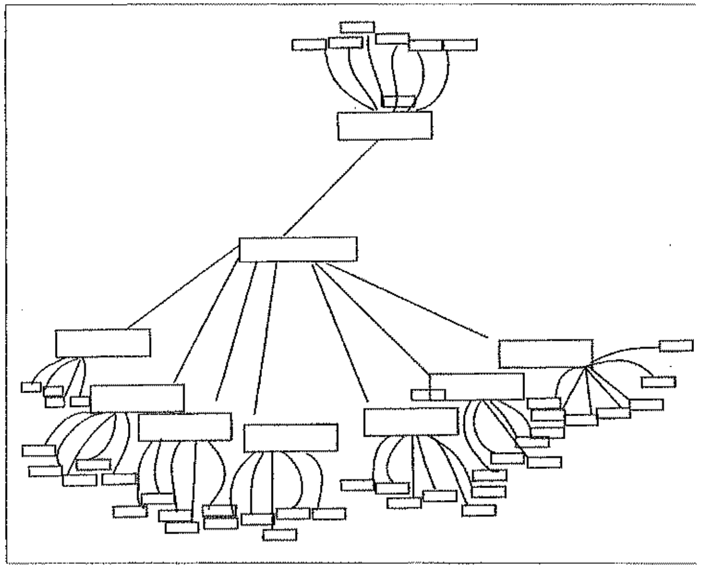

Figure 3. Example of hyperbolic tree (after Lamping and Rao).

larger set of data than could normally be displayed on a typical computer screen. Its use of hyperbolic geometry offers an "elegant solution to the problem of visualizing large hierarchies" [10]. What is different about this tree metaphor, of course, is that the very essence of a tree—a structure with developing branches—is abstracted so that what we see is almost a bird's eye view of a tree, not a human's view. We are placed parallel to the intimate structure of a tree, with our awareness of its branches and individual parts more central to our vision. In contrast, our normal view of trees is from the ground, where our main focus is the trunk. However, since we are placed in a different position here, we are able to take advantage of the intricate visual network of limbs and branches to focus in on certain information while still keeping the larger structure in view. Thus, in this sense, the tree diagram becomes significantly changed but still retains enough conventional similarity to enable users to mentally associate the idea of trees and branches to the visualization. "Whether treemaps will spread or not has to be seen. It's obvious that this is an interesting technique to see both the forest and the trees at a glance in a visually intuitive way" [11].

Similar to the table lens is the fisheye concept which also facilitates both the need to focus, along with the need to keep the context within view. This concept, first authored by George Furnas in 1981, presents the idea of generating a small display of a large structure. The problem Furnas was trying to address was that although the amount of generated data in work situations was growing, the space within which to view it—the computer screen—was still small. As Furnas argued, although the use of a zoom lens is helpful because the user can zero in on an area of interest, it also prevents the user from seeing the larger context around it [12]. With a fisheye view (Figure 4), however, the user sees "the whole structure—with decreasing magnification, less detail—as one gets further away from the center of view" [12, p. 314].

Another visualization tool that mimics the metaphor of focusing in on something while retaining an understanding of the whole is the bifocal lens, which, as its name suggests, mimics the idea of eye glasses. This technique allows both an overall view and a close-up view to be enabled. Figure 5 shows an example of a bifocal lens.

Of course, all of these techniques alert us to the idea that information visualization enables users to rearrange information in an interactive way and see insights into the data that might not be otherwise realized. The table lens is one example. Set up much like a table with rows and columns, it can enable a user to use the mouse to scroll down a column and reorder the data. Alternatively, the user

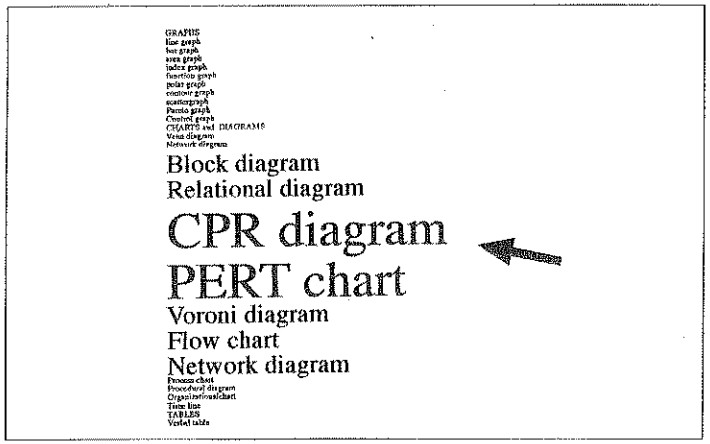

Figure 4. Example of a fisheye view.

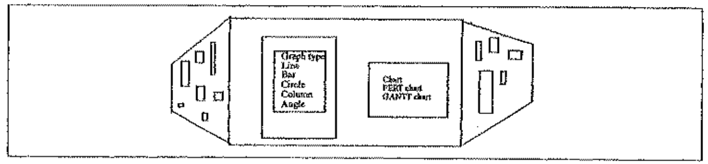

Figure 5. Example of a bifocal lens (after Spence).

can use a magnifying glass icon to zero in on one part of the data while still keeping the whole view in perspective. This kind of table lens can facilitate close introspection of a special area of interest but it can also obscure some areas. Consequently, alternative views such as bifocal displays and perspective walls can be very effective.

Another productive technique is data mapping, a tool that facilitates the use of textual data. The following example, as shown in Figure 6, is one example produced with a product called DIstudio [14].

According to its creators, DIstudio "provides flexible tools to create interactive electronic forms, map any-to-any data, and create any type of business rules. DIstudio is used to create maps, which consist of rules for data-content transformation, data validation, and electronic forms. This process is facilitated by convenient 'from' and 'to' windows, drag-and-drop techniques, and spreadsheet-like rule" [14]. Using a map as the overall metaphor allows the developers to connect to concepts already in the users' minds.

HOW IS INFORMATION VISUALIZATION WRITTEN ABOUT AND TAUGHT?

For those researchers and scholars who work in the area of information visualization, the approach to its description is usually quite enthusiastic. Card, Mackinlay, and Shneiderman, for example, believe information visualization is beneficial because it takes advantage of our perceptual abilities at the same time as it exploits the dynamic, interactive, inexpensive medium of graphical computers" [5, p. 5]. Robert Spence writes that information visualization is most useful when "a body of data is available and a human being wishes to gain insight into that data" [3, p. 4]. As Spence points out, this data does not have to be numerical. It can also be ordinal, meaning that it can involve data that naturally follows a certain order such as days of the week. It can also be categorical data such as the names of animals, which have no order in and of themselves [3, p. 4]. Colin Ware writes that visualization "has now come to mean something more like a graphical representation of data or concepts" [2, p. 1]. Ware also believes that one of information visualization's best features is the "sheer quantity of information that can be rapidly interpreted if it is presented well" [2, p. 1].

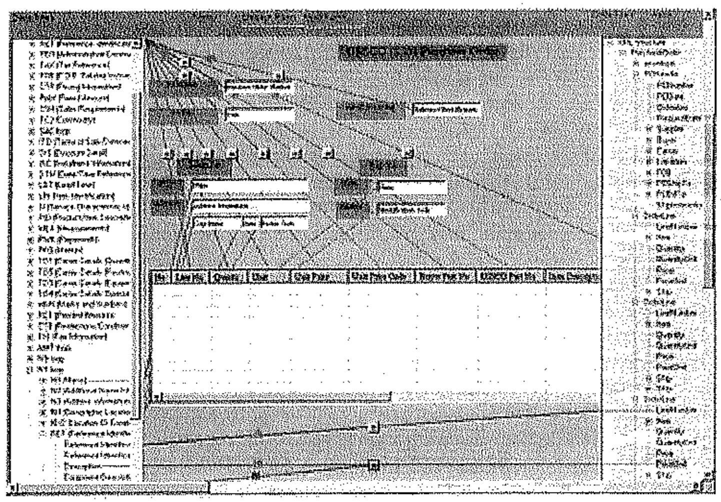

Figure 6. Data-mapping from DIcentral
DIstudio™ is a trademark of DIcentral Corporation [14].

Finally, William Cleveland calls visualization "an approach to data analysis that stresses a penetrating look at the structure of data" [15, p. 5]. Ben Shneiderman has concluded that any user of a visualization must perform seven abstract tasks: 1) get an overview of the information; 2) zoom in to focus on detail; 3) filter to particularize that detail; 4) access details on demand; 5) relate different information to each other; 6) understand their own usage history; and 7) be able to retrace steps, and abstract the results [16]. With a Web site like SmartMoney (www.SmartMoney.com), some of these needs can be met relatively easily with its map of the stock market.

WHAT IS THE RELATIONSHIP OF TEXT TO INFORMATION VISUALIZATION?

One of the most familiar methods of identifying information in traditional static graphs has been to label the information. This, of course, allows the reader of the graph to have a verbal interpretation of the visual image. In information visualization, however, labels are not such a clear-cut issue. Of primary concern to developers is the issue of graphic complexity. Thus, the inclination, according to Skupin, is to reduce the number of labels or to label only a subset of the

information [17]. In addition to determining the number of labels, information visualization designers also need to make decisions about the choice of label positions, a problem in two-dimensional displays containing dense feature clusters [17]. Finally, the terms used for labels must be decided upon. If single terms are being used in a vector field, this should not be a problem. "However, if documents themselves are visualized, the choice of label terms is more difficult" [17]. As we compare the needs of textual markers in information visualization to the more static genres, we can see many of the same issues come up. Where should we put labels and at what point do they become intrusive rather than helpful?

WHAT THEORY UNDERLIES THE INFORMATION VISUALIZATION GENRE?

We already have speculated earlier that the same kinds of cognitive and objectivist theories that are found problematic in the genres discussed earlier in the book may also transfer to information visualization. The objective stance used by researchers and scholars still posits a universal viewer who is guided by universally standard perceptual skills. In the information visualization field, Jacques Bertin's theories of perceptual-based graph design are now being applied to information visualization programs in an effort to develop a programming model that works well with a human's perceptual learning. Any technical visual genre which rests its foundation either on a rationalist perspective or on research results of perceptual factors such as shape, color, and orientation is a theoretical model that has both pluses and minuses. The plus is that any genre developed with an understanding of humans' perceptual abilities is more likely to succeed in delivering its messages to users. If visualizations aren't designed in this way, they won't be intuitive to our natural abilities. However, when a developing genre's research agenda looks to perceptual-based algorithms as its foundation, this can lessen the role of the user, whose individual and cultural experience often throws monkey wrenches into the idea of what a universal user can do and comprehend based on his or her perceptual abilities. According to Barbara Mirel, "the prevailing computer science orientation to data visualizations is severely limited for addressing many of the usability concerns associated with supporting users in three critical problem areas—sophisticated visual literacy, complex data analysis, and new paradigms of visual inquiry" [4, p. 491].

It is important, then, to examine what forces have the most influence on the development of the genre and what impact this has on the reception of the genre. Barbara Mirel states that serious problems exist in the research methods of information visualization researchers. For example, "studies on the usability of visual design and perceptual cues focus on isolated features (such as) the number of colors to use for color coding or the data structures that best match both users' purposes and their subsequent actions for analysis" [4, p. 10]. Such research, while valuable, does not focus on the user's interaction. Instead, isolated features are chosen and tested in laboratory settings. This is true despite the fact that "users' domain knowledge often biases and leads them to mistaken meanings about visual cues; similarly, the more unfamiliar users are with a type of graphic, the more likely they are to read things into the view that are not actually there" [4, p. 10].

Other critiques of the area's research agenda come from cartographers who complain that "research in information visualization rarely makes reference to geographic or cartographic research" [18]. Skupin argues that the geospatial sciences have developed many methods and techniques of visualizing information that can be very fruitful to information visualization specialists [17]. He argues that one of information visualization's problems has been to reduce visual complexity through such techniques as fisheye views and tree condensing. Yet "cartographers manage to create maps in which geographic meaning is preserved through the scales, despite the large number of objects involved" [17]. Skupin claims that the root of problems in displaying large and complex sets of data lies in "a conflict between the number of visualized features, the size of symbols and the size of the display surface" [17]. The answer to the understanding that scale is extremely problematic in information visualizations, Skupin argues, is that problems such as how to place labels, which add to complexity issues, can be addressed with some of the cartographers' techniques when designing maps. In addition, the symbols that are used to indicate visual hierarchies can also be taken from geographic science's mapping techniques.

A recent research study by Stasko, Catrambone, Guzdial, and McDonald looked at the ways in which visualization tools for depicting hierarchies were perceived by students at the Georgia Institute of Technology. Participants performed typical file/directory search and analysis tasks using the Treemap method and the Sunburst method. Results revealed that participants preferred the Sunburst tool, which also appeared to influence performance. The most interesting result was summed up in this statement by the researchers: "In addition to usefulness and the ability to aid user tasks, the success of an information visualization tool also depends on users' subjective opinions of the tool's interface and utility" [18, p. 19]. This is important because it brings to the forefront the user's central role. He or she in this light is seen as a more subjective individual, not as someone simply ruled by innate perceptual abilities. Of course, it is significant to note that while the results are interesting, the computer science students in the study were tested in an empirical testing situation which did not have the same relevance for them as if they were in their normal work context. Indeed, the researchers' instructions to subjects indicate that the tasks that the subjects were asked to perform were isolated mechanical interface tasks, not tasks based on familiar data and familiar contexts. For example, subjects were asked to perform tasks such as "identify the largest directory" and "locate a file," given its entire path and name. So in one way we are getting interesting results that measure the difference between two types of

visualization tools but at the same time we are also getting less applicable results since they are not tested on users in real situations.

Of course, the most researched area in information visualization, as it is in the traditional technical visual genres, is perception-based research. Researchers want to know how to make the best use of humans' perceptual abilities. We already have a good body of research on perception, almost always set in controlled experiments. Many studies are carried out using only one or two observers, often encompassing the principal investigator and a lab assistant or student [2, p. 17]. And, like the studies of static data graphs, the results are then generalized to the entire population. This furthers the trend evident in the static-based genres and signals a continuation of the same kinds of theoretical underpinnings in this developing genre.

HOW IS INFORMATION VISUALIZATION DESIGNED?

The design of information visualization in some ways parallels traditional static-based graph design. "Raw data is generated, then transformed into tables, converted to a visual structure which is filtered through an interface through which the user interacts" [5, p. 17]. However, the difference in the kinds of data is important. While numerical, nominal, and ordinal data still make up much of the work of information visualization, just as static graphs do, data such as text which does not have innate numerical qualities also are fodder for information visualizers.

To map data into a visual form, developers take raw data, usually in the form of spreadsheets or text and transform it into "a relation or set of relations that are more structured and thus easier to map to visual forms" [5, p. 17]. During this process there is always some loss or gain of information, but once mapped to visual structures, they are more effective since they would make the information faster to interpret [5, p. 23]. Some of the decisions that the designers of information visualization make are, of course, specific to the technique they are using. For example, a designer who uses a table lens as the primary visual structure has to contend with the idea of affordance, which refers to how users perceive visual metaphors and their attributes. Thus, if you design an information visualization in which a window or door is used, you must be sure that what the user perceives to be the window or door's abilities (such as opening and closing) must mimic each other [3, p. 18].

CONCLUSION

Looking to the future, it is unclear how visualization of information is going to develop, especially when paper-based communication is the dominant form of communication. However, we can look at palm pilots and envision a future where presentation of information is predominantly screen-based and where mputer technology becomes less tied to the cord in the outlet and more tied to ireless systems. Will corporation's annual reports still come out in paper-based rums? This is likely but, just as computer companies are more reluctant to ip paper-based documentation to their buyers and instead to rely on on-line lp and tutorial sessions, the likelihood is that information graphics will slowly insfer to a medium in which screen presentation is the dominant mode.

We have to be careful, though, about making such wide speculations and suming a goodness within them. There will still be people working in technical mpanies and in the public at large who cannot afford to buy the needed rdware. They may still need to see static graphs as their main conduit of sualized technical information and we cannot leave them behind as we look rward in this next millennium. We also know that newspapers are still with , although television has supplanted their role as a primary medium for communication. For most people, seeing something live or on tape is more compelling an reading about it in a newspaper the next day. Who would have predicted, r example, the withdrawal of key newspapers in cities like Detroit, Chicago, d elsewhere? Print communication of information is struggling to keep up with √ and the Internet. We are entering a new world, and the current inroads in formation visualization may be the next great leap in information technology d communication.

As we have seen in the previous chapters, the traditional technical visual nres have met the needs to understand the information and take advantage of ır visual sense. As such, they have been important tools for understanding w things are related and what their meaning is within the larger picture. Their istence seems justified by recent developments in visual-based learning, telesion and computer communication. At this point in time the visual display information stands beside verbal displays as a legitimate conduit of communication. But its problems cannot be discounted. In 1999, Bill Hibbard of e Space Science and Engineering Center at University of Wisconsin-Madison ovided the field with the top ten problems that now exist in information sualization, including the overall problem of the lack of quality in visual splays—the screens on which we read the information [19]. But problems in is developing genre will occur, according to LaTour, who writes, "When actors e unstable and the observers' points of view shift endlessly we are entering ıighly unstable and negotiated situation in which domination is not yet exerted" 0, p. 115]. Although the dominant theory in visualization seems to be objectivist, ough instability exists for those who seek to make changes to have an effect ı its ultimate end.

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