Chapter 1

An Overview of Information Visualization

In this chapter, readers will be provided with an overview that covers the history, evolution, and definition of information visualization. Chapter 2 will introduce and address the fundamental concepts and knowledge in information visualization, including major visualization principles, types, and techniques. A special focus will be placed on the introduction of emerging software tools, such as Tableau and Google Charts.

In chapters 3 and 4, insight into the applications and practices of information visualization in libraries will be covered, with chapter 3 specifically describing the driving forces that necessitate information visualization in libraries and current trends and directions. Chapter 4 presents real-world cases in which information visualization is used to improve library activities, services, and programs. It also addresses user experience enhancements via better data interpretation, discovery, and understanding.

Chapter 5 describes an overview of challenges and opportunities derived from the interplay of information visualization and the library. Then, chapter 6 will list pertinent instructional resources and learning opportunities for librarians and library professionals who are interested in diving deeper into this field.

Finally, a brief overview of the contents covered will recap the flow of the information provided, offering insight into the transitions of the technology discussed.

History and Evolution of Information Visualization

The history of information visualization dates back to the sixteenth century, when geometric diagrams and maps were used to aid navigation and exploration. From that point on, information visualization has evolved considerably, with each century bringing new methodologies into the equation. The seventeenth century saw the rise of analytic geometry, as well as the birth of measurements and theories that were used to estimate time, distance, and space. It was also during this period that significant fields of study and information processing were founded, including estimation, probability, demography, and the entire field of statistics. All of these things significantly advanced the way solutions were made, thereby paving the way for *visual thinking*.

The birth of visual thinking was followed by expansion in the use of economic statistics that involved the use of numbers pertaining to social, moral, medical, and other statistics. These figures were used for governmental response, such as policy making and activity planning, in the eighteenth and nineteenth centuries. During the same period, information visualization shifted, and the use of diagrams to illustrate mathematical proofs and functions became commonplace.[1] These centuries also saw an evolution in information visualizations as nomograms that aided in calculations were developed. Apart from nomograms, other impactful inventions were created, including modern graphic forms such as line graphs, histograms, scatter plots, and others.

Yet it was just in the twentieth century that information visualization began to become even more prominent. This was in part due to significant developments in information visualization, especially in the late twentieth century. For example, it was in the 1970s that the power of information visualization was introduced as a means of exploring and making sense of data.[2] In 1977, Princeton statistics professor John

Tukey introduced exploratory data analysis, known as EDA. EDA was and remains a predominant visual approach to exploring and analyzing data. With the emergence of computers, an exciting path was paved to help cultivate the use of information visualizations that people could actually view and interact with using a computer. Since then, according to American psychologist and professor Michael Friendly, information visualization and its techniques have expanded and evolved yet again, now displaying large networks, databases, and text, especially in organizations where there are persistent problems of large-scale data presentation that continue to emerge. Big corporations and libraries are two such organizations.[3]

Information Visualization Definitions and Basics

Humans perceive things in a variety of ways, such as through smell, taste, hearing, and vision. Among all the senses, vision is considered very dominant, as it has a wide "bandwidth" (the bit-rate of consumed information capacity) for sensing.[4] In addition, human vision is *pre-attentive*.[5] Pre-attentive vision is broadly defined as the visual processes that operate before humans attend to an object. During this stage of visual search, early visual processes operate in parallel over a large portion of the visual field, extracting information from each item's basic visual features. For example, human vision is highly selective when it comes to different sizes, shapes, colors, spatial positions, and so on, and that is what makes human vision a powerful tool for data analysis and interpretation. By organizing and presenting data in a carefully designed, selective way, one can exploit human vision to gain different interpretations and understandings from the data. Additionally, vision helps extend memory and cognitive capacity, both of which play a significant role in how people process information. By considering all these facts and findings, an exciting portrait reveals itself, one that has led to the emergence of the study of information visualization. Since a picture is worth a thousand words, it becomes a significant and noble pursuit to study the issues involving how one can translate plain data into a graphical display that speaks to the audience in a more intuitive, powerful way.

To help understand information visualization, let's break down both words and evaluate them individually. What is information? According to Stephen Few, an educator and innovator in the field of information visualization, information comes from items, entities, and things that cannot and do not have a direct correspondence to physical structures or objects.[6] Some good examples include football statistics, stock market prices, connections between socioeconomic status and criminal rates, and relationships between car attributes and mileage per gallon. On the other hand, examples for an entity that has a correspondence to physical structures or objects include human anatomy and three-dimensional cell structure. The "information" in this context is abstract, as it comes from an analysis of some type of data. The second part of information visualization is visualization. *Visualization* refers to the creation of two-dimensional or three-dimensional representations of data that enable new discoveries of both insights and knowledge.[7] With the close connection between human vision and cognitive capacity, visualization can also be seen as the use of computer-supported, interactive visual representations of data to enhance cognition.[8] Together, these two words describe a new meaning that has changed the way we perceive information and understand data in a highly impactful, more memorable manner.

The views of information and visualization bring up two important aspects to consider: (1) information visualization is used to discover new insights and knowledge from abstract data through graphical means; and (2) information visualization can be considered a representation of data that amplifies cognition. Card, Mackinlay, and Shneiderman explained the overall information visualization process using a "reference model," in which three subprocesses are included.[9] First, there is the data transformation subprocess, which transforms raw data into data tables that offer structure and ease of manipulation. Second, data tables are mapped onto visual structures that include the application of spatial substrates, marks, and graphical properties. With the third subprocess, view transformations, visual structures are transformed into human views, which involves graphic parameters, such as position, scaling, and clipping.

Based on the discussions above, there is no singular definition or concept of information visualization. Through evaluating Few's work, it is noted that he explains his thoughts and research on information visualization by sharing this: "The use of images to represent information . . . is only now becoming properly appreciated for the benefits it can bring to business. It provides a powerful means both to make sense of data and to then communicate what we've discovered to others."[10] In another work, Friendly defines information visualization as "the science of visual representation of 'data,' defined as information which has been abstracted in some schematic form, including attributes or variables for the units of information."[11] Friendly's definition offers valuable insight, which resonates with the most comprehensive definition of visual information proposed by Hal Varian, Chief Economist at Google and emeritus professor at the University of California, Berkeley. Varian defines information visualization as "the ability to take data—to be able to understand it, to process it,

to extract value from it, to visualize it, and to communicate it."[12] In an article by Jayanta Kr. Nayek and Dibakar Sen, information visualization is defined as "a method for representing data accurately on the web and elsewhere. It gives a unique perspective on the data set. It is a representation of data in a visual context, which helps to understand the significance of data. There are different types of data, which require different representation to fulfill different purposes, like musical data, geographical data, scientific data, etc."[13]

Just like the definition of information visualization, the purpose or the use of information visualization has also evolved over the years. For example, in *Smashing Magazine* cofounder Vitaly Friedman's article, he defines the purpose of information visualization as the "ability to visualize data, communicating information clearly and effectively" but also "in a more intuitive way."[14] The Institute of Development Studies explains the purpose of data visualization as a way "to explain and to explore data" to "be used as a tool for analysis, finding patterns as well as discovering questions amongst other things."[15] Today, the way we define information visualization is grounded in the visual elements, and in particular pictorial or graphical formats. Its key use has been identified as its ability to help decision makers see analytics, further helping them to comprehend difficult concepts and even identify new patterns. The evolution of digital technologies has only broadened the use of information visualization as it is now being used to extract information from data for more detail. Current trends and demands show us that information visualization is now interactively changing the way the human brain visualizes and processes complex data. Information visualization is easier for the brain to process than other forms of data, such as reports or spreadsheets.

Conclusion

The term *information visualization* is easily associated with thoughts of making graphics and images. However, it truly offers more insights than that alone. Information visualization is a cognitive process that is used for analysis and presentation, allowing us to better understand data and offering the opportunity to act upon the understanding it offers. It also enables effective communications and presentations, further solidifying the fact that the purpose of visualization is to gain insights, not simply to view pictures.

Notes

1. Michael Friendly, "Milestones in the History of Thematic Cartography, Statistical Graphics, and Data Visualization," York University, Department of Mathematics and Statistics, August 24, 2009, www.math.yorku.ca/SCS/Gallery/milestone/milestone.pdf.
2. Stephen Few, "Data Visualization Past, Present, and Future," Perceptual Edge, January 10, 2007, accessed September 26, 2016, https://www.perceptualedge.com/articles/Whitepapers/Data_Visualization.pdf.
3. Friendly, "Milestones in the History."
4. Christof Koch and Naotsugu Tsuchiya, "Attention and Consciousness: Two Distinct Brain Processes," *Trends in Cognitive Sciences* 11, no. 4 (2007): 16–22.
5. Lawrence L. Appelbaum and Anthony M. Norcia, "Attentive and Pre-attentive Aspects of Figural Processing," *Journal of Vision* 9, no. 18 (2009): 1–12.
6. Stephen Few, *Now You See It: Simple Visualization Techniques for Quantitative Analysis* (Berkeley, CA: Analytics Press, 2009).
7. Tom Soukup and Ian Davidson, *Visual Data Mining: Techniques and Tools for Data Visualization and Mining* (Hoboken, NJ: Wiley, 2002).
8. Stuart K. Card, Jock Mackinlay, and Ben Shneiderman. *Readings in Information Visualization: Using Vision to Think* (San Francisco: Morgan Kaufmann, 1999).
9. Ibid.
10. Few, "Data Visualization," 2.
11. Friendly, "Milestones in the History," 2.
12. Hal Varian, "Hal Varian on How the Web Challenges Managers," McKinsey & Company, January 2009, www.mckinsey.com/industries/high-tech/our-insights/hal-varian-on-how-the-web-challenges-managers.
13. Jayanta Kr. Nayek and Dibakar Sen, "Data Literacy and Library: An Overview." *College Libraries* (West Bengal College Librarians' Association) 30, no. 1–2 (2015): 42, https://www.researchgate.net/publication/304597538_Data_Literacy_and_Library_An_Overview.
14. Vitaly Friedman, "Data Visualization and Infographics," *Smashing Magazine*, January 14, 2008, https://www.smashingmagazine.com/2008/01/monday-inspiration-data-visualization-and-infographics.
15. Institute of Development Studies, "Introduction to Data Visualisation," Research to Action, August 2013, www.researchtoaction.org/wp-content/uploads/2014/02/Introduction-to-Data-Visualisation.pdf, 1.