

Preface for the Second Edition

When the original version of *Information Visualisation and Virtual Environments* (IVVE) was published in the summer of 1999, the only book available to readers anywhere on the globe was the now widely cited volume of 52 pioneering articles ingeniously interwoven together by the three masterminds – the “Readings”. As it turned out, a few more people were simultaneously working on their own books to introduce and redefine the subject. Five years on, the field of information visualization has grown in leaps and bounds. Practitioners and researchers now enjoy a wealth of books on the subject of information visualization from a rich spectrum of perspectives: Colin Ware’s thorough coverage of the foundation of perception and cognition, Bob Spence’s well-articulated text on the fine details of the work of many creative minds, Martin Dodge and his colleagues’ hand-picked exemplars from a geologist’s mindset, and Ben Bederson and Ben Shneiderman’s more recent touch with the years of work from their lab at the University of Maryland. Since 2002, the field has its own journal – *Information Visualization* (IVS) – and numerous conferences where information visualization has its place.

What are the most significant changes over the past five years? Do we have more successful stories to tell about information visualization? What are the remaining challenges? And what are the new ones lurking from the most unexpected directions? My original intention in 1999 was two-fold: (1) providing an integrative introduction to information visualization and (2) establishing a connection between information visualization and virtual environments. With hindsight, the first goal echoes the first of the two generations of information visualization, which I will explain shortly, whereas the second goal may correspond to the second generation. There is increasingly prolific evidence that we are experiencing a profound but underlying transition from the first to the second.

The history of information visualization can be characterized by two distinct but often overlooked focuses: structure and change. The majority of the showcase information visualization work is about structure. The holy grail of information visualization is to make the insights stand out from otherwise chaotic and noisy data. Naturally, the mission of the first generation in the 1990s and the beginning of 2000s has been revealing structures that would be otherwise invisible. The unique position of structure is also evident from various navigation strategies, from the focus + context design rationale to the so-called drill-down tactics. Although the content is always a part of the equation, it has never been the real rival of structure.

The first part of the book closely reflects the *structure-centric* tradition – everything is a structure. The process of abstracting structures from seemingly unstructured data is not something unique to information visualization. Cartographers, for example, have established a complete line of business that can

represent the geographic features of the real world on various maps. The tradition of structuralism is most apparent in one of the earliest columns of information visualization – graph drawing. Until recently the level of clarity and aesthetics of how the structure of a given graph can be drawn algorithmically has been the predominant driving force behind the development of various increasingly sophisticated graph drawing algorithms.

The second part of the book, consisting of individual differences studies and spatially organized multi-user virtual environments, was an attempt to establish the potentially fruitful connection between the two communities. Information visualization models embedded in shared virtual environments call for explicit and direct attention to an extensible framework that can accommodate the growth of such information visualization models, especially when the virtual environment itself drives the subsequent evolution. However, back in 1998 I was preoccupied with our own research findings and wanted to use the book as a vehicle to convey as much as our research. Furthermore, many things we take for granted today were unheard of, or more precisely, unseen five years ago. And this is the time to address the second generation.

The second generation is about change. It is *dynamics-centric*. It is about growth, evolution, and development. It is about sudden changes as well as gradual changes. A good starting point for explaining the second generation would be a well-known example in scientific visualization – the storm, how it started, evolved, and eventually came to an end. One of the often quoted definitions of information visualization is that information visualization deals with data that do not have inherited geometry. In other words, one has the freedom of mapping the underlying data to any geometric forms so long as one asserts meanings, no matter how arbitrarily, to the end product of such mapping. As a result, it does not come easy to put my visualization and your visualization side by side and compare even if they are about the same underlying phenomena. The key question is: what distinguishes scientific visualization and information visualization? Are they really that different?

On the surface, scientific visualization appears to have the blessing of scientific theories that can quantify the meaning of each pixel and leave no room for ambiguity or misconception. If scientific visualization is a mapping from a physical phenomenon to its visual representation, this is like saying that the mapping is unique and it is complete because the geometry is more likely than not to be inherited in the underlying scientific model. In most geographic visualizations, the geographic framework is retained and the mapping preserves the geometry. On the other hand, Harry Beck's classic schematic design of the London underground map in 1933 constantly reminds us that a good design is not necessarily built on geometric details even if it comes with the data. Charles Minard's classic map depicting Napoleon's disastrous retreat from Moscow has set a good example of what information visualization should achieve. If a picture is worth thousands of words, then Mindard's map unfolds a vivid story.

Behind scientific visualization, we are likely to find the provision of not only quantitative and geometric models, but also models that govern the dynamics of an underlying phenomenon. Just as in the storm example, scientific visualization typically works with data that are either readily presentable in visual forms or readily computable to a presentable level. In contrast, information visualization is often characterized by the absence of such readiness. Typical information data are not readily presentable due to the lack of built-in visual-spatial attributes. They

are not readily computable due to the lack of an underlying computational model. Information visualization, therefore, faces a much tougher challenge because one has to fill up the two gaps before reaching starting points of scientific visualization. Meanwhile, the tight coupling between visualizations and underlying theoretical models in scientific visualization has left something to be desired in information visualization, such as the descriptive and predictive power and reasoning capabilities.

The need to fill up the two gaps is echoed by the emergence of the second generation of information visualization. Information visualization has to re-examine the nature of a semantic mapping and the meaning of visual-spatial configurations in the context of intended cultural and social settings.

The recent citation analysis of information visualization clearly identifies the role of earlier pioneers such as Edward Tufte and Jacques Bertin. Tufte's three books have been the source of inspiration for generations of researchers and practitioners in information visualization and design. In August 2003, I searched for "information visualization" on Google's three billion-strong indexed web pages and it returned 44,500 hits. Adding a more specific term to the query rapidly reduced the number. The following numbers may give us a glimpse of what information visualization is about, at least on the web: focus + context (6980), evolution (4370), graph drawing (3200), empirical study (2750), fisheye (1960), hyperbolic (1910), treemap (934), Spotfire (808), SOM (659), semiotics (563), detect trend (356), Pathfinder (300), and detect abrupt change (48).

The focus + context issue is the most widely known, followed by evolution, graph drawing and empirical studies. Specific visualization techniques and systems are topped by fisheye and hyperbolic views, which are in line with the popular awareness of the focus + context issue. Although it commanded 563 hits, semiotics as a relatively broad term is apparently underrepresented in information visualization. The least popular topic in this group is "detect abrupt change," which is a precious 48 out of three billion web pages. This second edition of the book pays particular attention to empirical studies accumulated over the past five years, the role of semiotics in information visualization, and the need for detecting emerging trends and abrupt changes.

This edition continues the unique and ambitious quest for setting information visualization in an interdisciplinary context, especially in relation to virtual environments because they provide a particularly stimulating context for us to understand theoretical and practical implications of various fundamental issues and specific information visualization features. This new edition is particularly tailored to the need of practitioners, including a number of newly added in-depth analyses of successful stories and entirely new chapters on semiotics and empirical studies. A number of chapters are thoroughly updated. The new edition is also suitable for an introductory course to information visualization.

The new edition is entitled *Information Visualization: Beyond the Horizon*. In part, this refers to the transition that is quietly taking place, which will ultimately transcend the first, structure-centric, generation of information visualization to the emerging second, dynamics-centric, generation. Furthermore, there are a number of promising trends on the horizon of information visualization, notably the vibrating area of Knowledge Domain Visualizations (KDViz), new perspectives on the role of information visualization in detecting abrupt changes and emerging trends, and a whole new front of empirical studies of information visualization.

Among the eight chapters in the new edition, the degree of update and revision varies a great deal, from new chapters, substantially updated chapters, to moderately

updated chapters. I have particularly concentrated on two new chapters: Chapter 6 on empirical studies of information visualization and Chapter 8 on detecting abrupt changes and emerging trends. I regard these two topics as having the most profound implications on information visualization in the next five years. There are simply so many grounds to cover in each of the topics. Chapter 5 contains some of the materials in the original Chapter 4 in the first edition, plus a new study on visualizing scientific paradigms. Several sections in Chapter 4 have been substantially rewritten. Chapter 7 includes a new study of group tightness. The remaining chapters have been updated to a much less degree, although all chapters are reorganized accordingly.

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