Data Visualization

Principles and Practice

Second Edition

Alexandru Telea

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Cover image: The cover shows the combination of scientific visualization and information visualization techniques for the exploration of the quality of a dimensionality reduction (DR) algorithm for multivariate data. A 19-dimensional dataset is projected to a 2D point cloud. False-positive projection errors are shown by the alpha-blended colored textures surrounding the points. The five most important point groups, indicating topics in the input dataset, are shown using image-based shaded cushions colored by group identity. The bundled graph shown atop groups highlights the all-pairs false-negative projection errors and is constructed by a mix of geometric and image-based techniques. For details, see Section 11.5.7, page 524, and [Martins et al. 14].

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To my family

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Preface to Second Edition

THIS is the second edition of the book *Data Visualization: Principles and Practice* first published in 2008. Since its first edition, many advances and developments have been witnessed by the data-visualization field. Several techniques and methods have evolved from the research arena into the practitioner's toolset. Other techniques have been improved by new implementations or algorithms that capitalize on the increased computing power available in mainstream desktop or laptop computers. Different implementation and dissemination technologies, such as those based on the many facets of the Internet, have become increasingly important. Finally, existing application areas have gained increasing importance, such as those addressed by information visualization, and new application areas at the crossroads of several disciplines have emerged.

The second edition of this book provides a revised and refined view on data visualization principles and practice. The structure of the book in terms of chapters treating various visualization techniques was kept the same. So was the bottom-up approach that starts with the representation of discrete data, and continues with the description of the visualization pipeline, followed by a presentation of visualization techniques for increasingly complex data types (scalar, vector, tensor, domain modeling, images, volumes, and non-spatial datasets). The second edition revises and extends the presented material by covering a significant number of additional visualization algorithms and techniques, as follows. Chapter 1 positions the book in the broad context of scientific visualization, information visualization, and visual analytics, and also with respect to other books in the current visualization literature. Chapter 2 completes the transitional overview from graphics to visualization by listing the complete elements of a simple but self-contained OpenGL visualization application. Chapter 3 covers the gridless

interpolation of scattered datasets in more detail. Chapter 4 describes the desirable properties of a good visualization mapping in more detail, based on a concrete example. Chapter 5 discusses colormap design in additional detail, and also presents the enridged plots technique. Chapter 6 extends the set of vector visualization techniques discussed with a more detailed discussion of stream objects, including densely seeded streamlines, streaklines, stream surfaces, streak surfaces, vector field topology, and illustrative techniques. Chapter 7 introduces new examples of combined techniques for diffusion tensor imaging (DTI) visualization, and discusses also illustrative fiber track rendering and fiber bundling techniques. Chapter 8 introduces additional techniques for point-cloud reconstruction such as non-manifold classification, alpha shapes, ball pivoting, Poisson reconstruction, and sphere splatting. For mesh refinement, the Loop subdivision algorithm is discussed. Chapter 9 presents six additional advanced image segmentation algorithms (active contours, graph cuts, mean shift, superpixels, level sets, and dense skeletons). The shape analysis discussion is further refined by presenting several recent algorithms for surface and curve skeleton extraction. Chapter 10 presents several new examples of volume rendering. Chapter 11 has known arguably the largest expansion, as it covers several additional information visualization techniques (simplified edge bundles, general graph bundling, visualization of dynamic graphs, diagram visualization, and an expanded treatment of dimensionality reduction techniques). Finally, the appendix has been updated to include several important software systems and libraries. Separately, all chapters have been thoroughly revised to correct errors and improve the exposition, and several new references to relevant literature have been added.

Additionally, the second edition has been complemented by online material, including exercises, datasets, and source code. This material can serve both to practice the techniques described in the book, but also as a basis to construct a practical course in data visualization. Visit the book's website: http://www.cs.rug.nl/svcg/DataVisualizationBook.