Preface

Technological advances in computer vision algorithms and sensor hardware have greatly reduced the implementation and financial costs of eye tracking, making this data acquisition method accessible to a large population of researchers. Thus, it is unsurprising to witness a significant increase in its use as a research tool in fields beyond the traditional domains of biological vision, psychology, and neuroscience, in particular, in visualization and human-computer interaction research. Recording the observer's gaze can reveal how dynamic graphical displays are visually accessed and it can show the visual information that is relevant to the observer at any given point in time. Nonetheless, standardized practices for technical implementations and data interpretation remain unresolved.

One of the key challenges lies in the analysis, interaction, and visualization of complex spatio-temporal datasets of gaze behavior, which is further complicated by complementary datasets such as semantic labels, user interactions and/or accompanying physiological sensor recordings. Ultimately, the research objective is to allow eye-tracking data to be effectively interpreted in terms of the observer's decision-making and cognitive processes. To achieve this, it is necessary to draw upon our current understanding of gaze-behavior across various and related fields, from vision and cognition to visualization.

Therefore, the analysis and visualization of such spatio-temporal gaze data—along with additionally attached data from the stimulus or further physiological sensor recordings—becomes a challenging factor in this emerging discipline. From the perspectives of human-computer interaction and cognitive science, this will be key to a better understanding of human behavior and the cognitive processes that underlie it, which would translate to genuine advances in user-centered computing systems. Taken together, this makes *eye tracking* an important field to be understood, be it in the sense of *data analysis* and *visualization*, *interaction*, or *user-based evaluation of visualization*.

ETVIS Workshop

To foster this growing field of eye tracking and visualization, we organized a workshop at the IEEE VIS Conference (http://ieeevis.org): *The First Workshop on Eye Tracking and Visualization (ETVIS)*. The workshop took place in Chicago, Illinois, USA, on October 25, 2015. Its web page is www.etvis.org.

The goal of this workshop was twofold. First, we intended to build a community of eye-tracking researchers within the visualization community. Since eye-tracking related research has been conducted in *information visualization*, *scientific visualization*, and *visual analytics*, this workshop served as a way of connecting between these subfields that are represented at IEEE VIS and share a common interest in eye tracking. Second, the workshop established connections to related fields, in particular, to human-computer interaction, cognitive science, and psychology, promoting the exchange of established practices and innovative use scenarios. We were pleased with the interdisciplinarity of the attendees, including researchers from human-computer interaction, psychology, cognitive science, and eye-tracking research to complement the traditional IEEE VIS audience. In particular, a large portion of the attendees indicated that they were first-time attendees of IEEE VIS and that ETVIS was the reason for attending IEEE VIS 2015. Thus, we saw that this novel initiative worked well in establishing common grounds across diverse disciplines and promoting interdisciplinary dialog.

The program of ETVIS 2015 consisted of two parts: The first part (morning sessions) was organized as the workshop itself. The program started with the keynote presentation by Kenneth Holmqvist (Lund University) on "Measures and Visualizations from Eye Movement Data." He presented a comprehensive overview of the many different measures that researchers use on eye-tracking data and showed several of the visualization techniques that have evolved over the last 15 years. A central question to take away from his talk is: when is visualization of eye gaze data helpful and when does it just provide the people who use it with a "wrong" sense of understanding? He highlighted this issue by using heat maps as an example, which are particularly popular in (web) usability. He discussed interesting examples of un-reflected uses of visualizations and the over-interpretation of heat maps. This provided a great starting point for further discussions.

The keynote was followed by oral presentations of the accepted workshop papers. In the afternoon, there was an accompanying meetup session to foster in-depth and open discussions between all attendees and allow for planning for the future of ETVIS. The success of ETVIS 2015 led us to organize a follow-up workshop at IEEE VIS 2016: ETVIS 2016 will take place October 23, 2016, in Baltimore, Maryland, USA.

More information about the ETVIS workshops can be found on the web page of the workshops: www.etvis.org.

Review Process

The chapters of this book were selected and revised during a review process with several stages. It started with a call for short papers (4 pages and 1 additional page for references) for ETVIS 2015. Submitted papers were reviewed by members of the international program committee (IPC) of ETVIS 2015 (see the list of IPC members on page ix). We had 3–4 reviews per paper. Decisions about acceptance were made by the ETVIS 2015 organizers, who are also the editors of this book. For submissions that had conflicts with some of the organizers, the review process was hidden from these organizers and decisions were made by the other organizers. We accepted 13 papers to the workshop. The workshop papers were not published as archival papers.

For the book, we invited the ETVIS authors to submit revised and extended versions of their papers. In addition, we solicited two additional chapter submissions in order to complement the contents and scope of the book: "A Task-Based View on the Visual Analysis of Eye Tracking Data" (by Kurzhals et al.) as a survey of visualization techniques for analyzing eye-tracking data, and "Unsupervised Clustering of EOG as a Viable Substitute for Optical Eye Tracking" (Flad et al.) as a complementary basis of data acquisition in eye-tracking experiments. All submitted chapters were reviewed by 2–3 expert reviewers (see page ix for the list of reviewers); for most book chapter submissions, there was (partial) reviewer continuity from the ETVIS review process. Decisions about acceptance were made by the editors of this book. Again, we took care that reviewing and decision-making were hidden from editors with conflicts. At the end, we accepted 12 extended ETVIS papers and the two additional chapters for the book.

Organization of this Book

The book is organized in two parts with a total of 14 chapters. The first part covers "Visualization, Visual Analytics, and User Interfaces". Its first chapter provides an overview of visualization approaches toward analyzing data that is acquired in the context of eye-tracking experiments: the chapter entitled "A Task-Based View on the Visual Analysis of Eye-Tracking Data" (by Kurzhals et al.). It includes references to several other chapters of this book to provide an overarching perspective on how visualization can be used to improve the analysis of eye-tracking data. The following two chapters cover visualization techniques that highlight the temporal aspect of attention and eye movement patterns: "Interactive Visualization for Understanding of Attention Patterns" (Nguyen et al.) and "The VERP Explorer: A Tool for Exploring Eye Movements of Visual-Cognitive Tasks Using Recurrence Plots" (Demiralp et al.). Then, Löwe et al. show gaze information in the context of immersive video stimuli ("Gaze Visualization for Immersive Video"). Blaha et al. describe a visual-motor analytics dashboard that supports the joint study of eye movement and hand/finger movement dynamics ("Capturing You Watching You: Characterizing Visual-Motor Dynamics in Touchscreen Interactions"). The following chapter integrates the visualization of eye-tracking data in the context of the ACT-R cognitive architecture: "Visualizing Eye Movements in Formal Cognitive Models" (Balint et al.). Then, Beck et al. discuss "Word-Sized Eye-Tracking Visualizations" to augment transcribed recordings for protocol analysis with eye-tracking data. Finally, Tateosian et al. describe "GazeGIS: A Gaze-based Reading and Dynamic Geographic Information System".

The second part contains chapters that focus on "Data and Metrics". Flad et al. investigate electrooculography (EOG) as an alternative of acquiring information about eye movements in the chapter on "Unsupervised Clustering of EOG as a Viable Substitute for Optical Eye Tracking". This is followed by a chapter on data acquisition with optical monocular gaze tracking—with a focus on accuracy: "Accuracy of Monocular Gaze Tracking on 3D Geometry" (Wang et al.). Ma et al. apply tomography methods to obtain a description of 3D saliency ("3D Saliency from Eye Tracking with Tomography"). Schulz et al. address the issue of incorrect eye-tracking data and how such data can be cleaned with visualization support ("Visual Data Cleansing of Low-Level Eye-Tracking Data"). The last two chapters of this book discuss metrics for eye tracking: "Visualizing Dynamic Ambient/Focal Attention with Coefficient $\mathscr{K}$" (Duchowski and Krejtz) and "Eye Fixation Metrics for Large Scale Evaluation and Comparison of Information Visualizations" (Bylinskii et al.).

We hope that this book will stimulate further research in the interdisciplinary area of eye tracking and visualization, fostering the interaction between researchers from visualization and other disciplines.

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