

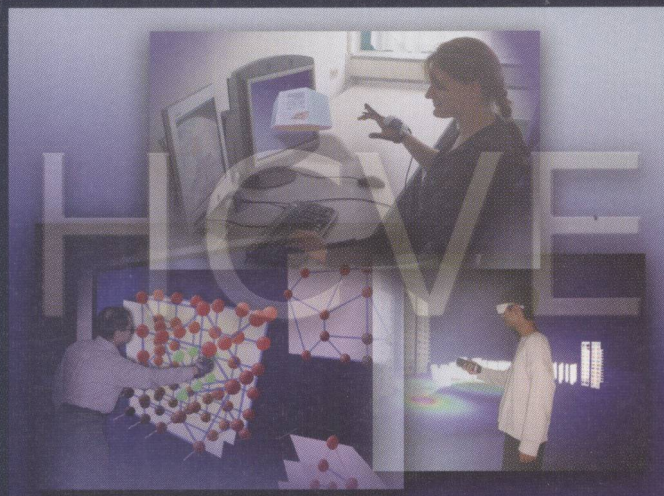
Tutorial

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Andreas Kerren
Achim Ebert
Jörg Meyer (Eds.)

Human-Centered Visualization Environments

GI-Dagstuhl Research Seminar
Dagstuhl Castle, Germany, March 2006
Revised Lectures



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Preface

Human-Centered Visualization Environments combine traditional Visualization techniques with the ability of the human visual-brain system and the haptic-motoric system to explore and analyze complex data comprehensively. This kind of visualization merges several aspects of different research areas, such as Information Visualization, Scientific Visualization, Human-Computer Interaction, Data Mining, Information Design, Graph Drawing, and Computer Graphics. From all subfields in Visualization, this textbook focuses mainly on Information Visualization, which centers on the visualization of abstract data, e.g., hierarchical, networked, or symbolic information sources, in order to help users understand and analyze such data.

For most practical applications, researchers try to find the best visual representation of the given information. That is the core problem of each visualization; but sometimes the seemingly best representation does not suffice if the human information processing and the human capability of information reception are not adequately taken into account. Additionally, these aspects depend on the data to be visualized and on the user's background. While developing Human-Centered Visualization Environments, user abilities and requirements, visualization tasks, tool functions, and visual representations should be equally taken into account. The design of Human-Centered Visualization Environments is one of the big challenges of Information Visualization, Software Visualization, and of many application areas, such as the visualization of biological/biochemical or geographical information.

This textbook is the outcome of a GI-Dagstuhl Research Seminar organized by the editors, which was supported by the Gesellschaft für Informatik e.V. (GI) and took place at the International Conference and Research Center for Computer Science (IBFI) at Schloss Dagstuhl, March 5-8, 2006.

GI-Dagstuhl Research Seminars are targeted at doctoral students and recent post-doctoral graduates who are interested in learning actively about new developments not well covered in textbooks. They were selected mainly according to their scientific qualification.

Subtopics from the area of this seminar were assigned to the participants, who prepared comprehensive overview papers. During the seminar, their summaries and findings were presented and discussed. After the seminar, close to 9 months was spent on writing the chapters of this book, which were cross-reviewed internally. The editors intend the textbook to be used as an introduction to the

field and as a basis for graduate-level courses in Human-Centered Visualization, Information Visualization, etc.

We would like to thank all participants of the seminar for the lively discussions during and after the seminar as well as for writing the chapters of this textbook. Special thanks go to Wim Fikkert, Carsten Görg, Olga Kulyk, Robert S. Laramée, and Martin Nöllenburg for serving as chapter coordinators. We are also grateful to the GI and Schloss Dagstuhl, Germany, for their support and the privilege to hold the seminar at such a great venue.

December 2006

Andreas Kerren
Achim Ebert
Jörg Meyer

List of Contributors



Marco D'Ambros is a Ph.D. student at the Faculty of Informatics of the University of Lugano, Switzerland, where he is working together with Prof. Michele Lanza. His current interests lie in the domain of software engineering with a special focus on software visualization, software evolution and software defect analysis. In 2005, he received his master degree "cum laude" from the Politecnico di Milano and from the University of Illinois at Chicago. In his graduation thesis, he introduced a new approach, called software archeology, to study the evolution of software systems in case of incomplete information. He was the co-organizer of MSR2006 Challenge and co-reviewer for various conferences and journals. He is also a member of the COSE project, a research venture which aims to analyze and control the evolution of complex software systems.



Torsten Bierz is a Ph.D. student in the International Research Training Group (IRTG) for the visualization of large unstructured datasets of the University of Kaiserslautern, Germany. After obtaining his Master degree in Computer Science in 2004, he was working on the HapTEK project in the Computer Graphics and Visualization Group at the University of Kaiserslautern, which focused on the design and development of a human machine interface for advanced simulation in developing and production processes. In January 2005, Torsten joined the International Research and Training Group as a Ph.D. student dealing with the topic of immersive visualization systems. His research interests within this topic are haptic interaction, visual representation on large displays and interaction with optical tracking systems, which include the usage of GPU accelerated methods and techniques.



Achim Ebert is an Assistant Professor with the University of Kaiserslautern, Germany, since 2005. Dr. Ebert is also affiliated with the German Research Center for Artificial Intelligence (DFKI GmbH) in Kaiserslautern, Germany. He received his Ph.D. from the University of Kaiserslautern, Germany, in 2004. Dr. Ebert's research interest include virtual and mixed reality, human computer interaction, information visualization, mobile visualization, and artificial intelligence in the visualization context. The application scenarios are manifold: document management, visualization of search

engine results, waste water treatment, virtual clothing, process visualization, etc. Dr. Ebert has lead and has served on multiple conference and program committees. Since 2005, he is the co-chair of the IASTED Visualization and Image Processing (VIIP) conference.



Wim Fikkert is active as a Ph.D. student at the Human Media Interaction (HMI) group of the University of Twente, The Netherlands. Wim obtained his Bachelor degree in Computer Science in 2003 at the Saxion Universities in The Netherlands by creating a simulator able to control a team in real and simulated robot soccer matches. He obtained his Master of Science in Computer Science in December 2005 at the University of Twente

by researching how to unobtrusively estimate the gaze direction of a student in a commercial driving simulator. Wim started his academic career as a Ph.D. student at the HMI group in January 2006. Presently he is active in the Dutch nation-wide BioRange project in which the research group he works in aims to develop a multidisciplinary scientific collaborative environment. Wim's personal research interests therein lie with natural, human-like gestural input and visualizing the requested output. These interactions are influenced by contextual information that describe (current) user(s') tasks.



Carsten Görg is currently working as a postdoctoral research fellow, funded by the German Academic Exchange Service (DAAD), at the College of Computing at the Georgia Institute of Technology in Atlanta. He studied computer science and mathematics as a double major at Saarland University in Germany where he also received his Ph.D. in computer science. His research interests include graph drawing, in particular dynamic

graph drawing, information and software visualization, and also software engineering and software evolution.



T.J. Jankun-Kelly is an assistant professor of computer science and engineering within the James Worth Bagley College of Engineering, Mississippi State University. His research areas are at the intersection of scientific and information visualization. His goal is to make visualization techniques and systems more effective by improving interaction methods and visualization utilization. Towards this end, he focuses on visualization interfaces,

visualization modeling, and applications such as volume, graph, and security visualization; recent efforts include extending these to large-scale displays. T.J. has a Master's and Ph.D. from the University of California, Davis and a B.S. from Harvey Mudd College. He is a member of the ACM, SIGGRAPH, IEEE, and the IEEE Computer Society and was a founding Contest Co-Chair for IEEE Visualization during 2004-2006.



Andreas Kerren is currently a Senior Researcher at the Computer Science Department of the University of Kaiserslautern, Germany. He will move to Växjö University, Sweden, in Spring 2007, where he has been appointed for a position as Associate Professor in Computer Science. Until the end of his Ph.D. studies in 2002, he was Research Assistant at the Computer Science Department of the Saarland University in Germany. From 2002 to 2004, he worked as Assistant Professor at the Institute of Computer Graphics and Algorithms at the Computer Science Department of the Vienna University of Technology, Austria. Andreas Kerren was involved in various successful research projects, e.g., in the DFG project "Generation of Interactive Multimedia Visualizations and Animations for Learning Software in Compiler Design" or in the FWF project "Hierarchies of Plane Graphs for the Acquisition, Analysis and Visualization of Geographic Information". Dr. Kerren was and is a member of several program and organizing committees, for example, the ACM Symposia on Software Visualization 2005 and 2006 or the IASTED International Conferences on Graphics and Visualization in Engineering as well as on Visualization, Imaging, and Image Processing in 2007. He has served as reviewer for several international journals. His main research interests lie in the areas of Software Visualization, Information Visualization, Software Engineering, Computer Science Education, Human-Computer Interaction, and Programming Languages.



Robert Kosara is currently an Assistant Professor at the Department of Computer Science, College of Information Technology, at the University of North Carolina at Charlotte (UNCC), where he is also a member of the Charlotte Visualization Center. He received both his Ph.D. (2001) and M.S. (1999) degrees from Vienna University of Technology, Vienna, Austria. Before coming to Charlotte, he worked at the VRVis Research Center, and the "in-silico" pharmaceutical research company Inte:Ligand. His main research focus is Information Visualization (InfoVis), which is the search for methods to depict abstract data in ways that allow one to find patterns, correlations, clusters, etc., by simply looking at and interacting with the resulting images. His goal is to bring together computer science, statistics, perceptual psychology, and the arts. His main interests are developing effective means of visualization and interaction with large and complex data, and finding the link between InfoVis and the visual arts.



Olga Kulyk is a Ph.D. student at the Human Media Interaction Group, University of Twente, The Netherlands, since October 2005. Her research interests include human-computer interaction, collaborative visualization environments, computer-supported cooperative work, analysis and design of complex interactive systems, and situational awareness. Her current research within Bsik project BioRange is on the user-centered de-

sign and evaluation to enhance scientific collaboration and creative problem solving of multidisciplinary research teams in bioinformatics domain. During 2003-2005 Olga was a research trainee at User-System Interaction Design post-masters program, Department of Technology Management, Technical University of Eindhoven, the Netherlands. There she received a degree of 'Professional Doctorate in Engineering' in 2005. During her final project at User Centered Engineering Group, Industrial Design, Technical University of Eindhoven, Olga worked on the design and evaluation of a service providing real-time feedback on visual attention during meetings, as a part of the EU-funded CHIL project. In 2003, she received masters and in 2001 bachelors in computer science from the National University of 'Kyiv-Mohyla Academy', Ukraine.



Robert S. Laramee received a bachelors degree in physics, cum laude, from the University of Massachusetts, Amherst in 1997. In 2000, he received a masters degree in computer science from the University of New Hampshire, Durham. He was awarded a Ph.D. from the Vienna University of Technology, Austria at the Institute of Computer Graphics in 2005. His research interests

are in the areas of scientific visualization, computer graphics, and human-computer interaction. He has contributed research papers to IEEE Visualization, the Joint EUROGRAPHICS-IEEE TVCG Symposium on Visualization, EUROGRAPHICS, and the CHI conference on Human-Computer Interaction as well as their respective journals. From 2001 to 2006 he was a Researcher at the VRVis Research Center (www.vrvis.at) and a software engineer at AVL (www.avl.com) in the department of Advanced Simulation Technologies. Currently, he is a Lecturer (Assistant Professor) at the University of Wales, Swansea, in the Department of Computer Science.



Mircea Lungu is a Ph.D. student at the University of Lugano, Switzerland, where he is working together with Prof. Dr. Michele Lanza. Before joining the University of Lugano, he received his Diploma-Engineer title from the Computer Science Faculty of the Polytechnic University in Timisoara, Romania. His diploma thesis, developed in collaboration with the Software Composition Group in Bern, proposed a novel way of aggregating metrics

into higher level abstractions that can be used for software quality analysis. His current research interests are related to software engineering and reverse engineering with a special emphasis on program understanding and software visualization. He maintains a live interest in generic information visualization and programming languages.



Andrés Moreno is a Ph.D. student at the University of Joensuu, Finland, since May 2005. He received his Master's degree from the Polytechnic University of Madrid, Spain. His Master's thesis developed an intermediate code for Program Animation, and was jointly supervised by professors Erkki Sutinen and Mordechai Ben-Ari. He is currently researching on program visualization and animation for novices, focusing on how to make current visualization tools aware of the personal differences of the users. Having published in conferences such as ACM ITiCSE and IEEE ICALT, he is an active member of the Algorithm Animation community. He has also taken part in several working groups at ITiCSE.



Jörg Meyer is an Assistant Professor with a shared appointment in the Department of Electrical Engineering & Computer Science and the Department of Biomedical Engineering in the Henry Samueli School of Engineering at the University of California, Irvine. He joined UC Irvine in 2002. Dr. Meyer is also affiliated with the Center of GRAVITY (Graphics, Visualization and Imaging Technology) in the California Institute for Telecommunications and Information Technology (Calit2). He received his Ph.D. from the University of Kaiserslautern, Germany, in 1999. He held an appointment as a post-doctoral researcher and lecturer in the Computer Science Department at the University of California, Davis, from 1999 to 2000, and maintains an Adjunct Assistant Professorship at the Computer Science and Engineering Department at Mississippi State University, where he was also affiliated with an NSF-sponsored Engineering Research Center (2000-2002). Dr. Meyer's research interests include large-scale scientific visualization, biomedical imaging, digital image processing, interactive rendering and virtual reality. His research efforts are aimed at developing interactive rendering methods for large scientific data sets. Medical data sets range from Magnetic Resonance Imaging (MRI), Computed Tomography (CT) and Confocal Laser-scanning Microscopy to Optical Coherence Tomography and other modalities. Other applications are in the field of Civil Engineering and include ground motion and structural response simulations. The common theme in these interdisciplinary domains is the occurrence of giga- to tera-byte volumetric data sets that need to be rendered interactively. Dr. Meyer has developed multi-level-of-detail data representation techniques based on hierarchical space-subdivision algorithms and wavelet-based compression schemes, enabling interactive data storage, transmission and rendering of large volumetric data sets. Dr. Meyer has lead and has served on multiple conference and program committees for various professional organizations, including IEEE, ACM SIGGRAPH and IASTED. He has published over 112 journal articles, book chapters, conference papers, abstracts and posters in his field.



Martin Nöllenburg is a Ph.D. student at Karlsruhe University, Germany since October 2005. He is working as a Research Assistant in the group GeoNet of Dr. Alexander Wolff. He received his Diploma with Distinction in Computer Science from Karlsruhe University in August 2005. In 2002/03 he was a visiting student at McGill University, Montreal in the computational biology group of Dr. Mike Hallett. In his Diploma thesis he studied

the problem of automatically drawing schematic metro maps and implemented an algorithm based on mixed-integer programming. For this work he received the NRW Undergraduate Science Award 2005. His current research interests are in the field of graph drawing and computational geometry, specifically algorithms for the visualization of geometric graphs and networks, e.g. metro maps.



Mathias Pohl is a scientific assistant at the chair for software engineering at the University of Trier, Germany, since March 2006. He graduated in January 2005 at the University of Saarbrücken. From April 2005 to February 2006, he was a member of the Ph.D. program at the University of Kaiserslautern, Germany. His research interests cover the visualization of time-varying data and graph drawing.



Ermir Qeli is a research assistant at the department of mathematics and computer science at the University of Marburg. He is working at the "Distributed Systems" research group of Bernd Freisleben on visualization techniques for systems biology. He received his diploma in Computer Science from the University of Tirana, Albania, in 2000. His research interests include: Information Visualization and its application in Systems Biology, Data

Mining and Machine Learning, especially unsupervised learning techniques (clustering), as well as Comparison of structured data, such as XML files etc.



Jaime Urquiza is a lecturer of Computer Science and a Ph.D. student at the Rey Juan Carlos University, Spain. He received his Advanced Studies degree in 2003 from the Rey Juan Carlos University and his Bachelor degree in Computer Science in 1999 from the Polytechnic University of Madrid, Spain. His research areas are information visualization and, program and algorithm visualization applied to computer science education. His research

goal is the development of usable program and algorithm animations in computer science education, taking into account both students and teachers.



Ingo H.C. Wassink is Ph.D. student at the University of Twente, the Netherlands, of the sub department of Human Media Interaction of the department of Computer Science. He did his master thesis in dynamic scenario generation for driving simulators. The system is based on the movie world, where a multi agent system is developed for orchestrating the driving scenarios.

His main interests are in visualization, computer vision, artificial intelligence and multi agent systems. Currently, he is doing research in computer visualization techniques for physical scientific collaborative environments. In such an environment, visualization and interaction with different kinds of display devices play an important role. These displays can differ in size and the way things are visualized (e.g. 2D or stereoscopic) and therefore require different kinds of visualization techniques. On these displays devices, information should be presented in an efficient way that helps researchers discussing their experiments. Important research topics are visualization of experiments, visualization and control of the flow of the experiment and visualization for comparing (intermediate) results of the experiment.



Kai Xu is currently a researcher at National ICT Australia. He is also an Honorary Associate of School of Information Technologies at University of Sydney. He received his Ph.D. in Computer Science in 2004 from the University of Queensland, Australia. Before that, he received his bachelor degrees in Computer Science and Business from Shanghai Jiao Tong University, China in 1999. His main research interest is applying graph visualization

in bioinformatics, which involves modeling, visualizing, and analyzing various biological networks such as metabolic pathways and protein-protein interactome.

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