VisWeek 2012 Tutorial

Uncertainty and Parameter Space Analysis in Visualization

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Uncertainty and parameter space analysis in visualization

2. Organizers

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3. Organizer Bios

Christoph Heinzl
University of Applied Sciences – Upper Austria

Christoph Heinzl received his PhD degree in Computer Science from the Vienna University of Technology (VUT) in 2009 in the field of visualization and analysis of industrial computed tomography data. He is now senior researcher at the University of Applied Sciences – Upper Austria. His research interests include uncertainty visualization, visualization of industrial computed tomography data, image processing, dimensional measurement, simulation, 3D reconstruction. Christoph Heinzl is IEEE and Eurographics member.

Stefan Bruckner
Vienna University of Technology

Stefan Bruckner received his master's degree in Computer Science from the Vienna University of Technology (VUT), Austria in 2004 and his Ph.D. in 2008 from the same university. He is currently an Assistant Professor at the Institute of Computer Graphics and Algorithms at VUT. In 2009/2010, he spent one year as a visiting Postdoctoral Research Fellow at Simon Fraser University, Canada. His research interests include biomedical and illustrative visualization, volume rendering, and visual data exploration. In 2011, he was awarded the Eurographics Young Researcher Award. He is a member of the IEEE Computer Society, ACM SIGGRAPH, and Eurographics.

Eduard Gröller
Vienna University of Technology

Eduard Gröller (http://www.cg.tuwien.ac.at/staff/EduardGroeller.html) is professor at the Vienna University of Technology, Austria, and adjunct professor of computer science at the University of Bergen, Norway. His research interests include computer graphics, scientific visualization, medical visualization, information visualization and visual analytics. He co-authored more than 200 scientific publications and acted as a co-chair, IPC member, and reviewer for numerous conferences and journals in the field. Dr. Gröller has been Co-Chief Editor of the Computer Graphics Forum journal (2008-2011) and chair of the EuroVis 2012 conference.

4. Speakers

The speakers of the sessions are listed below. The background and contact information for each speaker is given in the individual session descriptions.

Alex T. Pang (University of California, Santa Cruz), <pang@cse.ucsc.edu>
Hans-Christian Hege (Zuse-Institut Berlin), <hege@zib.de>
Kristi Potter (Scientific Computing and Imaging Institute, Utah), <kpotter@sci.utah.edu>
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5. Speaker Bios:

Alex T. Pang
University of California, Santa Cruz

Alex Pang is a Professor of Computer Science at UC Santa Cruz. He received his PhD in Computer Science from UCLA in 1990, and his BS in Industrial Engineering from University of the Philippines with magna cum laude in 1981. His research interests are in comparative and uncertainty visualization, flow and tensor visualization, and collaborative visualization. His research has been supported by various funding agencies such as NSF, ONR, Darpa, DOE, LANL, and NASA, as well as industrial partners such as Sun and HP. Professor Pang has received a certificate of recognition for previous NASA work, as well as an excellence in teaching award from UCSC. He served as an associate editor of the IEEE Transactions on Visualization and Computer Graphics, papers co-chair for IEEE Visualization 2006 and 2007, and UCSC Chief Scientist for CITRIS during 2006 and

2007.

Hans-Christian Hege
Zuse Institute Berlin, Germany

Hans-Christian Hege (http://www.zib.de/hege) is director of the Visualization and Data Analysis department at Zuse Institute Berlin. He studied physics and mathematics, and performed research in computational physics and quantum field theory at Freie Universität Berlin. In 1989 he joined the High-Performance Computing division at ZIB and in 1991 he started the Scientific Visualization department in the Numerical Mathematics division. His department performs research in visual data analysis and develops software such as Amira.
He co-founded three companies in the field of computer graphics and visualization. He taught at Free University Berlin, Universitat Pompeu Fabra, Barcelona, and German Film School. His research interests include visual computing and applications in life and natural sciences. He co-authored about 250 publications and acted as a co-chair, IPC member, and reviewer for various conferences in the field.

Kristin Potter
Scientific Computing and Imaging Institute, University of Utah

Kristi Potter is currently a Research Scientist at the SCI Institute. In 2010 she received her Ph.D. from the University of Utah and began life as a computer scientist at the University of Oregon, where she earned her B.S. in computer science and fine arts. Her current research focuses on the integration of uncertainty into visualization. This work draws from the fields of scientific and information visualization and uncertainty quantification and is motivated by the need to increase the utility of visualization as a decision making tool. By visually describing the uncertainties present in a display, a scientist will be better informed on the quality of the data and thus be capable of making improved and more confident decisions. The greatest challenge to this work is in understanding the sources and quantifications of the uncertainty and in designing effective visual metaphors.

Rüdiger Westermann
Technical University Munich

Rüdiger Westermann, born in Mai 1966, is Professor of Computer Graphics and Visualization in the Computer Science Department of the Technische Universität München. He serves as Coordinator of the Center for Computational and Visual Data Exploration, and he is member of the board of the TUM International Graduate School for Science and Engineering and the TUM Institute for Advanced Studies. His research interests include visual data exploration, visual simulation and real-time simulation and computer graphics. He was recently awarded with an Advanced Grant (2.3 million Euro) for pursuing research on uncertainty

visualization by the European Research Council.
He received his Diploma in Computer Science from the Technische Universität Darmstadt in 1991 and his Doctoral degree "with highest honours" from the University of Dortmund in 1996. From 1992 to 1997 he was a member of the research staff at the German National Institute for Mathematics and Computer Science in St. Augustin, Bonn, where he worked together with Wolfgang Krüger on parallel graphics algorithms. In 1998, he joined the Computer Graphics Group at the University of Erlangen-Nuremberg as a Research Scientist. Before he became an Assistant Professor in the Visualization Group at the University of Stuttgart in 1999 he was a Research Assistant in the Mulitres Group at Caltech and a Visiting Professor with the Scientific Computing Laboratory at the University of Utah. In 2001 he was appointed by the RWTH-Aachen as an Associate Professor for Scientific Visualization in the Department of Computer Science. Since 2003, Rüdiger Westermann is Chair of the Computer Graphics and Visualization group at the Technische Universität München.

Tobias Pfaffelmoser
Technical University Munich

Tobias Pfaffelmoser studied Technomathematics with minor subjects in computer science and medical engineering at Technische Universität München, where he received his Diploma degree in 2009. His Diploma Thesis focused on numerical algorithms for artifact correction in medical imaging procedures. Since 2009, he is with the Computer Graphics and Visualization Group at Technische Universität München, where he is currently working on his Ph.D. Furthermore, he is a member of the Munich Center of Advanced Computing (MAC) and involved in an interdisciplinary project on "Efficient Inversion Methods for Parameter Identification in the Earth Sciences". His research includes uncertainty visualization, visualization in geophysics and volume rendering.

Torsten Möller
Simon Fraser University

Torsten Möller is a professor at the School of Computing Science at Simon Fraser University. He received his PhD in Computer and Information Science from Ohio State University in 1999 and a Vordiplom (BSc) in mathematical computer science from Humboldt University of Berlin, Germany. He is a senior member of IEEE and ACM, and a member of Eurographics. His research interests include the fields of Visualization and Computer Graphics, especially the mathematical foundations thereof.
He is co-director of the Graphics, Usability and Visualization Lab (GrUVi). He is the appointed Vice Chair for Publications of the IEEE Visualization and Graphics Technical Committee (VGTC). He has served on a number of program committees and has been papers co-chair for IEEE Visualization, EuroVis, Graphics Interface, and the Workshop on Volume Graphics as well as the Visualization track of the 2007 International Symposium on Visual Computing. He has also co-organized the 2004 Workshop on Mathematical Foundations of Scientific Visualization, Computer Graphics, and Massive Data Exploration as well as the 2010 Workshop on Sampling

and Reconstruction: Applications and Advances at the Banff International Research Station, Canada. He is a co-founding chair of the Symposium on Biological Data Visualization (BioVis). In 2010, he was the recipient of the NSERC DAS award. He received best paper awards from IEEE Conference on Visualization (1997), Symposium on Geometry Processing (2008), and EuroVis (2010), as well as two second best paper awards from EuroVis (2009, 2012).

Christoph Heinzl
University of Applied Sciences – Upper Austria

Christoph Heinzl received his PhD degree in Computer Science from the Vienna University of Technology (VUT) in 2009 in the field of visualization and analysis of industrial computed tomography data. He is now senior researcher at the University of Applied Sciences – Upper Austria. His research interests include uncertainty visualization, visualization of industrial computed tomography data, image processing, dimensional measurement, simulation, 3D reconstruction. Christoph Heinzl is IEEE and Eurographics member.

Stefan Bruckner
Vienna University of Technology

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Eduard Gröller
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Eduard Gröller (http://www.cg.tuwien.ac.at/staff/EduardGroeller.html) is professor at the Vienna University of Technology, Austria, and adjunct professor of computer science at the University of Bergen, Norway. His research interests include computer graphics, scientific visualization, medical visualization, information visualization and visual analytics. He co-authored more than 200 scientific publications and acted as a co-chair, IPC member, and reviewer for numerous conferences and journals in the field. Dr. Gröller has been Co-Chief Editor of the Computer Graphics Forum journal (2008-2011) and chair of the EuroVis 2012 conference.

6. Abstract

Within the past decades visualization advanced to a powerful means of exploring and analyzing data. Recent developments in both hard- and software contributed to previously unthinkable evaluations and visualizations of data with strongly increasing sizes and levels of complexity.

Providing just insight into available data of a problem seems not to be sufficient anymore: Uncertainty and parameter space analyses in visualization are becoming more prevalent and may be found in astronomic, (bio)-medical, industrial, and engineering applications. The major goal is to find out, at which stage of the pipeline - from data acquisition to the final rendering of the output image - how much uncertainty is introduced and consequently how the desired result (e.g., a dimensional measurement feature) is affected. Therefore effective methods and techniques are required by domain specialists, which help to understand how data is generated, how reliable is the generated data, and where and why data is uncertain.

Furthermore, as the problems to investigate are becoming increasingly complex, also finding suitable algorithms providing the desired solution tends to be more difficult. Additional questions may arise, e.g., how does a slight parameter change modify the result, how stable is a parameter, in which range is a parameter stable or which parameter set is optimal for a specific problem. Metaphorically speaking, an algorithm for solving a problem may be seen as finding a path through some rugged terrain (the core problem) ranging from the high grounds of theory to the haunted swamps of heuristics. There are many different paths through this terrain with different levels of comfort, length, and stability. Finding all possible paths corresponds in our case to doing an analysis of all possible parameters of a problem solving algorithm, which yields a typically multi-dimensional parameter space. This parameter space allows for an analysis of the quality and stability of a specific parameter set.

In many cases of conventional visualization approaches the issues of uncertainty and parameter space analyses are neglected. For a long time, uncertainty - if visualized at all - used to be depicted as blurred data. But in most cases the uncertainty in the base data is not considered at all and just the quantities of interest are calculated. And even to calculate these quantities of interest, too often an empirically found parameter set is used to parameterize the underlying algorithms without exploring its sensitivity to changes and without exploring the whole parameter space to find the global or a local optimum.

This tutorial aims to open minds and to look at our data and the parameter sets of our algorithms with a healthy skepticism. In the tutorial we combine uncertainty visualization and parameter space analyses which we believe is essential for the acceptance and applicability of future algorithms and techniques. The tutorial provides six sessions starting with an overview of uncertainty visualization including a historical perspective, uncertainty modeling and statistical visualization. The second part of the tutorial will be dedicated to structural uncertainty, parameter space analysis, industrial applications of uncertainty visualization and an outlook in this domain.