Solved Problems in Visualization
IEEE VIS 2015 Panel Proposal

Organizer: Robert S Laramee, Swansea University, UK

Panelists:

Thomas Ertl, University of Stuttgart, Germany
Chris Johnson, Utah University, US
Robert Moorhead, Mississippi State University, US
Penny Rheingans, University of Maryland, Baltimore County, US
William Ribarsky, UNC Charlotte, US

INTRODUCTION

Evaluation, solved and unsolved problems, and future directions are popular themes pervading the visualization research community over the last decade. The top unsolved problems in both scientific and information visualization was the subject of an IEEE Visualization Conference panel in 2004 (Rhyne et al 2004). The future of graphics hardware was another important topic of discussion the same year (Johnson et al 2004). The subject of how to evaluate visualization returned a few years later (House et al., 2005, Van Wijk 2005). Chris Johnson published a list of top problems in scientific visualization research (Johnson 2004) in 2004. This was followed up by report of both past achievements and future challenges in visualization research as well as financial support recommendations to the National Science Foundation (NSF) and National Institute of Health (NIH) (Johnson et al 2006). C. Chen published the first list of top unsolved information visualization problems (Chen 2005) in 2005. Future research directions in topology-based visualization were also a major theme of a workshop on topology-based visualization methods (Hauser et al., 2005, Scheuermann et al., 2005). Laramee and Kosara published a list of top future challenges in human-centered visualization (Laramee and Kosara 2007) in 2007. Laramee et al presented a list of top unsolved problems and future challenges in multi-field visualization (Laramee et al., 2014). These pervasive themes coincide roughly with the 20th anniversary of what is often recognized as the start of visualization in computing as a distinct field of research (McCormick et al., 1987).

However, these lists, panels, and papers imply that that some fundamental problems have been solved in visualization. After 30 years, what have we as a visualization research community solved? Is there any consensus on solved problems in visualization? This panel addresses some very difficult, core, fundamental questions such as (but not limited to):

- What visualization (scientific and information) problems have we, the visualization research community, solved?
- Is there any consensus on what problems have been solved?
- How can we as a community define an “open” or “solved” problem?
- When is a problem considered solved (or a challenge resolved)?
- Have any of the top challenges identified 10 or 20 years ago been solved?
- What about visual analytics?

The panel organizer already had some informal discussions on this topic with some well known leaders in the field at EuroVis 2015 in Cagliari, Italy (Min Chen, Gerik Scheuermann, and Anders Ynnernam). It was clear from these discussions that this is an exciting and interesting topic for further discussion.

Why this panel at IEEE VIS 2015?

This is an important and timely theme for the visualization research community that addresses difficult and challenging questions. To the best of our knowledge, no such panel has ever been presented. This central topic touches on the experience and interest of every researcher in visualization. It should be especially interesting for newcomers to the field. While the choice of future research directions is very important, there is a wide variety of opinion on this topic within the visualization research community. We think a panel addressing the question of what constitutes a solved problem in visualization research will form the basis of lively discussions that address these questions and more from the audience.

PANEL FORMAT AND LOGISTICS

The panelists will present their positions addressing each question posed in the introduction.

- The introductory remarks will be made by

Bob Laramee. His introduction will last for 5 minutes.
- He will chair the panel and he himself is not a panelist.
- Each panelist will be given 5-10 minutes, for a total of 25-45 minutes of presentations.
- This will allow for approximately 35-55 minutes of audience participation in the discussion.
- All panelists will have the opportunity to offer a summary view at the end of the panel (2 minutes each).

The panel chair will solicit audience feedback after the position statements have been delivered. The panel format will also be described in the panel opening.

POSITION STATEMENTS

Thomas Ertl
Lists of unsolved problems as we know them from fields like mathematics and theoretical computer science tend to describe problems, which remain static until solved once and forever. I would argue that the solutions to most visualization problems, which we developed as a community over the years, are dynamic in nature. The rapid changes in the problem environment, like data size or display size, hardware performance or cognitive abilities, require constant improvements of our solutions in order to provide ongoing benefit for the application domains. Many of the research results of our community have found their way into successful visualization tools and products, most notably in medicine and life sciences, maps and environment, engineering and business analytics. However, for declaring specific problems to be solved, we need to make our research more reproducible based on open platforms and quantitative measures.

Besides these scientific problems, we should not forget about the academic issues, which we have promoted and solved over the years. Visualization is a growing and vibrant community and this success is partly due to the infrastructures, which were established by highly motivated volunteers and professional societies. This includes well-arranged conferences affiliated with highly reputed journals, a truly international focus with many collaborations across continents, a respected awards system, support for young researchers and an open mind to reach out to new fields and ideas. This all contributes to making visualization a much more respected field of computer science with many more funding opportunities and career paths than could be anticipated decades ago. However, our highly dynamic world requires to continuously advancing our academic structures to prepare the ground for next generation of researchers to successfully deal with the unsolved problems of today.

Christopher Johnson
When I wrote the Visualization Viewpoints article on Top Scientific Visualization Research Problems (Johnson 2004), my motivation was to start a discussion on important research issues, review common practices, and hopefully motivate visualization researchers to think either about new problems or about persistent problems in new ways. I noted that the items on my list were not necessarily “problems”; but rather possible “topics” or “directions”. I recently did an informal survey of the topics listed in my 2004 paper to see which, if any, saw new or renewed interest. The results were interesting and point a way to discuss visualization research problems in varying degrees of maturity and also levels of difficulty. I will present the results of my survey on scientific visualization research problems and rank these problems with regard to their maturity and levels of difficulty.

Robert Moorhead
There are many solved visualization problems, although as we solve problems, we tend to discover better solutions or see new problems that need to be solved. First, we can now quickly, often in realtime, construct images that are hard to differentiate from reality. This was not the case in 1987. Second, we can now present those images at a rate that causes the viewer to be convinced he is seeing a physically-evolving phenomenon (e.g., smoke flowing over and around obstacles, fluid moving naturally, etc.). Many of these solutions have allowed us to visualize with confidence phenomenon that we cannot actually see, directly or remotely, with our own eyes. From those visualizations, we are to determine how to address a problem before we cut open a human or enter a disabled nuclear power plant.
Many solutions are more technology advances than knowledge advances. However, knowledge about how humans perceive (how the human vision system operates, how the brain operates, etc.) – solved problems -- has enabled the technologists.
In my presentation I will reference several lists of visualization problems from the 1990s and argue many have been solved.

Penny Rheingans
Thirty years of visualization research has changed how we define the field, how we approach research challenges, and what we consider to be fundamental background knowledge. Visualization has developed into a field with a foundation of seminal research, a rich collection of traditional methods, a variety of approaches to introducing students to the discipline, and a tradition of articulating lists of research challenges. Evidence of our relative youth and lack of notoriety as a discipline can be seen in the lack of a single iconic introductory text, the scarcity of visualization groups or courses at many universities, and the regularity with which researchers in other fields rediscover basic visualization methods. A list of solved problems (or solved elements of open

problems) can define a body of core truths about our discipline that serve as a comfortable starting point for exploration.

I will examine the methods we hold up to our students as the “right way” to accomplish a given task. Some of these rightly represent solid solutions to solved problems. Some leave open room for debate. Which will be the fun part.

William Ribarsky
It may be risky to describe a visualization problem as unequivocally “solved”. After all, one might pinpoint a problem on which fellow researchers, including perhaps in the future oneself, would want to write a research paper! I will therefore take the more timid tack of identifying problems that seem “well studied” or well developed. In doing this, I will concentrate more on the areas I have been working on in the past several years. One area that seems well developed is interactive visualization of large scale terrains, often as part of global terrain visualization systems. Another area is what may be called standard information visualization interfaces, which are now successfully used in many areas of visualization and which even have available powerful, standardized toolkits. I will discuss these and some other visualization problems. In doing so, I will touch upon how solved problems might be used to attack unsolved ones and, strangely enough, how in some cases solved problems suddenly become unsolved again.

BIOGRAPHIES

Professor Thomas Ertl
Thomas Ertl received an MSc in computer science from the University of Colorado at Boulder and a PhD in theoretical astrophysics from the University of Tuebingen. He is a full professor of computer science at the University of Stuttgart now leading the Visualization and Interactive Systems Institute (VIS) and the Visualization Research Center of the University of Stuttgart (VISUS). His research interests include visualization, computer graphics and human computer interaction in general with a focus on volume rendering, flow and particle visualization, parallel and hardware accelerated graphics, large datasets and interactive steering, visual analytics of text collections and social media, user interfaces and navigation systems for the blind. Dr. Ertl is co-author of more than 400 scientific publications and a member of numerous program committees (e.g. Eurographics, ACM SIGGRAPH, IEEE VIS) and a papers co-chair for several conferences (e.g. Eurographics, IEEE Visualization, EuroVIS, PacificVis). From 2007-2010 Dr. Ertl was Editor- in-Chief of the IEEE Transactions on Visualization and Graphics (TVCG) and in 2011/2012 he served as Chairman of the Eurographics Association. He received the Outstanding Technical Contribution Award of the Eurographics Association and the Technical Achievement Award of the IEEE Visualization and Graphics Technical Committee in 2006. In 2007 he was elected as a Member of the Heidelberg Academy of Sciences and Humanities. He received Honorary Doctorates from the Vienna University of Technology in 2011 and from the University of Magdeburg in 2014.

Professor Chris Johnson
Chris Johnson is the founding director the Scientific Computing and Imaging (SCI) Institute at the University of Utah where he is a Distinguished Professor of Computer Science and holds faculty appointments in the Departments of Physics and Bioengineering. His research interests are in the areas of scientific visualization and scientific computing. Dr. Johnson founded the SCI research group in 1992, which has since grown to become the SCI Institute employing over 200 faculty, staff and students. Professor Johnson serves on several international journal editorial boards, as well as on advisory boards to several national research centers. Professor Johnson has received several awards, including the the NSF Presidential Faculty Fellow (PFF) award from President Clinton in 1995 and the Governor's Medal for Science and Technology from Governor Michael Leavitt in 1999. He is a Fellow of the American Institute for Medical and Biological Engineering, a Fellow of the American Association for the Advancement of Science, and in 2009 he was elected a Fellow of the Society for Industrial and Applied Mathematics (SIAM) and received the Utah Cyber Pioneer Award. In 2010 Professor Johnson received the Rosenblatt Award from the University of Utah and the IEEE Visualization Career Award. In 2012, Professor Johnson received the IEEE IPDPS Charles Babbage Award and in 2013 Professor Johnson received the IEEE Sidney Fernbach Award . In 2014, Professor Johnson was elected an IEEE Fellow.

Professor Robert J Moorhead II
Robert J. Moorhead II, received a BSEE from Geneva College in 1980 and a MSEE and his Ph.D. in Electrical and Computer Engineering from North Carolina State University in 1982 and 1985 respectively. He is currently the Billie J Bill Professor of Electrical and Computer Engineering at Mississippi State University, as well as Director of both the Geosystems Research and Northern Gulf Institutes. He has published over 160 papers, 70 of which are refereed, is the lead author on one patent, is the author of one book, has been the editor for 5 other books, and is the author of 7 book chapters. He has been the major professor for 10 PhD students. He has been the major professor for 19 MS thesis students and major professor for 21 non-thesis MS students. He has received the Career Achievement Award and the Outstanding Engineering Research Award from the Bagley College of Engineering at Mississippi State

University. He on the Board of Directors of the IEEE Computer Society's Technical Committee on Visualization and Graphics, having served as Chair, Vice-Chair for Conferences (twice), and IEEE Visualization Conference Chair over the past 20 years. He has lead visualization research and development efforts in support of many geospatial problems (physical oceanography, disposal of dredged materials, coastal / severe weather, etc.). Over the past 5 years, he has developed an unmanned air / surface vehicle program focused on precise agriculture and watersheds.

Professor Penny Rheingans
Penny Rheingans is a Professor of Computer Science and Electrical Engineering and Director of the Center for Women in Technology (CWIT) at the University of Maryland Baltimore County.
She received a Ph.D in Computer Science from the University of North Carolina, Chapel Hill and an AB in Computer Science from Harvard University. Her research interests include the visualization of predictive models, visualization of data with associated uncertainty, perceptual and illustration issues in visualization, educational analytics, and the experimental validation of visualization techniques. Dr. Rheingans has over eighty published works. In particular, she coauthored the NIH/NSF Visualization Research Challenges report, published in 2006 by IEEE. As CWIT Director, she oversees a scholarship program for undergraduates committed to increasing gender diversity in the technology fields and develops programs to increase the interest and retention of women in technology programs.

Professor William Ribarsky
William Ribarsky is the Bank of America Endowed Chair in Information Technology at UNC Charlotte and the founding director of the Charlotte Visualization Center. He has been Chair of the Computer Science Department. He was Principal Investigator for the DHS SouthEast Regional Visualization and Analytics Center. He received a Ph.D. in physics from the University of Cincinnati. His research interests include visual analytics; 3D multimodal interaction; bioinformatics visualization; virtual environments; visual reasoning; and interactive visualization of large-scale information spaces. He has authored over 170 research publications. Dr. Ribarsky is the former Chair and a current Director of the IEEE Visualization and Graphics Technical Committee. He served from 2012 to 2014 as a member of the overall Steering Committees for IEEE VisWeek. He was an Associate Editor of IEEE Transactions on Visualization and Computer Graphics and is currently an Editorial Board member of IEEE Computer Graphics & Applications. Dr. Ribarsky co-founded the Eurographics/IEEE visualization conference series (now called EG/IEEE EuroVis) and led the effort to establish the Virtual Reality Conference series. For the above efforts on behalf of IEEE, Dr. Ribarsky won the IEEE Meritorious Service Award in 2004. In 1995-96, he was general co-chair of IEEE Visualization and In 2007, he was general co-chair of the IEEE Visual Analytics Science and Technology (VAST) Symposium. He is now Chair of the IEEE VAST Steering Committee.

References

(Chen 2005) C. Chen. Top 10 Unsolved Information Visualization Problems. IEEE Computer Graphics and Applications, 25(4):12–16, July/August 2005.

(Hauser et al., 2005) H. Hauser, P.T. Bremer, H Theisel, M. Trener, and X. Tricoche. Panel: What are the most demanding and critical problems, and what are the most promising research directions in Topology-Based Flow Visualization? In Topology-Based Methods in VisualizationWorkshop, 2005, September 2005. Held in Budmerice, Slovakia.

(House et al, 2005) D. House, V. Interrante, D. Laidlaw, R. Taylor, and C. Ware. Panel: Design and Evaluation in Visualization Research. In Proceedings IEEE Visualization 2005, pages 705–708, 2005.

(Johnson 2004) C.R. Johnson. Top Scientific Visualization Research Problems. IEEE Computer Graphics and Applications, 24(4):13–17, July/August 2004.

(Johnson et al 2006) C.R. Johnson, R. Moorhead, T. Munzner, H Pfister, P. Rheingans, and T. S. Yoo. NIH/NSF Visualization Research Challenges (Final Draft, January 2006). Technical report, 2006.

(Johnson et al 2004) G. Johnson, D. Ebert, C. Hansen, D. Kirk, B. Mark, and H. Pfister. Panel: The Future Visualization Platform. In Proceedings IEEE Visualization 2004, pages 569–571, 2004.

(Laramee and Kosara 2007) R. S. Laramee and R. Kosara. Human-Centered Visualization Environments, chapter Future Challenges and Unsolved Problems, pages 231–254. Springer Verlag, 2007. Springer Lecture Notes in Computer Science (LNCS) 4417.

(Laramee et al, 2014) R S. Laramee, H Carr, M Chen, H Hauser, L Linsen, K Mueller, V Natarajan, H Obermaier, R Peikert, and E Zhang, Future Challenges and Unsolved Problems in Multi-field Visualization, in*Scientific Visualization: Uncertainty, Multifield, Biomedical, and Scalable Visualization*, Mathematics and Visualization, C.D. Hansen, M. Chen, C.R. Johnson, A.E. Kaufman, H. Hagen, Editors, 2014 pages 205-211, ISBN 978-1-4471-6496-8, Springer

(McCormick et al, 1987) B.H. McCormick, T.A.

DeFanti, and M.D. Brown. Visualization in Scientific Computing. Technical report, The National Science Foundation (NSF), 1987.

(Rhyne et al., 2004) T.-M. Rhyne, B. Hibbard, C. Johnson, C. Chen, and S. Eick. Panel: Can We Determine the Top Unresolved Problems of Visualization? In Proceedings IEEE Visualization 2004, pages 563–565, 2004.

(Scheuermann et al, 2005) G. Scheuermann, C. Garth, and R. Peikert. Panel: Even more theory, or more practical applications to particular problems: In which direction will Topology-Based Flow Visualization go? In Topology-Based Methods in Visualization Workshop, 2005, September 2005. Held in Budmerice, Slovakia.

(Van Wijk 2005) J. J. van Wijk. The Value of Visualization. In Proceedings IEEE Visualization ’05, pages 79–86. IEEE Computer Society, 2005