2D VS 3D
IEEE VIS 2014 Panel Proposal

Organizer: Robert S Laramee, Swansea University, UK

Panelists:

Chuck Hansen, Utah University, US
Silvia Miksch, Vienna University of Technology, Austria
Klaus Mueller, SUNY Stony Brook, US
Bernhard Preim, University of Magdeburg, Germany
Colin Ware, University of New Hampshire, US

1 INTRODUCTION

Most of us agree that visualization design is a critical aspect of any visualization research. There are many different aspects to the topic of visualization design including: data characteristics and type, data enhancement, visualization mapping, e.g., choice of shape, color, opacity, and texture etc. Another critical aspect is the spatial domain in which the final visualization is presented. In general, 1, 2, or 3 spatial dimensions are used when designing a visualization.

The vast majority of visualizations in the literature reside in 2 or 3 spatial dimensions. However, there are differing opinions as to what constitutes an ideal spatial dimensionality when it comes to visualization design (Ware, 2001). Some believe that 3D space is preferable since it may convey more information than 2D. However, others believe that 2D is preferable because it may result in less occlusion and complexity. In this panel, we discuss precisely this topic: What is the best spatial dimensionality for a given visualization? We address questions such as:

- Is there an objective or scientific way to choose between a 2D or 3D representation?
- Which is better, 2D or 3D? And why? Is one generally better than the other?
- When is 2D or 3D the most appropriate for visualization design?
- What is the most appropriate way to evaluate the ideal spatial dimensionality when designing a visualization?
- What factors should be considered when choosing between a 2D and 3D visualization?
- What are the advantages of 2D over 3D and vice-versa?
- When is a 3D spatial representation best for abstract data?
- When is a 2D spatial representation best for volumetric data?

Why this panel at VIS 2014?
This basic and central topic touches upon the experience and sentiment of every researcher in visualization. It is especially challenging for newcomers to the field. Although the choice of 2D versus 3D space is so basic, universal, and fundamental, there is little agreement and perhaps an abundance of subjective bias in the visualization community. It will form the basis of lively discussions that address these questions and perhaps more from the audience.

2 LOGISTICS

The panelists will present their positions. The introductory remarks will be made by Bob Laramee. His introduction will last for 5 minutes. 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).

3 POSITION STATEMENTS

Chuck Hansen: Not 0D

The question is not whether 2D is better or worse than 3D for visualization but what tasks are being addressed by a visualization system. Users that may be familiar with 2D systems, such as Adobe Photoshop, may prefer visualization and interaction with a 2D representation. Conversely, when the spatial data is inherently 3D, 3D may provide a richer set of analysis solutions such as in cell tracking. We have effectively combined 2D with 3D for specific tasks as in interactive neural segmentation and visualization. I suggest that the tasks to be solved determine which is better: 2D or 3D but we can all agree that 0D is likely not and answer.

Silvia Miksch: 2D First

Two dimensional vs three dimensional visualization is a challenging and widely discussed topic – I support simple and easy to understand visualizations according to particular data, users, and tasks. Three dimensions are appropriate in order to visualize physical objects, like surgeons planning where it is important to visualize the patient's body. However, it includes challenges such as navigation, visual clutter, etc. All dimensions need to be considered seriously according our perceptual and cognitive system when exploring and analyzing multivariate data. Therefore, we should first explore 2D. I will illustrate, that 2D is sufficient for visual analytics exploration for particular data, users, and tasks.

Klaus Mueller: Take Advantage of 3D

Three dimensions has become all the hype in movies and home TV. These media cater to the desire of humans to see the world as realistic as possible, and more. Humans have the ability to fuse imagery acquired from two slightly different viewpoints into a 3D cognitive model. Three dimensional perception is learnt at early childhood when the required neural circuits are built. These circuits can not only make inferences about 3D shapes and topologies, they can also resolve complex patterns and textures. So why not take advantage of this complex circuitry, either by ways of stereo vision or motion parallax. Especially the latter is an interesting concept since we can easily facilitate it on the computer, via interaction, without the need for special glasses. It is also how we perceive 3D objects further away. And finally, we can also use other depth cues, such as shadows, depth of field, and transparency, and control them via interaction. I will show some examples in the field of information visualization where 3D graphics, paired with natural interaction has shown good promise.

Bernhard Preim: 2D and 3D

In medicine, 3D visualizations are considered to give an overview on spatial relations of anatomical and pathological structures. The planning of treatments, such as the insertion of implants, biopsy needles or radiation treatment benefits from 3D visualizations that highlight access paths. However, the necessary interaction to define the placement and orientation of devices, to measures distances or angles, is difficult to perform precisely in 3D visualizations. Slice-based 2D visualizations where each voxel is indeed visible (in one of the slices) are better suited. Also for specific diagnostic tasks, such as searching for small nodules, 2D visualizations are an indispensable part of the process. Thus, in medicine, the most important question is usually not 2D or 3D visualization but how these complementing views are coordinated to support diagnostic, treatment planning and documentation. With recent developments, such as Acrobat 3D and web-based 3D visualizations,rotateable 3D views gain importance for summarizing findings in reports, documentation and patient education.
Thus, a useful sequence often involves 3D visualizations early in the process as a starting point, then to use primarily 2D visualizations for precise exploration and interaction and 3D visualizations at the end of the process to communicate results.

This, however, is rather an assessment of the author; not the water-proof result of scientific investigations. More research is clearly needed to better understand the role of 2D and 3D visualizations. However, to yield relevant results, realistic tasks and representative members of the target user group need to be involved.

Coin Ware: Visual Dimensions are Not All the Same

Human perception is neither 3D nor 2D, but it is more 2D than 3D; the most powerful pattern processing machinery of the human visual system devoted to 2D patterns and the visual world is laid out in a 2D plane; depth information is only extracted with difficulty and at much lower resolution. Depth is derived from depth cues, such as occlusion, stereoscopic depth, motion parallax, perspective (linear, texture gradients, size gradients), and for the most part these can be used on an as as needed basis by visualization designers. So 3D design is not an all or none decision, we can use a single cue, such as occlusion, or several, depending on what is most effective in supporting the analytic task.

2.5D design is a catchphrase meant to empasize that vision is not 3D. It should not be taken literally. In reality we see much less than 2.5D, 2.05D would be more accurate, although a simplification. The idea of 2.5D design is to take the nature of perceptual space into account and pay especial attention to layout in the plane orthogonal to the line of sight. Just as we selectively use color, line and texture to create visually efficient designs so too we should use depth cues as needed for perceptual and cognitive efficiency. An additional consideration is interaction. With 3D designs, interaction is often more difficult and time consuming and these costs must be taken into account. For example, motion parallax only works when things are moving, but it is hard to select moving things.

Careful use of 3D cues can often be beneficial. Occulsion helps us see where lines or tubes cross without intersection, motion can help us resolve layers and 3D structures, and shading is an effective way of showing the shape of surfaces. The important thing is to determine the tasks in perceptual terms and design visual displays that helps scientists, engineers and data analysts to perform those task efficiently.

4 BIOGRAPHIES

Bernhard Preim

Bernhard Preim was born in 1969 in Magdeburg, Germany. He received the diploma in computer science in 1994 (minor in mathematics) and a Ph.D. in 1998 from the Otto-von-Guericke University of

Magdeburg. In 1999 he finished his work on a German textbook on Human Computer Interaction. He then moved to Bremen where he joined the staff of MeVis. In close collaboration with radiologists and surgeons he directed the work on "computer-aided planning in liver surgery". Since March 2003 he is full professor for "Visualization" at the computer science department at the Otto-von-Guericke-University of Magdeburg, heading a research group which is focussed on medical visualization and applications in surgical education and surgery planning. These developments were summarized in two textbooks Visualization in Medicine (Co-author Dirk Bartz, 2007) and "Visual Computing for Medicine (Co-author: Charl Botha, 2013). His continuous interest in HCI lead to another textbook "Interaktive Systeme" (Co-author: R. Dachselt) (Springer, 2010).

He was Co-Chair and Co-Organizer of the first and second Eurographics Workshop on Visual Computing in Biology and Medicine (VCBM) and is now member of the steering committee of that workshop. He is the chair of the scientific advisory board of ICCAS (International Competence Center on Computer-Assisted Surgery) Leipzig since 2010 and president of the German society for Computer- and Robot-Assisted Surgery (since 2013).

Chuck Hansen

Charles (Chuck) Hansen is an IEEE Fellow and a Professor of Computer Science in the School of Computing and an Associate Director of the Scientific Computing and Imaging Institute at the University of Utah.

He received a BS in computer science from Memphis State University in 1981 and a PhD in computer science from the University of Utah in 1987. Since 1997, he has been on the faculty in Computer Science at the University of Utah. He was a visiting professor at the University Joseph Fourier in 2011-2012 and a visiting scientist at INRIA-Rhone Alpes in the GRAVIR group in 2004-2005. From 1989 to 1997, he was a Technical Staff Member in the Advanced Computing Laboratory (ACL) located at Los Alamos National Laboratory, where he formed and directed the visualization efforts in the ACL. He was a Bourse de Chateaubriand PostDoc Fellow at INRIA, Rocquencourt France, in 1987 and 1988.

Chuck Hansen has published over 150 peer reviewed journal and conference papers and has been a co-author on three papers recognized with ``Best Paper Awards'' at the IEEE Visualization Conference (1998, 2001, 2002). He was co-author on the Best Paper at IEEE Pacific Visualization 2010. He was awarded the IEEE Technical Committee on Visualization and Graphics "Technical Achievement Award" in 2005 in recognition of seminal work on tools for understanding large-scale scientific data sets.

He is an Associate Editor in Chief of IEEE Transactions on Visualization and Computer Graphics and is currently on the editorial board of Elsevier Computers and Graphics Journals. His research has made contributions to the fields of scientific visualization, computer graphics, parallel computation and computer vision.

Silvia Miksch

Silvia Miksch is Associate University Professor and head of the Information and Knowledge Engineering research group, Institute of Software Technology & Interactive Systems, Vienna University of Technology. Her main research interests are Information Visualization and Visual Analytics (in particular Focus+Context and Interaction methods), and Time. She established the awarded Laura Bassi Centre of Expertise "CVAST – Center for Visual Analytics Science and Technology (Design, Interact & Explore)" funded by the Federal Ministry of Economy, Family and Youth, Austria.

One of her main scientific achievements is a book presenting and discussing a systematic view of the visualization of time-oriented data (Aigner et al, 2011). This view is structured along three key questions. While the aspects of time and associated data describe what is being visualized, user tasks are related to the question why something is visualized. These characteristics and tasks determine how the visualization is to be designed.

Furthermore, she designed and developed within her group various interactive Visual Analytics concepts and solutions for time-oriented data and information with particular focus on medicine and electronic health record. (for example, CareCruiser (Gschwandtner et al 2001), Disco, Gravi++ (Hinum et al 2005), HypoVis, Midgaard (Bade et al 2004), MobiGuide (Quaglini et al, 2013), VieNA, VisuExplore (Ring et al, 2010)). A particular focus in her research is the main goal of Visual Analytics – the facilitation of deeper insights into huge heterogeneous data resources – which can be achieved by considering (1) the characteristics of the data, (2) the users, and (3) the users' tasks and needs.

Silvia has served on various program committees of international scientific conferences and was, for example, conference paper co-chair of the IEEE Conferences on Visual Analytics Science and Technology (IEEE VAST 2010 and 2011) at VisWeek, International Workshop on Visual Analytics (EuroVA 2011), Eurographics/IEEE Conference on Visualization (EuroVis 2012). She launched together with David Riaño and Annette ten Teije the workshop series Knowledge Representation for Health-Care (KR4HC), which is an annual workshop and selected papers are published in Springer LNAI.

Klaus Mueller

Klaus Mueller received a PhD in computer science from Ohio State University and is currently a professor of computer science at Stony Brook University. His research interests are visualization, visual analytics, and medical imaging. He won the NSF CAREER award in 2001 and the SUNY Chancellor Award for Excellence in Scholarship and Creative Activity in 2011. He is the current chair of the IEEE Technical Committee for Visualization and Graphics and a former Associate Editor of IEEE TVCG.

Colin Ware

Colin Ware is the Director of the Data Visualization Research Lab which is part of the Center for Coastal and Ocean Mapping at the University of New Hampshire. He combines interests in both basic and applied research and he has advanced degrees in both computer science (MMath, Waterloo) and in the psychology of perception (PhD,Toronto). He is cross appointed between the Departments of Ocean Engineering and Computer Science. Ware specializes in advanced data visualization and has a special interest in applications of visualization to Ocean Mapping.

Ware has published over 160 articles in scientific and technical journals and leading conference proceedings. Many of these articles relate to the use of color, texture, motion and 3D displays in information visualization. His approach is always to combine theory with practice and his publications range from rigorously scientific contributions to the Journal of Physiology and Vision Research to applications-oriented articles in ACM Transactions on Graphics and various visualization and human-computer Interaction Journals. Colin Ware's book *Information Visualization: Perception for Design* 2012 3rd Edition is a standard reference on what the science of perception can tell us about visualization design. His other book: *Visual Thinking for Design* is an up to date account of the psychology of how we think using graphic displays as tools.

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