Eurographics 2015 Tutorial:
Tools & Techniques for Direct Volume Interaction
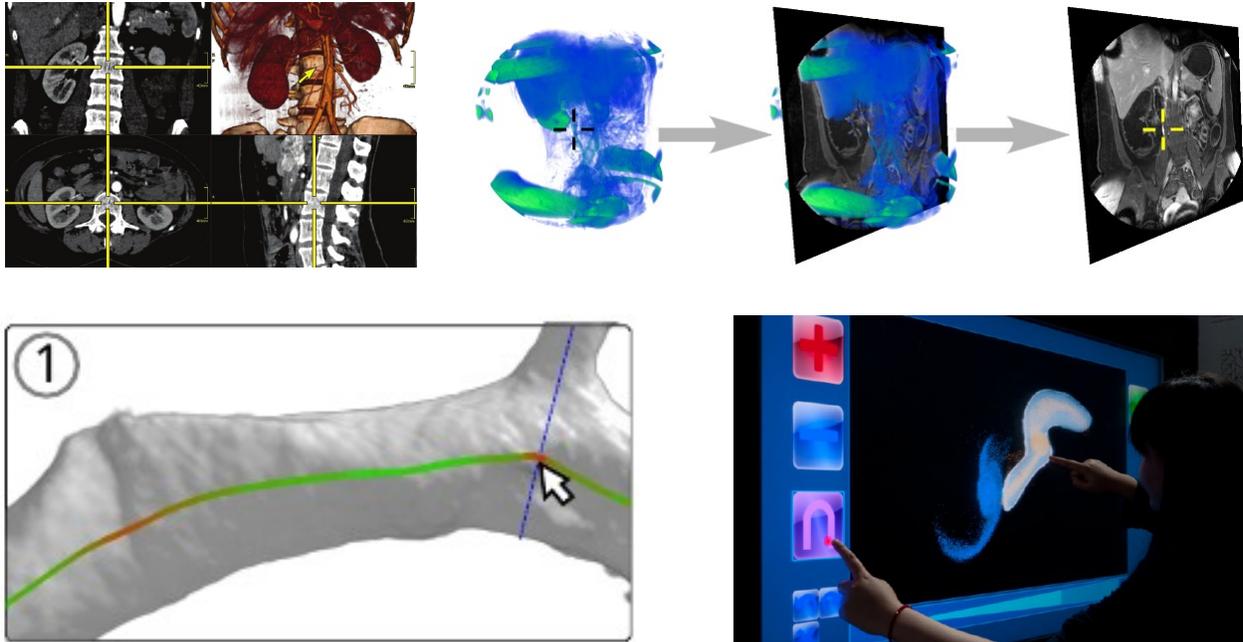
Tutorial Materials and Website

- http://tutorials.awmw.org/DirectVolumeInteraction/

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Keywords:

Interaction, interactive selection, sketching, manipulation, volume rendering, volume data, point clouds, volume picking, point picking, marking, volume pinpointing, novel interaction platforms, guided navigation, guided exploration

Abstract:

Volumetric data, continuous as well as scattered, are close to ubiquitous in natural sciences, medicine and engineering. While the visualization of such data itself is not straightforward, interaction with and manipulation of volumetric data - essential aspects of effective data analysis - pose even further challenges. Due to the three-dimensional nature of the data, it is not straightforward how to select features, pick positions, segment regions or otherwise interact with the rendering or the data themselves in an intuitive manner. In this tutorial we will present state of the art approaches and methods for addressing these challenges.
The tutorial will start by reviewing common classes of interaction tasks in volume visualization, motivating the need for direct interaction and manipulation, and describing the usually encountered difficulties. Interaction with visualization traditionally happens in PC-based environments with mouse and 2D displays. The second part of the tutorial discusses specific interaction methods that deal with the challenges in this context. Furthermore, an overview of the range of applications of these techniques is given to demonstrate their utility. The use of alternative paradigms for interaction with volumes is discussed in the third part. Such paradigms, e.g. in the context of touch interfaces or immersive environments, provide novel opportunities for volume exploration and manipulation, but also pose specific challenges themselves. The last part completes the tutorial's scope by a treatment of higher-level interaction techniques guiding users in navigation and exploration of the data using automatic or semi-automatic methods for identifying relevant parameter ranges. Such techniques employ additional, sometimes workflow-specific, information to assist in choosing effective volume visualization techniques and related attributes.

Tutorial Type

Half day tutorial (150 minutes)

Outline:

Detailed Outline of the Tutorial:
Monday, 2015-05-04
13:20 - 13:25 Introduction (Timo Ropinski)
13:25 - 13:55 **Part 1**: Visualization of volume data and the need of interaction (Timo Ropinski)
13:55 - 14:00 Questions
14:00 - 14:30 **Part 2**: Direct manipulation (Alexander Wiebel)
14:30 - 14:35 Questions and discussion
14:35 - 14:50 **Part 3**: Interaction with non-standard input and output devices (Tobias Isenberg)
14:50 - 15:10 Break
15:10 - 15:25 **Part 3**: Continued.
15:25 - 15:30 Questions
15:30 - 16:00 **Part 4**: Guided Navigation and Exploration (Stefan Bruckner)
16:00 - 16:05 Questions and discussion
16:05 - **16:10** Closing remarks (Alexander Wiebel)

Necessary Background:

An intermediate knowledge level of interactive computer graphics and scientific visualization algorithms is required. Programming experience of interactive graphics and some awareness of issues regarding interaction with and perception of volume data visualization may be helpful. Not required: prior knowledge of or background in 3D user interfaces, perceptual psychology, or human-computer interaction.

Target Audience:

The intended audience consists of computer graphics and visualization researchers, programmers, other users of volume visualization and all those interested in tools and techniques for direct interaction with volume data its challenges, common solutions and the latest advances.

Description of the Tutorial Notes:

The tutorial notes will include the description of the tutorial, the overview of the material covered in each talk, a copy of each presenter's slides, and reprints of selected publications that describe some of particular techniques presented in our lectures.

Brief Resume of the Presenters Indicating their Background in the Area the Tutorial Addresses (in alphabetical order)

Stefan Bruckner is professor in visualization at the Department of Informatics of the University of Bergen, Norway. He 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 was awarded the habilitation (venia docendi) in Practical Computer Science in 2012. From 2008 to 2013, he was an assistant professor at the Institute of Computer Graphics and Algorithms at VUT. His research interests include interactive visualization techniques for biomedical data, illustrative visualization, volume rendering, and visual data exploration. His research has received publication awards at several international events including VCBM 2014 (best paper and honorable mention), SCCG 2013 (best paper), EuroVis 2010 (best paper), and Eurographics 2007 (3rd best paper). He won the Karl-Heinz-Höhne Award for Medical Visualization in 2006 and received the 2011 Eurographics Young Researcher Award. He is a member of the IEEE Computer Society, ACM SIGGRAPH, and Eurographics.

Tobias Isenberg is senior research scientist (directeur de recherche) with the AVIZ project team at INRIA-Saclay, south of Paris in France. He received his Ph.D. degree from the University of Magdeburg, Germany. Previously he held positions as post-doctoral fellow at the University of Calgary, Canada, and as assistant professor at the University of Groningen, the Netherlands. His research interests comprise topics in scientific visualization, in illustrative and non-photorealistic rendering, and interactive visualization techniques. In particular, he is interested in how we can make use of touch-enabled displays to support intuitive and effective forms of interaction with scientific data. He is a member of the IEEE, ACM, ACM SIGGRAPH, and Eurographics.

Timo Ropinski is professor in Visual Computing at Ulm University, Germany, where he is heading the Visual Computing Group. Before moving to Ulm he was Professor in Interactive visualization at Linköping University, Sweden, where he was heading the Scientific Visualization group. He received his Ph.D. in 2004 from the University of Muenster, where he was also awarded the habilitation (venia legendi) in 2009. Ropinski's research is focused on volume rendering, biomedical visualization and interactive visual decision making. He headed the winning team of the IEEE Visualization contest 2010, and he has held tutorials at Eurographics, ACM SIGGRAPH and IEEE Visualization. Furthermore, he is a member of the IEEE Computer Society, ACM, and Eurographics.

Alexander Wiebel is professor of visual computing at Coburg University of Applied Sciences in Germany. He received his Dipl.-Inf. (MS in computer science) degree from the University of Kaiserslautern in 2004 and his Ph.D. degree from Universität Leipzig in 2008. For both degrees he performed research in the context of flow visualization. As a postdoctoral researcher at Max Planck Institute for Human Cognitive and Brain Sciences, and later at Zuse Institute Berlin (ZIB), he conducted research in interactive visualization of 3D MRI data with a focus on intuitive selection of structures in direct volume renderings. During this time, Alexander Wiebel lectured at Universität Leipzig and Freie Universität Berlin. His research received a nomination for the best paper award and an honorable mention at IEEE Visualization in 2007 and 2010 respectively.

Part 1: Visualization of volume data and the need of interaction Timo Ropinski

Abstract: Within this part, we lay the foundation for the rest of the tutorial. We review common classes of interaction tasks in volume visualization, whereby we delineate direct from indirect interaction paradigms. To bring previous work into a common context, we will analyze interaction techniques by considering them as the method for changing parameters of volume visualizations. We will discuss how different paradigms can be used to either modify spatial parameters or to alter global, non-spatial parameters. Based on these observations and classifications of general interaction tasks, we will describe interaction tasks in the context of volume visualization. We will show how these tasks can be considered from a semantic point of view or a technical point of view, e.g., selection vs. picking. From a technical perspective, we will derive and discuss the common basic demands these tasks have, and address challenges related to 2D and 3D interaction.

Relevant Literature:

1. M. Brehmer, T. Munzner. A Multi-Level Typology of Abstract Visualization Tasks. IEEE TVCG, 19(12):2376-2385, 2013. [http://www.cs.ubc.ca/labs/imager/tr/2013/MultiLevelTaskTypology/brehmer_infovis13.pdf]

2. B. Shneiderman. The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations. IEEE Symposium on Visual Languages, p. 336-343, Washington, 1996. [https://www.cs.umd.edu/~ben/papers/Shneiderman1996eyes.pdf]

3. K.T. Nguyen, A. Ynnerman, T. Ropinski. Analyzing and Reducing DTI Tracking Uncertainty by Combining Deterministic and Stochastic Approaches. International Symposium on Visual Computing, pages 266-279, 2013. [http://scivis.itn.liu.se/publications/2013/NYR13//NYR13.pdf]

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6. T. Ropinski, I. Viola, M. Biermann, H. Hauser, K. Hinrichs. Multimodal Visualization with Interactive Closeups. EGUK Theory and Practice of Computer Graphics, p. 17-24, 2009. [http://scivis.itn.liu.se/publications/2009/RVBHH09//tpcg09.pdf]

7. J. Mensmann, T. Ropinski, K. Hinrichs. Interactive Cutting Operations for Generating Anatomical Illustrations from Volumetric Data Sets. Journal of WSCG, 16(2): 89-96, 2008. [http://scivis.itn.liu.se/publications/2008/MRH08//wscg08-deformation.pdf]

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Part 2: Direct Manipulation Alexander Wiebel

Abstract: Interaction with and manipulation of volumetric renderings and volumetric data are naturally non-trivial tasks when carried out on common 2D displays with mouse and keyboard input. This part will concentrate on techniques which take the provided 2D input and translate it into direct 3D actions and manipulations regarding the volume. Input types we will discuss include points (picking), lines (sketching) or regions (marking). The semantics of the resulting 3D actions ranges from simple selec-

tion of positions, lines and surfaces in 3D, to segmentation, labeling, 3D painting, and adaption of the transfer function or the data themselves. We will give a detailed description of the possibly needed additional or meta data for each technique. An overview of common applications of the mentioned techniques for imaging and simulation data from medicine and natural sciences will demonstrate the utility of the techniques.

Relevant Literature:
1. A. Wiebel, F. M. Vos, D. Foerster, H.-C. Hege. WYSIWYP: What You See Is What You Pick. IEEE TVCG, 18(12):2236-2244, 2012. [http://forschung.awmw.org/PDF/wiebel_2012_SciVis.pdf]
2. S. Owada, F. Nielsen, T. Igarashi. Volume catcher. In Proceedings of the 2005 Symposium on interactive 3D graphics and games, I3D '05, p. 111–116, New York, USA, 2005. [http://dx.doi.org/10.1145/1053427.1053445]
3. L. Yu, K. Efstathiou, P. Isenberg, T. Isenberg. Efficient structure-aware selection techniques for 3D point cloud visualizations with 2DOF input. IEEE TVCG, 18(12):2245-2254, Dec. 2012. [http://tobias.isenberg.cc/VideosAndDemos/Yu2012ESA]
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9. See part 1 reference 4: "From imprecise user input …"

Part 3: Data Exploration on Novel Interaction Platforms Tobias Isenberg

Abstract: In addition to traditional PC-based interactive platforms for the exploration of volumetric data, several others exist that place emphasis on spatial perception, direct manipulation, or mobility. For example, stereoscopic environments such as CAVEs provide an excellent visual immersion which is essential for the exploration of 3D spatial data such as volumes. More recently, touch-based interaction became available on large displays which provides immersion through direct manipulation. This part of the tutorial will explore the interaction challenges when using these environments to explore volumetric data. In particular, we will highlight the benefits and challenges of indirect interaction in immersive environments, discuss the challenges of touch-based navigation, selection, and other interaction tasks when manipulating 3D data on 2D touch surfaces, and discuss combinations of touch interaction and immersive environments.

Relevant Literature:
1. S. Bryson. Virtual reality in scientific visualization. Communications of the ACM 39(5):62–71, 1996. [doi> 10.1145/229459.229467]
2. D. Coffey, N. Malbraaten, T. Le, I. Borazjani, F. Sotiropoulos, A. G. Erdman, D. F. Keefe. Interactive slice WIM: Navigating and interrogating volume datasets using a multi-surface, multi-touch VR interface. IEEE TVCG 18(10):1614–1626, 2012. [doi> 10.1109/TVCG.2011.283]
3. P. Isenberg, T. Isenberg. Visualization on interactive surfaces: A research overview. i-com 12(3):10–17, 2013. [doi> 10.1524/icom.2013.0020]
4. J. Jankowski, M. Hachet. A survey of interaction techniques for interactive 3D environments. In Eurographics State of the Art Reports. Eurographics Assoc., 2013, p. 65–93. [doi> 10.2312/conf/EG2013/stars/065-093]

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[doi> 10.1111/j.1467-8659.2012.03115.x]

7. D. Valkov, F. Steinicke, G. Bruder, K. Hinrichs. 2D touching of 3D stereoscopic objects. In Proc. CHI. New York: ACM, 2011, pp. 1353–1362. [doi> 10.1145/1978942.1979142]

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9. See part 2 reference 3: "Efficient structure-aware selection …"

Part 4: Guided Navigation and Exploration Stefan Bruckner

Abstract: In particular in the context of applications targeted at users with a limited technical back-ground, it can be beneficial to constrain the users' freedom and instead provide automated guidance and suggestions to simplify the interaction. This part of the tutorial will focus on guided navigation and exploration strategies which exploit additional information in order to fully or semi-automatically assist the user in specifying relevant visualization parameters. This includes common settings such as the viewpoint, clipping planes, transfer functions, but also extends to the choice of the visualization tech-nique itself. Such approaches frequently rely on additional knowledge and we will discuss different strategies for obtaining the required information. Finally, we will review approaches for integrating such guidance into existing workflows with a particular focus on medical and biological applications.

Relevant Literature:

1. P. Kohlmann, S. Bruckner, A. Kanitsar, M. E. Gröller. LiveSync: Deformed Viewing Spheres for Knowledge-Based Navigation. IEEE TVCG, 13(6): 1544–1551, 2007.
[http://www.ii.uib.no/vis/team/bruckner/publication/Kohlmann-2007-LDV]

2. See part 2 reference 8: "Contextual Picking …"

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7. See part 2 reference 7: "WYSIWYG …"