IEEE VIS 2016 Tutorial Proposal

Jun Tao, Hanqi Guo, Bei Wang, Christoph Garth, and Tino Weinkauf

TITLE

TBD

DURATION

The tutorial is half-day, including 200 miniutes presentation and discussion and 30 miniutes coffee break.

ORGANIZERS

Jun Tao	University of Notre Dame
Hanqi Guo	Argonne National Laboratory
Bei Wang	University of Utah
Christoph Garth	University of Kaiserslautern
Tino Weinkauf	KTH Stockholm

ABSTRACT

TBA

LEVEL

Intermediate/Advanced.

PREREQUISITE

A general understanding of flow fields and flow visualization, including basic concepts and techniques, such as different kinds of field lines, critical points, and particle tracing, etc.

AUDIENCE

The intended audience includes students, researchers and practitioners who are interested in the recent advances in flow visualization. More details to be added.

IMPORTANCE

TBA

SCHEDULE

Introduction	All	10 minutes
Talk1	TBD	30 minutes
Talk2	TBD	30 minutes
Talk3	TBD	30 minutes
Break	———	30 minutes
Talk4	TBD	30 minutes
Talk5	TBD	30 minutes
Discussion	All	10 minutes

DESCRIPTION

The description and outline of each topic are presented as the followings:

Spatio-temporal Flow Analysis
Tino Weinkauf

Abstract Understanding the processes in time-dependent flows is of crucial importance in many domains. Different methods exist for this purpose. This talk reviews methods that build on a spatio-temporal concept where the temporal dimension is treated on equal footing with the spatial dimensions. This means, an n-dimensional unsteady flow is analyzed as an (n+1)-dimensional steady flow. This has led to a number of powerful analysis and visualization methods in the last decade such as Feature Flow Fields [20], [18], Swirling Motion Cores [15], Streak Lines as Tangent Curves [16], [17], and more. The talk will cover the range from theoretical foundations to the applications on real data.

Feature Extraction, Feature Tracking and Feature Simplification with Robustness
Bei Wang

Abstract This talk will review topological approaches for flow visualization. In particular, we will discuss a recent line of research that spans feature extraction, feature tracking, and feature simplification of vector fields based upon the topological notion of robustness that captures structural stability of the data. Robustness, a concept similar to persistent homology, quantifies the stability of critical points with respect to the minimum amount of perturbation in the fields required to remove them. We will discuss how this line of work can potentially increase the interpretability of data, specifically, by giving a coherent and multi-scale view of the flow dynamics under both stationary and time-varying settings. We will demonstrate how robustness-based approaches are independent of the topological skeleton and are scalable to large-scale datasets.

Expressive Flow Field Exploration
Jun Tao

Abstract A major task of visualizing steady flow fields is to allow users perceive the flow patterns and locate features of interest. Traditional flow visualization approaches, such as *seed placement* and *streamline selection*, generate an appropriate set of streamlines to describe steady flow fields. However, only limited capabilities are provided to meet specific needs from different users, especially at the streamline segment level. In this talk, I will start from a unified framework that automatically selects best streamlines to display and selects best viewpoint to observe them simultaneously. Then, three interactive techniques will be presented to demonstrate the benefit of interactive exploration, including a graph-based technique to capture the relations among streamlines and spatial regions, a deformation framework to achieve focus+context visualization, and a vocabulary approach to query flow patterns in a textual manner.

Contribution This part of the tutorial focuses on the exploration of steady flow fields. Through the presented techniques, two trends of flow visualization are shown. First, user interactions are highly involved. This allows users to specify, identify and observe their interested patterns/features in a more desired way. Second, features are captured at both coarser and finer levels. Unlike most of the early works that treat each streamline as an entity, more local features residing on segments of streamlines can be compared, matched and discovered as well.

TUTORIAL NOTES

The tutorial notes will consist of the description of the tutorial, copies of the slides for each talk, and an extensive bibliography including

- *Jun Tao is with University of Notre Dame. E-mail: jtao1@nd.edu.*
- *Hanqi Guo is with Argonne National Laboratory. Email: hguo@anl.gov.*
- *Bei Wang is with University of Utah. Email: beiwang@sci.utah.edu.*
- *Christoph Garth is with University of Kaiserslautern. Email: garth@cs.uni-kl.de.*
- *Tino Weinkauf is with KTH Stockholm. Email: weinkauf@kth.se.*

specific references used in the tutorial as well as a general selection of relevant references.

SPEAKERS

The background of each speaker is listed in alphabetical order.

Hanqi Guo
Argonne National Laboratory

Hanqi Guo is a Postdoctral Appointee in the Mathematics and Computer Science Division, Argonne National Laboratory. He received his PhD degree in computer science from Peking University in 2014, and the BS degree in mathematics and applied mathematics from Beijing University of Posts and Telecommunications in 2009. His research interests are mainly on uncertainty visualization, flow visualization, and large-scale scientific data visualization.

RELEVANT PUBLICATIONS

[1] H. Guo, W. He, T. Peterka, H.-W. Shen, S. M. Collis, and J. J. Helmus, "Finite-time lyapunov exponents and lagrangian coherent structures in uncertain unsteady flows," *IEEE Transactions on Visualization and Computer Graphics*, 2016, to appear.

[2] R. Liu, H. Guo, J. Zhang, and X. Yuan, "Comparative visualization of vector field ensembles based on longest common subsequence," to appear, 2016.

[3] H. Guo, J. Zhang, R. Liu, L. Liu, X. Yuan, J. Huang, X. Meng, and J. Pan, "Advection-based sparse data management for visualizing unsteady flow," *IEEE Transactions on Visualization and Computer Graphics*, vol. 20, no. 12, pp. 2555–2564, 2014.

[4] H. Guo, X. Yuan, J. Huang, and X. Zhu, "Coupled ensemble flow line advection and analysis," *IEEE Transactions on Visualization and Computer Graphics*, vol. 19, no. 12, pp. 2733–2742, 2013.

Jun Tao
University of Notre Dame

Jun Tao is currently a postdoctoral researcher at University of Notre Dame. He received a PhD degree in computer science from Michigan Technological University in 2015. His major research interest is scientific visualization, especially on applying information theory, optimization techniques, and topological analysis to flow visualization and multivariate data exploration. He is also interested in graph-based visualization, image collection visualization, and software visualization. He received the Deans Award for Outstanding Scholarship and the Finishing Fellowship at Michigan Technological University in 2015, and a Best Paper Award at IS&T/SPIE VDA 2013.

RELEVANT PUBLICATIONS

[5] J. Tao, C. Wang, and C.-K. Shene, "FlowString: Partial streamline matching using shape invariant similarity measure for exploratory flow visualization," in *Proceedings of IEEE Pacific Visualization Symposium*, 2014, pp. 9–16.

[6] J. Tao, C. Wang, C.-K. Shene, and S. H. Kim, "A deformation framework for focus+context flow visualization," *IEEE Transactions on Visualization and Computer Graphics*, vol. 20, no. 1, pp. 42–55, 2014.

[7] J. Tao, J. Ma, C. Wang, and C.-K. Shene, "A unified approach to streamline selection and viewpoint selection for 3D flow visualization," *IEEE Transactions on Visualization and Computer Graphics*, vol. 19, no. 3, pp. 393–406, 2013.

[8] J. Tao, C. Wang, C.-K. Shene, and R. A. Shaw, "A vocabulary approach to partial streamline matching and exploratory flow visualization," *IEEE Transactions on Visualization and Computer Graphics*, vol. 22, no. 5, pp. 1503–1516, 2016.

[9] M. Wang, J. Tao, J. Ma, Y. Shen, and C. Wang, "FlowVisual: A visualization app for teaching and understanding 3d flow field concepts," in *Proceedings of IS&T Conference on Visualization and Data Analysis*, San Francisco, CA, 2016.

Bei Wang
University of Utah

Bei Wang is an assistant professor at the School of Computing and the Scientific Computing and Imaging Institute, University of Utah. Her main research interests lie in the theoretical, algorithmic, and application aspects of data analysis and data visualization, with a focus on topological techniques. She is also interested in computational biology and bioinformatics, machine learning and data mining. She is a member of ACM and IEEE.

RELEVANT PUBLICATIONS

[10] P. Skraba, P. Rosen, B. Wang, G. Chen, H. Bhatia, and V. Pascucci, "Critical point cancellation in 3d vector fields: Robustness and discussion," *IEEE Transactions on Visualization and Computer Graphics*, 2016, PacificVis Best Paper, to appear.

[11] P. Skraba, B. Wang, G. Chen, and P. Rosen, "Robustness-based simplification of 2d steady and unsteady vector fields," *IEEE Transactions on Visualization and Computer Graphics*, vol. 21, no. 8, pp. 930–944, 2015.

[12] P. Skraba and B. Wang, "Interpreting feature tracking through the lens of robustness," in *Topological Methods in Data Analysis and Visualization III*, 2014, pp. 19–37.

[13] P. Skraba, B. Wang, G. Chen, and P. Rosen, "2D vector field simplification based on robustness," in *Proceedings of IEEE Pacific Visualization Symposium*, Best Paper, 2014, pp. 49–56.

[14] B. Wang, P. Rosen, P. Skraba, H. Bhatia, and V. Pascucci, "Visualizing robustness of critical points for 2d time-varying vector fields," in *Computer Graphics Forum*, vol. 32, 2013, pp. 221–230.

Tino Weinkauf
KTH Stockholm

Tino Weinkauf received his diploma in computer science from the University of Rostock in 2000. From 2001, he worked on feature-based flow visualization and topological data analysis at Zuse Institute Berlin. He received his Ph.D. in computer science from the University of Magdeburg in 2008. In 2009 and 2010, he worked as a postdoc and adjunct assistant professor at the Courant Institute of Mathematical Sciences at New York University. He started his own group in 2011 on Feature-Based Data Analysis in the Max Planck Center for Visual Computing and Communication, Saarbrcken. Since 2015, he holds the Chair of Visualization at KTH Stockholm. His current research interests focus on flow analysis, discrete topological methods, and information visualization.

RELEVANT PUBLICATIONS

[15] T. Weinkauf, J. Sahner, H. Theisel, and H.-C. Hege, "Cores of swirling particle motion in unsteady flows," *IEEE Transactions on Visualization and Computer Graphics*, vol. 13, no. 6, pp. 1759–1766, Nov. 2007.

[16] T. Weinkauf, H.-C. Hege, and H. Theisel, "Advected tangent curves: A general scheme for characteristic curves of flow fields," *Computer Graphics Forum*, vol. 31, no. 2, pp. 825–834, May 2012.

[17] T. Weinkauf and H. Theisel, "Streak lines as tangent curves of a derived vector field," *IEEE Transactions on Visualization and Computer Graphics*, vol. 16, no. 6, pp. 1225–1234, Nov. 2010, Received the Vis 2010 Best Paper Award.

[18] T. Weinkauf, H. Theisel, A. Van Gelder, and A. Pang, “Stable Feature Flow Fields,” *IEEE Transactions on Visualization and Computer Graphics*, vol. 17, no. 6, pp. 770–780, Jun. 2011.

[19] T. Stter, T. Weinkauf, H.-P. Seidel, and H. Theisel, “Implicit integral surfaces,” in *Proceedings of International Workshop on Vision, Modeling and Visualization*, Magdeburg, Germany, Nov. 2012, pp. 127–134.

OTHER REFERENCES

[20] H. Theisel and H.-P. Seidel, “Feature flow fields,” in *Data Visualization*, 2003, pp. 141–148.