

Preface

Message from the Paper Chairs and Guest Editors

These are the proceedings of IEEE VIS 2015, held during October 25-30, 2015. This year, VIS celebrates its 26th year and is held in Chicago, Illinois. The conference venue, the Palmer House Hilton, is a historic hotel located in the heart of downtown Chicago, the third largest city in the United States and home to world-class architecture, museums, parks, and restaurants.

VIS consists of three conferences, held concurrently: the IEEE Visual Analytics Science and Technology Conference (VAST 2015), the IEEE Information Visualization Conference (InfoVis 2015), and the IEEE Scientific Visualization Conference (SciVis 2015).

Visualization continues to develop rapidly as a research discipline and the three conferences are maintaining their positions as the leading annual events for researchers and practitioners to share the most innovative and impactful results of an increasingly diverse and influential community.

REVIEW PROCESS

The three conferences continued to benefit from a common review process. This kicked off at the end of 2014 with the selection of a program committee of experts from academia, government and industry for each meeting. A general call for review volunteers was then issued. We asked all reviewers to identify their areas of expertise and read and agree with our ethics guidelines. These ensure that ideas are protected; reviews are detailed, specific, helpful and tactful; and that conflicts of interest are avoided: http://vgtc.org/about_us/conferences/ethics-guidelines.

Submitted papers were assigned to members of the conference program committees by the conference papers chairs who put great effort into matching paper topics to the areas of expertise of committee members. Committee members were then invited to express preferences for the submitted papers based on an initial reading of the abstracts prior to paper submission to facilitate this matching process. Careful effort was made at all levels of reviewing to identify potential conflicts of interest and to quarantine them from decision-making.

Reviewing itself was undertaken through a two-stage procedure. In the first review cycle, each paper was reviewed by at least four reviewers. Two international program committee members acted as the primary and secondary reviewers. Each primary and secondary reviewer appointed an external (tertiary) reviewer in addition to preparing a review themselves. In order to adhere to the TVCG standards, authors had the option of submitting their manuscript anonymously for a double-blind review. In such cases, the names and affiliations of authors were known only to the primary and secondary reviewers. After all reviews had been completed and individual recommendation scores had been made, the primary reviewer led a short discussion

phase among all reviewers and was responsible for writing a summary review and making a recommendation based upon the consensus.

As papers chairs, we facilitated this process; evaluated the reviews, the discussion between all reviewers, and any confidential comments made; and considered the recommendation of the primary and secondary reviewers in conjunction with the scores and the self-specified expertise levels of the reviewers. This collection of 1919 reviews and summary reviews—IEEE VAST (655), IEEE InfoVis (725) and IEEE SciVis (539)—enabled us to collectively finalize the decisions of the first review cycle. Decisions were based on the detailed reviewers' comments and recommendations, rather than on numerical scores alone. To inform conditional acceptance decisions, we consulted primary reviewers as needed in cases in which consensus was not achieved or in which the recommendation was uncertain or borderline.

Conditionally accepted papers then underwent a second review cycle, in which authors were given a list of improvements to make—including conditional changes and suggestions to improve the paper. Authors were also required to provide a cover letter describing how they addressed the reviewers' comments and on the changes that they decided to incorporate. In the second review cycle, the primary reviewer judged whether the authors satisfactorily addressed the issues raised by the reviewers in the first review cycle, and provided a corresponding final recommendation. Authors were able to clarify aspects through anonymous email with the primary reviewer or the papers chairs.

Numerous individuals have contributed their generous time and energy to making the IEEE VIS 2015 and this special issue a success. We would like to thank the authors of all submitted papers, the 167 members of the IEEE VAST (54), IEEE InfoVis (60) and IEEE SciVis (53) Program Committees, and all the other reviewers for their many hours of hard work.

IEEE VAST 2015

The IEEE Visual Analytics Science and Technology (VAST) Conference is now in its tenth year, and its sixth year as an IEEE Conference. It remains the primary venue for the rapidly growing field of visual analytics. Visual analytics is the science of analytical reasoning supported by highly interactive visual interfaces, and seeks to integrate computational analytics with human cognitive processes. Visual analytics requires interdisciplinary science, going beyond traditional visualization to include statistics, mathematics, knowledge representation, management and discovery technologies, cognitive and perceptual sciences, decision sciences, and more.

IEEE VAST 2015 offers an exciting papers program. Its featured themes include managing visual analytics process;

complementing visual and algorithmic analysis; platforms of visual analytics; uncertainty, correlation, and causality; visual analytics of temporal network data, movement and transport data, social media data, and textual data; and visual analytics in medicine and healthcare, and in design and development. Following the same format in the previous year, IEEE VAST 2015 presents accepted papers in two categories.

(a) *TVCG-Track*. Papers that exhibit the highest quality in terms of originality, rigor and significance will appear in a special issue of the IEEE *Transactions on Visualization and Computer Graphics (TVCG)*, together with the papers from the IEEE Information Visualization and Scientific Visualization Conferences. IEEE VAST 2015 received 149 paper submissions. Following the initial processing by co-chairs, 148 papers entered the review process. After two review cycles, 33 papers were finally accepted into the *TVCG* track, for an acceptance rate of 22%.

(b) *Conference-only Track*. In order to increase the exposure of visual analytics applications, and participation of interdisciplinary researchers, this additional track features innovative advances and applications in visual analytics that may have focuses beyond the scope of *TVCG*. 14 papers were finally accepted into the *Conference-only* track.

Papers in both tracks will be presented in the conference, be included in the IEEE VAST USB, and appear in the IEEE Digital Library.

The VAST 2015 best paper was chosen by a best paper award committee consisting of David S. Ebert, Silvia Miksch, and William Ribarsky. The best paper committee carefully considered the top 6 papers and their reviews. We congratulate Stef van den Elzen, Danny Holten, Jorik Blaas, and Jarke J. van Wijk for their paper “Reducing Snapshots to Points: A Visual Analytics Approach to Dynamic Network Exploration”. As the award committee acknowledged, “this paper provides a strong foundation for analysis of dynamic networks that is both elegant and novel”. The committee also selected two honorable mentions, noted in the table of contents of this special issue.

IEEE INFOVIS 2015

Information visualization involves the design of visual data representations and interaction techniques that support human activities, where the spatial layout of the visual representation is chosen by the designer. IEEE InfoVis 2015 is the 21st annual IEEE InfoVis meeting and our ninth year as the IEEE Information Visualization Conference, a venue that remains the primary meeting in the field of information visualization. Core research issues in the field include the design of perceptually and cognitively effective visual encodings for a variety of data types, novel interaction techniques for creating and manipulating visualizations, and application development and evaluation to advance realworld data visualization efforts.

InfoVis updates its international program committee each year, with a maximum of 3 years of consecutive service. Due to a recent growth in submissions, this year we

increased the committee size to 60 members (up from 53 in 2014). Of these, 29 people returned from last year, we welcomed back 18 members who had served some time before, and added 13 new members—established researchers who wrote strong reviews in prior years.

This year’s IEEE InfoVis Conference received 178 submissions. Of these, we ultimately accepted 38, following two rounds of review and revision. The overall acceptance rate was 21.3%, slightly lower than the 23.0% in 2014.

Regarding specific paper categories, we received 64 technique / algorithm papers (36.0% of all submissions, 14 accepted), 51 application / design study papers (28.7%, 9 accepted), 36 evaluation papers (20.2%, 6 accepted), 18 theory papers (10.1%, 7 accepted) and 9 systems papers (5.1%, 2 accepted). Compared to 2014, this year saw a substantial increase in the number of design study papers submitted.

Longstanding topics of interest in this year’s proceedings include human perception, experimental evaluation, and novel techniques for multidimensional data and set-typed data. Compared to previous years, this year there is less emphasis on geographic data, text, trees, and networks, but we see increased research attention paid to human reasoning, temporal data, and interactive systems. We also see increased attention to design methodologies and applications covering various domains such as bioinformatics, poetry, weather forecasting, traffic analysis, and personal visualization. The papers as a whole constitute a healthy balance between novel techniques and applications showing the potential and value of InfoVis, and empirical and theoretical work seeking to strengthen the foundations of the field.

Five of the finally accepted papers were nominated for the best paper award by the IEEE InfoVis Papers Chairs. These were among the highest rated papers as determined by the reviewers and were considered to have made a significant contribution to the discipline of Information Visualization. Note that IEEE VIS policy specifies that InfoVis Papers Chairs are not eligible to receive a Best Paper Award or be given Honorable Mention.

The Best Paper Committee consists of three members chosen by the IEEE InfoVis Papers Chairs, in consultation with the IEEE InfoVis Steering Committee to ensure expertise whilst avoiding any conflicts of interest. This year Chris Weaver chaired the committee. Frank van Ham and Stephen North participated as members. The committee read reviews and final versions of papers on the shortlist. They each ranked all the papers and met as a group to discuss and reach a consensus, selecting the Best Paper and the sole Honorable Mention. For the Best Paper award, the committee selected “HOLA: Humanlike Orthogonal Network Layout” by Steve Kieffer, Tim Dwyer, Kim Marriott, and Michael Wybrow. They reported that this paper develops and applies an impressively effective human-centered approach to graph visualization, building on existing knowledge of more mechanical optimization approaches to realize the style and quality of handmade designs. Careful

human factors research, combined with clever synthesis of graph drawing algorithms, implementation, and evaluation, make this paper a well rounded information visualization paper. The committee believe it points the wayforward for the design of appealing and readable layouts in graphs and beyond, and has the potential for very broad impact.

The committee also selected one paper for Honorable Mention: “Beyond Weber’s Law: A Second Look at Ranking Visualizations of Correlation” by Matthew Kay and Jeffrey Heer. This paper meticulously analyzes known experimental data with modern analysis tools, revisiting and extending prior work. They believe that it provides a great example of how the scientific method can be applied to help build a rigorous foundation to information visualization and perception research. From this perspective, the paper’s tight focus and confirmatory results are assets. The extraordinary quality of exposition in text and figures deserves a special mention.

We congratulate all of the authors for this excellent work and thank the Best Paper Committee for their diligence.

IEEE SciVis 2015

Scientific visualization continues to be a strong focus of the IEEE Visualization conference series since its inception 25 years ago. The goal of the SciVis conference is to promote fundamental research and development of techniques, systems, and interaction methods for analyzing data from a wide range of scientific and application domains. In addition to its core that focuses on scalar, vector, and tensor data visualization and analysis using topological, geometric, and statistical methods, the conference also covers emerging areas such as visual computing and applications, machine learning, data analytics, data sciences, interaction techniques, or display technologies and devices, that broaden the foundation of scientific visualization. From its outset, IEEE SciVis has always given great emphasis to applications of scientific visualization. This year, the conference particularly welcomed papers that make advances towards understanding or solving real world problems, or that impact a particular application in a significant way. Also new this year, IEEE SciVis 2015 presents an expanded set of accepted papers in two categories.

(a) *TVCG* Track. Papers that exhibit the highest quality in terms of originality, rigor and significance are included in this special issue of the *IEEE Transactions on Visualization and Computer Graphics (TVCG)*, together with the papers from the IEEE Information Visualization and IEEE VAST Conferences.

(b) Conference-only Track. Innovative SciVis submissions with a focus beyond the scope of the IEEE *TVCG* journal.

Papers in both tracks will be presented at the conference, be included in the IEEE VIS USB, and appear in the IEEE Digital Library.

The IEEE SciVis 2015 papers program accepted 33 papers to the *TVCG* track and 9 to the conference track,

describing state-of-the-art tools, techniques and technology in the field of scientific visualization. They were selected from 134 submissions by an international program committee of 53 members and numerous external reviewers after two review cycles. The acceptance rate for the *TVCG* track is 24.6% and the overall acceptance rate for both the *TVCG* track and conference track is 31.3%.

The available paper categories (Algorithm/Technique, System, Application/Design Study, Evaluation, Theory/Model) are used with different intensity by our community. Technique papers (with 83 of the submissions) form the majority, followed by design study papers (with 37 of the submissions). System papers (with 6 of the submissions), evaluation papers (with 4 of the submissions), and model papers (with 4 of the submissions) are a smaller, but highly relevant, subset of the submissions. The program contains a blend of emerging and traditional topics including scalar field analysis, topology, volume rendering, flow visualization, visual integration and design, perception and evaluation, or comparative and sketch-based visualization. Applications included climate modeling and weather forecasting, biomedical imaging, eye tracking, brain connectomics, cell migration, species distribution, polymer structures, superconductors, nanomaterials, urban mobility, and multi-projector displays.

The best paper for SciVis 2015 was chosen by a best paper award committee consisting of Amitabh Varshney (chair), Valerio Pascucci, and Anders Ynnerman, who reviewed the top six papers and their peer reviews. We congratulate David Schroeder and Daniel F. Keefe with their best paper, “Visualization-by-Sketching: An Artist’s Interface for Creating Multivariate Time-Varying Data Visualizations”. The motivation for the award is: “To take the next leap forward in realizing the extraordinary potential of scientific visualization, we need to empower all to create insightful visualizations. This paper shows how visual design of interfaces and interaction methods can be used to enable non-experts to design visually engaging, easy-to-understand, and accurate visualizations.” The committee also selected one honorable mention for the paper “Rotation Invariant Vortices for Flow Visualization” by Tobias Günther, Maik Schulze, and Holger Theisel, with the motivation: “Vortices are one of the most important features in flow visualization. This paper tackles the challenge of formulation and visualization of rotationally invariant measures of vortices that arise in several real-world applications of rotating flow fields such as those induced by helicopters and ventilators.”

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We warmly thank the IEEE VIS General Chairs, Michael E. Papka and Maxine Brown, and Coordinating Chair, Laura Wolf, for their leadership and coordination. We especially appreciate the valuable advice and guidance from Tamara Munzner as Chair of VIS Executive Committee. We thank the Program Chair, Gautam Chaudhary, for his considerable help in coordinating activities; the VIS publication and project coordinator, Meghan Haley, both for her guid-

ance throughout the year and for bringing the publication together so effectively once again; and James Stewart, Precision Conference Solutions, for the smooth running of the PCS system, and for his prompt and effective support to many queries from us.

The IEEE VIS 2015 conference also features tutorials, workshops, panels, posters, exhibits, the SciVis contest, the VAST challenge, the practitioner experiences track, the doctoral colloquium, the art program, industry outreach activity, Compass activities, meetups, and fast forward sessions among other activities and events held throughout the week. There are also three co-located events: Large Data Analysis and Visualization (LDAV) symposium, Visualization for Cyber Security (VizSec) symposium, and Visualization in Data Science (VDS) symposium. None of these would exist were it not for the time and effort spent by our community members. We appreciate the support from all colleagues involved in organizing VIS 2015. We also take this opportunity to thank Klaus Mueller as Chair of the IEEE Visualization and Graphics Technical Committee (VGTC) during 2012-2015. The organisers of VAST, InfoVis and SciVis are looking forward to working with Claudio T. Silva as the incoming VGTC chair in the coming years.

We especially acknowledge the support of Leila De Floriani as Editor-in-Chief of *TVCG*, and the coordination by Charles Hansen for the presentation of *TVCG* papers in VIS 2015. We thank the IEEE CS Production team, Erin Espriu, Meera Patel, Kimberly Sperka, Joyce Arnold, and Alison Larkin, for their time and much effort in helping produce these proceedings.

PAPER CHAIRS AND GUEST EDITORS

JAMES AHRENS

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Dr. James Ahrens graduated in 1996 with a Ph.D. in computer science from the University of Washington. Following his graduate studies, he joined Los Alamos National Laboratory. He is the founder and design lead of ParaView, a widely-adopted visualization and data analysis package for large-scale scientific simulation data. At Los Alamos, he is the leader of a data analysis and visualization team as well as a national leader of U.S. Department of Energy programmatic initiatives.



GENNADY ANDRIENKO

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Gennady Andrienko is a lead scientist responsible for the visual analytics research at Fraunhofer IAIS and professor (part time) at City University London, UK.

He co-authored monographs “Exploratory Analysis of Spatial and Temporal Data” (Springer, 2006) and “Visual Analytics of Movement” (Springer, 2013) and more than 60 peer-reviewed journal papers. Gennady Andrienko is associate editor of three journals, Information Visualization, IEEE Transactions on Visualization and Computer Graphics, and International Journal of Cartography. Gennady Andrienko received best paper awards at AGILE 2006 and IEEE VAST 2011 and 2012 conferences, honorable mention award at IEEE VAST 2010, VAST challenge awards 2008 and 2014, and best poster award at AGILE 2007 conferences.



MIN CHEN

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Min Chen is currently the professor of scientific visualization at University of Oxford and a fellow of Pembroke College. His research interests include visualization and visual analytics, computer graphics, human-computer interaction and aspects of computer vision. He has co-authored over 150 publications. His services include papers co-chair of IEEE Visualization 2007 and 2008, Eurographics 2011, IEEE VAST 2014; co-chair of Volume Graphics 1999 and 2006, EuroVis 2014; associate editor-in-chief of IEEE *TVCG*; and co-director of Wales Research Institute of Visual Computing. He is a fellow of British Computer Society, European Computer Graphics Association, and Learned Society of Wales.



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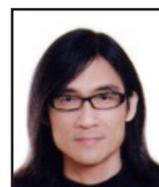
Bongshin Lee is a researcher at Microsoft Research. Her research interests include Information Visualization, Visual Analytics, Human-Computer Interaction, and User Interfaces & Interaction Techniques. Her research focuses on the design, development, and evaluation of interactive technologies for people to create visualizations, interact with their data, and visually share data-driven stories, leveraging Natural User Interfaces (NUIs) including pen and touch.



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Jos Roerdink is currently professor of scientific visualization and computer graphics at the University of Groningen, where he also serves as director of the Johann Bernoulli Institute for Mathematics and Computer Science. His research interests include biomedical visualization, neuroimaging, and mathematical morphology. He was on the editorial boards of *Pattern Recognition* and the *Journal of Mathematical Imaging and Vision*. His services include papers cochair of IEEE BioVis 2011 and 2012, cochair of VCBM 2012, and general cochair of BioVis 2013 and 2014. He will be general chair of EuroVis 2016, the EG / VGTC Conference on Visualization, Groningen.



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Melanie Tory is a Research Scientist at Tableau Software. Her research spans visualization, human-computer interaction, and computer-supported cooperative work. She is particularly interested in interfaces to support collaborative data analysis, sensemaking, and intuitive data exploration. Melanie is also an associate editor for IEEE *Computer Graphics and Applications*. Formerly, she was an Associate Professor of Computer Science at the University of Victoria.



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Huamin Qu is a professor in the Department of Computer Science and Engineering at the Hong Kong University of Science and Technology. His main research interests are in visualization and computer graphics, with focuses on urban informatics, social network analysis, e-learning, and text visualization. He is an associate editor of IEEE *TVCG*.

