UltraVis

SciDAC Institute for Ultrascale Visualization

Final Report
Institute for Ultrascale Visualization

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Abstract

The SciDAC Institute for Ultrascale Visualization brought together leading experts from visualization, high-performance computing, and science application areas to make advanced visualization solutions for SciDAC scientists and the broader community. Over the five-year project, the Institute introduced many new enabling visualization techniques, which have significantly enhanced scientists' ability to validate their simulations, interpret their data, and communicate with others about their work and findings. This Institute project involved a large number of junior and student researchers, who received the opportunities to work on some of the most challenging science applications and gain access to the most powerful high-performance computing facilities in the world. They were readily trained and prepared for facing the greater challenges presented by extreme-scale computing. The Institute's outreach efforts, through publications, workshops and tutorials, successfully disseminated the new knowledge and technologies to the SciDAC and the broader scientific communities. The scientific findings and experience of the Institute team helped plan the SciDAC3 program.
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Table of Contents

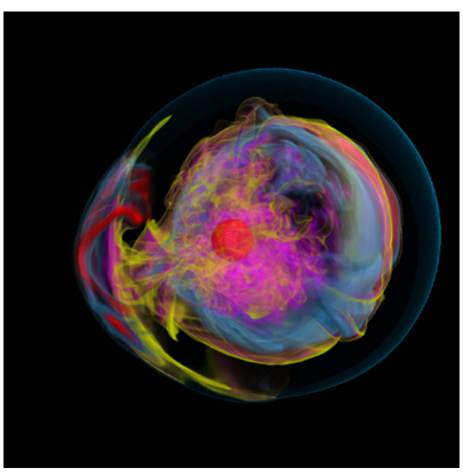
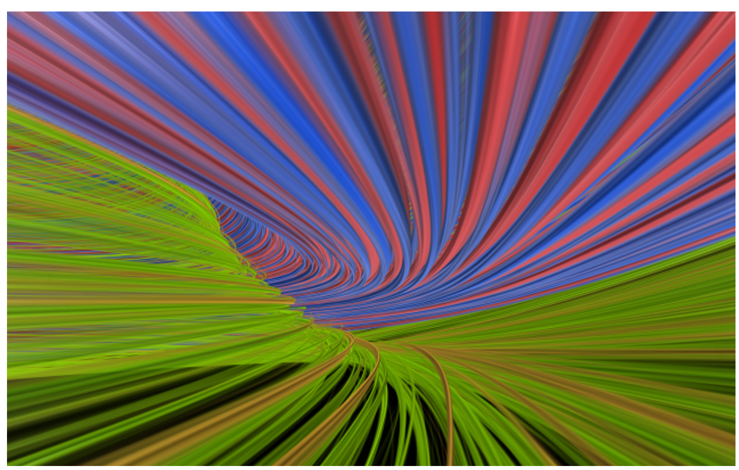
Executive Summary

Understanding the science behind extreme-scale simulations and high-throughput experiments requires extracting meaning from data sets of hundreds of terabytes or more. Visualization is the most plausible path to understanding data at this scale, but current visualization approaches were not designed with this scale in mind. This technology must be readily accessible by application scientists, portable to the wide variety of high performance computing (HPC) systems in use, and scalable to allow for timely generation of results. Fundamental advances in a variety of areas related to scientific visualization are necessary in order to effectively analyze data sets of this size.

The Institute for Ultrascale Visualization (UltraVis), a five-year research and outreach effort funded by the U.S. Department of Energy (DOE) SciDAC program, took the mission to advance and promote visualization technologies to enable knowledge discovery at peta- and exascale. The Institute involved investigators from both universities and DOE laboratories. The PIs targeted several major data analysis and visualization challenges facing SciDAC scientists, including architectures for parallel visualization, fundamental algorithms in areas such as vector field and in situ visualization, and novel techniques through which scientists might better explore the results of their labor. Through internal collaborations, the PIs in the Institute were able to tackle these complex challenges much more effectively than they could on their own, and through the Institute they were better able to interact with the SciDAC community.

Working together with other SciDAC Institutes, CETs, and application projects, the Institute made substantial research accomplishments. Likewise, through outreach activities the UltraVis Institute provided leadership in research community efforts focusing on extreme-scale visualization. These activities included hosting specialized workshops and panels at leading conferences to stimulate widespread participation.

This report mainly highlights the research accomplishments, collaborations, and outreach activities of the Institute from September 2006 to December 2011. Notably, several of the Institute projects led to visualization solutions and tools that enable SciDAC scientists to better validate their simulations, to uncover previously unseen patterns and relationships in their data, and to see their data in new inspiring ways. Institute members were able to identify critical gaps in current visualization technologies and tackle some of the most pressing issues. The Institute produced over 200 technical papers and played a major role in key activities in the fields of visualization and high-performance computing. These successes, both in research and in collaboration, set a sound foundation for SciDAC3 and the following development of extreme-scale scientific visualization technologies.

Visualization of data from a supernova simulation (Left) and a fusion simulation (Right)

Major Accomplishments

The accomplishments of the Institute for Ultrascale Visualization are best seen in three primary areas:

1. Research innovations and enabling technologies
2. Training new leaders and next generation visualization researchers
3. Outreach

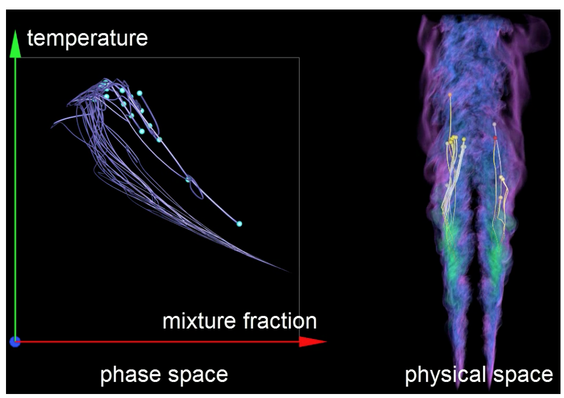
This report highlights the most important accomplishments.

1. Research Innovation and Enabling Technologies

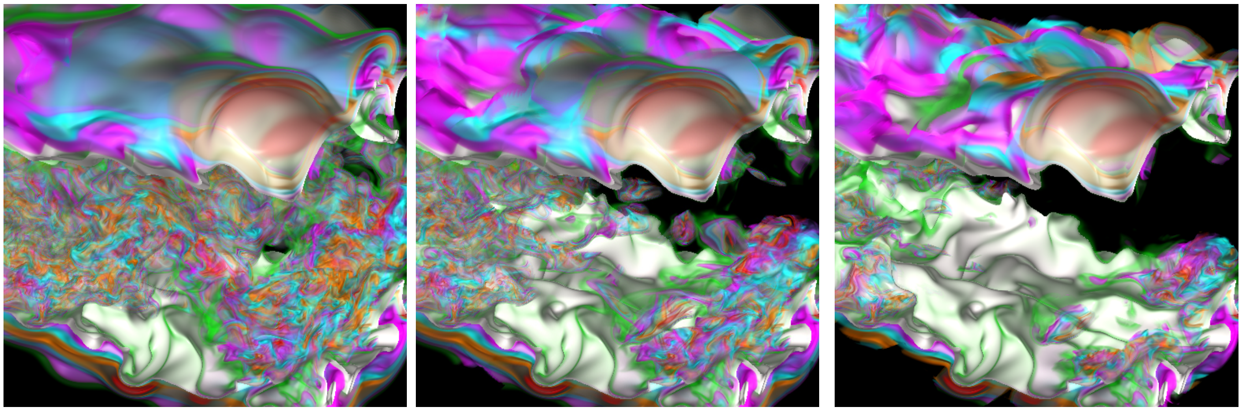
In Situ Visualization. The most significant accomplishment of this Institute project, under the leadership of Professor Kwan-Liu Ma, is the development, demonstration, and promotion of in situ data visualization and analysis methods [38,41,52,58,59,70,94,173]. By the end of this Institute project, researchers in both the scientific simulation and visualization communities were convinced that the in situ approach is the most promising solution for extreme-scale scientific data visualization, analysis, and discovery. Consequently, in the following SciDAC3 program, the development and deployment of in situ data reduction, visualization, and analysis technologies become the primary effort in order to timely address the upcoming exascale challenges.

New visualization technologies and Enabling Visualization. As a result of close collaborations between application scientists and visualization researchers, many new concepts and techniques were introduced and evaluated over the course of this project. While these research efforts led to a large number of publications, more importantly some of the research results either spurred new research areas or were converted into usable software tools. For example, in situ visualization is one that has drawn new attention leading to a dozen new publications produced by researchers outside the Institute team. The Visualization by Proxy (aka. Exploration Image) design is a particularly promising one, which makes in situ visualization much more appealing to simulation scientists.

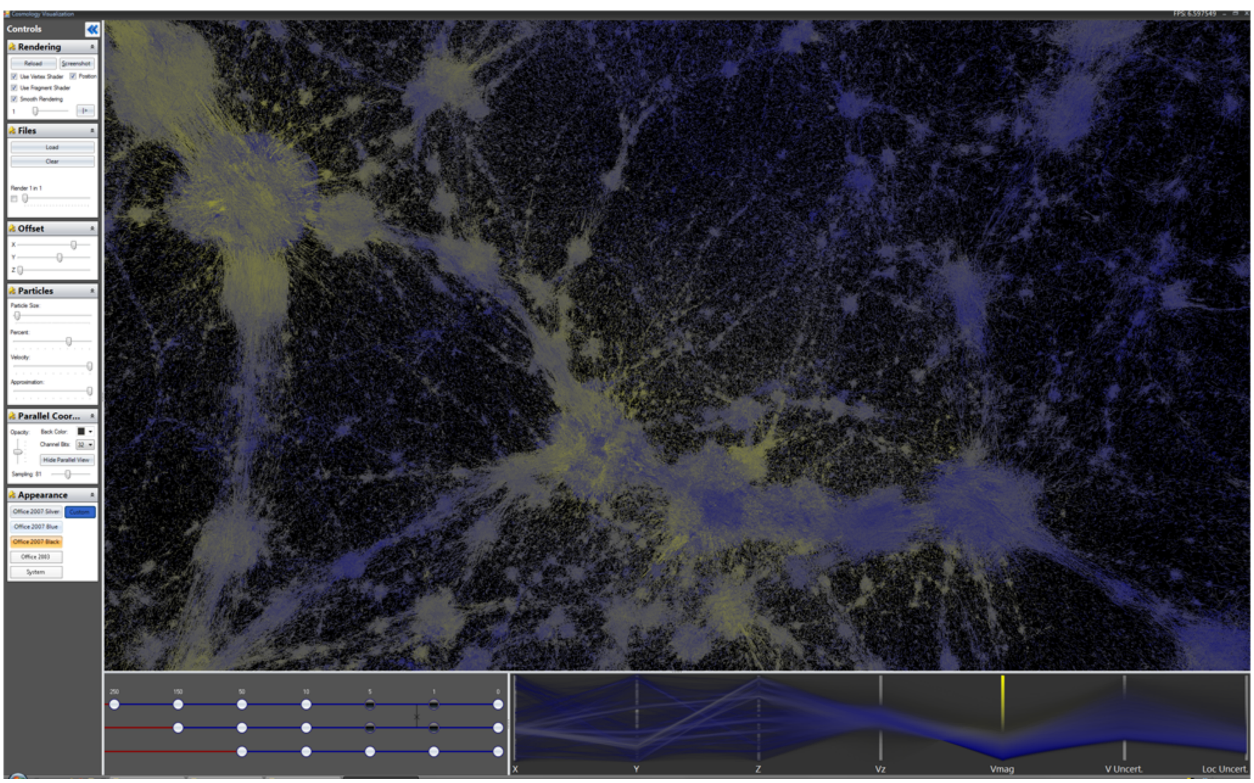
The Institute team has also introduced many new visualization techniques for studying time-varying 3D flow data including scalar fields, vector fields, and particles. Several of these techniques have been incorporated into open-source or commercial visualization toolkits such as Paraview, VisIt, and FieldView, which have been routinely used by many simulation scientists. They allow the scientists to see their data in new ways and with greater clarity, facilitating correct interpretation and effective communication. Consequently, these new visualization capabilities enable scientists to more easily and thoroughly validate their simulation, more effectively communicate their work and findings with others, and possibly discover previous unknowns. The first example is a dual space visualization technique allowing scientists to study joint particle/field data in both phase space and physical space of the data. The visual correspondences established help scientists to better understand the complex, dynamic behaviors of the model turbulent flow. The image on the right shows such dual-space visualization.



The second example is a visualization technique based on distance field applied to petascale combustion simulations. It can not only substantially reduce the data but also allow the scientists to zoom in and see for the first time the interaction of small turbulent eddies with the preheat layer of a turbulent flame, a region that was previously obscured by the multi-scale nature of turbulence. The images below, from left to right, reveal the turbulent eddies according to their distance to the flame surface of interest.



The third example is the comparative visualization method and interface designed for cosmological simulation scientists, who have the need to visualize hundred millions of simulated cosmological particles and show how each varied across time and simulation run. The resulting visualization system allows the scientists compare a pair of simulations progressing over time. The image below shows the interface of this interactive, comparative visualization system. The approximated datasets present a more interesting challenge, as scientists wanted to examine how the differences developed over time. Most cosmologists assumed that they coalesce. However, our collaborators found that each particle's position and velocity varies more as time progresses. In other words the simulations diverge.



2. Training New Leaders & Next Generation Visualization Researchers

This Institute project provided all participants access to unique scientific applications and state-of-the-art high-performance computing facilities, and thus tremendous research opportunities. Each year, besides postdoctoral researchers, more than twenty student researchers were engaged in various projects. These students got the chance to work on the most challenging problems identified by the PI and collaborating scientists. Some of these students had access to the most powerful supercomputers in the world for their projects, and also obtained valuable internships at DOE national laboratories to work directly with the application scientists.

Through training many students and postdoctoral researchers, this project produced new leaders in the field of large-scale data visualization and analysis. Four of them are notably mentioned here:

- Tom Peterka is presently an assistant computer scientist at the Argonne National Laboratory (ANL), Fellow of the University of Chicago Computation Institute, and adjunct assistant professor at the University of Illinois at Chicago. His effort with the Institute has led to software products including the Radix-k compositing library, DIY, and Tess. He is currently a project lead at ANL, a participant of SciDAC3 SDAV project, and collaborating widely with application scientists and university researchers.
- Chaoli Wang (http://www3.nd.edu/~cwang11) is an associate professor of computer science and engineering at the Notre Dame University. He was extremely productive as a postdoctoral researcher at UC Davis, and became an assistant professor at Michigan Technological University in 2009. He joined Notre Dame University in 2014 and received the NSF CAREER award in the same year.
- Jon Woodring is presently a research scientist at the Los Alamos National Laboratory (LANL). He had several summer internships at LANL, received his PhD in 2009, and immediately joined LANL, where he is currently a project lead and also participating in the CESAR Co-Design project.
- Hongfeng Yu (http://vis.unl.edu/~yu/) is an assistant professor of computer science and engineering at the University of Nebraska-Lincoln (UNL). He got his PhD from UC Davis in 2008, and then worked as a postdoctoral researcher with the combustion simulation group at the Sandia National Laboratories before joining UNL. He is presently participating in the ExaCT Co-Design project.

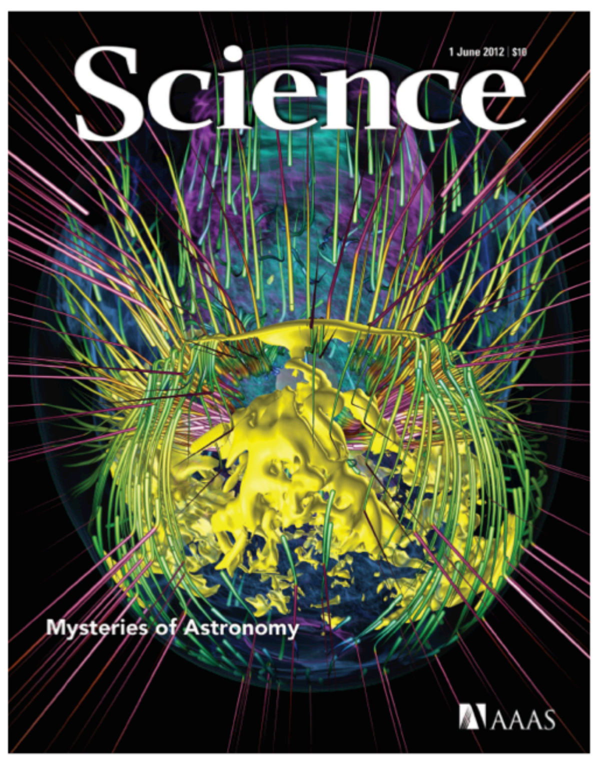
Several PIs of this project were in the early stages of their career. The unique resources made available through this project helped them build their profession career. They were able to establish strong connections to several large-scale scientific investigations, leading to long-term collaborative relationships. Some have become leaders in several of the following projects sponsored by DOE, including the SciDAC3 projects and ASCR basic research projects. Professors Jian Huang, John Owens, and Han-Wei Shen have all been promoted to full professors. Dr. Kenneth Moreland is presently participating in the SciDAC3 SDAV project, and also the lead PI for the XVis project, which consolidates three previous massively parallel visualization projects of DOE. Dr. Robert Ross is also participating in SciDAC3 SDAV project, and as the project lead for several other projects at the Argonne National Laboratory.

Senior people on this project continue their impact and contributions, and received significant recognitions from the respective communities. The lead PI, Professor Kwan-Liu Ma, presently participating in the SciDAC3 SDAV project and ASCR XVis project, was elected IEEE Fellow in 2012 and received the IEEE Visualization Technical Achievement award, the highest honor from his research community with the Technical Achievement Award, in 2013. Professor Nelson Max received the most prestigious recognition, the Steven A. Cons Award, from the ACM SIGGRAPH in 2007, and was elected ACM Fellow in 2011. Professor Deborah Silver has since continued her collaborations with DOE scientists. Professor Giulia Gallis is currently chair of the Extreme Physics and Chemistry of Carbon Directorate of the Deep Carbon Observatory.

3. Outreach

The outreach efforts by the Institute were very well received by the community. The most visible Institute outreach activities were the large number of workshops and tutorials organized by the Institute PIs. These activities brought a very efficient way to communicate with a large number of interested parties about new visualization technologies, applications, and requirements. For example, the Ultrascale Visualization Workshop has been held with the annual ACM/IEEE Supercomputing Conference for nine consecutive years (2006-2014). These workshops provided perfect venues for dialogue between visual analysis experts and computational scientists. In addition, over twenty tutorials on topics from large-scale data visualization and analysis, high-performance graphics/visualization, and data management were organized and taught by the Institute PIs at the annual Supercomputing Conferences, the annual SIAM Conferences on Parallel Processing for Scientific Computing, the IEEE Visualization Conferences, and the ACM SIGGRAPH Conferences.

Through goal-oriented collaborations, the institute PIs were able to target the most challenging and representative visualization applications in the Department of Energy, and the research results and findings have benefited the SciDAC community at large and beyond. The impact of the research results has been significant with the large number of conference presentations and journal publications, which helped direct the research community to those most essential and promising areas. Furthermore, the software tools and libraries made available by the Institute have helped accelerate the adoption and creation of new visualization technologies. The image on the right is the cover of the June 2012 issue of Science, which exhibits astonishing visualization of supernova simulation created by the Institute. Demonstrations of advanced visualization for some of the most challenging science applications as such have made scientists rethink about their overall research process and scientific discovery at extreme scale. As we can see, now visualization researchers are closely engaged in several of the major science teams. The value of visualization is highly recognized.



Publications (2006-2012)

1. Kwan-Liu Ma, Isaac Liao, Jennifer Frazier, Helwig Hauser, Helen-Nicole Kostis. Scientific Storytelling Using Visualization. IEEE Computer Graphics and Applications 32(1): 12-19, 2012.

2. Jishang Wei, Hongfeng Yu, Ray W. Grout, Jacqueline Chen, Kwan-Liu Ma. Visual Analysis of Particle Behaviors to Understand Combustion Simulations. IEEE Computer Graphics and Applications 32(1): 22-33, 2012.

3. Carlos D. Correa, Tarik Crnovrsanin, Kwan-Liu Ma. Visual Reasoning about Social Networks Using Centrality Sensitivity. IEEE Trans. Vis. Comput. Graph. 18(1): 106-120, 2012.

4. Zhuwen Li, Song Wang, Jinhui Yu, Kwan-Liu Ma. Restoration of Brick and Stone Relief from Single Rubbing Images. IEEE Trans. Vis. Comput. Graph. 18(2): 177-187, 2012.

5. Sheng-Jie Luo, Chun-Liang Liu, Bing-Yu Chen, Kwan-Liu Ma. Ambiguity-Free Edge-Bundling for Interactive Graph Visualization. IEEE Trans. Vis. Comput. Graph. 18(5): 810-821, 2012.

6. Nathaniel Fout, Kwan-Liu Ma. An Adaptive Prediction-Based Approach to Lossless Compression of Floating-Point Volume Data. IEEE Trans. Vis. Comput. Graph. 18(12): 2295-2304, 2012.

7. Nathaniel Fout, Kwan-Liu Ma. Fuzzy Volume Rendering. IEEE Trans. Vis. Comput. Graph. 18(12): 2335-2344, 2012.

8. Yingcai Wu, Guo-Xun Yuan, Kwan-Liu Ma. Visualizing Flow of Uncertainty through Analytical Processes. IEEE Trans. Vis. Comput. Graph. 18(12): 2526-2535, 2012.

9. Yuzuru Tanahashi, Kwan-Liu Ma. Design Considerations for Optimizing Storyline Visualizations. IEEE Trans. Vis. Comput. Graph. 18(12): 2679-2688, 2012.

10. Joyce Ma, Isaac Liao, Kwan-Liu Ma, Jennifer Frazier. Living Liquid: Design and Evaluation of an Exploratory Visualization Tool for Museum Visitors. IEEE Trans. Vis. Comput. Graph. 18(12): 2799-2808, 2012.

11. Wei-Hsien Hsu, Chun-Fu Wang, Kwan-Liu Ma, Hongfeng Yu, Jacqueline H. Chen. A Job Scheduling Design for Visualization Services Using GPU Clusters. In Proceedings of CLUSTER 2012, pp. 523-533.

12. Arnaud Sallaberry, Chris Muelder, Kwan-Liu Ma. Clustering, Visualizing, and Navigating for Large Dynamic Graphs. In Proceedings of Graph Drawing 2012, pp. 487-498.

13. Guo-Xun Yuan and Kwan-Liu Ma. Scalable Training of Sparse Linear SVMs. In Proceedings of ICDM 2012, pp. 775-784.

14. Jishang Wei, Zeqian Shen, Neel Sundaresan, Kwan-Liu Ma. Visual cluster exploration of web clickstream data. In Proceedings of IEEE VAST 2012, pp. 3-12.

15. Zeqian Shen, Jishang Wei, Neel Sundaresan, Kwan-Liu Ma. Visual analysis of massive web session data. In Proceedings of LDAV 2012, pp. 65-72.

16. Sedat Ozer, Jishang Wei, Deborah Silver, Kwan-Liu Ma, Pino Martin. Group dynamics in scientific visualization. In Proceedings of LDAV 2012, pp. 97-104.

17. Yuzuru Tanahashi, James R. Rowland, Stephen C. North, Kwan-Liu Ma. Inferring human mobility patterns from anonymized mobile communication usage. In Proceedings of MoMM 2012, pp. 151-160.

18. Kenneth Moreland, Brad King, Robert Maynard, Kwan-Liu Ma. Flexible Analysis Software for Emerging Architectures. SC Companion 2012, pp. 821-826.

19. Yuping He, Davide Donadio, and Giulia Galli. Morphology and Temperature Dependence of the Thermal Conductivity of Nanoporous SiGe. NANO Letters 11(9):3608-3611, 2011.

20. Yuping He, Davide Donadio and Giulia Galli. Heat Transport in Amorphous Silicon: Interplay Between Morphology and Disorder. *Applied Physics Letter* 98, 144101, 2011.

21. Q. Yin, E. R. Ylvisaker, and W. E. Pickett. Spin and Charge Fluctuations in Alpha-structure Layered Nitride Superconductors., *Phys. Rev. B* 83, 014509, 2011.

22. Yuping He, Davide Donadio, Joo-Hyoung Lee, Jeffrey C. Grossman, and Giulia Galli. Thermal Transport in Nanoporous Silicon: Interplay between Disorder at Mesoscopic and Atomic Scales. *ACS Nano* 5(3):1839-1844, 2011.

23. Wesley Kendall, Jian Huang, Tom Peterka, Robert Latham, Robert B. Ross. Toward a General I/O Layer for Parallel-Visualization Applications. IEEE Computer Graphics and Applications 31(6): 6-10, 2011.

24. Robert Sisneros, Jian Huang, George Ostrouchov, Forrest M. Hoffman. Visualizing Life Zone Boundary Sensitivities Across Climate Models and Temporal Spans. In Proceedings of ICCS 2011, pp.1582-1591.

25. Yingcai Wu, Thomas Provan, Furu Wei, Shixia Liu, Kwan-Liu Ma. Semantic-Preserving Word Clouds by Seam Carving. Comput. Graph. Forum 30(3): 741-750, 2011.

26. Tarik Crnovrsanin, Isaac Liao, Yingcai Wu, Kwan-Liu Ma. Visual Recommendations for Network Navigation. Comput. Graph. Forum 30(3): 1081-1090, 2011.

27. Cheng-Kai Chen, Shi Yan, Hongfeng Yu, Nelson Max, Kwan-Liu Ma. An Illustrative Visualization Framework for 3D Vector Fields. Comput. Graph. Forum 30(7): 1941-1951, 2011.

28. Cheng-Kai Chen, Chris Ho, Carlos D. Correa, Kwan-Liu Ma, Ahmed Elgamal. Visualizing 3D Earthquake Simulation Data. Computing in Science and Engineering 13(6): 52-

63, 2011.

29. Petra Isenberg, Niklas Elmqvist, Jean Scholtz, Daniel Cernea, Kwan-Liu Ma, Hans Hagen. Collaborative visualization: Definition, challenges, and research agenda. Information Visualization 10(4): 310-326, 2011.

30. Wei-Hsien Hsu, Kwan-Liu Ma, Carlos D. Correa. A rendering framework for multiscale views of 3D models. ACM Trans. Graph. 30(6): 131, 2011.

31. Yu-Shuen Wang, Chaoli Wang, Tong-Yee Lee, Kwan-Liu Ma. Feature-Preserving Volume Data Reduction and Focus+Context Visualization. IEEE Trans. Vis. Comput. Graph. 17(2): 171-181, 2011.

32. Carlos D. Correa, Kwan-Liu Ma. Visibility Histograms and Visibility-Driven Transfer Functions. IEEE Trans. Vis. Comput. Graph. 17(2): 192-204, 2011.

33. Carlos D. Correa, Robert Hero, Kwan-Liu Ma. A Comparison of Gradient Estimation Methods for Volume Rendering on Unstructured Meshes. IEEE Trans. Vis. Comput. Graph. 17(3): 305-319, 2011.

34. Cheng-Kai Chen, Chaoli Wang, Kwan-Liu Ma, Andrew T. Wittenberg. Static correlation visualization for large time-varying volume data. PacificVis 2011: 27-34.

35. Kwan-Liu Ma. Keynote address: New approaches to large data visualization. In Proceedings of PacificVis 2011.

36. Jishang Wei, Hongfeng Yu, Ray W. Grout, Jacqueline H. Chen, Kwan-Liu Ma. Dual space analysis of turbulent combustion particle data. PacificVis 2011: 91-98.

37. Chaoli Wang, Hongfeng Yu, Ray W. Grout, Kwan-Liu Ma, Jacqueline H. Chen. Analyzing information transfer in time-varying multivariate data. PacificVis 2011: 99-106.

38. Anna Tikhonova, Hongfeng Yu, Carlos D. Correa, Jacqueline H. Chen, Kwan-Liu Ma. A Preview and Exploratory Technique for Large-Scale Scientific Simulations. EGPGV 2011: 111-120.

39. Jishang Wei, Hongfeng Yu, Kwan-Liu Ma, Jackie H. Chen. Parallel clustering for visualizing large scientific line data. LDAV 2011: 47-55.

40. Kenneth Moreland, Utkarsh Ayachit, Berk Geveci, Kwan-Liu Ma. Dax Toolkit: A proposed framework for data analysis and visualization at Extreme Scale. LDAV 2011: 97-104.

41. Nathan Fabian, Kenneth Moreland, David Thompson, Andrew C. Bauer, Patrick Marion, Berk Geveci, Michel E. Rasquin, Kenneth E. Jansen. The ParaView Coprocessing Library: A scalable, general purpose in situ visualization library. In Proceedings of LDAV 2011, pp. 89-96.

42. Yubo Zhang, Carlos D. Correa, Kwan-Liu Ma. Graph-based Fire Synthesis. In Proceedings of the Symposium on Computer Animation 2011, pp. 187-194.

43. Carlos D. Correa, Kwan-Liu Ma. Visualizing Social Networks. Chapter 11 of Social Network Data Analytics, Springer, pp. 307-326. 2011.

44. Boonthanome Nouanesengsy, Teng-Yok Lee, Han-Wei Shen. Load-Balanced Parallel Streamline Generation on Large Scale Vector Fields. IEEE Trans. Vis. Comput. Graph. 17(12): 1785-1794, 2011.

45. Teng-Yok Lee, Oleg Mishchenko, Han-Wei Shen, Roger Crawfis. View point evaluation and streamline filtering for flow visualization. In Proceedings of PacificVis 2011, pp. 83-90.

46. Boonthanome Nouanesengsy, James P. Ahrens, Jonathan Woodring, Han-Wei Shen. Revisiting Parallel Rendering for Shared Memory Machines. In Proceedings of EGPGV 2011, pp. 31-40.

47. Tom Peterka, Robert B. Ross, Boonthanome Nouanesengsy, Teng-Yok Lee, Han-Wei Shen, Wesley Kendall, Jian Huang. A Study of Parallel Particle Tracing for Steady-State and Time-Varying Flow Fields. In Proceedings of IPDPS 2011, pp. 580-591.

48. Steven Martin, Han-Wei Shen. Histogram spectra for multivariate time-varying volume LOD selection. In Proceedings of LDAV 2011, pp. 39-46.

49. Tom Peterka, Robert B. Ross, Wesley Kendall, Attila Gyulassy, Valerio Pascucci, Han-Wei Shen, Teng-Yok Lee, Abon Chaudhuri. Scalable parallel building blocks for custom data analysis. In Proceedings of LDAV 2011, pp. 105-112.

50. Chun-Ming Chen, Lijie Xu, Teng-Yok Lee, Han-Wei Shen. A flow-guided file layout for out-of-core streamline computation. In Proceedings of LDAV 2011, pp. 115-116.

51. Stephane Marchesin, Cheng-Kai Chen, Chris Ho, and Kwan-Liu Ma. *View-Dependent Streamlines for 3D Vector Fields*. IEEE Transactions on Visualization and Computer Graphics, 16(6):1578-1586, 2010.

52. Anna Tikhonova, Carlos Correa and Kwan-Liu Ma. *Visualization by Proxy: A Novel Framework for Deferred Interaction with Volume Data*. IEEE Transactions on Visualization and Computer Graphics, Volume 16, Number 6, November/December 2010, 1551-1559. (IEEE Visualization 2010 Conference).

53. Chad Jones and Kwan-Liu Ma. *Visualizing Flow Trajectories using Locality-based Rendering and Warped Curve Plots*. IEEE Transactions on Visualization and Computer Graphics, Volume 16, Number 6, November/December 2010, pp. 1587-1594. (IEEE Visualization 2010 Conference).

54. C. Chen, C. Ho, C. Correa, K.-L. Ma, and A. Elgamal. Visualizing Three-Dimensional Earthquake Simulation Data. IEEE Computing in Science and Engineering (accepted for publication).

55. Hiroshi Akiba, Chaoli Wang, and Kwan-Liu Ma. *AniViz: A Template-based Animation Tool for Volume Visualization.* IEEE Computer Graphics and Applications, 30(5), September/October 2010, pp. 61-71.

56. A. Kaur, E. R. Ylvisaker, Y. Li, G. Galli, and W. E. Pickett. First-principles Study of Electronic and Vibrational Properties of $BaHfN_2$., *Physics Review B* 82, 155125, 2010.

57. Carlos Correa and Kwan-Liu Ma. *Dynamic Video Narratives*. ACM Transactions on Graphics, Volume 29, Number 3, July 2010, pp. (ACM SIGGRAPH 2010 Conference).

58. Anna Tikhonova, Carlos Correa, and Kwan-Liu Ma. *An Exploratory Technique for Coherent Visualization of Time-Varying Volume Data*. Computer Graphics Forum, 29(3), June 2010. (EuroVis 2010)

59. Hongfeng Yu, Chaoli Wang, Ray W. Grout, Jacqueline H. Chen, and Kwan-Liu Ma. *In Situ Visualization for Large-Scale Combustion Simulations.* IEEE Computer Graphics and Applications. 30(3), May/June 2010, pp. 45-57.

60. Chaoli Wang, H. Yu, and K.-L. Ma. *Application Driven Compression for Visualizing Large-Scale Time-Varying Data*. IEEE Computer Graphics and Applications, 30(1), January/February 2010, pp. 59-69.

61. Kwan-Liu Ma. *In-Situ Visualization at Extreme Scale: Challenges and Opportunities*. IEEE Computer Graphics and Applications, Volume 29, Number 6, November/December 2009, pp. 14-19.

62. Chris Muelder, Francois Gygi, and Kwan-Liu Ma. *Visual Analysis of Inter-Process Communication for Large-Scale Parallel Computing.* IEEE Transactions on Visualization and Computer Graphics, Volume 15, Number 6, November/December 2009, 1129-1136 (InfoVis 2009).

63. Carlos Correa and Kwan-Liu Ma. *The Occlusion Spectrum for Volume Classification and Visualization*. IEEE Transactions for Visualization and Computer Graphics , Volume 15, Number 6, November/December 2009, pp. 1465-1472 (Vis 2009).

64. Ove Daae Lampe, Carlos Correa, Kwan-Liu Ma, and Helwig Hauser. *Curve-Centric Volume Deformation for Comparative Visualization.* IEEE Transactions for Visualization and Computer Graphics , Volume 16, Number 5, November/December 2009, pp. 1235-1242 (Vis 2009).

65. Yuzuru Tanahashi, Cheng-Kai Chen, Stephane Marchesin, and Kwan-Liu Ma. *An Interface Design for Future Cloud-based Visualization Service.* In Proceedings of the CloudCom 2010.

66. Chad Jones, Ryan Armstrong, and Kwan-Liu Ma.*Visualizing the Commonalities between Hierarchically Structured Data Queries*. In Proceedings of the International Conference on Distributed Multimedia Systems, 2010, pp. 251-256.

67. Lin Zheng, Yingcai Wu, and Kwan-Liu Ma. *Relation*-Aware Spreadsheet for Multimodal Volume Segmentation and Visualization. MICCAI Workshop on Machine Learning in Medical Imaging, September 2010.

68. Fangfang Zhou, Yig Zhao, and Kwan-Liu Ma. *Parallel Mean Shift for Interactive Volume*

Segmentation. MICCAI Workshop on Machine Learning in Medical Imaging, September 2010.

69. Jeff Stuart, Cheng-Kai Chen, John Owens, and K.-L. Ma. *Multi-GPU Volume Rendering using MapReduce.* In Proceedings of MapReduce 2010, pp. 841-848.

70. Anna Tikhonova, Carlos Correa, and Kwan-Liu Ma. *Explorable Images for Visualizing Volume Data.* In Proceedings of IEEE Pacific Visualization Symposium , March 2010, pp. 177-184.

71. Tung-Ju Hsieh, Cheng-Kai Chen, and Kwan-Liu Ma. *Visualizing Field-Measured Seismic Data*. In Proceedings of IEEE Pacific Visualization Symposium, March 2010, pp. 65-72.

72. Jishang Wei, Chaoli Wang, Hongfeng Yu, and Kwan-Liu Ma. *A Sketch-Based Interface for Classifying and Visualizing Vector Fields.* In Proceedings of IEEE Pacific Visualization Symposium , March 2010, pp. 129-136.

73. Stephane Marchesin and Kwan-Liu Ma *Cross-Node Occlusion in Sort-Last Volume Rendering.* In Proceedings of Eurographics Parallel Graphics and Visualization Symposium (EGPGV) , May 2010.

74. Jeff A. Stuart, Michael Cox, and John D. Owens. GPU-to-CPU Callbacks. In UCHPC 2010: Proceedings of the Third Workshop on UnConventional High Performance Computing (Euro-Par 2010 Workshops), August 2010.

75. Andrew Davidson and John D. Owens. Toward Techniques for Auto-Tuning GPU Algorithms. In Para 2010: State of the Art in Scientific and Parallel Computing, June 2010.

76. Anjul Patney, Stanley Tzeng, and John D. Owens. Fragment-Parallel Composite and Filter. Computer Graphics Forum (Proceedings of the Eurographics Symposium on Rendering), 29(4):1251–1258, June 2010.

77. Everett H. Phillips, Roger L. Davis, and John D. Owens. Unsteady Turbulent Simulations on a Cluster of Graphics Processors. In Proceedings of the 40th AIAA Fluid Dynamics Conference, number AIAA 2010-5036, June 2010.

78. Jeff A. Stuart, Cheng-Kai Chen, Kwan-Liu Ma, and John D. Owens. Multi-GPU Volume Rendering using MapReduce. In HPDC '10: Proceedings of the 19th ACM International Symposium on High Performance Distributed Computing / MAPREDUCE '10: The First International Workshop on MapReduce and its Applications, pages 841–848, June 2010.

79. Stanley Tzeng, Anjul Patney, and John D. Owens. Task Management for Irregular-Parallel Workloads on the GPU. In Proceedings of High Performance Graphics 2010, pages 29–37, June 2010.

80. Yao Zhang, Jonathan Cohen, and John D. Owens. Fast Tridiagonal Solvers on the GPU. In Proceedings of the 15th ACM SIGPLAN Symposium on Principles and Practice of Parallel Programming (PPoPP 2010), pages 127–136, January 2010.

81. Dan A. Alcantara, Andrei Sharf, Fatemeh Abbasinejad, Shubhabrata Sengupta, Michael Mitzenmacher, John D. Owens, and Nina Amenta. Real-Time Parallel Hashing on the GPU. ACM Transactions on Graphics, 28(5):154:1–154:9, December 2009.

82. Shi Yan, Nelson Max, and Kwan Liu Ma, “Polygonal Surface Advection applied to Strange Attractors”, Computer Graphics Forum, Volume 29, No. 7, September 2010, pp. 2281 – 2290.

83. Nelson Max and Min Chen, "Local and Global Illumination in the Volume Rendering Integral", Hans Hagen (Ed.), *"Scientific Visualization: Advanced Concepts",* Dagstuhl Follow-ups, Vol.1, 2010, pp. 259-274.

84. Chaoli Wang, Hongfeng Yu, and Kwan-Liu Ma. "Application-Driven Compression for Visualizing Large-Scale Time-Varying Volume Data." IEEE Computer Graphics and Applications 30(1):59-69, 2010.

85. Carlos Correa and Kwan-Liu Ma. “The Occlusion Spectrum for Volume Classification and Visualization”, in Proceedings of IEEE Visualization 2009 Conference. Also IEEE Transactions for Visualization and Computer Graphics, Volume 15, Number 6, October 2009.

86. Ove Daae Lampe, Carlos Correa, Kwan-Liu Ma, and Helwig Hauser. “Curve-Centric Volume Deformation for Comparative Visualization”, in Proceedings of IEEE Visualization 2009 Conference. Also IEEE Transactions for Visualization and Computer Graphics, Volume 15, Number 6, October 2009.

87. Wei-Hsien Hsu, Jianqiang Mei, Carlos Correa, and Kwan-Liu Ma. “Depicting Time Evolving Flow with Illustrative Visualization Techniques”, in Proceedings of International Conference on Arts & Technology (ArtsIT 2009), September 2009.

88. Carlos Correa and Kwan-Liu Ma, “Visibility Driven Transfer Functions”, in Proceedings of IEEE Pacific Visualization 2009 Symposium, in press, April 2009.

89. Jeffrey Sukharev, Chaoli Wang, and Kwan-Liu Ma, “Correlation Study of Time-Varying Multivariate Climate Data Sets”, in Proceedings of IEEE Pacific Visualization 2009 Symposium, in press, April 2009.

90. Takayuki Itoh, Chris Muelder, Kwan-Liu Ma, and Jun Sese, “A Hybrid Space-Filling and Force-Directed Layout Method for Visualizing Multiple-Category Graphs”, in Proceedings of IEEE Pacific Visualization 2009 Symposium, in press. April 2009.

91. Chris Muelder and Kwan-Liu Ma, “Interactive Feature Extraction and Tracking by Utilizing Region Coherency”, in Proceedings of IEEE Pacific Visualization 2009 Symposium, in press April 2009.

92. J H Chen, A Choudhary, B de Supinski, M DeVries, E R Hawkes, S Klasky, W K Liao, K-L Ma, J Mellor-Crummey, N Podhorszki, R Sankaran, S Shende, and C S Yoo, “Terascale Direct Numerical Simulations of Turbulent Combustion using S3D”, Computational Science & Discovery Volume 2, January-March, 2009.

93. Nelson Max, Carlos Correa, Chris Muelder, Shi Yan, Cheng-Kia Chaen, and Kwan-Liu Ma, "Flow visualization in science and mathematics", Journal of Physics: Conference Series, Vol. 180, pp. 12087 – 12095, 2009.

94. Kwan-Liu Ma, Chaoli Wang, Hongfeng Yu, Kenneth Moreland, Jian Huang, and Robert Ross. *Next-Generation Visualization Technologies: Enabling Discoveries at Extreme Scale,* DOE SciDAC Review, 12:12-21, Spring 2009.

95. Anjul Patney, Mohamed S. Ebeida, and John D. Owens. Parallel View-Dependent Tessellation of Catmull-Clark Subdivision Surfaces. In Proceedings of High Performance Graphics 2009, pages 99–108, August 2009.

96. Luke J. Gosink, Kesheng Wu, E. Wes Bethel, John D. Owens, and Kenneth I. Joy. Data Parallel Bin-Based Indexing for Answering Queries on Multi-Core Architectures. In Proceedings of the 21st International Conference on Scientific and Statistical Database Management, volume 5566 of Lecture Notes in Computer Science, pages 110–129. Springer, June 2009.

97. Jeff A. Stuart and John D. Owens, “Message Passing on Data-Parallel Architectures”, In Proceedings of the 23rd IEEE International Parallel and Distributed Processing Symposium, May 2009.

98. Brian Budge, Tony Bernardin, Jeff A. Stuart, Shubhabrata Sengupta, Kenneth I. Joy, and John D. Owens, “Out-of-core Data Management for Path Tracing on Hybrid Resources’, Computer Graphics Forum (Proceedings of Eurographics 2009), 28(2): 385-396, April 2009.

99. Everett H. Phillips, Yao Zhang, Roger L. Davis, and John D. Owens, “Rapid Aerodynamic Performance Prediction on a Cluster of Graphics Processing Units”, in Proceedings of the 47th AIAA Aerospace Sciences Meeting, January 2009.

100. Anjul Patney and John D. Owens. Real-Time Reyes-Style Adaptive Surface Subdivision. ACM Transactions on Graphics (Proceedings of ACM SIGGRAPH Asia), 27(5), 143:1-143:8, December 2008.

101. Carlos Correa and Kwan-Liu Ma, “Visibility Driven Transfer Functions”, in Proceedings of IEEE Pacific Visualization 2009 Symposium, in press, April 2009.

102. Jeffrey Sukharev, Chaoli Wang, and Kwan-Liu Ma, “Correlation Study of Time-Varying Multivariate Climate Data Sets”, in Proceedings of IEEE Pacific Visualization 2009 Symposium, in press, April 2009.

103. Takayuki Itoh, Chris Muelder, Kwan-Liu Ma, and Jun Sese, “A Hybrid Space-Filling and Force-Directed Layout Method for Visualizing Multiple-Category Graphs”, in Proceedings of IEEE Pacific Visualization 2009 Symposium, in press. April 2009.

104. Chris Muelder and Kwan-Liu Ma, “Interactive Feature Extraction and Tracking by Utilizing Region Coherency”, in Proceedings of IEEE Pacific Visualization 2009 Symposium, in press April 2009.

105. J H Chen, A Choudhary, B de Supinski, M DeVries, E R Hawkes, S Klasky, W K Liao, K-L Ma, J Mellor-Crummey, N Podhorszki, R Sankaran, S Shende, and C S Yoo, “Terascale Direct Numerical Simulations of Turbulent Combustion using S3D”, Computational Science & Discovery Volume 2, January-March, 2009.

106. Everett H. Phillips, Yao Zhang, Roger L. Davis, and John D. Owens, “Rapid Aerodynamic Performance Prediction on a Cluster of Graphics Processing Units”, in Proceedings of the 47th AIAA Aerospace Sciences Meeting, January 2009.

107. Jeff A. Stuart and John D. Owens, “Message Passing on Data-Parallel Architectures”, In Proceedings of the 23rd IEEE International Parallel and Distributed Processing Symposium, May 2009.

108. Brian Budge, Tony Bernardin, Jeff A. Stuart, Shubhabrata Sengupta, Kenneth I. Joy, and John D. Owens, “Out-of-core Data Management for Path Tracing on Hybrid Resources’, Computer Graphics Forum (Proceedings of Eurographics 2009), 28(2), April 2009.

109. C. Ryan Johnson and Jian Huang, “Distribution Driven Visualization of Volume Data”, IEEE Transactions on Visualization and Computer Graphics, in press, Volume 15, 2009.

110. C. Ryan Johnson, Markus Glatter, Wesley Kendall, Jian Huang and Forrest Hoffman, “Querying for Feature Extraction and Visualization in Climate Modeling”, Geo Computation (ICCS’09), Lecture Notes in Computer Science, in press, Springer, 2009.

111. Teng-Yok Lee and Han-Wei Shen, “Visualizing Time-Varying Features with TAC-based Distance Fields”, in Proceedings of IEEE Pacific Visualization 2009 Symposium, in press, April 2009.

112. Abon Chaudhuri and Han-Wei Shen, “A Self-Aaptive Treemap-based Technique for Visualizing Hierarchical Data in 3D”, in Proceedings of IEEE Pacific Visualization 2009 Symposium, in press, April 2009.

113. Jonathan Woodring and Han-Wei Shen, Semi-Automatic Time-Series Transfer Functions via Temporal Clustering and Sequencing, urographics/IEEE-VGTC Symposium on Visualization 2009.

114. Firdaus Janoos, Boonthanome Nouanesengsy, Raghu Machiraju, Han-Wei Shen, and Istvan Akos Morocz, Visual Analysis of Brain Activity from fMRI Data, Eurographics/IEEE-VGTC Symposium on Visualization 2009.

115. Thomas Kerwin, Han-Wei Shen, and Don Stredney, Enhancing Realism of Wet Surfaces in Temporal Bone Surgical Simulation, IEEE Transactions on Visualization and Computer Graphics 15(5):747-758, 2009.

116. Chaoli Wang, Hongfeng Yu, and Kwan-Liu Ma. "Importance-Driven Time-Varying Data Visualization." IEEE Transactions on Visualization and Computer Graphics (Also IEEE Visualization 2008 Conference Proceedings), Volume 14, October, 2008.

117. Carlos Correa and Kwan-Liu Ma. "Size-based Transfer Functions: A New Volume Exploration Technique." IEEE Transactions on Visualization and Computer Graphics (Also IEEE Visualization 2008 Conference Proceedings), Volume 14, October, 2008.

118. Chris Muelder and Kwan-Liu Ma. "Rapid Graph Layout using Space Filling Curves." IEEE Transactions on Visualization and Computer Graphics (also Information Visualization 2008 Conference Proceedings), Volume 14, October, 2008.

119. Steve Haroz and K. Heitmann, "Seeing the Difference between Cosmological Simulations", IEEE Computer Graphics and Applications, 28(5), September-October 2008, pp. 27-45.

120. Antoine Bouthors, Fabrice Neyret, Nelson Max, E. Brunton, and C Crassin, "Interactive multiple anisotropic scattering in clouds", proceedings of I3D (ACM symposium on Interactive 3D Graphics and Games), 2008, pp. 173 - 182.

121. Christian Hofsetz, Nelson Max, and Rui Bastos, "Object Space Visibility Ordering for Point-Based and Volume Rendering", Computer Graphics Forum, Vol. 27 No. 1, 2008, pp. 91 - 101.

122. Anjul Patney and John D. Owens. Real-Time Reyes-Style Adaptive Surface Subdivision. ACM Transactions on Graphics (Proceedings of ACM SIGGRAPH Asia), 27(5), December 2008. http://graphics.idav.ucdavis.edu/publications/print_pub?pub_id=952.

123. Sanjiv S. Samant, Junyi Xia, Pınar Muyan-Özçelik, and John D. Owens. High performance computing for deformable image registration: Towards a new paradigm in adaptive radiotherapy. Medical Physics, 35(8):3546–3553, August 2008. http://dx.doi.org/10.1118/1.2948318.

124. Pınar Muyan-Özçelik, John D. Owens, Junyi Xia, and Sanjiv S. Samant. Fast Deformable Registration on the GPU: A CUDA Implementation of Demons. In Proceedings of the 2008 International Conference on Computational Science and Its Applications (First Technical Session on UnConventional High Performance Computing [UCHPC '08]), pages 223–233, July 2008. http://graphics.idav.ucdavis.edu/publications/print_pub?pub_id=941.

125. Mark Silberstein, Assaf Schuster, Dan Geiger, Anjul Patney, and John D. Owens. Efficient Computation of Sum-products on GPUs Through Software-Managed Cache. In Proceedings of the 22nd ACM International Conference on Supercomputing, pages 309–318, June 2008.

126. Adam Moerschell and John D. Owens. "Distributed Texture Memory in a Multi-GPU Environment," Computer Graphics Forum, 27(1), March 2008.

127. John D. Owens, Mike Houston, David Luebke, Simon Green, John E. Stone, and James C. Philips. "GPU Computing," Proceedings of the IEEE, 96(3), March 2008.

128. Markus Glatter, Jian Huang, Sean Ahern, Jamison Daniel and Aidong Lu, "Visualizing Temporal Patterns in Large Multivariate Data using Textual Pattern Matching", IEEE Transactions on Visualization and Computer Graphics, 14(6), pp. 1467-1474, 2008. (special issue for IEEE Visualization'08).

129. Robert Sisneros, C. Ryan Johnson and Jian Huang, "Concurrent Viewing of Multiple Attribute-Specific Subspaces", Computer Graphics Forum (special issue for EuroVis'08), 27(3), pp. 783-790, 2008.

130. Joshua New, Wesley Kendall, Jian Huang, Elissa Chesler, "Dynamic Visualization of Gene Coexpression in Systems Genetics Data", IEEE Transactions on Visualization and Computer Graphics, 14(5), pp. 1081-1094, 2008.

131. Robert Sisneros, Markus Glatter, Brandon Langley, Jian Huang, Forrest Hoffman, David Erickson III, Time-Varying Multivariate Visualization for Understanding Terrestrial Biogeochemistry, Journal of Physics: Conference Series (SciDAC08), July 2008.

132. Wesley Kendall, Markus Glatter, Jian Huang, Forrest Hoffman, David E. Bernholdt, "Web Enabled Collaborative Climate Visualization in the Earth System Grid", Proc. of International Symposium on Collaborative Technologies and Systems (CTS 2008), Irvine, CA, May 2008.

133. Jinzhu Gao, Huadong Liu, Jian Huang, Micah Beck, Qishi Wu, Terry Moore and James Kohl, "Time-Critical Distributed Visualization with Fault Tolerance", Proc. of Eurographics Symposium on Parallel Graphics and Visualization, Crete, Greece, April 2008.

134. Qishi Wu, Jinzhu Gao, Mengxia Zhu, Nageswara Rao, Jian Huang and S. Sitharama Iyengar, "Self-Adaptive Configuration of Visualization Pipeline over Wide-Area Networks", IEEE Transactions on Computers, 57(1), pp. 55-68, January 2008.

135. Tom Peterka, Robert L. Kooima, Daniel J. Sandin, Andrew Johnson, Jason Leigh, and Thomas A. DeFanti. Advances in the Dynallax Solid-State Dynamic Parallax Barrier Autostereoscopic Visualization Display System. In IEEE Transactions on Visualization and Computer Graphics, to be printed in 2008.

136. Steve Haroz, Kwan-Liu Ma, Katrin Heitmann. "Multiple Uncertainties in Time-Variant Cosmological Particle Data." In Proceedings of IEEE Pacific Visualization Symposium, IEEE VGTC, March, 2008, pp. 207-214.

137. James Shearer, Michael Ogawa, Kwan-Liu Ma, Toby Kohlenberg. "Pixelplexing: Gaining Display Resolution Through Time." In Proceedings of IEEE Pacific Visualization Symposium, IEEE VGTC, March, 2008, pp. 159-266.

138. Michael Ogawa and Kwan-Liu Ma. "StarGate: A Unified, Interactive Visualization of Software Projects." In Proceedings of IEEE PacificVis Conference, March, 2008, pp. 191-198.

139. Tom Peterka, Hongfeng Yu, Robert Ross, and Kwan-Liu Ma. "Parallel Volume Rendering on the IBM Blue Gene/P." In Proceedings of Eurographics Parallel Graphics and Visualization Symposium (EGPGV 2008) April, 2008, pp. 73-80.

140. Anna Tikhonova and Kwan-Liu Ma. "A Scalable Parallel Force-Directed Graph Layout Algorithm." In Proceedings of Eurographics Parallel Graphics and Visualization Symposium (EGPGV 2008) April, 2008, pp. 25-32.

141. Kwan-Liu Ma, Chaoli Wang. "Social-Aware Collaborative Visualization for Large Scientific Projects." In Proceedings of International Symposium on Collaborative Technologies and Systems May, 2008.

142. Chaoli Wang, Kwan-Liu Ma. "A Statistical Approach to Volume Data Quality Assessment." IEEE Transactions on Visualization and Computer Graphics Volume 14, Number 3, May/June, 2008, pp. 590-602.

143. Rob Ross, Tom Peterka Han-Wei Shen, Kwan-Liu Ma, Hongfeng Yu, and Ken Moreland. "Visualization and Parallel I/O at Extreme Scale." Journal of Physics (Conference Series), Volume 125, July, 2008.

144. Chad Jones, Kwan-Liu Ma, Stephane Ethier, Wei-Li Lee. "An Integrated Exploration Approach to Visualizing Multivariate Particle Data." Computing in Science & Engineering, Vo.lume 10, Number 4, July/August, 2008, pp. 20-29.

145. Hongfeng Yu, Chaoli Wang, and Kwan-Liu Ma. "Parallel Volume Rendering using , Image Compositing for an Arbitrary Number of Processors." In Proceedings of Proceedings of IEEE/ACM Supercomputing 2008 Conference, November 2008.

146. Jonathan Woodring and Han-Wei Shen, Multi-scale Time Activity Data Exploration via Temporal Clustering Visualization Spreadsheet, IEEE Transactions on Visualization and Computer Graphics, 15(1):123-137, 2008

147. Ying Tu and Han-Wei Shen, Ballon Filter, A Seamless Multi focus+context technique for TreeMaps, to appear in Proceedings of IEEE Information Visualization Conference 2008.

148. Hsien-Hsi Hsieh, Liya Li, Han-Wei Shen, and Wen-Kai Tai , A Volume Rendering Framework for Visualizing 3D Flow Fields, Journal of Fluid Science and Technology, Vol 3, No. 4, 2008

149. Liya Li, Hsien-His Hsieh, Han-Wei Shen, Illustrative Streamline Placement and Visualization, in Proceedings of IEEE Pacific Visualization 2008

150. Steve Martin, Han-Wei Shen, and Ravi Samtaney, Efficient Rendering of Extrudable Curvilinear Volumes, in Proceedings of IEEE Pacific Visualization 2008

151. Aidong Lu and Han-Wei Shen, Interactive Storyboard for Overall Time-Varying Data Visualization, in Proceedings of IEEE Pacific Visualization 2008

152. Guanfeng Ji, Han-Wei Shen, and Jinzhu gao, Interactive Exploration of Remote Isosurface with Point-based Non-Photorealistic Rendering, in Proceedings of IEEE Pacific Visualization 2008

153. Yuan Hong and Han-Wei Shen, Parallel Reflective Symmetry Transformation for Volume Data, accepted to Computers and Graphics.

154. Steve Haroz and K. Heitmann, “Seeing the Difference between Cosmological Simulations”, IEEE Computer Graphics and Applications, 28(5), September-October 2008, pp. 27-45.

155. Kenneth Moreland, David Rogers, John Greenfield, Berk Geveci, Patrick Marion, Alexander Neundorf, and Kent Eschenberg. "Large Scale Visualization on the Cray XT3 Using ParaView." In Cray User Group 2008.

156. Kenneth Moreland, Daniel Lepage, David Koller, and Greg Humphreys. "Remote rendering for ultrascale data." Journal of Physics: Conference Series, 125(012096), 2008.

157. Kenneth Moreland, C. Charles Law, Lisa Ice, and David Karelitz. “Analysis of Fragmentation in Shock Physics Simulation.” In Proceedings of 2008 Ultrascale Visualization Workshop, November, 2008.

158. Kwan-Liu Ma. “Emerging Visualization Technologies for Ultra-Scale Simulations,” In press, CTWatch Quarterly, Volume 3, Number 4, November 2007.

159. Hongfeng Yu, Chaoli Wang, and Kwan-Liu Ma. “Parallel Hierarchical Visualization of Large 3D Time-Varying Vector Fields,” In Proceedings of ACM/IEEE Supercomputing 2007 Conference (SC07), November 2007.

160. Ying Tu and Han-Wei Shen, “Visualizing Changes of Hierarchical Data using Treemaps,” IEEE Symposium on Information Visualization (InfoVis’07), also a special issue of IEEE Transactions on Visualization and Computer Graphics.

161. Biddiscombe, John, Berk Geveci, Ken Martin, Kenneth Moreland, David Thompson. "Time Dependent Processing in a Parallel Pipeline Architecture." In Proceedings of IEEE Visualization 2007 Conference, October 2007.

162. Aaron E. Lefohn, Shubhabrata Sengupta, and John D. Owens. “Resolution-Matched Shadow Maps,” ACM Transactions on Graphics, 26(4), October 2007.

163. Nathan Fout and Kwan-Liu Ma. “Transform Coding for Hardware-Accelerated Volume Rendering,” in Proceedings of IEEE Visualization 2007 Conference, October 2007, also special issue of IEEE Transactions on Visualization and Computer Graphics.

164. Yue Wang, James Shearer, and Kwan-Liu Ma. “VICA: A Voronoi Interface for Visualizing Collaborative Annotation,” In Proceedings of the 4th International Conference on Cooperative Design, Visualization, and Engineering, September 2007.

165. Kwan-Liu Ma. “Machine Learning to Boost the Next Generation of Visualization Technology,” IEEE Computer Graphics and Applications, Volume 27, Number 5, September/October 2007, pp. 6-9.

166. Runzhen Huang, Hongfeng Yu, Kwan-Liu Ma, and Oliver Staadt. “Automatic Feature Modeling Techniques for Volume Segmentation Applications,” In Proceedings of Volume Graphics 2007, September 2007.

167. Kwan-Liu Ma. “The Next Surge of Visualization Research,” VisFiles, ACM SIGGRAPH Computer Graphics Quarterly, Volume 41, Number 3, August, 2007.

168. Mark Harris, Shubhabrata Sengupta, and John D. Owens. “Parallel Prefix Sum (Scan) with CUDA,” In Hubert Nguyen, editor, GPU Gems 3, chapter 39, pp. 851-876. Addison Wesley, August 2007.

169. Shubhabrata Sengupta, Mark Harris, Yao Zhang, and John D. Owens. “Scan Primitives for GPU Computing.” In Graphics Hardware 2007, pp. 97-106, August 2007.

170. Mark Harris, Shubhabrata Sengupta, and John D. Owens. “Parallel Prefix Sum (Scan) with CUDA.” In Herbert Nguyen, editor, GPU Gems 3, chapter 39. Addison Wesley, August 2007.

171. Jian Huang, Huadong Liu, Jinzhu Gao, Andrew Gaston, Micah Beck, and Terry Moore. “Visualization Viewpoints: Dynamic Sharing of Large-Scale Visualization.” *IEEE Computer Graphics and Applications*, Vol. 27, No. 1, pp. 20-25, July – August, 2007.

172. Liya Li and Han-Wei Shen, “Imaged Based Streamline Generation and Rendering,” IEEE Transactions on Visualization and Computer Graphics, Vol 13, No. 3, pp. 630-640, 2007.

173. Kwan-Liu Ma, Chaoli Wang, Hongfeng Yu, Anna Tikhonova. “In-Situ Processing and Visualization for Ultrascale Simulation,” Journal of Physics (Conference Series), Volume 78, also Proceedings of SciDAC 2007 Conference, June 2007.

174. Kwan-Liu Ma, Robert Ross, Jian Huang, Greg Humphreys, Nelson Max, Kenneth Moreland, John D. Owens, and Han-Wei Shen. “Ultrascale Visualization: Research and Education.” Journal of Physics (Conference Series), Volume 78, also Proceedings of SciDAC 2007 Conference, June 2007.

175. Chad Jones, Kwan-Liu Ma, Allen Sanderson, and Lee Roy Myers Jr. “Visual Interrogation of Gyrokinetic Particle Simulations.” Journal of Physics (Conference Series), Volume 78, also Proceedings of SciDAC 2007 Conference, June 2007.

176. Hiroshi Akiba and Kwan-Liu Ma. “A Tri-Space Visualization Interface for Analyzing Time-Varying Multivariate Volume Data.” In Proceedings of the Joint Eurographics-IEEE VGTC Symposium on Visualization, May 2007.

177. Yuan Hong and Han-Wei Shen. “Parallel Reflective Symmetry Transformation for Volume Data.” In the proceedings of Eurographics/ACM SIGGRAPH Symposium on Parallel Graphics and Visualization 2007, pp. 77-85, May 2007.

178. Hiroshi Akiba, Kwan-Liu Ma, Jackie Chen, and Evatt Hawkes. “Visualizing Multivariate Volume Data from Turbulent Combustion Simulations.” *IEEE Computing in Science and Engineering*, Volume 9, Issue 2, pp. 76-83, March – April, 2007.

179. T. J. Jankun-Kelly, Kwan-Liu Ma, and Michael Gertz. “A Model and Framework for Visualization Exploration,” IEEE Transactions for Visualization and Computer Graphics, Volume 13, Number 2, March 2007, pp. 257-369.

180. John D. Owens, David Luebke, Naga Govindaraju, Mark Harris, Jens Krüger, Aaron E. Lefohn, and Tim Purcell. “A Survey of General-Purpose Computation on Graphics Hardware.” Computer Graphics Forum, Vol. 26, No. 1, pp. 80-113, March 2007.

181. David Luebke and Greg Humphreys. How GPUs Work, IEEE Computer, February 2007.

182. Ewen Cheslack-Postava, Nolan Goodnight, Ren Ng, Ravi Ramamoorthi, and Greg Humphreys, “4D Compression and Relighting with High-Resolution Light Transport Matrices”, in Proceedings of ACM Symposiumon Interactive 3D Graphics, 2007.

183. Runzhen Huang, Eric Lum, and Kwan-Liu Ma. “Multi-Scale Morphological Volume Segmentation and Visualization,” In Proceedings of Asia-Pacific Symposium on Visualization, February 2007, pp. 121-128.

184. George Chen, Yang Liu, and Nelson Max, "Real Time View Synthesis from a Sparse Set of Views", Signal Processing: Image Communication, Vol. 22, No. 2, 2007, pp. 188 - 202.

185. Hye Kyung Kim, Oyeon Kum, and Nelson Max, "Computer Assisted Image Analyis Based on Clustered Hounsfield Values", Journal of the Korean Physical Society, Vol. 51, No. 1, 2007, pp. 235 – 244.

186. Robert Sisneros, Chad Jones, Jian Huang, Jinzhu Gao, Byung-Hoon Park and Nagiza Samatova. “A Multi-Level Cache Model for Run-Time Optimization of Remote Visualization.” *IEEE Transactions on Visualization and Computer Graphics*, Vol. 13, No. 5, January – February, 2007.

187. Chaoli Wang, Antonio Garcia, and Han-Wei Shen. “Interactive Level-of-Detail Selection Using Image-Based Quality Metric for Large Volume Visualization.” *IEEE Transactions on Visualization and Computer Graphics,* Vol 13, No. 1, p. 122-132, January – February, 2007.

188. Kenneth Moreland, Lisa Avila, and Lee Ann Fisk. "Parallel Unstructured Volume Rendering in ParaView." In Visualization and Data Analysis 2007, Proceedings of SPIE-IS&T Electronic Imaging, pp. 64950F-1–12, January 2007.

189. John Biddiscombe, Berk Geveci, Ken Martin, Kenneth Moreland, David Thompson. "Time Dependent Processing in a Parallel Pipeline Architecture." In Proceedings of IEEE Visualization 2007, October, 2007.

190. Jonathan Woodring and Han-Wei Shen. “Incorporating Highlighting Animations into Static Visualizations.” In the proceedings of SPIE Electronic Imaging 07, January 2007.

191. Nelson Max, "Hexahedron Projection for Curvilinear Grids," Journal of Graphics Tools, Vol. 12, No 2, 2007, pp. 33 – 45.

192. Nelson Max and Tino Weinkauf, "Critical Points of the Electric Field from a Collection of Point Charges," Proceedings of the International Workshop on Topology-Based Methods in Visualization, Kloster Nimbschen, March 4-6, 2007.

193. Hye Kyung Kim, Oyeon Kum, and Nelson Max, "Computer Assisted Image Analyis Based on Clustered Hounsfield Values," Journal of the Korean Physical Society, Vol. 51, No. 1, 2007, pp. 235 – 244.

194. John D. Owens. Towards Multi-GPU Support for Visualization. Journal of Physics: Conference Series, 78:012055 (5pp), June 2007.

195. Daniel Lewis, Steve Haroz, and Kwan-Liu Ma. “Layout of Multiple Views for Volume Visualization: A User Study.” Proceedings of International Symposium on Visual Computing, pp. 215-226, November 6-8, 2006.

196. Tiankai Tu, Hongfeng Yu, Leonardo Ramirez-Guzman, Jacobo Bielak, Omar Ghattas, Kwan-Liu Ma, and David R. O'Hallaron. “From Mesh Generation to Scientific Visualization - An End-to-End Approach to Parallel Supercomputing.” In Proceedings of SC06, the International Conference for High Performance Computing, Networking, Storage and Analysis, November 2006.

197. Markus Glatter, Colin Mollenhour, Jian Huang and Jinzhu Gao, “Scalable Data Servers for Large Multivariate Volume Visualization”, IEEE Transactions on Visualization and Computer Graphics, Vol. 12, No. 5, pp. 1291-1299, 2006.

198. Eric Lum, James Shearer, and Kwan-Liu Ma. “Interactive Multi-Scale Exploration for Volume Classification,” In Proceedings of Pacific Graphics 2006 Conference, October 2006, pp. 622-630.

199. Chaoli Wang and Han-Wei Shen, LOD Maps, “A Visual Interface for Navigating Multiresolution Volume Visualization,” IEEE Transactions on Visualization and Computer Graphics, Vol 12 No. 5, pp. 1029-1037, also in the proceedings of IEEE Visualization 2006.

200. Jonathan Woodring and Han-Wei Shen, “Multi-variate, Time-varying, and Comparative Visualization with Contextual Cues,” IEEE Transactions on Visualization and Computer Graphics, Vol 12 No. 5, pp. 909-917, also in the proceedings of IEEE Visualization 2006.

201. Guangfeng Ji and Han-Wei Shen, “Dynamic View Selection for Time-varying Volumes,” IEEE Transactions on Visualization and Computer Graphics, Vol 12 No. 5, pp. 1109-1117, also in the proceedings of IEEE Visualization 2006.

202. James Ahrens, Katrin Heitmann, Salman Habib, Lee Ankeny, Patrick McCormick, Jeff Inman, Ryan Armstrong, and Kwan-Liu Ma. “Quantitative and Comparative Visualization Applied to Cosmological Simulations,” Journal of Physics: Conference Series, Volume 46, June 2006, pp. 526-534.

203. Guangfeng Ji and Han-Wei Shen. “Feature Tracking Using Earth Mover’s Distance and Global Optimization.” In the proceedings of Pacific Graphics, October 2006.