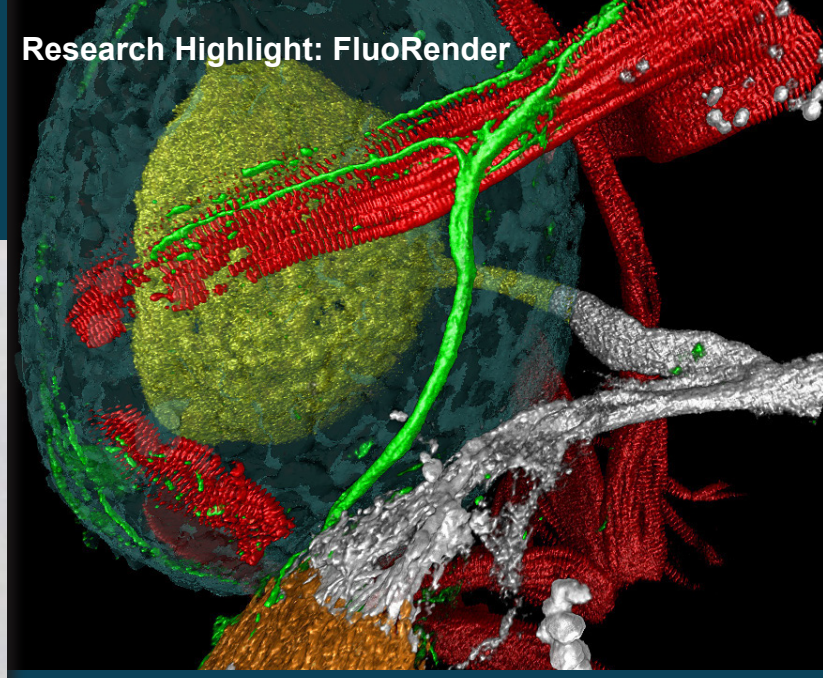
Fresh Tracks

News from the Scientific Computing and Imaging Institute

September 2013

In this issue

www.sci.utah.edu



Message from the Director

Welcome to the Fresh Tracks Newsletter, highlighting news from the SCI Institute. Since our first newsletter six months ago, SCI Institute faculty, staff, and students have continued to perform exciting research, lead international conferences, perform important professional service, and educate students at the graduate, undergraduate, and even high school levels.

In this issue, we emphasize research on FluoRender, which is an interactive tool for confocal microscopy data visualization. Confocal microscopy is an important imaging technique in biology used to study three-dimensional (3D) structures of biological samples. Together with biologists, Professor Charles Hansen and his graduate student Yong Wan (who successfully defended his Ph.D. dissertation in April 2013) designed and developed FluoRender. In addition to being a useful visualization tool for biologists, FluoRender has been used to create stunning images that have garnered awards in international biology image competitions.

I am pleased to draw attention to one of my very successful Ph.D. students and early SCI members, Han-Wei Shen, who is now a Professor of Computer Science and Engineering at the Ohio State University. Han-Wei continues to perform cutting-edge visualization research and educate new visualization researchers. Professor Shen founded and leads the Graphics and Visualization Study (GRAVITY) research group at OSU. Han-Wei is also an amazing educator, having graduated 12 Ph.D. students, which means I have 12 more “academic grandchildren”, and several M.S. students. He received the Department’s Outstanding Teaching Award twice.

We hope you will continue to join us for the 2013-14 SCI Institute Distinguished Lecture Series on Fridays at 2:00 p.m. in the Evans Conference Room. If you can’t attend in person, these Distinguished Lectures are available on the SCI TV section of our website. Details of all our upcoming seminars and lectures, along with an archive of previous seminars are available at:

http://www.sci.utah.edu/the-institute/events.html.

Sincerely,

Chris R. Johnson, Ph.D.
Director,
Scientific Computing and Imaging (SCI) Institute
Distinguished Professor,
School of Computing
University of Utah

SCI Events

Clockwise from top: Chris Johnson speaking at Future in Review 2013, Greg Jones touring SCI with HI GEAR Camp, the HBM Hackathon Challenge.

Chris Johnson Speaks at FiRe 2013

Chris Johnson was a featured speaker at the 2013 Future in Review (FiRe 2013) conference. He was among a number of other distinguished guests including Vint Cerf and Leroy Hood. The conference, which was held May 21-24 in Laguna Beach, California, was unified under the theme "Digitizing the Planet."
www.futureinreview.com

HI GEAR (Girls Engineering Abilities Realized) Camp

On June 19, the SCI Institute hosted nineteen 9th-12th grade female students. Orly Alter, Professor of Bioengineering, presented her research in the Genomic Signal Processing Lab. The students then toured the SCI Institute with one of the institute's associate directors, Greg Jones. One of the girls enrolled in the SCI High School Summer internship program.

The SCI Institute also sponsored the Utah National Center for Women and Information (NCWIT) Award for Aspiration in Computing, which encourages young women in our community to continue pursuing their interests in technology, and emphasizes the importance of women's participation in computing and IT (www.ncwit.org/award)

SCI Team Wins HBM Hackathon Challenge

Congratulations to Kris Zygmunt, Wei Liu, and Sean McKenna for winning one of the three challenges of the 2013 HBM Hackathon sponsored by Allen Institute for Brain Science and Amazon Web Services.

Kris Zygmunt represented the SCI Institute team over the course of the four-day event. The team started by using Professor Tom Fletcher's group's techniques for high-dimensional data analysis to explore the Allen Human Brain Atlas gene expression data, which consists of nearly 60,000 gene probes sampled for each of almost 1,000 brain regions. After reprocessing the expression data, the data was loaded into the iCorrPlot visualization tool developed by Miriah Meyer's group, in collaboration with SCI alum Sam Gerber. This tool allowed the team to look at the correlation of gene expression profiles across brain regions and the correlation of spatial brain location across gene probes. Finally, the team was able to display the data colored by principal component level overlaid on a brain MR image.

On the third day of the contest, the teams presented their preliminary findings to the judges. That evening, two finalists were chosen for each of the three challenges. The finalists had until noon the next day to prepare any new results for presentation. Wei, Sean and Kris repeated the analysis for a second brain in order to compare the expression profiles across multiple brains. The team then rapidly identified a way to combine the data from both brains within the same visualization to enable direct comparisons.

This project is a great example of collaboration between two of our main strengths at the SCI Institute: image/data analysis and visualization.

A list of winners for all three challenges and links to their presentations can be found on the hackathon blog.

Awards and Acknowledgements

SCI Institute Director Chris Johnson has been elected as a member of the Computing Research Association (CRA) Board of Directors. Johnson's three-year term on the board began July 1, 2013. CRA's mission is to strengthen research and advanced education in the computing fields, expand opportunities for women and minorities, and improve public and policymaker understanding of the importance of computing and computing research in our society. The CRA Board of Directors is made up of distinguished computing researchers in academia and industry and members are elected by their peers.

Congratulations to SCI faculty member Ross Whitaker who was recently selected to serve on the Computing Research Association's (CRA) Computing Community Consortium (CCC). The goal of the CCC is to catalyze and empower the U.S. computing research community to pursue audacious, high-impact research. Dr. Whitaker will serve a three-year term on the consortium.

Guido Gerig received a gift from the H. Harold Burton Foundation for his research in autism. The R. Harold Burton Foundation strives to continue R. Harold Burton's legacy of service by supporting educational, scientific, literary, and health projects in the greater Salt Lake Metropolitan area. Find out more at www.rharoldburton-foundation.org. The gift will sponsor an undergraduate student to process, analyze, and qualify MRI images of infants participating in an autism clinical trial. At the SCI Institute, we believe exposing young undergraduate students to important research ideas and projects is critical to the motivation of the next generation of researchers and this program exemplifies that belief.

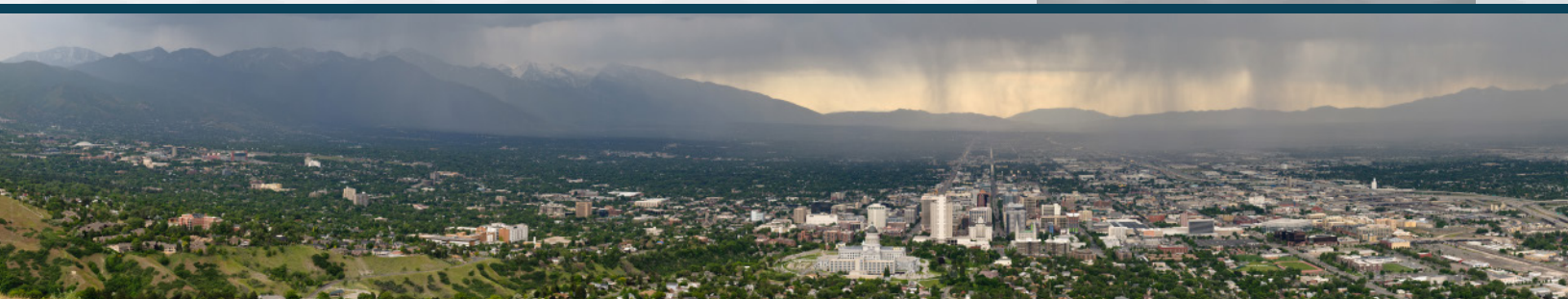
Miriah Meyer presented at the TED2013: The Young. The Wise. The Undiscovered. All of the 2013 TED Fellows joined this year's week of ideas, connections, and fresh TED Talks, in Long Beach, California in February 2013.

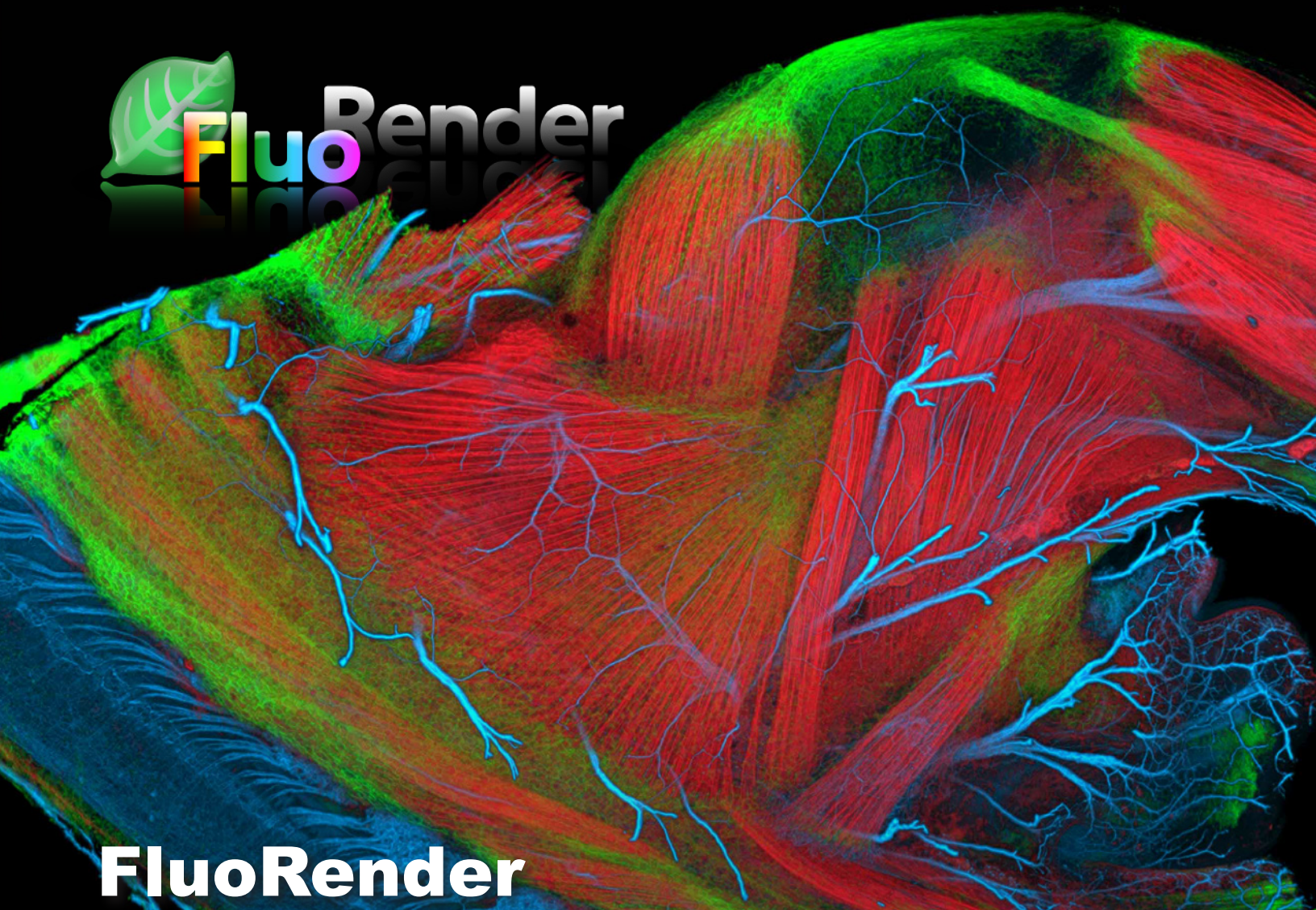
Best Paper Awards

H. Bhatia, G. Norgard, V. Pascucci, P.-T. Bremer. "*The Helmholtz-Hodge Decomposition - A Survey*," In IEEE Transactions on Visualization and Computer Graphics (TVCG), Vol. 19, No. 8, pp. 1386-1404. Selected as the Spotlight paper for IEEE Transactions on Visualization and Computer Graphics (TVCG) August 2013 issue. The paper surveys the use of the Helmholtz-Hodge Decomposition in modeling flow phenomena in various fields of science and addresses the problem of the fragmented nature of research in this area. The goal of this paper is to promote further research in the field by creating a common repository of HHD techniques and assemble a large collection of example applications in a broad range of areas. See: TVCG August 2013.

S. Philip, B. Summa, J. Tierny, P.-T. Bremer, V. Pascucci. "*Scalable Seams for Gigapixel Panoramas*," in Proceedings of the 2013 Eurographics Symposium on Parallel Graphics and Visualization, pp.25-32. Best Paper at the 2013 Eurographics Symposium on Parallel Graphics and Visualization. The paper presents a fast and efficient method for blending seams between images in very large panoramas composed of mosaics of smaller images. While current methods may take many hours (or even days) to blend the images composing a gigapixel panorama, the new method takes just a few minutes.

M. Schott, T. Martin, A.V.P. Grosset, S.T. Smith, C.D. Hansen. "*Ambient Occlusion Effects for Combined Volumes and Tubular Geometry*," In IEEE Transactions on Visualization and Computer Graphics (TVCG), Vol. 19, No. 6, pp. 913-926. Selected as the Spotlight paper for June 2013 issue of IEEE Transactions on Visualization and Computer Graphics (TVCG). This publication made the cover of the issue. The paper details a method for interactive direct volume rendering that computes ambient occlusion effects for visualizations that combine both volumetric and geometric primitives, specifically tube-shaped geometric objects representing streamlines, magnetic field lines, or DTI fiber tracts. See: TVCG June 2013.





FluoRender

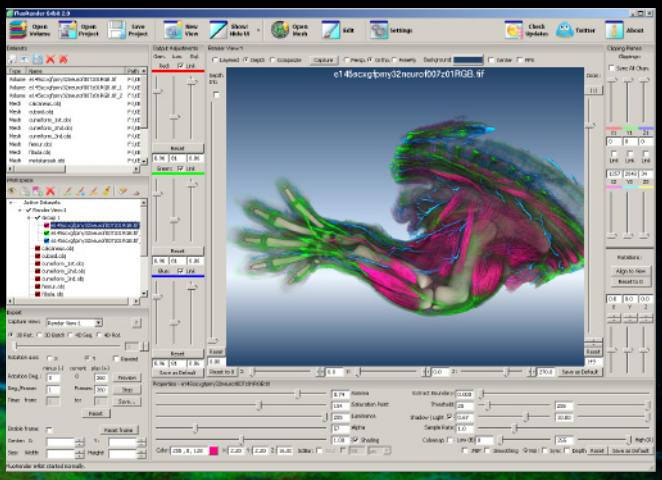
Interactive rendering tool for confocal microscopy data visualization

Confocal microscopy has become a popular imaging technique in biology research in recent years. It is used to study three-dimensional (3D) structures of biological samples. Confocal data is commonly multichannel, with each channel resulting from a different fluorescent stain. This technique is able to resolve finely detailed structures, such as neuron fibers, in 3D. Despite the plethora of volume rendering techniques that have been available for many years, there is a demand from biologists for a flexible tool that allows interactive visualization and analysis of multichannel confocal data. This demand prompted biologist Chi-Bin Chien (Faculty, Department of Neurobiology and Anatomy, deceased in 2011) and his Post Doctoral Fellow Hideo Otsuna to partner with SCI Institute faculty member and Associate Director Charles Hansen and his graduate student Yong Wan (graduated May 2013) in the design and development of the software package Fluorender. FluoRender incorporates volume rendering techniques such as multi-dimensional transfer functions and multi-channel intermixing. Rendering results can be enhanced through tone-mappings and overlays. To facilitate analyses of confocal data, FluoRender provides interactive operations for extracting complex structures.

The FluoRender project resulted in an NIH award - Fluorender: An Imaging Tool for Visualization and Analysis of Confocal Data as Applied to Zebrafish Research, R01-GM098151-01. FluoRender is an interactive tool built upon a slice-based volume rendering kernel. FluoRender is capable of reading multiple channels of confocal volumes with a variety of formats, rendering and mixing channels with different modes, applying 2D image space enhancements, playing back time-sequence confocal data, extracting structures by painting on the volume-rendered results, and visualizing polygon models from those extracted structures along with volumetric data. Despite offering many integrated functionalities, the design of FluoRender provides usability and intuitiveness to its users. FluoRender has been freely available for four years and has seen many applications in biological research.

Confocal microscopy often focuses on extraction and comparison of geometric and topological properties of fine structures. FluoRender's advanced visualization capabilities facilitate qualitative analysis of confocal microscopy data, but quantitative analysis typically requires extracting and measuring important features. For this reason, the Fluo-

Render team added interactive segmentation functions to the software package. FluoRender uses morphological diffusion for region-growing. This method generates stable results for confocal data in real-time. Furthermore, Fluorender's interaction scheme explores the visualization capabilities of our existing confocal visualization pipeline and lets users paint directly on volume rendering results and select desired structures. A close integration of visualization and segmentation techniques within one tool allows users to extract structures of interest from their visualization workflow. In turn, segmentation further improves visualization results by removing occluding structures or emphasizing important structures.

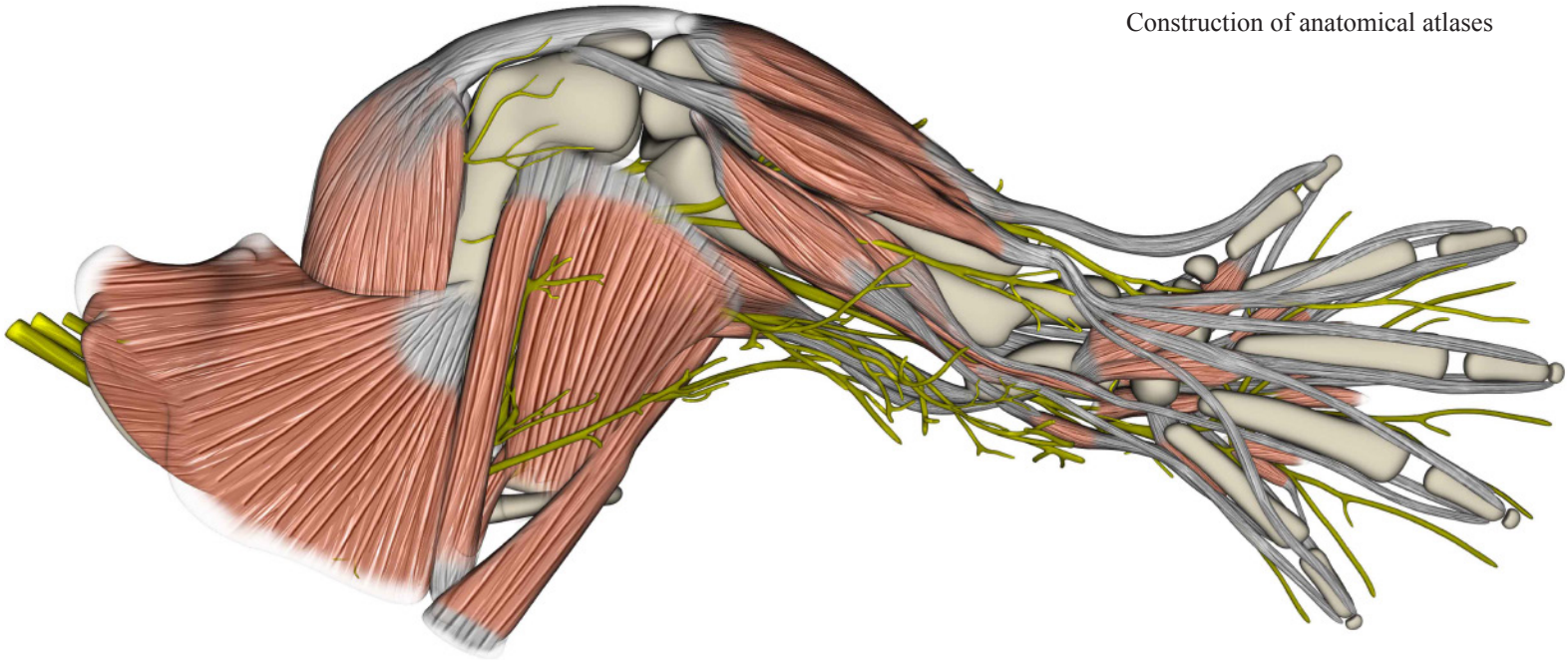


Segmentation and analysis of confocal microscopy data: Interactive extraction of biological structures from confocal microscopy data.

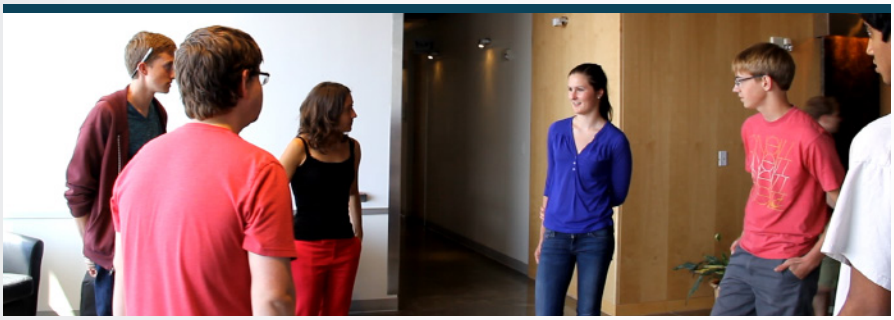
Beyond visualization and quantification, the FluoRender team has also addressed anatomical atlases. Anatomical atlases of humans and other species are important scientifically for understanding normal anatomy, the development and function of anatomical structures, and for determining the etiology of congenital abnormalities. Unfortunately, it is difficult to rapidly generate atlases, especially those that combine informative content and aesthetic quality. To this purpose the FluoRender team designed a generalized workflow capable of generating anatomical atlases from confocal microscopy scans. FluoRender is used in a workflow adapted from a computer graphic (CG) artist's workflow that builds 3D models for animated films and video games, along with artists' tools such as Maya and Mudbox. Yong Wan worked closely with biologists and artists during the development of this capability. The atlas workflow, as applied to a mouse model, starts with the acquisition of confocal scans of mouse limbs, which are visualized using FluoRender's rendering pipeline. Structures such as muscles, tendons, bones, and nerves are then extracted using FluoRender's interactive segmentation functions. The modeling process of the workflow first converts segmented volume data into coarse polygon models, and then these polygon models are processed with shrink-wrap simulations, which generate smooth and well-structured models. It is also fairly easy to unwrap the texture coordinate of these simulated models. A digital painting package is then used to transcribe textures from confocal scans to the polygon models. Finally, FluoRender is used for the presentation of the finished atlases. An example of the limbs of 14.5-day mouse embryos is shown below.

Yong Wan, Ph.D.
Ph.D. Dissertation: "Fluorender, an Interactive Tool for Confocal Microscopy Data Visualization and Analysis."
Advisor: Charles Hansen, Ph.D. Associate Director, SCI Institute

Construction of anatomical atlases



Student Internships



High School Internships

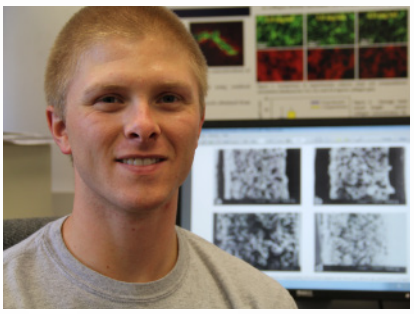
Four high school students from Juan Diego, Waterford, and West High, in the Salt Lake area, have joined the SCI Institute for a summer project, working with James Hughes, a software developer from the Center for Integrated Biomedical Computing (CIBC). The students are learning how to use Seg3D and ImageVis3D, two software tools developed by CIBC and available on the SCI Institute website. Using a data set of their choice, they are experimenting with the software on a desktop and then transferring the data to an iPad. They will present a summary of their experiences to their classmates when they return to school in September. We would like to offer this program again next summer.

Wathsala Nayomi
Los Alamos National Laboratory

"I was working as an intern at the Data Science at Scale Team in Los Alamos National Laboratory (LANL) during this summer. This is my second internship at LANL, and I was mainly continuing my earlier research done at the lab. My research is implementing a data-parallel friend-of-friends halo finding operator in PISTON, which is a portable framework intended for implementing visualization and analysis operators. A halo is a feature of interest found in cosmology data, and I am focusing on implementing an efficient and scalable data-parallel halo finding operator. To achieve this, I make use of merge trees, a topological data structure. A merge tree is a data structure in the area of topology that is capable of encoding a large set of features and simplifications for a wide range of feature parameters. Thus I am able to effectively store and extract the halo and its statistics for a range of values. The internship was a really enjoyable and interesting time. You get to interact with a lot of different people, and the internship allows you to expand your horizons."

Shusen Liu
Lawrence Livermore National Laboratory

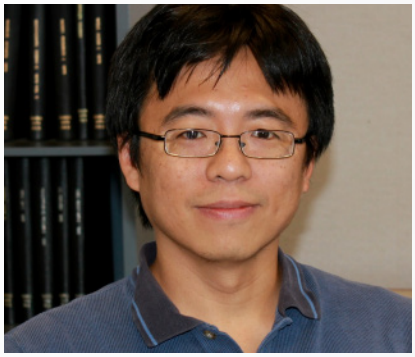
"During the summer, I worked at Lawrence Livermore National Laboratory (LLNL) on the coupled CT segmentation of industrial CT images project. We are interested in coupling the reconstruction phase with the segmentation phase. We proposed an flexible/fuzzy segmentation representation that can be used for the detection phase. In our scheme, the fuzzy segmentation is represented as a connected multi-hierarchy. One of the key components in this project is a reliable initial segmentation algorithm that over-segments the domain to help identify all the object boundaries we may be interested in later in the pipeline. During the internship I was working toward this goal by adopting superpixel segmentation to our CT dataset. LLNL provides an excellent place to learn. Even though the project I worked on this summer is not exactly correlated with my current research at school, it did provide a great opportunity to expand my experience into a broader area."



Jared Zitnay
Undergraduate student at Michigan University, SCI Summer Internship

"This summer I have had the opportunity to come to the SCI Institute and work in the Musculoskeletal Research Laboratories (MRL) as an undergraduate intern. Under the guidance of Drs. Weiss, Ellis, and Reese, I have been working to develop physical surrogates for multiscale characterization and validation of a multiscale finite element framework for connective tissues. The variety of components involved in developing these physical surrogates has provided great exposure to the experimental side of computational biomechanics, from making simple collagen hydrogels to the development and manufacture of laboratory apparatus. Although it may not have been a primary objective, my summer here at the MRL has also given me the opportunity to explore and enjoy all the Salt Lake area has to offer in the summer months. The ability to participate in full-time research in the academic environment and spend an extended time in the area has been and will continue to be invaluable in the process of applying to and selecting a graduate program. Websites and short visits aid in learning about the programs available, but the opportunity to spend three months in a lab fully exposes the culture of a lab, the breadth of research being conducted, and some often overlooked aspects of a program such as the recreation opportunities and lifestyle of the surrounding area."

Alumni Highlight



Han-Wei Shen
P.h.D. in Computer Science, '98
Professor, Computer Science, The Ohio State University

Han-Wei Shen is among the very first SCIers. He began his doctoral work under Prof. Chris Johnson before the institute was even named. He received his B.S. degree from the Department of Computer Science and Information Engineering at the National Taiwan University in 1988, his M.S. degree in Computer Science from State University of New York at Stony Brook in 1992 (under Prof. Arie Kaufman), and his Ph.D. in Computer Science from the University of Utah in 1998 (Dissertation: High-Performance Visualization Algorithms for Large-Scale Scientific Data. Advisor: Chris Johnson). He worked at NASA Ames Research Center in California from 1996 to 1999, where he was a research scientist in NASA's Advanced Supercomputing Division (NSA). Dr. Shen is currently a full professor in the Department of Computer Science and Engineering at the Ohio State University. He is also the head of the Graphics and Visualization Study (GRAVITY) research group.

Professor Shen's research focus is primarily on scientific visualization and computer graphics. For the past two decades, he has been tackling several fundamental problems in the core area of scientific visualization. His best known works include acceleration of isosurface extraction, steady and unsteady flow visualization techniques, algorithms and data structures for the analysis and visualization of time-varying multivariate data sets, information visualization, and efficient parallel visualization algorithms. More recently he has pioneered work in developing an information-theoretical framework for quality assessment, management, and visualization of data generated from extreme-scale scientific simulations.

Professor Shen is a winner of the National Science Foundation's CAREER award and the US Department of Energy's Early Career Principal Investigator Award. He also won the Outstanding Teaching Award twice in the Department of Computer Science and Engineering at the Ohio State University. He was an associate editor for IEEE Transactions on Visualization and Computer Graphics, and a paper chair for IEEE Pacific Visualization 2009 and 2010. He currently serves as a paper chair for IEEE SciVis 2013, one of the main conferences under IEEE Visualization 2013. He has directed many federally funded research projects by DoE, NSF, NIH, and NASA. He continues to collaborate with SCI institute faculty members, including Chris Johnson, Chuck Hansen, and Valerio Pascucci.

www.sci.utah.edu/people/alumni

Join Us at

- **Medical Image Computing and Computer Assisted Intervention.**
September 22-26, Nagoya, Japan.
Sarang Joshi and Tom Fletcher are co-organizing the Mathematical Foundation of Computational Anatomy workshop, devoted to statistical and geometrical methods for modeling the variability of biological shapes (www-sop.inria.fr/asclepios/events/MFCA13). The DTI Tractography Challenge is being co-organized by Guido Gerig (dti-challenge.org).

- **Biomedical Engineering Society (BMES) 2013 Annual Meeting Track on Bioinformatics, Computational and Systems Biology.**
September 25-28, Seattle, WA.
This year's track is organized and chaired by Orly Alter. The theme is discovery from mathematical modeling of large-scale biomedical data. This multidisciplinary and international track features a record 11 platform sessions and more than a 100 posters by bioengineers, computer scientists, electrical engineers, mathematicians, medical researchers, and physicists from 16 countries (bmes.org).

- **Vis2013, October 13-18, Atlanta, Ga.**
The SCI Institute will again host a booth at Vis2013. The SCI Institute will present its latest research projects in Bio-, Info-, Uncertainty Visualization as well as software tools demos (ieeevis.org).

Where is SCI Presenting Next?

- Current Challenges in Computing 2013: Biomedical Research, September 3, Napa, CA.
- International Conference on Image Processing (ICIP), September 15-18, Melbourne, Australia.
- Biomedical Visual Analysis, September 20, NIH NLM Workshop, Woods Hole.
- International Conference in Medical Image Computing and Computer Assisted Intervention (MICCAI), September 22-26, Nagoya, Japan.
- Computing in Cardiology, September 22-25, Zaragoza, Spain.
- Image-Based Biomedical Modeling, Simulation, and Visualization, September 27, BMES 2013, Seattle, WA.
- International Meshing Roundtable conference organized by Sandia National Laboratories, October 13-16, Orlando, FLA.
- IEEE Vis 2013, October 13-18, Atlanta, GA.
- Large-Scale Visual Analysis, October 29, High Performance Computing, China, Guilin.
- SC2013, November 17-22, Denver, CO.

SCI Distinguished Lectures

- George Spirou: Structural Dynamics of Developing Neural Circuits at Nanoscale Resolution.
- Alfio Quarteroni: The Challenge of Complexity in Numerical Simulations.
- James E. Ferrell: Bistability and Trigger Waves in Mitosis.
- Tamara Munzner: Dimensionality Reduction From Several Angles.
- Xavier Pennec: The Stationary Velocity Field Framework for Modeling the Progression of Alzheimer's Disease.
- Danny Alexander: Microstructure Imaging with Diffusion MRI.
- Michael Goodchild: Communicating Geospatial Uncertainty.

More in 2013

- Oct 4: Matt Scott - Stanford University.
- Oct 11: Tinsley Oden - University of Texas, Austin.
- Nov 8: Mark Ainsworth - Brown University

You can find all SCI Events at:
www.sci.utah.edu/the-institute/events

Attendees unwind at Keys on Main after CMBBE

New SCI Staff and Students in 2013

- John Edwards
  Post Doctoral Fellow
  Dr. Pascucci / Dr. Johnson
- Shireen Elhabian
  Post Doctoral Fellow
  Dr. Whitaker / Dr. Gerig
- Alyson Froehlich
  Research Associate
  Dr. Fletcher
- Amy Gooch
  Research Computer Scientist
  Dr. Pascucci / CEDMAV
- Haya Gur
  Computer Professional
  Dr. Jones
- Hadi Meidani
  Post Doctoral Fellow
  Dr. Kirby / Dr. Berzins
- Mahsa Mirzargar
  Post Doctoral Fellow
  Dr. Kirby / Dr. Whitaker
- Hoa Nguyen
  Graduate Research Assistant
  Dr. Kirby
- Joseph Peterson
  Graduate Research Assistant
  Dr. Berzins
- Shawn Reese
  Research Associate
  Dr. Weiss / MRL

Sabbaticals

Guido Gerig (Professor of Computer Science and SCI Institute Associate Director) will spend his sabbatical at McGill University, Montreal. He will be collaborating with the Montreal Neurological Institute (MNI) directed by Prof. Alan Evans and the School of Computing Centre for Intelligent Machines, led by Prof. Kaleem Siddiqi.

Sarang Joshi (Associate Professor of Bioengineering) will spend the coming year on sabbatical with the Imaging Group, at the Department of Computer Science, University of Copenhagen. Sarang will be collaborating with Mads Nielse's group on Medical Image Processing.

Conference Organization

Jeff Weiss chaired the **11th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering (CMBBE)** held for the first time in the United States in Salt Lake City, Utah, in April 2013. The meeting was hosted by the University of Utah and the SCI Institute. CMBBE is a leading international symposium on computational biomechanics that promotes international collaborations and networking. The four-day meeting welcomed 250 participants from well-known research groups, commercial companies, and scientific organizations.

Visit: cmbbe13.sci.utah.edu

Sarang Joshi co-chaired the **23rd biennial International Conference on Information Processing in Medical Imaging (IPMI 2013)** with Kilian Pohl and Sandy Wells. The conference was held at the Asilomar Conference Center, in California on June 28 - July 3, 2013. This conference was the latest in a series where novel developments in the acquisition, formation, analysis and display of medical images are presented, discussed, dissected, and extended. During the last three decades, IPMI has evolved with the medical imaging community it serves. Today IPMI is widely recognized as one of the preeminent international forums for presentation of leading-edge research in the medical imaging field.

Visit: ipmi2013.ipmi-conference.org.

Asilomar, CA. Home to IPMI 2013

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