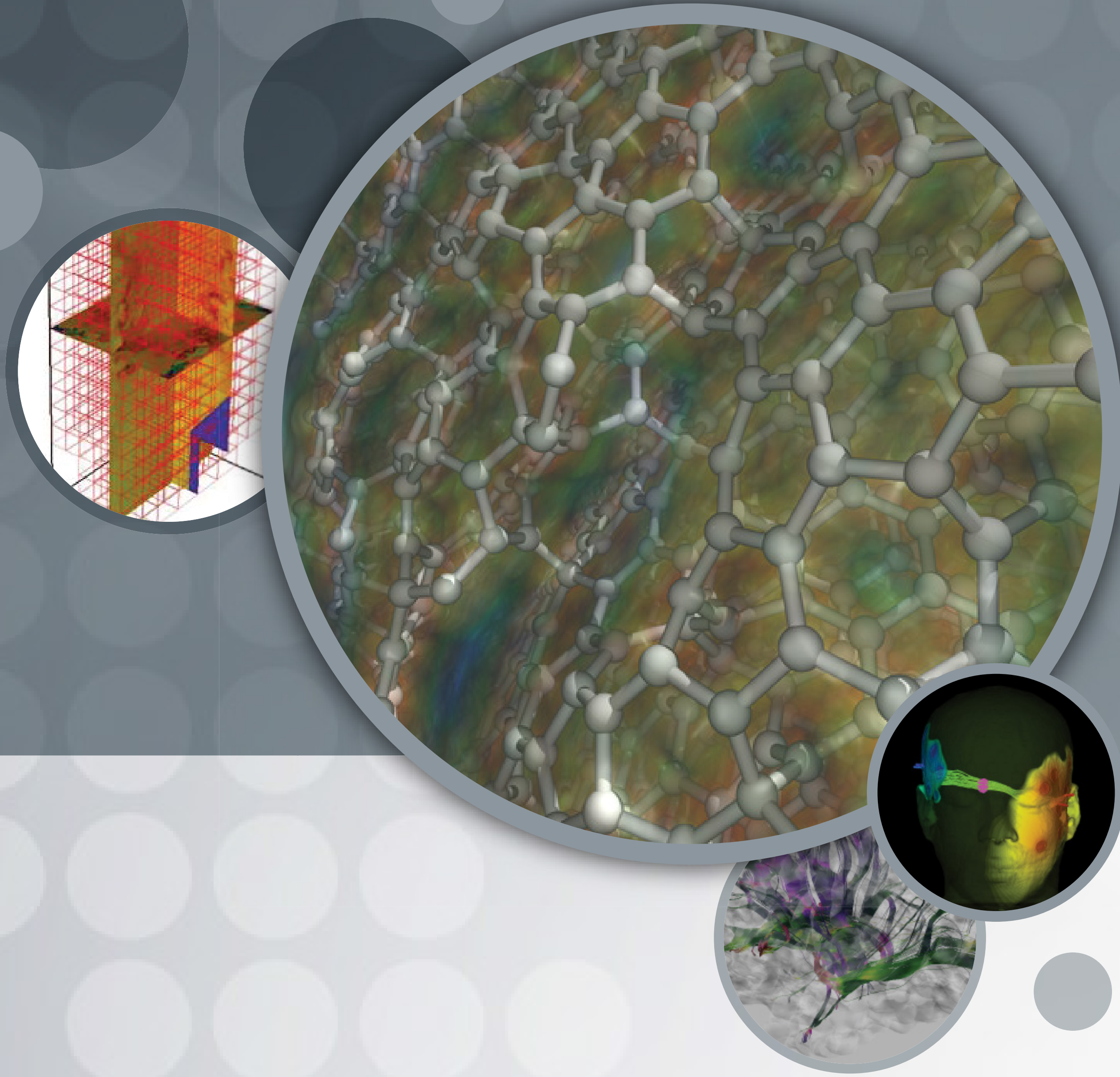


SCIENTIFIC COMPUTING AND IMAGING INSTITUTE

University of Utah

SCI

www.sci.utah.edu

Scientific Computing and Imaging Institute

The SCI research group was founded in 1994 by Drs. Chris Johnson and Rob MacLeod along with five graduate students. In 1996, they became the Center for Scientific Computing and Imaging and in 2000, the SCI Institute. The Scientific Computing and Imaging (SCI) Institute is now one of eight permanent research institutes at the University of Utah and home to over 200 faculty, students, and staff. The 16 tenure-track faculty are drawn primarily from the School of Computing, Department of Bioengineering, Department of Mathematics, and Department of Electrical and Computer Engineering, and virtually all faculty have adjunct appointments in other, largely medical, departments. Recent growth in the SCI Institute has come in part from the award in 2007 from the state of Utah of a USTAR (Utah Science and Technology Advanced Research) cluster in Imaging Technology. This allowed the Institute to recruit three new faculty in image analysis: Professors Guido Gerig, Tom Fletcher, Tolga Tasdizen. During this same time period, they were also able to recruit Professor Valerio Pascucci in visualization. In 2011, USTAR funding allowed two more: Orly Alter who specializes in genomic signal processing and Miriah Meyer, who's novel biological visualization tools are revolutionizing the way scientists view and understand their data. In 2012, the SCI Institute recruited Dongbin Xiu. Dongbin is one of the most recognized names and highly cited researchers in the area of uncertainty quantification, and has made a wonderful addition to the Institute. 2014 saw the addition of Christopher Butson. Dr. Butson is the Director of Neuromodulation Research and an Associate Professor in the departments of Biomedical Engineering and Neurology & Neurosurgery. In 2015 we added Alexander Lex (information visualization) and Akil Narayan (mathematics) to our faculty team.

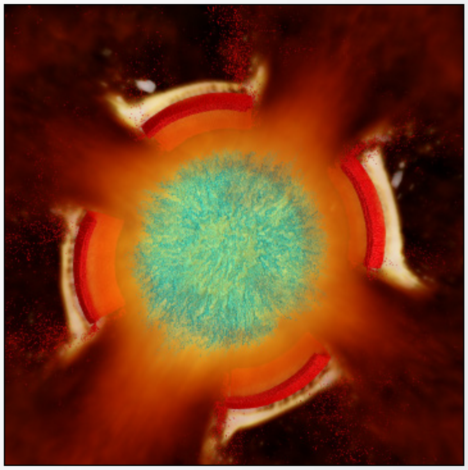
Over the past decade, the SCI Institute has established itself as an internationally recognized leader in visualization, scientific computing, and image analysis applied to a broad range of application domains. The overarching research objective is to conduct application-driven research in the creation of new scientific computing techniques, tools, and systems. An important application focus of the Institute continues to be biomedicine, however, SCI Institute researchers also address challenging computational problems in a variety of application domains such as manufacturing, defense, and energy. SCI Institute research interests generally fall into the areas of: scientific visualization, scientific computing and numerics, image processing and analysis, and scientific software environments. SCI Institute researchers also apply many of the above computational techniques within their own particular scientific and engineering sub-specialties, such as fluid dynamics, biomechanics, electrophysiology, bioelectric fields, parallel computing, inverse problems, and neuroimaging.

A particular hallmark of SCI Institute research is the development of innovative and robust software packages, including the SCIRun scientific problem solving environment, Seg3D, ImageVis3D, VisTrails, ViSUS, and map3d. All these packages are broadly available to the scientific community under open source licensing and supported by web pages, documentation, and users groups.

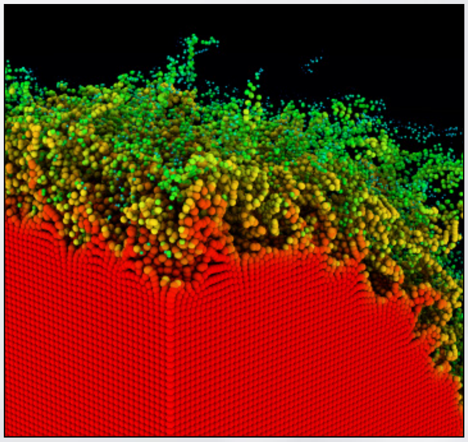
The SCI Institute either directs or is associated with several national research centers: the NIH Center for Integrative Biomedical Computing (CIBC), the DoE Scalable Data Management, Analysis, and Visualization (SDAV), the NIH National Alliance for Medical Image Computing (NA-MIC), the DoE Scientific Data Management Center, the NIH Center for Computational Biology, and the DoE Center for the Simulation of Accidental Fires and Explosions (C-SAFE). In July, 2008, SCI was chosen as one of three NVIDIA Centers of Excellence in the U.S. (University of Illinois and Harvard University are the other two NVIDIA Centers).

Scientific Computing

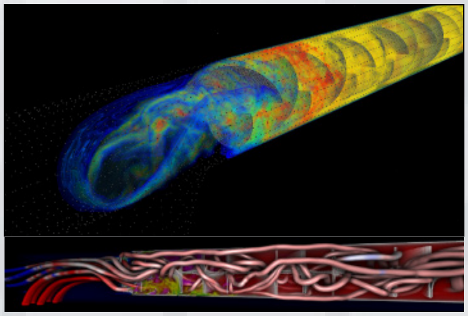
Numerical simulation of real-world phenomena provides fertile ground for building interdisciplinary relationships. The SCI Institute has a long tradition of building these relationships in a win-win fashion – a win for the theoretical and algorithmic development of numerical modeling and simulation techniques and a win for the discipline-specific science of interest. High-order and adaptive methods, uncertainty quantification, complexity analysis, and parallelization are just some of the topics being investigated by SCI faculty. These areas of computing are being applied to a wide variety of engineering applications ranging from fluid mechanics and solid mechanics to bioelectricity.



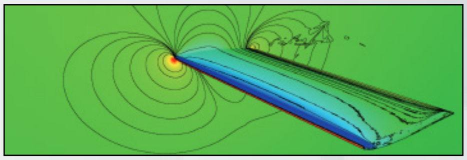
Parametric study of a contained explosive detonation.



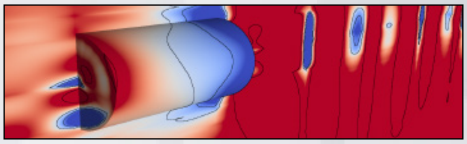
Material Point Method simulation of container heat up with global illumination.



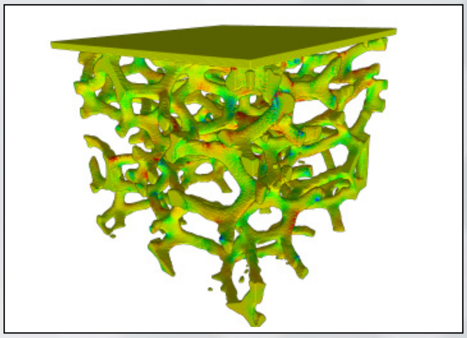
Examples of two chemical mixing simulations within the Uintah Computational Framework.



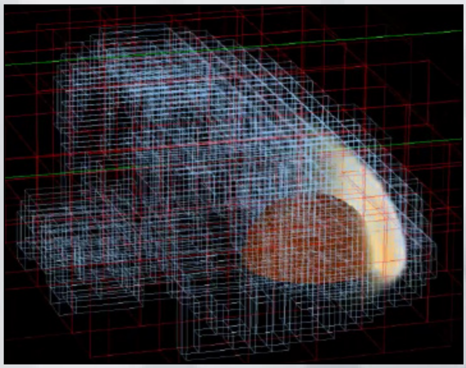
ElVis: A System for the Accurate and Interactive Visualization of High-Order Finite Element Solutions. Shown here is the pressure field on the ONERA M6 Wing.



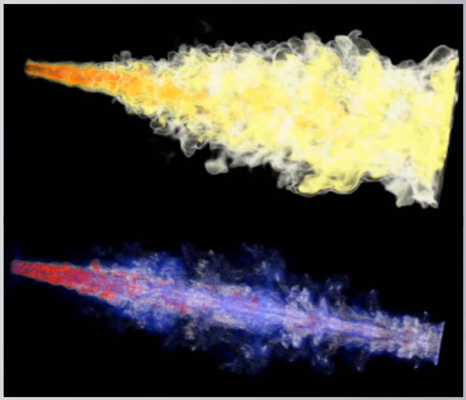
View of the pressure field of a rotating canister moving through an incompressible fluid. A color map of the field, along with contours of constant pressure, have been applied to the cylinder and the cut-plane.



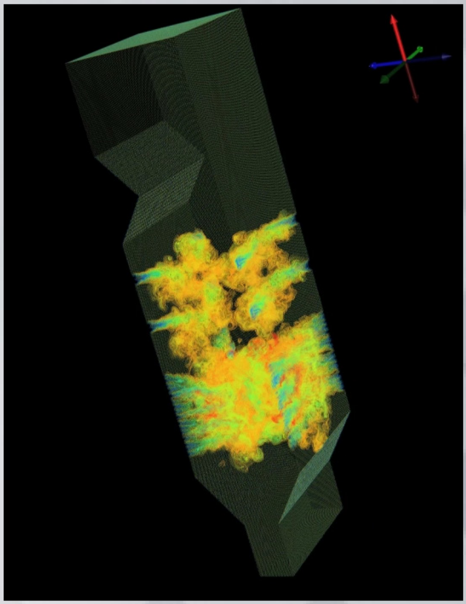
Simulating the stress points during a foam compaction study.



Automatic mesh refinement on the ball shockwave simulation.



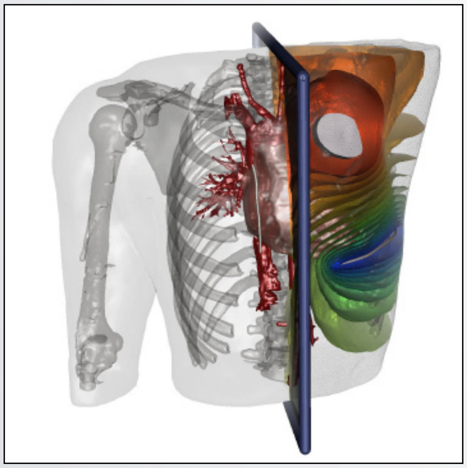
The Uintah Computational Framework is being extended to model various energy technologies from traditional air-fired coal, oxy-fired coal/natural gas, fluidized bed coal combustion and coal gasification to more exotic coal technologies such as chemical looping and under ground thermal treatment.



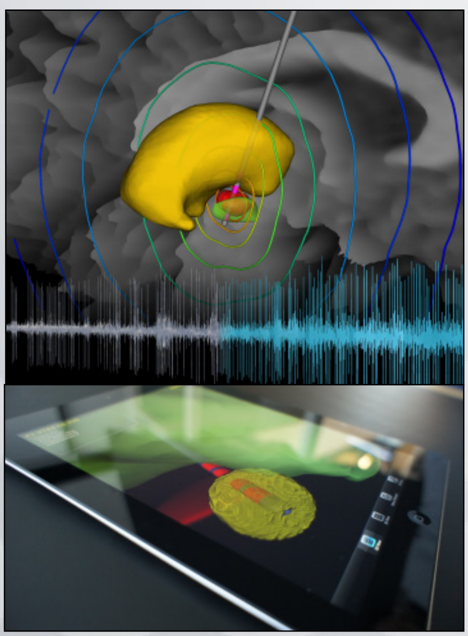
The Carbon-Capture Multidisciplinary Simulation Center (CCMSC) is demonstrating exascale computing with V&V/UQ to more rapidly deploy a new technology for providing low cost, low emission electric power generation to meet the growing energy needs of the U.S.

Biomedical Computing

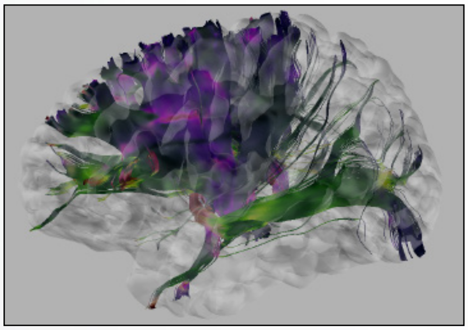
Biomedical computing combines the diagnostic and investigative aspects of biology and medical science with the power and problem-solving capabilities of modern computing. Computers are used to accelerate research learning, simulate patient behavior and visualize complex biological models.



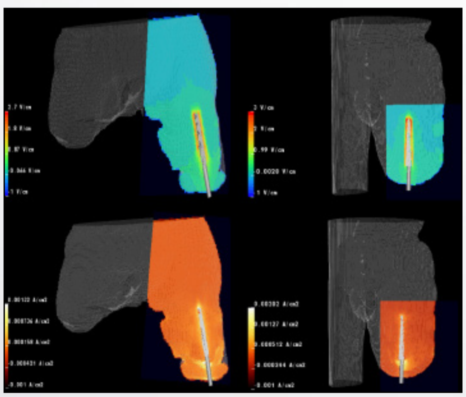
We have developed software to interactively explore novel locations for implantable cardiac defibrillators (ICDs) in children, allowing logical placement of electrodes rather than clinical trial and error.



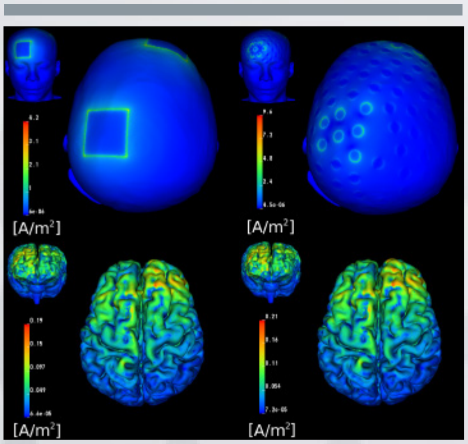
Interactive simulation of electrode placement in deep brain stimulation (DBS). SCI has deployed an interactive visualization system (ImageVis3D Mobile) for experimental use in DBS planning.



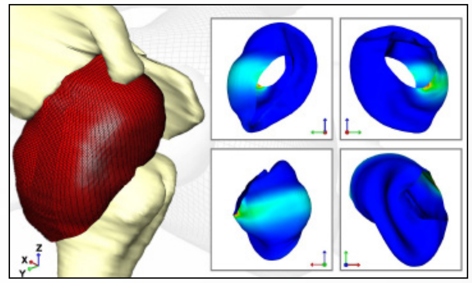
Interactive exploration of large tractography and EEG data for source localization



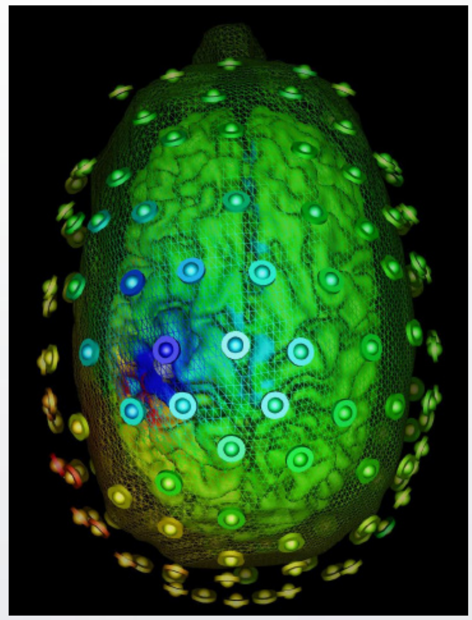
Osseointegration simulation. Electric Field (top) and Current Density (bottom) distributions at the bone-implant interface.



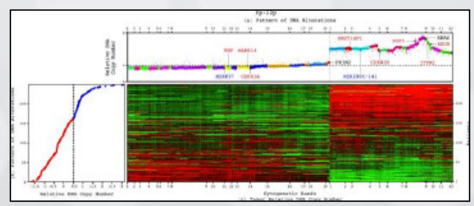
Transcranial DC (electrical) Stimulation of standard and high density electrodes.



Finite element predictions of shoulder capsule strain



Inverse EEG - localizing the source of an epileptic seizure.

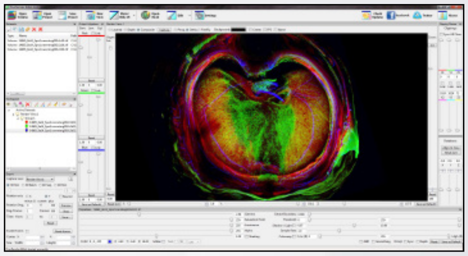


SCI researchers are exploring patterns of DNA copy-number alterations in personalized diagnostic and prognostic tests. These patterns will be used in personalized diagnostic and prognostic pathology laboratory tests.

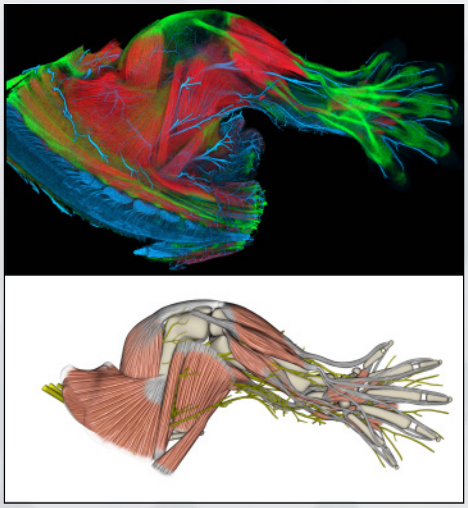
Scientific Visualization

Scientific visualization, sometimes referred to as visual data analysis, uses the graphical representation of data as a means of gaining understanding and insight into the data. Scientific visualization research at SCI has focused on applications spanning computational fluid dynamics, medical imaging and analysis, and fire simulations. Research involves novel algorithm development to building tools and systems that assist in the comprehension of massive amounts of scientific data. In helping researchers to comprehend spatial and temporal relationships between data, interactive techniques provide better cues than noninteractive techniques; therefore, much of scientific visualization research focuses on better methods for visualization and rendering at interactive rates.

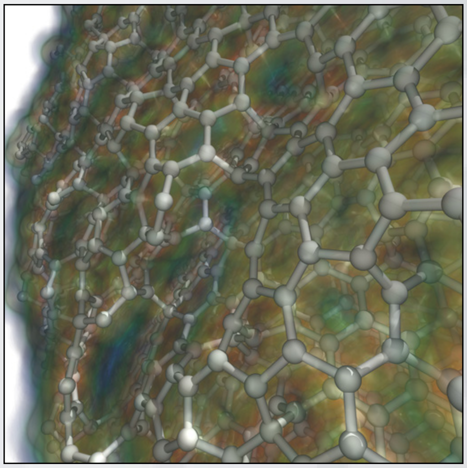
A visualization of a topological analysis and volume visualization of one time step in a large-scale combustion simulation.



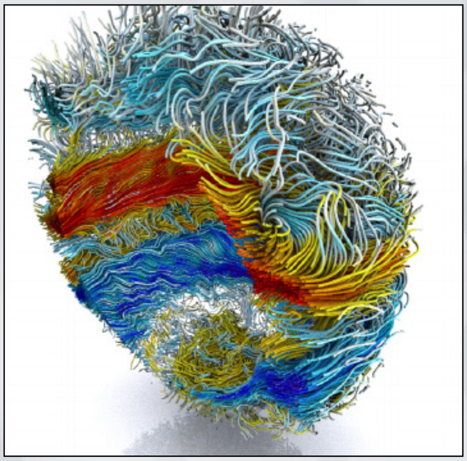
FluoRender is an interactive tool for multi-channel fluorescence microscopy data visualization and analysis. It has been designed especially for neurobiologists.



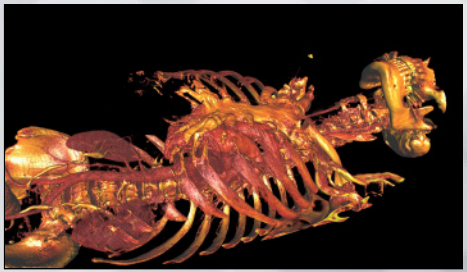
Creating anatomical models from fluorescence microscopy.



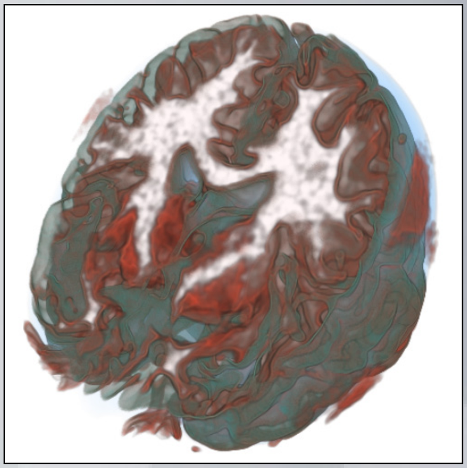
Ray Tracing and Volume Rendering Large Molecular Data. Shown is a small carbon nanosphere (90K atoms) with volumetric lighting and shadows.



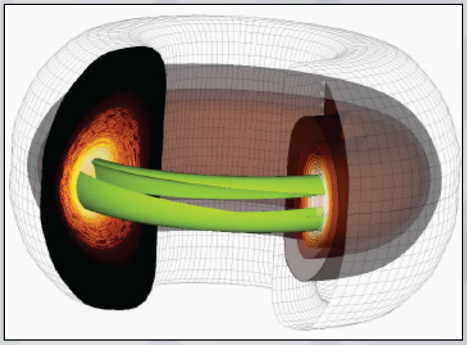
Visualizing the magnetic fields of our sun.



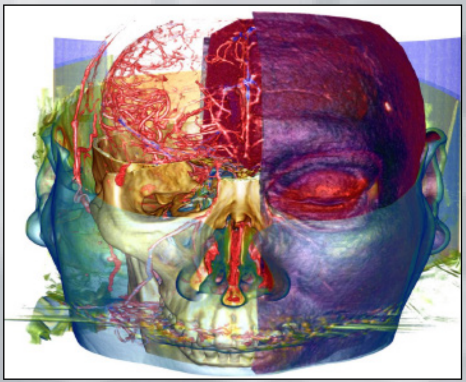
Exploring large data with ImageVis3D.



A visualization of the brain using transfer functions that express the risk associated with classification.



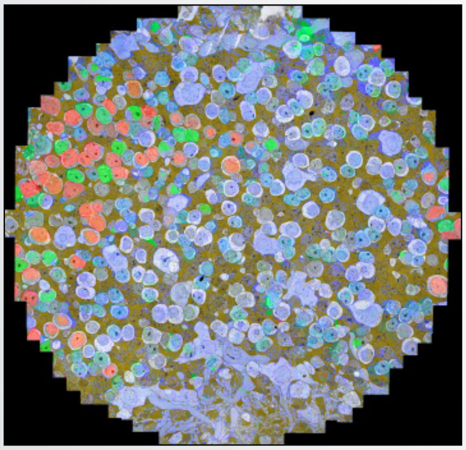
Tokamak fusion visualization. Here we see the magnetic island chain that dominates the inner core of the simulation.



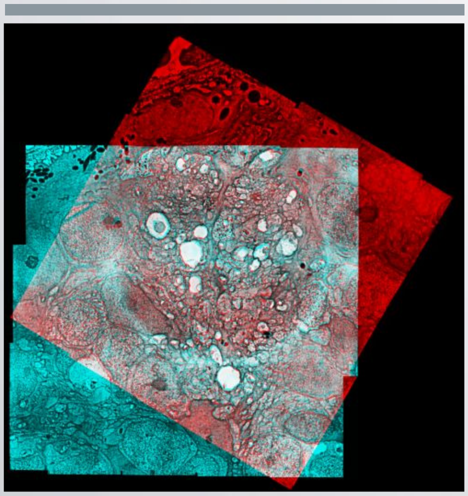
Multi-surface volume rendering.

Image Analysis

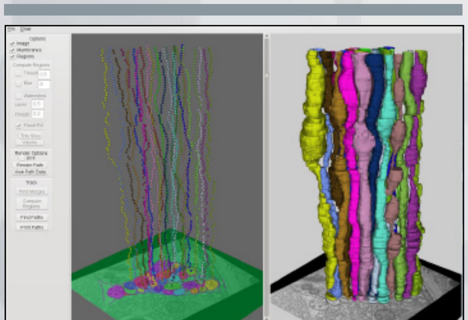
SCI's imaging work addresses fundamental questions in 2D and 3D image processing, including filtering, segmentation, surface reconstruction, and shape analysis. In low-level image processing, this effort has produce new nonparametric methods for modeling image statistics, which have resulted in better algorithms for denoising and reconstruction. Work with particle systems has led to new methods for visualizing and analyzing 3D surfaces. Our work in image processing also includes applications of advanced computing to 3D images, which has resulted in new parallel algorithms and real-time implementations on graphics processing units (GPUs). Application areas include medical image analysis, biological image processing, defense, environmental monitoring, and oil and gas.



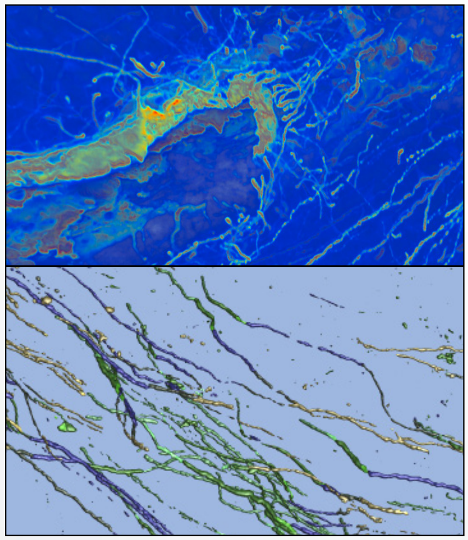
Classification of mosaic slice through the rabbit retina.



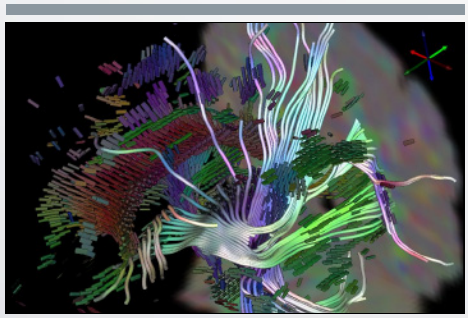
Automatic alignment of TEM images.



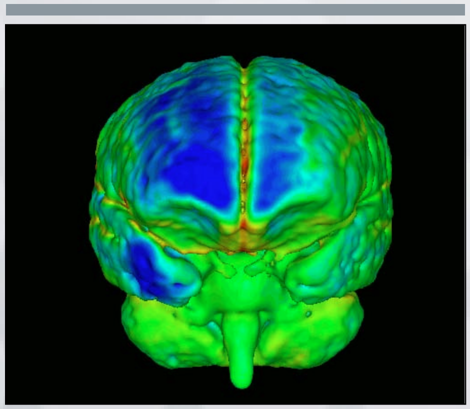
NeRV - automatic detection of non-branching processes in C. elegans.



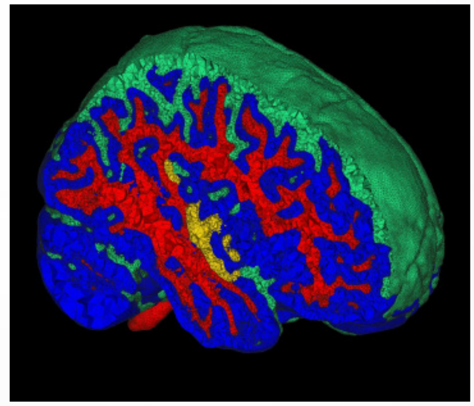
Examples of sthe egmentation of neural pathways with NeuroTracker.



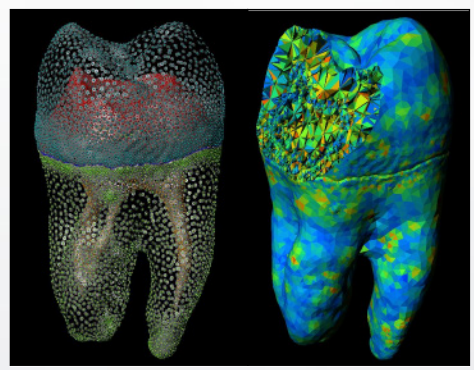
Diffusion tensor imaging with superquadric glyphs.



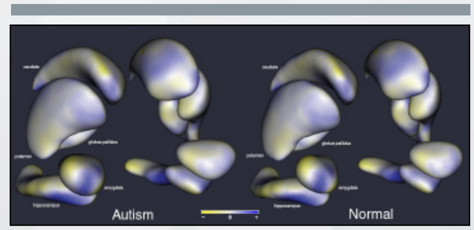
Computational anatomy to assess longitudinal trajectory of brain growth.



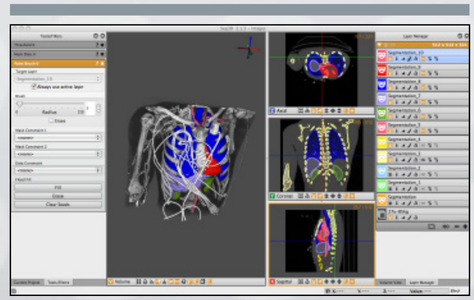
High resolution mesh of the brain.



Particle meshing of a tooth.



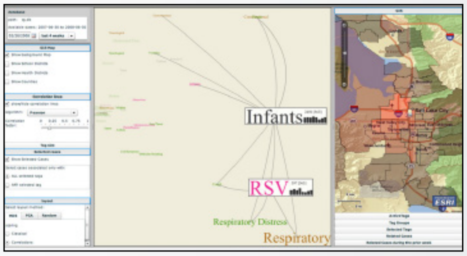
Shape analysis between normal and autistic brains.

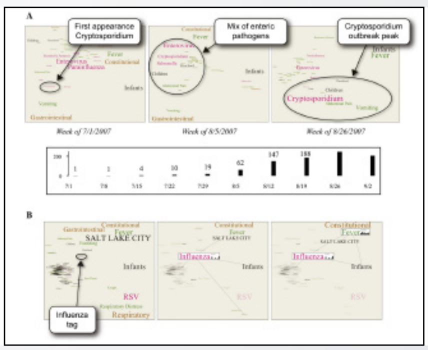


Segmentation and processing with Seg3D.

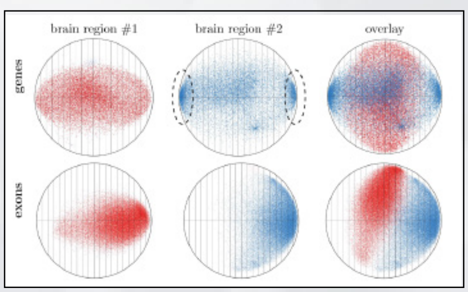
Information Visualization

Information visualization is the study of (interactive) visual representations of abstract data to reinforce human cognition. The abstract data include both numerical and non-numerical data, such as text and geographic information. However, information visualization differs from scientific visualization: "it's infovis [information visualization] when the spatial representation is chosen, and it's scivis [scientific visualization] when the spatial representation is given."

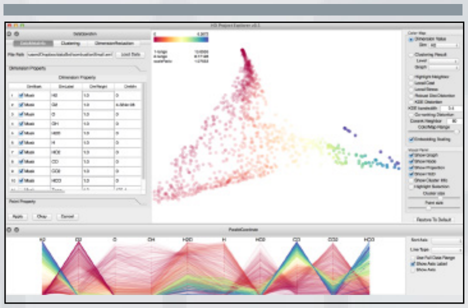




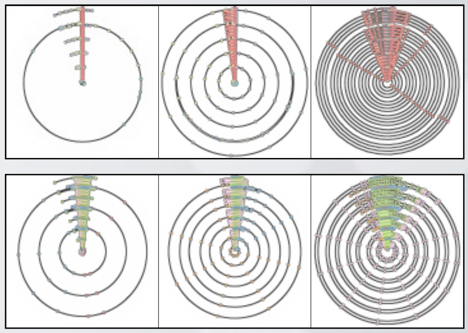
EpiCanvas software environment for monitoring disease spread (top). Time lapse of outbreak (bottom).



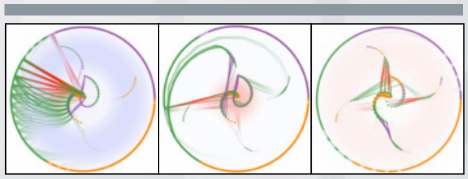
s-CorrPlot: An interactive scatterplot for exploring correlation.



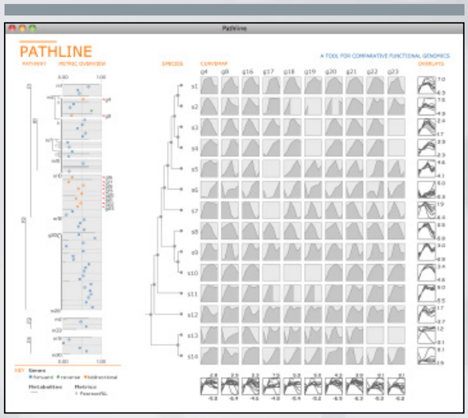
Distortion-guided structure-driven interactive exploration of high-dimensional data.



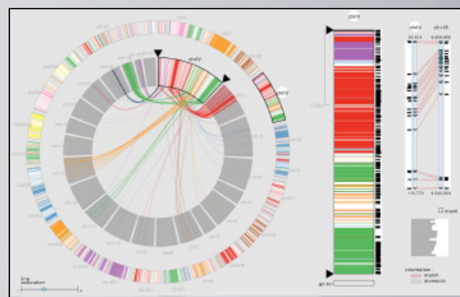
Topological analysis and visualization of cyclical memory reference behavior.



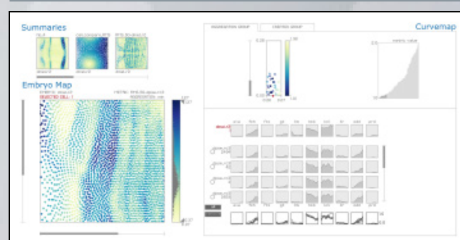
Abstract visualization of runtime memory behavior.



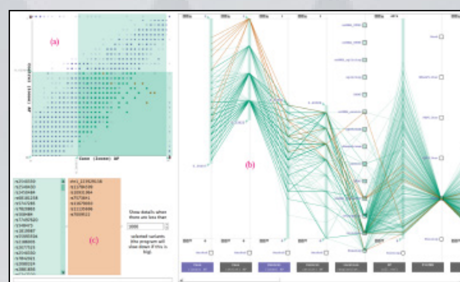
Pathline, a tool for comparative functional genomics.



MizBee, a multiscale synteny browser for genomic comparison.



Multeesum software environment supports inspection and curation of data sets showing gene expression over time.



compreheNGSive. a tool for exploring next-generation sequencing variants.

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