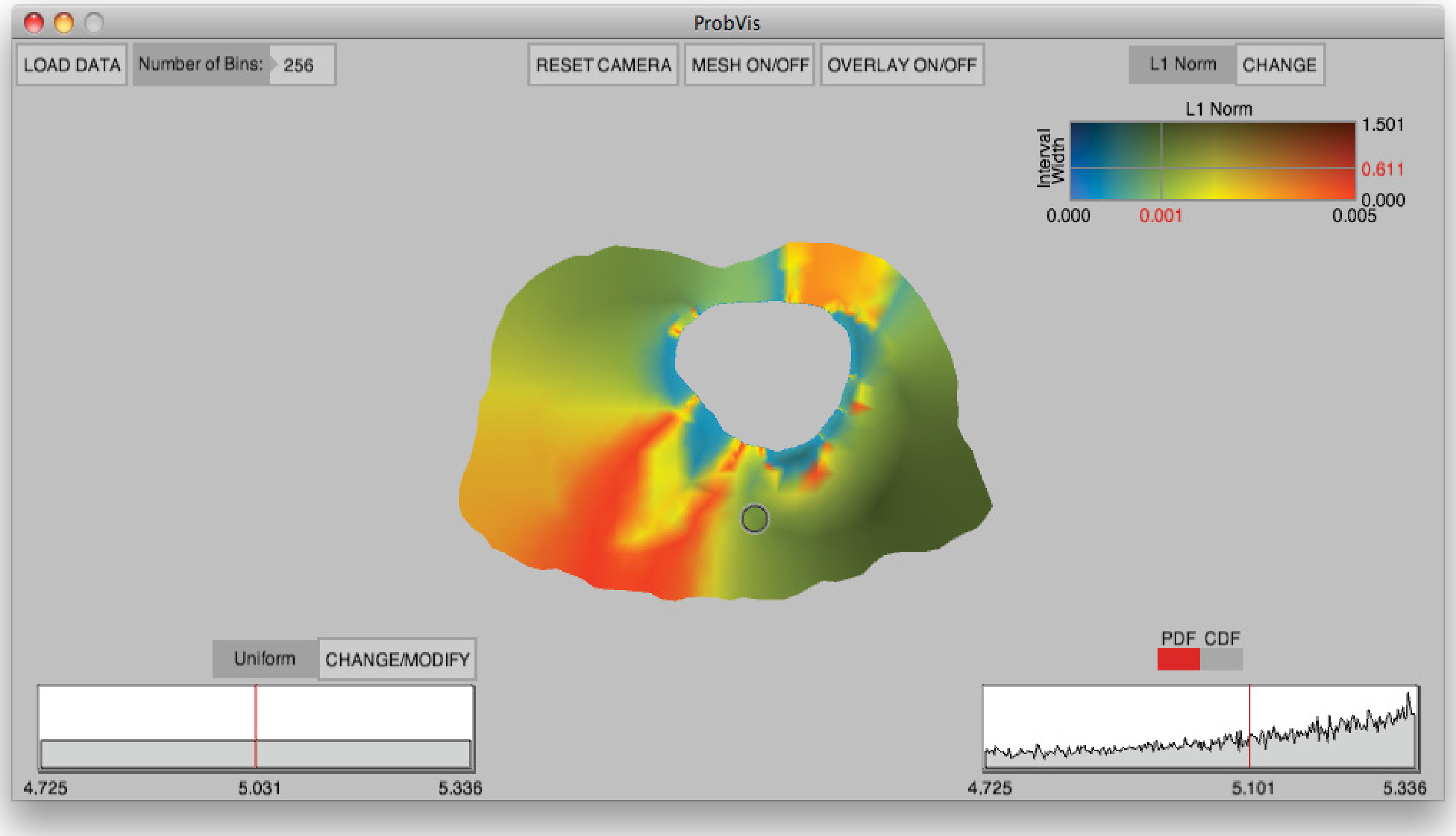
Uncertainty Visualization at SCI

KAUST · NATIONAL INSTITUTES OF HEALTH · DOENETL Unconventional and Renewable Energy Research Utilizing Advanced Computer Simulations · SCI X 2012

Interactive Visualization of Probability and Cumulative Density Functions.

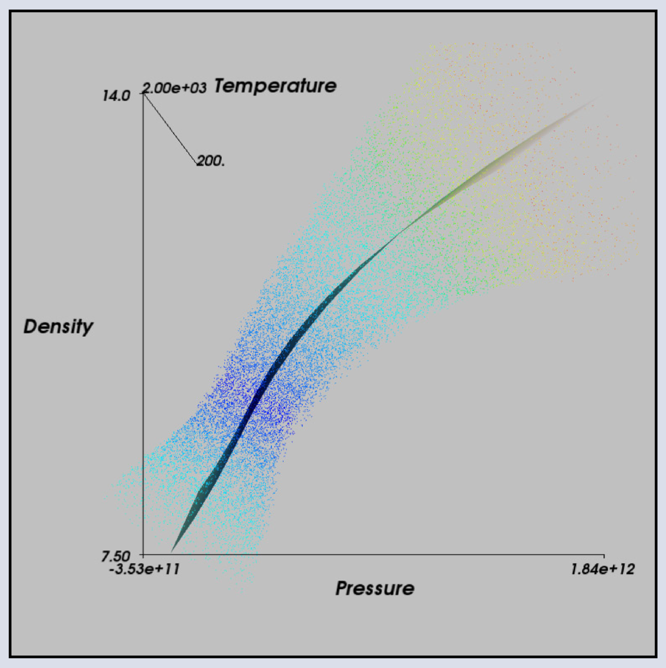
The probability density function (PDF), and its corresponding cumulative density function (CDF), provide direct statistical insight into the characterization of a random process or field. Typically displayed as a histogram, one can infer probabilities of the occurrence of particular events. When examining a field over some two-dimensional domain in which at each point a PDF of the function values is available, it is challenging to assess the global (stochastic) features present within the field. In this paper, we present a visualization system that allows the user to examine two-dimensional datasets in which PDF (or CDF) information is available at any position within the domain. The tool provides a contour display showing the normed difference between the PDFs and an ansatz PDF selected by the user, and furthermore allows the user to interactively examine the PDF at any particular position. Canonical examples of the tool are provided to help guide the reader into the mapping of stochastic information to visual cues along with a description of the use of the tool for examining data generated from a uncertainty quantification exercise accomplished within the field of electrophysiology.

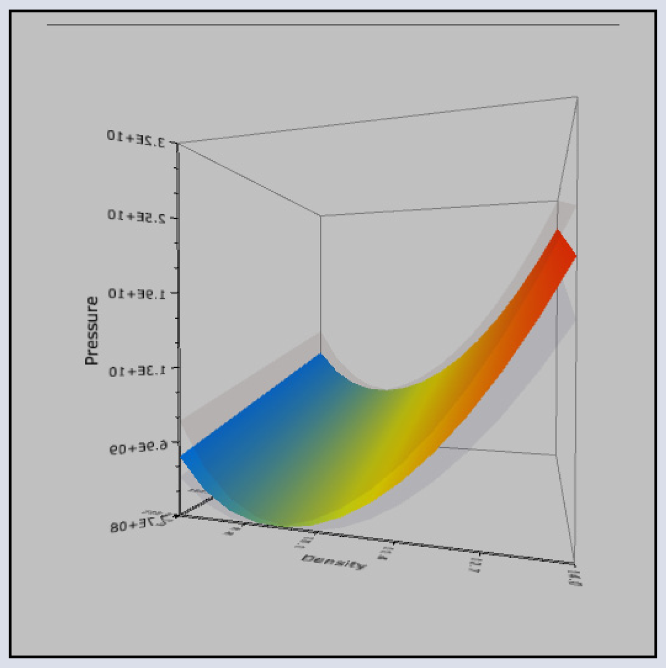


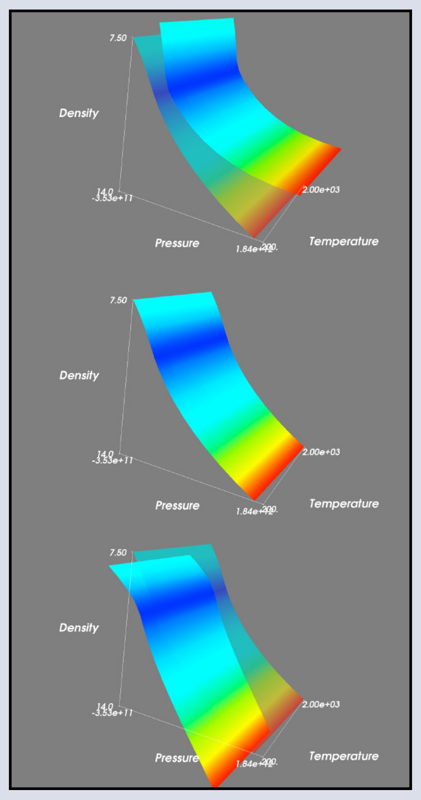
Interactive Visualization of Probability and Cumulative Density Functions. Kristin Potter, Robert M. Kirby, Dong Bin Xiu, and Chris R. Johnson. In International Journal of Uncertainty Quantification. vol. 2, no. 4, pp. 397-395, 2012.

Uncertainty in the Development and Use of Equation of State Models

In this work we performed series of focus groups on the visualization of uncertainty in equation-of-state (EOS) models. The initial goal was to identify the most effective way to present EOS uncertainty to analysts, code developers, and material modelers. Four prototype visualizations were developed, and focus group participants valued particular features of the various techniques for different use cases. All the prototypes presented EOS surfaces in a three-dimensional, thermodynamic space, which was helpful for seeing a large amount of information at once and for a big-picture view. However, participants also desired relatively simple, two- dimensional graphics for a better quantitative view and because these plots are the existing visual language for material models. In the course of the research, several themes and issues emerged that are as compelling as the original goal. In particular, a distributed workflow centered around material models was identified. Participants contribute and extract information at different points in the workflow depending on their role, but institutional and technical barriers restrict the flow of information. Visualization can be help- ful in addressing bottlenecks and improving communication across this workflow.



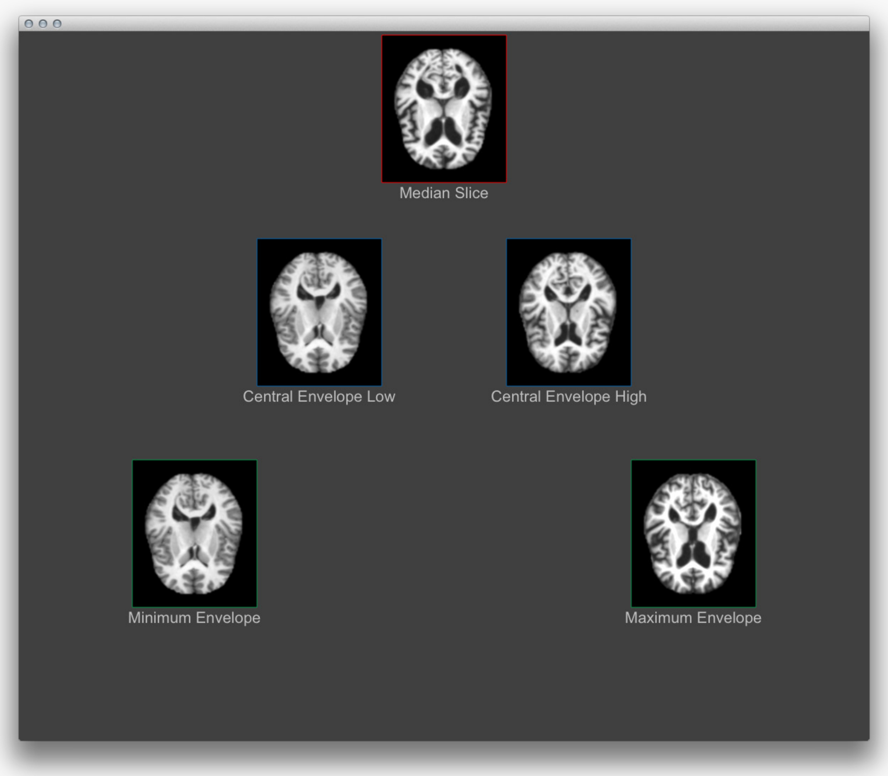




Uncertainty in the Development and Use of Equation of State Models. V.Gregory Weirs, Nathan Fabian, Kristin Potter, Laura McNamara, and Thomas Otahal. In International Journal for Uncertainty Quantification. 2012.

Visualization of Uncertainty Data Using Surface Boxplots

As a collaboration between the SCI Institute and KAUST/IAMCS, we have developed a prototype to explore the use of functional surface boxplots to extract boxplot-type statistics from functional data in 3D. The application investigates a central slice of each volumetric data set, and uses functional box plots to find the median slice, as well as inner and outer envelopes. The functional boxplot uses band depth as a metric for ordering functions such that box-plot like statistics can be defined as well as identifying outliers. The developed prototype uses the R statistics package to calculate the boxplot and uses Rcpp to access the R code from a C++ platform which leverages the Cinder graphics library for display.



From Quantification to Visualization: A Taxonomy of Uncertainty Visualization Approaches

Quantifying uncertainty is an increasingly important topic across many domains. The uncertainties present in data come with many diverse representations having originated from a wide variety of disci- plines. Communicating these uncertainties is a task often left to visualization without clear connection between the quantification and vi- sualization. In this paper, we first identify frequently occurring types of uncertainty. Second, we connect those uncertainty representations to ones commonly used in visualization. We then look at various approaches to visualizing this uncertainty by partitioning the work based on the di- mensionality of the data and the dimensionality of the uncertainty. We also discuss noteworthy exceptions to our taxonomy along with future research directions for the uncertainty visualization community.

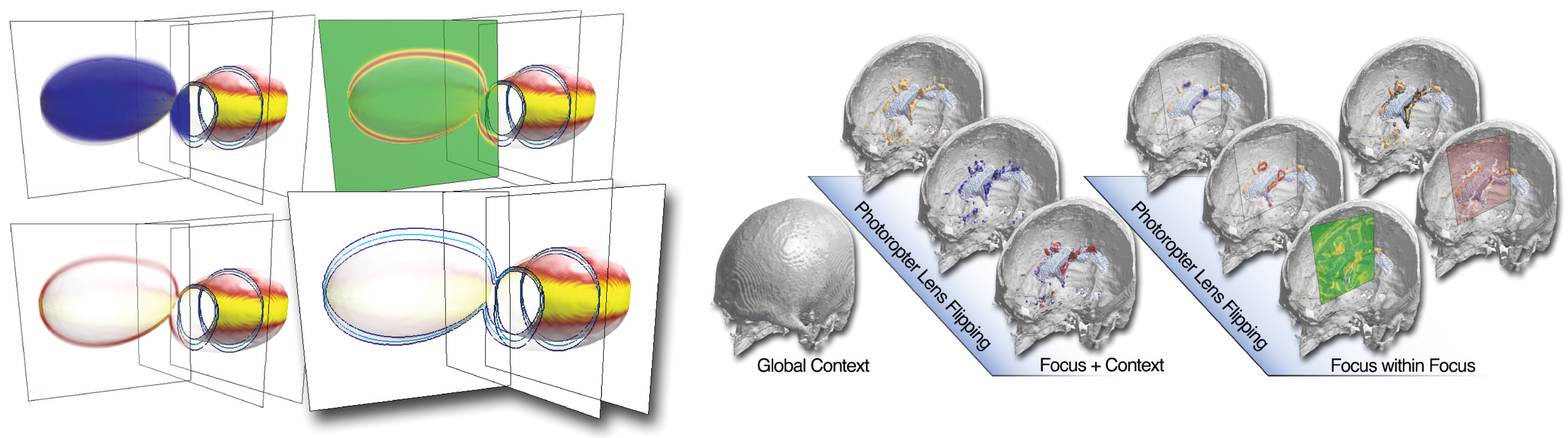
From Quantification to Visualization: A Taxonomy of Uncertainty Visualization Approaches. Kristin Potter, Paul Rosen, and Chris R. Johnson. In IFIP Advances in Information and Communication Technology Series.Andrew Dienstfrey, and Ronald Boisvert (eds). pp. (To Appear), 2012.

	Uncertainty Dimensionality		
Data Dim.	Scalar	Vector	Tensor
1D	[62] [77] [85] [82]		
2D	[5] [11] [12] [20] [25] [28] [29] [34] [43] [45] [44] [49] [53] [51] [56] [60] [64] [69] [72] [78] [79] [77] [76] [83] [91] [95] [14] [15] [26] [82]	[6] [7] [33] [53] [56] [63] [67] [66] [92] [97]	
3D	[10] [18] [17] [16] [42] [46] [47] [50] [54] [55] [59] [58] [71] [72] [73] [75] [80] [81] [86] [87] [93] [96] [13] [82] [61]	[3] [50] [53] [52] [68] [92]	[9] [35] [37] [41]
ND	[2] [21] [24] [32] [90]		

Table 1: Our taxonomy of uncertainty visualization approaches. Cells in light yellow represent categories with no known work. Citations in green refers to work with an emphasis on evaluation.

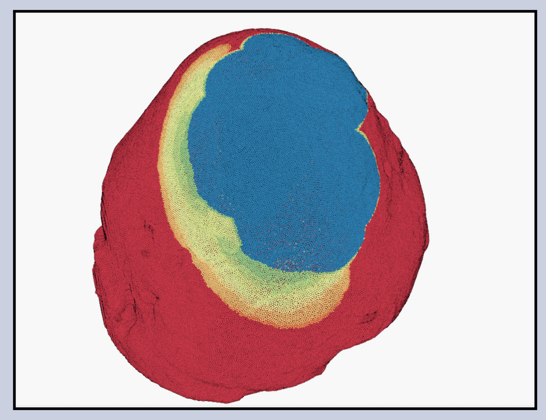
QuizLens: A Multi-Lens Uncertainty Visualization Environment

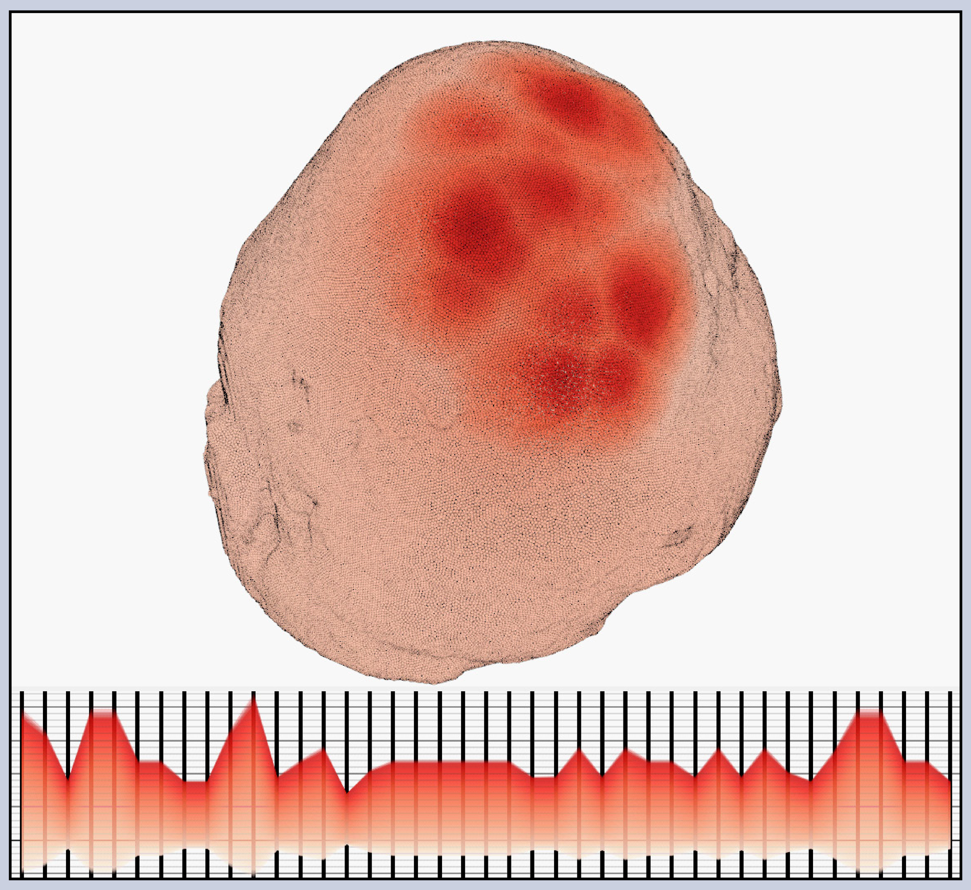
In this work, we propose a multi-lens system that allows users to cycle through and combine a variety of uncertainty-based visualization techniques within a single context. While each lens describes a unique visualiza- tion method, they share several components, including the placement, orientation, sizing and references to specific scene geometries. This abstraction enables efficient toggling between the different visualization tasks, as well as scene geometries, in order to better understand data uncertainty and compose hierarchical focus-versus-context visualizations. We demonstrate the use of our system through two different volumetric scalar field examples, in- cluding: probabilities for multiple tissue types compiled from segmentations of Magnetic Resonance Image (MRI) data, as well as simulated probabilities of Diffusion Tensor Image (DTI) fiber bundle intersections.

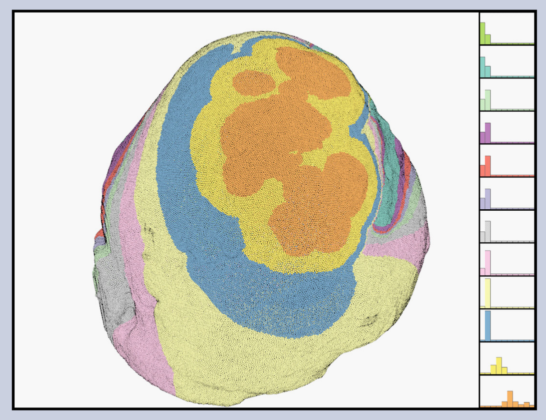


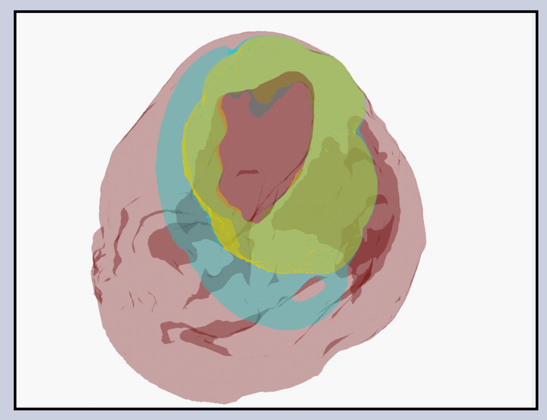
Visual Exploration of Uncertainty in Heart Ischemia Simulation

Myocardial ischemia is a condition of reduced oxygen levels to the heart caused by decreased blood flow which can cause serious abnormal heart rhythms. By modeling and simulating the condition, it is hoped that better treatments can be formulated. However, the models used in these simulation contain many underlying assumptions and unknowns. In order to better understand these uncertainties, polynomial chaos is used to generate an ensemble of multiple simulations which represent the range of possible values. The goal of this work is to communicate the structure associated with the variation of values that occur in these simulations.









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