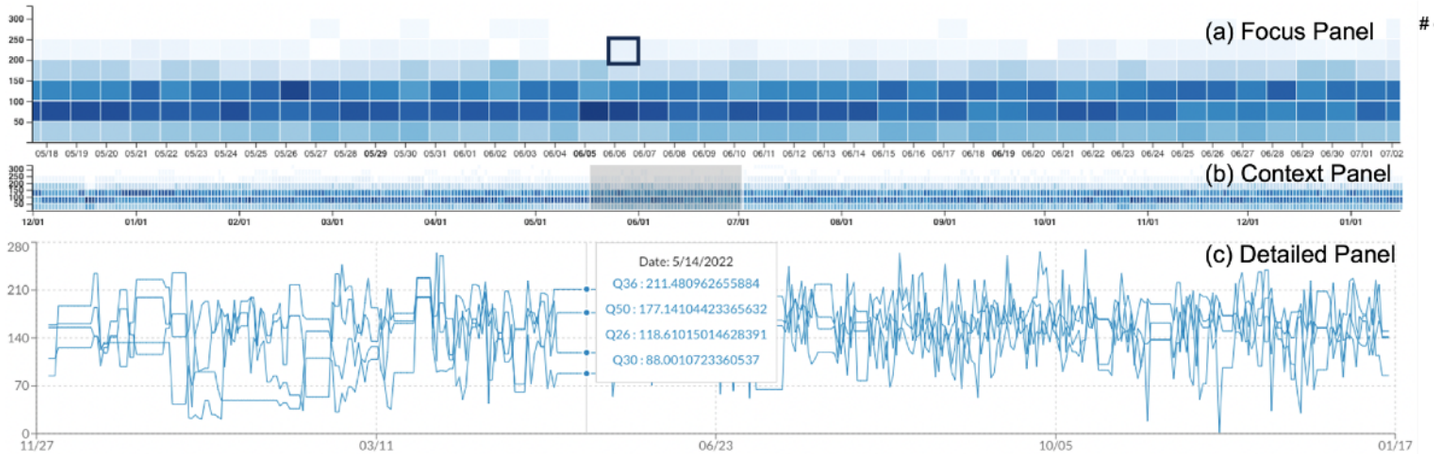
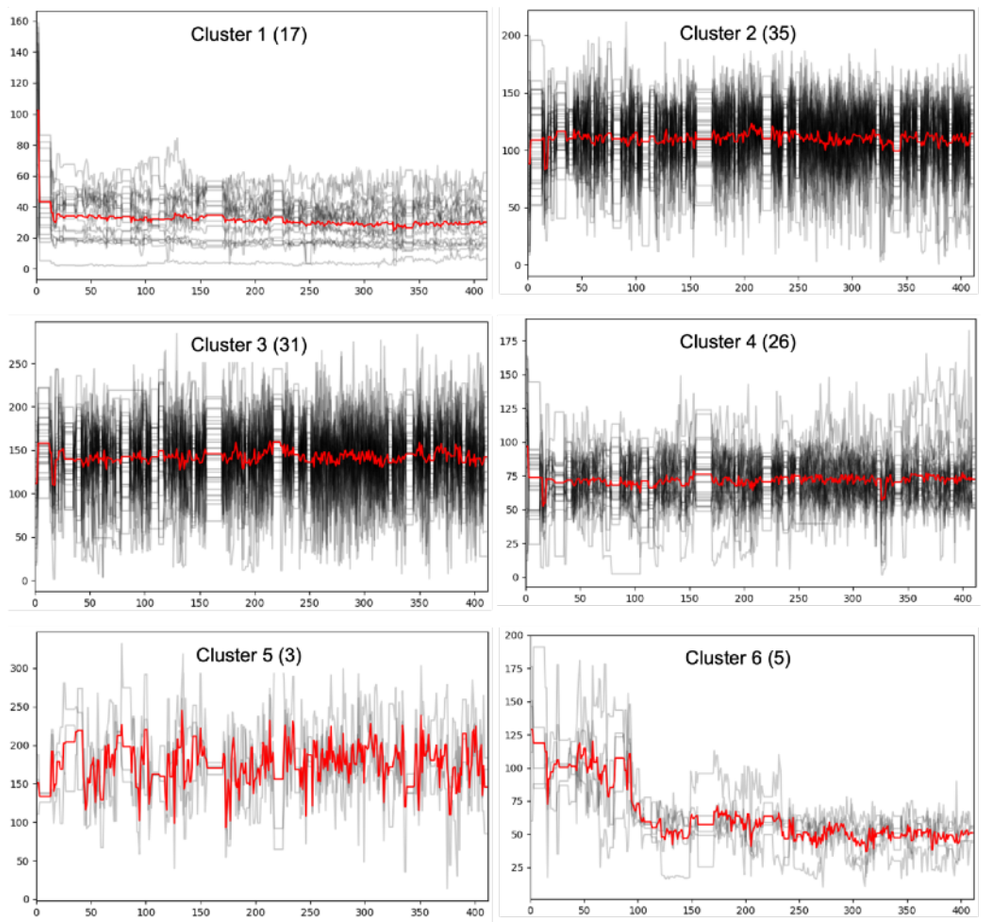
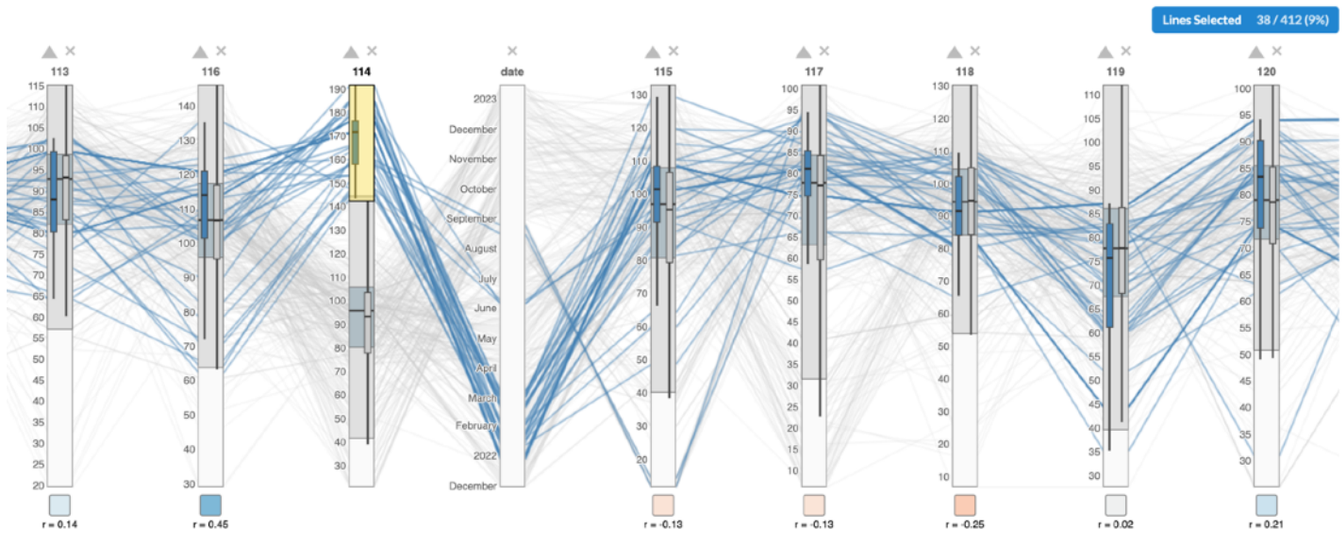
QVis





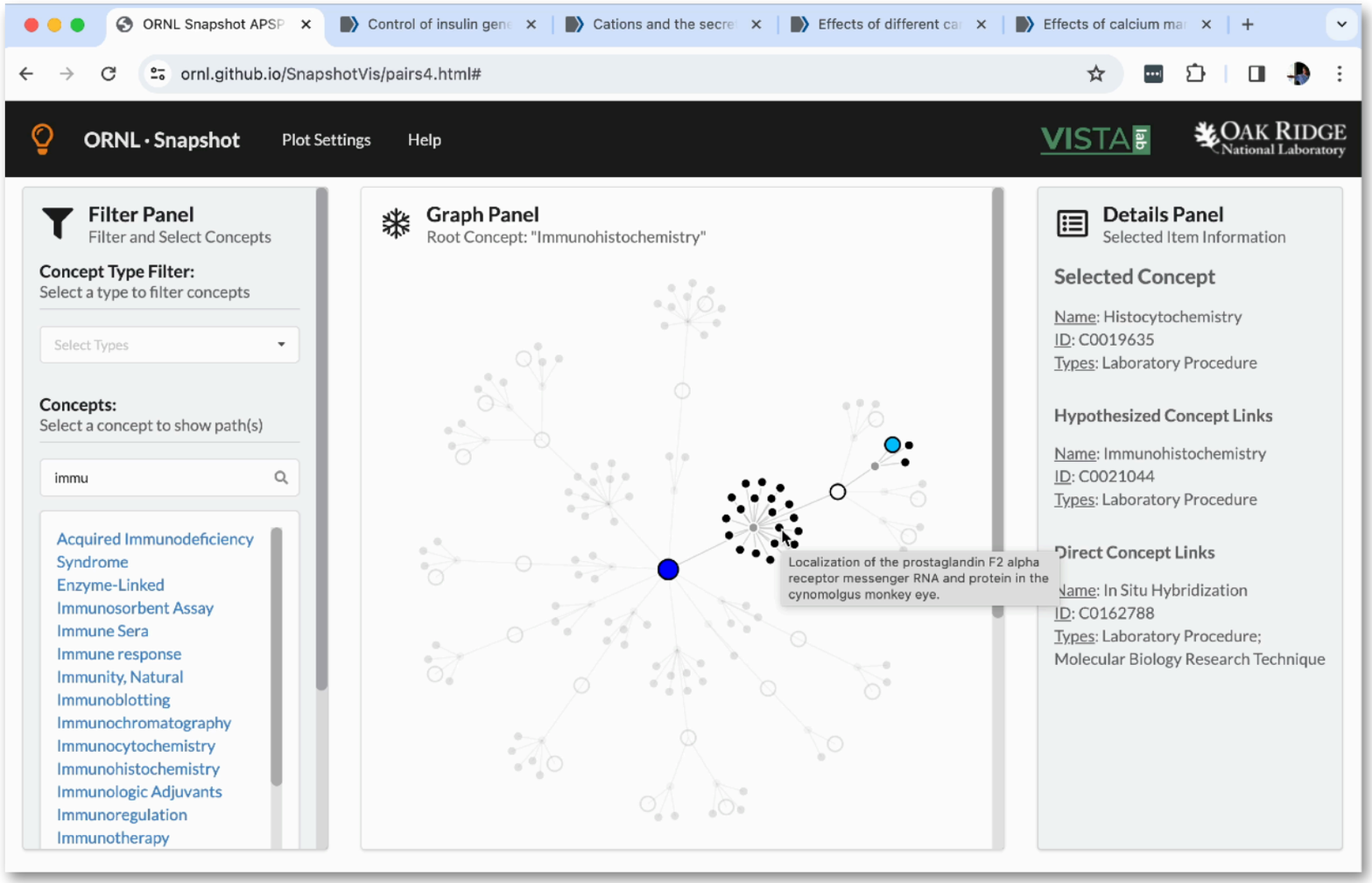


QVis is a web-based application for guided, exploratory analysis of quantum device performance data. Working with quantum computing scientists affiliated with the DOE-funded Quantum Science Center, we developed QVis to help scientists uncover temporal and multivariate variations in noise properties of quantum devices. Although quantum computing has tremendous potential for information processing, current devices suffer from significant noise resulting in high error rates during computation. Using real-world systems, QVis gives scientists the ability to explore correlations and trends for multiple performance metrics with clustering and other machine learning methods that highlight potentially significant patterns.

Citation: Chad A. Steed, Junghoon Chae, Samudra Dasgupta, Travis S. Humble. QVis: A Visual Analytics Tool for Exploring Noise and Errors in Quantum Computing Systems. In *Proceedings of IEEE International Conference on Quantum Computing and Engineering*, Bellevue, WA, Sep. 2023.

Chad A. Steed • steedca@ornl.gov

SnapshotVis

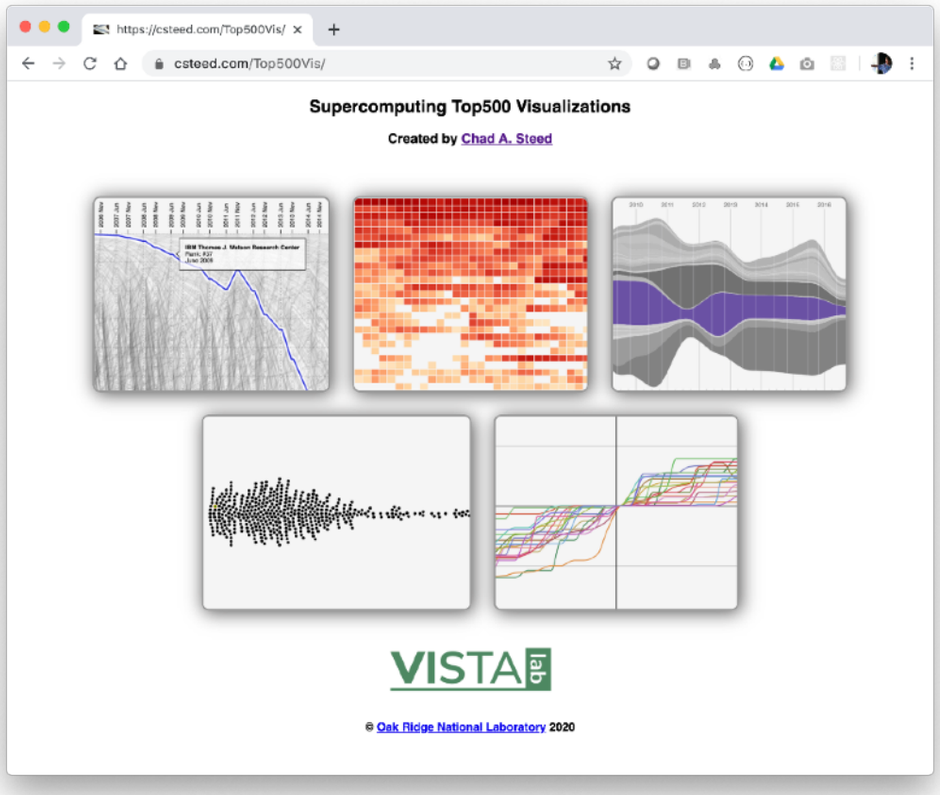


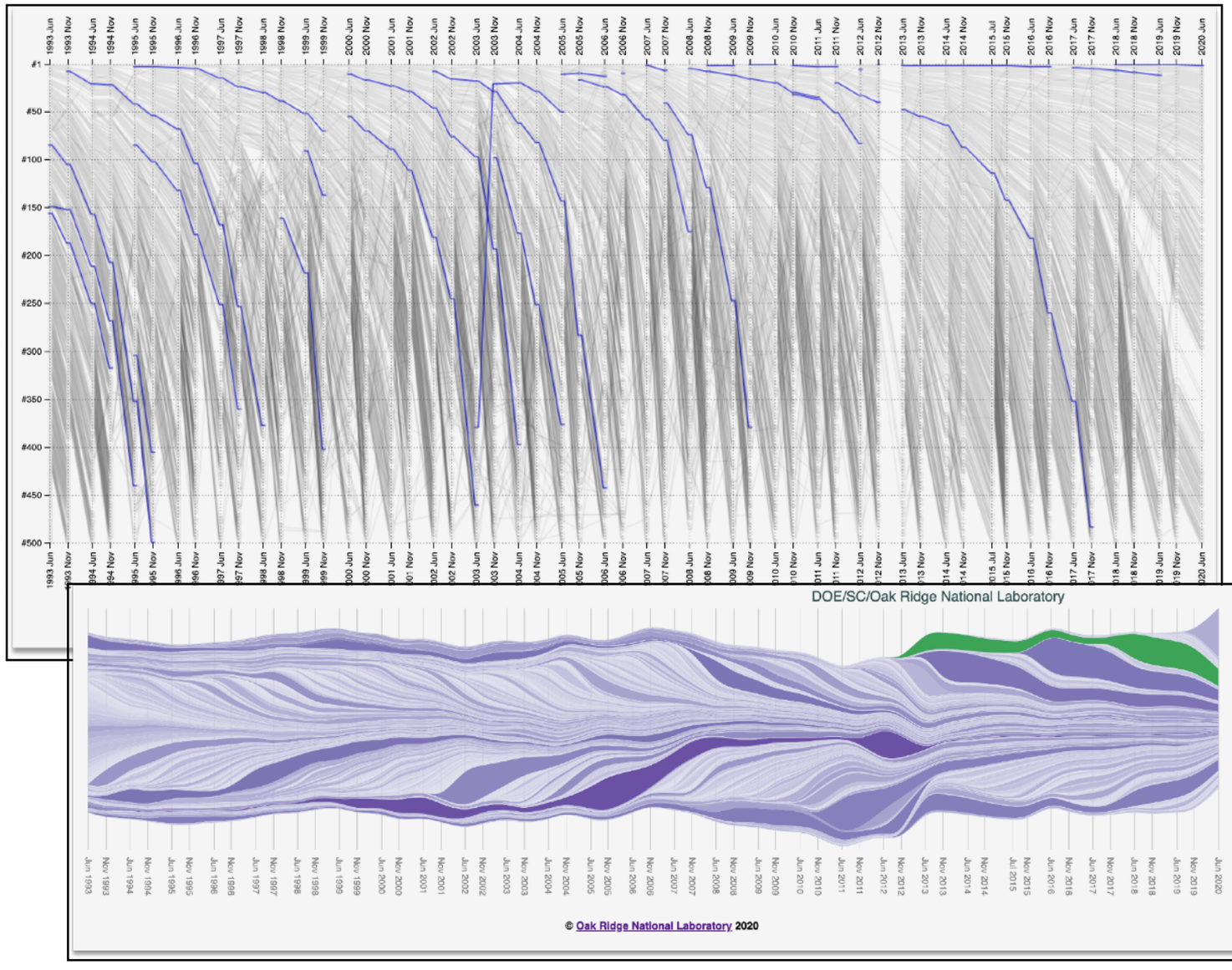
SnapshotVis is a web-based application for exploring co-occurrences of medical terms in PubMed papers. In a separate process, papers are mined for key medical terms. Then, an all-pairs-shortest path algorithm is used to find connections between papers and these terms. SnapshotVis uses the resulting network to show connections between medical terms giving researchers the ability to explore linkages in medical research. The goal is to support new research studies through indirect, and perhaps unforeseen, connections between medical concepts. SnapshotVis with sample data is available at https://ornl.github.io/SnapshotVis/pairs4.html.

Applications: biomedical, graph and network data analysis, and text mining

Chad A. Steed • **steedca@ornl.gov**

Top500Vis



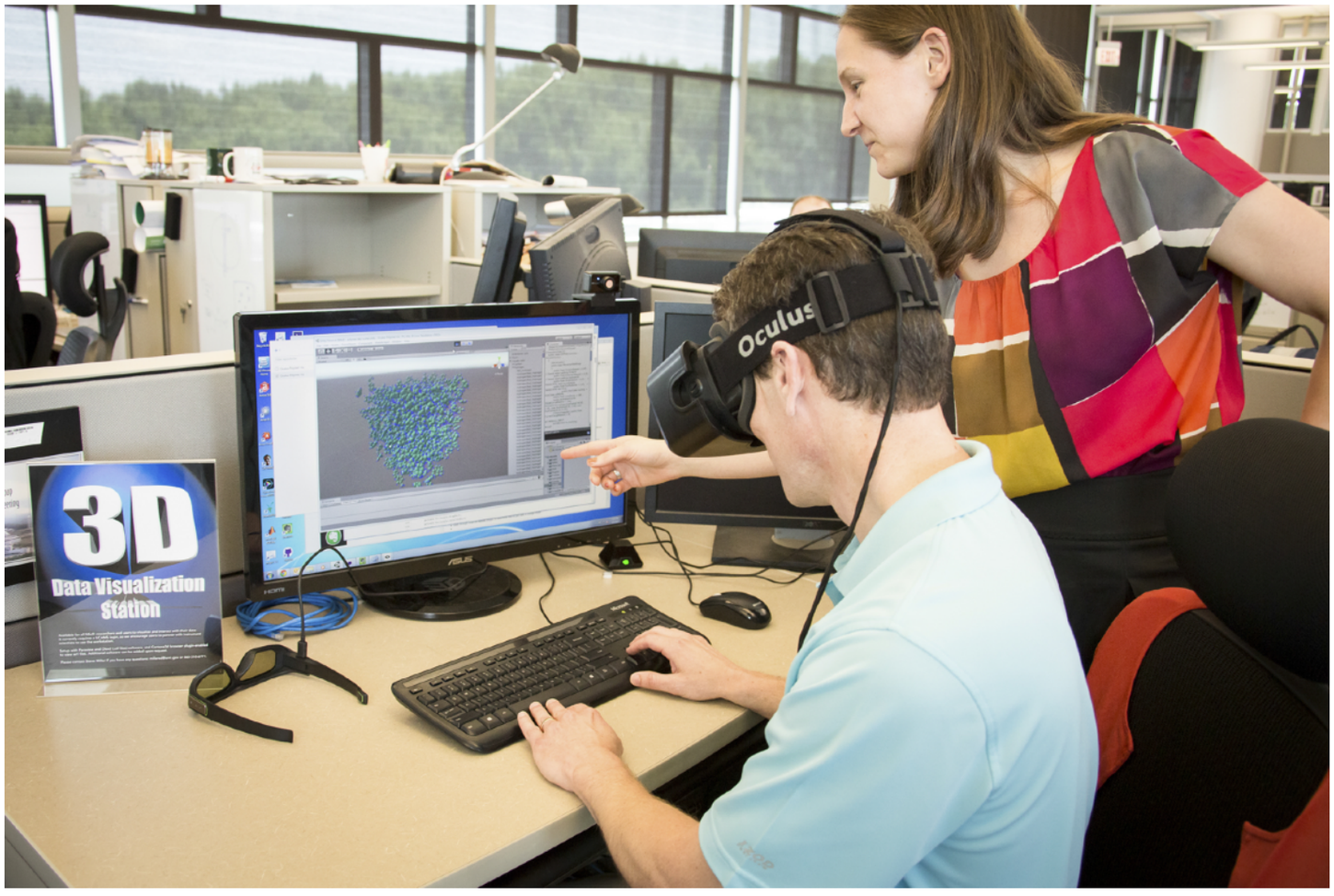


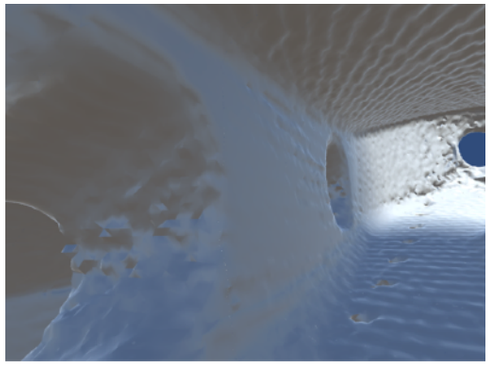
Top500Vis is a collection of prototype web-based visualizations of the University of Tennessee's SuperComputing Top500 List, which ranks the world's fastest supercomputers. In collaboration with Dr. Jack Dongara, who established the Top500 list, we developed multiple interactive visualizations to explore time series information and multivariate relationships. Top500Vis is available at https://csteed.com/Top500Vis/.

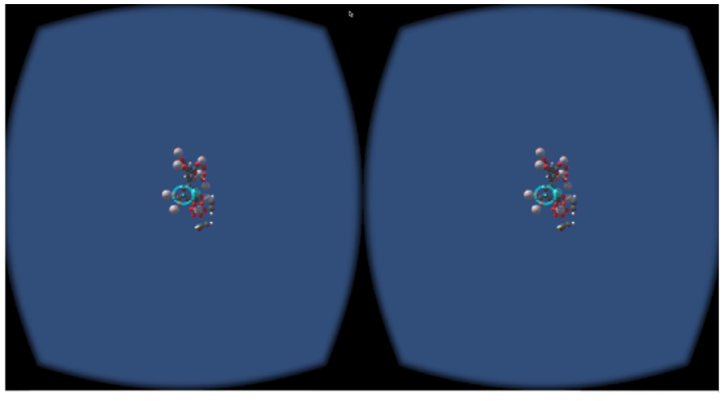
Applications: HPC system performance and time series analysis

Chad A. Steed • steedca@ornl.gov

Immersive Visual Analytics







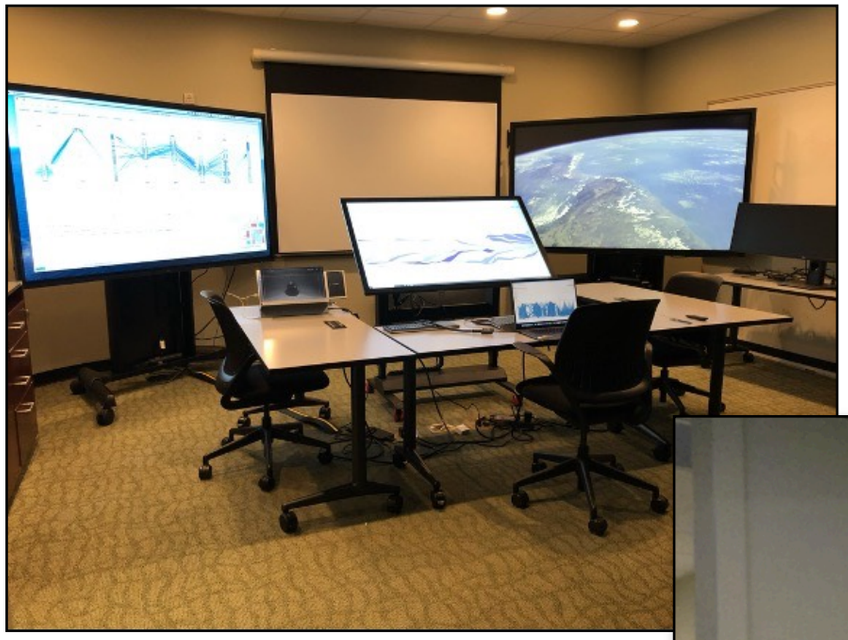
Through student collaborations, I have developed and applied **immersive visual analytics** techniques using a variety of augmented reality (AR) and virtual reality (VR) hardware to materials science, manufacturing, and climate science data sets. In addition to understanding human perception and endurance on these devices, we have used new interaction modalities, such as eye gaze, to enhance the human's ability to navigate and explore complex structures. Each project was developed in close collaboration with domain experts.

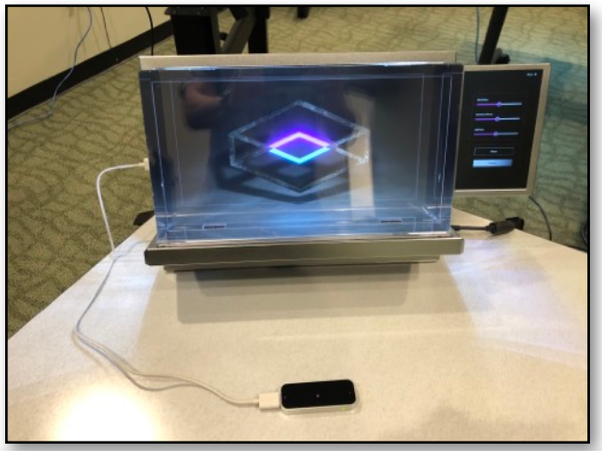
Applications: materials science, climate science, additive manufacturing, and neutron scattering

Citation: **Immersive Visual Analytics for Transformative Neutron Scattering Science**, Chad A. Steed, Jamison Daniel, Margaret Drouhard, Thomas Proffen, and Steven Hahn, *Proceedings of the Workshop on Immersive Analytics at IEEE Virtual Reality*, 2016.

Chad A. Steed • steedca@ornl.gov

ORNL Visual Informatics for Science and Technology Advances (VISTA) Laboratory



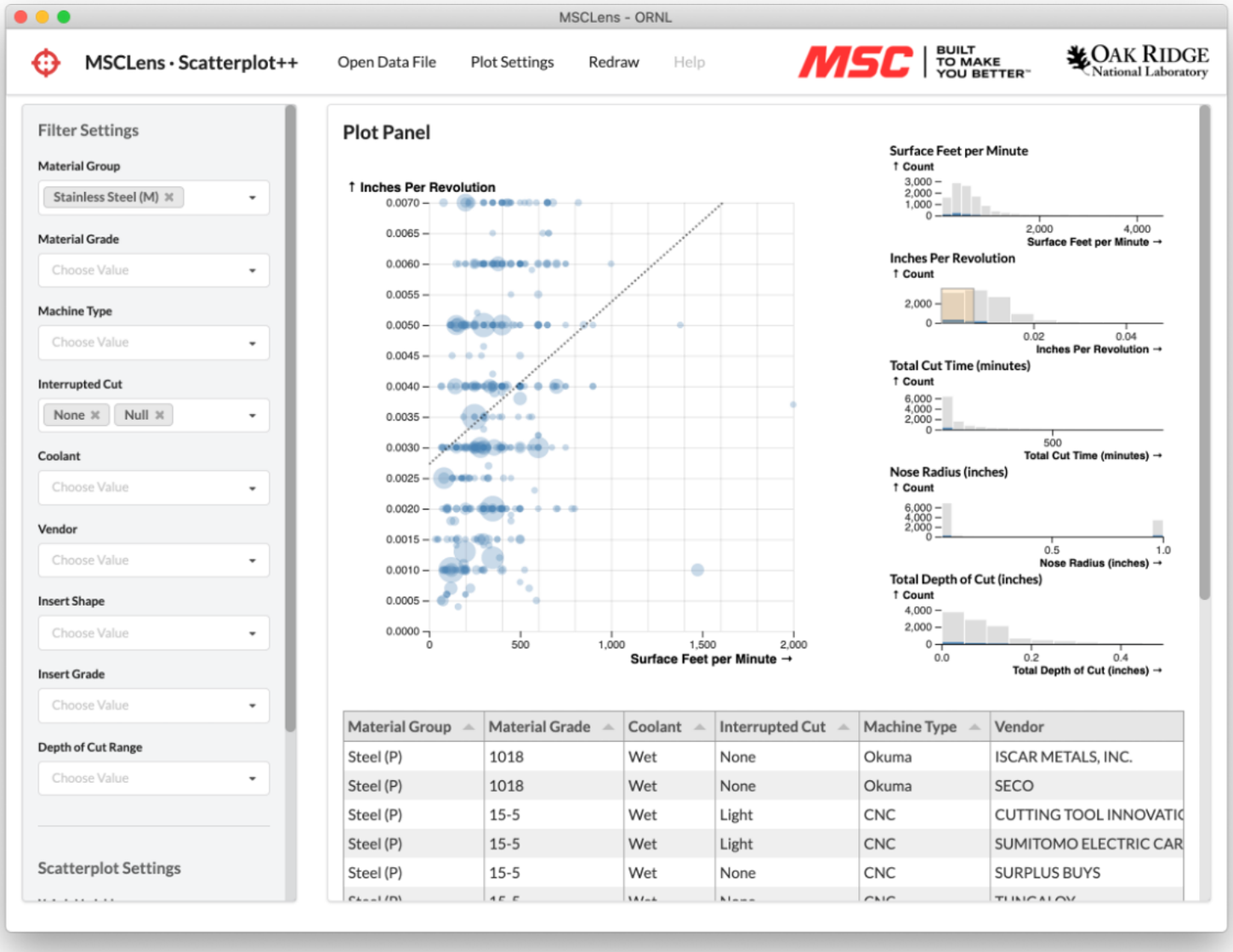


I was the founding director of the ORNL Visual Informatics for Science and Technology Advances (**VISTA**) Lab . VISTA's mission was to improve domain experts' ability to explore large and complex data through the development and application of interactive data visualization and analysis systems. By acting as a bridge connecting ORNL data visualization specialists across multiple directorates to domain-specific data analysis challenges, VISTA improved experts' ability to transform the vast volumes of data generated at ORNL into crucial knowledge in domains of national significance. VISTA was successful at enhancing ORNL's reputation as a premiere institution for advanced data analytics research and led to the creation of a new Data Visualization Group at ORNL.

YouTube Video: https://www.youtube.com/watch?v=2E5rq9i8K_U

Chad A. Steed • steedca@ornl.gov

MSCLens

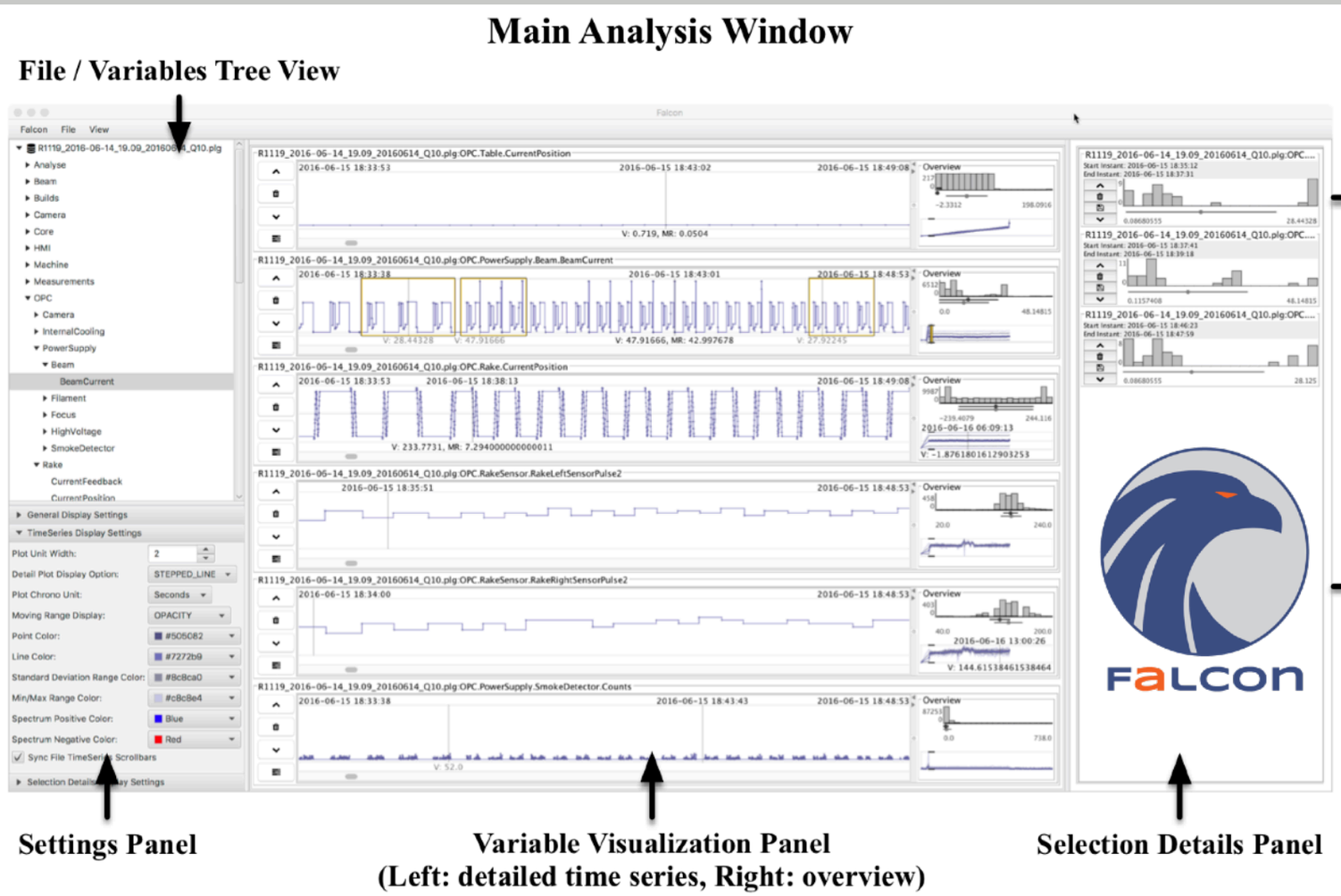


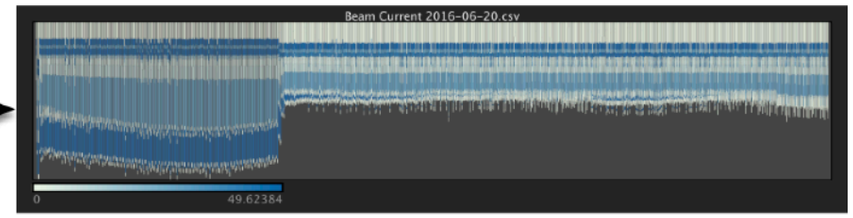
MSCLens is a visual analytics tool developed through a cooperative partnership with MSC Industrial Supply Company. MSCLens uses historical data on machine tooling parts and customer settings to support internal analysts as they advise consumers on how to utilize tools in practical applications for longer life and efficiency. MSCLens is a web-based tool that uses D3.js for its visualizations and Semantic UI for its user interface. MSCLens is currently under consideration for an R&D 100 award. MSCLens is a proprietary tool that is not openly available.

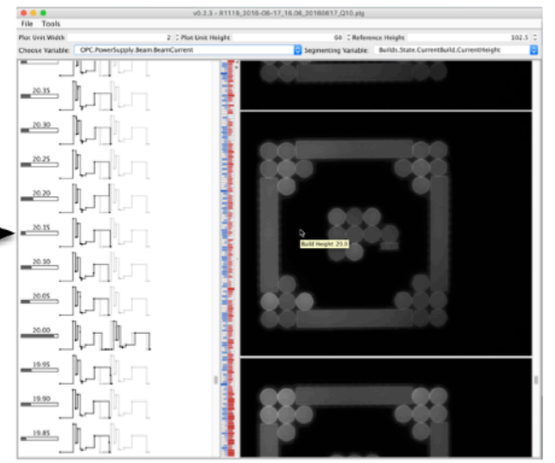
Applications: industrial parts sales and customer support

Chad A. Steed • **steedca@ornl.gov**

Falcon







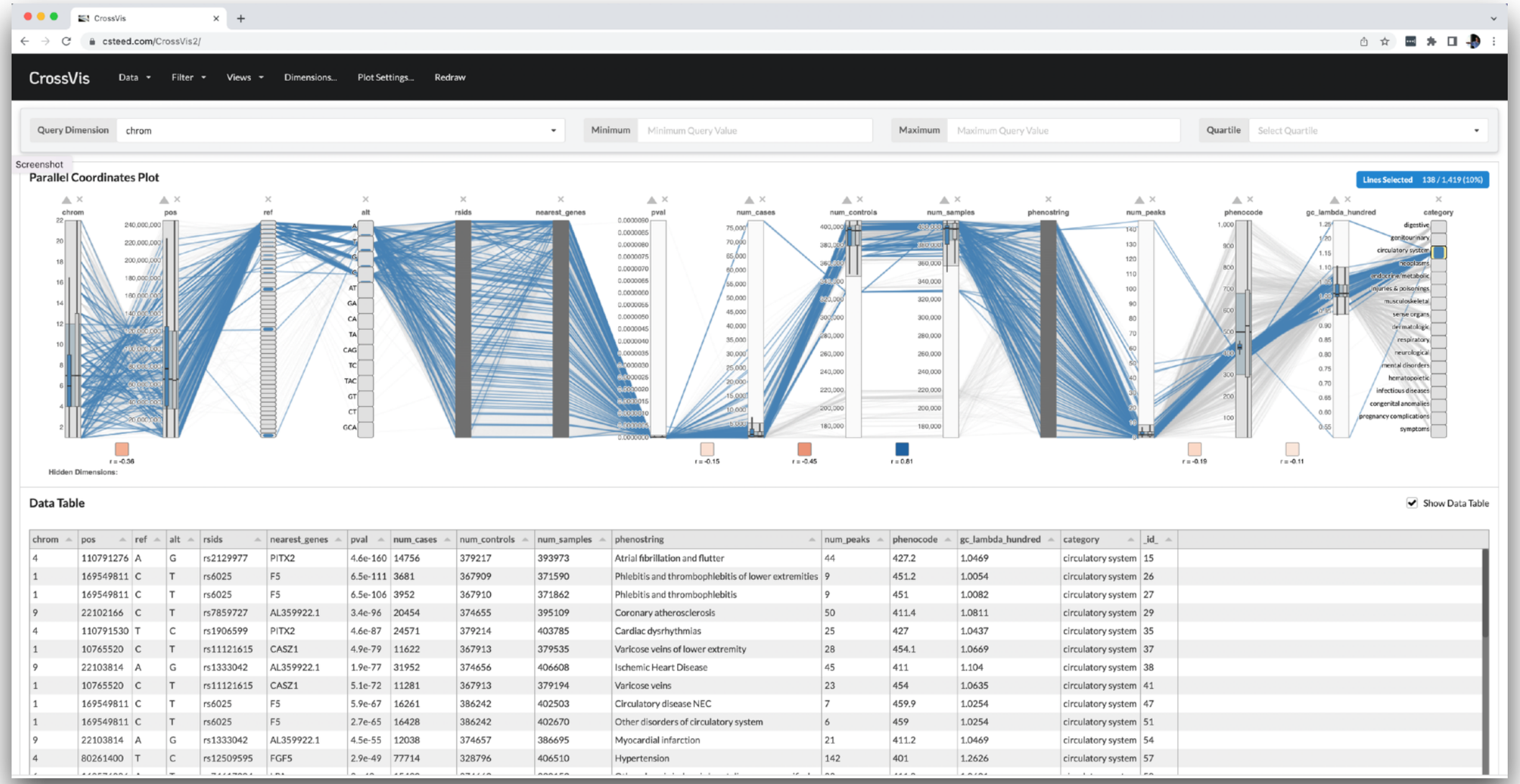
Falcon is a visual analytics tool for exploring long, multivariate time series datasets. Although it is suitable for general cases, Falcon's capabilities target specific needs of additive manufacturing researchers. The goal Falcon is to allow users to discover statistical insights and temporal variations and correlations using human-directed visual analysis techniques and automated analytical guidance. The main analysis window provides a flexible set of panels for exploring details and overviews of specific variables. The waterfall visualization provides micro and macro level details for a specific variable. The segmented time series visualization combines imagery and time series data in a single interactive tool. Falcon is available at https://github.com/csteed/falcon.

Applications: additive manufacturing, cyber security, and national security

Citation: Chad A. Steed, William Halsey, Ryan Dehoff, Sean L. Yoder, Vincent Paquit, and Sarah Powers. "Falcon: Visual Analysis of Large, Irregularly Sampled, and Multivariate Time Series Data in Additive Manufacturing." Computers & Graphics, vol. 63, 2017, pp. 50-64. DOI: 10.1109/TVCG.2018.2865029

Chad A. Steed • steedca@ornl.gov

CrossVis2



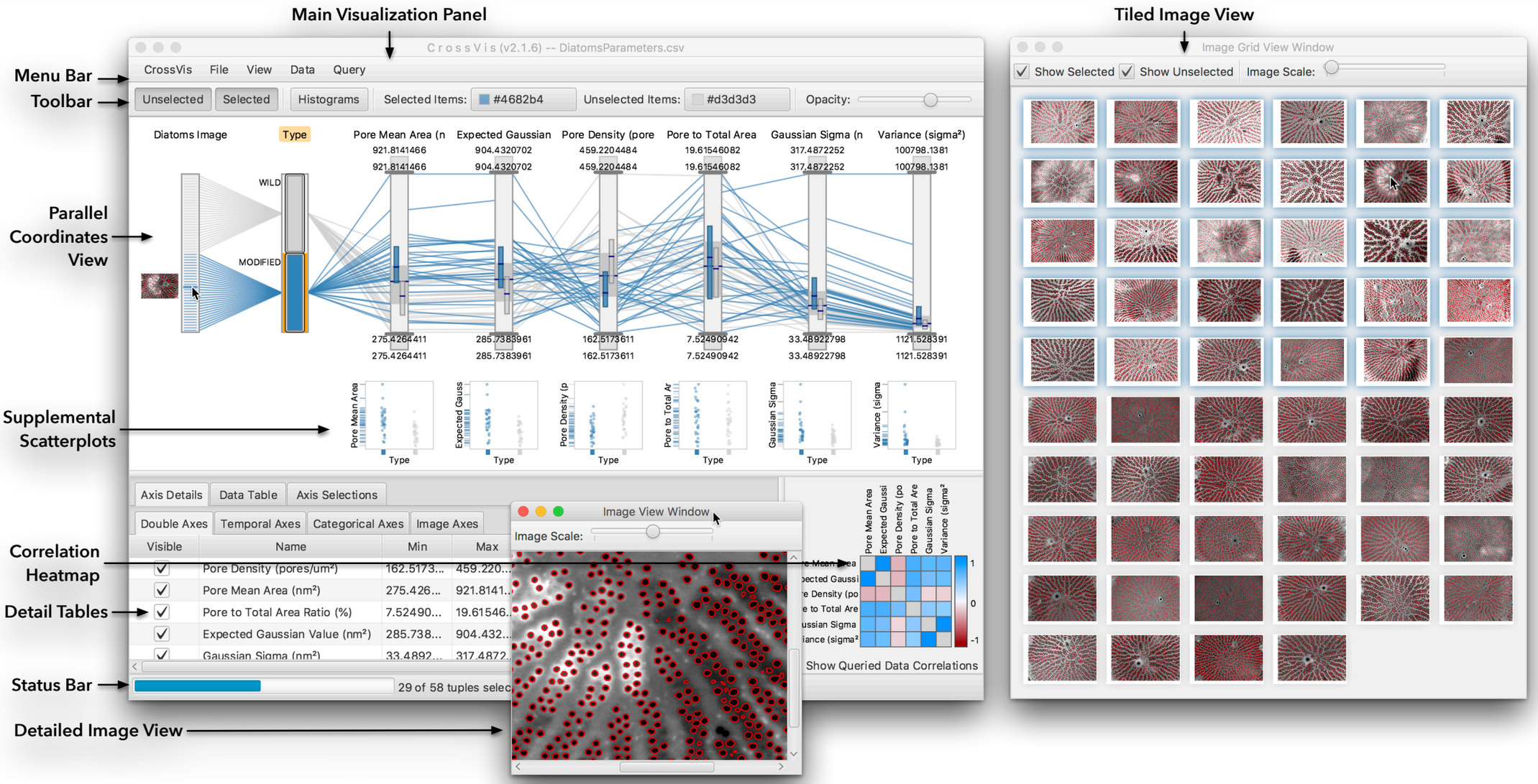
chrom	pos	ref	alt	rsids	nearest_genes	pval	num_cases	num_controls	num_samples	phenostring	num_peaks	phenocode	gc_lambda_hundred	category	_id_
4	110791276	A	G	rs2129977	PITX2	4.6e-160	14756	379217	393973	Atrial fibrillation and flutter	44	427.2	1.0469	circulatory system	15
1	169549811	C	T	rs6025	F5	6.5e-111	3681	367909	371590	Phlebitis and thrombophlebitis of lower extremities	9	451.2	1.0054	circulatory system	26
1	169549811	C	T	rs6025	F5	6.5e-106	3952	367910	371862	Phlebitis and thrombophlebitis	9	451	1.0082	circulatory system	27
9	22102166	C	T	rs7859727	AL359922.1	3.4e-96	20454	374655	395109	Coronary atherosclerosis	50	411.4	1.0811	circulatory system	29
4	110791530	T	C	rs1906599	PITX2	4.6e-87	24571	379214	403785	Cardiac dysrhythmias	25	427	1.0437	circulatory system	35
1	10765520	C	T	rs11121615	CASZ1	4.9e-79	11622	367913	379535	Varicose veins of lower extremity	28	454.1	1.0669	circulatory system	37
9	22103814	A	G	rs1333042	AL359922.1	1.9e-77	31952	374656	406608	Ischemic Heart Disease	45	411	1.104	circulatory system	38
1	10765520	C	T	rs11121615	CASZ1	5.1e-72	11281	367913	379194	Varicose veins	23	454	1.0635	circulatory system	41
1	169549811	C	T	rs6025	F5	5.9e-67	16261	386242	402503	Circulatory disease NEC	7	459.9	1.0254	circulatory system	47
1	169549811	C	T	rs6025	F5	2.7e-65	16428	386242	402670	Other disorders of circulatory system	6	459	1.0254	circulatory system	51
9	22103814	A	G	rs1333042	AL359922.1	4.5e-55	12038	374657	386695	Myocardial infarction	21	411.2	1.0469	circulatory system	54
4	80261400	T	C	rs12509595	FGF5	2.9e-49	77714	328796	406510	Hypertension	142	401	1.2626	circulatory system	57

With **CrossVis2**, the original CrossVis application was converted into a web-based application. In addition to providing easier access through the web browser, CrossVis2 includes a more efficient user interface based on Semantic UI and it features a mixture of vector-based, SVG graphics and canvas-based, raster graphics for enhanced scalability. CrossVis2 can be accessed at https://ornl.github.io/CrossVis2/ (use the Data menu to open a sample dataset).

Applications: materials science, image analysis, cyber security, healthcare, finance, and general multivariate data analysis

Chad A. Steed • steedca@ornl.gov

CrossVis



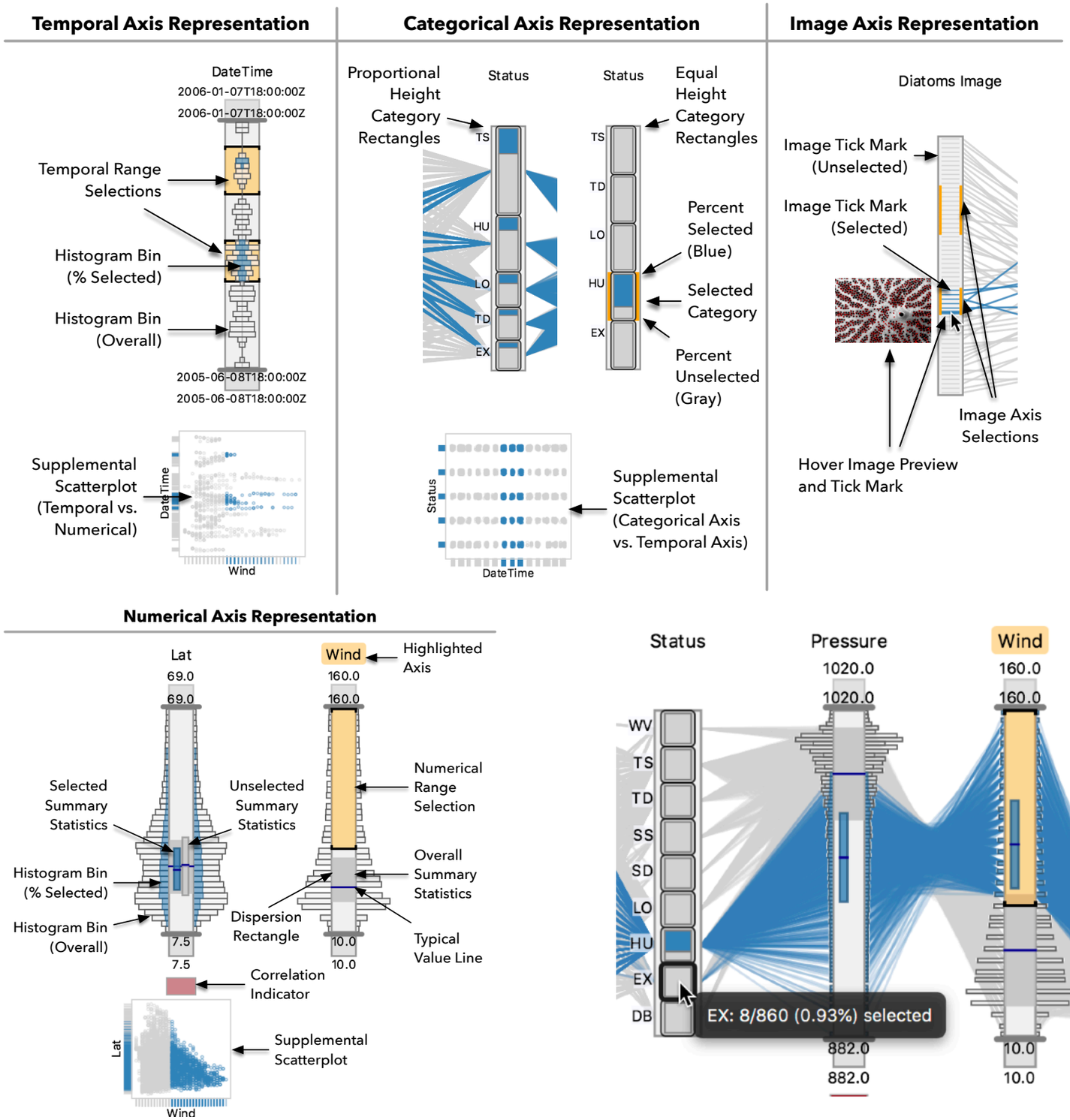
CrossVis represents a significant expansion of the EDEN system to include support for several new data types beyond numerical data, namely images, categorical, and temporal data. CrossVis also incorporates a new data model that is more efficient than prior iterations and scales to higher data volumes. In addition, CrossVis provides several supplemental linked views for images and bi-variate plots that can be directly embedded in parallel coordinate plots. CrossVis is available at http://github.com/csteed/eden/.

Applications: materials science, image analysis, cyber security, healthcare, finance, and eXplainable AI

Citation: Chad A. Steed, John R. Goodall, Junghoon Chad, and Artem A. Trofimov. "CrossVis: A Visual Analytics System for Exploring Heterogeneous Multivariate Data with Applications to Materials and Climate Sciences." Computers & Visual Computing. vol. 3:200013, 2020. DOI: 10.1016/j.gvc.2020.200013.

Chad A. Steed • steedca@ornl.gov

CrossVis

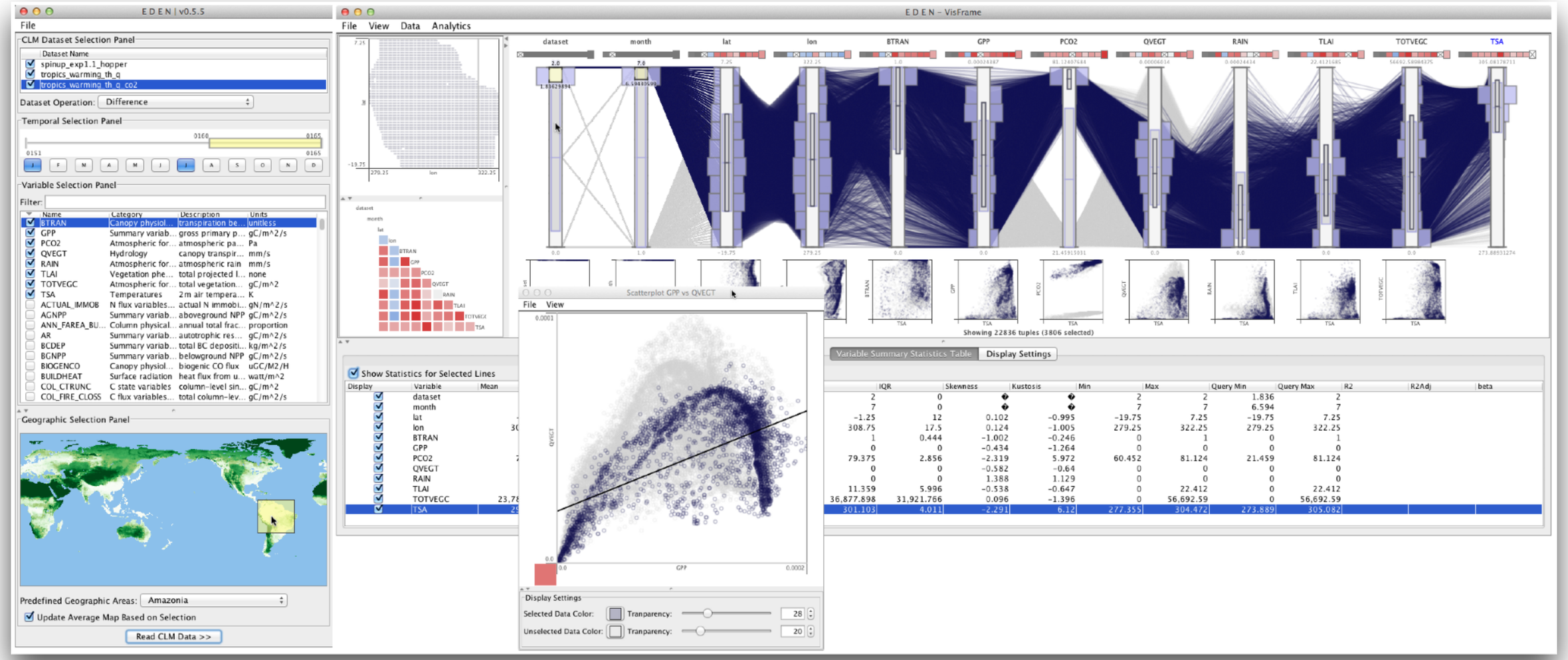


CrossVis supports new axis representations for temporal, categorical, and image data, in addition to numerical data. The unique characteristics of each data type inform the designs, which are augmented with statistical graphics from automated analytics algorithms. CrossVis also supports directly embedding a bi-variate scatterplot within a parallel coordinate plot, which are traditionally restricted to uni-variate axes.

Citation: Chad A. Steed, John R. Goodall, Junghoon Chad, and Artem A. Trofimov. "CrossVis: A Visual Analytics System for Exploring Heterogeneous Multivariate Data with Applications to Materials and Climate Sciences." Computers & Visual Computing. vol. 3:200013, 2020. DOI: 10.1016/j.gvc.2020.200013.

Chad A. Steed • steedca@ornl.gov

Exploratory Data analysis ENvironment (EDEN)



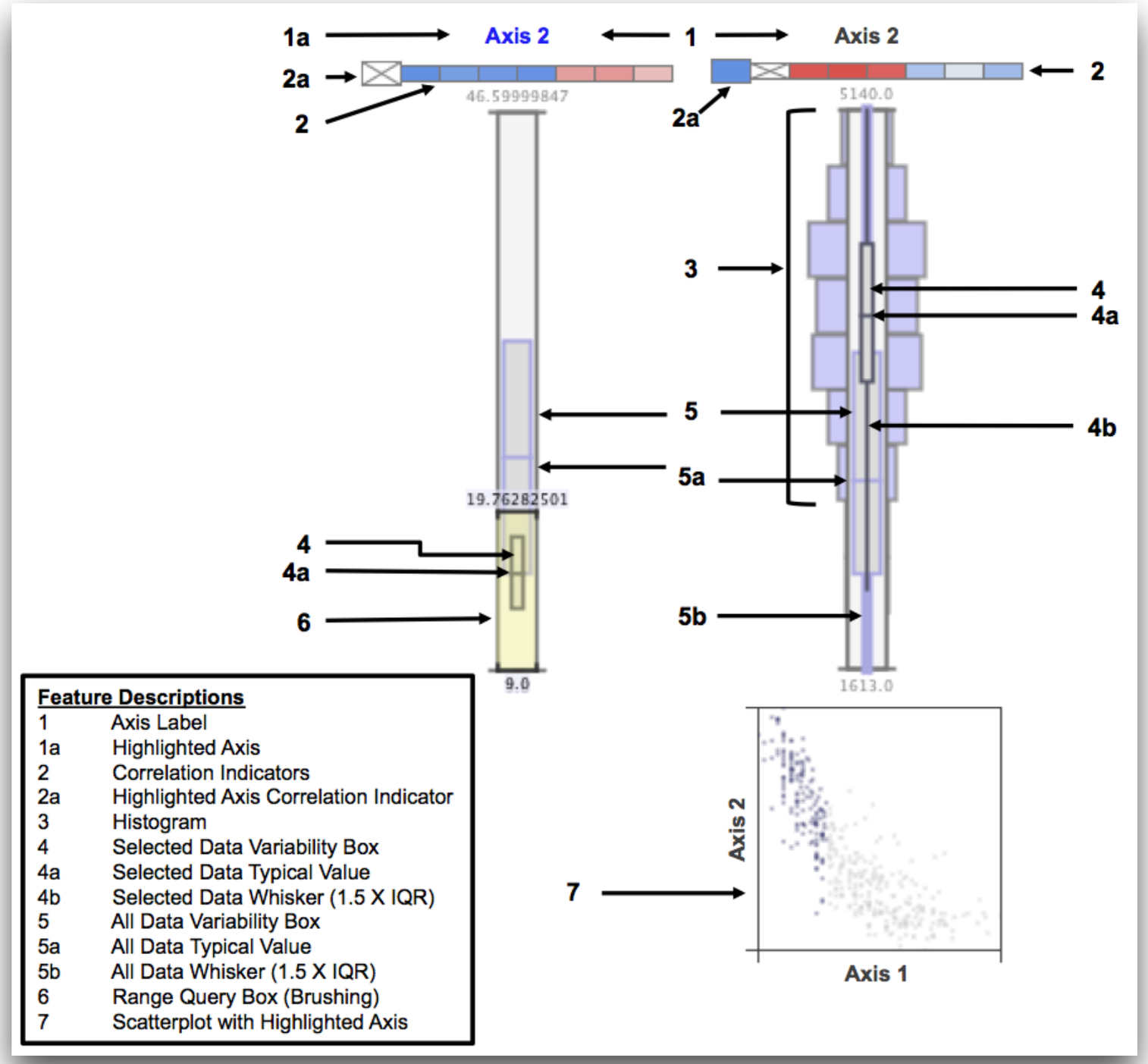
EDEN is a highly interactive visual analytics system that allows exploratory analysis of large and complex, multivariate data sets using a parallel coordinates based visual canvas. Multiple visualizations (scatterplots, geographic views, and correlation matrices) are linked to the parallel coordinates panel via a coordinated data model that propagates selections and other user interactions. EDEN is available at http://github.com/csteed/eden/.

Applications: climate simulation science, cyber security, biomedical, manufacturing, neutron science, and other domains.

Citation: Chad A. Steed, Daniel M. Ricciuto, Galen Shipman, Brian Smith, Peter E. Thornton, Dali Wang, and Dean N. Williams. "Big Data Visual Analytics for Earth System Simulation Analysis." Computers & Geosciences. vol. 61, Dec. 2013, pp. 71-82. DOI: 10.1016/j.cageo.2013.07.025.

Chad A. Steed • steedca@ornl.gov

Exploratory Data analysis ENvironment (EDEN)

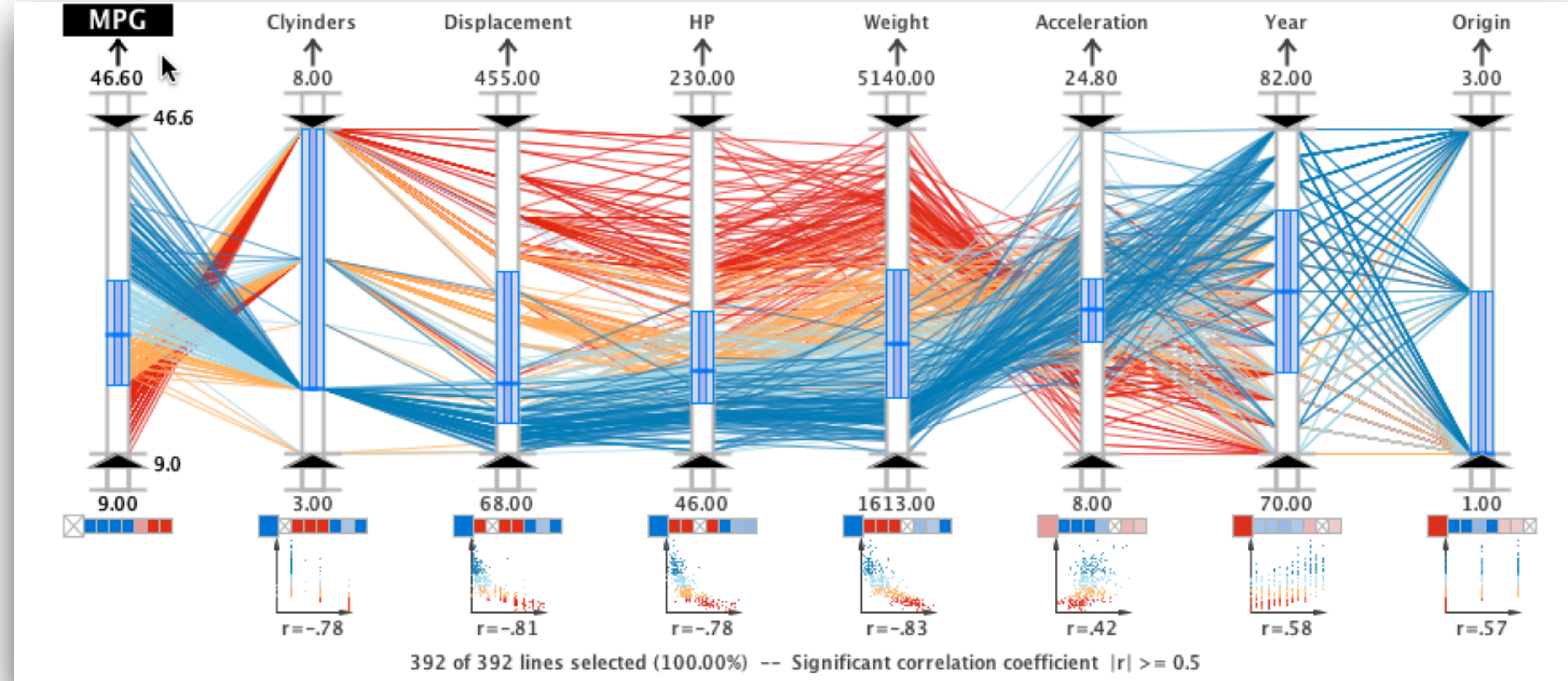


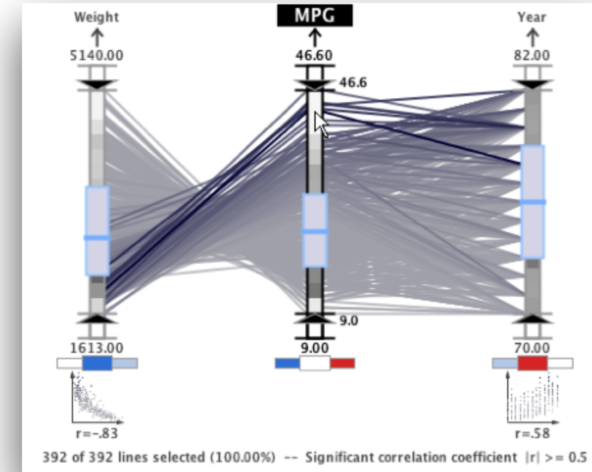
Exploratory Data analysis ENvironment (EDEN) extends the standard parallel coordinates axis with "scented" axis widgets. Key descriptive statistics are used to illuminate the display with dynamic summaries, correlations, and scatterplots. The information from statistical analytics are also visually encoded within each axis interior to emphasize trends and associations in the data. In this way, EDEN allows machine-guided, visual data mining using information scent.

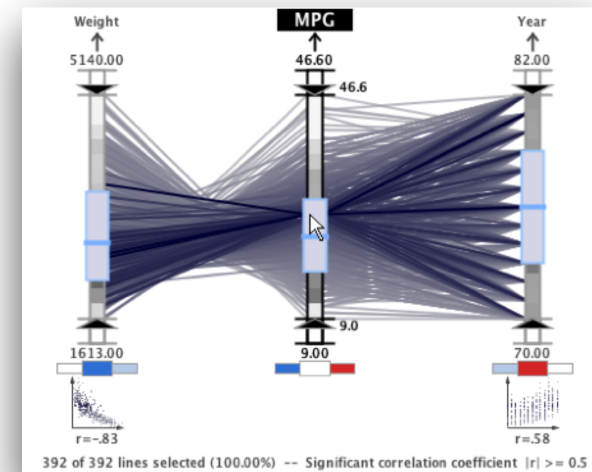
Citation: Chad A. Steed, Daniel M. Ricciuto, Galen Shipman, Brian Smith, Peter E. Thornton, Dali Wang, and Dean N. Williams. "Big Data Visual Analytics for Earth System Simulation Analysis." Computers & Geosciences. vol. 61, Dec. 2013, pp. 71-82. DOI: 10.1016/j.cageo.2013.07.025.

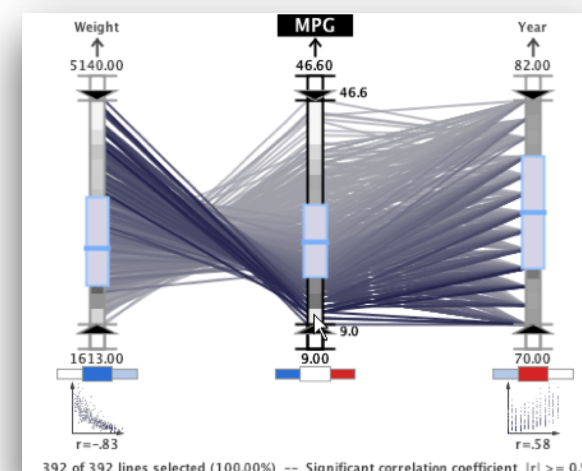
Chad A. Steed • steedca@ornl.gov

Multivariate Data eXplorer (MDX)









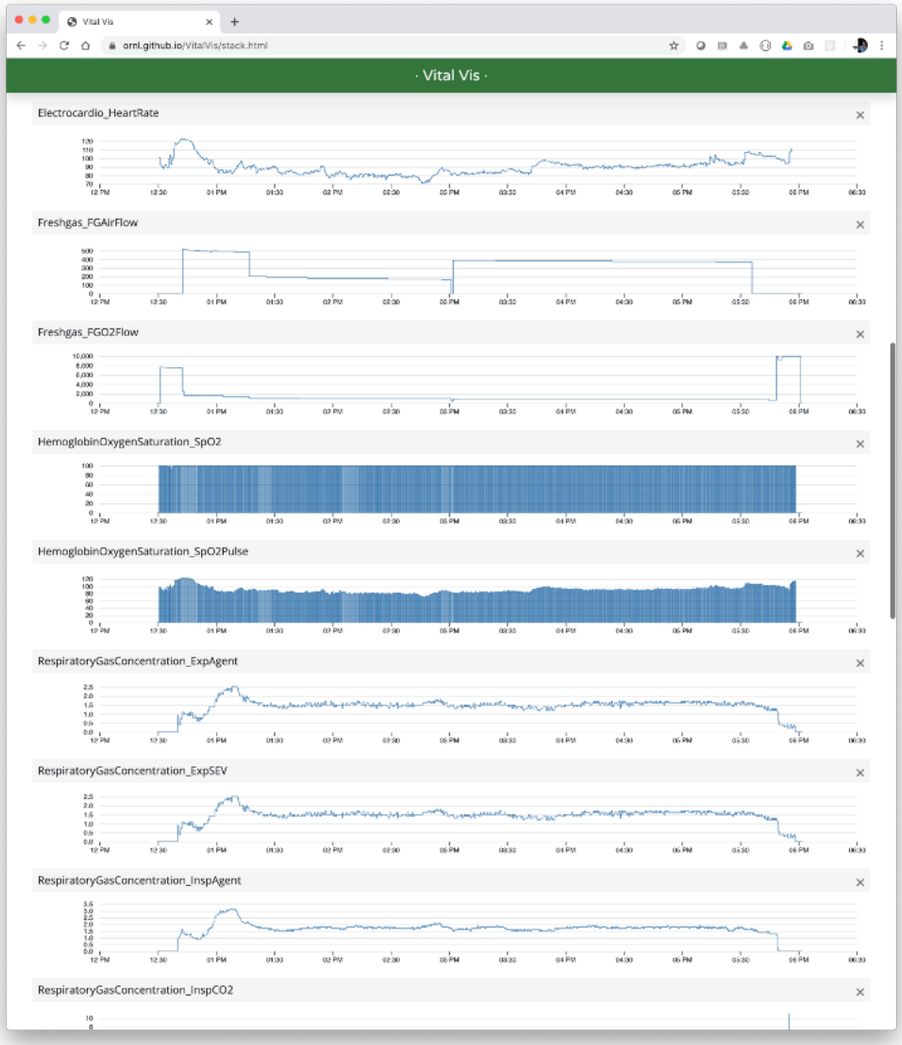
MDX is EDEN's predecessor. MDX demonstrated eXplainable AI and human-machine collaboration a decade before these terms became popular. MDX also uses a parallel coordinates based canvas to enable multivariate data exploration. MDX includes automated intelligence guidance and classification algorithms that highlight categories of statistically similar records (categories are indicated by polyline color in top figure). MDX also includes a proximity shading technique (right) for polylines based on distance to the mouse cursor. The shading allows dynamic queries and mimics tonal shading in fine art whereby foreground items are more salient and background items have less contrast.

Applications: weather science, biomedical, oceanography, and underwater acoustics

Citation: Chad A. Steed, J. Edward Swan II, Patrick J. Fitzpatrick, and T.J. Jankun-Kelly. A Visual Analytics Approach for Correlation, Classification, and Regression Analysis. In Innovative Approaches of Data Visualization and Visual Analytics. Eds. Maolin Huang and Weidong Huang. pp. 25-45, 2013. doi:10.4018/978-1-4666-4309-3.ch002

Chad A. Steed • steedca@ornl.gov

VitalVis

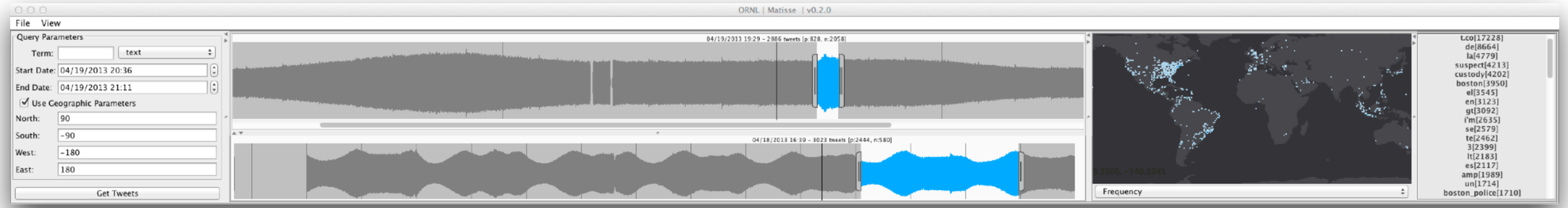


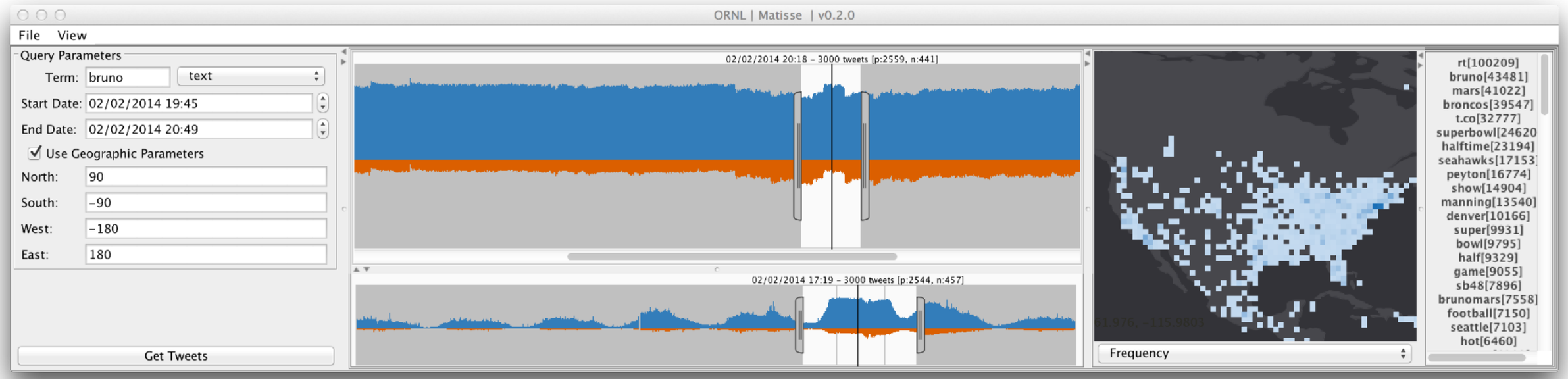
VitalVis is a web-based visual analytics tool that was designed specifically for exploring sensor data collected during surgeries. These sensors capture vital signs of patients (e.g., blood pressure, respiratory, heart rate) as well as drug and fluid dosages. The sensor data reveal, through visual displays and statistical computations, a comprehensive picture of the patient's state over time. The combination of vitals and drug/fluid dosages also provides a unique picture of human responses to various medications and fluids and opportunities to learn and predict outcomes. Due to patient data sensitivities, VitalVis is not openly accessible.

Applications: healthcare data science

Chad A. Steed • **steedca@ornl.gov**

Matisse





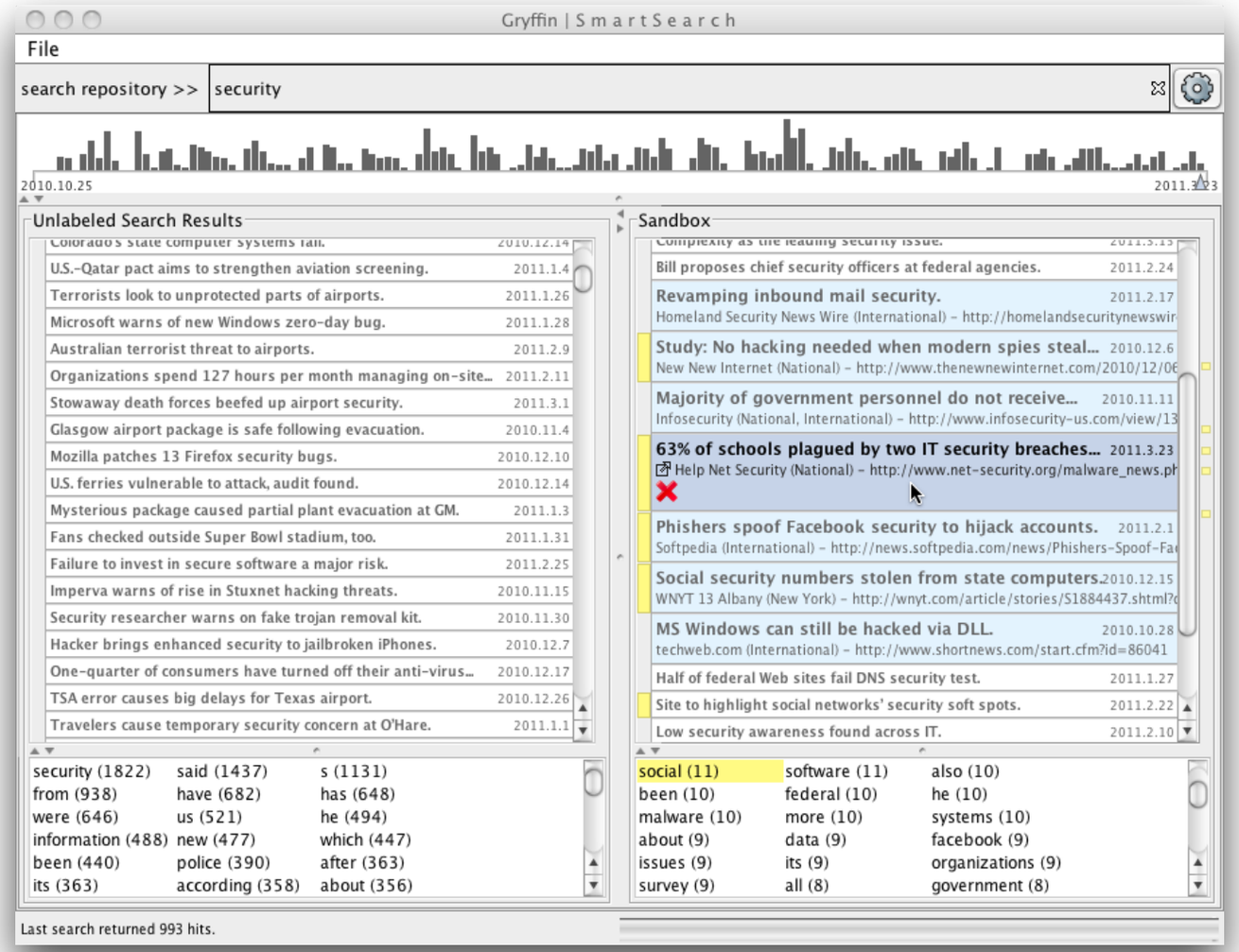
Matisse is a visual analytics system for exploring spatio-temporal patterns in streaming text data, such as social media streams. Matisse provides temporal visualizations with linked geographical and top term views. In addition to univariate statistical views (top), Matisse can encode positive and negative sentiment (bottom) as segmented graphs using blue and orange bars, respectively. In the temporal visualizations, Matisse uses an overview+detail interaction technique, which combines a longer time series (bottom, lower time series) and a detailed view (bottom, upper time series).

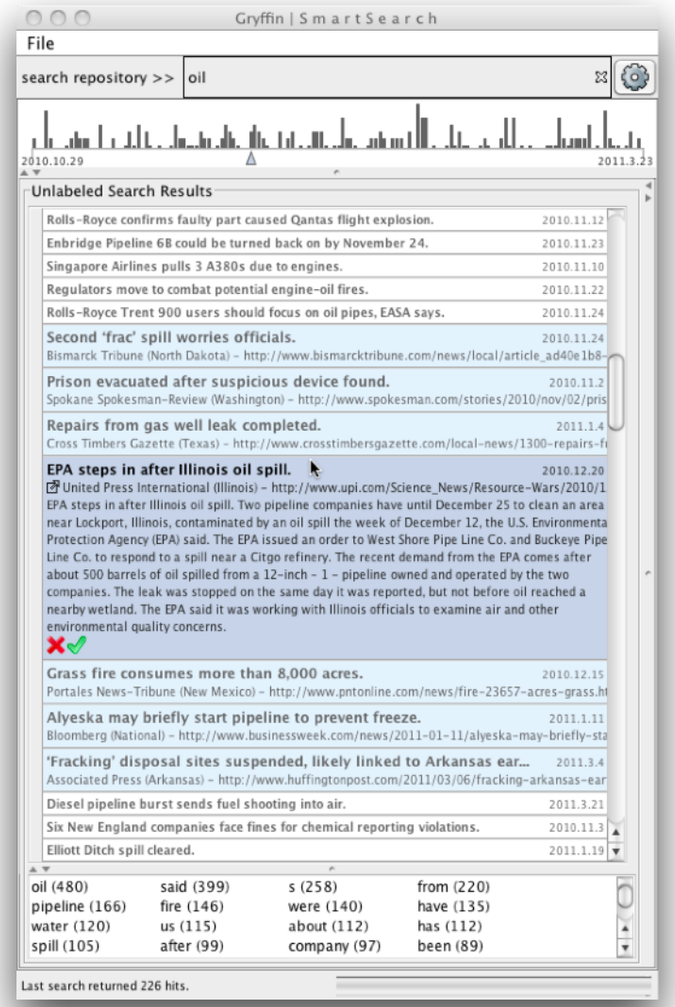
Applications: national security, marketing, and general text mining.

Citation: Chad A. Steed, Margaret Drouhard, Justin Beaver, Joshua Pyle, and Paul L. Bogen II. "Matisse: A Visual Analytics System for Exploring Emotion Trends in Social Media Text Streams." In Proceedings of the IEEE International Conference on Big Data (IEEE Big Data 2015), Oct. 2015.

Chad A. Steed • steedca@ornl.gov

Gryffin





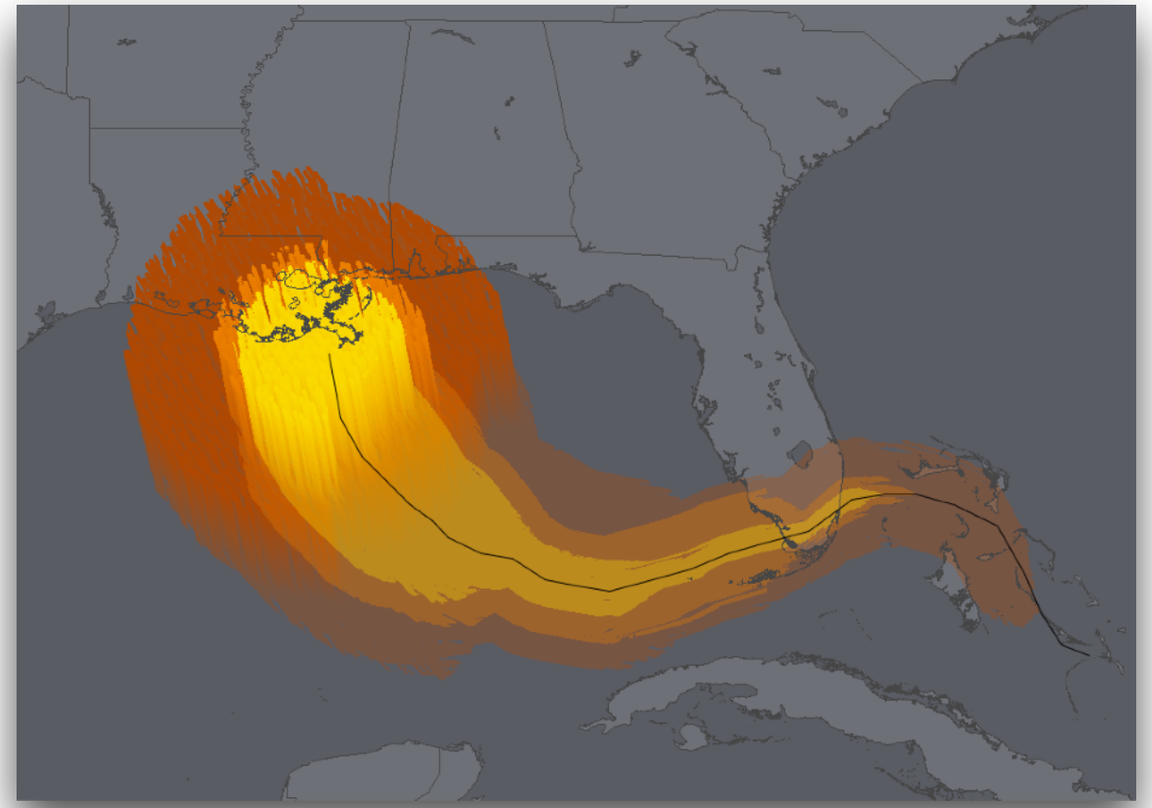
Gryffin is a visual analytics system for personalized text mining of document collections. Gryffin offers several interactive visualizations with "scented" widgets for search-based exploration via focus+context document list views, temporal timelines, and term-frequency views using a coordinated data model. Furthermore, user interactions are tracked and used to label documents that are relevant or irrelevant to the topic of interest. These labels are then used to drive semi-supervised machine learning algorithms that re-rank unlabeled documents moving potentially relevant records to the top of the list view.

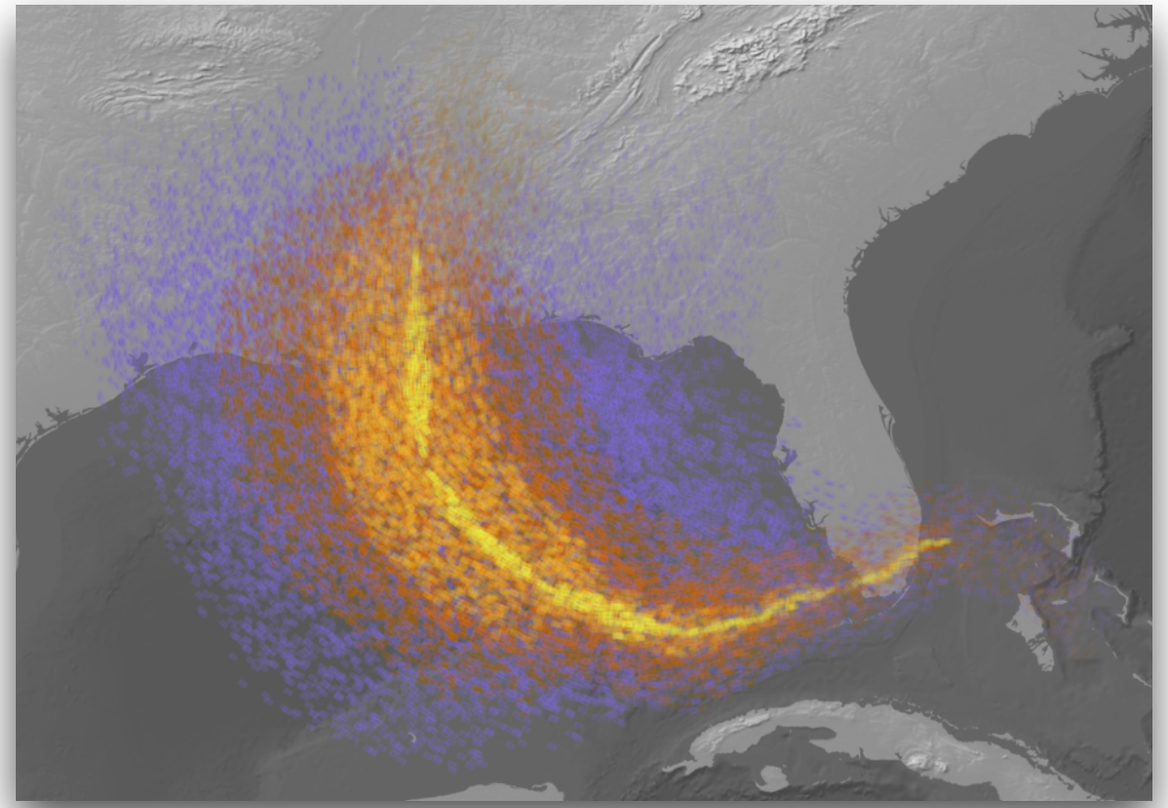
Applications: national security, homeland security, and general document/text analysis

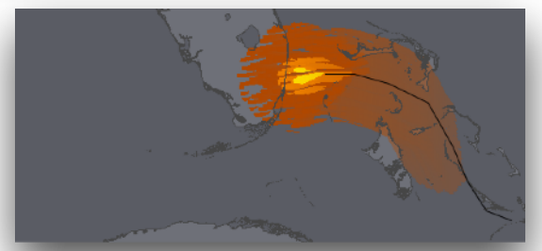
Citation: Chad A. Steed, Christopher Symons, Frank DeNap, and Thomas E. Potok. "Guided Text Analysis Using Adaptive Visual Analytics." In Proceedings of the Visualization and Data Analysis Conference, Jan. 2012. DOI:10.1117/12.904904

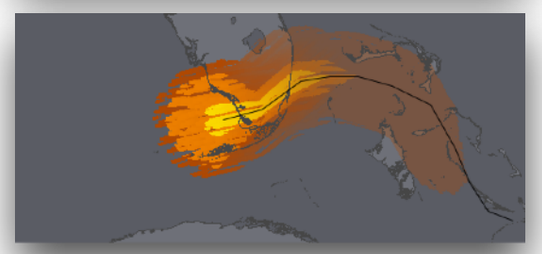
Chad A. Steed • steedca@ornl.gov

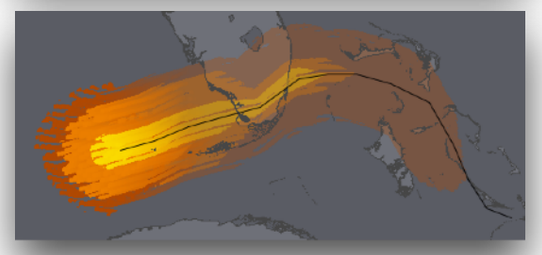
Illustrative Visualization









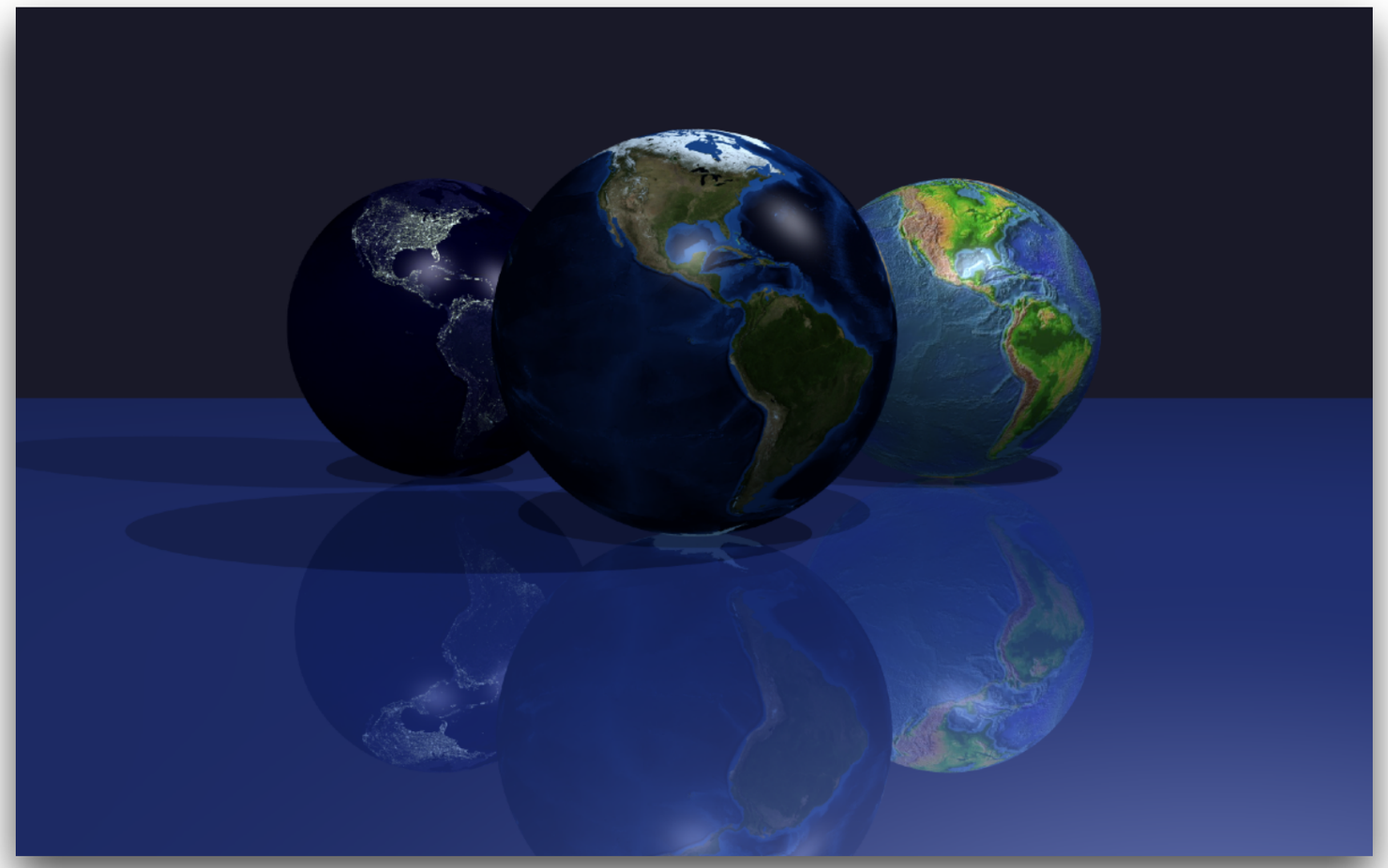


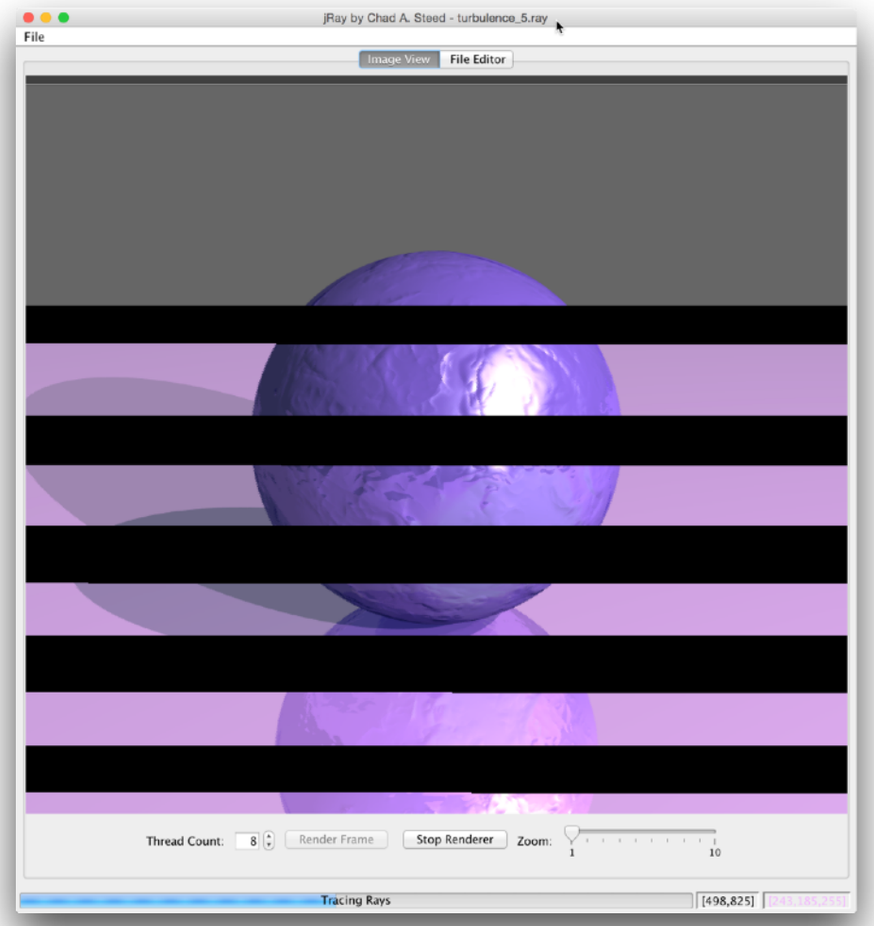
An art-inspired illustrative visualization encodes multiple data dimensions using visual features that resemble artistic brush strokes. The long brush stroke method (left) resembles a large bristle brush stroke. A small stroke method (right) is designed to mimic an impressionist style painting with many small brush marks. The technique can be animated (bottom right) to track a hurricane's progression while representing several dimensions in a single display. The technique is generalizable to any quantitative multi-dimensional dataset such as simulated data from ocean models using glyph attributes.

Citation: Chad A. Steed, T.J. Jankun-Kelly, and J. Edward Swan II. "Illustrative Visualization of Hurricane Advisory Information." In Proceedings of MTS/IEEE Oceans 2009, pp. 1–9, Oct. 2009.

Chad A. Steed • steedca@ornl.gov

jRay

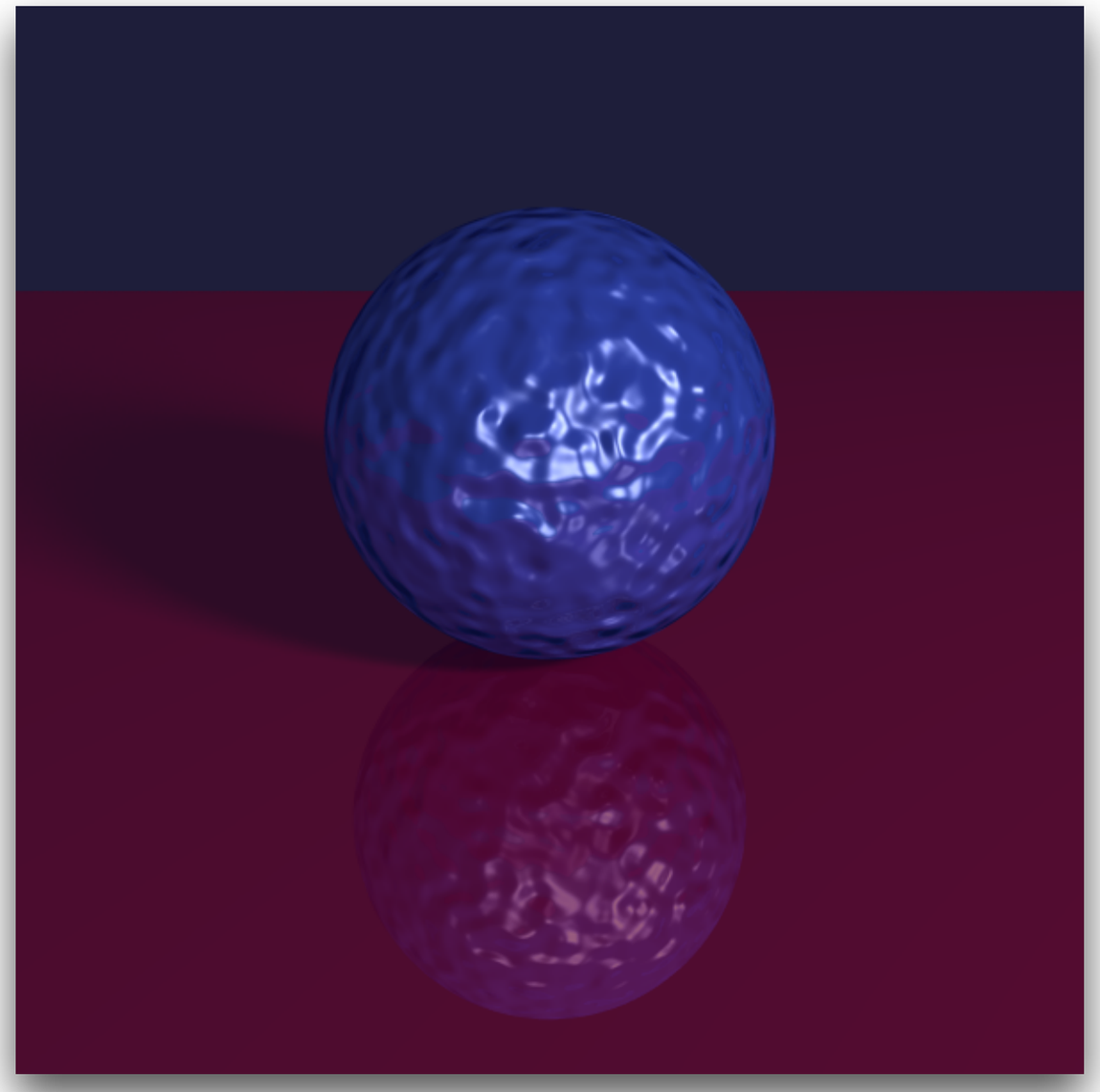


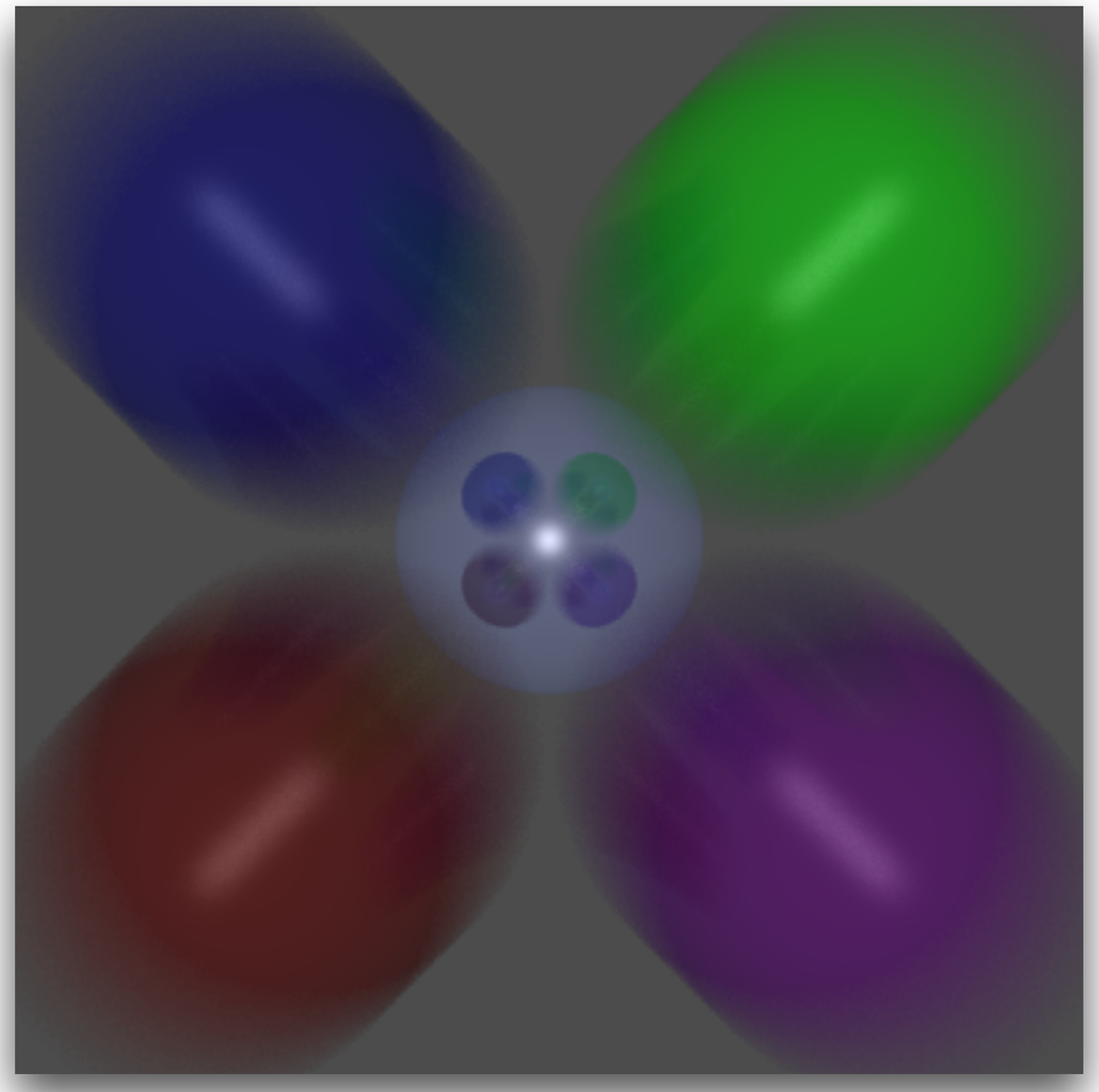


jRay is a java ray tracing system I developed from scratch during my Ph.D. studies. Initially developed as a project for my Advanced Computer Graphics course, I wrapped the library with a Java GUI to edit the custom scene parameters and launch/monitor the ray tracing process. As shown in the right image, the rendering process is multi-threaded. Each thread writes to the GUI display independently using a multiple pass scheme for fast viewing. Several advanced rendering options are available to achieve complex surface properties, antialias settings, reflections, textures, etc. The system also generates movies of procedurally generated Perlin noise textures mapped to geometric objects.

Chad A. Steed • **steedca@ornl.gov**

jRay





Additional output images from **jRay** demonstrating Perlin noise textures (left) and motion blur / reflections (right).

Chad A. Steed • **steedca@ornl.gov**