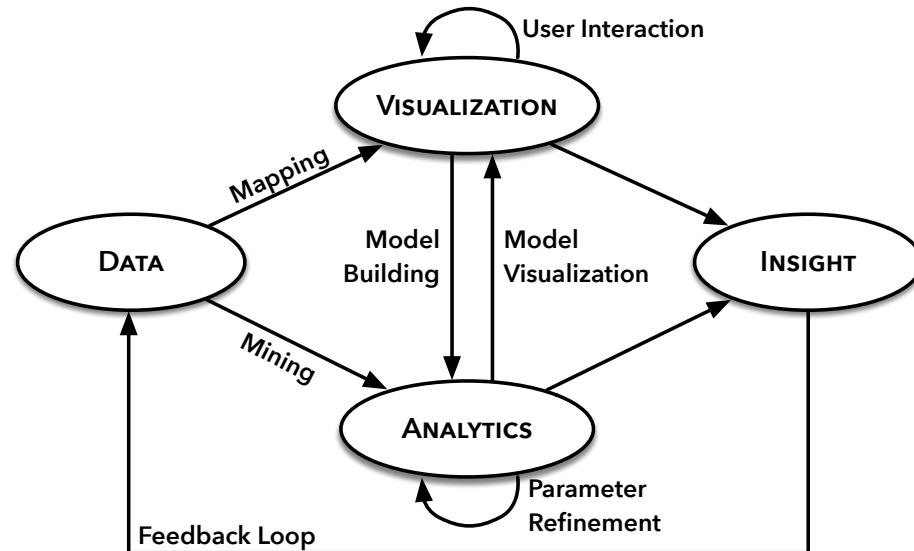


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- **Research Focus:** Improve human capacity to explore large and complex data by integrating data visualization and automated analytical algorithms
 - Preserves human ingenuity in scientific analysis while leveraging computational guidance
 - Increases scale and depth of data exploration, which increases probability of new discoveries in key domains
- **Interdisciplinary Collaborations/Applications:** Materials science, climate science, additive manufacturing, cyber security, cyber physical systems, health care, and national security
- **Practical Results:** Open source systems (CrossVis, EDEN, Falcon), patented systems (Matisse, MDX), long-standing collaborations, publication and commercialization awards, R&D 100 award



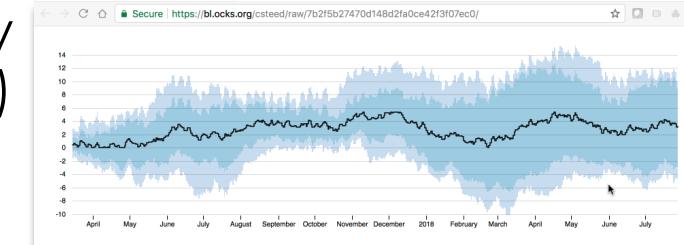
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- **Recent Scientific Data Analysis Projects**

- SciDAC RAPIDS: Visual analytics to materials and climate science
- BER Climate Simulation: Visual analysis of large scale, multidimensional data sets from Earth system models
- Materials Science: Applications of visual analytics and new VR/AR approaches for Explainable AI and general scientific data exploration

- **Recent National Security Projects**

- Cyber Security: Find and explore anomalies in computer network traffic
- Cyber Physical: Explore sensor data streams to improve resiliency in critical systems (e.g., power grid, user facilities, manufacturing)
- Nuclear Nonproliferation: Analyze the performance of radiation detection systems



CrossVis: Guided Exploratory Data Analysis

Scientific Achievement

CrossVis enables flexible exploration and comprehensive understanding of large, heterogeneous, and multivariate data by integrating interactive visualizations and statistical analytics.

Significance and Impact

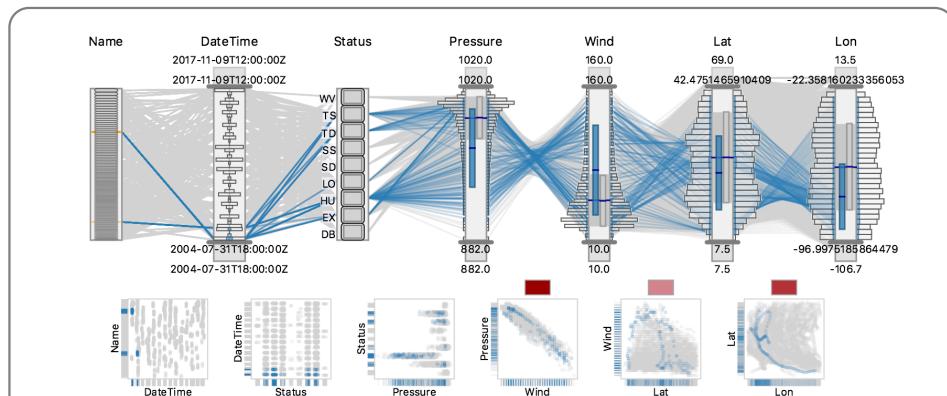
CrossVis helped materials scientists at ORNL CNMS understand and improve a neural network classification process for microscopic imagery with genetic engineering applications.

CrossVis allowed ORNL BER climate scientists to consider more variables from large scale, land model parameter sensitivity analyses and ultimately improve DOE model accuracy.

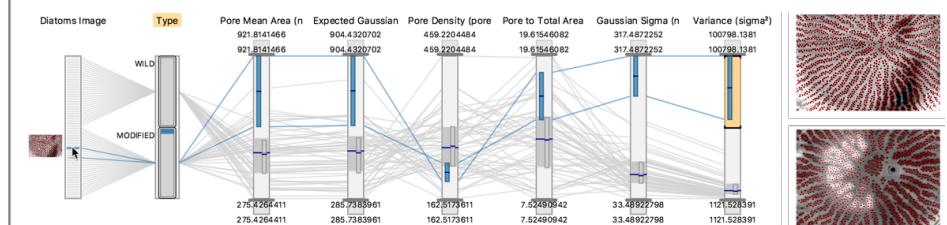
Research Details

- CrossVis implements theoretical information foraging concepts, whereby information dynamically derived from statistical analytics are used to augment interactive data visualizations making key patterns visually salient.
- CrossVis provides an advanced multivariate visual analytics framework supporting heterogeneous data types (e.g., images, temporal, categorical), progressive high-performance rendering, and a scalable data model.
- Design requirements stem from over a decade of experience collaborating with scientists from a variety of domains.

Citation: A. Trofimov, ... **C. Steed.** “Deep Data Analytics for Genetic Engineering of Diatoms Linking Genotype to Phenotype via Machine Learning”, *npj Computational Materials*, 2019.



Exploration of Historical Hurricane Observations



Analyze Neural Networks for Microscopic Imagery

CrossVis is a visual analytics tool that integrates statistical analytics and an extended version of parallel coordinates to allow flexible exploratory of large and heterogeneous multivariate data. In addition to climate and materials science, CrossVis has been applied to cyber security, manufacturing, power grid, and system performance projects.

Falcon: Visual Analysis of Large, Irregularly Sampled, Multivariate Time Series Data for Additive Manufacturing

- A new visual analytics system for exploratory analysis of large and complex time series data
- Integrates several interactive data visualization techniques extending the limits of conventional time series analysis methods
- Semi-supervised machine learning agents learn the user's interest and provide guidance to interesting relationships for scalable exploration
- Novel segmented time series data visualization methods that provide overviews and details
- Applied successfully to additive manufacturing, climate, and cyber security domains
 - Gain understanding of why 3D printing defects occur
 - Climate model ensemble sensitivity analysis
 - Reveal network flow patterns in cyber attacks
 - Applicable to AI algorithm analysis

Citation: C. Steed, R. Dehoff, W. Halsey, S. Yoder, S. Powers, and V. Paquit, "Falcon: Visual Analysis of Large, Irregularly Sampled, and Multivariate Time Series Data in Additive Manufacturing", *Computers & Graphics*, 2017.

