Improving Scientific Data Analysis Through Multi-touch Enabled Interactive Data Visualization with Applications to Neutron Science

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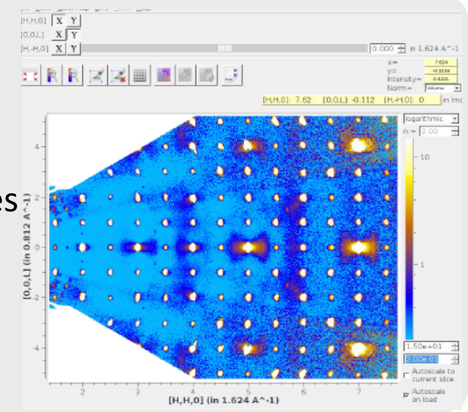
Objective

Develop new human multi-touch interaction, interactive data visualization, and effective user interfaces for improving large-scale scientific data analysis.

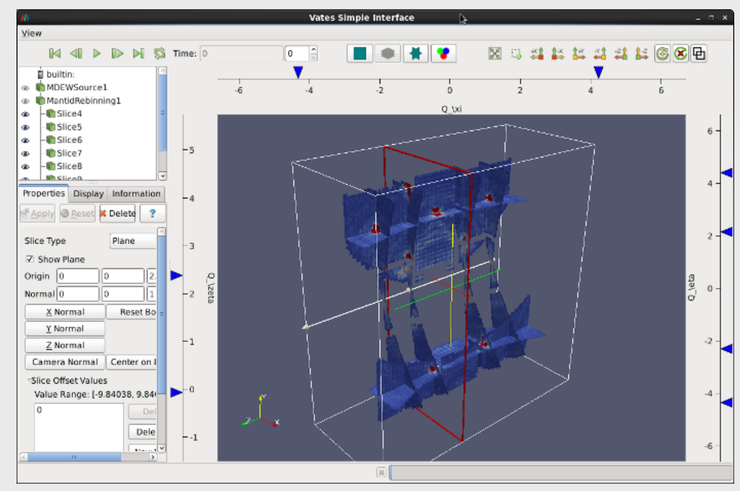
Motivation

- Huge volume of complex scientific data are collected from large-scale experiments.
- Although several scientific data visualization tools are available, challenges remain that can only be addressed through more interactive techniques.
- Human-computer interaction (HCI) techniques are rarely considered in scientific data analysis.
- There is a chasm between HCI techniques and scientific data analysis.

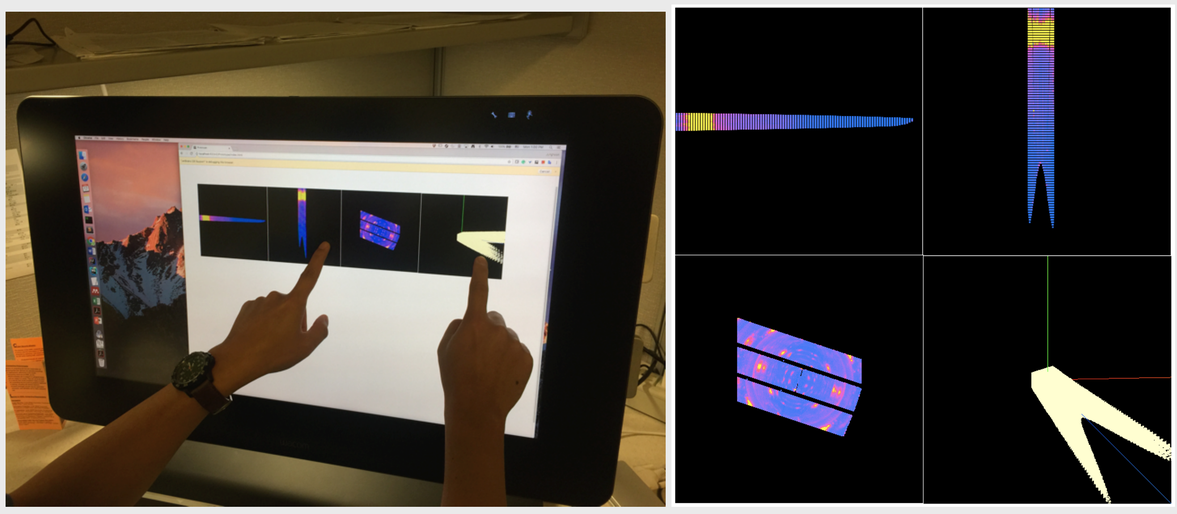


Neutron Scattering Science at the ORNL SNS

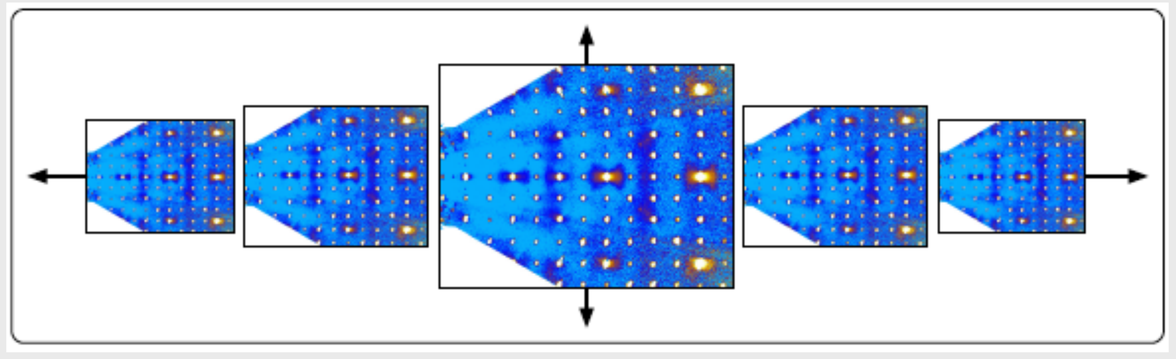
- Oak Ridge National Laboratory's Spallation Neutron Science (SNS) is a unique Department of Energy user facility that offers the most intense pulsed neutron beams in the world for scientific research and industrial developments.
- SNS produces neutrons directed to experiment stations that host a variety of sensing capabilities for scientists.
- Scientists use SNS neutron scattering instruments to determine complex crystal structures that are described by unit cells with tens to millions of atoms.
- Experiments generate data sets that are **large**, **multi-dimensional**, and involve **complex transformations**.
- We are focusing on improving the efficacy of a specific visual analysis technique called volume slicing, which SNS users state is critical to understanding neutron scattering data. Volume slicing is applied to a 3D volume of data. The user extracts a slice by specifying a 2D plane, which is intersected with the 3D volume.



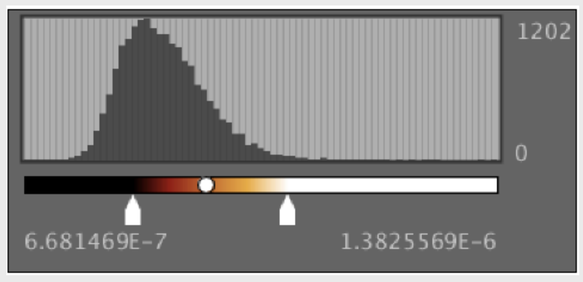
New Multi-touch Enabled Interactive Data Visualization for Neutron Scattering Data



- The discovery of important patterns in neutron scattering experiments hinges on selecting the right slice–a 2D array of values extracted from 3D volume that is visually encoded as colored pixels in an image, and applying a color scale that maps the widest range of colors to the most important range of values.
- The current tool yields an ineffective user experience that inhibits direct human interactions with the data visualization and delays visual perception of key patterns.
- New touch interactions that allow the user to **adjust the color scale mappings** and dedicate a wider range of colors to the data values.
- Furthermore, multi-touch interactions with the volume slice visualization will allow the user to **create and adjust volume slice planes dynamically**.



- Exploring alternative layouts such as a horizontal layout for each slice plane that lets the user can swipe through. The current slice larger and the neighboring slices progressively smaller based on the distance from the current slice.
- **Providing spatial awareness in the 2D views** through linking and interaction and thereby reduce the need for a 3D view.



- A statistical technique that **automatically sets the initial color scale mappings** using the interquartile range and median values for the overall data distribution.
- Improving initial view of the data, which is often skewed by large outliers or peaks, by assigning the maximum range of colors to the bulk of the data value space.

Conclusion

We are developing new interactive data visualization and analysis techniques that allow SNS researchers to unlock the full potential of the large and complex data they analyze for neutron scattering experiments. In the future, we will incorporate machine learning techniques to infer intent and automatically find patterns of interest by monitoring the researcher's interaction with the tool.

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