Sandia National Laboratories

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Modular Web Application Design for the Visualization and Analysis of Nuclear Detector Characterization Data

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Abstract

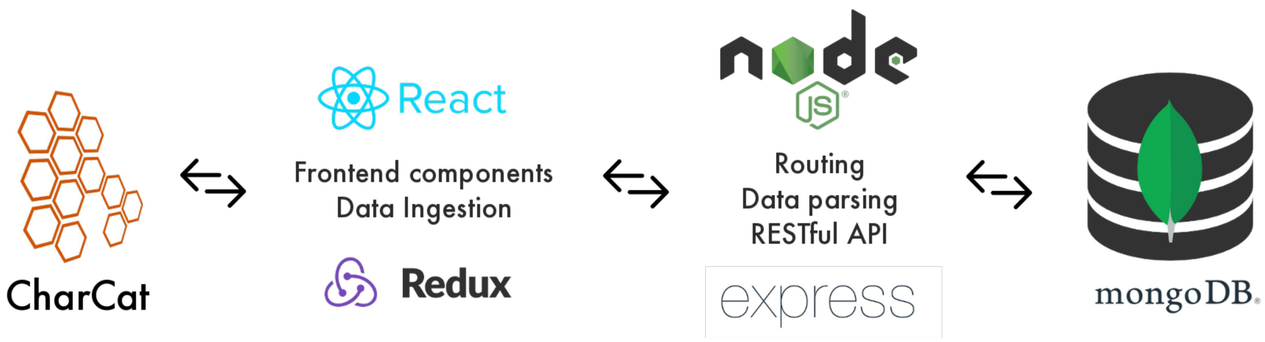
The Instrument Characterization Catalog (**CharCat**) is an online reference tool to be used by the Department of Homeland Security/Countering Weapons of Mass Destruction (CWMD) test scientists as part of the Data Mining, Analysis, and Modeling Cell (DMAMC) tool suite. The purpose of the application is to contain and visualize characterization and inventory data for a variety of radiation detection instruments. Utilizing modular web design principles along with modern web frameworks in the creation of CharCat allowed for flexible, iterative development with scalable design solutions.

Architecture

CharCat utilizes MERN, an open-source software stack for building dynamic web applications. The components of the MERN stack are as follows:

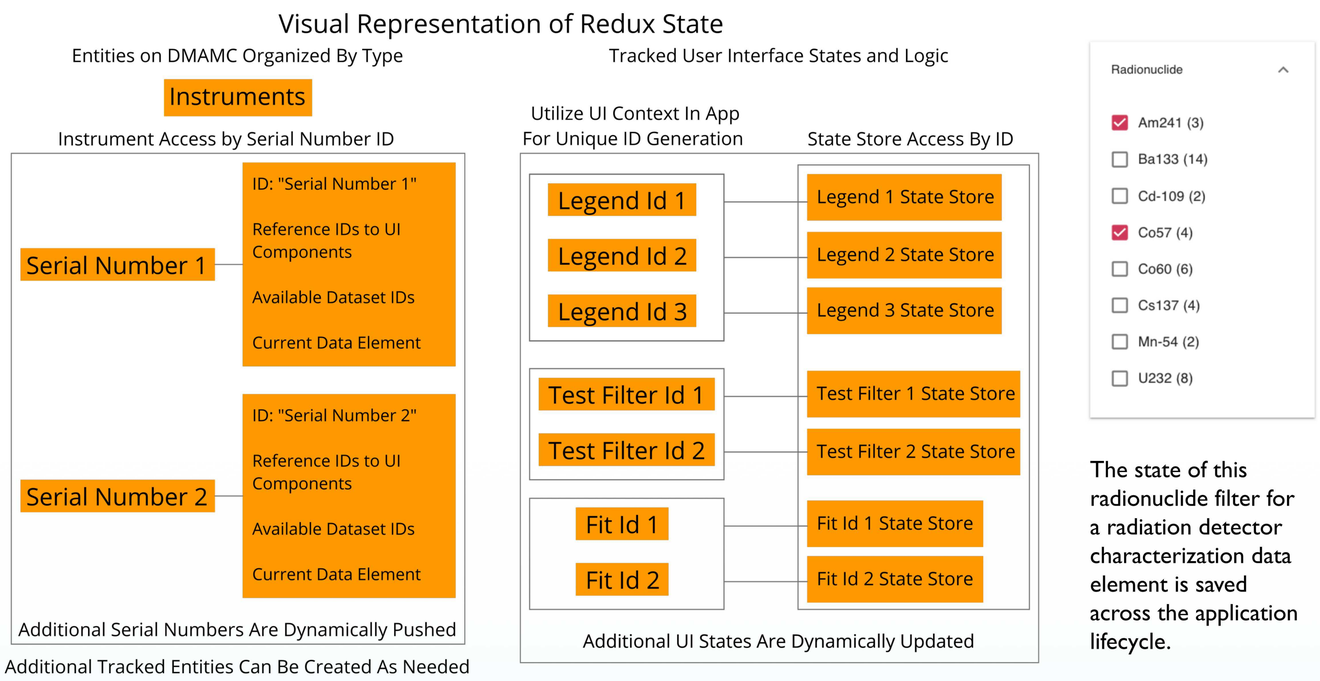
- **M**ongoDB, a general purpose NoSQL, document-based database.
- **E**xpress.js, a web application server framework for Node.js.
- **R**eact.js, a JavaScript library for building component-based interfaces in a declarative way.
- **N**ode.js, an open-source cross-platform runtime built on Google's V8 JavaScript engine.

Additional JavaScript libraries for data formatting, computation and visualization are also used.



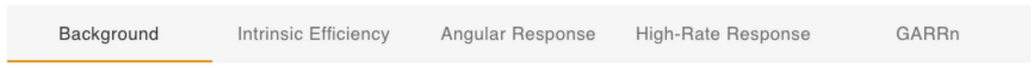
State Management with Redux

Redux is a JavaScript library commonly used in applications with complicated workflows as a solution for state management. We use Redux to centralize CharCat's application state and logic, enabling content persistence for the user.

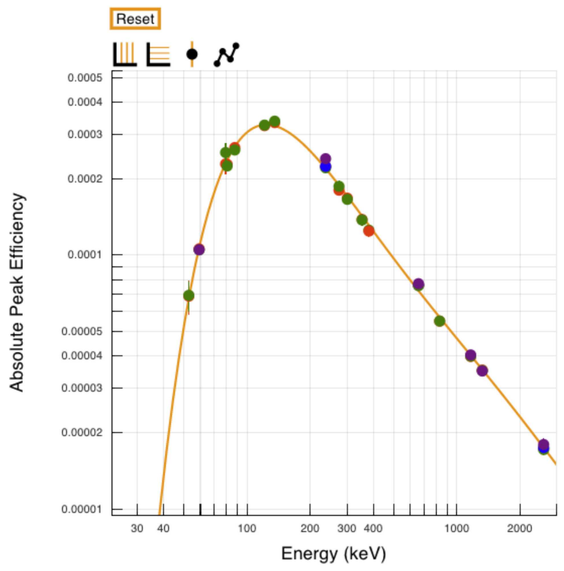


The state of this radionuclide filter for a radiation detector characterization data element is saved across the application lifecycle.

Front-end Modules

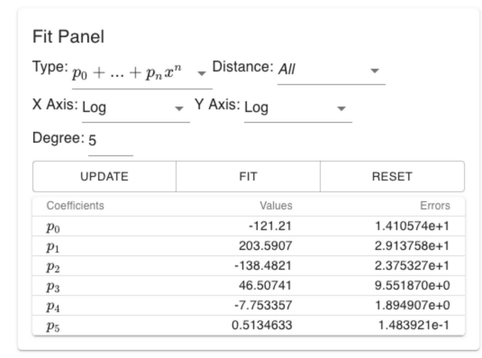


Tabs are dynamically generated from instrument data to show each of the measured data elements. When clicking on a tab, a panel is displayed below showing details about the measured data element, as well as a data table or chart for visualizing statistical data.

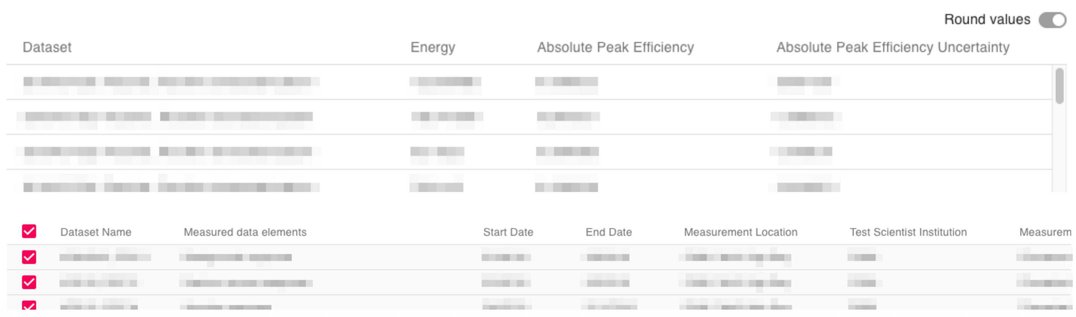


The scatter chart uses D3.js, a JavaScript library for dynamic, interactive data visualization.

Features:
- Shows data points with color and shape attributes
- Supports both continuous and discrete axes
- Closest point hovering with detailed point labels
- Error bars
- Curve fitting
- Zooming/panning
- Conversion to line chart



We developed a custom library for the plot fit panel that uses common regression techniques, such as linear least squares and root squared. It also gives users the ability to customize settings like the number of degrees for polynomial fits, independently scale the X and Y axes, and fit using a multitude of fitting types. The panel draws the line of best fit on the chart and displays the fitting coefficients on the panel with their standard errors. We tested our own library against the CERN ROOT library to verify its accuracy.



The data table component is used to display different types of ordered or unordered data, including HTML elements or numbers with high decimal precision. The table detects numeric cells and rounds the values to minimal precision. The component utilizes the 'react-virtualized' library to display large datasets without sacrificing performance by rendering only the visible rows of data.

Security

The CharCat application is open to the world wide web. Therefore, many security concerns need to be addressed to protect sensitive data. Basic authentication is used to authenticate and authorize users. Credentials are encrypted using basic access authentication, and secure transport from client to server is done through TLS. Passwords are compared to their salted and hashed counterparts for validation. In the future, the login system will be converted to use an OAuth 2.0 token-based setup, offering session management and key revocation options.

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