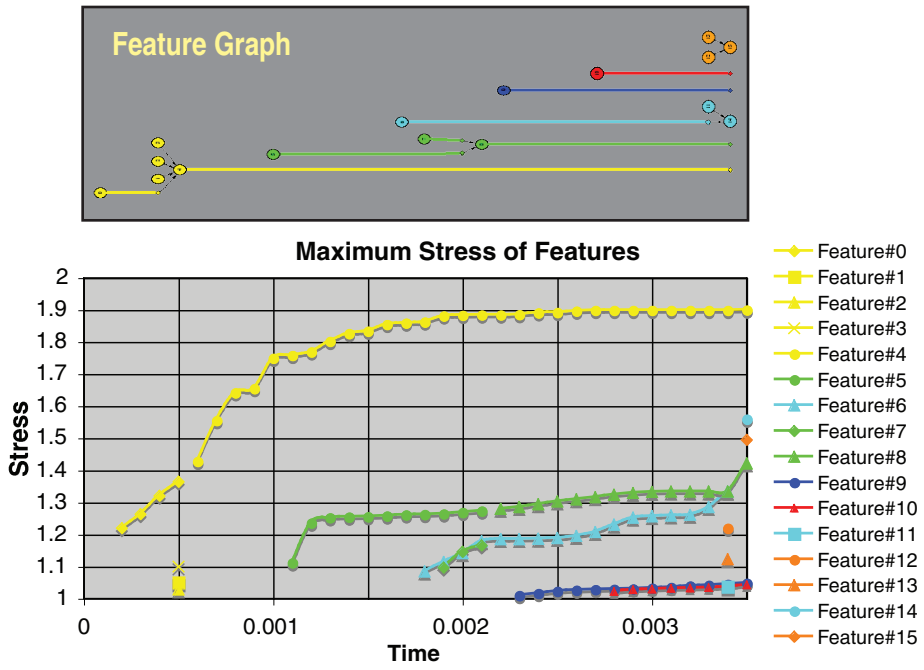
FCLib

A Library for Building Data Analysis and Data Discovery Tools



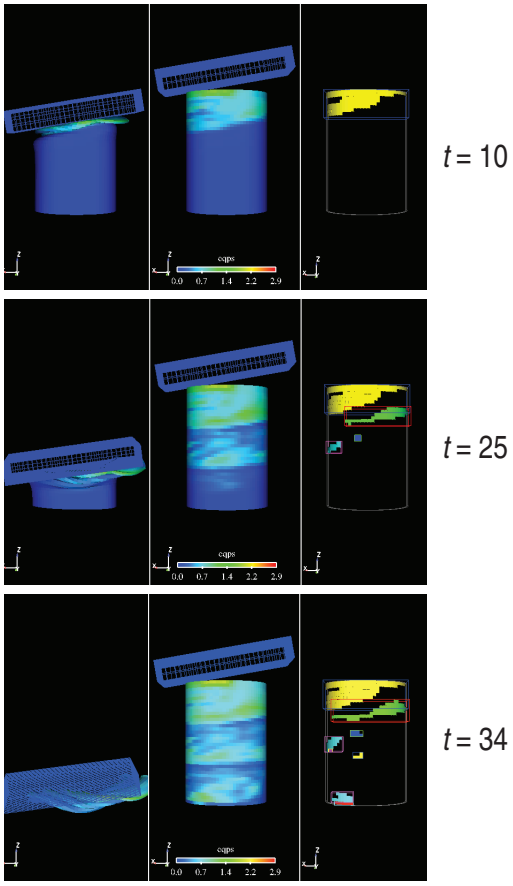


Figure 1. FCLib was used to track and analyze features corresponding to the crumpled regions of a can being crushed (right). The feature graph (top left) shows how the features interacted over time. Below the feature graph is a plot of a selected statistic (maximim stress) per feature over time. The big, yellow feature at the top of the can formed first and obtained the highest maximum stress.

FCLib, a data analysis toolkit, was constructed to meet the needs of data discovery in large-scale, spatio-temporal data. FCLib is a C library toolkit of building blocks that can be used to assemble analyses for data discovery. Important features of FCLib include the following:

(1) Support for feature-based analysis
(2) Minimization of low-level processing
(3) Ease of use
(4) Applications in a wide variety of science domains

Data discovery is the iterative process of exploring data to extract information. As data increase in size and complexity, current data analysis methods become more cumbersome, slower, and more error-prone since these methods rely on analysts to examine each piece of data and move data between tools. FCLib was designed to automate as much low-leveling processing as possible, while still allowing analysts the freedom to flexibly compose their own chains of analysis. Instead of worrying about low-level details, users of FCLib can compose data analyses at a higher level.

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Most data analysis tools lack a key capability useful for analyzing large data: the native ability to manipulate small regions of interest known as "features". Features are usually coherent structures that persist over some period of time. Examples include vertex tubes in fluid-dynamical systems, failure zones in mechanical systems, and hot spots in chemical systems. Although feature-based analysis is a common approach, most data analysis tools do not directly support this approach. Instead analysts typically hand-select regions of interest and then export these regions to other tools for further analysis. In contrast to other data analysis tools, FCLib provides a native data structure for features, as well as analysis building blocks that are feature-aware.

Table 1. Partial listing of FCLib building blocks.

Mesh Topology	
Get mesh entity children	Get vertices that make up an element.
Get mesh entity parents	Get elements that contain a vertex.
Get mesh entity neighbors	Get adjacent entities within a mesh.
Segment	Separate mesh or subset into connected components.
Get skin	Get the outside edges or faces of a mesh or subset.
Mesh Geometry (Spatial)	
Find entities	Get mesh entities within a bounding box or sphere.
Get sizes	Determine edge lengths, surface areas, and region volumes.
Bounding box routines	Determine the axis-aligned boundaries of meshes and subsets; can also combine and test for overlap of bounding boxes.
Centroid routines	Find the center of mass for meshes and subsets.
Variable	
Variable math	Create new variables as mathematic combinations of current variables (+, *, sqrt(), pow(), etc.).
Statistics routines	Determine min/max/mean/st.dev./sum.
Decompose vectors	Decompose into normal and tangent components against an arbitrary vector.
Kernel smooth variables	Replace variable field values with local averages.
Threshold	Find subset of entities that meet threshold criteria.
Subsets	
Set operations	Create new subsets using AND, OR, or XOR.
Feature tracking	Track subsets over time.

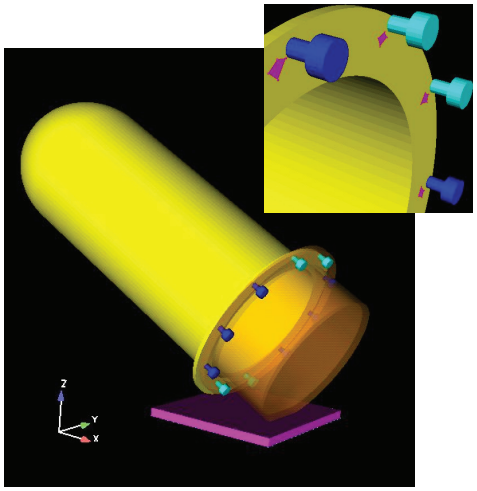
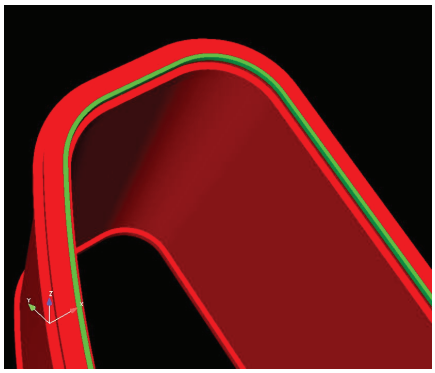


Figure 2. FCLib was used to build a spot-weld analysis program. The original analysis was performed by hand and used an approximation to calculate partial failures. The new analysis was completely automated, robust in the face of changing conditions, and capable of calculating the full partial failure.



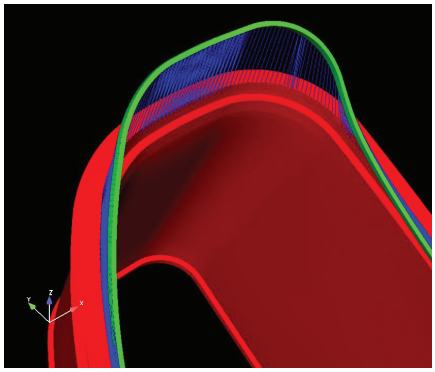


Figure 3. Example of an analysis currently under development. The gap analysis creates line elements to join meshes that were adjacent at time zero. At time zero (left), the green gasketlike ring rests inside the lip of the can. As time progresses (right), the ring falls out of the can. The blue "gap" lines show the relative change in position of the two mesh surfaces. These lines can be used to find and quantify gaps.

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