VisIt for NDE: Real-Time Visualization for Large NDE Data Sets

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LLNL's Center for Nondestructive Characterization (CNDC) needs a tool to provide fast, real-time, 3-D visualization of feature metrology within very large data sets. Considerable resources have been spent increasing the spatial resolution and, therefore, the size of NDE data sets. Current data sets typically range in size from 4 GB (1 voxel) to 108 GB (27 voxels), and future data sets will be 2 TB (512 voxels). Visualization of such data is currently performed off-line and can take days or weeks to complete. VisIt is a real-time, 3-D visualization and quantitative analysis software tool that can use parallel processing machines on multiple platforms to visualize large data sets in seconds or minutes. We explored the capabilities of VisIt with the intent to facilitate its application to very large NDE data sets.

Project Goals

The project goals were to:

1. verify that features for NDE visualization are available in VisIt by operating on small computed tomography (CT) data sets;
2. test for limitations of visualization of large data sets;
3. write a graphical user interface or scripts incorporating visualization features relevant to NDE data; and
4. demonstrate VisIt to NDE users to stimulate interest and obtain feedback about desired features.

Relevance to LLNL Mission

The project addresses LLNL's need for non-contact dimensional metrology of millimeter-sized 3-D structures (HEDS and ICF target requirements), and highly improved imaging, processing, and analyzing methods that are applicable to large-size data sets ranging from terabytes to petabytes. The project also supports LLNL's engineering core competencies in nondestructive characterization and signal/image processing and control.

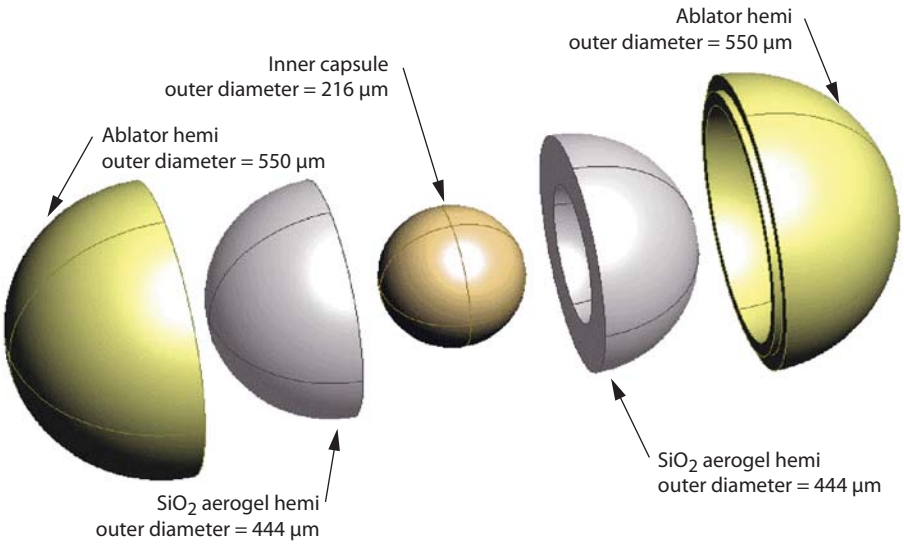

Figure 1. Schematic of the components that make up a double-shell target. The target consists of an inner shell (or capsule), a two-piece spherical aerogel intermediary shell, and a two-piece spherical outer shell. The three elements are concentric, with the aerogel shell acting as a spacer between the inner shell and outer shell. There are zero to a minimum number of air gaps in the final assembly.

FY2006 Accomplishments and Results

A Windows-based PC platform for VisIt was set up for NDE data. Several CT data sets (128^3 to $1{,}200^3$ voxels in size) were placed locally on the PC and remotely on the Livermore Computing (LC) OCF file system. Visualizations of both local and remote data were performed. Figure 1 is a schematic of components of a double-sided shell target. Figure 2 is a sample volume rendering of a 512^3-voxel data set. The processing time for larger data sets and/or more complex operations decreased when LC machines were used. VisIt contains many useful features for NDE data applications such as:

1. viewing 3-D objects from any angle;
2. slicing data sets with planes oriented in any direction;
3. manipulating threshold and opacity levels to view object features within the context of the whole data set;
4. extracting line-outs of data values; and
5. performing quantitative analyses.

Visualization of data is constrained by the number of processors scheduled, length of time required, and region of interest desired. No limitations were encountered in this project. For example, visualization of the $1{,}200^3$-voxel data set was done using 64 to 256 processors, and LC maintains several machines with between 1-K and 4-K processors and even one ("Blue Gene") with 128-K processors. Large numbers of processors can be scheduled for visualization and/or analysis.

Some sample scripts were written to implement desired calculations. For example, one measures object sphericity and another determines boundary surfaces between materials of different attenuation.

Some attractive features of VisIt are:

1. the ability to perform remote desktop visualization of data stored on LC OCF/SCF file systems;
2. visualization of multiple materials in a single view using opacity control;
3. real-time analysis of metrology information; and
4. comparative overlaying of CT data with data generated by other means.

Some desired features for VisIt are:

1. scripts for concentricity and wall thickness of nested spherical shells;
2. "fly-through" movies with opacity control; and
3. hierarchal data structures that permit high-resolution "close-ups" of subsets of coarsely-sampled data sets.

Related References

1. Childs, H., E. Brugger, K. Bonnell, J. Meredith, M. Miller, B. Whitlock, and N. Max, "A Contract Based System for Large Data Visualization," *Proceedings of IEEE Visualization*, 2005.

2. Brown, W. D., and H. E. Martz, Jr., "X-ray Digital Radiography and Computed Tomography of ICF and HEDP Materials, Subassemblies and Targets," *Digital Imaginig IX, An ASNT® Topical Conference*, Mashantucket, Connecticut, July 24-26, 2006.

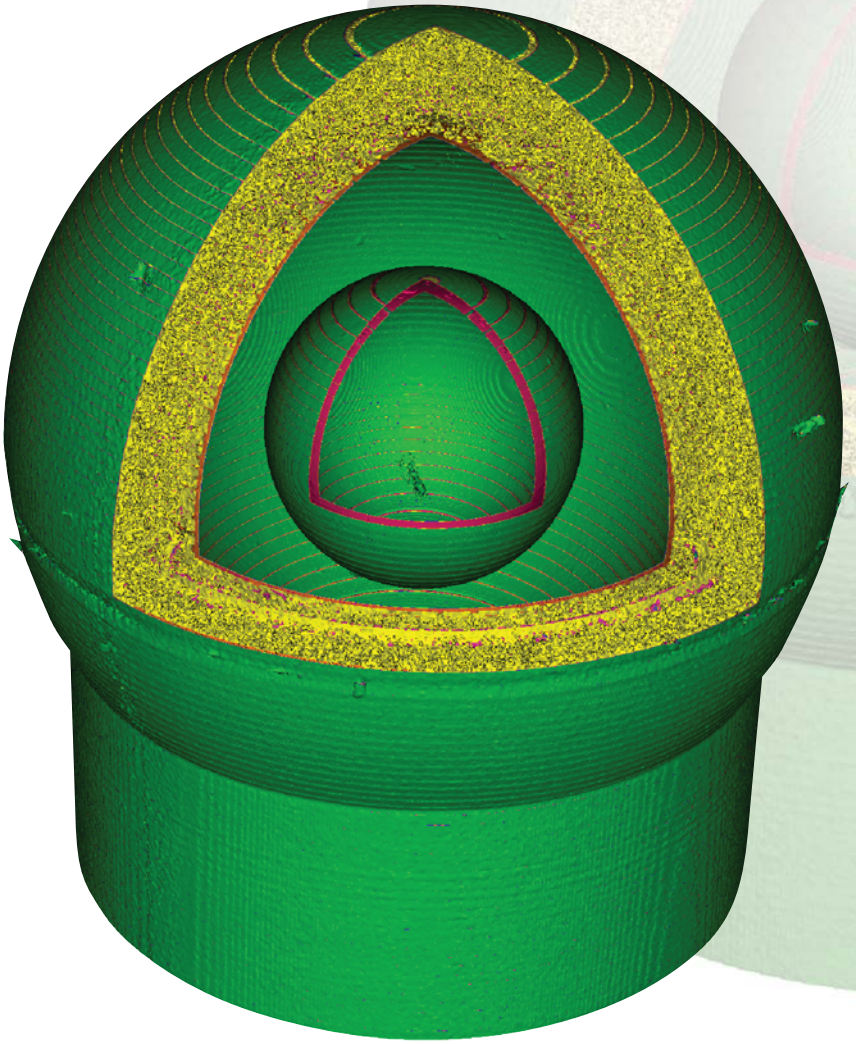

Figure 2. VisIt volume rendering of a real double-shell target (as depicted in Fig. 1) while still mounted on its manufacturing pedestal. The rendering is of a 512^3-voxel CT data set. The cutaway view provides a look inside both the inner and outer shells. The aerogel material has been removed from view via thresholding.