Visualization and Analysis of HPC Simulation Data with VisIt

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Cyrus Harrison
Lawrence Livermore National Laboratory
cyrush@llnl.gov
ATPESC 2016 Outline

- **Talk**
  - VisIt Project Introduction (10 min)
  - Guided Tour of VisIt (20 min)
  - Exploration of an Aneurysm Simulation (30 min)

- **Additional Hands-on Materials**
  - Exploration of a Water Flow Simulation
  - Volume Rendering
  - Advanced Movie Making
Tutorial Resources

- Tutorial Prep

- Example Datasets

- Aneurysm Simulation Exploration

- Additional Tutorial Materials

- Cyrus’ Email: cyrush@llnl.gov
Aneurysm Simulation Dataset

Simulated using the LifeV (http://www.lifev.org/) finite element solver.

Available thanks to:

- Gilles Fourestey and Jean Favre
  Swiss National Supercomputing Centre (http://www.cscs.ch/)
VisIt Project Introduction
VisIt is an open source, turnkey application for data analysis and visualization of mesh-based data.

- Production end-user tool supporting scientific and engineering applications.
- Provides an infrastructure for parallel post-processing that scales from desktops to massive HPC clusters.
- Source released under a BSD style license.

Pseudocolor plot of Density
(27 billion element dataset)
VisIt supports a wide range of use cases.

- **Data Exploration**
- **Quantitative Analysis**
- **Visual Debugging**
- **Comparative Analysis**
- **Presentation Graphics**
VisIt provides a wide range of plotting features for simulation data across many scientific domains.

- Streamlines / Pathlines
- Vector / Tensor Glyphs
- Pseudocolor Rendering
- Volume Rendering
- Molecular Visualization
- Parallel Coordinates
VisIt uses MPI for distributed-memory parallelism on HPC clusters.

We are enhancing VisIt’s pipeline infrastructure to support threaded processing and many-core architectures.
VisIt is a vibrant project with many participants.

- The VisIt project started in 2000 to support LLNL’s large scale ASC physics codes.
- The project grew beyond LLNL and ASC with research and development from DOE SciDAC and other efforts.
- VisIt is now supported by multiple organizations:
  - LLNL, LBNL, ORNL, UC Davis, Univ of Utah, Intelligent Light, ...
- Over 75 person years of effort, 1.5+ million lines of code.
The VisIt team focuses on making a robust, usable product for end users.

- **Regular Releases (~ 6 / year)**
  - Binaries for all major platforms
  - End-to-end build process script ``build_visit``

- **User Support and Training**
  - visitusers.org, wiki for users and developers
  - Email lists: visit-users, visit-developers
  - Beginner and advanced tutorials
  - VisIt class with detailed exercises

- **Documentation**
  - Getting Data Into VisIt Manual
  - Python Interface Manual
  - Users Reference Manual

Tutorials on visitusers.org

VisIt class materials
VisIt provides a flexible data model, suitable for many application domains.

- **Mesh Types**
  - Point, Curve, 2D/3D Rectilinear, Curvilinear, Unstructured
  - Domain Decomposed, AMR
  - Time Varying
  - Primarily linear element support, limited quadratic element support

- **Field Types**
  - Scalar, Vector, Tensor, Material Volume Fractions, Species
“How do I get my data into VisIt?”

- Experiment with the *visit_writer* utility:

- Write to a commonly used format:
  - VTK, Silo, Xdmf, PVTK

- Consult the [Getting Data Into VisIt Manual](http://www.cs.sandia.gov/VisIt/manuals.html) and its associated source code examples.
VisIt employs a parallelized client-server architecture.

**Client Computer**
- VisIt Viewer
- VisIt GUI
- VisIt CLI
- Python Clients
- Java Clients

**Parallel HPC Cluster**
- VisIt Engine
- Data Plugin
- Data

**Network Connection**
- MPI
- (Files or Simulation)
VisIt automatically switches to a scalable rendering mode when plotting large data sets on HPC clusters.

In addition to scalable surface rendering, VisIt also provides scalable volume rendering.
VisIt’s infrastructure provides a flexible platform for custom workflows.

- **C++ Plugin Architecture**
  - Custom File formats, Plots, Operators
  - Interface for custom GUIs in Python, C++ and Java

- **Python Interfaces**
  - Python scripting and batch processing
  - Data analysis via Python Expressions and Queries

- **In-Situ Coupling**
  - VisIt’s *Libsim* library allows simulation codes to link in VisIt’s engine for in situ visualization
VisIt is used as a platform to deploy visualization research.

- **DOE ASCR Research Collaborations:**
  - **2006 – 2011**
  - **2012 – 2017**

- **Research Focus:**
  - Light weight In Situ Processing
  - Node Level Parallelism
  - Distributed Memory Parallel Algorithms

**Methods research:** How to incorporate statistics into visualization.

**Algorithms research:** Reconstructing material interfaces for visualization.

**Scaling research:** Scaling to 10Ks of cores and trillions of cells.
VisIt is a robust, usable tool, that provides a broad set of visualization capabilities for HPC simulation data.

- **Provides Features that span the “power of visualization”**
  - Data Exploration
  - Confirmation
  - Communication

- **Provides Features for different kinds of users**
  - Visualization Experts
  - Code Developers
  - Code Consumers

VisIt is actively developed and has vibrant developer and user communities.
Guided Tour of VisIt

- Materials from:
VisIt’s interface is built around five core abstractions.

- **Databases**: Read data
- **Plots**: Render data
- **Operators**: Manipulate data
- **Expressions**: Generate derived quantities
- **Queries**: Summarize data
Aneurysm Simulation Exploration

Additional Hands-on Materials

- Water Flow Simulation Exploration

- Volume Rendering

- Advanced Movie Making
Resources

- **Presenter Contact Info:**
  - Cyrus Harrison: cyrush@llnl.gov

- **User resources:**
  - Main website: [http://www.llnl.gov/visit](http://www.llnl.gov/visit)
  - Wiki: [http://www.visitusers.org](http://www.visitusers.org)
  - Email: visitusers@ornl.gov

- **Developer resources:**
  - Email: visit-developers@ornl.gov
  - SVN: [http://visit.ilight.com/svn/visit/](http://visit.ilight.com/svn/visit/)