

Fluid Flow Visualization of Biological Processes In Three Dimensional Space

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http://www.csm.ornl.gov/Internships/rams_05/abstracts/j_bennett.pdf

Abstract

Under the on-going Virtual Soldier Project research, supported by the Defense Advanced Research Projects Agency, the particular subtask being undertaken is to visualize fluid flow through the pulmonary airways and blood flow in a large artery. The pulmonary flow studies were previously obtained from finite element simulation of a 3-D geometrical model made up of six airway branches (generations). The cardiovascular arterial model consists of a single axisymmetric tube with elastic walls. Currently, the blood flow in the latter model is computed in two spatial dimensions. Results will be visualized in 3-D using rotation around the axis of flow. Data is inputted using the HDF5 file format (Hierarchical Data Format), a file format for large datasets and data groups. The HDF5 files will then be used in SCIRun to visualize three dimensional flow.

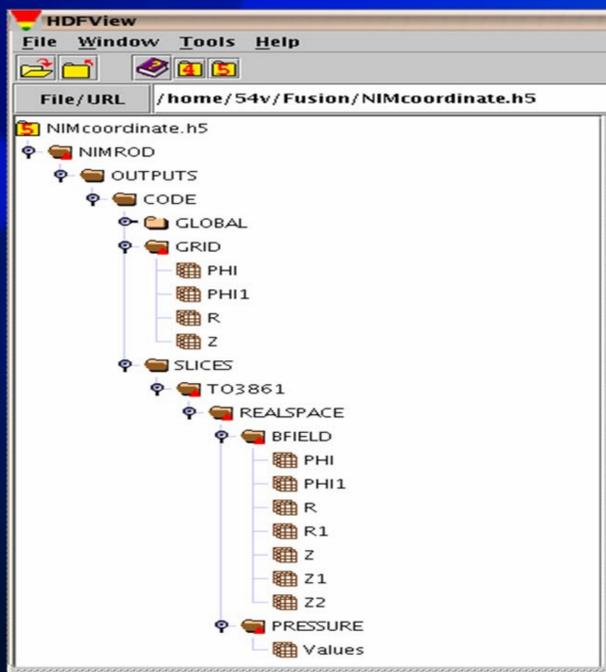


Fig 1. HDF5: Example of hierarchy in HDF5

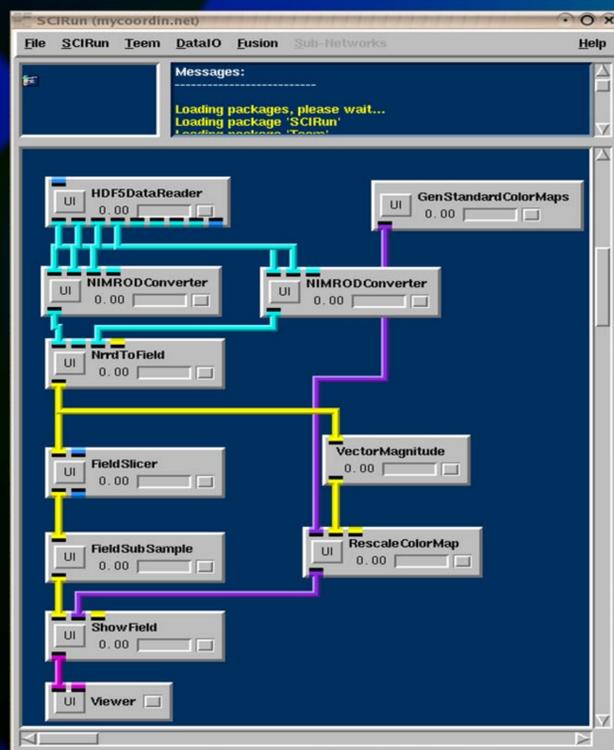


Fig 2. SCIRun Network: Example of modular network within SCIRun. Data is passed from input reader to output viewer.

Goals

- Convert large flow datasets of various formats into standard three dimensional formats
- Implement SCIRun (University of Utah) visualization software package
- Acquire, test and modify dataflow visualization network for display of flow in biological systems in SCIRun
- Use SCIRun to visualize results from simulations of biological processes including pulmonary and cardiovascular flow for showing flow in 3-D (Fig. 2)

Processes

Artery Fluid Flow

- Converts data from 2D to 3D space by rotating it about the Z axis
- Puts data into HDF5 (Hierarchical Data Format) file format (Fig. 1)
- Creates a network of modules to compute and interpret the data (Fig. 2)
- SCIRun Viewer module launches GUI (Graphical User Interface) for users to interactively explore scalar and vector flow fields with this SCIRun network (Fig. 3)

Pulmonary Flow

- Pulmonary flow studies were processed similarly to artery flow by connecting 3D output of finite element simulations to HDF5 format (Fig. 4).

Results

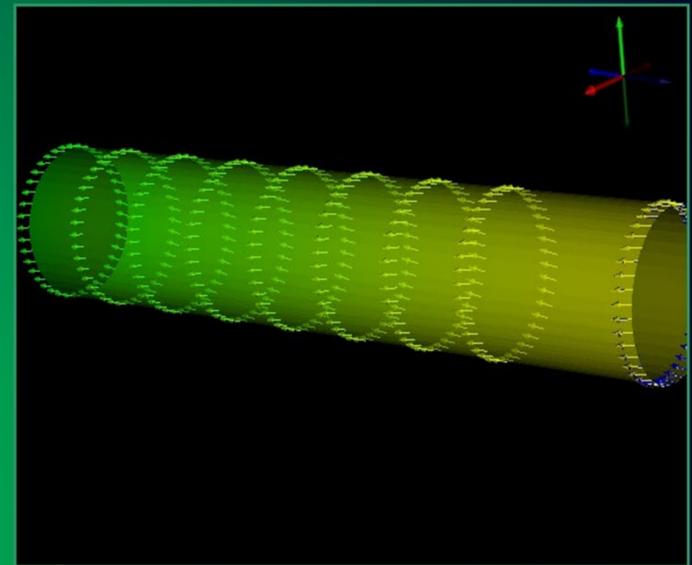


Fig 3. SCIRun Visualization: Model tube of fluid flow in large artery

Conclusions

- Successful development of conversion of data from 2D to HDF5 3D data
- Successful creation of modular network to visualize the data
- SCIRun enables interactive traversal of the results of pulmonary and arterial flow simulations

Future Research

- Incorporate the flow visualization network developed this summer into the next phase of the Virtual Soldier Project