Visualization with ParaView

Greg Johnson
Before we begin...

- Make sure you have ParaView 3.8.0 installed so you can follow along in the lab section
  - [http://paraview.org/paraview/resources/software.html](http://paraview.org/paraview/resources/software.html)
Background

- Open-source, multi-platform parallel data analysis and visualization application
- Mature, feature-rich interface
- Good for general-purpose, rapid visualization
- Built upon the Visualization ToolKit (VTK) library
- Primary contributors:
  - Kitware, Inc.
  - Sandia National Laboratory
  - Los Alamos National Laboratory
  - Army Research Laboratory
Data Types

• Supports a wide variety of data types
  – Structured grids
    • uniform rectilinear, non-uniform rectilinear, and curvilinear
  – Unstructured grids
  – Polygonal data
  – Images
  – Multi-block
  – AMR

• Time series support
Visualization Algorithms

• Supports a wide variety of visualization algorithms
  – Isosurfaces
  – Cutting planes
  – Streamlines
  – Glyphs
  – Volume rendering
  – Clipping
  – Height maps
  – …
Special Features

• Supports derived variables
  – New scalar / vector variables that are functions of existing variables in your data set
• Scriptable via Python
• Saves animations
• Can run in parallel / distributed mode for large data visualization
Data Formats

• Supports a wide variety of data formats
  – VTK (http://www.vtk.org/VTK/img/file-formats.pdf)
  – EnSight
  – Plot3D
  – Various polygonal formats

• Users can write data readers to extend support to other formats

• Conversion to the VTK format is straightforward
Data Formats

- **VTK Simple Legacy Format**
  - ASCII or binary
  - Supports all VTK grid types
  - Easiest for data conversion

- **Note:** use *VTK XML format* for parallel I/O

VTK simple legacy format ([http://www.vtk.org/VTK/img/file-formats.pdf](http://www.vtk.org/VTK/img/file-formats.pdf))
Data Formatting Example

- Data set: 4x4x4 rectilinear grid with one scalar variable

```vtk
# vtk DataFile Version 2.0
one scalar variable on a rectilinear grid
ASCII
DATASET RECTILINEAR_GRID
DIMENSIONS 4 4 4
X_COORDINATES 4 float
0 1 2.5 4.5
Y_COORDINATES 4 float
0 2 4 6
Z_COORDINATES 4 float
0 3 6 9
POINT_DATA 64
SCALARS scalar_variable float 1
LOOKUP_TABLE default
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
17 18 19 20 21 22 23 24 25 26 27 28 29 30
31 32 33 34 35 36 37 38 39 40 41 42 43 44
45 46 47 48 49 50 51 52 53 54 55 56 57 58
59 60 61 62 63
```
ParaView Visualization Pipeline

- All processing operations (filters) produce data sets
- Can further process the result of every operation to build complex visualizations
  - e.g. can extract a cutting plane, and apply glyphs (i.e. vector arrows) to the result
    - Gives a plane of glyphs through your 3D volume
Demonstration

• WRF weather forecast data set
  – Rectilinear grid
  – Multiple scalar and vector variables
  – Time series

• Can show:
  – Clouds
  – Wind
  – Temperature
  – …
ParaView Test-Drive
Getting Started

• Download example data file ‘RectGrid2.vtk’
  – http://portal.longhorn.tacc.utexas.edu/training/
  – Right-click, Save link as…

• Open ParaView
ParaView

Today we will:

• Create isosurfaces for a scalar variable
• Clip and slice the isosurfaces
• Use glyphs to display a vector field
• Use streamlines to show flow through a vector field
• Edit color maps
• Add slices to show variable values over a plane
• Adjust opacities of filters
• Add color legends
• Create volume rendering
ParaView

Open the file
RectGrid2.vtk

- Click **File** -> **Open**
- **Select** RectGrid2.vtk
- Click **OK**
- Click blue **Apply**
- Box outline of dataset extent displayed
Open the file
 RectGrid2.vtk

- Click File -> Open
- Select RectGrid2.vtk
- Click OK
- Click blue Apply
- Box outline of dataset extent displayed
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Create isosurfaces

- **Click** Filters -> Common -> Contour

- In Isosurfaces box, click Delete All

- **Click** New Range

- Keep defaults, click **OK**

- **Click** blue **Apply**

- **Click** Display tab

- In **Color by** box, select vectors
Create isosurfaces

- **Click** Filters -> Common -> Contour
- **In Isosurfaces box, click** Delete All
- **Click** New Range
- Keep defaults, **click** OK
- **Click** blue Apply
- **Click** Display tab
- **In Color by** box, select vectors
ParaView

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Create isosurfaces

- Click **Filters -> Common -> Contour**
- In **Isosurfaces box**, click **Delete All**
- Click **New Range**
- Keep defaults, click **OK**
- Click **blue Apply**
- Click **Display tab**
- In **Color by box**, select **vectors**
ParaView

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ParaView

Clip isosurfaces

- Click \( +Y \) view button
- Click Filters -> Common -> Clip
- Drag arrow point around to front of surface (arrow turns red when selected)
- Click blue Apply
- Click Inside Out checkbox
- Click blue Apply
- Click Show Center button to remove crosshairs
ParaView

Clip isosurfaces

- Click $+Y$ view button
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- Click blue **Apply**
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Slice isosurfaces

- Click eye next to Clip1 to hide clip plot
- Click Contour1 in Pipeline Browser
- Click Filters -> Common -> Slice
- Drag arrow point around to front of surface (arrow turns red when selected)
- Click blue Apply
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ParaView 3.8.0 Capture

File Edit View Sources Filters Tools Macros Help

Pipeline Browser

Stream

- Clip1
- Contour1
- Slice1

ParaView Window

Slice Inspector

- Show Plane
  - Origin: -0.541272 0 0.47633228
  - X Normal: 0 1 0
  - Y Normal: 0 0 1
  - Z Normal: 0 0 0
  - Camera Normal: 0 0 0
  - Center on Bounds

Slice Offset Values

- Value Range: [-0.955888, 0.955888]
  - 0
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ParaView

Create Glyph of Vector Field

• **Click** `RectGrid2.vtk` in Pipeline Browser
• **Click** Filters -> Common -> Glyph
• **Click** blue Apply
ParaView

Create Glyph of Vector Field

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- **Click** Filters $\rightarrow$ Common $\rightarrow$ Glyph
- **Click** blue Apply
ParaView

Create Glyph of Vector Field

- Click **RectGrid2.vtk** in Pipeline Browser
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- Click **blue Apply**
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Create Glyph of Vector Field

- Click RectGrid2.vtk in Pipeline Browser
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- Click blue Apply
ParaView

Create Streamlines

- **Click eye next to Glyph1** to hide glyph plot
- **Click RectGrid2.vtk in Pipeline Browser**
- **Click Filters -> Common -> Stream Tracer**
- **Click blue Apply**
- **Under Display tab, in the Color by box, select Vorticity**
ParaView

Create Streamlines

- Click eye next to **Glyph1** to hide glyph plot
- **Click** *RectGrid2.vtk* in Pipeline Browser
- Click **Filters** -> **Common** -> **Stream Tracer**
- Click **blue** **Apply**
- Under **Display** tab, in the **Color by** box, select **Vorticity**
ParaView

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Create Tubes

- **Click** StreamTracer1 in Pipeline Browser
- **Click** Filters -> Alphabetical -> Tube
- **Click blue Apply**
ParaView

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- **Click** blue **Apply**
ParaView

Create Tubes

- Click StreamTracer1 in Pipeline Browser
- Click Filters -> Alphabetical -> Tube
- Click blue Apply
Edit Color Map

- Click Edit Color Map
- Click Choose Preset
- Select BLUE...HSV
- Click blue OK
- Click blue Close
ParaView

Edit Color Map

- Click Edit Color Map
- **Click** Choose Preset
- **Select** BLUE...HSV
- Click blue OK
- Click blue Close
Edit Color Map

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- **Click** Choose Preset
- **Select** BLUE...HSV
- **Click** blue OK
- **Click** blue Close
ParaView

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- Click Edit Color Map
- Click Choose Preset
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ParaView

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• Click Edit Color Map
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• Select BLUE...HSV
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ParaView

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- Click blue OK
- Click blue Close
ParaView

Create Slice

- **Click** `RectGrid2.vtk` in Pipeline Browser
- **Click** Filters -> Common -> Slice
- Drag arrow point around to front of surface (arrow turns red when selected)
- Or click Y Normal
- **Click** blue Apply
- **Click** Show Plane
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ParaView

Background Color

• **Click the button above the 3D view**
• **Click Choose Color**
• **Drag box to black**
• **Click blue**  Ok
• **Click blue**  Ok
ParaView

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Object Opacity

• **Click Slice2** in Pipeline Browser
• **Click Display**
• **Change Opacity to 0.70** → Enter
• **Click Color by vectors**
• **Click eye next to RectGrid2.vtk to hide box outline**
Object Opacity

- Click **Slice2** in Pipeline Browser
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Enable Color Legend

- **Click** Display
- **Click** Edit Color Map
- **Click** Color Legend
- **Click** Show Color Legend
- **Click** -> Blue Close
- **Select** Color Legend (notice white rectangle) and move to top of 3D viewer
ParaView

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Create Volume Rendering

- **Click** `RectGrid2.vtk` in Pipeline Browser
- **Click** Filters -> Common -> Tetrahedralize
- **Click** -> Apply
- **Click** Display
- **Click** Representation
- **Select** Volume
- **Click** -> Edit Color Map (To edit transfer function)
ParaView

Create Volume Rendering

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- **Click** Display
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ParaView

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- Click `Filters` -> `Common` -> `Tetrahedralize`
- Click -> `Apply`
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- Click -> `Edit Color Map` (To edit transfer function)
ParaView

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Questions?

• More tutorials available: