Enjoying the ParaView: Extending & Enhancing ParaView

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AMCG Seminar Series

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- Slides and examples available via

https://github.com/jrper/ParaViewTalk

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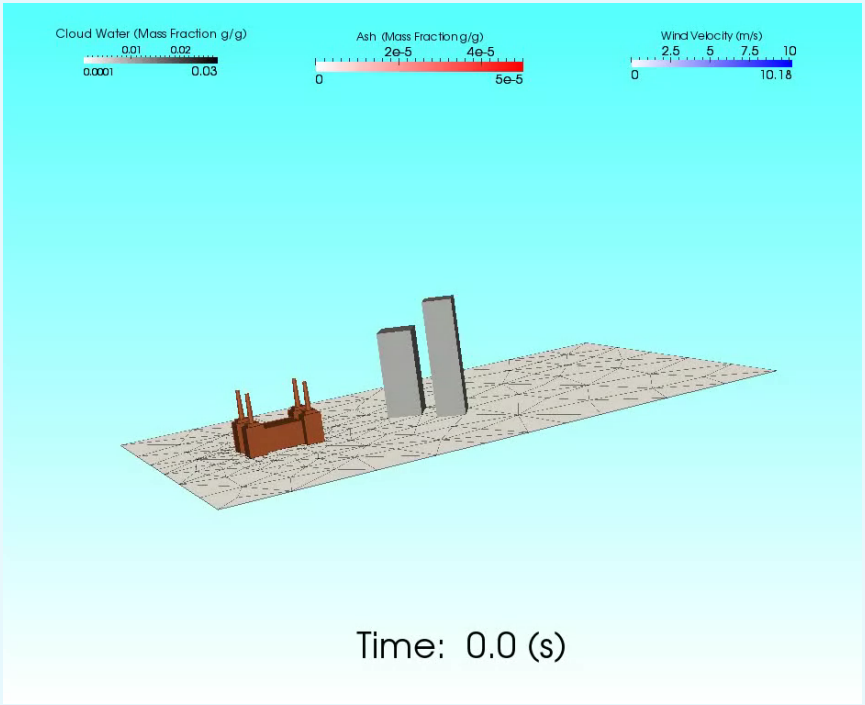
Paraview

- “ParaView is an open-source, multi-platform data analysis and visualization application.”
- www.paraview.org
- Developed by Kitware Inc

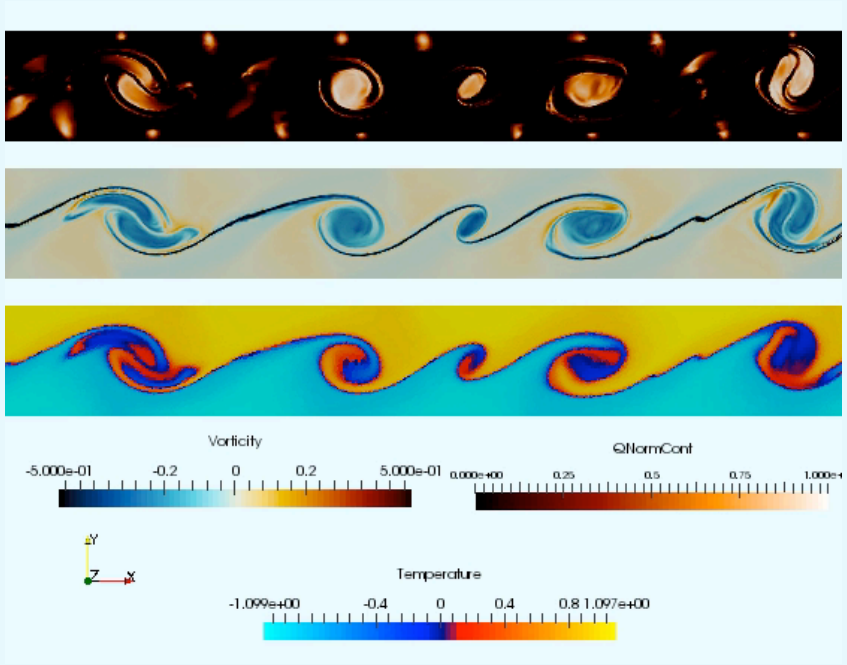
ParaView

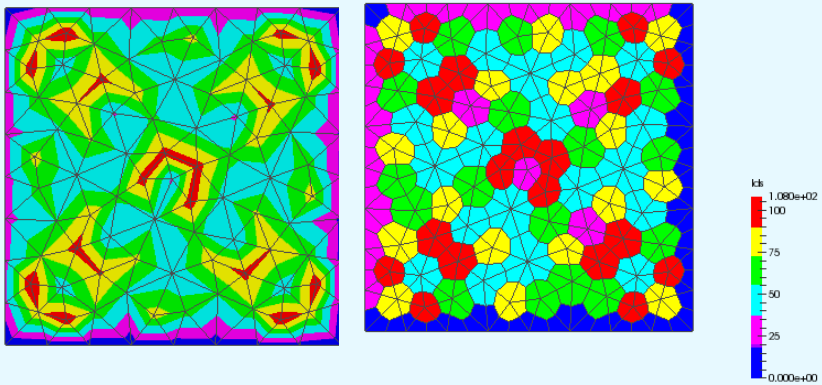
- Used in AMCG/ESE for visualization/post-processing of large unstructured data sets



Why Extend Paraview?

- ParaView isn't perfect
- ParaView is generic tools, applied to specific problems.
- We understand our own data best
- Pretty visualisations help sell good science
- Boring repetition is boring





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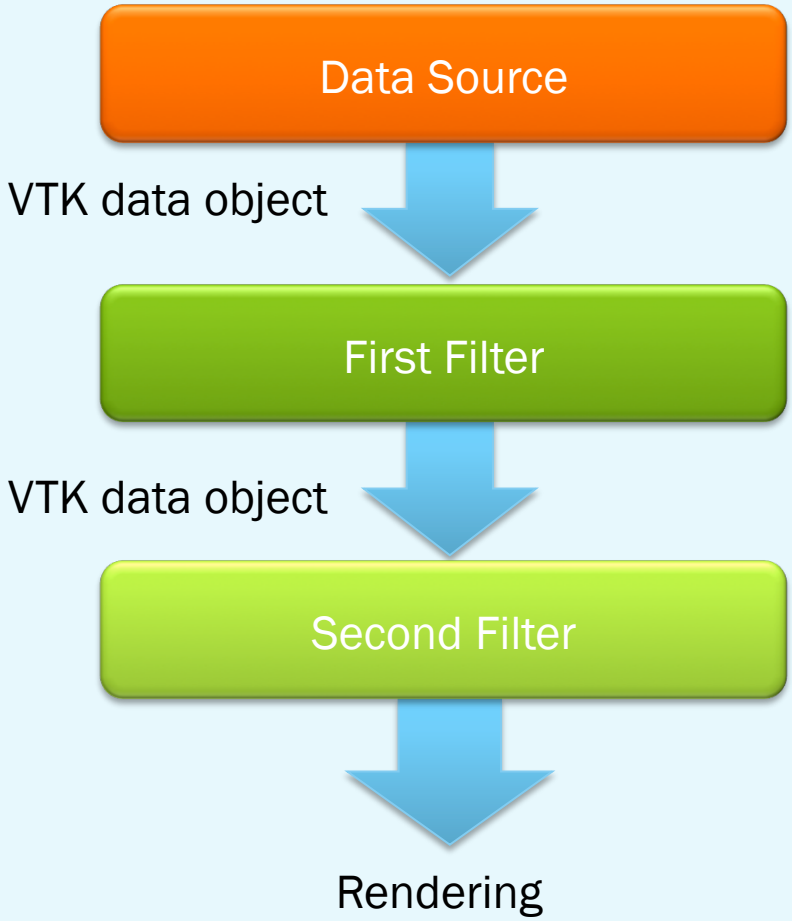
The ParaView Data Model

- Pipeline based system
- Sources generate original data
- Chains of filters modify data/view
- Change to one level causes later levels to update themselves.



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VTK

- Much of ParaView wraps VTK functions, the Visualisation Tool Kit
- www.vtk.org
- “Language”/framework for visualisation
- C++ code with python wrappings

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VTK

Python wrapping

```
from vtk import *

#Create a source
textSource = vtkTextSource();
textSource.SetText("Hello AMCG!");
textSource.SetForegroundColor(1.0, 0.0, 0.0);
textSource.BackingOn();
textSource.Update();
```

```
from vtk import *

#Create a source
textSource = vtkTextSource();
textSource.SetText("Hello AMCG!");
textSource.SetForegroundColor(1.0, 0.0, 0.0);
textSource.BackingOn();
textSource.Update();

e a mapper and actor
r = vtkPolyDataMapper();
r.SetInputConnection(textSource.GetOutputPort());

 vtkActor();
etMapper(mapper);


e a renderer, render window, and interactor
er = vtkRenderer();
Window = vtkRenderWindow();
Window.AddRenderer(renderer);
WindowInteractor = vtkRenderWindowInteractor();
WindowInteractor.SetRenderWindow(renderWindow);

he actor to the scene
.AddActor(actor);
renderer.SetBackground(1,1,1); # Background color white

#Render and interact
renderWindow.Render();
renderWindowInteractor.Start();
```

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The ParaView/VTK split

ParaView

- GUI
- Colourmaps
- Labels
- File series
- Graphs
- Screenshots/Animations

VTK

- Data formats
- Drawing stuff
- Geometry
- Maths

Making things prettier

- Use LaTeX in figure text
  - just add $s
- Import your own colour maps

```
<ColorMap space="HSV”  indexedLookup="false” name=”Example">
  <Point x="1" o="1" r="0" g="0" b="1"/>
  <Point x="2" o="1" r="1" g="0" b="1"/>
  <NaN r="0" g="0" b="0"/>
</ColorMap>
```

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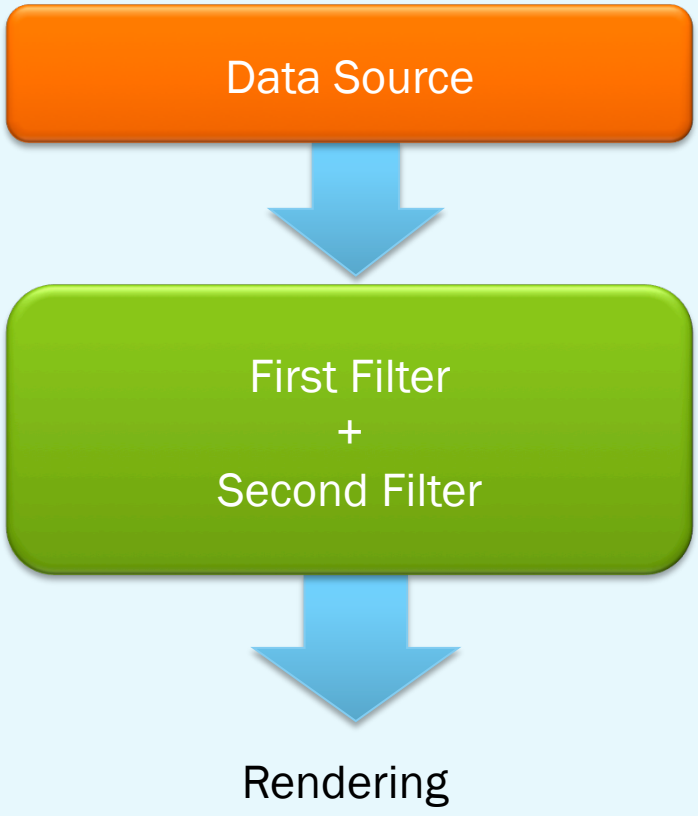
ParaView Custom Filters

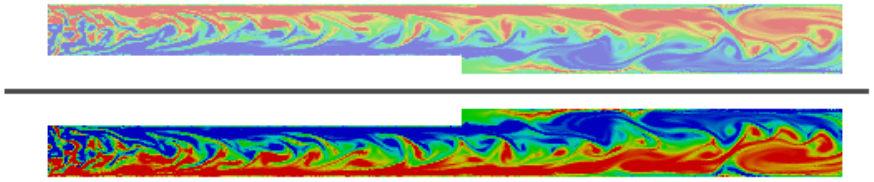
- Quick and easy way to replay the same set of filters onto data.
- Selectable direct from the GUI.
- Can only do stuff you could do eventually anyway.



Example: The Australian Filter

Let's reflect some data to be upside down.

To the live demonstration!



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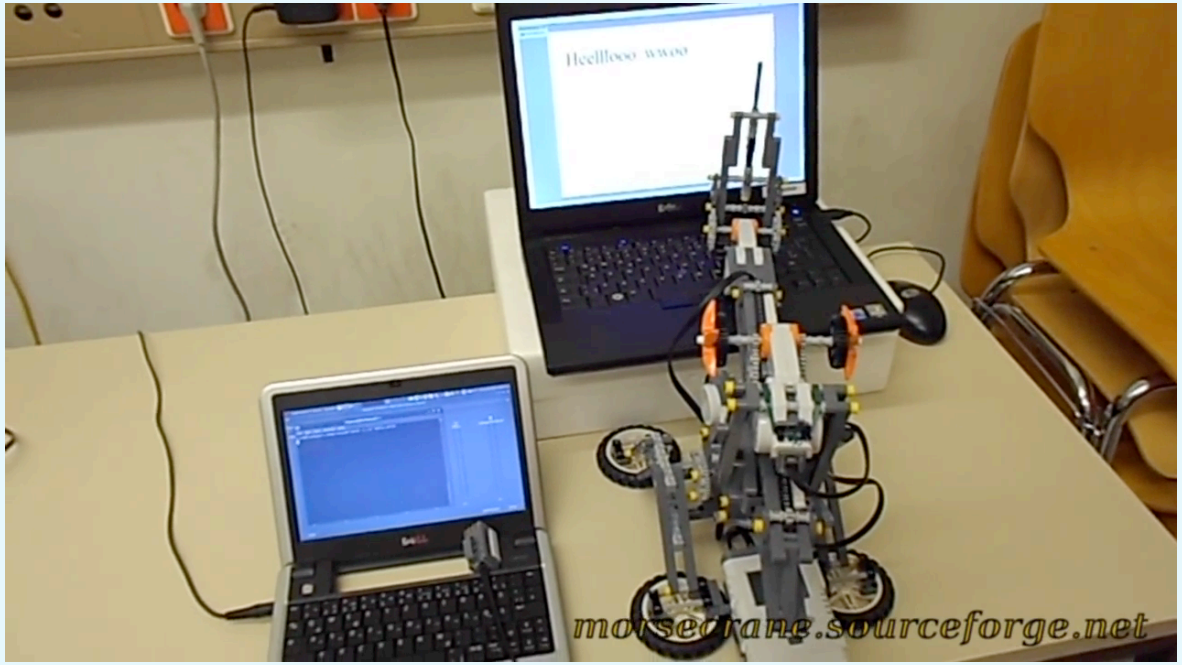
ParaView Macros



video: morsecrane.sourceforge.net, CC license

- Playback operations programmatically:
- Need a python script describing the operation
- Script can be recorded from the GUI.
- Can touch almost anything you can

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ParaView Macros

- Example code adds a logo widget from a file to the current view
- Uses a VTK feature not fully wrapped in paraview.

```
from paraview.simple import *
import vtk

image = vtk.vtkPNGReader()
image.SetFileName('AMCGLogo.png')
image.Update()

rep = vtk.vtkLogoRepresentation()
rep.SetImage(image.GetOutput())
intr = GetRenderView().GetInteractor()

widget = vtk.vtkLogoWidget()
widget.SetRepresentation(rep)
widget.SetInteractor(intr)
widget.On()
Render()
```

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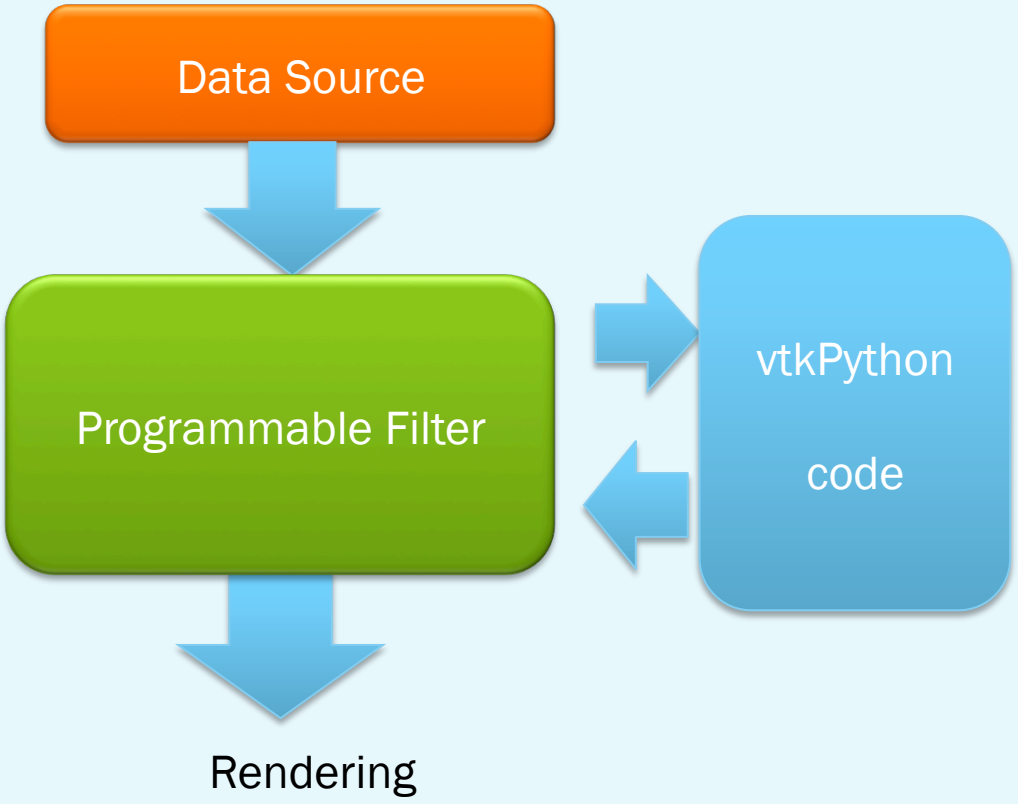
The Python Programmable Filter

- Run arbitrary python code so long, as it produces a VTK object as output
- Modify your data as you see fit
- Australia Mark II



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The Python Programmable Filter

- “script” run when input data updates
- Australia Mark II
- Written in vtk Python

```
input = self.GetInput()
output = self.GetOutput()

output.DeepCopy(input)

points = output.GetPoints()

x = [0.0,0.0,0.0]
for i in range(points.GetNumberOfPoints()):
    points.GetPoint(i,x)
    x[1] = -x[1]
    points.SetPoint(i,x)

output.GetPointData().DeepCopy(input.GetPointData())
output.GetCellData().DeepCopy(input.GetCellData())
```

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C++ Plugins

- Highest tech option
- Largest barrier to use.
- Effectively write your own ParaView/VTK source, plus extra XML information to tell the GUI how to work
- Tools>Manage Plugins

```
#include "vtkAustraliaFilter.h"
#include "vtkInformation.h"
#include "vtkInformationVector.h"
#include "vtkPoints.h"
#include "vtkPointData.h"
#include "vtkCellData.h"
#include "vtkUnstructuredGrid.h"
#include "vtkSmartPointer.h"
#include "vtkDataObject.h"
#include "vtkObjectFactory.h"
#include "vtkStreamingDemandDrivenPipeline.h"

vtkCxxRevisionMacro(vtkAustraliaFilter, "$Revision: 0.0$");
vtkStandardNewMacro(vtkAustraliaFilter);

vtkAustraliaFilter::vtkAustraliaFilter(){
  this->SetNumberOfInputPorts(1);
  this->SetNumberOfOutputPorts(1);
};
vtkAustraliaFilter::~vtkAustraliaFilter(){};

int vtkAustraliaFilter::RequestData(
                                                    vtkInformation* vtkNotUsed(request),
                                                    vtkInformationVector **inputVector,
                                                    vtkInformationVector* outputVector )
{

  vtkUnstructuredGrid* input=this->GetUnstructuredGridInput(0);
  vtkUnstructuredGrid* output=this->GetOutput();
  vtkSmartPointer<vtkPoints> points= vtkSmartPointer<vtkPoints>::New();

#ifndef NDEBUG
  this->DebugOn();
#endif

  points->DeepCopy(input->GetPoints());
  double x[3];
  for (vtkIdType j=0; j<points->GetNumberOfPoints(); j++) {
    points->GetPoint(j,x);
    x[1]=-x[1];
    points->SetPoint(j,x);
  }
  output->SetCells(input->GetCellTypesArray(),
                                                    input->GetCellLocationsArray(),
                                                    input->GetCells());
  output->SetPoints(points);
  output->GetCellData()->DeepCopy(input->GetCellData());
  output->GetPointData()->DeepCopy(input->GetPointData());

  return 1;
}
```

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Anatomy of a plug-in

- ShowCVs
  - CMakeList.txt # CMake instruction file
  - vtkShowCVs.h # C++ header file
  - vtkShowCVs.cxx # C++ source code
  - showCVs.xml # XML for ParaView GUI

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CMake

- Kitware's build automation tool.
- www.cmake.org
- Like autoconf/ configure

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CMakeLists.txt

- Example minimal CMakeLists.txt file for a ParaView plugin
- If the code uses other libraries, gets more complicated

```
FIND_PACKAGE(ParaView REQUIRED)
INCLUDE(${PARAVIEW_USE_FILE})

ADD_PARAVIEW_PLUGIN(
  AustraliaFilter "0.0"
  SERVER_MANAGER_XML
AustraliaFilter.xml
  SERVER_MANAGER_SOURCES
vtkAustraliaFilter.h vtkAustraliaFilter.cxx
  )
```

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AustraliaFilter.xml

- GUI xml file tells ParaView the contract your plugin provides
- Sets the widgets shown in properties tab.
- Also allows documentation.

```
<ServerManagerConfiguration>
  <ProxyGroup name="filters">
    <SourceProxy name="vtkAustraliaFilter"
                 class="vtkAustraliaFilter"
                 label="Australia Filter">
      <Documentation long_help="AustraliaFilter Filter"
                     short_help="Australia Filter">
      </Documentation>
      <InputProperty
          name="Input"
          command="SetInputConnection">
        <ProxyGroupDomain name="groups">
          <Group name="sources"/>
          <Group name="filters"/>
        </ProxyGroupDomain>
        <DataTypeDomain name="input_type">
          <DataType value="vtkUnstructuredGrid"/>
        </DataTypeDomain>
      </InputProperty>
    </SourceProxy>
  </ProxyGroup>
</ServerManagerConfiguration>
```

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the core of the plugin

```
int vtkAustraliaFilter::RequestData(
                        vtkInformation* vtkNotUsed(request),
                        vtkInformationVector **inputVector,
                        vtkInformationVector* outputVector )
{
 vtkUnstructuredGrid* input=this->GetUnstructuredGridInput(0);
 vtkUnstructuredGrid* output=this->GetOutput();
 vtkSmartPointer<vtkPoints> points=vtkSmartPointer<vtkPoints>::New();
 points->DeepCopy(input->GetPoints());
 double x[3];
 for (vtkIdType j=0; j<points->GetNumberOfPoints(); j++) {
     points->GetPoint(j,x);
     x[1]=-x[1];
     points->SetPoint(j,x);
 }
 output->SetCells(input->GetCellTypesArray(),
                  input->GetCellLocationsArray(),
                  input->GetCells());
 output->SetPoints(points);
 output->GetCellData()->DeepCopy(input->GetCellData());
 output->GetPointData()->DeepCopy(input->GetPointData());

 return 1;
}
```

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Summary

Extension Method	Ease of use	Ease of creation	Power	Repeatable
Custom Filter	Easiest	Easy	Limited	Easy
Python Macro	Easy	Moderate	Do lots	Limited
Python Programmable Filter	Moderate	Moderate	Do lots	Easy
C++ plugin	Moderate	Hard	Do anything	Easy

QUESTIONS & COMMENTS

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Where to go next:

- ParaView internal help documentation
- Paraview website & wiki:
  - www.paraview.org/Wiki/ParaView
- vtk documentation:
  - http://www.vtk.org/doc/nightly/html/
- My ParaView Plugins
- Your colleagues