12th Summer School on SCIENTIFIC VISUALIZATION

VTK Tutorial

Data structures, filtering and rendering

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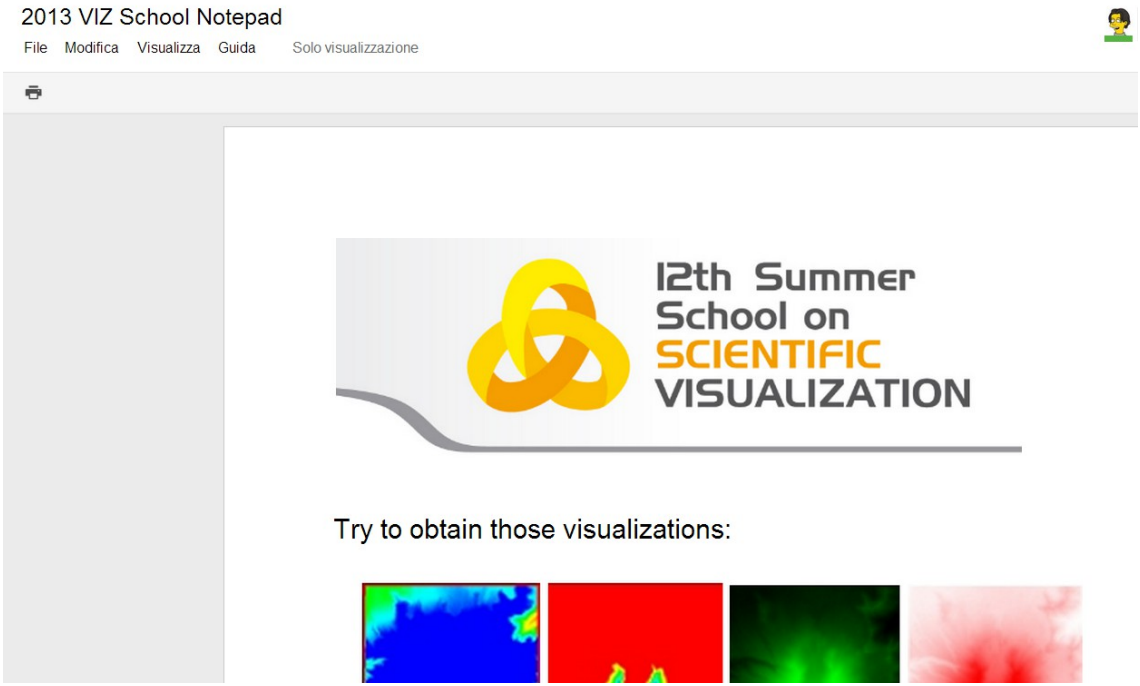
Live material

http://notepad.stefanoperticoni.org



Prerequisites

The following Python 2.7 and vtk 5.10 execution environment for Windows is recommended:

http://ftp.ntua.gr/pub/devel/pythonxy/Python(x,y)-2.7.3.1.exe

Otherwise download a pure Python 2.7/ VTK 5.8 execution environment for your Win/Mac/Linux system from:

http://vtk.org/files/release/5.8/tmp/

Working dir structure

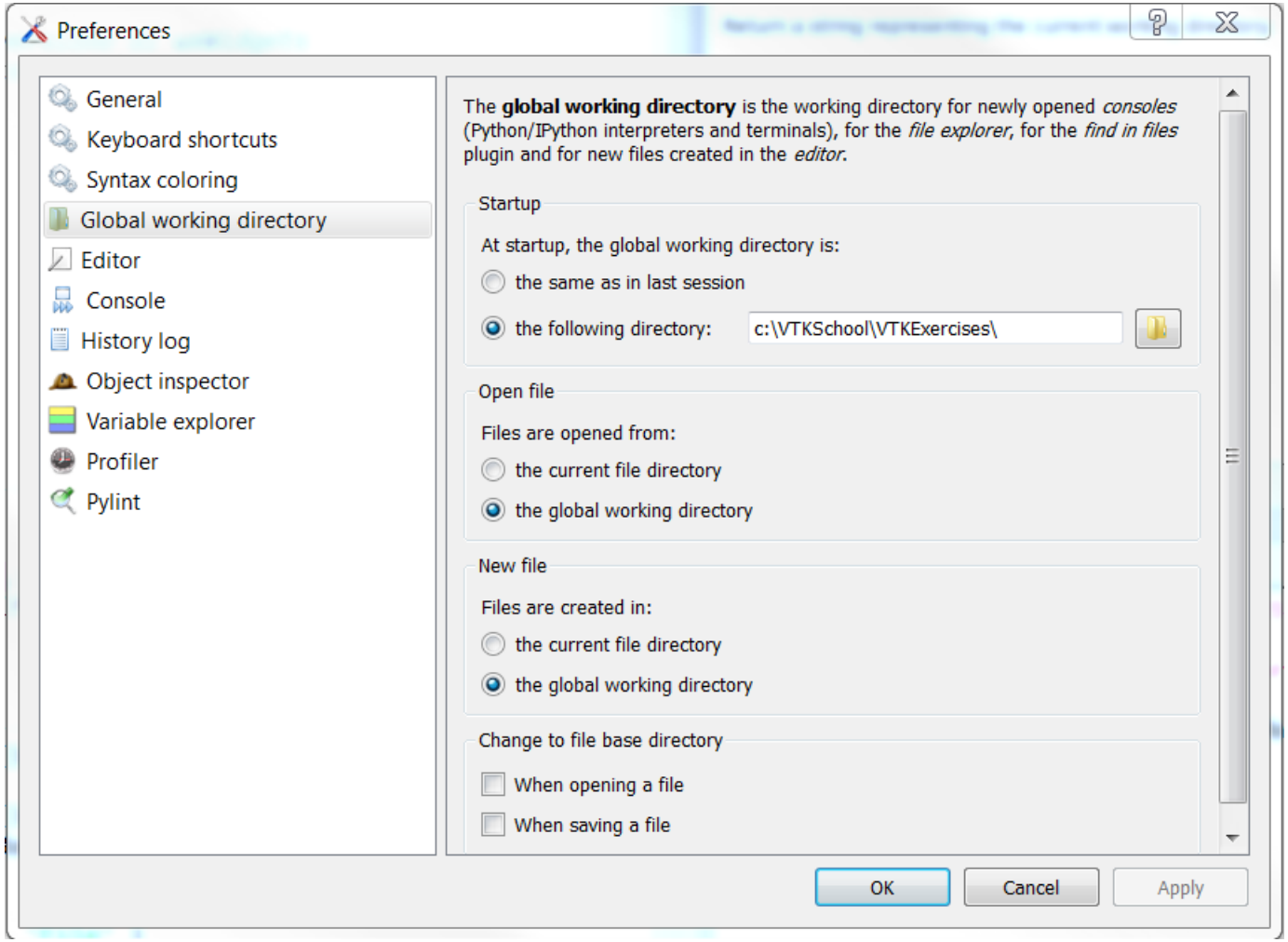
Set up and check your data folders:

1. Create a folder C:/VTKSchool/

2. Unzip C:/VTKSchool/VTKExercises.zip inside it to obtain:
   C:/VTKSchool/VTKExercises/

3. Check that 3. c:/VTKSchool/VTKExercises/ contains
   c:/VTKSchool/VTKExercises/SaintHelen.py

Spyder set up



Spyder set up

1. Open Spyder: Just write Spyder in Windows search box

2. Tools → Preferences → Global working directory:
   Set the global working directory to c:\VTKSchool\VTKExercises\

3. Restart Spyder

4. Open a python shell: Interpreters → Open Interpreter
and check the path:

```
>>> os.getcwd()
'c:\\VTKSchool\\VTKExercises'
```

If this is the result your environment is OK

Exercise: learn vtkArray

1 Make an array

```
myArray = vtk.vtkDoubleArray()
list_dir(myArray)
help(myArray.SetValue)
print(myArray)
myArray.SetName('my first array')
myArray.SetNumberOfComponents(1)
myArray.SetNumberOfTuples(500*500) #going to make a 500x500 picture
```

2 Fill it with data

```
from math import sin, cos
for x in range(0,500):
    for y in range(0,500):
        myArray.SetValue(x*500+y, 127.5+(1.0+sin(x/25.0)*cos(y/25.0)))
```

Exercise: learn vtkArray

1. Create the Data structure

```
id = vtk.vtkImageData()
```

2. Define its Geometry

```
id.SetOrigin(0,0,0)
id.SetSpacing(1,1,1)
```

3. Define its Topology

```
id.SetDimensions(500,500,1)
```

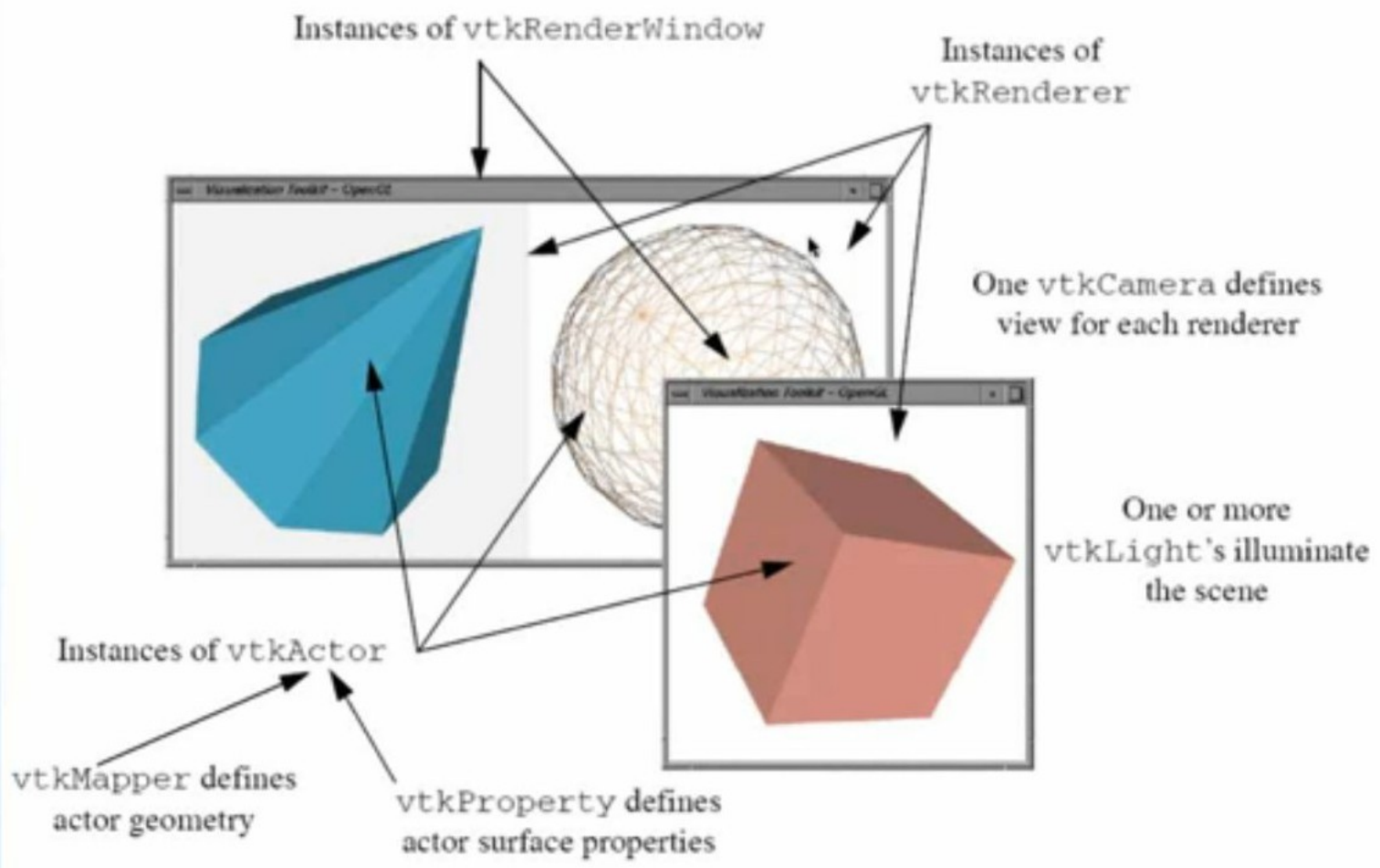
4. Assign Data to the Structure, Geometry and/or Topology

```
id.SetScalarType(vtk.VTK_DOUBLE)
id.GetPointData().SetScalars(myArray)
```

5. Inspect it

```
print(id)
print(id.GetPointData())
array = id.GetPointData().GetArray('my first array')
array.GetRange()
```

The VTK Graphics Subsystem



vtkRenderWindow

- SetSize() — set the size of the window
- AddRenderer() — add another renderer which draws into this
- SetInteractor() — set class to handles mouse/key events
  - vtkRenderWindowInteractor->SetInteractorStyle()
- Render() — updates pipeline and draws scene

vtkRenderer

- SetViewport() - specify where to draw in the render window
- SetLayer() - set pane/depth in render window to draw on

- AddViewProp() - add objects to be rendered
- AddLight() - add a light to illuminate the scene
- SetAmbient() - set the intensity of the ambient lighting
- SetBackground() - set background color

- SetActiveCamera() - specify the camera to use to render the scene
- ResetCamera() - reset the camera so that all actors are visible

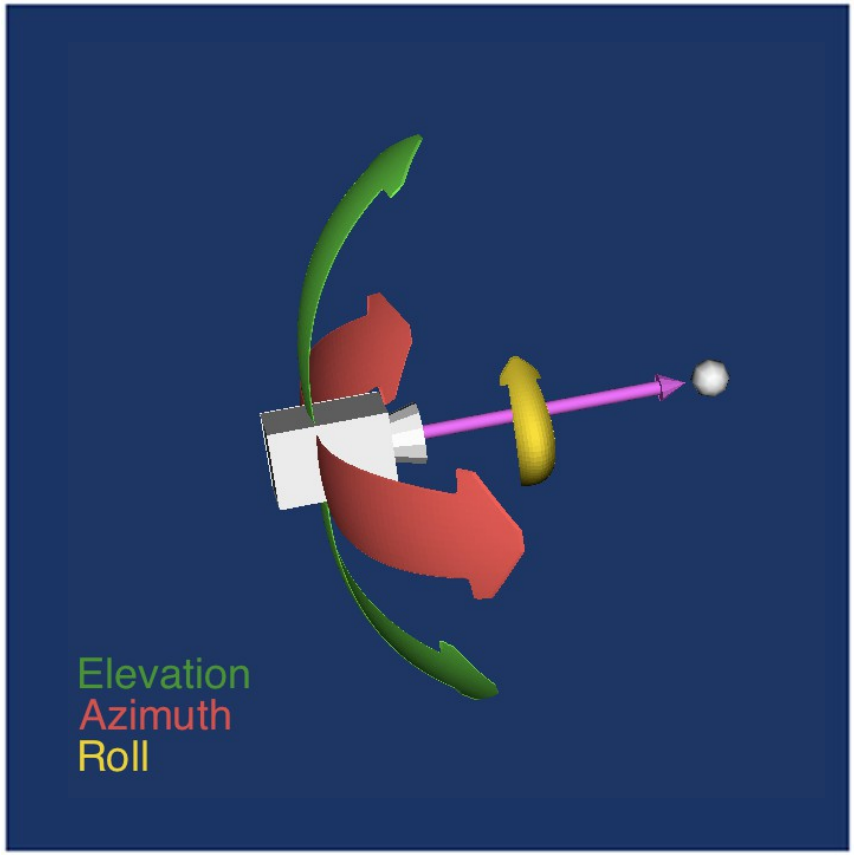
vtkCamera

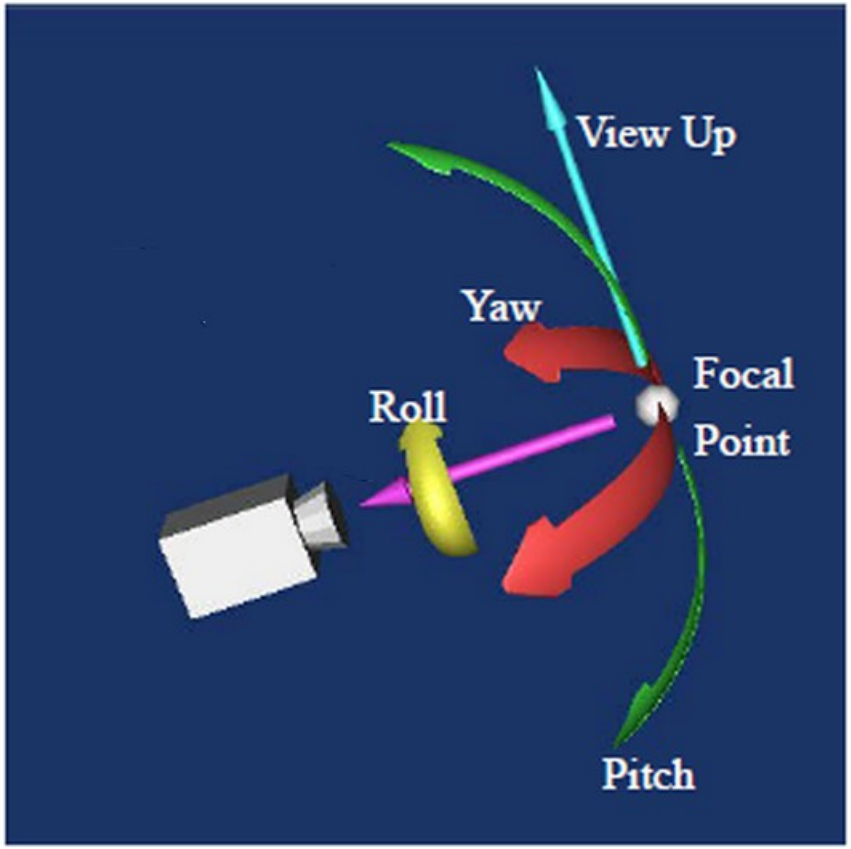
- Position - where the camera is located
- FocalPoint - where the camera is pointing
- ViewUp - which direction is "up"
- ClippingRange - data outside of this range is clipped
- ViewAngle - the camera view angle controls perspective effects
- ParallelProjection - turn parallel projection on/off (no perspective effects)

- Roll, Pitch, Yaw, Elevation, Azimuth move the camera in a variety of ways

- Zoom, Dolly - changes view angle (Zoom); move camera closer (Dolly)

vtkCamera





vtkActor (subclass of vtkProp)

- Visibility - is the actor visible?
- Pickable - is the actor pickable?

- Texture - a texture map associated with the actor
- SetOrigin/Scale/UserTransform - control where it is drawn
- GetBounds

- vtkProperty - surface lighting properties

Exercise: make a window

1. Make a window

```
renwin = vtk.vtkRenderWindow()
renwin.SetSize(500,500)
```

2. Make a renderer for that window

```
renderer = vtk.vtkRenderer()
renwin.AddRenderer(renderer)
```

3. Control how it all looks

```
renderer.SetBackground2(1,1,1)
renderer.SetGradientBackground(1)
```

4. Show it

```
renwin.Render()
```

Exercise: show some data

1. Access the data processing pipeline that has your data

```
mapper = vtk.vtkDataSetMapper()
mapper.SetInput(id)
mapper.ScalarVisibilityOff() # we'll talk about this soon
```

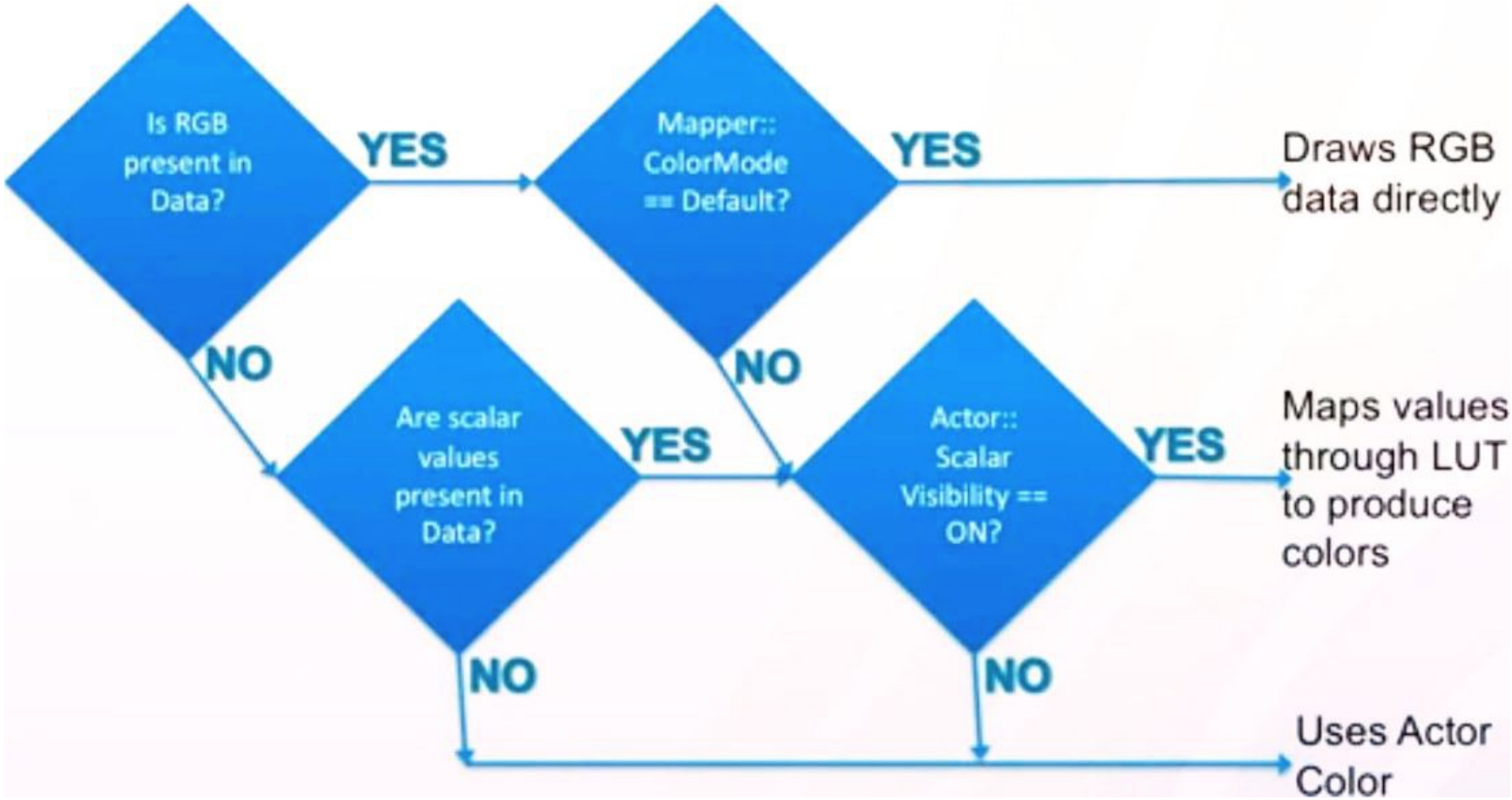
2. Link that to the display system

```
actor = vtk.vtkActor()
actor.SetMapper(mapper)
renderer.AddViewProp(actor)
renwin.Render()
```

3. Adjust the camera for a better view

```
renderer.ResetCamera()
renwin.Render()
```

Color contro by vtkActor and vtkMapper



vtkProperty (Actor has)

- AmbientColor, DiffuseColor, SpecularColor — a different color for ambient, diffuse, and specular lighting
- Color — sets the three colors above to the same
- Interpolation - shading interpolation method (Flat, Gouraud)

- Representation — how to represent itself (Points, Wireframe, Surface)

- Opacity — control transparency

vtkMapper (Actor also has)

- ScalarVisibilityOn()/Off()
  - Color cells/points by data values or entire object by actor color

- Choose which array to color by
  - SetScalarModeToDefault()
  - SetScalarModeToUsePointData()
  - SetScalarModeToUseCellData()
  - SelectColorArray(array name)

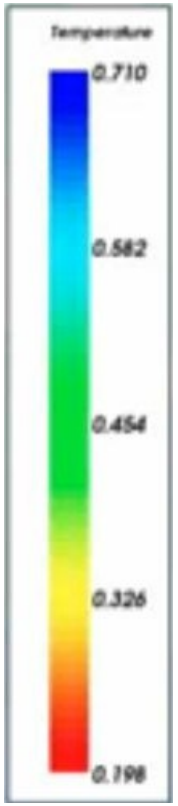
- SetLookupTable(lut)
- SetScalarRange(min, max)
  - range of data values for lut

- InterpolateScalarBeforeMappingOn()/Off()
  - whether to interpolate colors across cells in color or data space

vtkLookupTable (Mapper has)

- NumberOfColors - number of colors in the table
- TableRange - the min/max scalar value range to map
- If building a table from linear HSVA ramp:
  - HueRange - mm/max hue range
  - SaturationRange - min/max saturation range
  - ValueRange - min/max value range
  - AlphaRange - min/max transparency range

- If manually building a table
  - Build (after setting NumberOfColors)
  - SetTableValue(idx, rgba) for each NumberOfColors entries



Exercise : Visualize the topology

1. Specify whole Prop color

```
actorProperty = actor.GetProperty()
actorProperty.SetDiffuseColor(0,1,1)
renwin.Render()
```

2. Change from surface to edges rendering

```
actorProperty.SetRepresentationToWireframe()
renwin.Render()
renderer.GetActiveCamera().Zoom(10)
renwin.Render()
```

3. Reset

```
actorProperty.SetRepresentationToSurface()
renderer.ResetCamera()
```

Exercise : Visualize the topology

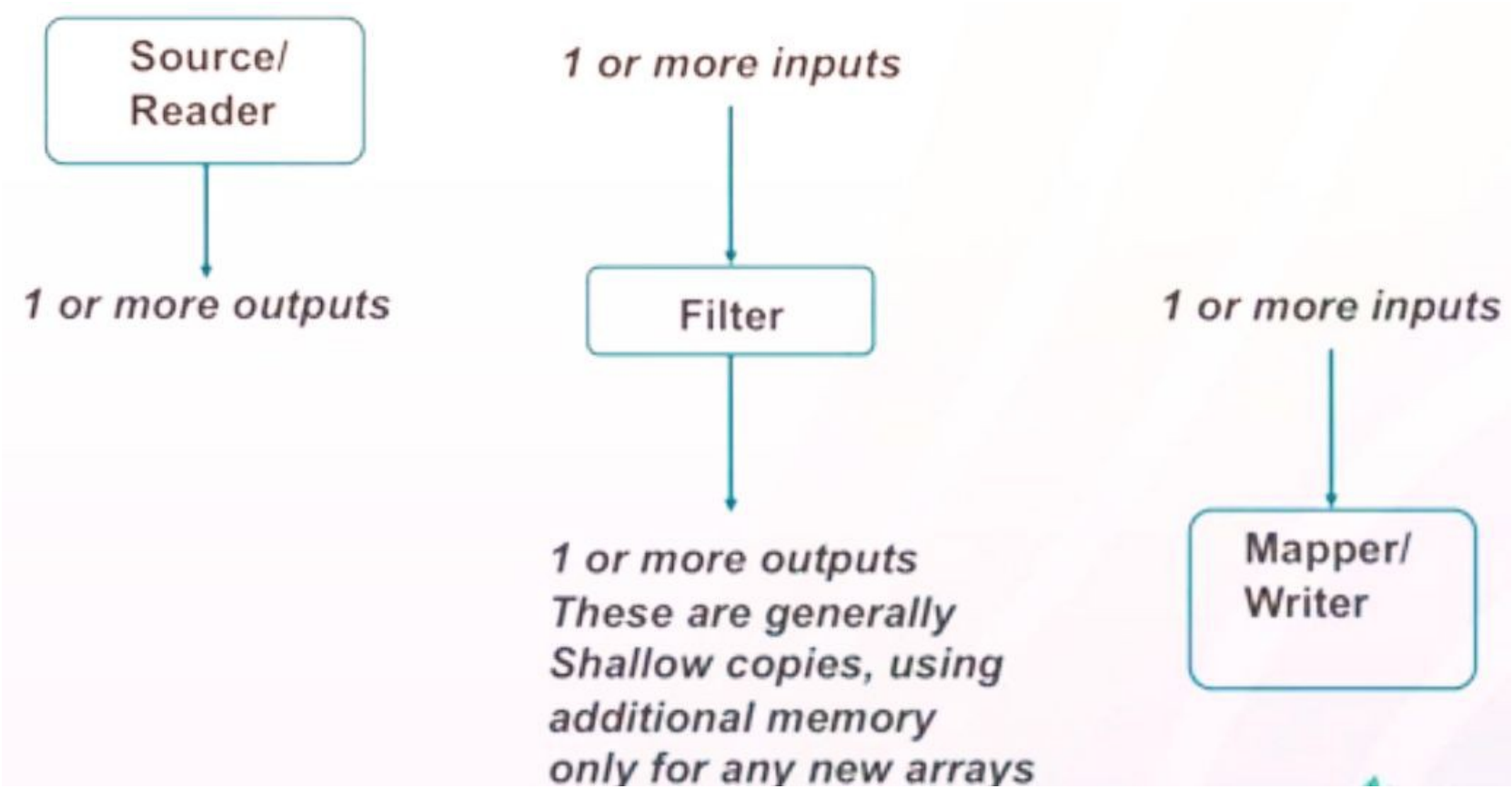
1. Turn on color from values

```
mapper.ScalarVisibilityOn()
renwin.Render()
```

2. Match up lookuptable range

```
myArray.GetRange()
mapper.SetScalarRange(127,129)
renwin.Render()
```

Algorithms


Source/
Reader
1 or more outputs
1 or more inputs
Filter
1 or more outputs
These are generally
Shallow copies, using
additional memory
only for any new arrays
1 or more inputs
Mapper/
Writer

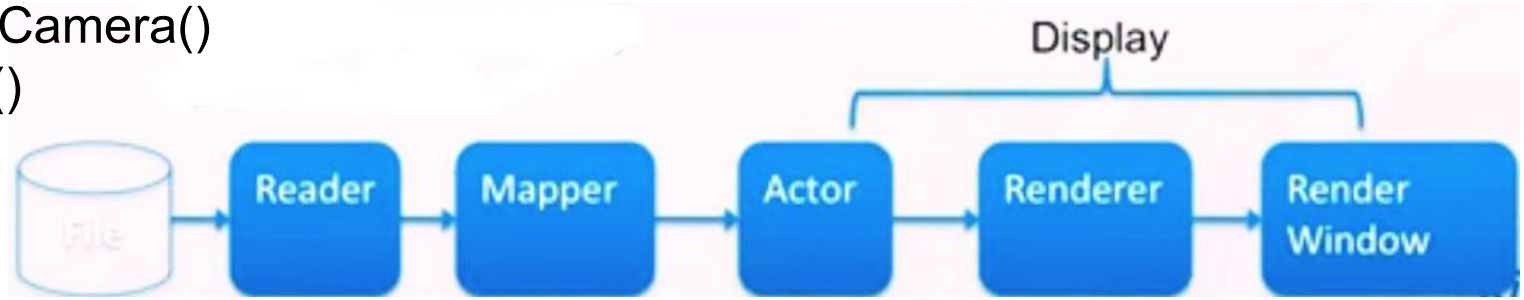
Read a data file, inspect and visualize

1. Create a reader, tell it what file and run it

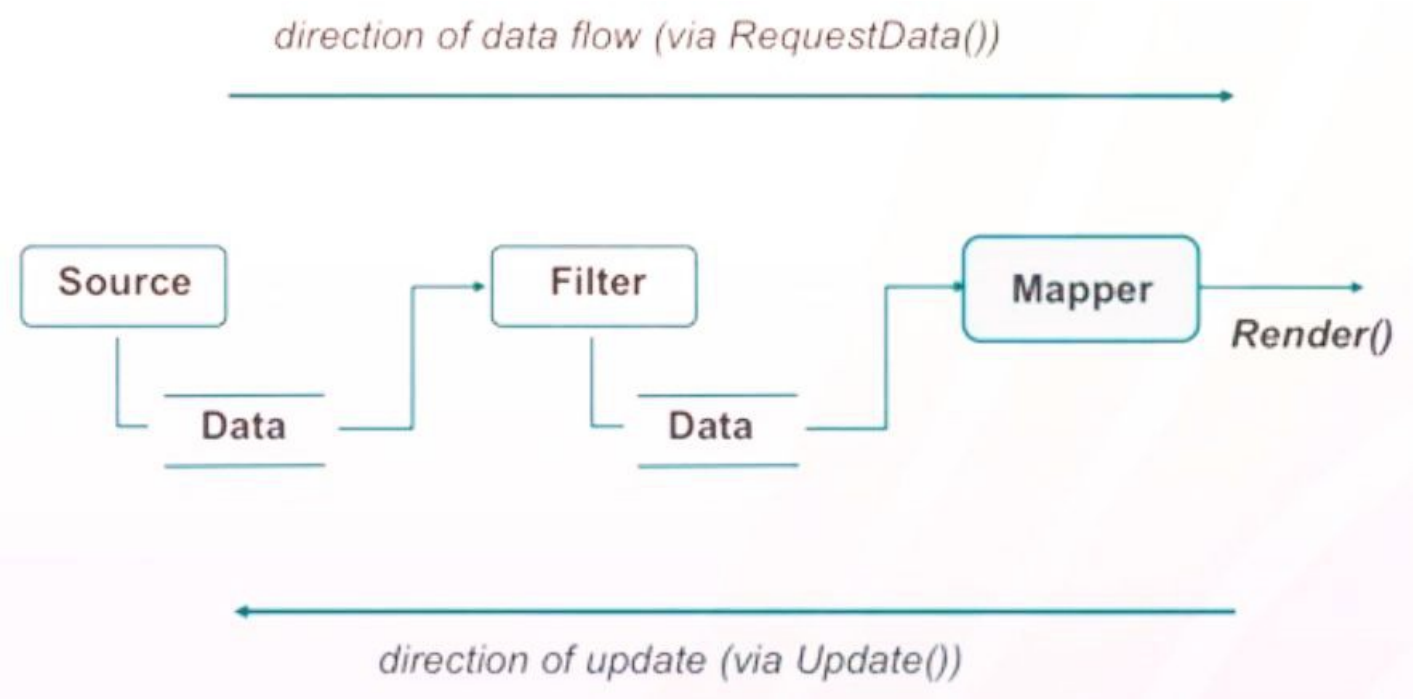
```
reader = vtk.vtkDataSetReader()
reader.SetFileName("c:/Data/SaintHelens.vtk")
```

2. Examine the result

```
id = reader.GetOutput()
print id.GetPointData().GetArray(0)
reader.Update()
print id.GetPointData().GetArray(0).GetRange()
mapper.SetInputConnection(reader.GetOutputPort())
mapper.SetScalarRange(682.0, 2543.0)
renwin.Render()
renderer.ResetCamera()
renwin.Render()
```



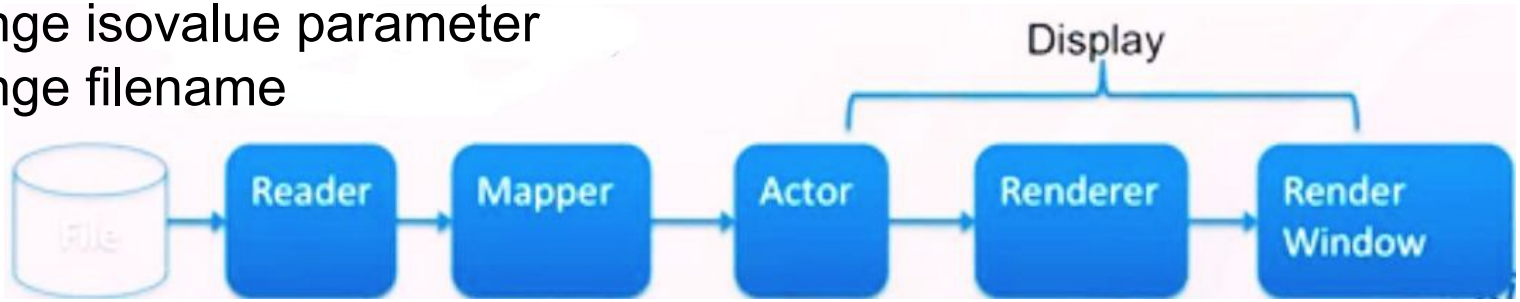
Pipeline execution model



Demand Driven Pipeline

- Lazy evaluation
  - Pipeline only produces results when you ask it to Update or Render()
  - Changing a parameter or rearranging the pipeline doesn't do that.
  - Each filter caches its most recent output

- Modified time
  - Each filter keeps track of when it last produced data, and when its parameters were last changed
  - Pipeline only updates as far back as it has to
  - Examples:
    - Camera motion - data isn't reread, only mapper has to execute
    - Change isovalue parameter
    - Change filename



Exercise : manipulate the read in data

1. Make filter to convert to a less constrained data structure

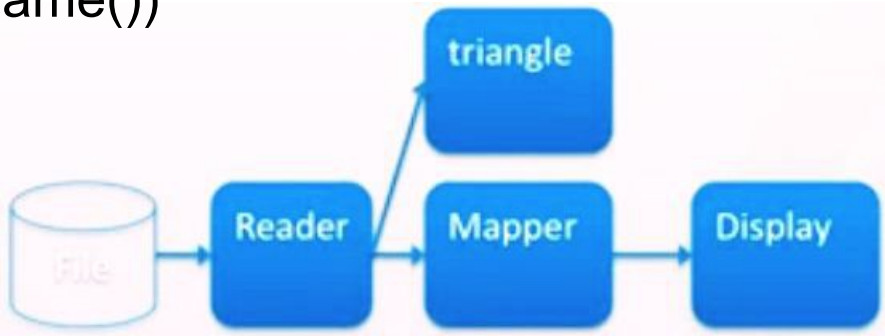
```
triangles = vtk.vtkDataSetTriangleFilter()
```

2. Connect it

```
triangles.SetInputConnection(reader.GetOutputPort())
```

3. Run it

```
triangles.Update()
print(reader.GetOutput().GetClassName())
print(triangles.GetOutput().GetClassName())
```



Exercise: manipulate the read in data

1. Make and use a filter to change the geometry

```
warp = vtk.vtkWarpScalar()
warp.SetInputConnection(triangles.GetOutputPort())
warp.Update()
print(triangles.GetOutput().GetBounds())
print(warp.GetOutput().GetBounds())
```

2. Show it

```
mapper.SetInputConnection(warp.GetOutputPort())
renwin.Render()
```

Exercise: manipulate the data

1. Make a clip filter and put it in pipeline

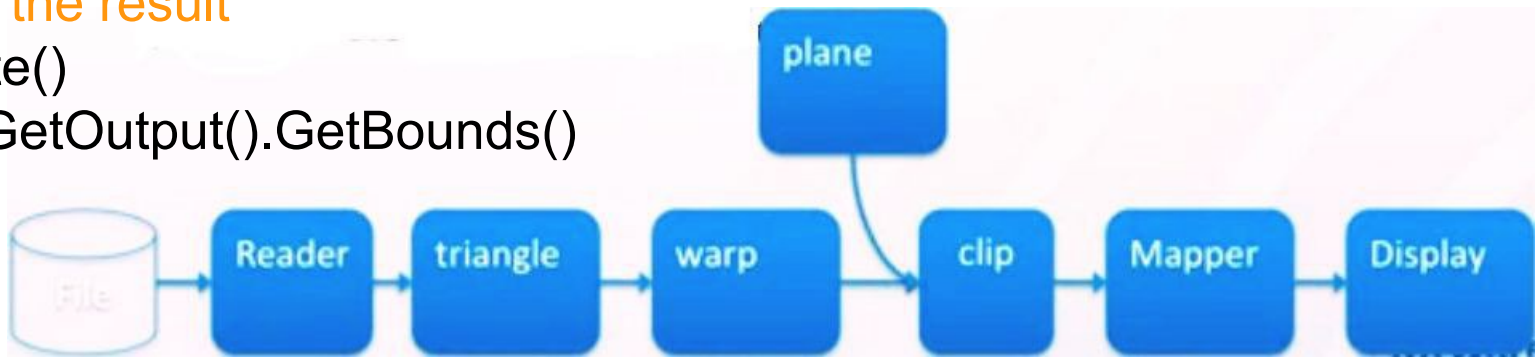
```
clip = vtk.vtkClipDataSet()
clip.SetInputConnection(warp.GetOutputPort())
mapper.SetInputConnection(clip.GetOutputPort())
```

2. Make a source to orient clip filter with

```
plane = vtk.vtkPlane()
clip.SetClipFunction(plane)
plane.SetOrigin(560000,5120000,2000)
```

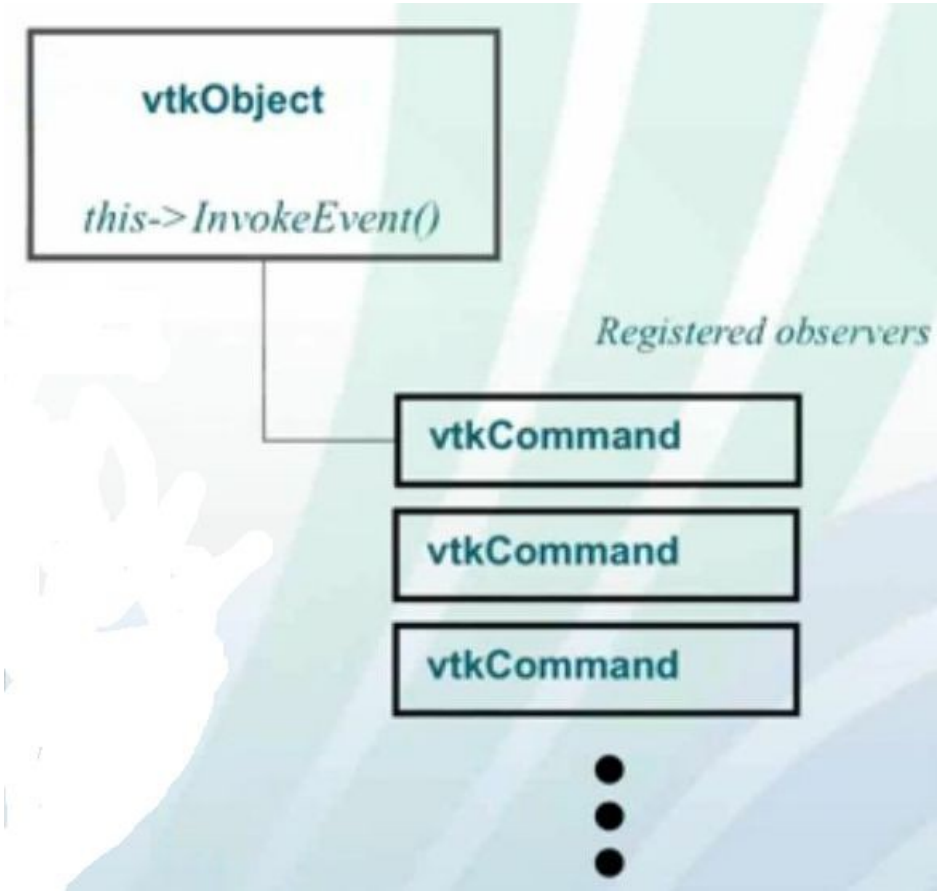
3. Inspect the result

```
clip.Update()
print clip.GetOutput().GetBounds()
```



Interaction

- Events
  - Instances of vtk classes can fire events and watch events fired by others
  - watcher executes some code whenever the event occurs
- Interactors
  - Watch mouse, keyboard, window system events to move camera call render etc
- Widgets
  - Special purpose classes that are drawn in scene and watch events



Exercise: use a widget to interact with the data

1. Get a hold of window events

```
iren = vtk.vtkRenderWindowInteractor()
renwin.SetInteractor(iren)
```

2. Make and initially place the widget

```
widget = vtk.vtkImplicitPlaneWidget()
widget.PlaceWidget(warp.GetOutput().GetBounds())
widget.SetOrigin([plane.GetOrigin()[x] for x in 0,1,2])
widget.SetNormal([plane.GetNormal()[x] for x in 0,1,2])
```

3. Connect it to the renderwindow's events

```
widget.SetInteractor(iren)
```

Exercise: use a widget to interact with the data

1. Connect the widget's events to our pipeline

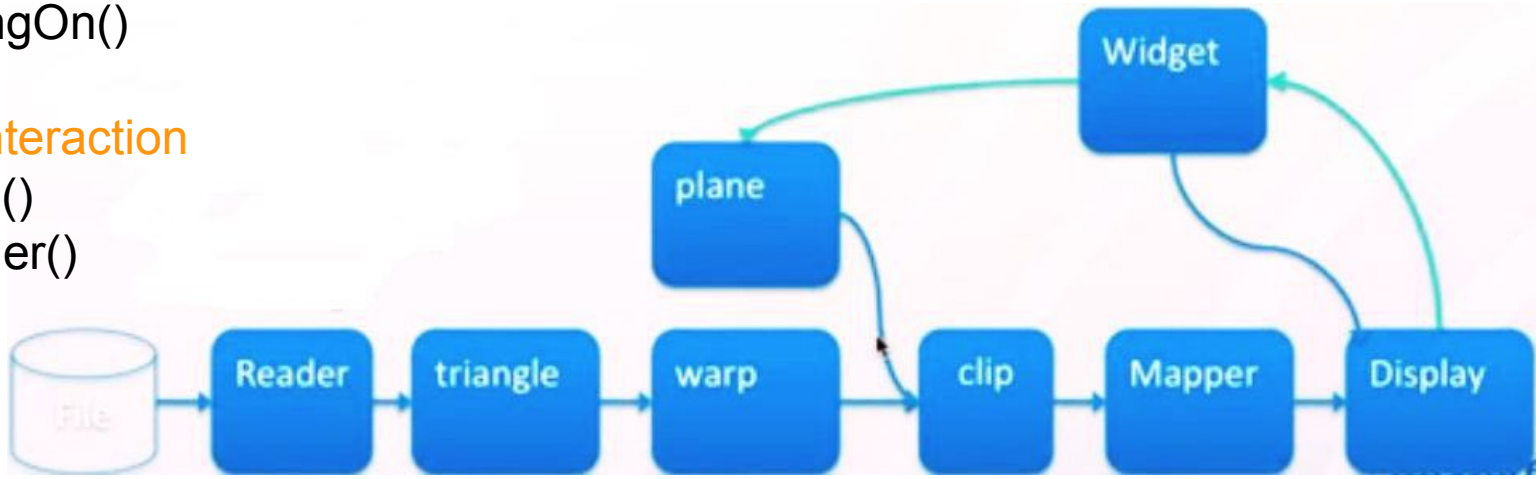
```
def eventhandler(obj , event):
        global plane
        obj.GetPlane(plane)

widget.AddObserver("InteractionEvent", eventhandler)
```

2. Configure the widget

```
widget.SetEnabled(1)
widget.DrawPlaneOn()
widget.TubingOn()
```

3. Turn on interaction

```
iren.Initialize()
renwin.Render()
iren.Start()
```



Tutorial: Import timevarying data, visualize it and export as Unstructured Grid

Tutorial: Create a cone and scale it with a 3D widget

Exercise: Import timevarying data, visualize it and export as Structured Points