Medical Images

Session 10

Programming Volume Rendering

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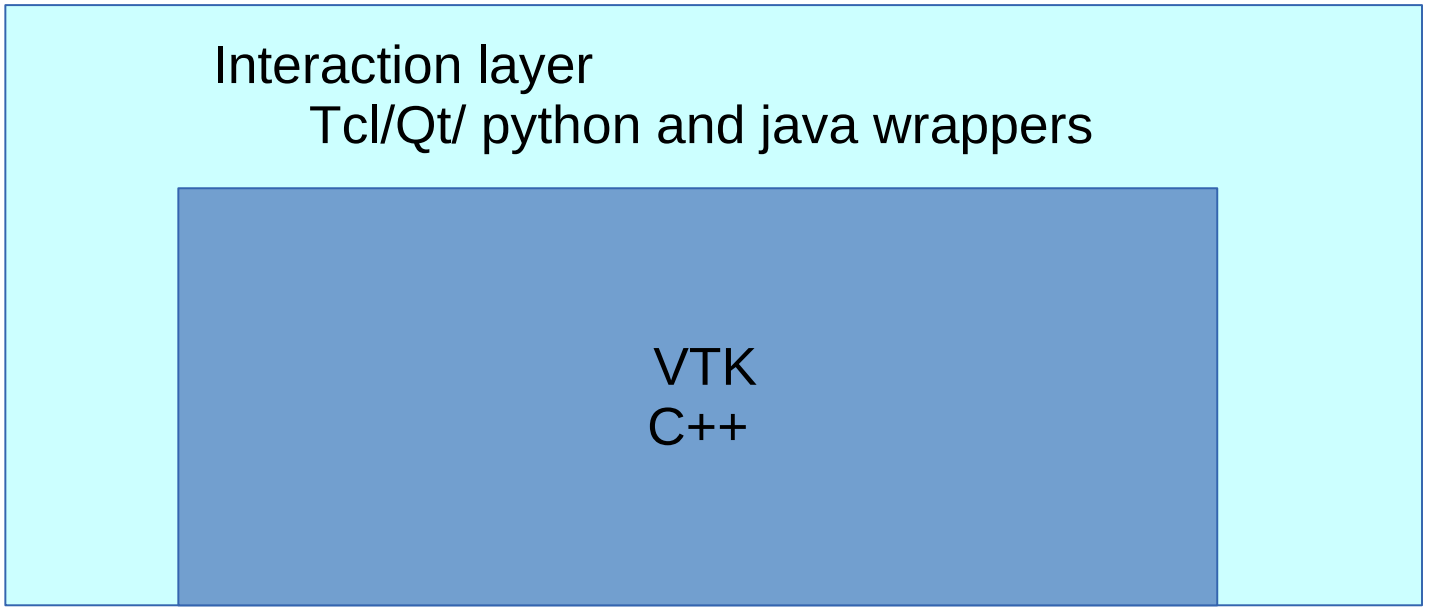
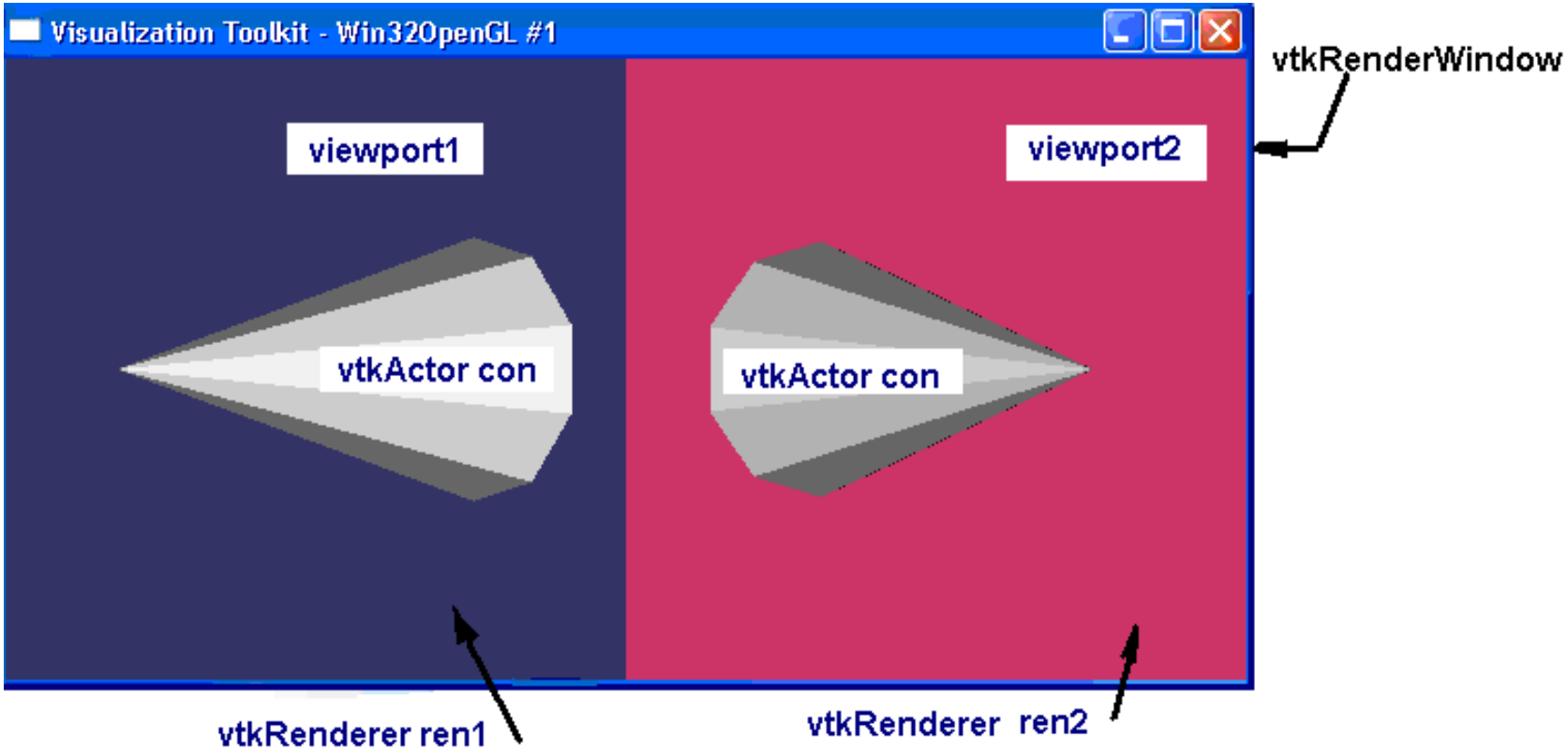
Programming with vtk

VTK




```
$ python
>>> import vtk
>>> dir(vtk)
>>> help(vtk.vtkActor)
Q
```

Visualization



RenderWindow: graphical window in which render happens
Viewport: viewport in the render window
Renderer: object in charge of rendering
Actors and volumes: objects that are rendered
Interactor: object in charge of user interaction

Class rendering

Implement `rendering.py`

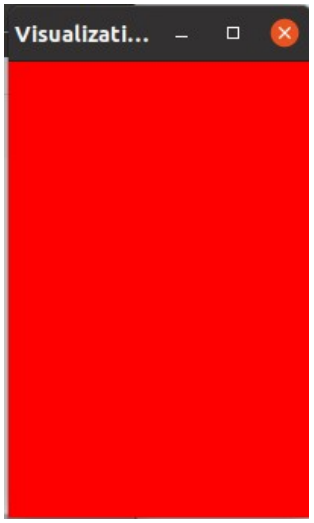
```
import vtk
class Rendering :
    def __init__(self, size, color) :
        self.renderer = vtk.vtkRenderer()
        self.renderer.SetBackground(color[0], color[1], color[2])
        self.render_window = vtk.vtkRenderWindow()
        self.render_window.SetSize(size[0], size[1])
        self.render_window.AddRenderer(self.renderer)
        self.interactor = vtk.vtkRenderWindowInteractor()
        self.interactor.SetRenderWindow(self.render_window)
        self.interactor.Initialize()

if __name__=='__main__':
    ren = Rendering((900, 800), (1, 0, 0))
    ren.interactor.Start()
```

Renderer

Render window

Interactor

Class Rendering



Run:

```
python3 rendering.py
```

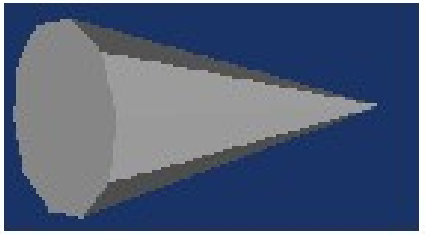
Try to modify the size of the RenderWindow
Try to change the background color
In which range are color specified?

Try to change its name. Look in the documentation of vtk classes or do `dir(vtk.vtkRenderWindow)` to look for available methods.

Main objects

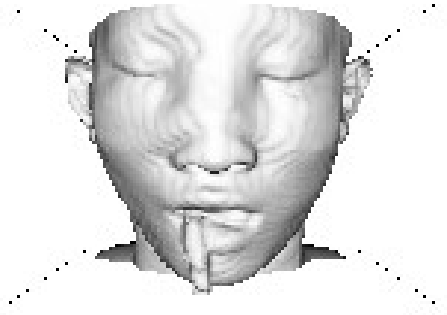
vtkProp3D

- vtkActor



Surfaces either parametric or read from a file or created from volumes

- vtkVolume

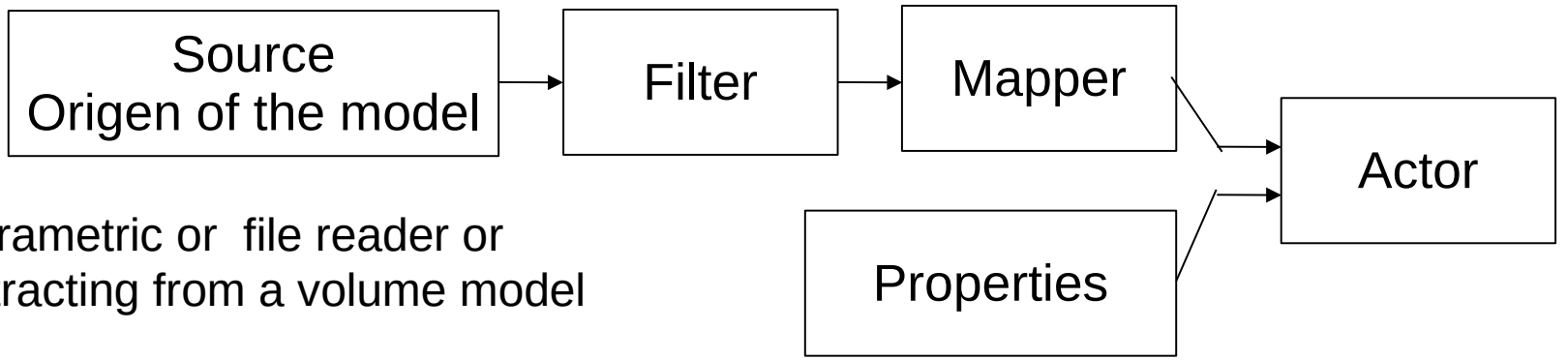


Volumes read from a file or created from other volumes

```
>>> a = vtk.vtkActor()
>>> a
(vtkOpenGLActor)0x2d67310
>>> b = vtk.vtkVolume()
(vtkVolume)0x2d6675
```

Surface models

Data processing flow



Parametric or file reader or
extracting from a volume model

Actors need to be added to the `renderer` to be rendered:

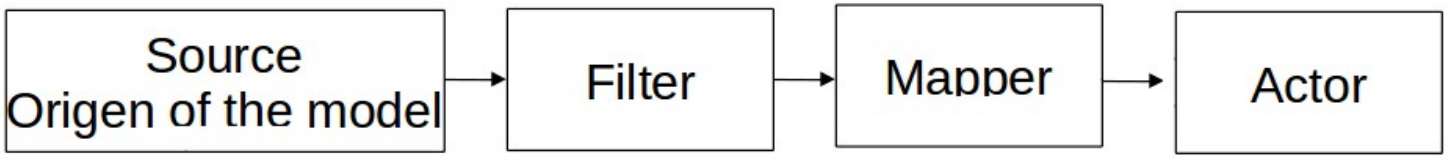
```
renderer.AddActor(actor)
```

Class Surface

Create the module surface.py with the class Surface that inherits from vtkActor

```
import vtk
class Surface(vtk.vtkActor) :
    def __init__(self, name, source,  mat= None):
        super().__init__()
        self.name = name
        mapper = vtk.vtkPolyDataMapper()
        mapper.SetInputConnection(source.GetOutputPort())
        mapper.ScalarVisibilityOff()
        self.SetMapper(mapper)
        self.SetProperty(mat)
```

To render the surface with its own material

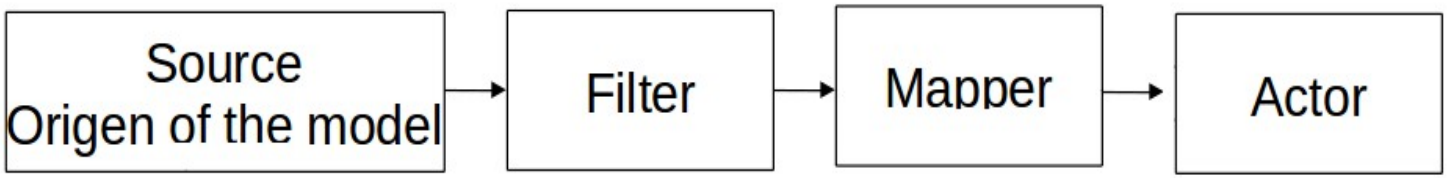


Here, we don’t apply filters.

Class Surface

In the same module, create the class method to create a sphere

```
@classmethod
def from_sphere(cls, name, center, radius, res, mat=None):
     source =  vtk.vtkSphereSource()
     source.SetCenter(center)
     source.SetRadius(radius)
     source.SetThetaResolution(res[0])
     source.SetPhiResolution(res[1])
     return cls(name, source, mat)
```



Class Rendering

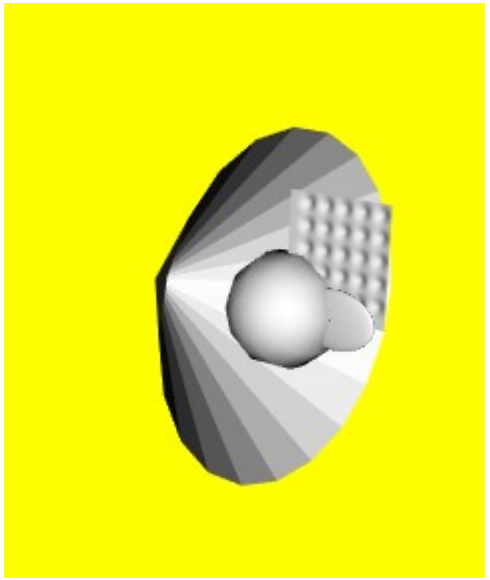
In the class Rendering, a method to add a surface to the renderer:

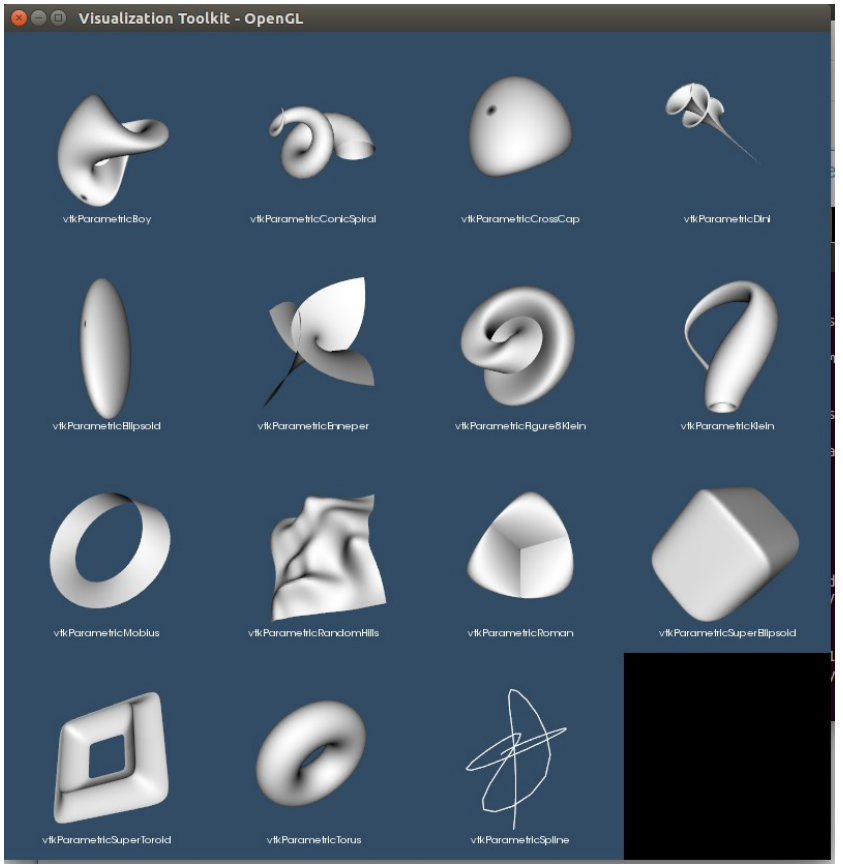
```
import vtk
class Rendering :
    def __init__(self, size, color) :
        self.renderer = vtk.vtkRenderer()
        self.renderer.SetBackground(color[0], color[1], color[2])
        self.render_window = vtk.vtkRenderWindow()
        self.render_window.SetWindowName('Example 1')
        self.render_window.SetSize(size[0], size[1])
        self.render_window.AddRenderer(self.renderer)
        self.interactor = vtk.vtkRenderWindowInteractor()
        self.interactor.SetRenderWindow(self.render_window)
        self.interactor.Initialize()

    def add_actor(self, actor):
        self.renderer.AddActor(actor)
```

Extend

Add other parametric objects
(see http://www.vtk.org/Wiki/VTK/Examples/Python/GeometricObjects/ParametricObjectsDemo)

```
@classmethod
def from_random_fields(cls, mat=None):
    random_field =vtk.vtkParametricRandomHills()
    random_field.AllowRandomGenerationOff()
    source = vtk.vtkParametricFunctionSource()
    source.SetParametricFunction(random_field)
    return cls('random_hills', source, mat)
```

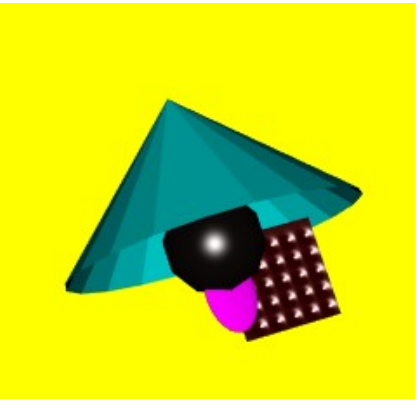




Optical properties

Optical properties for surface shading are part of the class `vtk.vtkProperty`. In the module `material.py` implement the class `SurfaceMaterial`

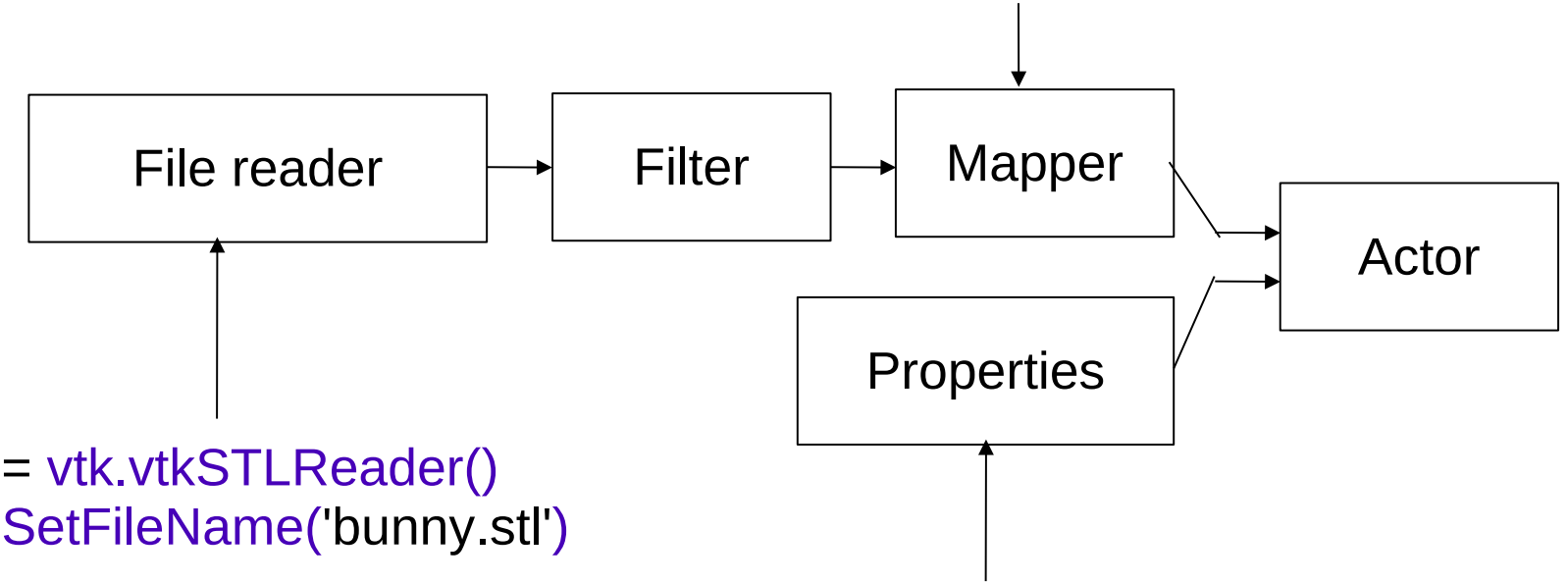
```
import vtk
class SurfaceMaterial(vtk.vtkProperty) :
    def __init__(self, name, Od, kd, Os, ks, n, alpha):
        super().__init__()
        self.SetMaterialName(name)
        self.SetDiffuseColor(Od[0], Od[1], Od[2])
        self.SetDiffuse(kd)
        self.SetSpecularColor(Os[0], Os[1], Os[2])
        self.SetSpecular(ks)
        self.SetSpecularPower(n)
        self.SetOpacity(alpha)
```



Create a material, pass it as a parameter to the sphere instantiation. Play with parameters.

STL files

```
surfMapper = vtk.vtkPolyDataMapper()
surfMapper.SetInputConnection(rabbit.GetOutputPort() )
```

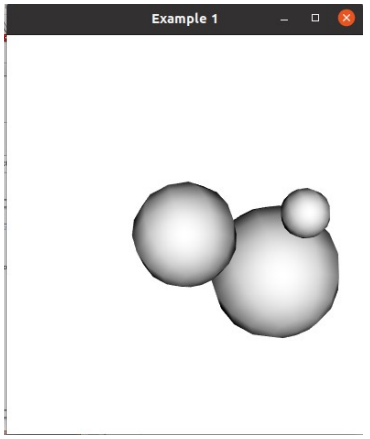



```
rabbit = vtk.vtkSTLReader()
rabbit.SetFileName('bunny.stl')
```

```
property = vtk.vtkProperty()
property.SetColor(1.0, 0.3882, 0.2784)
property.SetDiffuse(0.7)
property.SetSpecular(0.4)
property.SetSpecularPower(20)
```

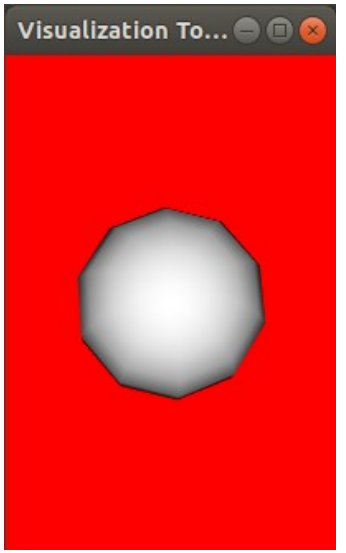
Usage

Modify the main program:




```
if __name__=='__main__':
    ren = Rendering((900, 800), (1, 0, 0))
    from surface import Surface
    s1 = Surface.from_sphere('sphere_1', (0, 0, 0), 2, (10, 10))
    ren.add_actor(s1)
    ren.interactor.Start()
```

Try then to add new spheres.

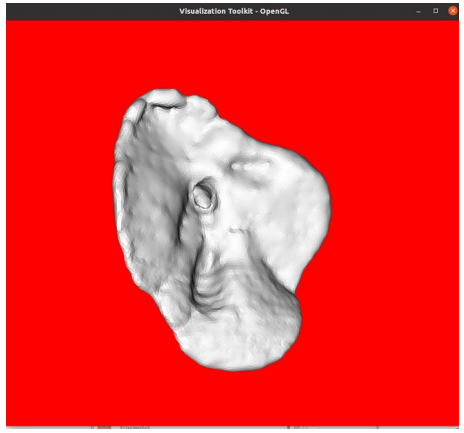


STL Files

In surface.py add a class method to read a stl file

In main, read an stl file and add it to the renderer

```
@classmethod
def from_stl_file(cls, filename, name ='', mat=None):
        reader  = vtk.vtkSTLReader()
        reader.SetFileName(filename)
        if name == '' :
             base_name = os.path.basename(filename)
             name, extension = os.path.splitext(base_name)
        return cls(name, reader, mat)
```



STL Files

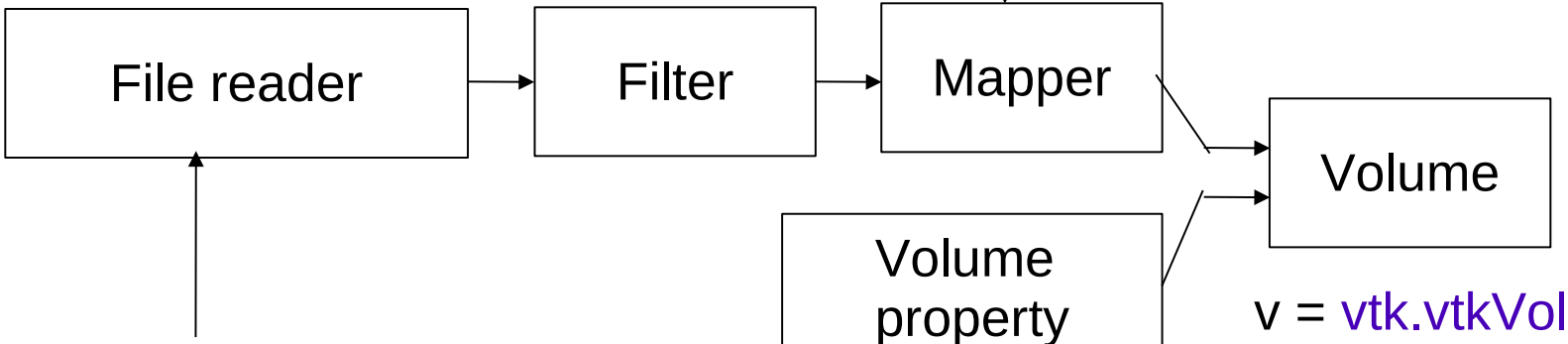
In surface.py add a class method to read a stl file

In main, read an stl file and add it to the renderer

```
@classmethod
 def from_stl_file(cls, filename, name =’’, mat=None):
        reader  = vtk.vtkSTLReader()
        reader.SetFileName(filename)
      if name == ‘’ :
           base_name = os.path.basename(filename)
           name, extension = os.path.splitext(base_name)
        return cls(name, reader, mat)
```

DVR pipeline

```
mapper.SetVolumeRayCastFunction(raycast)
mapper = vtk.vtkGPUVolumeRayCastMapper()
mapper.SetInputConnection(source.GetOutputPort())
mapper.SetBlendModeToComposite()
```




```
data = vtk.vtkDataSetReader()
data.SetFileName(filename)
```

```
v = vtk.vtkVolume()
v.AddProperty(property)
v.AddMapper(mapper)
```

```
property = vtk.vtkVolumeProperty()
```

DVR

Create the module `volume.py` with a definition of the class `Volume`

```
class Volume(vtk.vtkVolume) :
    def __init__(self, name, reader, mat):
        self.name = name
        mapper = vtk.vtkFixedPointVolumeRayCastMapper()
        mapper.SetInputConnection(reader.GetOutputPort())
        mapper.SetBlendModeToComposite()
        self.reader = reader
        self.SetMapper(mapper)
        self.SetProperty(mat)
```

DVR

Define the transfer functions to create a new class of material:

```
class VolumeMaterial(vtk.vtkVolumeProperty) :
    def __init__(self, name, rgb, opac):
        self.name = name
        colorTF = vtk.vtkColorTransferFunction()
        for point in rgb :
            colorTF.AddRGBPoint(point[0], point[1][0],
                    point[1][1] , point[1][2])
        self.SetColor(colorTF)
        opacTF = vtk.vtkPiecewiseFunction()
        for point in opac :
                opacTF.AddPoint(point[0], point[1])
        self.SetScalarOpacity(opacTF)
```

Suggestion: investigate how to apply surface shading

DVR

Add the class method read_vtk_file. Create default transfer functions.

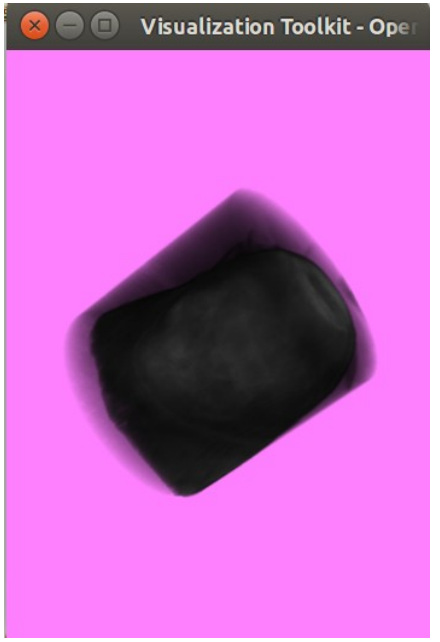
```
@classmethod
def read_vtk_file(cls, filename, mat=None):
    reader =  vtk.vtkDataSetReader()
    reader.SetFileName(filename)
    reader.Update()
    if mat == None:
       minv, maxv = reader.GetOutput().GetScalarRange()
       mat = VolumeMaterial.basic(minv, maxv)

    return cls('volume', reader, mat)
```

Suggestion: change the name by the name of the file without path and extension

DVR

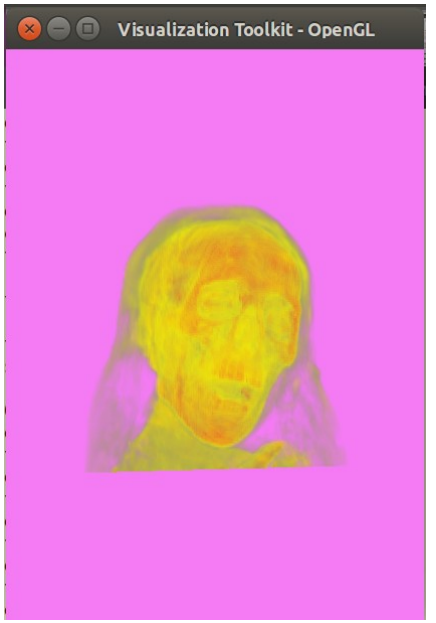
Try to render mummy.vtk

```
def main() :
    ren = Rendering((200, 300), (1, 0.5, 1))
    mummy = Volume.read_vtk_file('mummy.vtk')
    ren.renderer.AddVolume(mummy)
    ren.interactor.Initialize()
    ren.interactor.Start()
```



Homework: Create a suitable transfer function as a class method of VolumMaterial

```
mat_mum = VolumeMaterial.mummy()
Mummy = Volume.read_vtk_file('mummy.vtk',
                             mat_mum)
```



Thank you