MayaVi2 Users Guide

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Contents

Vision

MayaVi2 seeks to provide easy and interactive visualization of 3D data. It does this by the following:

- *an (optional) rich user interface with dialogs to interact with all data and objects in the visualization.*
- *a simple and clean scripting interface in Python, including one-liners, a-la mlab, or object-oriented programming interface.*
- *harnesses the power of the VTK toolkit without forcing you to learn it.*

Additionally Mayavi2 strives to be a reusable tool that can be embedded in your applications in different ways or combined with the envisage application-building framework to assemble domain-specific tools.

Introduction

MayaVi2 is a general purpose, cross-platform tool for 3-D scientific data visualization. Its features include:

- *Visualization of scalar, vector and tensor data in 2 and 3 dimensions*
- *Easy scriptability using Python*
- *Easy extendability via custom sources, modules, and data filters*
- *Reading several file formats: VTK (legacy and XML), PLOT3D, etc.*
- *Saving of visualizations*
- *Saving rendered visualization in a variety of image formats*

- *Convenient functionality for rapid scientific plotting via mlab (see Using mlab)*

Unlike its predecessor MayaVi1, MayaVi2 has been designed with scriptability and extensibility in mind from the ground up. While the mayavi2 application is usable by itself, it may be used as an Envisage plugin which allows it to be embedded in user applications natively. Alternatively, it may be used as a visualization engine for any application.

Technical details

MayaVi-2 provides a general purpose visualization engine based on a pipeline architecture similar to that used in VTK. MayaVi2 also provides an Envisage plug-in for 2D/3D scientific data visualization. MayaVi2 uses the Enthought Tool Suite (ETS) in the form of Traits, TVTK and Envisage. Here are some of its features:

- *Allows users to easily visualize scalar, vector and (eventually) tensor field data in 2 and 3 dimensions.*
- *Easier to script than MayaVi-1 due to a much cleaner MVC design.*
- *Easy to extend with added sources, components, modules and data filters.*
- *Envisage plugin. This implies that it is:*
  - *easy to use other envisage plugins in mayavi. For example, Mayavi provides an embedded Python shell. This is an Envisage plugin and requires one line of code to include in Mayavi.*
  - *easy to use Mayavi inside Envisage based applications. Thus, any envisage based application can readily use the mayavi plugin and script it to visualize data.*
- *wxPython/Qt4 based GUI (thanks entirely to Traits, PyFace and Envisage). It is important to note that there is no wxPython or Qt4 code used directly in Mayavi source.*
- *Persistent visualizations like in MayaVi1.*
- *Ability to save rendered visualizations to various image formats.*

Installation

Up-to-date install instructions are always available at the MayaVi2 web page. The following instructions are likely not up-to-date but should give you a good idea of the general installation procedure and a start on where to look.

Requirements

Mayavi requires at the very minimum the following packages:

- *VTK >= 4.4 (5.x is ideal)*
- *numpy >= 1.0.1*
- *wxPython 2.6.x*
- *setuptools (for installation and egg builds)*
- *TVTK (enthought.tvtk)*
- *Traits >= 2.0 (enthought.traits)*
- *Envisage == 2.x (enthought.envisage)*

One can install the requirements in several ways.

- *Win32: Under Win32 the best way to get all the dependencies is to use Enthought's enstaller.*
- *Linux: Most Linux distributions will have installable binaries available for the some of the above. For example, under Debian or Ubuntu you would need* `python-vtk`, `python-wxgtk2.6`, `python-setuptools`, `python-numpy`.
- *Mac OS X: The best available instructions for this platform are available on the IntelMacPython25 page.*

There are several ways to install TVTK, Traits and MayaVi. These are described in the following.

Eggs

MayaVi is part of the Enthought Tool Suite (ETS). ETS has been organized into several different Python packages. These packages are distributed as Python Eggs. Python eggs are fairly sophisticated and carry information on dependencies with other eggs. As such they are rapidly becoming the standard for distributing Python packages.

Introduction to Eggs

There are primarily two ways to use ETS eggs.

1. *The first and easiest is to use pre-built eggs built for your particular platform. More instructions on this follow.*
2. *The second is to build the eggs from the source tarballs. This is also fairly easy to do if you have a decent build environment.*

Given this background please see the following:

- *InstallWithEggs describes how ETS can be installed with eggs. Check this page first.*
- *If there aren't any pre-built eggs for your platform, first make sure the requirements are installed, and then build and install the eggs like so:*

```
$ easy_install -f http://code.enthought.com/enstaller/eggs/source \
> enthought.mayavi
```

This one command will download, build and install all the required ETS related modules that mayavi needs. If you run into trouble please check the InstallWithEggs pages. Note that the above is really one line, it has been split with the \ character into two lines in order to fit on the printed version of this document.

- *Install describes the various ways to install the ETS of which mayavi2 is a part.*
- *Additionally, non-modular source tarballs can be downloaded at http://code.enthought.com/downloads/source/ giving the different ETS dependencies for mayavi as a set of monolithic downloads.*

The bleeding edge: SVN

If you want to get the latest development version of mayavi, we recommend that you check it out from SVN.

- Currently the easiest way to get mayavi from the SVN repository is to do the following:

  1. *Make sure you have all the requirements installed.*
  2. *Checkout the branches (current development is occurring in the branches):*

     ```
     svn co https://svn.enthought.com/svn/enthought/branches
     ```
  3. *Run `egg_builder.py` like so (the built eggs will be put in the `dist` directory):*

     ```
     cd branches
     python egg_builder.py
     ```
  4. *Install the necessary packages and pull any packages not in the branches from the last stable release:*

     ```
     $ cd branches
     $ easy_install -f http://code.enthought.com/enstaller/eggs/source \
     > -f dist enthought.mayavi
     ```
  5. *You should be all set. Try any of the examples in your working copy.*

The easiest way to test if your install is OK is to run the mayavi2 command like so:

```
mayavi2
```

To get more help on the command try this:

```
mayavi2 -h
```

`mayavi2` is the mayavi application. On some platforms like win32 you will need to double click on the `mayavi2.exe` program found in your `Python2X\Scripts` folder. Make sure this directory is in your path.

Mayavi can be used in a variety of other ways but the the `mayavi2` application is the easiest to start with.

If you have the source tarball of mayavi or downloaded it via SVN, you can run the examples in `enthought.mayavi*/examples`. There are plenty of example scripts illustrating various features. Tests are available in the `enthought.mayavi*/tests` subdirectory.

An overview of MayaVi

All the following sections assume you have a working mayavi Installation.

As a user there are two primary ways to use mayavi:

1. *Use the `mayavi2` application completely graphically. More information on this is in the Using MayaVi section.*
2. *Script MayaVi from Python. MayaVi features a powerful and general purpose scripting API.*
    a. *You can script mayavi while using the `mayavi2` application in order to automate tasks and extend mayavi's behavior.*
    b. *You can script mayavi from your own Python based application.*
    c. *You can embed mayavi into your application in a variety of ways either using Envisage or otherwise.*

    More details on this are available in the Scripting MayaVi chapter.

MayaVi is a scientific data visualizer. There are two primary ways to make your data available to it.

1. *Use a supported file format like VTK legacy or VTK XML files etc. See VTK file formats for more information on the VTK formats.*
2. *Generate a TVTK dataset via numpy arrays or any other sequence.*

More information on datasets in general and how to create VTK files or create them from numpy arrays is available in the Creating data for MayaVi section.

MayaVi uses a pipeline architecture like VTK. As far as a user is concerned this basically boils down to a simple hierarchy.

- *The user visualizes data on a TVTK Scene -- this is an area where the 3D visualization is performed. New scenes may be created by using the File->New->VTK Scene menu.*

- *On each scene the user loads data (either using a file or created from a script). Any number of data files or data objects may be opened.*
- *This data is optionally processed using Filters that operate on the data and visualized using visualization Modules. The Filters and Modules are accessible via the Visualize menu on the UI or may be instantiated as Python objects.*

More information on each of these are available in the following sections.

Quick tour

To get acquainted with mayavi you may start up `mayavi2` like so:

```
$ mayavi2
```

On windows you can double click on the installed `mayavi2.exe` executable (usually in the `Python2X\Scripts` directory).

Once mayavi starts, you may resize the various panes of the user interface to get a comfortable layout. These settings will become the default "perspective" of the mayavi application. More details on the UI are available in the General layout of UI section.

Before proceeding on the quick tour it is important to locate some data to experiment with. The mayavi sources ship with several useful data files for examples and testing. These may be found in the `examples/data` directory inside the root of the mayavi source tree. If these are not installed, the sources may be downloaded from here: http://code.enthought.com/enstaller/eggs/source/

If for some reason the sample data files are not available or there is no Internet access to download them, one can always create some interesting looking surfaces using the File->Open->Create Parametric surface source menu item. This will let us create very pretty looking surfaces without reference to any external data. This is described in the Parametric surfaces example section below.

`heart.vtk` example

This section describes a simple example with the `heart.vtk` file. This is a simple volume of 3D data (32 x 32 x 12 points) with scalars at each point (the points are equally spaced). The data is a structured dataset (an ImageData in fact), we'll read more about these later but you can think of it as a cube of points regularly spaced with some scalar data associated with each point. The data apparently represents a CT scan of a heart. I have no idea whose heart! The file is a readable text file, look at it in a text editor if you'd like to.

1. *With `mayavi2` started, we start by opening the data file. Go to the File->Open->VTK File menu item and then in the file dialog, navigate to the directory that contains the sample data. There select the `heart.vtk` file.*

Once you choose the data, you will see a new node on the MayaVi tree view on the left that says VTK file (heart.vtk). Note that you ***will not*** *see anything visualized on the TVTK scene yet.*

2. *To see an outline (a box) of the data, navigate to the Visualize->Modules menu item and select the Outline module. You will immediately see a white box on the TVTK scene. You should also see two new nodes on the tree view, one called Modules and one underneath that called Outline.*
3. *You can change properties of the outline displayed by clicking on the Outline node on the left. This will create an object editor window on left bottom of the window (the object editor tab) below the tree view. Play with the settings here and look at the results. If you double-click a node on the tree view it will pop up the editor dialog rather than show it in the embedded object editor.*

   Note that in general, the editor window for a Module will have a section for the Actor, one for the Mapper and one for Property. These refer to TVTK/VTK terminology. You may think of Properties as those related to the color, representation (surface, wireframe, etc.), line size etc. Things grouped under Actor are related to the object that is rendered on screen and typically the editor will let you toggle its visibility. In VTK parlance, the word Mapper refers to an object that converts the data to graphics primitives. Properties related to it will be grouped under the Mapper head.
4. *To interact with the TVTK scene window, look at the section on* Interaction with the scene *for more details. Experiment with these options till you are comfortable.*
5. *Now create an iso-surface by selecting the Visualize->Modules->IsoSurface menu item. You will see a new IsoSurface node on the left and an iso-contour of the scalar data on the scene. The iso-surface is colored as per the particular iso-value chosen. Experiment with the settings of this module.*
6. *To produce meaningful visualizations you need to know what each color means. To display this legend on the scene, click on the Modules node on the tree view and on the object editor activate the Show scalar bar check-box. This will show you a legend on the TVTK scene. The legend can be moved around on the scene by clicking on it and dragging on it. It can also be resized by clicking and dragging on its edges. You can change the nature of the color-mapping by choosing various options on the object editor.*
7. *Create a simple "grid plane" to obtain an idea of the actual points on the grid. This can be done using the GridPlane module, and created via the Visualize->Modules->GridPlane menu item.*
8. *You can delete a particular module by right clicking on it and choos-*

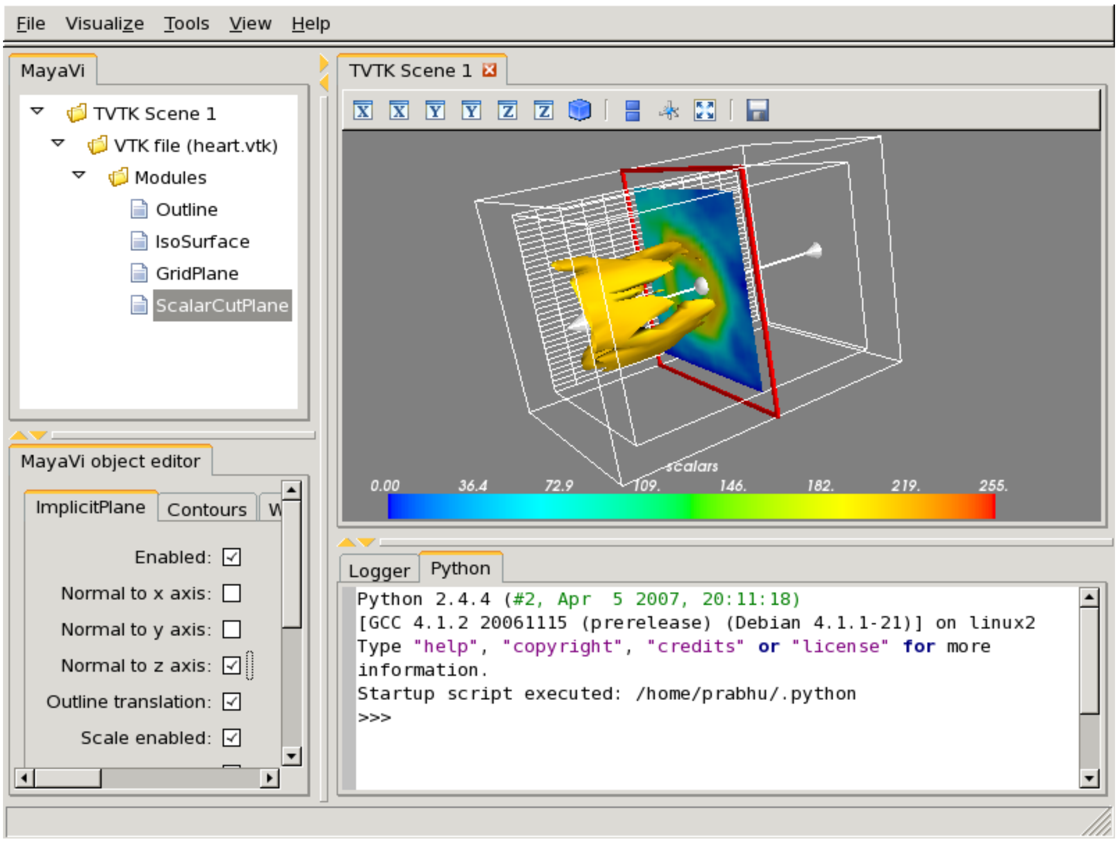
ing delete. Try this on the GridPlane module. Try the other right click menu options as well.

9. *Experiment with the ContourGridPlane module and also the ScalarCutPlane module a little.*

   The ScalarCutPlane module features a very powerful feature called 3D widgets. *On the TVTK scene window you will see a cut plane that slices through your data showing you colors representing your data. This cut plane will have a red outline and an arrow sticking out of it. You can click directly on the cut plane and move it by dragging it. Click on the arrow head to rotate the plane. You can also reset its position by using the editor window for the scalar cut plane.*

10. *You can save the visualization to an image produced by clicking on the little save icon on the TVTK scene or via any of the options on the File->Save Scene As menu.*

You should have a visualization that looks something like the one shown below.



The nice thing about mayavi is that although in this case all of the above was done using the user interface, all of it can be done using pure Python scripts as well. More details on this are available in the Scripting MayaVi section.

Opening data files and starting up modules can also be done from the command line. For example we could simply have done:

```
$ mayavi2 -d /path/to/heart.vtk -m Outline -m IsoSurface \
> -m GridPlane -m ScalarCutPlane
```

More details are available in the Command line arguments section.

`fire_ug.vtu` example

Like `heart.vtk`, the `fire_ug.vtu` example dataset is available in the `examples/data` directory. This dataset is an unstructured grid stored in a VTK XML file. It represents a room with a fire in one corner. A simulation of the fluid flow generated by this fire was performed and the resulting data at a particular instant of time is stored in the file. The dataset was provided by Dr. Philip Rubini, who at the time was at Cranfield University. A VRML file (`room_vis.wrl`) is also provided to show the context of the room in which the fire is taking place.

1. *With mayavi2 started, select File->Open->VTK XML file to load the data. Again, you will see a node on the tree view on the left but nothing on the TVTK scene. This dataset contains different scalars and vectors in the same data file. If you select the VTK XML file ... node on the left you will see a drop list of all the scalars, vectors etc. in this data file. Select any that you wish to view.*
2. *Create an outline of the data as described earlier using an Outline module. View an iso-surface of the data by creating an IsoSurface module. Also experiment with the ScalarCutPlane module.*
3. *Show the scalar bar that represents the color mapping (via a Look up table that maps scalar values to colors) by clicking on the Modules and enabling the Show scalar bar. Experiment with the different color maps provided by default.*
4. *Now click on the VTK XML file ... and select different scalar values to see how the data has changed. Your legend should automatically update when the scalar value is changed.*
5. *This data also features vectors. The scalar data has u, v and w but not the magnitude of the velocity. Lets say we'd like to be able to view iso-contours of the magnitude of the velocity. To do this lets use the ExtractVectorNorm filter. This is created by choosing the Visualize->Filters->Extract Vector Norm menu.*
6. *If you now create a ScalarCutPlane, you will see a new Modules node under the ExtractVectorNorm node. This scalar cut plane is displaying colors for the velocity magnitude that the filter has created. You can drag the iso-surface module from the other Modules*

node and drop it on this Modules node so that the IsoSurface generated is for the velocity magnitude and not for the scalars chosen in the data.

Note that the view on the left represents a pipeline of the flow of the data from source -> filter -> modules. Essentially the data flows from the parent node down to the children nodes below it.

Now if you want to visualize something on a different "branch" of the pipeline, lets say you want to view iso-surfaces of the temperature data you must first click on the modules or the source object (the VTK XML File ... node) itself and then select the menu item. When you select an item on the tree, it makes that item the current object *and menu selections made after that will in general create new modules/filters below the current object.*

7. *You can filter "filtered data". So select the ExtractVectorNorm node to make it the active object. Now create a Threshold filter by selecting Visualize->Filters->Threshold. Now set the upper and lower thresholds on the object editor for the Threshold to something like 0.5 and 3.0. If you create a VectorCutPlane module at this point and move the cut plane you should see arrows but only arrows that are between the threshold values you have selected. Thus, you can create pretty complicated visualization pipelines using this approach.*
8. *There are several vector modules. VectorCutPlane, Vectors, WarpVectorCutPlane and Streamlines. If you view streamlines then mayavi will generate streamlines of vector data in your dataset. To view streamlines of the original dataset you can click on the original Outline module (or the source) and then choose the Streamline menu item. The streamline lets you move different type of seeds on screen using 3D widgets. Seed points originating from these positions are used to trace out the streamlines. Sphere, line and plane sources may be used here to initialize the streamline seeds.*
9. *You can view the room in which the fire is taking place by opening the VRML file by the File->Open->VRML2 file menu item and selecting the* `room_vis.wrl` *file included with the data.*
10. *Once you setup a complex visualization pipeline and want to save it for later experimentation you may save the entire visualization via the File->Save Visualization menu. A saved file can be loaded later using the File->Load Visualization menu item. This option is not 100% robust and is still experimental. Future versions will improve this feature. However, it does work and can be used for the time being.*

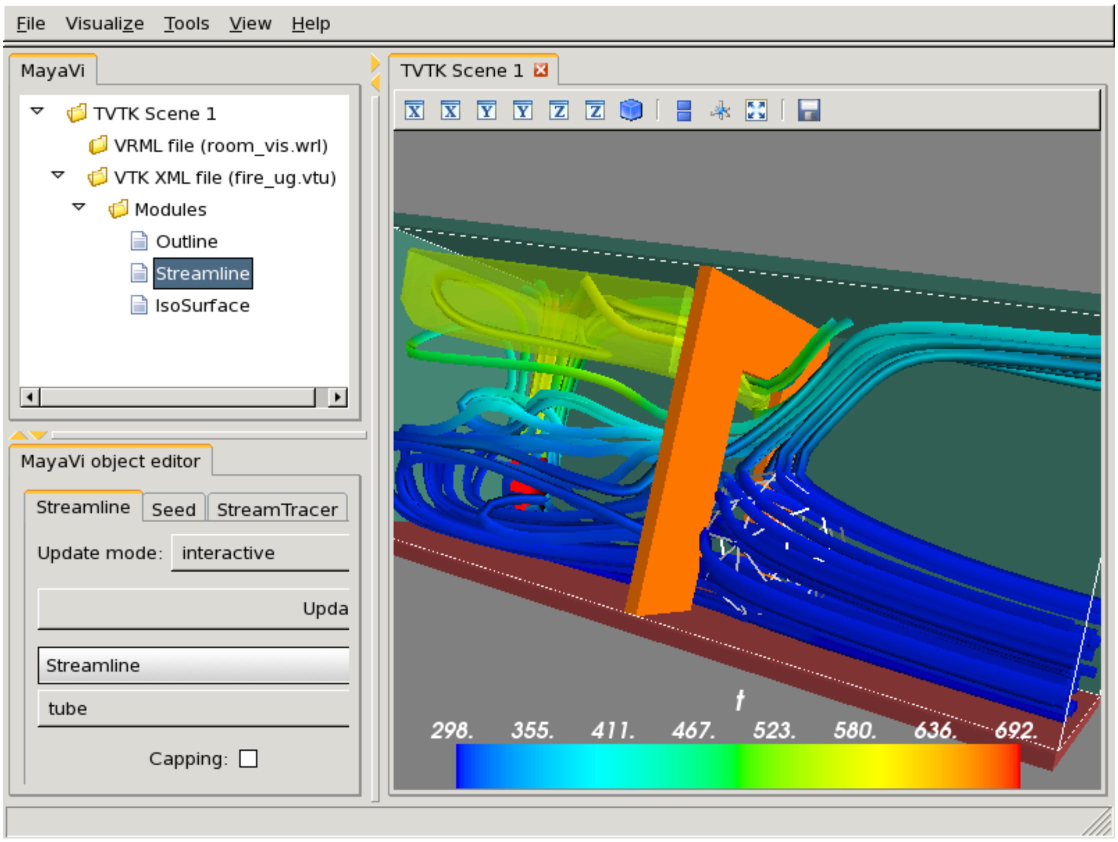
Once again, the visualization in this case was created by using the user interface. It is possible to script this entirely using Python scripts. A simple script demonstrating several of the above modules is available in `examples/streamline.py`. This file may be studied. It can be run either like so:

```
$ cd examples
$ python streamline.py
```

or so:

```
$ mayavi2 -x streamline.py
```

As can be seen from the example, it is quite easy to script mayavi to visualize data. An image of a resulting visualization generated from this script is shown below.



Parametric surfaces example

Parametric surfaces are particularly handy if you are unable to find any data to play with right away. Parametric surfaces are surfaces parametrized typically by 2 variables, u and v. VTK has a bunch of classes that let users explore Parametric surfaces. This functionality is also available in MayaVi. The data basically is a 2D surface embedded in 3D. Scalar data is also available on the surface. More details on parametric surfaces in VTK may be obtained from Andrew Maclean's Parametric Surfaces document.

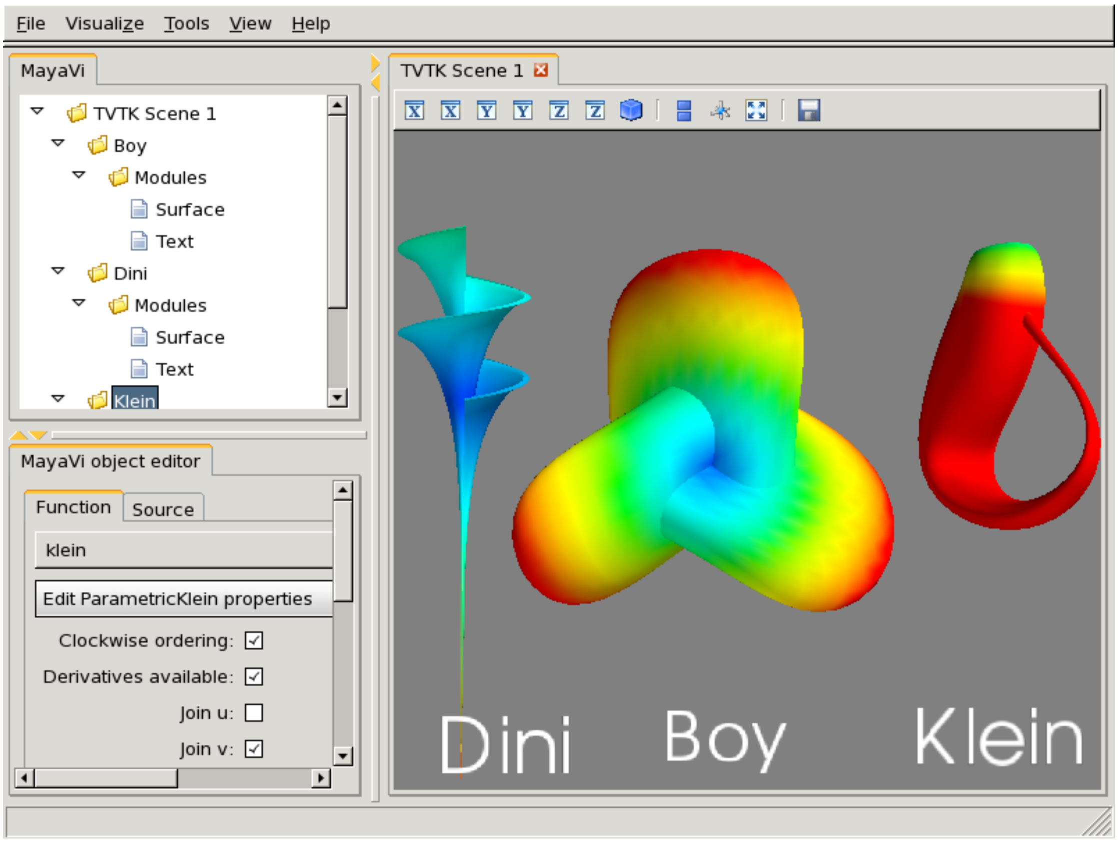
1. *After starting mayavi2, create a simple Parametric surface source by selecting File->Open->Create Parametric Surface source. Once you create the data, you will see a new node on the MayaVi tree view on the left that says ParametricSurface. Note that you **will not** see anything visualized on the TVTK scene yet.*

   You can modify the nature of the parametric surface by clicking on the node for the ParametricSurface source object.
2. *To see an outline (a box) of the data, navigate to the Visualize->Modules menu item and select the Outline module. You will immediately see a white box on the TVTK scene. You should also see two new nodes on the tree view, one called Modules and one underneath that called Outline.*
3. *You can change properties of the outline displayed by clicking on the Outline node on the left. This will create an object editor window on left bottom of the window (the object editor tab) below the tree view. Play with the settings here and look at the results. If you double-click a node on the left it will pop up the editor dialog rather than show it in the embedded object editor.*
4. *To navigate the scene look at the section on Interaction with the scene section for more details. Experiment with these.*
5. *To view the actual surface create a Surface module by selecting Visualize->Modules->Surface. You can show contours of the scalar data on this surface by clicking on the Surface node on the left and switching on the Enable contours check-box.*
6. *To look at the color legend click on the Modules node on the tree view and on the object editor activate the Show scalar bar check-box. This will show you a legend on the TVTK scene. The legend can be moved around on the scene by clicking on it and dragging on it. It can also be resized by clicking and dragging on its edges. You can change the nature of the color-mapping by choosing various options on the object editor.*
7. *You can add as many modules as you like. Not all modules make sense for all data. MayaVi does not yet grey out menu items and options if they are invalid for the particular data chosen. This will be implemented in the future. However making a mistake should not in general be disastrous, so go ahead and experiment.*
8. *You may add as many data sources as you like. It is possible to view two different parametric surfaces on the same scene. Whether this makes sense or not is up to the user. You may also create as many scenes you want to and view anything in those. You can cut/paste/copy sources and modules between any nodes on the tree view using the right click options.*
9. *To delete the Outline module say, right click on the Outline node*

and select the Delete option. You may also want to experiment with the other options.

10. *You can save the rendered visualization to a variety of file formats using the File->Save Scene As menu.*
11. *The visualization may itself be saved out to a file via the File->Save Visualization menu and reloaded using the Load visualization menu.*

Shown below is an example visualization made using the parametric source. Note that the positioning of the different surfaces was effected by moving the actors on screen using the actor mode of the scene via the 'a' key. For more details on this see the section on Interaction with the scene.



The examples detailed above should provide a good general idea of how to visualize data with MayaVi2 and also an idea of its features and capabilities.

Using MayaVi

This chapter primarily concerns using the `mayavi2` application. Some of the things mentioned here also apply when mayavi is scripted. We recommend that new users read this chapter before going to the more advanced ones.

Command line arguments

The `mayavi2` application features several useful command line arguments that are described in the following section. These options are described in the `mayavi2` man page as well.

MayaVi can be run like so:

```
mayavi2 [options] [args]
```

Where `arg1`, `arg2` etc. are optional file names that correspond to saved MayaVi2 visualizations (`filename.mv2`) or MayaVi2 scripts (`filename.py`). If no options or arguments are provided mayavi will start up with a default blank scene.

The options are:

`-h` This prints all the available command line options and exits. Also available through --help.

`-V` This prints the MayaVi version on the command line and exits. Also available through --version.

`-z` *`file_name`*
: This loads a previously saved MayaVi2 visualization. Also available through --viz file_name or --visualization file_name.

`-d` *`vtk_file`* Opens a (legacy or XML) VTK file (`*.vt*`) passed as the argument. Also available through --vtk.

`-p` *`plot3d_xyz_file`*
: This opens a PLOT3D co-ordinate file passed as the argument. The plot3d-xyz-file must be a PLOT3D single block co-ordinate file. Also available through --plot3d-xyz.

`-q` *`plot3d_q_file`*
: This opens a PLOT3D (single block) solution file passed as the argument. Please note that this option must always follow a -q or --plot3d-xyz option. Also available through --plot3d-q.

`-w` *`vrml-file`*
: Imports a VRML2 scene given an appropriate file. Also available through --vrml.

`-3` *`threed-studio-file`*
: Imports a 3D Studio scene given an appropriate file. Also available through --3ds.

`-m` *`module-name`*
: A module is an object that actually visualizes the data. The given `module-name` is loaded in the current `ModuleManager`. The module name must be a valid one if not you will get an error message.
If a module is specified as `package.sub.module.SomeModule then the module (‘‘SomeModule`) is imported from `package.sub.module`. Standard modules provided with `mayavi2` do not need the full path specification. For example:

`mayavi2 -d data.vtk -m Outline -m m2_user_modules.TestModule`

In this example `Outline` is a standard module and `m2_user_modules.TestModule` is some user defined module. Also available through --module.

`-f` *`filter-name`*
: A filter is an object that filters out the data in some way or the other. The given `filter-name` is loaded with respect to the current source/filter object. The filter name must be a valid one if not you will get an error message.

  If the filter is specified as `package.sub.filter.SomeFilter then the filter (``SomeFilter)` is imported from `package.sub.filter`. Standard modules provided with `mayavi2` do not need the full path specification. For example:

  `mayavi2 -d data.vtk -f ExtractVectorNorm -f m2_user_filters.TestFilter`

  In this example `ExtractVectorNorm` is a standard filter and `m2_user_filters.TestFilter` is some user defined filter. Also available through --filter.

`-M`
: Starts up a new module manager on the MayaVi pipeline. Also available through --module-mgr.

`-n`
: Creates a new window/scene. Any options passed after this will apply to this newly created scene. Also available through --new-window.

`-x` *`script-file`*
: This executes the given script in a namespace where we guarantee that the name 'mayavi' is MayaVi's script instance -- just like in the embedded Python interpreter. Also available through --exec.

Note that `-x` or `--exec` uses execfile, so this can be dangerous if the script does something nasty!

It is important to note that mayavi's **command line arguments are processed sequentially** in the same order they are given. This allows users to do interesting things.

Here are a few examples of the command line arguments:

```
$ mayavi2 -d heart.vtk -m Axes -m Outline -m GridPlane \
> -m ContourGridPlane -m IsoSurface

$ mayavi2 -d fire_ug.vtu -m Axes -m Outline -m VectorCutPlane \
> -f MaskPoints -m Glyph
```

In the above examples, `heart.vtk` and `fire_ug.vtu` VTK files can be found in the `examples/data` directory in the source. They may also be installed on your computer depending on your particular platform.

General layout of UI

When the mayavi2 application is started it will provide a user interface that looks something like the figure shown below.

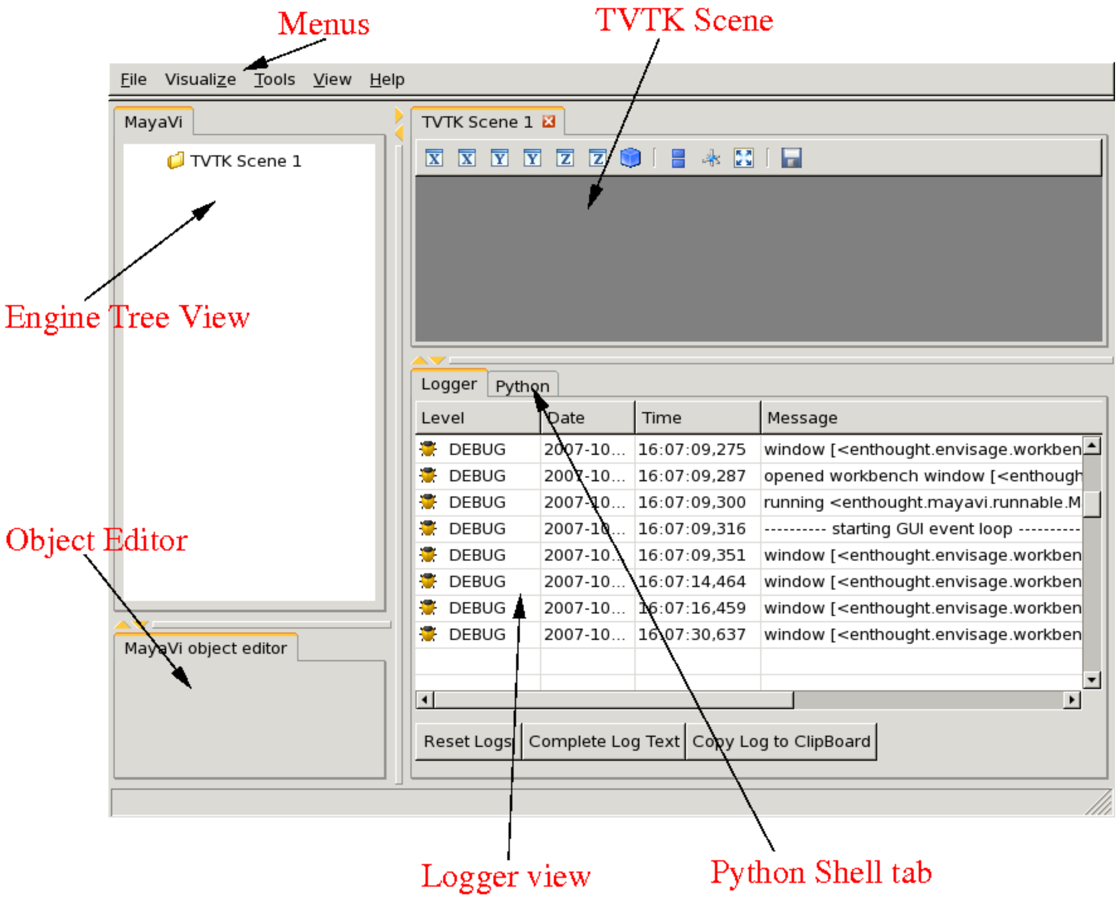


Figure of MayaVi's initial UI window.

The UI features several sections described below.

Menus

The menus let you open files, load modules, set preferences etc.

The MayaVi engine tree view

This is a tree view of the mayavi pipeline.

- *Right click a tree node to rename, delete, copy the objects.*
- *Left click on a node to edit its properties on the object editor below the tree.*
- *It is possible to drag the nodes around on the tree. For example it is possible to drag and move a module from one set of Modules to another, or to move a visualization from one scene to another.*

The object editor

This is where the properties of mayavi pipeline objects can be changed when an object on the engine's pipeline is clicked.

TVTK scenes

This is where the visualization of the data happens. One can interact with this scene via the mouse and the keyboard. More details are in the following sections.

Python interpreter

The built-in Python interpreter that can be used to script mayavi and do other things. You can drag nodes from the mayavi tree and drop them on the interpreter and then script it!

Logger

Application log messages may be seen here.

MayaVi's UI layout is highly configurable:

- *the line in-between the sections can be dragged to resize particular views.*
- *most of the "tabs" on the widgets can be dragged around to move them anywhere in the application.*
- *Each view area (the mayavi engine view, object editor, python shell and logger) can all be disabled and enabled at will using the View menu by toggling the views on and off.*

Each time you change the appearance of mayavi it is saved and the next time you start up the application it will have the same configuration. In addition, you can save different layouts into different "perspectives" using the View->Perspectives menu item.

Shown below is a specifically configured mayavi user interface view. In this view the size of the various parts are changed. The Python shell is activated by default.

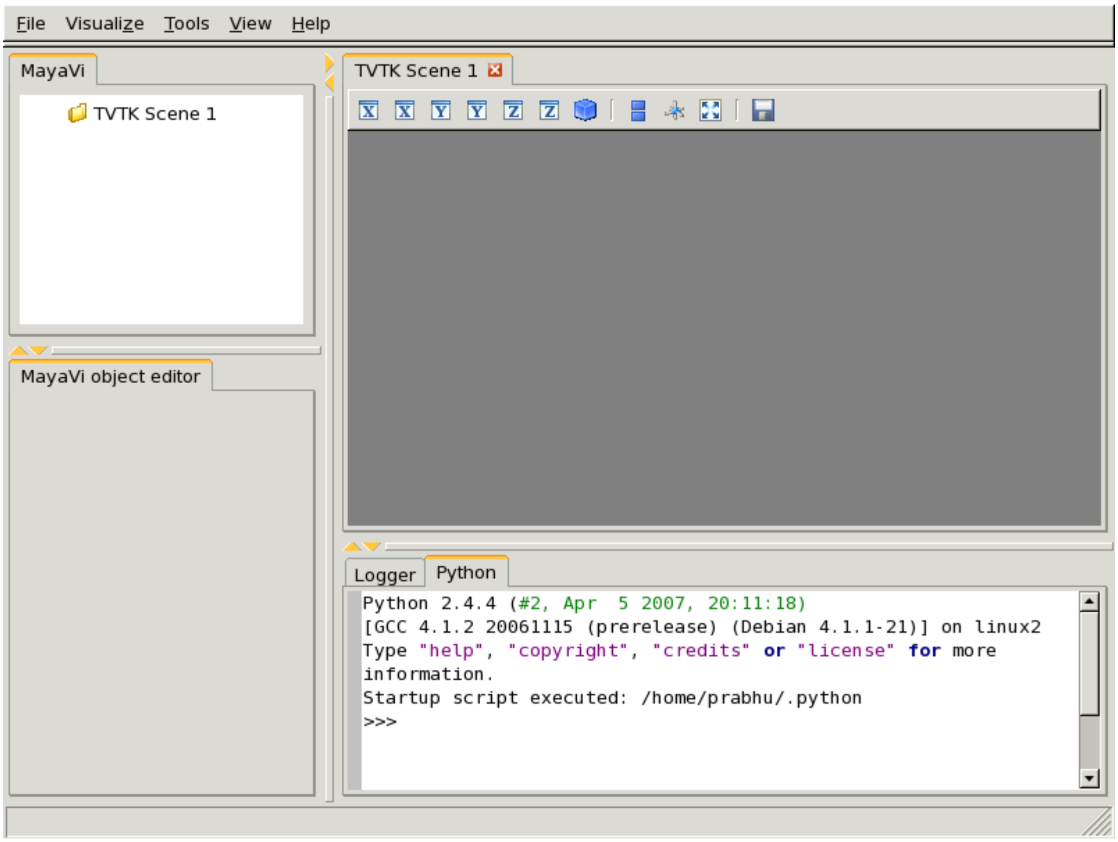


Figure of MayaVi's UI after being configured by a user.

Interaction with the scene

The TVTK scenes on the UI can be closed by clicking on the little 'x' icon on the tab. Each scene features a toolbar that supports various features:

- *Buttons to set the view to view along the positive or negative X, Y and Z axes or obtain an isometric view.*
- *A button to turn on parallel projection instead of the default perspective projection. This is particularly useful when one is looking at 2D plots.*
- *A button to turn on an axes to indicate the x, y and z axes.*
- *A button to turn on full-screen viewing. Note that once full-screen mode is entered one must press 'q' or 'e' to get back a normal window.*
- *A button to save the scene to a variety of image formats. The image format to use is determined by the extension provided for the file.*

The primary means to interact with the scene is to use the mouse and keyboard.

Mouse interaction

There are two modes of mouse interaction:

- *Camera mode: the default, where the camera is operated on with mouse moves. This mode is activated by pressing the 'c' key.*
- *Actor mode: in this mode the mouse actions operate on the actor the mouse is currently above. This mode is activated by pressing the 'a' key.*

The view on the scene can be changed by using various mouse actions. Usually these are accomplished by holding down a mouse button and dragging.

- *holding the left mouse button down and dragging will rotate the camera/actor in the direction moved.*
  - *Holding down "SHIFT" when doing this will pan the scene -- just like the middle button.*
  - *Holding down "CONTROL" will rotate about the camera's focal point.*
  - *Holding down "SHIFT" and "CONTROL" and dragging up will zoom in and dragging down will zoom out. This is like the right button.*
- *holding the right mouse button down and dragging upwards will zoom in (or increase the actors scale) and dragging downwards will zoom out (or reduce scale).*
- *holding the middle mouse button down and dragging will pan the scene or translate the object.*
- *Rotating the mouse wheel upwards will zoom in and downwards will zoom out.*

Keyboard interaction

The scene supports several features activated via keystrokes. These are:

- *'3': Turn on/off stereo rendering. This may not work if the 'stereo' preference item is not set to True.*
- *'a': Use actor mode for mouse interaction instead of camera mode.*
- *'c': Use camera mode for mouse interaction instead of actor mode.*
- *'e'/'q': Exit full-screen mode.*
- *'f': Move camera's focal point to current mouse location. This will move the camera focus to center the view at the current mouse position.*
- *'j': Use joystick mode for the mouse interaction. In joystick mode the mouse somewhat mimics a joystick. For example, holding the mouse left button down when away from the center will rotate the scene.*

- *'l': Configure the lights that are illumining the scene. This will pop-up a window to change the light configuration.*
- *'p': Pick the data at the current mouse point. This will pop-up a window with information on the current pick. The UI will also allow one to change the behavior of the picker to pick cells, points or arbitrary points.*
- *'r': Reset the camera focal point and position. This is very handy.*
- *'t': Use trackball mode for the mouse interaction. This is the default mode for the mouse interaction.*
- *'='/'+': Zoom in.*
- *'-': Zoom out.*
- *'left'/'right'/'up'/'down' arrows: Pressing the left, right, up and down arrow let you rotate the camera in those directions. When "SHIFT" modifier is also held down the camera is panned.*

The embedded Python interpreter

The embedded Python interpreter offers extremely powerful possibilities. The interpreter features command completion, automatic documentation tooltips and some multi-line editing. In addition it supports the following features:

- *The name* `mayavi` *is bound to the* `enthought.mayavi.script.Script` *instance. This may be used to easily script mayavi.*
- *The name* `application` *is bound to the envisage application.*
- *If a Python file is opened via the* `File->Open File...` *menu item one can edit it with a color syntax capable editor. To execute this script in the embedded Python interpreter, the user may type* `Control-r` *on the editor window. To save the file press* `Control-s`*. This is a very handy feature when developing simple mayavi scripts.*
- *As mentioned earlier, one may drag and drop nodes from the MayaVi engine tree view onto the Python shell. The object may then be scripted as one normally would. A commonly used pattern when this is done is the following:*

  ```
  >>> tvtk_scene_1
  <enthought.mayavi.core.scene.Scene object at 0x9f4cbe3c>
  >>> s = _
  ```

  In this case the name `s` *is bound to the dropped tvtk_scene object. The* `_` *variable stores the last evaluated expression which is the dropped object. Using* `tvtk_scene_1` *will also work but is a mouthful.*

Visualizing data

MayaVi modules can be used to visualize the data as described in the An overview of MayaVi section and the Quick tour section. One needs to have some data or the other loaded before a Module or Filter may be used. MayaVi supports several data file formats most notably VTK data file formats. More information on this is available here in the Creating data for MayaVi section.

Once data is loaded one can optionally use a variety of Filters to filter or modify the data in some way or the other and then visualize the data using several Modules. The Modules and Filters are briefly described in the subsequent sections.

Modules

Here is a list of the MayaVi modules along with a brief description.

Axes
: *Draws simple axes.*

ContourGridPlane
: *A contour grid plane module. This module lets one take a slice of input grid data and view contours of the data.*

CustomGridPlane
: *A custom grid plane with a lot more flexibility than GridPlane module.*

Glyph
: *Displays different types of glyphs oriented and colored as per scalar or vector data at the input points.*

GridPlane
: *A simple grid plane module.*

ImagePlaneWidget
: *A simple module to view image data.*

IsoSurface
: *A module that allows the user to make contours of input point data.*

OrientationAxes
: *Creates a small axes on the side that indicates the position of the co-ordinate axes and thereby marks the orientation of the scene. Requires VTK-4.5 and above.*

Outline
: *A module that draws an outline for the given data.*

ScalarCutPlane
: *Takes a cut plane of any input data set using an implicit plane and plots the data with optional contouring and scalar warping.*

SliceUnstructuredGrid
: *This module takes a slice of the unstructured grid data and shows the cells that intersect or touch the slice.*

Streamline
: *Allows the user to draw streamlines for given vector data. This supports various types of seed objects (line, sphere, plane and point seeds). It also*

allows the user to draw ribbons or tubes and further supports different types of interactive modes of calculating the streamlines.

StructuredGridOutline
: *Draws a grid-conforming outline for structured grids.*

Surface
: *Draws a surface for any input dataset with optional contouring.*

Text
: *This module allows the user to place text on the screen.*

VectorCutPlane
: *Takes an arbitrary slice of the input data using an implicit cut plane and places glyphs according to the vector field data. The glyphs may be colored using either the vector magnitude or the scalar attributes.*

Vectors
: *Displays different types of glyphs oriented and colored as per vector data at the input points. This is merely a convenience module that is entirely based on the Glyph module.*

Volume
: *The Volume module visualizes scalar fields using volumetric visualization techniques.*

WarpVectorCutPlane
: *Takes an arbitrary slice of the input data using an implicit cut plane and warps it according to the vector field data. The scalars are displayed on the warped surface as colors.*

Filters

Here is a list of the MayaVi Filters.

CellToPointData
: *Transforms cell attribute data to point data by averaging the cell data from the cells at the point.*

Delaunay2D
: *Performs a 2D Delaunay triangulation.*

Delaunay3D
: *Performs a 3D Delaunay triangulation.*

ExtractGrid
: *Allows a user to select a part of a structured grid.*

ExtractUnstructuredGrid
: *Allows a user to select a part of an unstructured grid.*

ExtractVectorNorm
: *Computes the norm (Euclidean) of the input vector data (with optional scaling between [0, 1]). This is useful when the input data has vector input but no scalar data for the magnitude of the vectors.*

MaskPoints

Selectively passes the input points downstream. This can be used to subsample the input points. Note that this does not pass geometry data, this means all grid information is lost.

PointToCellData

Does the inverse of the CellToPointData filter.

PolyDataNormals

Computes normals from input data. This gives meshes a smoother appearance. This should work for any input dataset. Note: this filter is called "Compute Normals" in MayaVi2 GUI (Visualize/Filters/Compute Normals).

Threshold

A simple filter that thresholds on input data.

TransformData

Performs a linear transformation to input data.

WarpScalar

Warps the input data along a particular direction (either the normals or a specified direction) with a scale specified by the local scalar value. Useful for making carpet plots.

WarpVector

Warps the input data along a the point vector attribute scaled as per a scale factor. Useful for showing flow profiles or displacements.

Scripting MayaVi

As elaborated in the Quick tour section, mayavi can be scripted from Python in order to visualize data. MayaVi2 was designed from the ground up to be highly scriptable. Everything that can be done from the user interface can be achieved using Python scripts.

If you are not looking to script mayavi itself but looking for quick ways to get your visualization done with simple code you may want to check out mayavi's mlab module. This is described in more detail in the Using mlab section.

To best understand how to script mayavi, a reasonable understanding of the mayavi internals is necessary. The following sections provides an overview of the basic design and objects in the mayavi pipeline. Subsequent sections consider specific example scripts that are included with the mayavi sources that illustrate the ideas.

MayaVi2 uses Traits and TVTK internally. Traits in many ways changes the way we program. So it is important to have a good idea of Traits in order to understand mayavi's internals. If you are unsure of traits it is a good idea to get a general idea about traits now. Trust me, your efforts learning Traits will not be wasted!

Design Overview

This section provides a brief introduction to mayavi's internal architecture.

The "big picture" of a visualization in mayavi is that an `Engine` (`enthought.mayavi.engine.Engine`) object manages the entire visualization. The `Engine` manages a collection of `Scene` (`enthought.mayavi.core.scene.Scene`) objects. In each `Scene`, a user may have created any number of `Source` (`enthought.mayavi.core.source.Source`) objects. A `Source` object can further contain any number of `Filters` (`enthought.mayavi.core.filter.Filter`) or `ModuleManager` (`enthought.mayavi.core.module_manager.ModuleManager`) objects. A `Filter` may contain either other filters or `ModuleManagers`. A `ModuleManager` manages any number of `Modules`. The figure below shows this hierarchy in a graphical form.

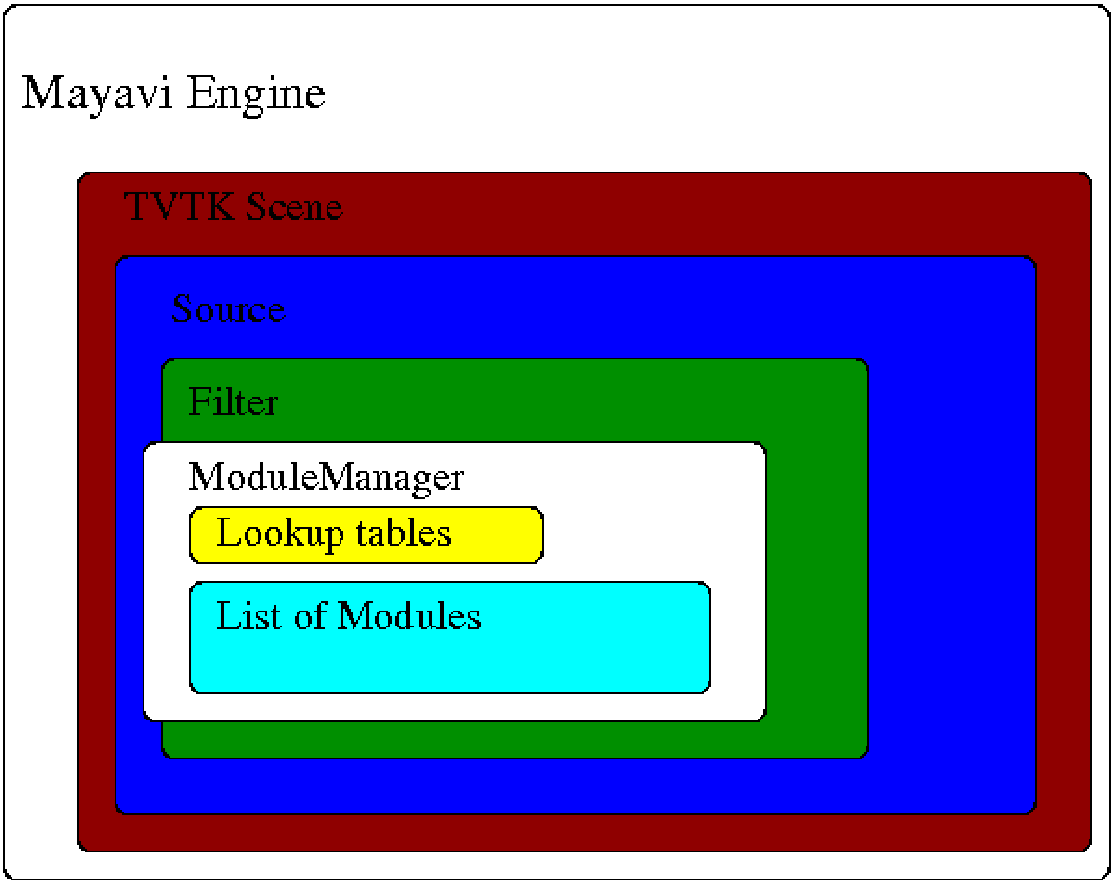


Illustration of the various objects in the mayavi pipeline.

This hierarchy is precisely what is seen in the MayaVi tree view on the UI. The UI is therefore merely a graphical representation of this internal world-view. A little more detail on these objects is given below. For even more details please refer to the sources.

All objects in the mayavi pipeline feature `start` and `stop` methods. The reasoning for this is that any object in mayavi is not usable (i.e. it may not provide any outputs) unless it has been started. Similarly the `stop` method "deactivates" the object. This is done because mayavi is essentially driving VTK objects underneath. These objects require inputs in order to do anything useful. Thus, an object that is not connected to the pipeline cannot be used. For example, consider an `IsoSurface` module. It requires some data in order to contour anything. Thus, the module in isolation is completely useless. It is usable only when it is added to the mayavi pipeline. When an object is added to the pipeline, its inputs are setup and its `start` method is called automatically. When the object is removed from the pipeline its `stop` method is called automatically.

Apart from the `Engine` object, all other objects in the mayavi pipeline feature a `scene` trait which refers to the current `enthought.pyface.tvtk.tvtk_scene.TVTKScene` instance that the object is associated with. The objects also feature an `add_child` method that lets one build up the pipeline by adding "children" objects. The `add_child` method is "intelligent" and will try to appropriately add the child in the right place.

Here is a brief description of the key objects in the mayavi pipeline.

`Engine`

The MayaVi engine is defined in the `enthought.mayavi.engine` module.

- *It possesses a `scenes` trait which is a Trait `List` of `Scene` objects.*
- *Features several methods that let one add a `Filter/Source/Module` instance to it. It allows one to create new scenes and delete them. Also has methods to load and save the entire visualization.*
- *The `EnvisageEngine` defined in the `enthought.mayavi.envisage_engine` module is a subclass of `Engine` and is the one used in the `mayavi2` application. The `Engine` object is not abstract and itself perfectly usable. It is useful when users do not want to use Envisage but still desire to use mayavi for visualization.*

`Scene`

Defined in the `enthought.mayavi.core.scene` module.

- *`scene` attribute: manages a `TVTKScene` (`enthought.pyface.tvtk.tvtk_scene`) object which is where all the rendering occurs.*
- *The `children` attribute is a `List` trait that manages a list of `Source` objects.*

`PipelineBase`

Defined in the `enthought.mayavi.core.pipeline_base` module. Derives from `Base` which merely abstracts out common functionality. The `PipelineBase` is the base class for all objects in the mayavi pipeline except the `Scene` and `Engine` (which really isn't in the pipeline but contains the pipeline).

- *This class is characterized by two events, `pipeline_changed` and `data_changed`. These are `Event` traits. They determine when the pipeline has been changed and when the data has changed. Therefore, if one does:*

  ```
  object.pipeline_changed = True
  ```

then the `pipeline_changed` *event is fired. Objects downstream of* `object` *in the pipeline are automatically setup to listen to events from an upstream object and will call their* `update_pipeline` *method. Similarly, if the* `data_changed` *event is fired then downstream objects will automatically call their* `update_data` *methods.*
- *The* `outputs` *attribute is a trait* `List` *of outputs produced by the object.*

`Source`
: *Defined in the* `enthought.mayavi.core.source` *module. All the file readers, Parametric surface etc. are subclasses of the* `Source` *class.*
  - *Contains the rest of the pipeline via its* `children` *trait. This is a* `List` *of either* `Modules` *or other* `Filters`*.*
  - *The* `outputs` *attribute is a trait* `List` *of outputs produced by the source.*

`Filter`
: *Defined in the* `enthought.mayavi.core.filter` *module. All the* `Filters` *described in the Filters section are subclasses of this.*
  - *Contains the rest of the pipeline via its* `children` *trait. This is a* `List` *of either* `Modules` *or other* `Filters`*.*
  - *The* `inputs` *attribute is a trait* `List` *of input data objects that feed into the filter.*
  - *The* `outputs` *attribute is a trait* `List` *of outputs produced by the filter.*
  - *Also features the three methods:*
    - `setup_pipeline`*: used to create the underlying TVTK pipeline objects if needed.*
    - `update_pipeline`*: a method that is called when the upstream pipeline has been changed, i.e. an upstream object fires a* `pipeline_changed` *event.*
    - `update_data`*: a method that is called when the upstream pipeline has* ***not*** *been changed but the data in the pipeline has been changed. This happens when the upstream object fires a* `data_changed` *event.*

`ModuleManager`
: *Defined in the* `enthought.mayavi.core.module_manager` *module. This object is the one called* Modules *in the tree view on the UI. The main purpose of this object is to manage* `Modules` *and share common data between them. All modules typically will use the same lookup table (LUT) in order to produce a meaningful visualization. This lookup table is managed by the module manager.*
  - *The* `source` *attribute is the* `Source` *or* `Filter` *object that*

is the input of this object.

- *Contains a list of* `Modules` *in its* `children` *trait.*
- *The* `scalar_lut_manager` *attribute is an instance of a* `LUTManager` *which basically manages the color mapping from scalar values to colors on the visualizations. This is basically a mapping from scalars to colors.*
- *The* `vector_lut_manager` *attribute is an instance of a* `LUTManager` *which basically manages the color mapping from vector values to colors on the visualizations.*
- *The class also features a* `lut_data_mode` *attribute that specifies the data type to use for the LUTs. This can be changed between 'auto', 'point data' and 'cell data'. Changing this setting will change the data range and name of the lookup table/legend bar. If set to 'auto' (the default), it automatically looks for cell and point data with point data being preferred over cell data and chooses the one available. If set to 'point data' it uses the input point data for the LUT and if set to 'cell data' it uses the input cell data.*

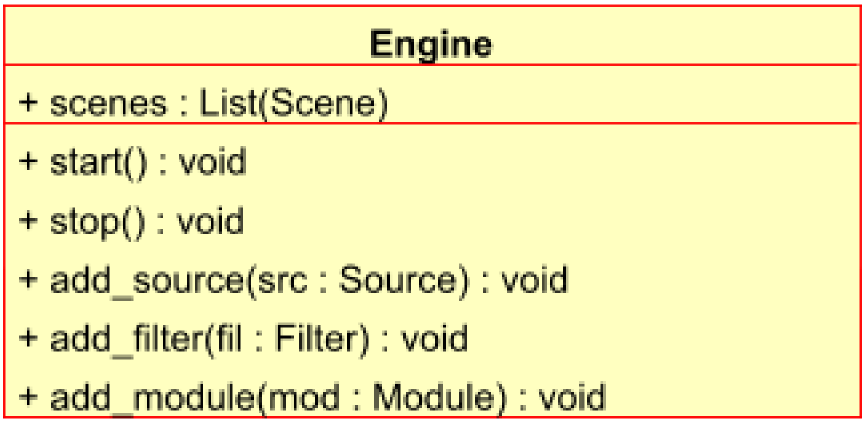
`Module`

Defined in the `enthought.mayavi.core.module` *module. These objects are the ones that typically produce a visualization on the TVTK scene. All the modules defined in the* Modules *section are subclasses of this.*

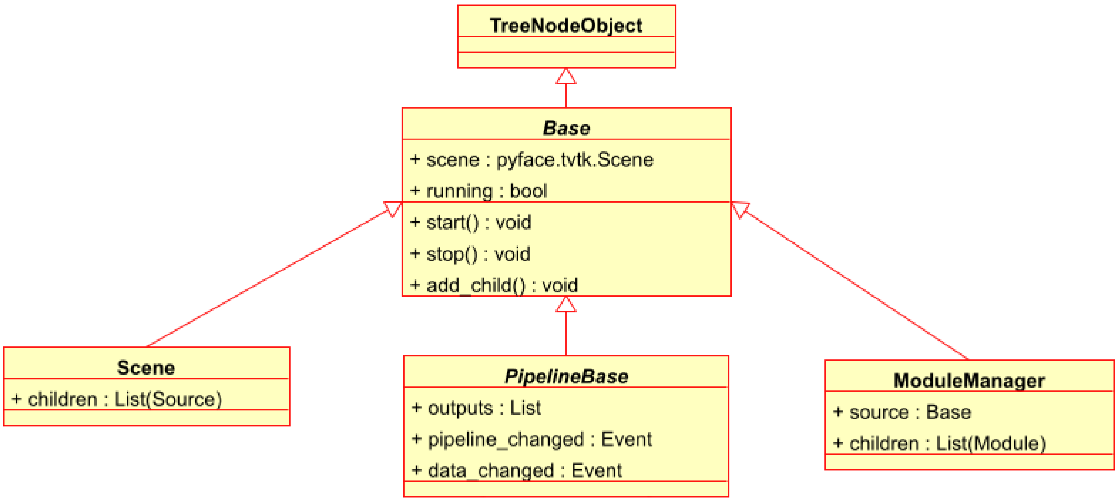
- *The* `components` *attribute is a trait* `List` *of various reusable components that are used by the module. These usually are never used directly by the user. However, they are extremely useful when creating new modules. A* `Component` *is basically a reusable piece of code that is used by various other objects. For example, almost every* `Module` *uses a TVTK actor, mapper and property. These are all "componentized" into a reusable Actor component that the modules use. Thus, components are a means to promote reuse between mayavi pipeline objects.*
- *The* `module_manager` *attribute specifies the* `ModuleManager` *instance that it is attached to.*
- *Like the* `Filter` *modules also feature the three methods:*
  - `setup_pipeline`*: used to create the underlying TVTK pipeline objects if needed.*
  - `update_pipeline`*: a method that is called when the upstream pipeline has been changed, i.e. an upstream object fires a* `pipeline_changed` *event.*
  - `update_data`*: a method that is called when the upstream pipeline has* **not** *been changed but the*

data in the pipeline has been changed. This happens when the upstream object fires a `data_changed` *event.*

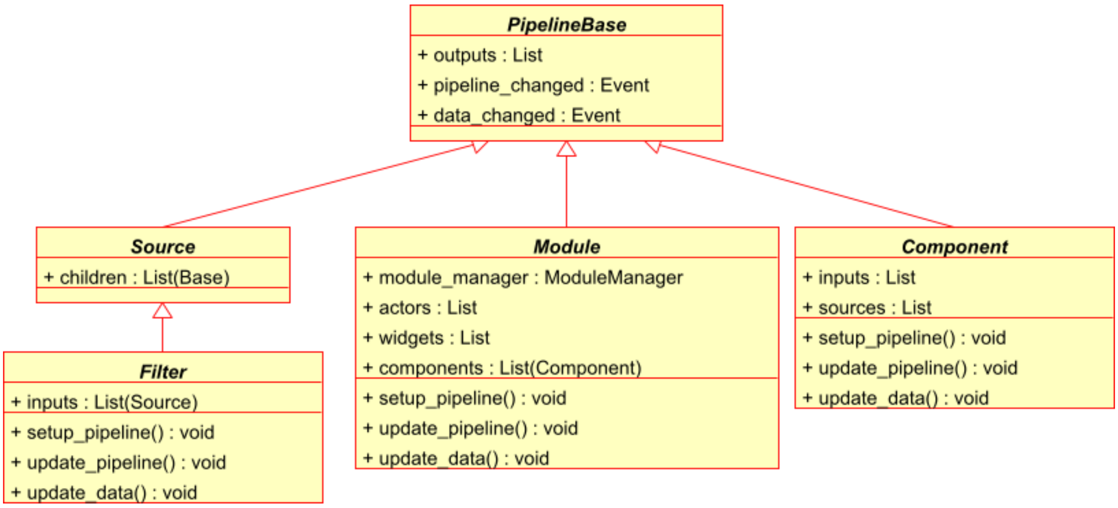
The following figures show the class hierarchy of the various objects involved.



The `Engine` *object and its important attributes and methods.*



This hierarchy depicts the `Base` *object, the* `Scene`*,* `PipelineBase` *and the* `ModuleManager`*.*



This hierarchy depicts the `PipelineBase` object, the `Source`, `Filter`, `Module` and the `Component`.

Scripting the `mayavi2` application

The `mayavi2` application is implemented in the `enthought.mayavi.scripts.mayavi2` module (look at the `mayavi2.py` file and not the `mayavi2` script). This code handles the command line argument parsing and runs the application.

`mayavi2` is an Envisage application. It starts the Envisage application in its `main` method. The code for this is in the `enthought.mayavi.app` module. Mayavi uses several envisage plugins to build up its functionality. These plugins are defined in the `enthought.mayavi.plugin_definitions` module. In this module there are two lists of plugins defined, `PLUGIN_DEFINITIONS` and the `NONGUI_PLUGIN_DEFINITIONS`. The default application uses the former which produces a GUI that the user can use. If one uses the latter (`NONGUI_PLUGIN_DEFINITIONS`) then the mayavi tree view, object editor and menu items will not be available when the application is run. This allows a developer to create an application that uses mayavi but does not show its user interface. An example of how this may be done is provided in `examples/nongui.py`.

Scripting from the UI

When using the `mayavi2` application, it is possible to script from the embedded Python interpreter on the UI. On the interpreter the name `mayavi` is automatically bound to an `enthought.mayavi.script.Script` instance that may be used to easily script mayavi. This instance is a simple wrapper object that merely provides some nice conveniences while scripting from the UI. It has an `engine` trait that is a reference to the running mayavi engine.

As described in The embedded Python interpreter section, one can always drag a mayavi object from the tree and drop it on the interpreter to script it directly.

One may select the File->Open File... menu to open an existing Python file in the text editor, or choose the File->New File menu to create a new file. The text editor is Python-aware and one may write a script assuming that the `mayavi` name is bound to the `Script` instance as it is on the shell. To execute this script one can press `Control-r` as described earlier. `Control-s` will save the script.

The nice thing about this kind of scripting is that if one scripts something on the interpreter or on the editor, one may save the contents to a file, say `script.py` and then the next time mayavi run it like so:

```
$ mayavi2 -x script.py
```

This will execute the script for automatically. The name `mayavi` is available to the script and is bound to the `Script` instance. This is very convenient. It is possible to have mayavi execute multiple scripts. For example:

```
$ mayavi2 -d foo.vtk -m IsoSurface -x setup_iso.py -x script2.py
```

will load the `foo.vtk` file, create an `IsoSurface` module, then run `setup_iso.py` and then run `script2.py`.

There are several scripts in the mayavi `examples` directory that should show how this can be done. The `examples/README.txt` contains some information on the recommended ways to script.

Scripting from IPython

It is possible to script MayaVi using IPython. IPython will have to be invoked with the `-wthread` command line option in order to allow one to interactively script the mayavi application:

```
$ ipython -wthread
```

To start a visualization do the following:

```
from enthought.mayavi.app import main
# Note, this does not process any command line arguments.
mayavi = main()
# 'mayavi' is the mayavi Script instance.
```

It is also possible to use mlab (see Using mlab) for this purpose:

```
from enthought.mayavi.tools import mlab
f = mlab.figure() # Returns the current scene.
mayavi = mlab.get_mayavi() # Returns the Script instance.
```

With this it should be possible to script mayavi just the way it is done on the embedded interpreter or on the text editor.

An example

Here is an example script that illustrates various features of scripting mayavi:

```
# Create a new mayavi scene.
mayavi.new_scene()

# Get the current active scene.
s = mayavi.engine.current_scene

# Read a data file.
from enthought.mayavi.sources.api import VTKXMLFileReader
d = VTKXMLFileReader()
# You must specify the full path to the data here.
d.initialize('fire_ug.vtu')
mayavi.add_source(d)

# Import a few modules.
from enthought.mayavi.modules.api import Outline, IsoSurface, Streamline

# Show an outline.
o = Outline()
mayavi.add_module(o)
o.actor.property.color = 1, 0, 0 # red color.

# Make a few contours.
iso = IsoSurface()
mayavi.add_module(iso)
iso.contour.contours = [450, 570]
# Make them translucent.
iso.actor.property.opacity = 0.4
# Show the colormapping.
iso.module_manager.scalar_lut_manager.show_scalar_bar = True

# A streamline.
st = Streamline()
mayavi.add_module(st)
# Position the seed center.
st.seed.widget.center = 3.5, 0.625, 1.25
st.streamline_type = 'tube'

# Save the resulting image.
s.scene.save('test.png')
```

```
# Make an animation:
for i in range(36):
    # Rotate the camera by 10 degrees.
    s.scene.camera.azimuth(10)

    # Resets the camera clipping plane so everything fits and then
    # renders.
    s.scene.reset_zoom()

    # Save the scene.
    s.scene.save_png('anim%d.png'%i)
```

Sometimes, given a mayavi `Script` instance or `Engine`, it is handy to be able to navigate to a particular module/object. In the above this could be achieved as follows:

```
x = mayavi.engine.scenes[0].children[0].children[0].children[-1]
print x
```

In this case `x` will be set to the `Streamline` instance that we just created.

There are plenty of examples illustrating various things in the `examples` directory. These are all fairly well documented.

In particular, the `standalone.py` example illustrates how one can script mayavi without using the envisage application at all. The `offscreen.py` example illustrates how this may be done using off screen rendering (if supported by your particular build of VTK).

`examples/README.txt` contains some information on the recommended ways to script and some additional information.

Using `mlab`

Mlab was originally written by the author of this document to provide a simple way for users to do visualization using just a few lines of code. It has since been completely rewritten by Gaël Varoquaux. The idea is to provide quick one-liners as done in the matplotlib `pylab` interface with an emphasis on 3D visualization using mayavi2. This allows users to perform quick 3D visualization while being able to use mayavi's powerful features.

The best way to use mayavi's mlab is to use IPython. IPython will have to be invoked with the `-wthread` command line option like so:

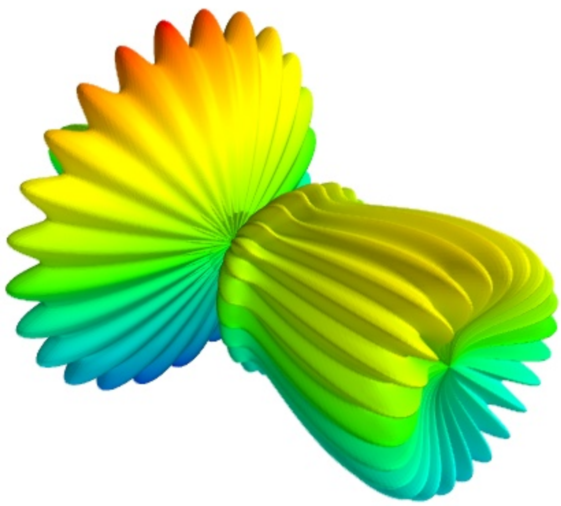
```
$ ipython -wthread
```

Once started, here is a pretty example showing a spherical harmonic:

```
from numpy import *
from enthought.mayavi.tools import mlab
# Create the data.
dphi, dtheta = pi/250.0, pi/250.0
```

```
[phi,theta] = mgrid[0:pi+dphi*1.5:dphi,0:2*pi+dtheta*1.5:dtheta]
m0 = 4; m1 = 3; m2 = 2; m3 = 3; m4 = 6; m5 = 2; m6 = 6; m7 = 4;
r = sin(m0*phi)**m1 + cos(m2*phi)**m3 + sin(m4*theta)**m5 + cos(m6*theta)**m7
x = r*sin(phi)*cos(theta)
y = r*cos(phi)
z = r*sin(phi)*sin(theta);
# View it.
f = mlab.figure()
s = mlab.surf(x, y, z)
```

Bulk of the code in the above example is to create the data. One line suffices to visualize it. This produces the following visualization in a mayavi window.



The data and visualization modules are all created by the single command `surf` in the above. One can now change the visualization using mayavi as described in other parts of this manual.

This is just a sampling of what you can do with mlab. More documentation on mlab is available here:

https://svn.enthought.com/enthought/attachment/wiki/MayaVi/mlab.pdf

Using the mayavi envisage plugins

The mayavi related plugin definitions to use are:

- *mayavi_plugin_definition.py*
- *mayavi_ui_plugin_definition.py*

These are in the `enthought.mayavi` package. To see an example of how to use this see the `enthought.mayavi.plugin_definitions` module and the `enthought.mayavi.app` module.

If you are writing Envisage plugins for an application and desire to use the mayavi plugins from your plugins/applications then it is important to note that mayavi creates three application objects for your convenience. These are:

- *enthought.mayavi.services.IMAYAVI: This is an* `enthought.mayavi.script.Script` *instance that may be used to easily script mayavi. It is a simple wrapper object that merely provides some nice conveniences while scripting from the UI. It has an* `engine` *trait that is a reference to the running mayavi engine.*
- *enthought.mayavi.services.IMAYAVI_ENGINE: This is the running mayavi engine instance.*
- *enthought.mayavi.services.IMAYAVI_ENGINE_VIEW: This is the view of the engine and is only exposed if the* `mayavi_ui_plugin_definition.py` *is used.*

A simple example that demonstrates the use of the mayavi plugin in an envisage application is included in the `examples/explorer` directory. This may be studied to understand how you may do the same in your envisage applications.

Creating data for MayaVi

This section of the user guide will be improved later. For now, the following two presentations best describe how one can create data objects or data files for MayaVi and TVTK.

- *Presentation on TVTK and MayaVi2 for course at IIT Bombay*
  https://svn.enthought.com/enthought/attachment/wiki/MayaVi/tvtk_mayavi2.pdf
  This presentation provides information on graphics in general, 3D data representation, creating VTK data files, creating datasets from numpy in Python, and also about mayavi.
- *Presentation on making TVTK datasets using numpy arrays made for SciPy07.*
  https://svn.enthought.com/enthought/attachment/wiki/MayaVi/tvtk_datasets.pdf
  This presentation focuses on creating TVTK datasets using numpy arrays.

There are several examples in the mayavi sources that highlight the creation of the most important datasets from numpy arrays. These may be found in the `examples` directory. Specifically they are:

- `polydata.py`: *Demonstrates how to create Polydata datasets from numpy arrays and visualize them in mayavi.*
- `structured_points2d.py`: *Demonstrates how to create a 2D structured points (or image data) dataset from numpy arrays and visualize them in mayavi. This is basically a square of equispaced points.*
- `structured_points3d.py`: *Demonstrates how to create a 3D structured points (or image data) dataset from numpy arrays and visualize them in mayavi. This is a cube of points that are regularly spaced.*
- `structured_grid.py`: *Demonstrates the creation and visualization of a 3D structured grid.*
- `unstructured_grid.py`: *Demonstrates the creation and visualization of an unstructured grid.*

These scripts may be run like so:

```
$ mayavi2 -x structured_grid.py
```

or better yet, all in one go like so:

```
$ mayavi2 -x polydata.py -x structured_points2d.py \
> -x structured_points3d.py -x structured_grid.py -x unstructured_grid.py
```

Tips and Tricks

Below are a few common tips and tricks.

Customizing mayavi2

See the `examples/mayavi_custom_ui.py` example that documents and shows how the UI of mayavi2 can be modified. The module documents how this can be done and provides a simple example.

Off screen rendering

Often you write mayavi scripts to render a whole batch of images to make an animation or so and find that each time you save an image, mayavi "raises" the window to make it the active window thus disrupting your work. This is needed since VTK internally grabs the window to make a picture. To get around this behavior you may click on the scene and set the "Off screen rendering" option on. Or from a script:

```
mayavi.engine.current_scene.scene.off_screen_rendering = True
```

This will stop raising the window. However, this may not be enough. If you are using win32 then off screen rendering should work well out of the box. On Linux and the Mac you will need VTK-5.1 (currently from CVS) to get this working properly.

If upgrading VTK is a problem there is another approach for any OS that supports X11. This option should work irrespective of the version of VTK you are using. The idea is to use the virtual framebuffer X server for X11 like so:

- *Make sure you have the xvfb package installed.*
- *Create the virtual framebuffer X server like so:*

  ```
  xvfb :1 -screen 0 1280x1024x24
  ```

  This creates the display ":1" and creates a screen of size 1280x1024 with 24 bpp. For more options check your `xvfb` *man page.*
- *Export display to :1 like so (on bash):*

  ```
  $ export DISPLAY=:1
  ```
- *Now run your mayavi script. It should run uninterrupted on this X server and produce your saved images.*

This probably will have to be fine tuned to suit your taste.

Note that if you want to use mayavi without the envisage UI or even a traits UI (i.e. with a pure TVTK window) and do off screen rendering with Python scripts you may be interested in the `examples/offscreen.py` example. This simple example shows how you can use MayaVi without using Envisage or the MayaVi envisage application and still do off screen rendering.

Miscellaneous

Tests for MayaVi2

MayaVi features a few simple tests. These are in the `tests` directory. The testing is performed using the same technique that VTK employs. Basically, a visualization is scripted and the resulting visualization window is captured and compared with an existing test image. If there are differences in the images then there is an error, if not the test passes. The test cases are themselves relatively simple and the magic of the actual generation of test images etc. is all in the `tests/common.py` module.

To run a test you may do something like the following:

```
$ cd tests
$ python test_array_source.py
```

Getting help

Most of the user and developer discussion for mayavi2 occurs on the Enthought OSS developers mailing list (enthought-dev@mail.enthought.com). This list is also available via gmane from here: http://dir.gmane.org/gmane.comp.python.enthought.devel

Discussion and bug reports are also sometimes sent to the mayavi-users mailing list (MayaVi-users@lists.sourceforge.net). We recommend sending messages to the enthought-dev list though.

The MayaVi web page: https://svn.enthought.com/enthought/wiki/MayaVi
is a trac page where one can also enter bug reports and feature requests.

If this manual, the mayavi web page and google are of no help feel free to post on the enthought-dev mailing list for help.

Helping out

We are always on the lookout for people to help this project grow. Feel free to send us patches -- these are best sent to the mailing list. Depending on your contributions we might grant you SVN checkin privileges. Thanks!