Chaco Documentation

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CONTENTS

Chaco is a Python package for building interactive and custom 2-D plots and visualizations. Chaco facilitates writing plotting applications at all levels of complexity, from simple scripts with hard-coded data to large plotting programs with complex data interrelationships and a multitude of interactive tools. While Chaco generates attractive static plots for publication and presentation, it also works well for interactive data visualization and exploration. Chaco is part of the Enthought Tool Suite.

Chaco includes renderers for many popular plot types, built-in implementations of common interactions with those plots, and a framework for extending and customizing plots and interactions. Chaco can also render graphics in a non-interactive fashion to images, in either raster or vector formats, and it has a subpackage for doing command-line plotting or simple scripting.

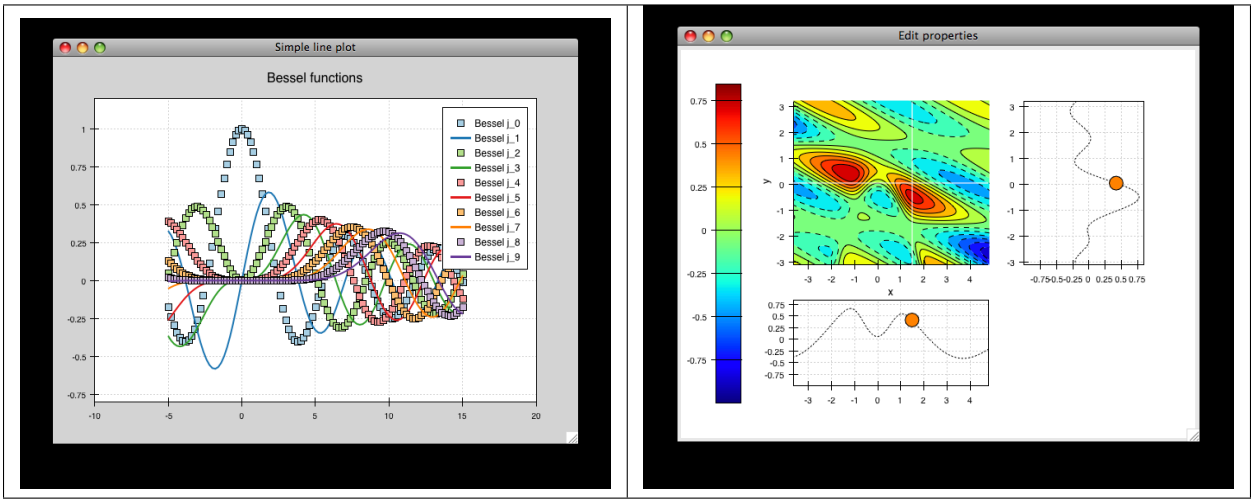
For a quick sample of Chaco's features, see the gallery, the *annotated examples* page, the *tutorial and examples* and the *resources* page.

CHAPTER

ONE

DOCUMENTATION

1.1 Quickstart



This section is meant to help users on well-supported platforms and common Python environments get started using Chaco as quickly as possible. Chaco users can subscribe to the enthought-dev mailing list to post questions, consult archives, and share tips.

1.1.1 Installation

There are several ways to get Chaco. The easiest way is through the Enthought Python Distribution (EPD), which is available for several platforms and also provides many other useful packages. Chaco may also be available through a package manager on your platform, such as apt on Ubuntu or MacPorts on OS X. You can also build Chaco yourself, but because of the number of packages required, we highly recommend you install EPD.

Dependencies

- Python 2.5 or later
- Traits, an event notification framework
- Kiva, part of the enable project, for rendering 2-D graphics to a variety of backends across platforms
- Enable, a framework for writing interactive visual components, and for abstracting away GUI-toolkit-specific details of mouse and keyboard handling

- NumPy, for dealing efficiently with large datasets
- Either wxPython or PyQt to display interactive plots. As an alternative to PyQt, Chaco is being tested more and more with the PySide toolkit (LGPL license).

Installing Chaco with EPD

Chaco, the rest of the Enthought Tool Suite, and a lot more are bundled with EPD. Getting EPD allows you to install Chaco and all its dependencies at once; however, these packages will be linked to a new instance of Python. The EPD Free distribution is free for all users and contains all that you need to use Chaco.

To get EPD, go to the EPD download page and get the appropriate version for your platform. After running the installer, you will have a working version of Chaco and several examples.

Building Chaco

Building Chaco on your machine requires you to build Chaco and each of its dependencies, but it has the advantage of installing Chaco on top of the Python instance you already have installed. The build process may be challenging and will require you to have SWIG, Cython and several development libraries installed.

To do this, you can either

1. Install Chaco and its *Dependencies* from PyPI using easy_install (part of setuptools) or using pip. For example

   easy_install chaco

   or

   pip install chaco

2. Or, download the source from the Chaco GitHub repository or alternatively as a part of ETS.

1.1.2 Built-in Examples

Chaco ships with several examples for testing your installation and to show you what Chaco can do. Almost all of the examples are stand-alone files that you can run individually, from any location. Depending on how you installed Chaco, you may or may not have the examples already.

Location

1. If you installed Chaco as part of EPD, the location of the examples depends on your platform:
   - On Windows, they are in the Examples\ subdirectory of your installation location. This is typically `C:\Python27\Examples\Chaco-<version>`. On MS Windows these examples can be browsed from the start menu, by clicking *Start* → *Applications* → *Enthought* → *Examples*.
   - On Linux, they are in the `Examples/Chaco-<version>` subdirectory of your installation location.
   - On Mac OS X, they are in the `/Applications/Enthought/Examples/chaco-<version>` directory.
2. If you downloaded and installed Chaco from source (from GitHub or via the PyPI tar.gz file), the examples are located in the `examples/` subdirectory inside the root of the Chaco source tree, next to `docs/` and the `enthought/` directories.
3. If you don't know how Chaco was installed, you can download the latest versions of examples individually from github:

https://github.com/enthought/chaco/tree/master/examples

For ETS 3.0 or Chaco 3.0, you can check out the examples with Subversion:

svn co https://svn.enthought.com/svn/enthought/Chaco/tags/3.0.0/examples

For ETS 2.8 or Chaco 2.0.x:

svn co https://svn.enthought.com/svn/enthought/Chaco/tags/enthought.chaco2_2.0.5/examples

Chaco examples can be found in the `examples/demo/` and `examples/tutorials/` directories. Some are classified by themes and located in separate directories. Almost all of the Chaco examples are standalone files that can be run individually. We will first show how to execute them from the command line, and then we will show how to run Chaco in an interactive way from IPython. This "shell" mode will be more familiar to Matplotlib or Matlab users.

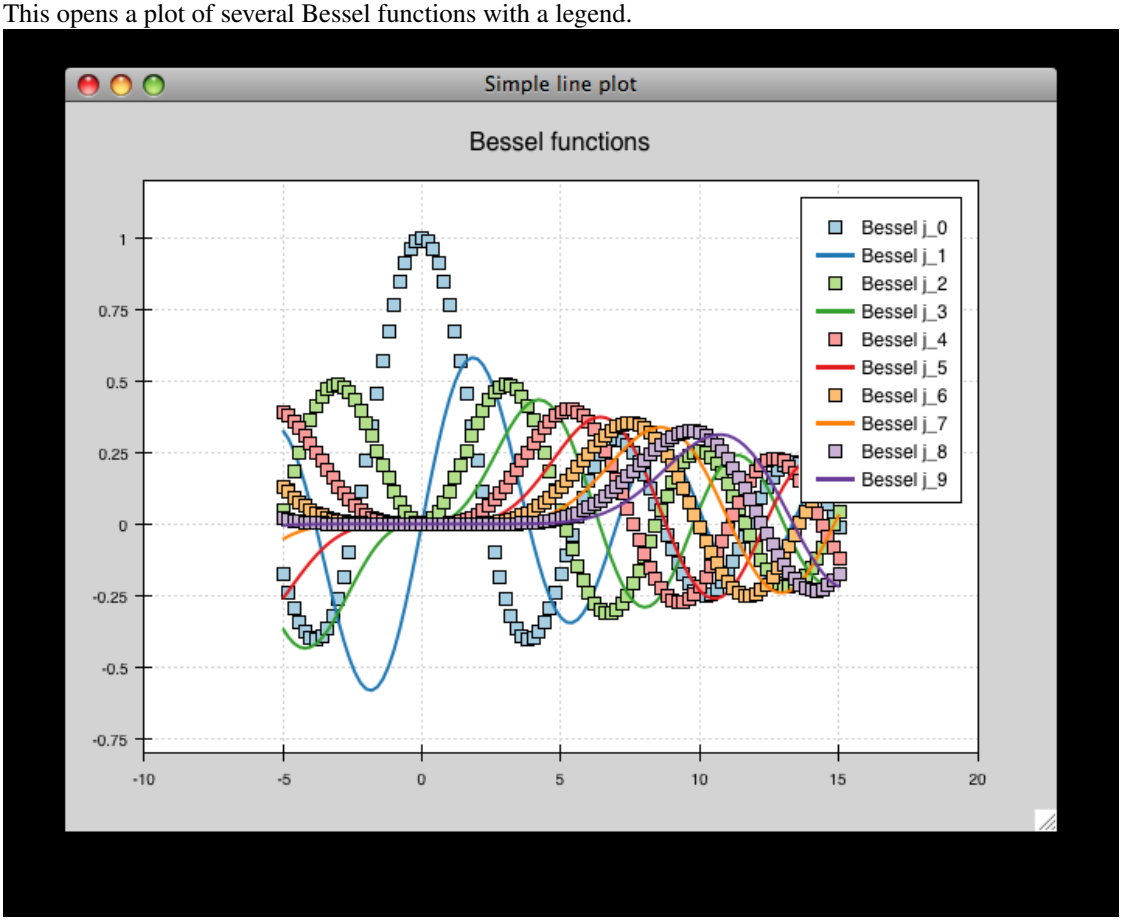
Note: Some of these examples can be visualized in our Chaco gallery.

First plots from the command line

From the `examples/demo` directory, run the `simple_line` example:

python simple_line.py

This opens a plot of several Bessel functions with a legend.



You can interact with the plot in several ways: .. Ctrl-Left and Ctrl-Right don't work in OS X?

- To pan the plot, hold down the left mouse button inside the plot area (but not on the legend) and drag the mouse.
- To zoom the plot:
  - Mouse wheel: scroll up to zoom in, and scroll down to zoom out (or the reverse you're on a version of OS X with 'natural scrolling').
  - Zoom box: Press `z`, and then draw a box region to zoom in on. (There is no box-based zoom out.) Press `Ctrl-Left` and `Ctrl-Right` to go back and forward in your zoom box history.
  - Drag: hold down the right mouse button and drag the mouse up or down. Up zooms in, and down zooms out.
  - For any of the above, press `Escape` to reset the zoom to the original view.
- To move the legend, hold down the right mouse button inside the legend and drag it around. Note that you can move the legend outside of the plot area.
- To exit the plot, click the "close window" button on the window frame or (on Mac) choose the Quit option on the Python menu. Alternatively, can you press `Ctrl-C` in the terminal.

You can run most of the examples in the the `examples/demo/basic/` directory and the `examples/demo/shell/` directory. The `examples/demo/advanced/` directory has some examples that require additional data or packages. In particular,

- `spectrum.py` requires that you have PyAudio installed and a working microphone.
- `data_cube.py` needs to download about 7.3mb of data from the Internet the first time it is executed, so you must have a working Internet connection. Once the data is downloaded, you can save it so you can run the example offline in the future.

For detailed information about each built-in example, see the *Annotated Examples* section.

First plots from IPython

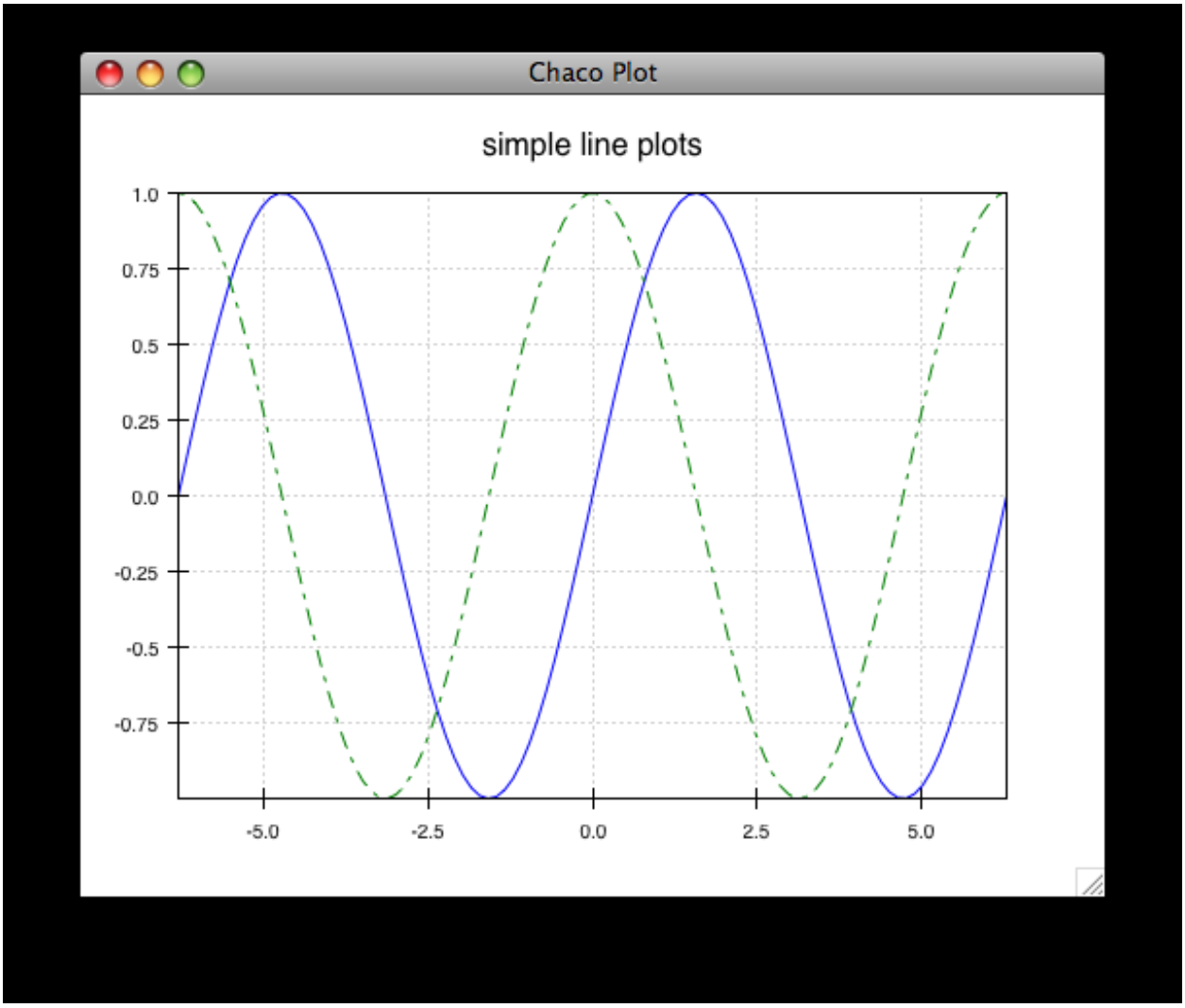
While all of the Chaco examples can be launched from the command line using the standard Python interpreter, if you have IPython installed, you can poke around them in a more interactive fashion.

Chaco provides a subpackage, currently named the "Chaco Shell", for doing command-line plotting like Matlab or Matplotlib. The examples in the `examples/demo/shell/` directory use this subpackage, and they are particularly amenable to exploration with IPython.

The first example we'll look at is the `lines.py` example. First, we'll run it using the standard Python interpreter:

python lines.py

This shows two overlapping line plots.



You can interact with this plot just as in the previous section.

Now exit the plot, and start IPython with the `--gui=wx` option [1]:

ipython –gui=wx

This tells IPython to start a wxPython mainloop in a background thread. Now run the previous example again:

```
In [1]: run lines.py
```

This displays the plot window, but gives you another IPython prompt. You can now use various commands from the `chaco.shell` package to interact with the plot.

Import the shell commands:

```
In [2]: from chaco.shell import *
```

Set the X-axis title:

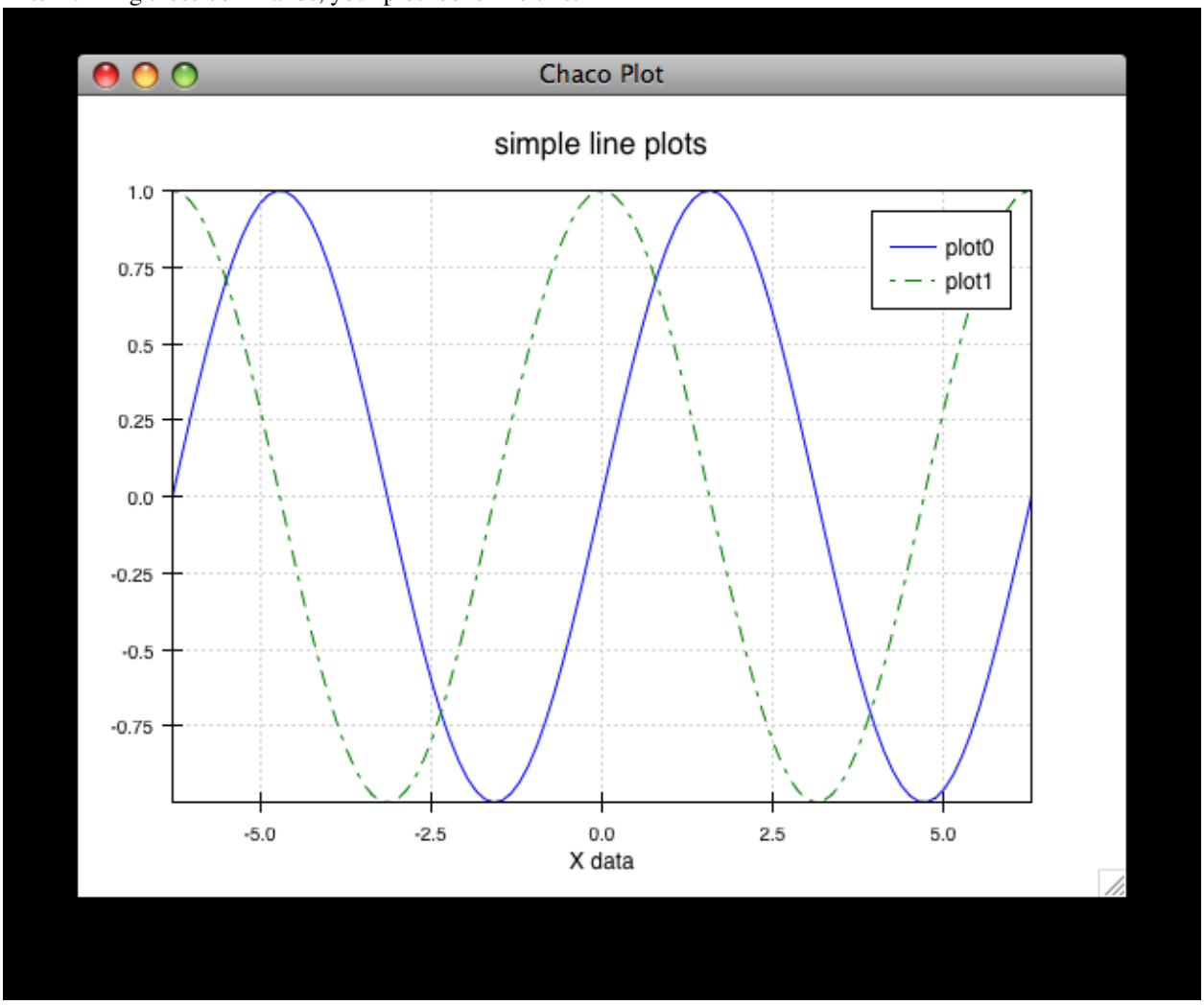
```
In [3]: xtitle("X data")
```

Toggle the legend:

[1] Starting from IPython 0.12, it is possible to use the Qt backend with `--gui=qt`. Make sure that the environment variable `QT_API` is set correctly, as described here

```
In [4]: legend()
```

After running these commands, your plot looks like this:



The `chaco_commands()` function display a list of commands with brief descriptions.

You can explore the Chaco object hierarchy, as well. The `chaco.shell` commands are just convenience functions that wrap a rich object hierarchy that comprise the actual plot. See the *tutorial_ipython* section for information on all you can do with Chaco from within IPython.

1.1.3 Chaco plot embedded in a Traits application

Let's create, from scratch, the simplest possible Chaco plot (embedded inside a Traits application).

First, some imports to bring in necessary components:

```
from chaco.api import ArrayPlotData, Plot
from enable.component_editor import ComponentEditor

from traits.api import HasTraits, Instance
from traitsui.api import View, Item
```

The imports from `chaco` and `enable` support the creation of the plot. The imports from `traits` bring in components to embed the plot inside a Traits application. (Refer to the Traits documentation for more details about building an interactive application using Traits.) Now let's create a Traits class with a view that contains only one element: a Chaco plot inside a slightly customized window:

```
class MyPlot(HasTraits):
    plot = Instance(Plot)
    traits_view = View(Item('plot', editor = ComponentEditor(), show_label = False),
                       width = 500, height = 500,
                       resizable = True, title = "My line plot")
```

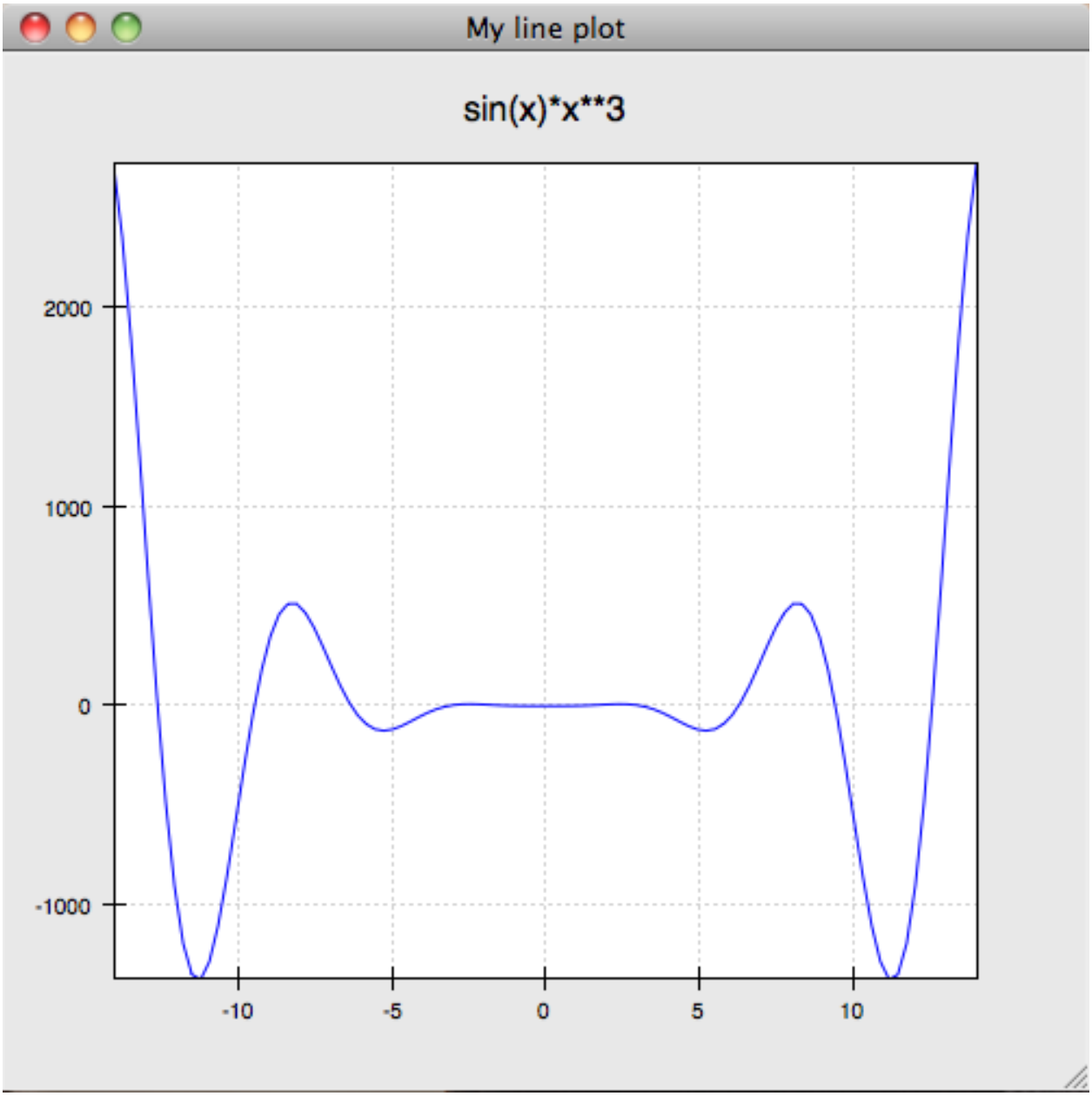
A few options have been set to control the window containing the plot. Now, when the plot is created, we would like to pass in our data. Let's assume the data is a set of points with coordinates contained in two NumPy arrays `x` and *y*. So, adding an `__init__` method to create the Plot object looks as follows:

```
class MyPlot(HasTraits):
    plot = Instance(Plot)
    traits_view = View(Item('plot', editor = ComponentEditor(), show_label = False),
                       width = 500, height = 500,
                       resizable = True, title = "My line plot")

    def __init__(self, x, y, *args, **kw):
        super(MyPlot, self).__init__(*args, **kw)
        plotdata = ArrayPlotData(x=x,y=y)
        plot = Plot(plotdata)
        plot.plot(("x","y"), type = "line", color = "blue")
        plot.title = "sin(x)*x**3"
        self.plot = plot
```

Since it inherits from HasTraits, the new class can use all the power of Traits, and the call to super() in its `__init__` method makes sure this object possesses the attributes and methods of its parent class. Now let's use our Traits object. Below, we generate some data, pass it to an instance of MyPlot and call configure_traits to create the UI:

```
import numpy as np
x = np.linspace(-14,14,100)
y = np.sin(x)*x**3
lineplot = MyPlot(x,y)
lineplot.configure_traits()
```

The result should look like



This might look like a lot of code to visualize a function, but this is a relatively simple basis on top of which we can build full-featured applications with custom UIs and custom tools. For example, the Traits object allows you to create controls for your plot at a very high level, add these controls to the UI with very little work, and add listeners to update the plot when the data changes. Chaco also allows you to create tools to interact with the plot and overlays that make these tools intuitive and visually appealing.

1.1.4 License

As part of the Enthought Tool Suite, Chaco is free and open source under the BSD license.

1.2 Tutorials, webinars, and examples

1.2.1 Tutorials

- *Tutorial: Interactive plotting with Chaco*

  This is the main Chaco tutorial and introduces the basic concepts of how to use Chaco and Traits UI to do basic plots, customize layout, and add interactivity.

- *Tutorial: Using Chaco from IPython*

  This tutorial explains how to use Chaco from IPython using the Chaco `shell` command-line plotting interface to build plots, in a Matlab or gnuplot-like style.

1.2.2 Webinars

- Step-by-step Chaco - 2D plotting with Python

  Webinar recorded on, July 17, 2009, available as Windows Media Player (.wmv) video, Matroska (.mkv) video, and as a slideshare slide show.

- EPDLab & Chaco

  Webinar recorded on, June 19, 2009, available as Windows Media Player (.wmv) video, Matroska (.mkv) video, and as a slideshare slide show.

1.2.3 Examples

- The *annotated examples* is a useful visual resource presenting a set of Chaco plots together with their source code.
- *Modeling Van del Waal's Equations* is a complete example of creating a data model and then using Traits and Chaco to rapidly create interactive plot GUIs.
- *Creating an interactive Hyetograph* is an example of a hyetograph (a plot of rainfall intensity in relation to time) application. This example introduces the `on_trait_listener` decorator and uses Chaco, simple Traits views, and live GUI interaction.

1.3 User guide

1.3.1 Introduction

What is Chaco?

Chaco is a 2D plotting library that is part of and integrates with the Enthought Tools Suite.

The strong points of Chaco are

1. it can be *embedded* in any wx, Qt, or TraitsUI application
2. it is designed for building interactive plotting applications, rather than static 2D plots
3. Chaco classes can be easily extended to create new plot types, interactive tools, and plot containers

At the lowest level, Chaco is a hierarchy of classes that defines 2D plotting elements: plots, containers, interactive tools, color bars, etc. In principle, applications can create instances of these elements and lay them out in a container to define components that can be *embedded in one of several of graphical back ends*. Working at this level allows the maximum flexibility, but requires understanding *Chaco's basic elements*.

Chaco defines two abstraction layers that allow a more high-level (albeit less flexible) plotting experience. First, Chaco contains a `Plot` class that defines several methods that create a complete plot given one or more data sets. In other words, `Plot` knows how to package data for the most common kinds of plots. Second, Chaco has a `shell` module that defines high-level plotting functions. This module allows using Chaco as an interactive plotting tool that will be familiar to users of matplotlib.

Basic elements

To venture deeper in Chaco's architecture it is useful to understand a few basic ideas on which Chaco is based:

- **Plots are compositions of visual components**

  Each plot is composed by a number of graphical widgets: the plot graphics, axes, labels, legend, colorbar, etc. Everything you see in a plot is an individual component with position, shape, and appearance attributes, and with an opportunity to respond to events.

- **Data and screen space are separated**

  Although everything in a plot eventually ends up rendering into a common visual area, there are aspects of the plot which are intrinsically screen-space, and some which are fundamentally data-space. For example, data about the height of college students lives in data space (meters), but needs to be rendered in screen space (pixels). Chaco uses the concept of *mapper* to translate one into the other. Preserving the distinction between these two domains allows us to think about visualizations in a structured way.

- **Layers**

  Plot components are split into several layers, which are usually plotted in sequence. For example, axes and labels are usually plotted on the "underlay" layer, plot data on the "plot" layer, and legends and other plot annotations on the "overlay" layer. In this way one can define interactive tools that add graphical elements to a plot without having to modify the drawing logic.

These pages describe in detail the basic building blocks of Chaco plots, and the classes that implement them:

Data sources

A data source is a wrapper object for the actual data that the plot will be handling. For the most part, a data source looks like an array of values, with an optional mask and metadata.

The *data source interface* provides methods for retrieving data, estimating a size of the dataset, indications about the dimensionality of the data, a place for metadata (such as selections and annotations), and events that fire when the data gets changed.

There are two primary reasons for a data source class:

- It provides a way for different plotting objects to reference the same data.
- It defines the interface to expose data from existing applications to Chaco.

In most cases, the standard `ArrayDataSource` will suffice.

Interface The basic interface for data sources is defined in `AbstractDataSource`. Here is a summary of the most important attributes and methods (see the docstrings of this class for more details):

`value_dimension`

The dimensionality of the data value at each point. It is defined as a `DimensionTrait`, i.e., one of "scalar", "point", "image", or "cube". For example, a `GridDataSource` represents data in a 2D array and thus its `value_dimension` is "scalar".

`index_dimension`

The dimensionality of the data value at each point. It is defined as a `DimensionTrait`, i.e., one of "scalar", "point", "image", or "cube". For example, a `GridDataSource` represents data in a 2D array and thus its `index_dimension` is "image".

`metadata`

A dictionary that maps strings to arbitrary data. Usually, the mapped data is a set of indices, as in the case of selections and annotations. By default, `metadata` contains the keys *"selections"* (representing indices that are currently selected by some tool) and *"annotations"*, both initialized to an empty list.

`persist_data`

If True (default), the data that this data source refers to is serialized when the data source is.

`get_data()`

Returns a data array containing the data referred to by the data source. Treat the returned array as read-only.

`is_masked()`

Returns True if this data source's data uses a mask. In this case, to retrieve the data, call `get_data_mask()` instead of `get_data()`.

`get_data_mask()`

Returns the full, raw, source data array and a corresponding binary mask array. Treat both arrays as read-only.

`get_size()`

Returns the size of the data.

`get_bounds()`

Returns a tuple (min, max) of the bounding values for the data source. In the case of 2-D data, min and max are 2-D points that represent the bounding corners of a rectangle enclosing the data set. If data is the empty set, then the min and max vals are 0.0.

Events `AbstractDataSource` defines three events that can be used in Traits applications to react to changes in the data source:

`data_changed`

Fired when the data values change.

Note: The majority of concrete data sources do not fire this event when the data values change. Rather, the event is usually fired when new data or a new mask is assigned through setter methods (see notes below).

`bounds_changed`

Fired when the data bounds change.

`metadata_changed`

Fired when the content of `metadata` changes (both the `metadata` dictionary object or any of its items).

List of Chaco data sources This is a list of all concrete implementations of data sources in Chaco:

`ArrayDataSource`

A data source representing a single, continuous array of numerical data. This is the most common data source for Chaco plots.

This subclass adds the following attributes and methods to the basic interface:

`sort_order`

The sort order of the data, one of 'ascending', 'descending', or 'none'. If the underlying data is sorted, and this attribute is set appropriately, Chaco is able to use shortcuts and optimizations in many places.

`reverse_map(pt)`

Returns the index of *pt* in the data source (optimized if `sort_order` is set).

Note: This class does not listen to the array for changes in the data values. The `data_changed` event is fired only when the data or the mask are set with the methods `set_data()`, `set_mask()`, or `remove_mask()`.

`ImageData`

Represents a 2D grid of image data.

The underlying data array is 3D, where the third dimension is either 1 (one scalar value at each point of the grid), 3 (one RGB vector at each point), or 4 (one RGBa vector at each point). The depth of the array is defined in the attribute `value_depth`.

Access to the image data is controlled by three properties: The boolean attribute `transposed` defines whether the data array stored by this class is to be interpreted as transposed; `raw_value` returns the underlying data array as-is, ignoring `transposed`; `value` returns the data array or its transposed depending on the value of `transposed`.

The correct usage pattern of these attributes is to give to the class contiguous image data, and assign `transposed` if the two axis should be swapped. Functions that would benefit from working on contiguous data can then use `raw_value` directly. (See the class docstrings for more details, and some caveats.)

Noteworthy methods of this class are:

`fromfile(filename)`

Factory method that creates an `ImageData` instance from an image file. *filename* can be either a file path or a file object.

`get_width()`, `get_height()`

Return the width or the height of the image (takes the value of `transposed` into account).

`get_array_bounds()`

Return ((0, width), (0, height)).

Note: This class does not implement the methods related to masking, and it does not fire `bounds_changed` events.

Note: This class does not listen to the array for changes in the data values. The `data_changed` event is fired only when the data are set with the method `set_data()`.

`GridDataSource`

Data source representing the coordinates of a 2D grid. It is used, for example, as a source for the index data in an `ImagePlot`.

It defines these attributes:

`sort_order`

Similar to the `sort_order` attribute for the `ArrayDataSource` class above, but this is a tuple with two elements, one per dimension.

Note: This class does not implement the methods related to masking, and it does not fire `bounds_changed` events.

Note: This class does not listen to the array for changes in the data values. The `data_changed` event is fired only when the data is set with the method `set_data()`.

`MultiArrayDataSource`

A data source representing a single, continuous array of multidimensional numerical data.

It is useful, for example, to define 2D vector data at each point of a scatter plot (as in `QuiverPlot`), or to represent multiple values for each index (as in `MultiLinePlot`).

As `ArrayDataSource`, this data source defines a `sort_order` attribute for its index dimension.

Warning: In `MultiArrayDataSource`, the `index_dimension` and `value_dimension` attributes are integers that define which dimension of the data array correspond to indices and which to values (default is 0 and 1, respectively). This is different from the same attributes in the interface, which are strings describing the *dimensionality* of index and value.

Note: This class does not listen to the array for changes in the data values. The `data_changed` event is fired only when the data or the mask are set with the method `set_data()`.

`PointDataSource`

A data source representing a set of (X,Y) points.

This is a subclass of `ArrayDataSource`, and inherits its methods and attributes. The attribute `sort_index` defines whether the data is sorted along the X's or the Y's (as specified in `sort_order`).

Note: This class does not listen to the array for changes in the data values. The `data_changed` event is fired only when the data or the mask are set with the method `set_data()`.

`FunctionDataSource`

A subclass of `ArrayDataSource` that sets the values of the underlying data array based on a function (defined in the callable attribute `func`) evaluated on a 1D data range (defined in `data_range`).

`FunctionImageData`

A subclass of `ImageData` that sets the values of the underlying data array based on a 2D function (defined in the callable attribute `func`) evaluated on a 2D data range (defined in `data_range`).

Data ranges

A data range expresses bounds on *data space* of some dimensionality. For example, the simplest data range is just a set of two scalars representing (low, high) bounds in 1-D. Data ranges are commonly used in plots to determine the range of plot axes.

Data ranges are typically associated to a data source, with their bounds set to `auto`, which means that they automatically scale to fit the data source bounds. Each data source can be associated with multiple ranges, and each data range can be associated with multiple data sources.

Interface The basic interface for data sources is defined in `AbstractDataRange` and `BaseDataRange`.

This is a summary of the most important attributes and methods (see the docstrings of this class for more details):

Attributes

`sources`

A list of data sources associated to the data range. Concrete implementations of data range listen to the event `data_changed` and refresh their bounds as appropriate (e.g., when the bounds are set to `auto`).

`low`

The actual value of the lower bounds of the range. The correct way to set it is to use the `low_setting` attribute.

`high`

The actual value of the upper bounds of the range. The correct way to set it is to use the `high_setting` attribute.

`low_setting`

Setting for the lower bound of the range. This can either be a valid lower bound value, or `auto` (default), in which case the lower bound is set automatically from the associated data sources.

`high_setting`

Setting for the upper bound of the range. This can either be a valid upper bound value, or `auto` (default), in which case the upper bound is set automatically from the associated data sources.

Methods

`add(*datasources)`

Convenience method to associate one or more data sources to the range. The method avoids adding the same data source twice.

`remove(*datasources)`

Convenience method to remove one or more data sources from the range. If one of the data sources is not associated with the range, it is ignored.

`clip_data(data)`

Given an array of data values of the same dimensionality as the range, return a list of data values that are inside the range.

`mask_data(data)`

Given an array of data values of the same dimensionality as the range, this method returns a mask array of the same length as data, filled with 1s and 0s corresponding to whether the data value at that index is inside or outside the range.

`bound_data(data)`

Given an array of *monotonic* data values of the same dimensionality as the range, returns a tuple of indices (start, end) corresponding to the first and last elements that fall within the range.

Events The basic data range interface defines a single event, `updated`, which is fired when the bound values change. The value of the event is a tuple `(low_bound, high_bound)`.

List of Chaco data ranges There are two data range implementations in Chaco, one for 1D and one for 2D ranges:

`DataRange1D`

`DataRange1D` represents a 1D data range. This subclass adds several more ways to control the bound of the range given the associated data sources.

First of all, a new parameter, `tight_bounds`, controls whether the bounds should fit exactly the range of the associated data sources (the default is True). If it is False, the range adds some padding on either side of the data, controlled by `margin`, which is expressed as a precentage of the full data width.

Second, `DataRange1D` defines a new setting, `track` for `low_setting` and `high_setting`. When one of the bounds is set to `track`, it follows the other bound by the amount set in `tracking_amount`.

Third, bounds can be computed using a user-supplied function specified in `bounds_func`. The function takes the arguments `(data_low, data_high, margin, tight_bounds)`, where `data_low` and `data_high` are the bounds computed *after* taking into account the `auto` or `track` settings, and `margin` and `tight_bounds` are defined as above.

The logic of computing the bounds is implemented in the function `calc_bounds()` in `chaco.data_range_1d`.

`DataRange2D`

`DataRange2D` represents a 2D data range. Under the hood, it is implemented using two `DataRange1D` objects, one for each dimension, which are stored in the `x_range` and `y_range` attributes. These can be accessed directly if one wants to use the full flexibility of the `DataRange1D` class.

The data range bounds, `low` and `high`, return 2-elements tuples containing the bounds for for the two dimensions.

Mappers

Mappers perform the job of mapping a data space region to screen space, and vice versa. They are used by plots to transform their data sources to pixel coordinates on the screen. While most of the time this is a relatively simple rescaling operation, mapper can also be used for non-linear transformations, most notably to map a data source to logarithmic coordinates on screen.

Interface The general interface for mappers is defined in `AbstractMapper` and defines only a few methods:

`map_screen(data_value)`, `map_data(screen_value)`

Maps a vector of data coordinates to screen coordinates, and vice versa.

`map_data_array(screen_value_array)`

Maps an array of points in data coordinates to screen coordinates. By default, this method just loops over the points, calling `map_data()` on each one. For vectorizable mapping functions, this implementation is overridden with a faster one.

Mappers for 1D data have a slightly larger interface, defined in `Base1DMapper`. These mappers rely on a `DataRange1D` object to find the bounds on the data domain.

`range`

A `DataRange1D` instance to define the data-space bounds of the mapper. The mapper listens to the `updated` event of the range and re-fires it as its own `updated` event (see below).

`low_pos`, `high_pos`, `screen_bounds`,

The screen space position of the lower/upper bound of the data space. `screen_bounds` is a convenience property to set/get the screen bounds with a single attribute.

`stretch_data`

When the screen bounds change (in response, for instance, to the window resizing) one could either fit more data space on the screen, or stretch the data space to the new bounds. If `stretch_data` is True (default), the data is stretched; if it is False, the mapper preserves the screen-to-data ratio.

Events The `AbstractMapper` interface defines a single generic event, `updated`, which is fired when the bound values change.

For subclasses of `Base1DMapper`, the `updated` event is also fired in response to an `updated` event fired by the underlying data range. The value of the new event is the tuple `(low_bound, high_bound)` contained in the triggering event.

List of Chaco data mappers `LinearMapper` (subclass of `Base1DMapper`)

This mapper transforms a 1D data space range linearly to a fixed 1D range in screen space.

`LogMapper` (subclass of `Base1DMapper`)

Maps a 1D data space range to a 1D range in screen space through a logarithmic transform. Data values smaller than or equal to 0.0 are substituted by `fill_value` (default is 1.0) before the logarithmic transformation.

`GridMapper`

Same as `LinearMapper` for 2D ranges. This class replaces the `Base1DMapper` attributes with analogous ones:

`range`

A `DataRange2D` instance to define the data-space bounds of the mapper.

`x_low_pos`, `y_low_pos`, `x_high_pos`, `y_high_pos`

Screen space positions for the lower and upper bounds of the x and y axes.

`screen_bounds`

Convenience property to set/get the screen bounds with a single attribute. The value of this attribute is a 4-element tuple `(x_low_pos, x_high_pos, y_low_pos, y_high_pos)`.

`GridMapper` uses two `Base1DMapper` instances to define mappers for the two axes (accessible from the two private attributes `_xmapper` and `_ymapper`). It thus possible to set them to be linear or logarithmic mappers. This is best made using the class constructor, which has this signature:

```
GridMapper(x_type="linear", y_type="linear", range=None,
**kwargs)
```

`x_type` and `y_type` can be either 'linear' or 'log', which will create a corresponding `LinearMapper` or `LogMapper` classes.

`PolarMapper`

This class should map data polar coordinates to screen cartesian coordinates, to use for example with a `PolarLineRenderer`, but at the moment it is a copy of `LinearMapper`.

Warning: The implementation of this mapper is under construction.

Plot renderers

Plot renderers are the classes that actually draw the different kinds of plots, or plot-like elements as for instance color bars.

This section describes the concepts that are common to all kind of plots. A separate page contains an exhaustive *list of all plot types* defined in Chaco.

Common interface The base interface is defined in the abstract class `AbstractPlotRenderer`, and provides attributes and methods to set size, position, and aspect of the plotting area.

Two more specialized interface are used by most concrete implementations, namely `BaseXYPlot`, which is the interface for *X-vs-Y plots*, and `Base2DPlot`, which is the interface for *2D plots* (e.g., *image plots* or *contour plots*).

The base interface inherits from a deep hierarchy of classes generating from the `enable` package, starting with `enable.coordinate_box.CoordinateBox` (representing a box in screen space) and `enable.interactor.Interactor` (which allows plot components to react to mouse and keyboard events), and down through `enable.component.Component` and `chaco.plot_component.PlotComponent` (follow *this link for a description of the relationship between Chaco and enable*). The class were most of the functionality is defined is `enable.component.Component`.

Here we give a summary of all the important properties exposed in `AbstractPlotRenderer`, without worrying too much about their origin in the hierarchy. Also, to avoid unnecessary cluttering of the page, attributes and methods that are of secondary importance are not listed. Please refer to the API documentation for more details.

Box properties All plot renderers are `enable` graphical components, and thus correspond to a rectangular area in screen space. The renderer keeps track of two areas: an inner box that only contains the plot, and an outer box that includes the padding and border area. The properties of the boxes are controlled by these attributes:

`position`

Position of the internal box relative to its container, given as a list [x,y]. If there is no container, this is set to [0, 0]. "Absolute" coordinates of point (i.e., relative to top-level parent `Window` object) can be obtained using `get_absolute_coords(*coords)`.

`x`, `y`, `x2`, `y2`

Coordinates of the lower-left (x,y) and upper-right (x2,y2) pixel of the internal box, relative to its container.

`bounds`, `width`, `height`

Bounds of the internal box, in pixels. `bounds` is a list [width, height].

`outer_position`, `outer_x`, `outer_y`, `outer_x2`, `outer_y2`, `outer_bounds`, `outer_width`, `outer_height`, `set_outer_position(index, value)`, `set_outer_bounds(index, value)`

Attributes for the outer box equivalent to those defined above for the inner box. Modifying the outer position attributes is the right way to move the plot without changing its padding or bounds. Similarly, modifying the outer bounds attributes leaves the lower-left position and the padding unchanged.

`resizable`, `fixed_preferred_size`

String that defines in which dimensions the component is resizable. One of '' (not resizable), 'v' (resizable vertically), 'h' (resizable horizontally), 'hv' (resizable in both directions, default). If the component is resizable, `fixed_preferred_size` can be used to specify the amount of space that the component would like to get in each dimension, as a tuple (width, height). In this case, width and height have to be understood as relative sized: if one component in a container specifies, say, a fixed preferred width of 50 and another one specifies a fixed preferred width of 100, then the latter component will always be twice as wide as the former.

`aspect_ratio`, `auto_center`

Ratio of the component's width to its height. This is used to maintain a fixed ratio between bounds when thet are changed independently, for example when resizing the window. `auto_center` specifies if the component should center itself in any space that is left empty (default is True).

`padding_left`, `padding_right`, `padding_top`, `padding_bottom`, `padding`, `hpadding`, `vpadding`

Padding space (in pixels). `padding` is a convenience property that returns a tuple of (left, right, top, bottom) padding. It can also be set to a single integer, in which case all four padding attributes are set to the same value.

`hpadding` and `vpadding` are read-only properties that return the total amount of horizontal and vertical padding (including the border width if the border is visible).

`get_absolute_coords(*coords)`

Transform coordinates relative to this component's origin to "absolute" coordinates, relative to top-level container.

Aspect properties These attributes control the aspect (e.g. color) of padding, background, and borders:

`bgcolor`

The background color of this component (default is white). This can be set to "transparent" or "none" if the component should be see-through. The color can be specified as a string or as an RGB or RGBa tuple.

`fill_padding`

If True (default), fill the padding area with the background color.

`border_visible`

Determines if the border is visible (default is False).

`border_width`

Thickness of the border around the component in pixels (default is 1).

`border_dash`

Style of the lines tracing the border. One of 'solid' (default), 'dot dash', 'dash', 'dot', or 'long dash'.

`border_color`

Color of the border. The color can be specified as a string or as an RGB or RGBa tuple.

Layers Each plot is rendered in a sequence of layers so that different components can plot at different times. For example, a line plot is drawn *before* its legend, but *after* the axes and background grid.

The default drawing order is defined in `draw_order` as a list of the names of the layers. The definition of the layers is as follows:

1. 'background': Background image, shading, and borders
2. 'image': A special layer for plots that render as images. This is in a separate layer since these plots must all render before non-image plots
3. 'underlay': Axes and grids
4. 'plot': The main plot area itself
5. 'annotation': Lines and text that are conceptually part of the "plot" but need to be rendered on top of everything else in the plot.
6. 'selection': Selected content are rendered above normal plot elements to make them stand out. This can be disabled by setting `use_selection` to False (default).
7. 'border': Plot borders
8. 'annotation': Lines and text that are conceptually part of the "plot" but need to be rendered on top of everything else in the plot
9. 'overlay': Legends, selection regions, and other tool-drawn visual elements

Concrete plot renderers set their default draw layer in `draw_layer` (default is 'plot'). Note that if this component is placed in a container, in most cases the container's draw order is used, since the container calls each of its contained components for each rendering pass.

One can add new elements to a plot by appending them to the `underlays` or `overlays` lists. Components in these lists are drawn underneath/above the plots as part of the 'underlay'/'overlay' layers. They also receive mouse and keyboard events.

Interaction Plot renderers also inherit from `enable.interactor.Interactor`, and as such are able to react to keyboard and mouse events. However, interactions are usually defined as tools and overlays. Therefore, this part of the interface is described at those pages.

TODO: add reference to interaction interface

Context Since plot renderers take care of displaying graphics, they keep references to the larger graphical context:

`container`

Reference to a container object (None if no container is defined). The renderer defines its position relative to this.

`window`

Reference to the top-level enable Window.

`viewports`

List of viewport that are viewing this component

Others

`use_backbuffer`

If True, the plot renders itself to an offscreen buffer that is cached for later use. If False (default), then the component will *never* render itself back-buffered, even if asked to do so.

`invalidate_and_redraw()`

Convenience method to invalidate our contents and request redraw. This method is sometimes useful when modifying a Chaco plot in an ipython shell.

X-Y Plots interface The class `chaco.base_xy_plot.BaseXYPlot` defines a more concrete interface for X-vs-Y plots. First of all, it handles data sources and data mappers to convert real data into screen coordinates. Second, it defines shortcuts for plot axes, labels and background grids.

Data-related traits X-Y plots need two sources of data for the X and Y coordinates, and two mappers to map the data coordinates to screen space. The data sources are stored in the attributes `index` and `value`, and the corresponding mappers in `index_mapper` and `value_mapper`.

'Index' and 'value' correspond to either the horizontal 'X' coordinates or the vertical 'Y' coordinates depending on the orientation of the plot: for `orientation` equal to 'h' (for horizontal, default), indices are on the X-axis, and values on the Y-axis. The opposite is true when `orientation` is 'v'. The convenience properties `x_mapper` and `y_mapper` allow accessing the mappers for the two axes in an orientation-independent way.

Finally, the properties `index_range` and `value_range` give direct access to the data ranges stored in the index and value mappers.

Axis, labels, and grids `BaseXYPlot` defines a few properties that are shortcuts to find axis and grid objects in the *underlays and overlays layers* of the plot:

`hgrid`, `vgrid`

Look into the underlays and overlays layers (in this order) for a `PlotGrid` object of horizontals / vertical orientation and return it. Return None if none is found.

`x_axis`, `y_axis`

Look into the underlays and overlays layers (in this order) for a `PlotAxis` object positioned to the bottom or top, or to the left or right of plot, respectively. Return the axis, or None if none is found.

`labels`

Return a list of all `PlotLabel` objects in the overlays and underlays layers.

TODO: add links to axis and grid documentation

Hittest `BaseXYPlot` also provides support for "hit tests", i.e., for finding the data point or plot line closest to a given screen coordinate. This is typically used to implement interactive tools, for example to select a plot point with a mouse click.

The main functionality is implemented in the method `hittest(screen_pt, threshold=7.0, return_distance=False)`, which accepts screen coordinates `(x,y)` as input argument `screen_pt`

and returns either 1) screen coordinates of the closest point on the plot, or 2) the start and end coordinates of the closest plot line segment, as a tuple `((x1,y1), (x2,y2))`. Which of the two behaviors is active is controlled by the attribute `hittest_type`, which is one of 'point' (default), or 'line'. If the closest point or line is further than `threshold` pixels away, the methods returns None.

Alternatively, users may call the methods `get_closest_point` and `get_closest_line`.

Others Two more attributes are worth mentioning:

`bgcolor`

This is inherited from the AbstractPlotRenderer interface, but is now set to 'transparent' by default.

`use_downsampling`

If this attribute is True, the plot uses downsampling for faster display (default is False). In other words, the number of display points depends on the plot size and range, and not on the total number of data points available.

Note: At the moment, only `LinePlot` defines a downsampling function, while other plots raise a `NotImplementedError` when this feature is activated.

2D Plots interface The class `chaco.base_2d_plot.Base2DPlot` is the interface for plots that display data defined on a 2D grid, like for example image and contour plots. Just like its companion interface, *BaseXYPlot*, it handles data sources and data mappers, along with convenient shortcuts to find axes, labels and grids.

Unlike other plot renderers, 2D plots draw on the *'image' layer*, i.e., above any underlay element.

Data-related traits 2D plots need two sources of data: one for the coordinates of the 2D grid on which data is displayed, stored in the attribute `index` (a subclass of `GridDataSource`); and one for the values of the data at each point of the grid, `value` (a subclass of `ImageData`). The index data source also needs a 2D mapper, `index_mapper`, to map data coordinates to the screen.

The orientation on screen is set by `orientation` (either 'h' – the default – or 'v'), which controls which of the two coordinates defined in `index` is mapped to the X axis. It is possible to access a mapper for the coordinates corresponding to the individual screen coordinates independently of orientation using the properties `x_mapper` and `y_mapper`.

Finally, `index_range` is a shortcut to the 2D range of the grid data.

Others The attribute `alpha` defines the global transparency value for the whole plot. It ranges from 0.0 for transparent to 1.0 (default) for full intensity.

Plot types

This section gives an overview of individual plot classes in Chaco. It is divided in three parts: the first part lists all plot classes implementing the *X-Y plots* interface, the second all plot classes implementing the *2D plots* interface, and finally a part collecting all plot types that do not fall in either category. See the *section on plot renderers* for a detailed description of the methods and attributes that are common to all plots.

The code to generate the figures in this section can be found in the path `tutorials/user_guide/plot_types/` in the examples directory.

For more complete examples, see also the *annotated examples* page.

X-Y Plot Types These plots display information in a two-axis coordinate system and are subclasses of `BaseXYPlot`.

The common interface for X-Y plots is described in *X-Y Plots interface*.

Line Plot Standard line plot implementation. The aspect of the line is controlled by the parameters

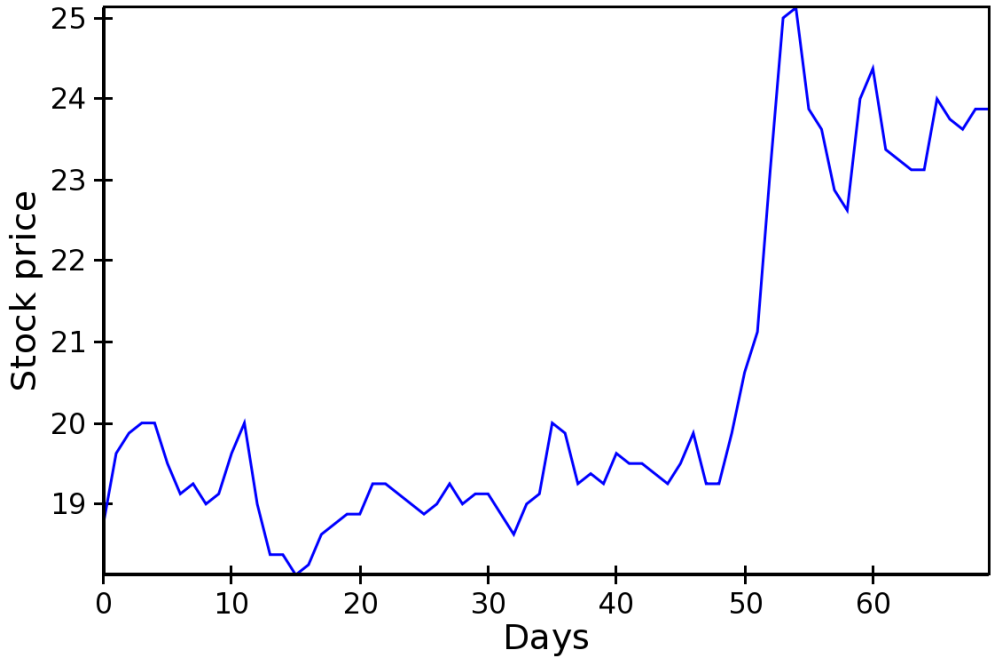
`line_width` The width of the line (default is 1.0)

`line_style` The style of the line, one of 'solid' (default), 'dot dash', 'dash', 'dot', or 'long dash'.

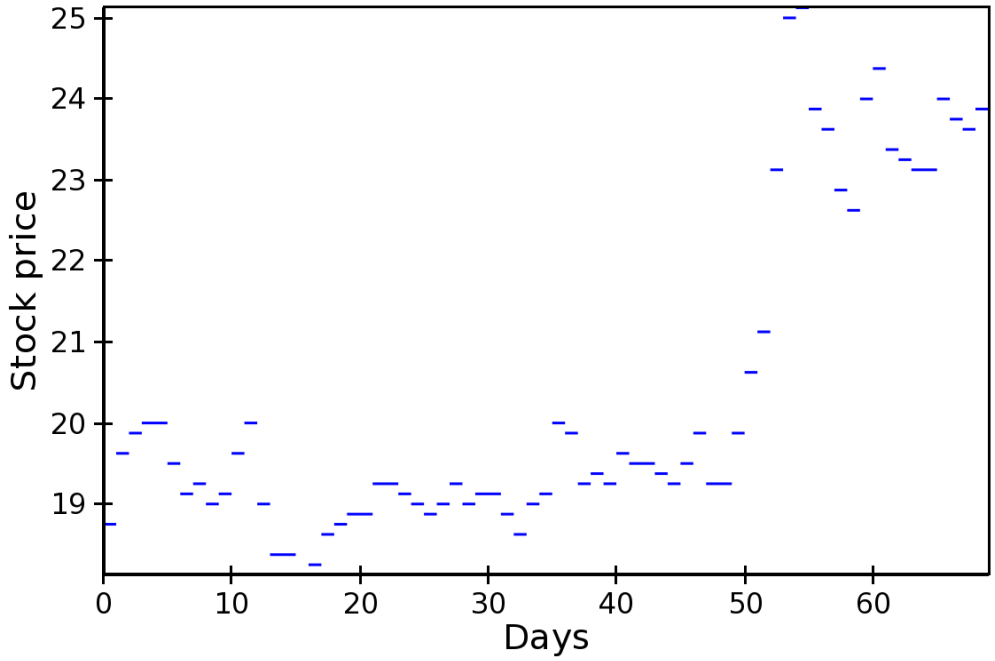
`render_style` The rendering style of the line plot, one of 'connectedpoints' (default), 'hold', or 'connectedhold'

These images illustrate the differences in rendering style:

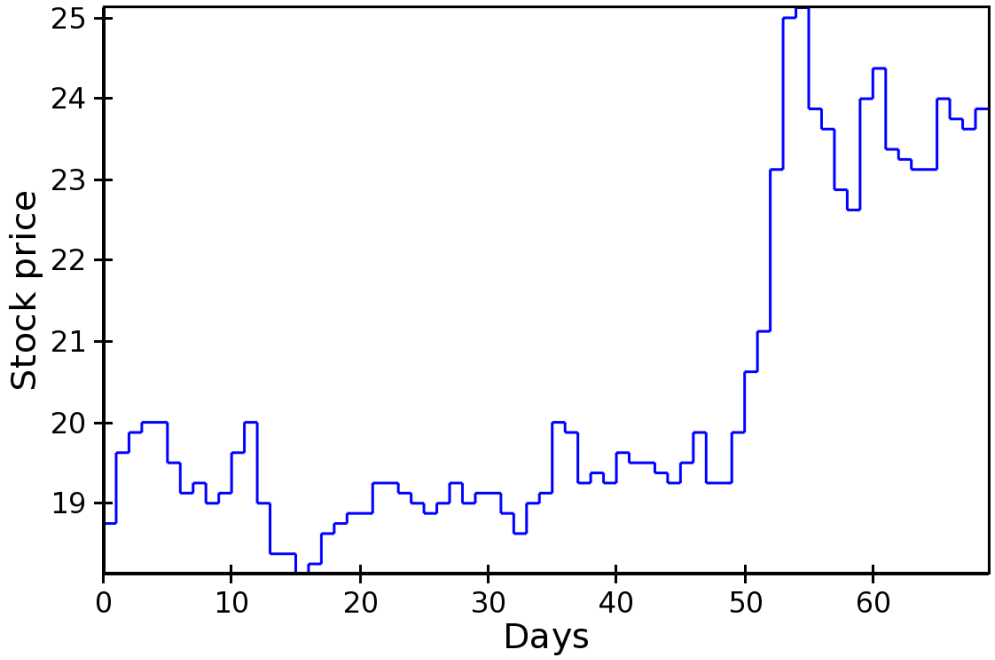
- `renderstyle='connectedpoints'`



- `renderstyle='hold'`



- `renderstyle='connectedhold'`



Scatter Plot Standard scatter plot implementation. The aspect of the markers is controlled by the parameters

`marker` The marker type, one of 'square'(default), 'circle', 'triangle', 'inverted_triangle', 'plus',

'cross', 'diamond', 'dot', or 'pixel'. One can also define a new marker shape by setting this parameter to 'custom', and set the `custom_symbol` parameter to a `CompiledPath` instance (see the file `demo/basic/scatter_custom_marker.py` in the Chaco examples directory).

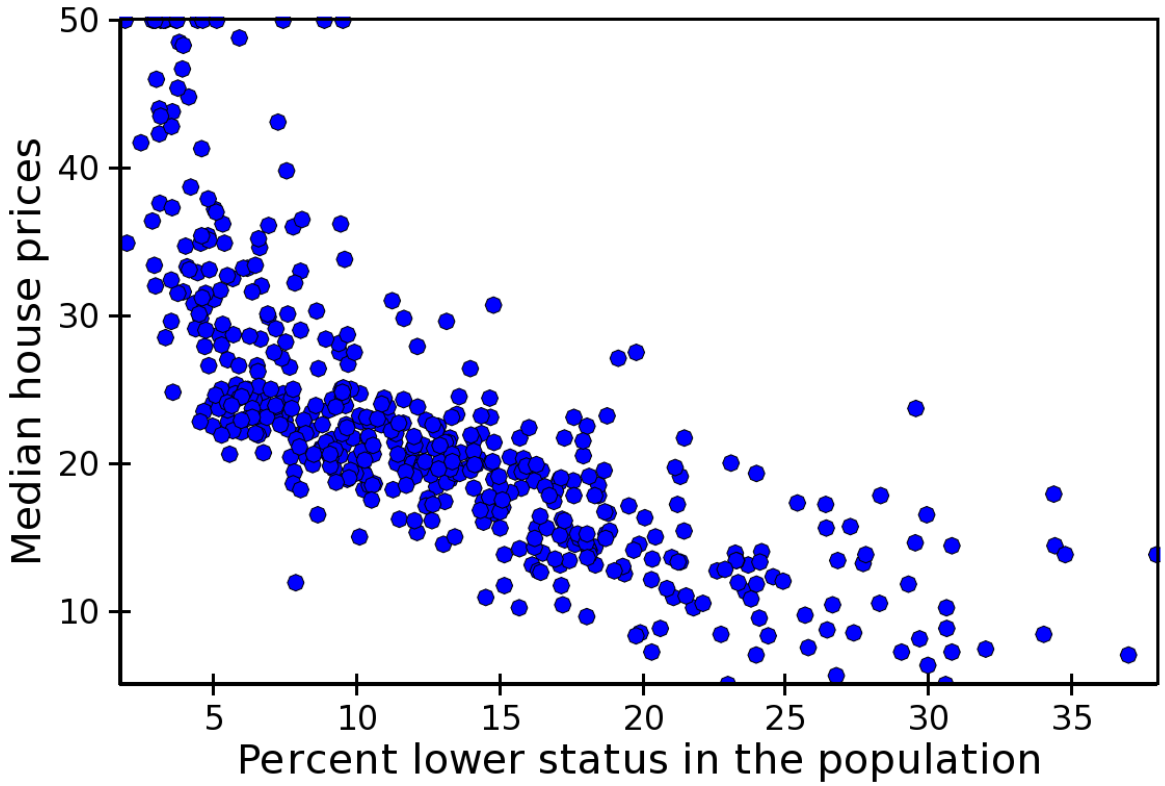
`marker_size` Size of the marker in pixels, not including the outline. This can be either a scalar (default is 4.0), or an array with one size per data point.

`line_width` Width of the outline around the markers (default is 1.0). If this is 0.0, no outline is drawn.

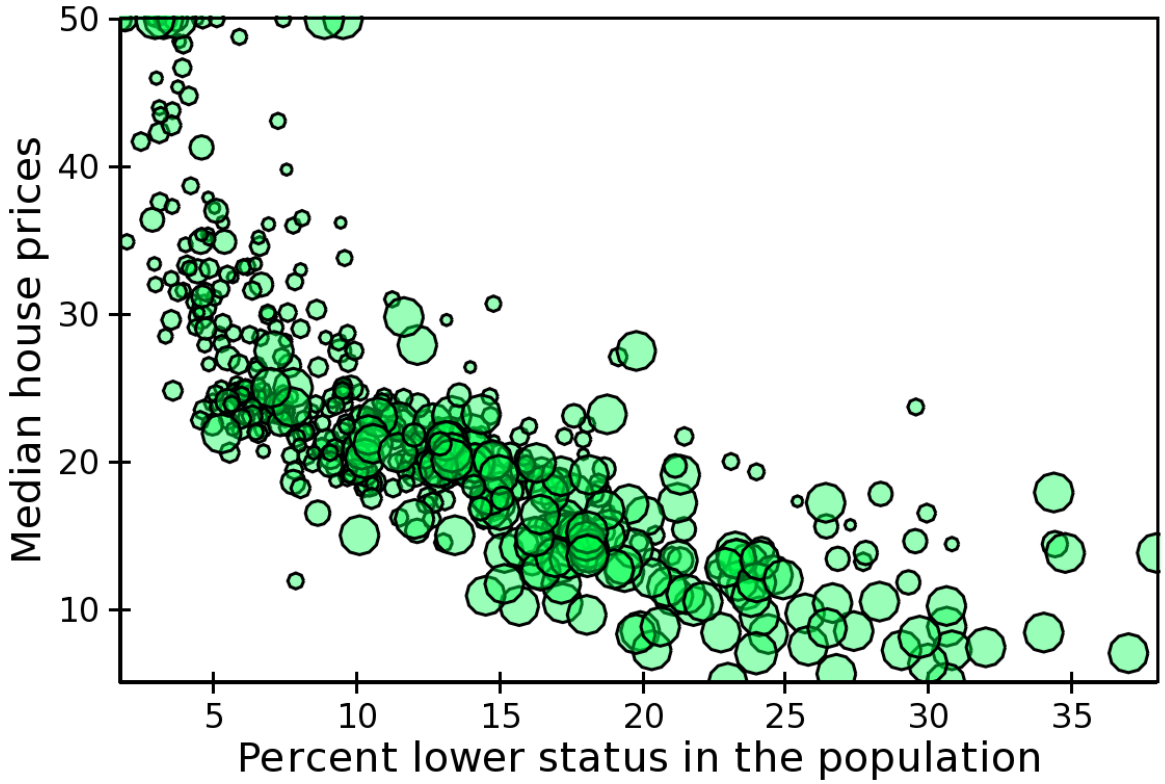
`color` The fill color of the marker (default is black).

`outline_color` The color of the outline to draw around the marker (default is black).

This is an example with fixed point size:



The same example, using marker size to map property-tax rate (larger is higher):



Colormapped Scatter Plot Colormapped scatter plot. Additional information can be added to each point by setting a different color.

The color information is controlled by the `color_data` data source, and the `color_mapper` mapper. A large number of ready-to-use color maps are defined in the module `chaco.default_colormaps`.

In addition to the parameters supported by a *scatter plot*, a colormapped scatter plot defines these attributes:

`fill_alpha` Set the alpha value of the points.

`render_method` Set the sequence in which the points are drawn. It is one of

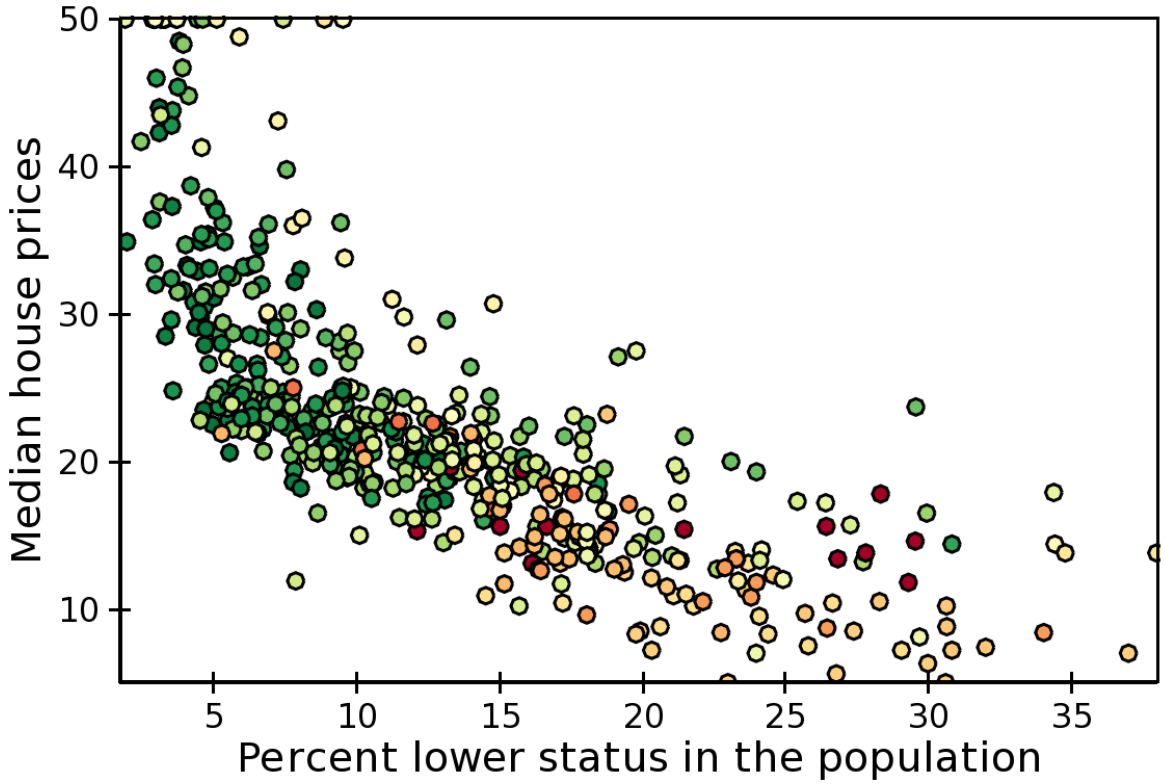
'banded' draw points by color band; this is more efficient but some colors will appear more prominently if there are a lot of overlapping points

'bruteforce' set the stroke color before drawing each marker

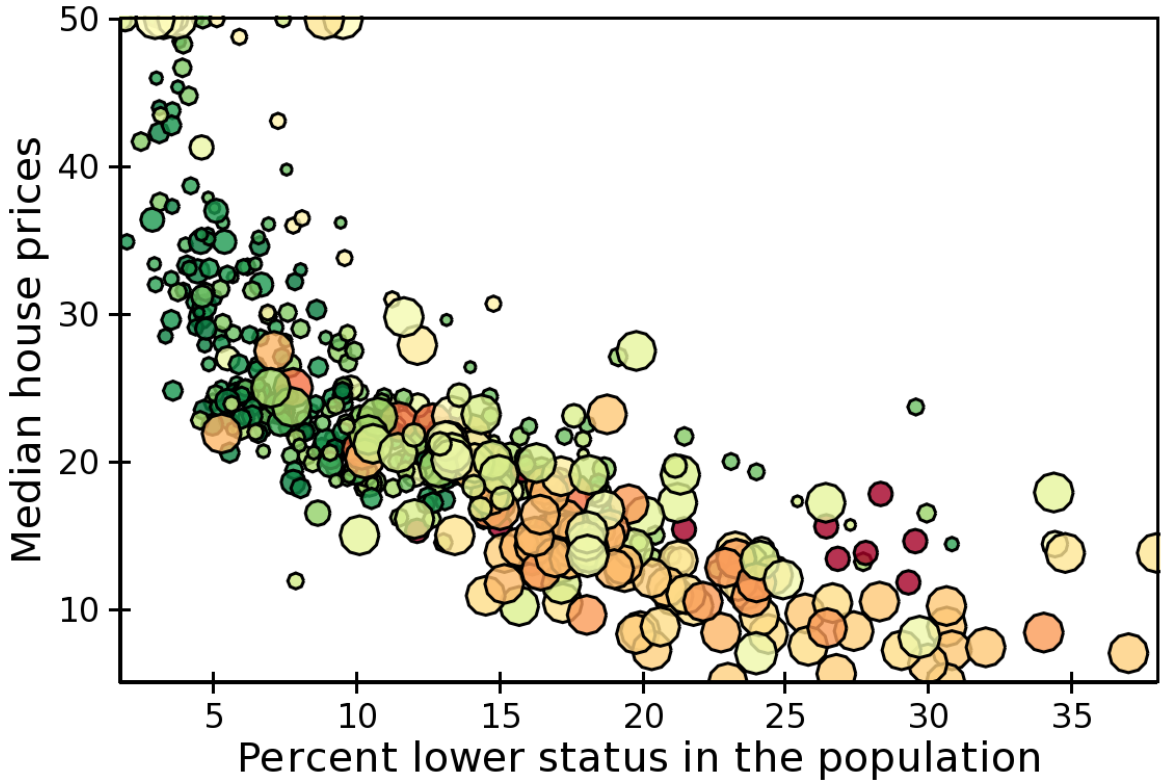
'auto' (default) the approach is selected based on the number of points

In practice, there is not much performance difference between the two methods.

In this example plot, color represents nitric oxides concentration (green is low, red is high):



Using X,Y, color, and size we can display 4 variables at the time. In this example, color is again, and size is nitric oxides concentration:



Candle Plot A candle plot represents summary statistics of distribution of values for a set of discrete items. Each distribution is characterized by a central line (usually representing the mean), a bar (usually representing one standard deviation around the mean or the 10th and 90th percentile), and two stems (usually indicating the maximum and minimum values).

The positions of the centers, and of the extrema of the bar and stems are set with the following data sources

`center_values` Value of the centers. It can be set to `None`, in which case the center is not plotted.

`bar_min` and `bar_max` Lower and upper values of the bar.

`min_values` and `max_values` Lower and upper values of the stem. They can be set to `None`, in which case the stems are not plotted.

It is possible to customize the appearance of the candle plot with these parameters

`bar_color` (alias of `color`) Fill color of the bar (default is black).

`bar_line_color` (alias of `outline_color`) Color of the box forming the bar (default is black).

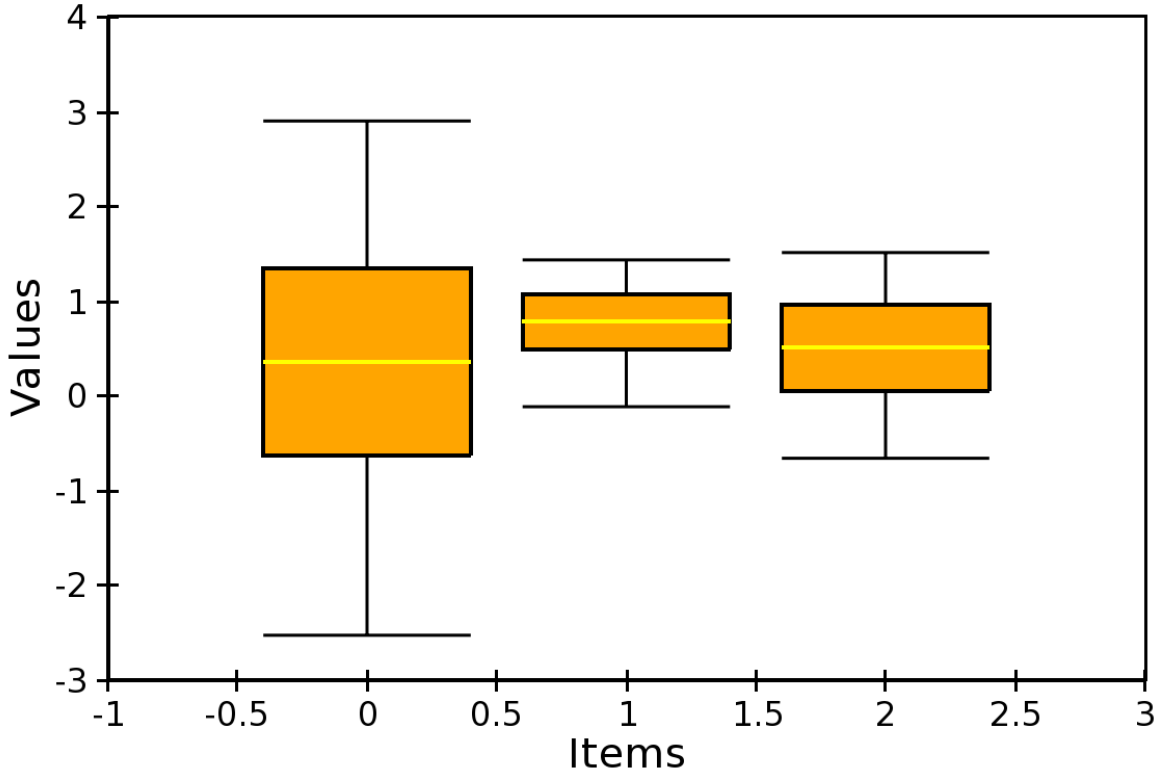
`center_color` Color of the line indicating the center. If `None`, it defaults to `bar_line_color`.

`stem_color` Color of the stems and endcaps. If `None`, it defaults to `bar_line_color`.

`line_width`, `center_width`, and `stem_width` Thickness in pixels of the lines drawing the corresponding elements. If `None`, they default to `line_width`.

`end_cap` If `False`, the end caps are not plotted (default is `True`).

At the moment, it is not possible to control the width of the central bar and end caps.



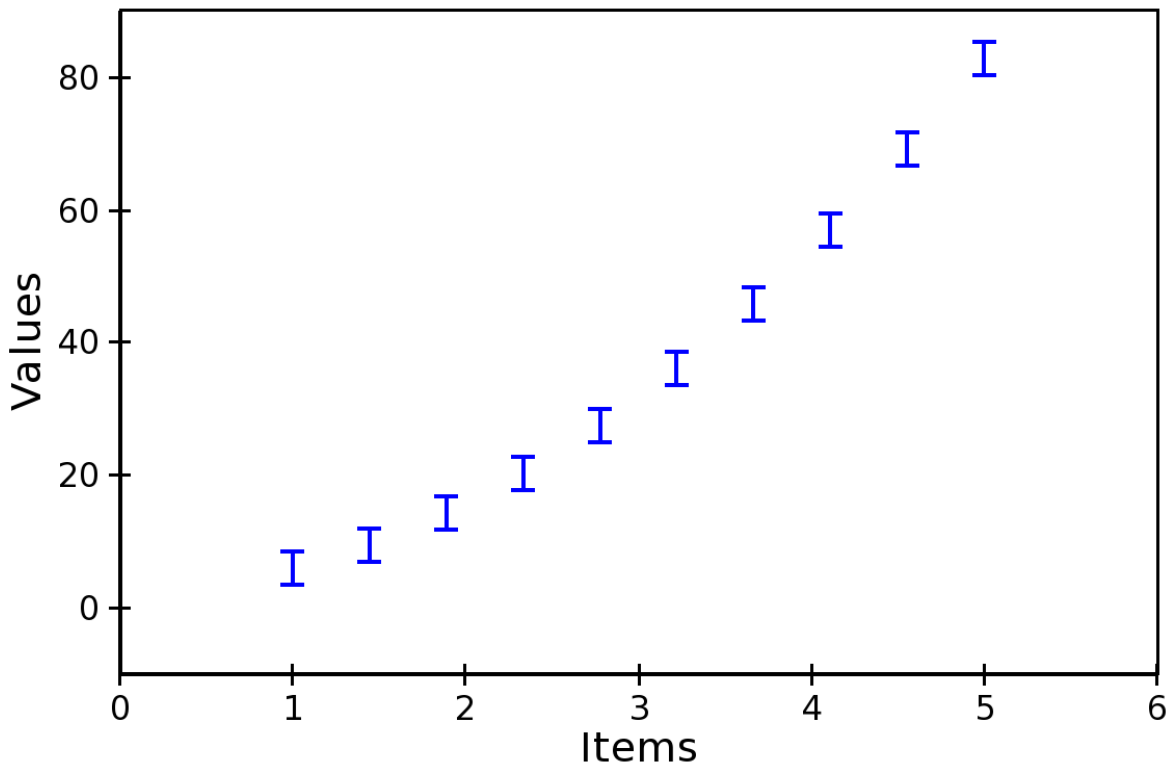
Errorbar Plot A plot with error bars. Note that `ErrorBarPlot` only plots the error bars, and needs to be combined with a `LinePlot` if one would like to have a line connecting the central values.

The positions of the extrema of the bars are set by the data sources `value_low` and `value_high`.

In addition to the parameters supported by a *line plot*, an errorbar plot defines these attributes:

`endcap_size` The width of the endcap bars in pixels.

`endcap_style` Either 'bar' (default) or 'none', in which case no endcap bars are plotted.



Filled Line Plot A line plot filled with color to the axis.

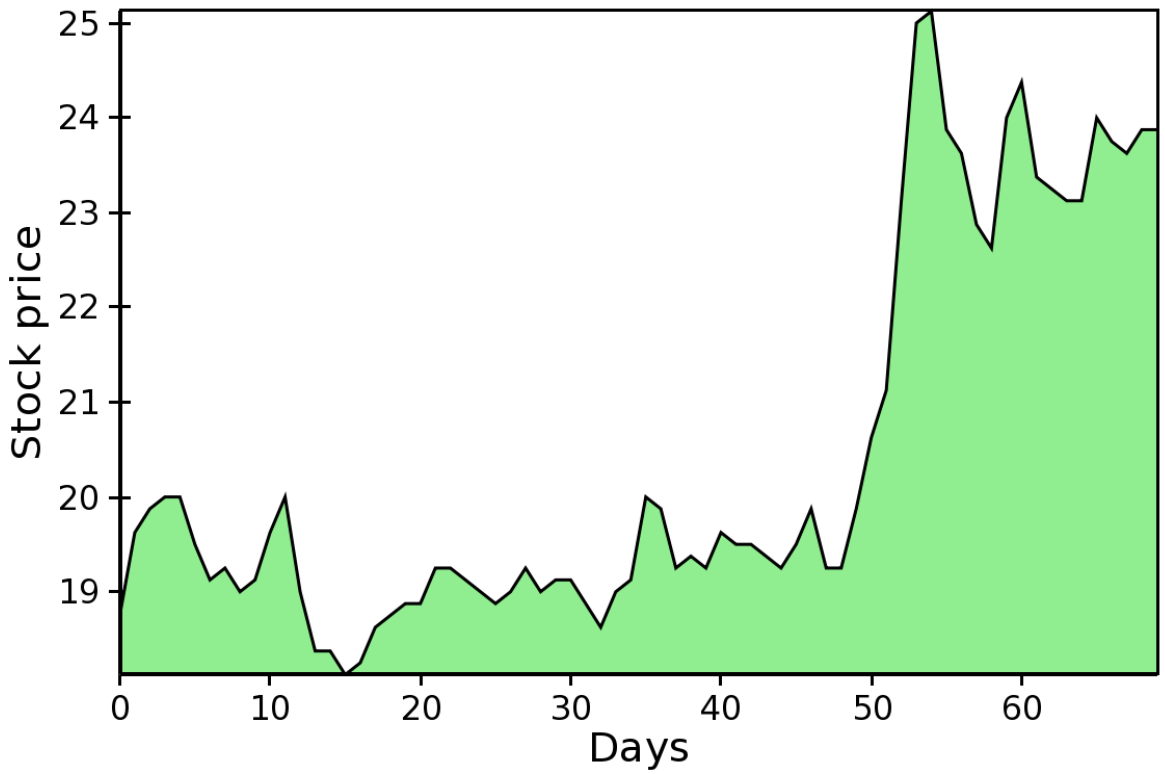
`FilledLinePlot` defines the following parameters:

`fill_color` The color used to fill the plot.

`fill_direction` Fill the plot toward the origin ('down', default) ot towards the axis maximum ('up').

`render_style` The rendering style of the line plot, one of 'connectedpoints' (default), 'hold', or 'connectedhold' (see *line plot* for a description of the different rendering styles).

`FilledLinePlot` is a subclass of `PolygonPlot`, so to set the thickness of the plot line one should use the parameter `edge_width` instead of `line_width`.



Multi-line Plot A line plot showing multiple lines simultaneously.

The values of the lines are given by an instance of `MultiArrayDataSource`, but the lines are rescaled and displaced vertically so that they can be compared without crossing each other.

The relative displacement and rescaling of the lines is controlled by these attributes of `MultiLinePlot`:

`index`

The usual array data source for the index data.

`yindex`

Array data source for the starting point of each line. Typically, this is set to `numpy.arange(n_lines)`, so that each line is displaced by one unit from the others (the other default parameters are set to work well with this arrangement).

`use_global_bounds`, `global_min`, `global_max`,

These attributes are used to compute an "amplitude scale" which that the largest trace deviation from its base y-coordinate will be equal to the y-coordinate spacing.

If `use_global_bounds` is set to False, the maximum of the absolute value of the full data is used as the largest trace deviation. Otherwise, the largest between the absolute value of `global_min` and `global_max` is used instead.

By default, `use_global_bounds` is set to False and `global_min` and `global_max` to 0.0, which means that one of these value has to be set to create a meaningful plot.

`scale`, `offset`, `normalized_amplitude`

In addition to the rescaling done using the global bounds (see above), each line is individually scaled by `normalized_amplitude` (by default this is -0.5, but is normally it should be something like 1.0). Finally, all the lines are moved by `offset` and multiplied by `scale` (default are 0.0 and 1.0, respectively).

`MultiLinePlot` also defines the following parameters:

`line_width`, `line_style`

Control the thickness and style of the lines, as for *line plots*.

`color`, `color_func`

If `color_func` is None, all lines have the color defined in `color`. Otherwise, `color_func` is a function (or, more in general, a callable) that accept a single argument corresponding to the index of the line and returns a RGBA 4-tuple.

`fast_clip`

If True, traces whose *base* y-coordinate is outside the value axis range are not plotted, even if some of the data in the curve extends into the plot region. (Default is False)

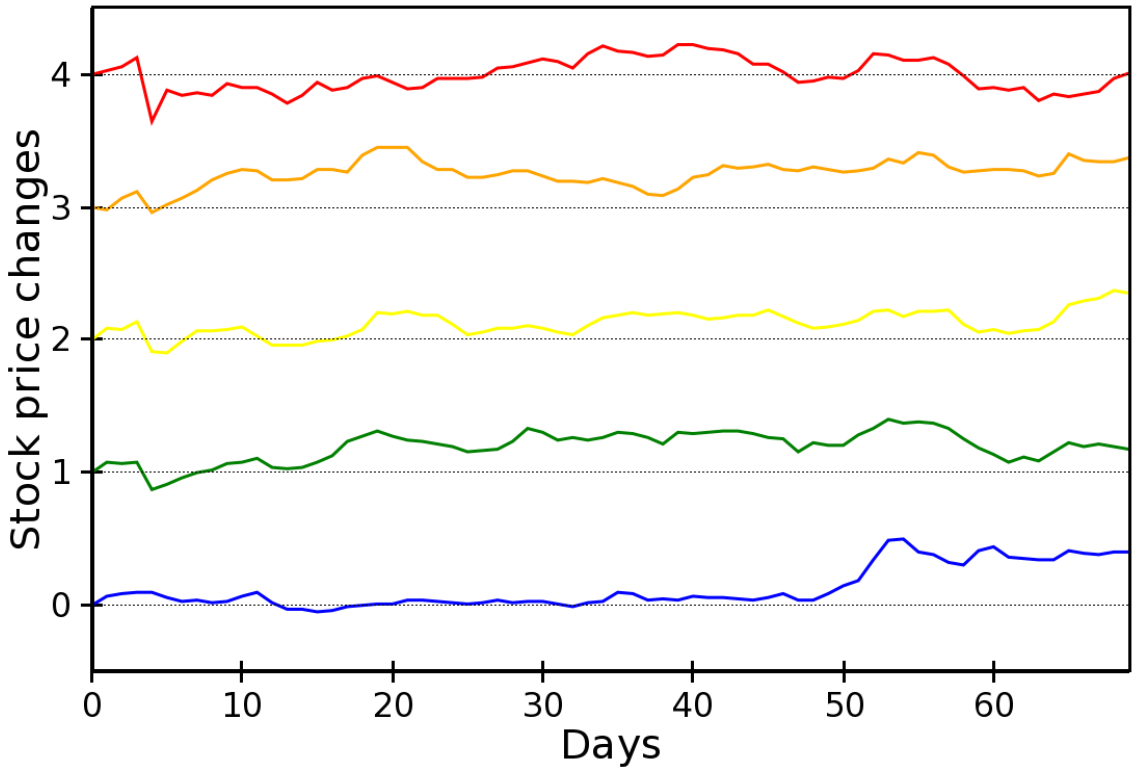
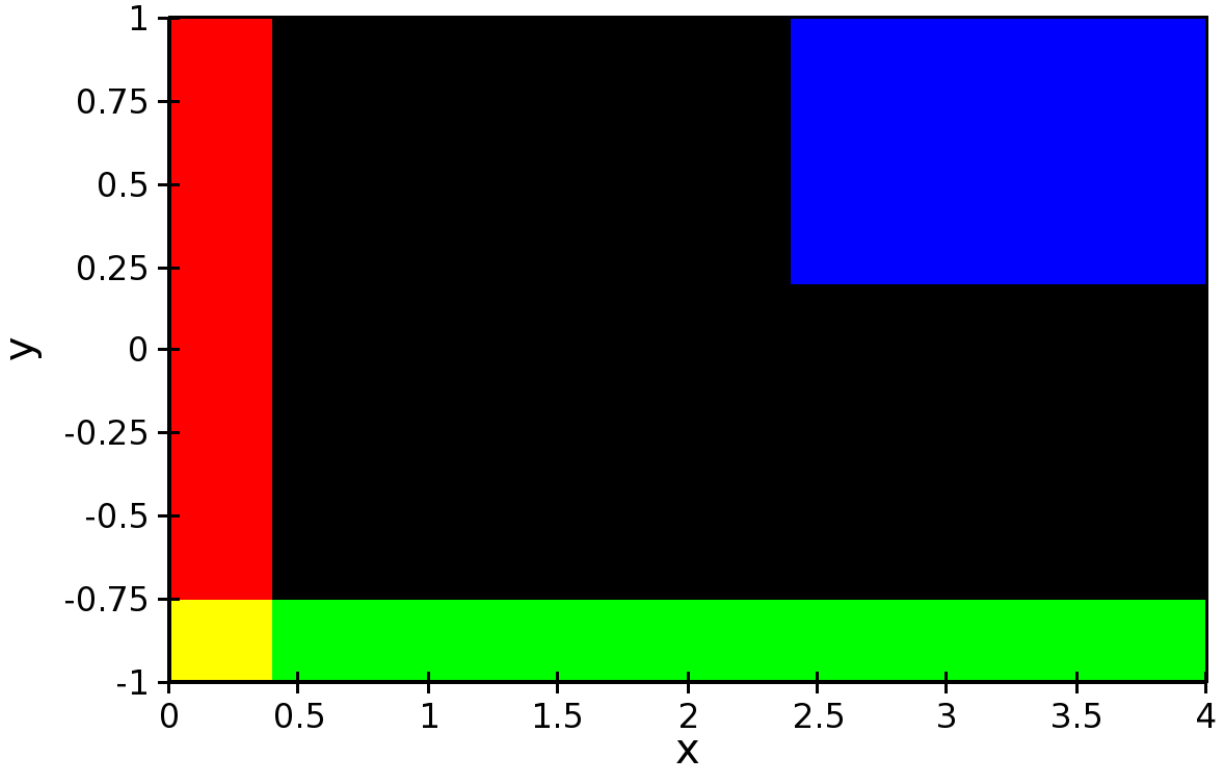


Image and 2D Plots These plots display information as a two-dimensional image. Unless otherwise stated, they are subclasses of `Base2DPlot`.

The common interface for 2D plots is described in *2D Plots interface*.

Image Plots Plot image data, provided as RGB or RGBA color information. If you need to plot a 2D array as an image, use a *colormapped scalar plot*

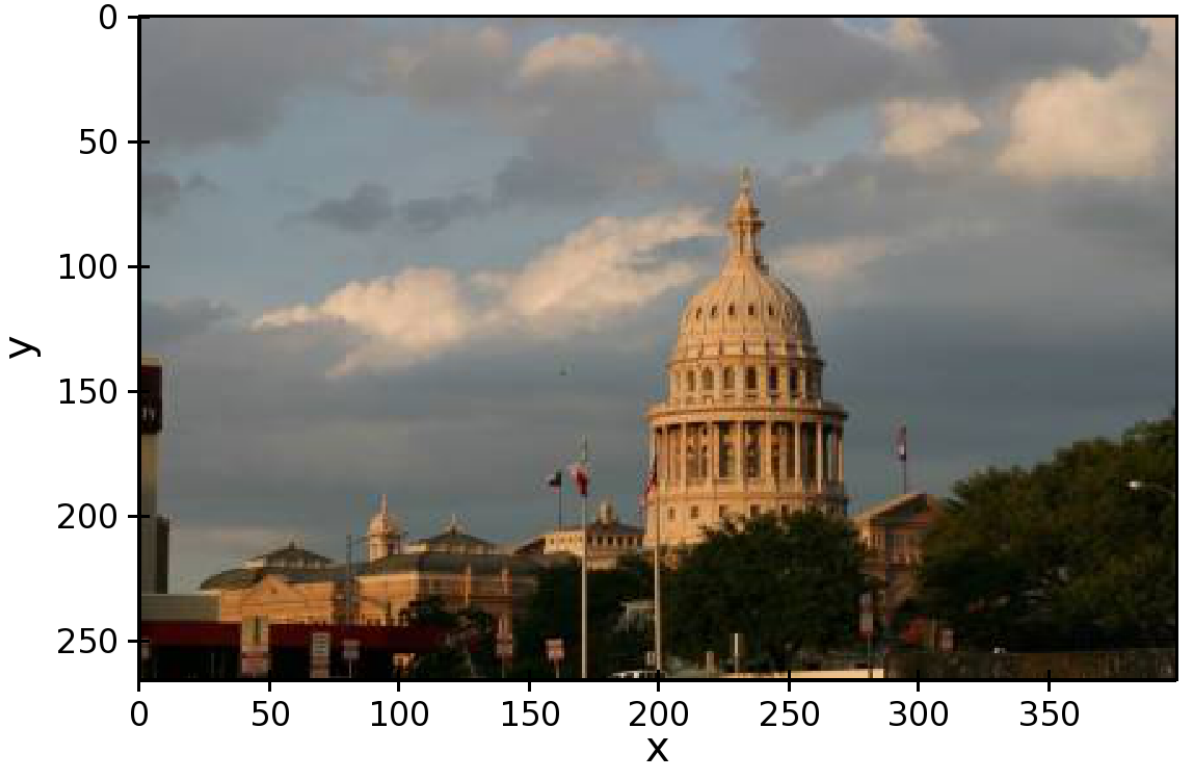
In an `ImagePlot`, the `index` attribute corresponds to the data coordinates of the pixels (often a `GridDataSource`). The `index_mapper` maps the data coordinates to screen coordinates (typically using a `GridMapper`). The *value* is the image itself, wrapped into the data source class `ImageData`.



A typical use case is to display an image loaded from a file. The preferred way to do this is using the factory method `from_file()` of the class `ImageData`. For example:

```
image_source = ImageData.fromfile('capitol.jpg')

w, h = image_source.get_width(), image_source.get_height()
index = GridDataSource(np.arange(w), np.arange(h))
index_mapper = GridMapper(range=DataRange2D(low=(0, 0),
                                            high=(w-1, h-1)))

image_plot = ImagePlot(
    index=index,
    value=image_source,
    index_mapper=index_mapper,
    origin='top left',
    **PLOT_DEFAULTS
)
```

The code above displays this plot:



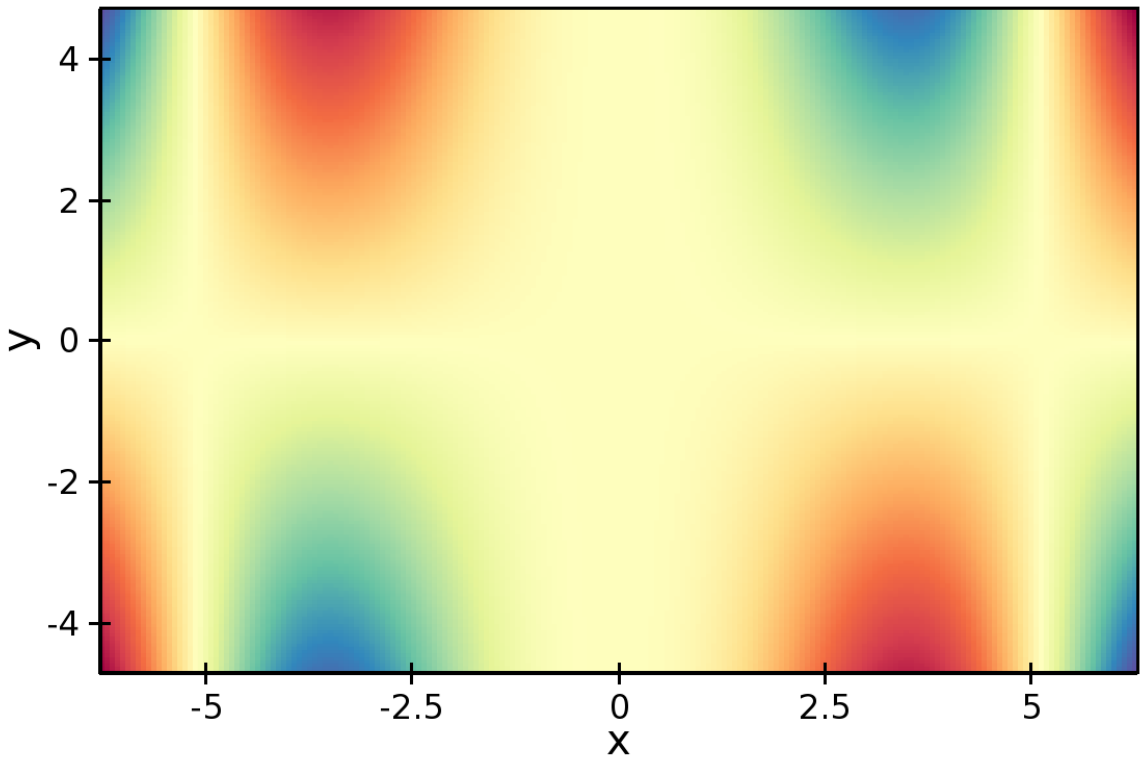
Colormapped Scalar Plot Plot a scalar field as an image. The image information is given as a 2D array; the scalar values in the 2D array are mapped to colors using a color map.

The basic class for colormapped scalar plots is `CMapImagePlot`. As in *image plots*, the `index` attribute corresponds to the data coordinates of the pixels (a `GridDataSource`), and the `index_mapper` maps the data coordinates to screen coordinates (a `GridMapper`). The scalar data is passed through the `value` attribute as an `ImageData` source. Finally, a color mapper maps the scalar data to colors. The module `chaco.default_colormaps` defines many ready-to-use colormaps.

For example:

```
xs = np.linspace(-2 * np.pi, +2 * np.pi, NPOINTS)
ys = np.linspace(-1.5*np.pi, +1.5*np.pi, NPOINTS)
x, y = np.meshgrid(xs, ys)
z = scipy.special.jn(2, x)*y*x

index = GridDataSource(xdata=xs, ydata=ys)
index_mapper = GridMapper(range=DataRange2D(index))

color_source = ImageData(data=z, value_depth=1)
color_mapper = dc.Spectral(DataRange1D(color_source))

cmap_plot = CMapImagePlot(
    index=index,
    index_mapper=index_mapper,
    value=color_source,
    value_mapper=color_mapper,
    **PLOT_DEFAULTS
)
```

This creates the plot:



Contour Plots Contour plots represent a scalar-valued 2D function, z = f(x, y), as a set of contours connecting points of equal value.

Contour plots in Chaco are derived from the base class `BaseContourPlot`, which defines these common attributes:

`levels` `levels` is used to define the values for which to draw a contour. It can be either a list of values (floating point numbers); a positive integer, in which case the range of the value is divided in the given number of equally spaced levels; or "auto" (default), which divides the total range in 10 equally spaced levels

`colors` This attribute is used to define the color of the contours. `colors` can be given as a color name, in which case all contours have the same color, as a list of colors, or as a colormap. If the list of colors is shorter than the number of levels, the values are repeated from the beginning of the list. If left unspecified, the contours are plot in black. Colors are associated with levels of increasing value.

`color_mapper` If present, the color mapper for the colorbar. TODO: not sure how it works

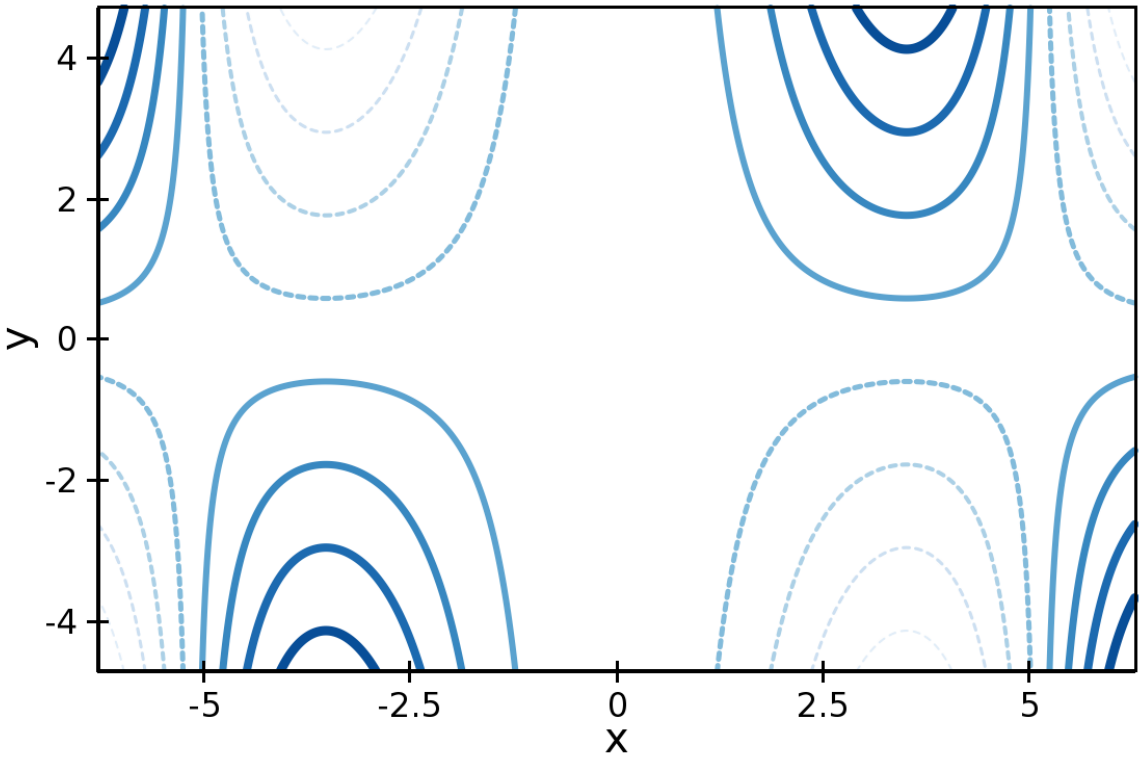
`alpha` Global alpha level for all contours.

Contour Line Plot Draw a contour plots as a set of lines. In addition to the attributes in `BaseContourPlot`, `ContourLinePlot` defines the following parameters:

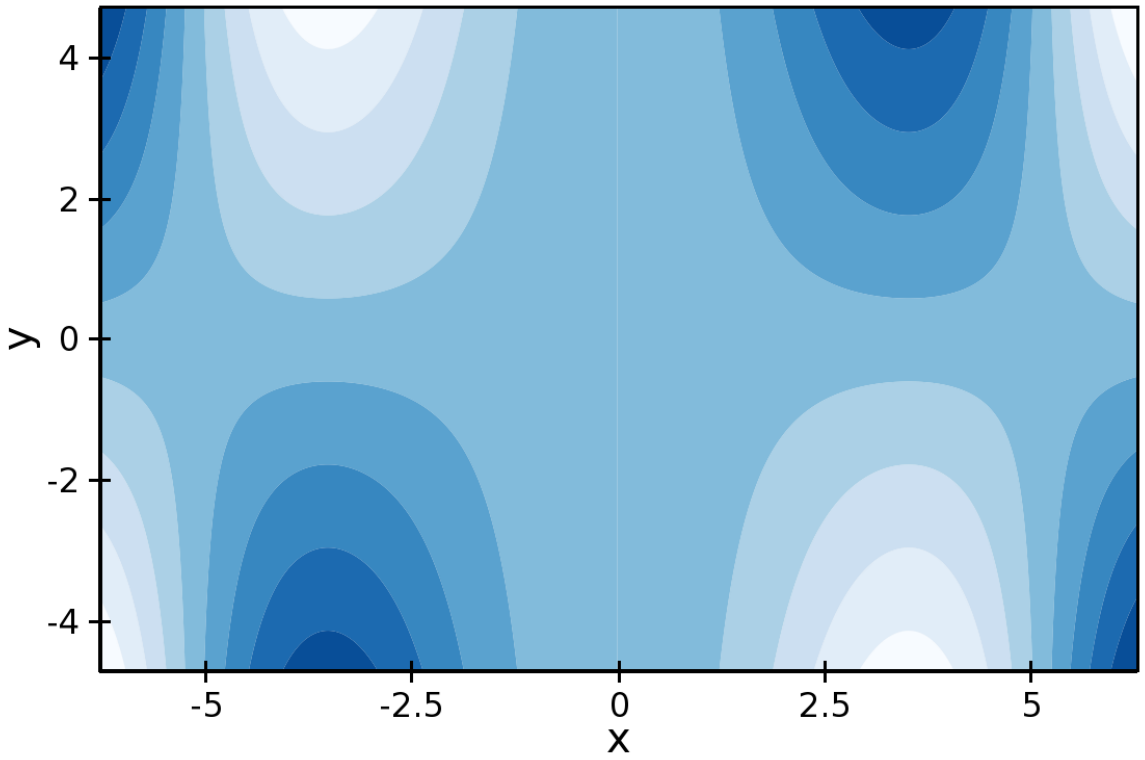
`widths` The thickness of the contour lines. It can be either a scalar value, valid for all contour lines, or a list of widths. If the list is too short with respect to the number of contour lines, the values are repeated from the beginning of the list. Widths are associated with levels of increasing value.

`styles` The style of the lines. It can either be a string that specifies the style for all lines (allowed styles are 'solid', 'dot dash', 'dash', 'dot', or 'long dash'), or a list of styles, one for each line. If the list

is too short with respect to the number of contour lines, the values are repeated from the beginning of the list. The default, 'signed', sets all lines corresponding to positive values to the style given by the attribute `positive_style` (default is 'solid'), and all lines corresponding to negative values to the style given by `negative_style` (default is 'dash').



Filled contour Plot Draw a contour plot as a 2D image divided in regions of the same color. The class `ContourPolyPlot` inherits all attributes from `BaseContourPlot`.



Polygon Plot Draws a polygon given the coordinates of its corners.

The x-coordinate of the corners is given as the `index` data source, and the y-coordinate as the `value` data source. As usual, their values are mapped to screen coordinates by `index_mapper` and `value_mapper`.

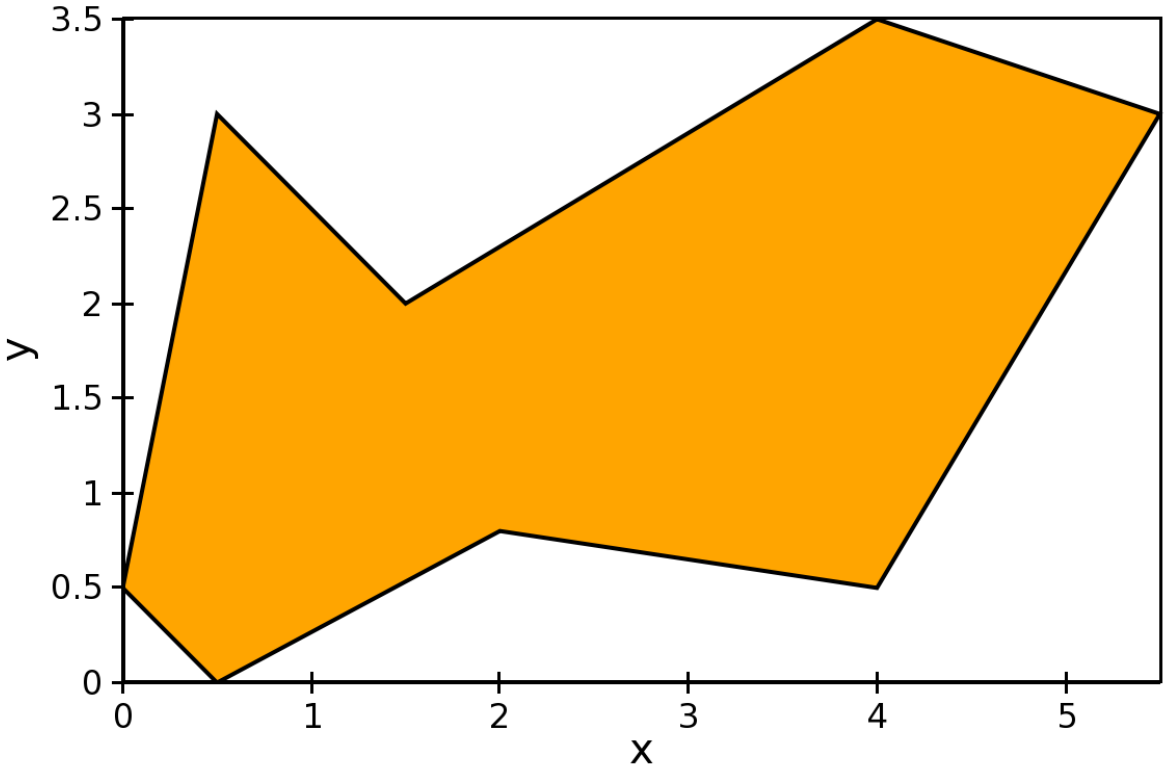
In addition, the class `PolygonPlot` defines these parameters:

`edge_color` The color of the line on the edge of the polygon (default is black).

`edge_width` The thickness of the edge of the polygon (default is 1.0).

`edge_style` The line dash style for the edge of the polygon, one of 'solid' (default), 'dot dash', 'dash', 'dot', or 'long dash'.

`face_color` The color of the face of the polygon (default is transparent).



Other Plot Types This section collects all plots that do not fall in the previous two categories.

Bar Plot Draws a set of rectangular bars, mostly used to plot histograms.

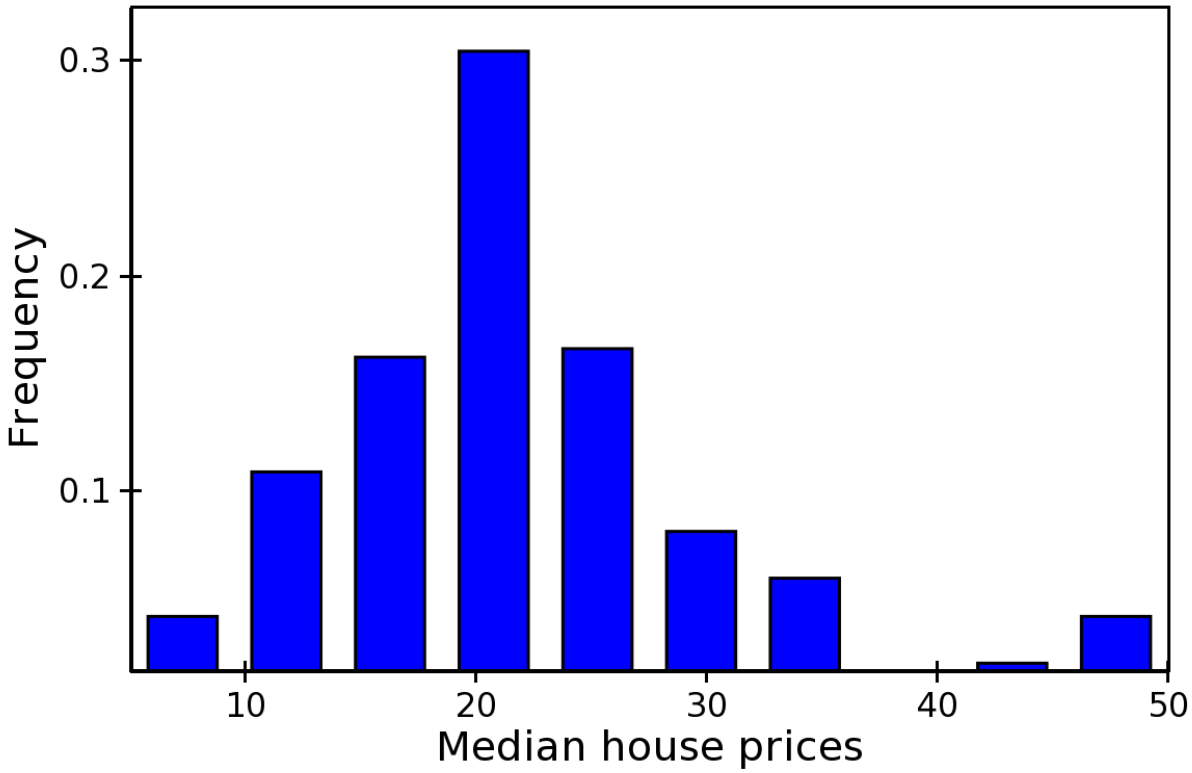
The class `BarPlot` defines the attributes of regular X-Y plots, plus the following parameters:

`sorting_value` While `value` is a data source defining the upper limit of the bars, `sorting_value` can be used to define their bottom limit. Default is 0. (Note: "upper" and "bottom" assume a horizontal for the plot.)

`bar_width_type` Determines how to interpret the `bar_width` parameter. If 'data' (default', the width is given in the units along the index dimension of the data space. If 'screen', the width is given in pixels.

`bar_width` The width of the bars (see `bar_width_type`).

`fill_color` The color of the bars.



Quiver Plot This is a kind of *scatter plot* which draws an arrow at every point. It can be used to visualize 2D vector fields.

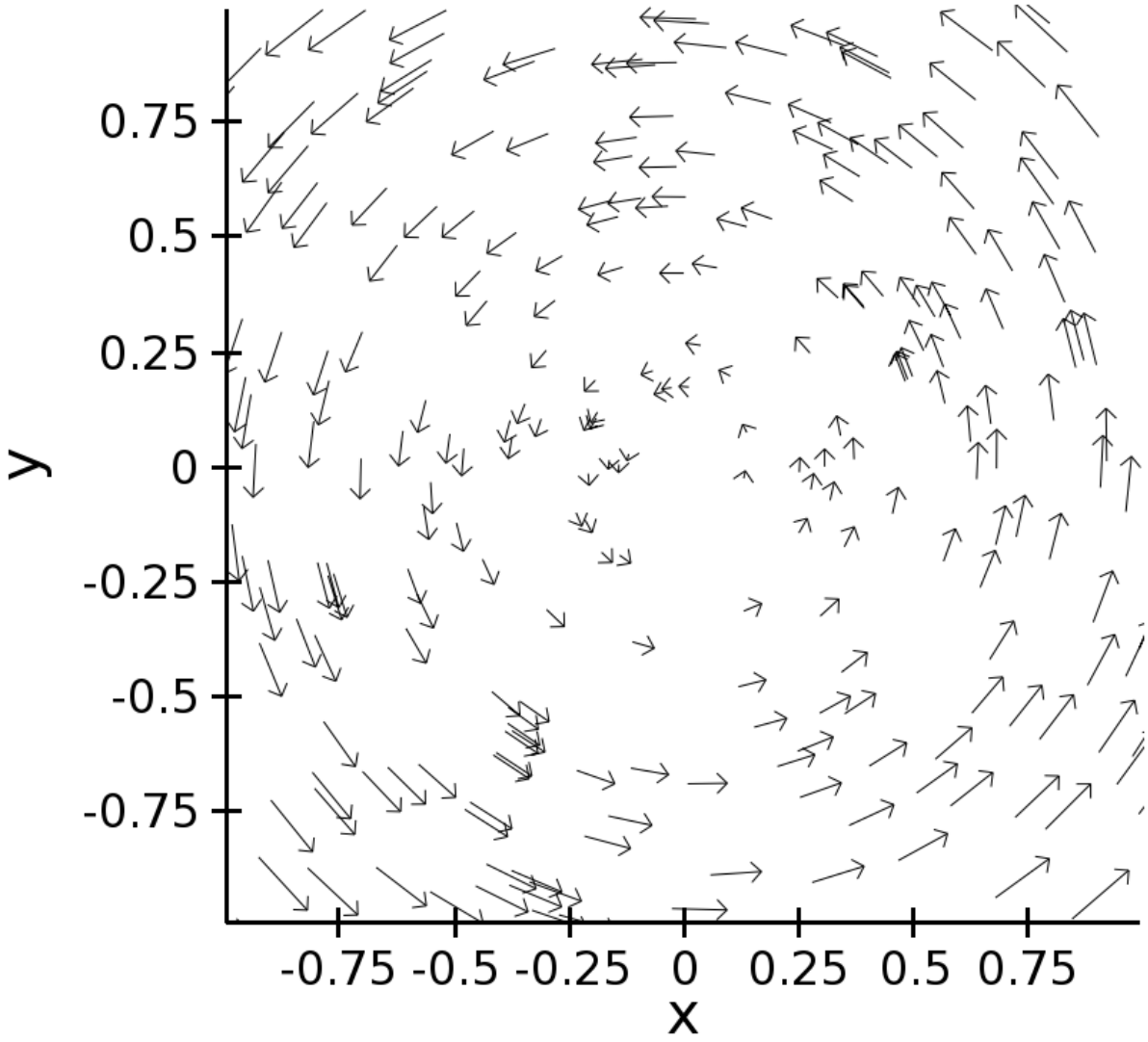
The information about the vector sizes is given through the data source `vectors`, which returns an Nx2 array. Usually, `vectors` is an instance of `MultiArrayDataSource`.

`QuiverPlot` defines these parameters:

`line_width` Width of the lines that trace the arrows (default is 1.0).

`line_color` The color of the arrows (default is black).

`arrow_size` The length of the arrowheads in pixels.



Polar Plot Display a line plot in polar coordinates.

The implementation at the moment is at a proof-of-concept stage. The class `PolarLineRenderer` relies on `PolarMapper` to map polar to cartesian coordinates, and adds circular polar coordinate axes.

> **Warning:** At the moment, `PolarMapper` does not do a polar to cartesian mapping, but just a linear mapping. One needs to do the transformation by hand.

The aspect of the polar plot can be controlled with these parameters:

`line_width` Width of the polar plot line (default is 1.0).

`line_style` The style of the line, one of 'solid' (default), 'dot dash', 'dash', 'dot', or 'long dash'.

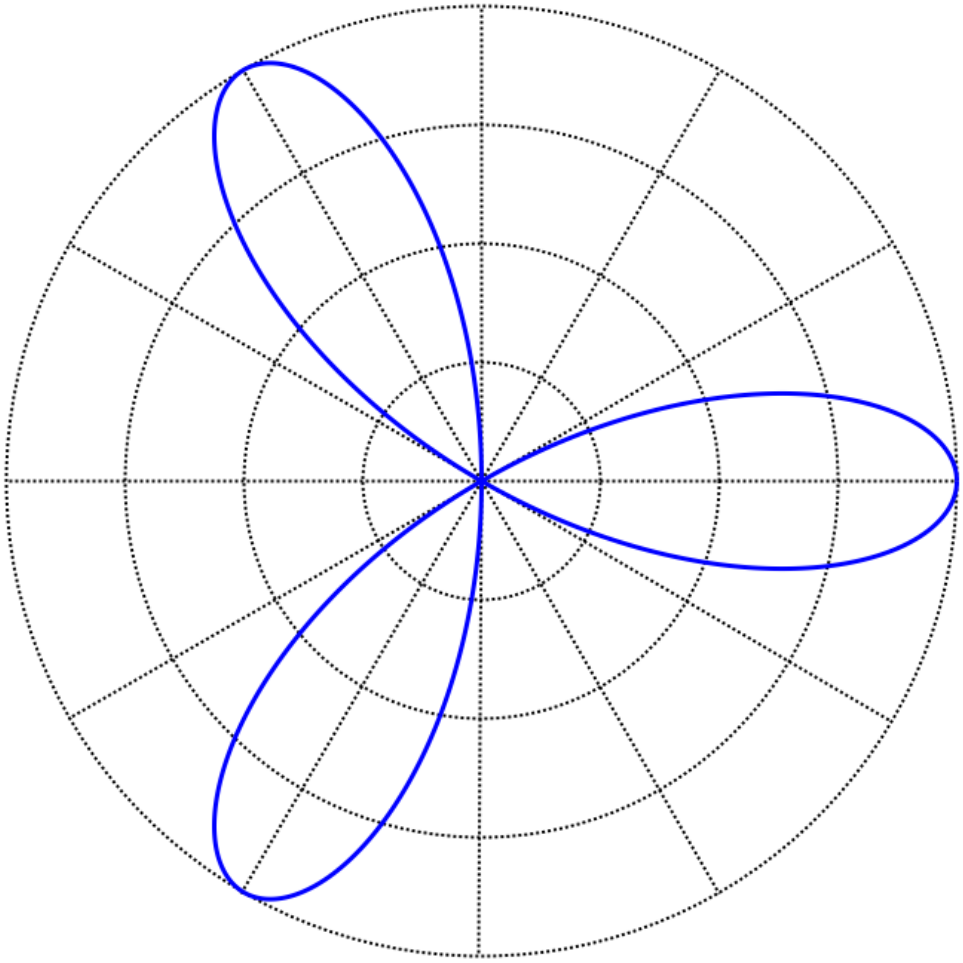
`color` The color of the line.

grid_style The style of the lines composing the axis, one of 'solid','dot dash', 'dash', 'dot' (default), or 'long dash'.

grid_visible If True (default), the circular part of the axes is drawn.

origin_axis_visible If True (default), the radial part of the axes is drawn.

origin_axis_width Width of the radial axis in pixels (default is 2.0).



Jitter Plot A plot showing 1D data by adding a random jitter around the main axis. It can be useful for visualizing dense collections of points. This plot has got a single mapper, called `mapper`.

Useful parameters are:

jitter_width The size, in pixels, of the random jitter around the axis.

marker The marker type, one of 'square'(default), 'circle', 'triangle', 'inverted_triangle', 'plus', 'cross', 'diamond', 'dot', or 'pixel'. One can also define a new marker shape by setting this pa-

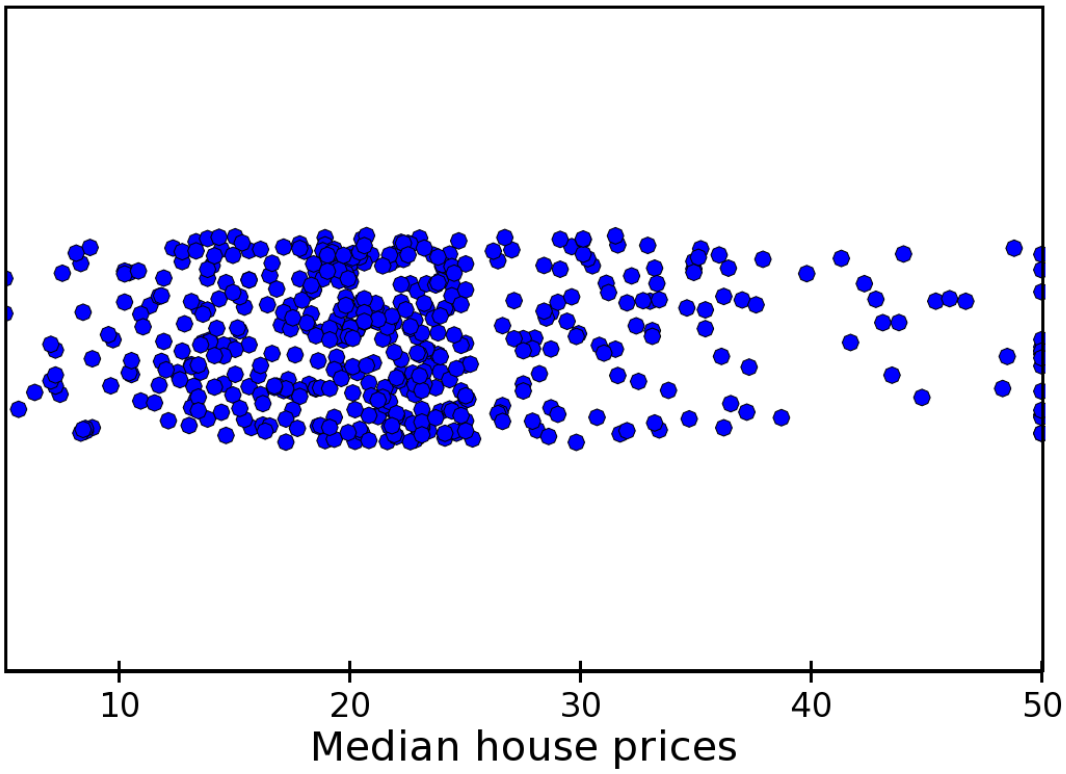
rameter to 'custom', and set the `custom_symbol` parameter to a `CompiledPath` instance (see the file `demo/basic/scatter_custom_marker.py` in the Chaco examples directory).

`marker_size` Size of the marker in pixels, not including the outline (default is 4.0).

`line_width` Width of the outline around the markers (default is 1.0). If this is 0.0, no outline is drawn.

`color` The fill color of the marker (default is black).

`outline_color` The color of the outline to draw around the marker (default is black).



TODO: add description of color bar class

Overlays: axis, legend, grid, etc.

Overlays are elements that decorate plots, like for example axes, legends, grids, etc.

Overlays are very similar to regular plot elements, and share most of their interface with *plot renderers* (both are subclasses of `chaco.plot_component.PlotComponent`).

In addition, they have a lightweight interface defined in `chaco.abstract_overlay.AbstractOverlay`: the additional features are that 1) they keep a reference to the plot they are decorating in `component`; 2) the background color `bgcolor` is 'transparent' by default; 3) they plot *on the 'overlay' layer* by default.

TODO: explain how to attach an overlay to an existing plot renderer

There are three important classes of overlays defined in Chaco: *axes*, *legends*, and *grids*.

Axes The Chaco overlay representing a plot axis is defined in the class `PlotAxis`.

A new axis is created by passing a mapper, usually the mapper defined for the corresponding plot data coordinate. `PlotAxis` also defines a range of attributes to customize the appearance of labels, ticks, and other axis elements. For example, given an X-Y plot renderer, `plot`, we can define a new x-axis as:

```
AXIS_DEFAULTS = {
    'axis_line_weight': 2,
    'tick_weight': 2,
    'tick_label_font': 'modern 16',
    'title_font': 'modern 20',
}

x_axis = PlotAxis(orientation='bottom',
                  title='My x axis',
                  mapper=plot.x_mapper,
                  component=plot,
                  **AXIS_DEFAULTS)
```

The newly created axis can then be attached to the plot renderer by appending it to its underlays layer:

```
plot.underlays.append(x_axis)
```

Attributes These attributes control the appearance of the axis:

`title`, `title_font`, `title_color`, `title_spacing`

> Define the axis label. `title` is a string or unicode object that is rendered using the given font and color. `title_font` is a string describing a font (e.g. '12 pt bold italic', 'swiss family Arial' or 'default 12'; see `TraitKivaFont` for details). Finally, `title_spacing` is the space between the axis line and the title (either the number of pixels or 'auto', default).

`tick_weight`, `tick_color`, `tick_in`, `tick_out`, `tick_visible`,

> These attributes control the aspect of the ticks on the axis. If `tick_visible` is True, ticks are represented as lines of color `tick_color` (default is black) and thickness `tick_weight` (in pixels, default is 1). Each line extends into the plot area by `tick_in` pixels and into the label area by `tick_out` pixels (default is 5).

`tick_label_font`, `tick_label_color`, `tick_label_rotate_angle`, `tick_label_alignment`, `tick_label_margin`, `tick_label_offset`, `tick_label_position`,

> These attributes allow to fine-tune the aspect of the tick labels: first of all, the font (e.g. '12 pt bold italic') and color of the labels. The position and orientation of the label can be also be closely controlled: `tick_label_rotate_angle` give the rotation angle (only multiples of 90 degrees are supported); `tick_label_alignment` selects whether the corner ('corner') or center ('edge', default) of the label are aligned to the corresponding tick ('corner' is better for 45 degrees rotation); `tick_label_margin` and `tick_label_offset` control the margin around the tick labels, and their distance from the axis; finally, `tick_label_position` can be set to either 'outside' (default) or 'inside' depending on whether the labels should be displayed inside or outside the plot area.

`tick_label_formatter`

> By default, tick labels are assumed to be floating point numbers, and are displayed as such after removing trailing zeros and the decimal dot if necessary (e.g., '10.000' will be displayed as '10', and '21.10' as '21.1'). The default behavior can be changed by setting `tick_label_formatter` to a callable that takes the value of the tick label and returns a formatted string.

`tick_interval`, `tick_generator`,

> Locations and distances of ticks are controlled by the attribute `tick_generator`
>
> Default is chaco.ticks.auto_ticks or chaco.ticks.log_auto_ticks

Events updated

Fired when the axis's range bounds change.

Legend

Grid TODO: find out how the selection features are organized

TODO: to see how these elements collaborate to build an interactive plot, give complete low-level example of line plot with simple tool and describe the exchange of information

Tools

before axes (axes are overlays) tools, overlays

Plotting with Chaco

The Plot class

Plot and PlotData

chaco.shell

Low-level Chaco plotting

1. create instances of PlotRenderer and add them to a Container. There are factory functions in plot_factory that make it simpler
2. Create a Plot instance, use methods to create new plots of different kinds. This automatizes 1) with an OverlayPlotContainer, i.e., it plots multiple curves on the same element

Plots can be rendered in a traitsui, wx, or qt window

Embedding Chaco plots

Traits UI

WxPython

Qt/PyQt

1.3.2 Plot types

This section gives an overview of individual plot classes in Chaco. It is divided in three parts: the first part lists all plot classes implementing the *X-Y plots* interface, the second all plot classes implementing the *2D plots* interface, and finally a part collecting all plot types that do not fall in either category. See the *section on plot renderers* for a detailed description of the methods and attributes that are common to all plots.

The code to generate the figures in this section can be found in the path `tutorials/user_guide/plot_types/` in the examples directory.

For more complete examples, see also the *annotated examples* page.

X-Y Plot Types

These plots display information in a two-axis coordinate system and are subclasses of `BaseXYPlot`.

The common interface for X-Y plots is described in *X-Y Plots interface*.

Line Plot

Standard line plot implementation. The aspect of the line is controlled by the parameters

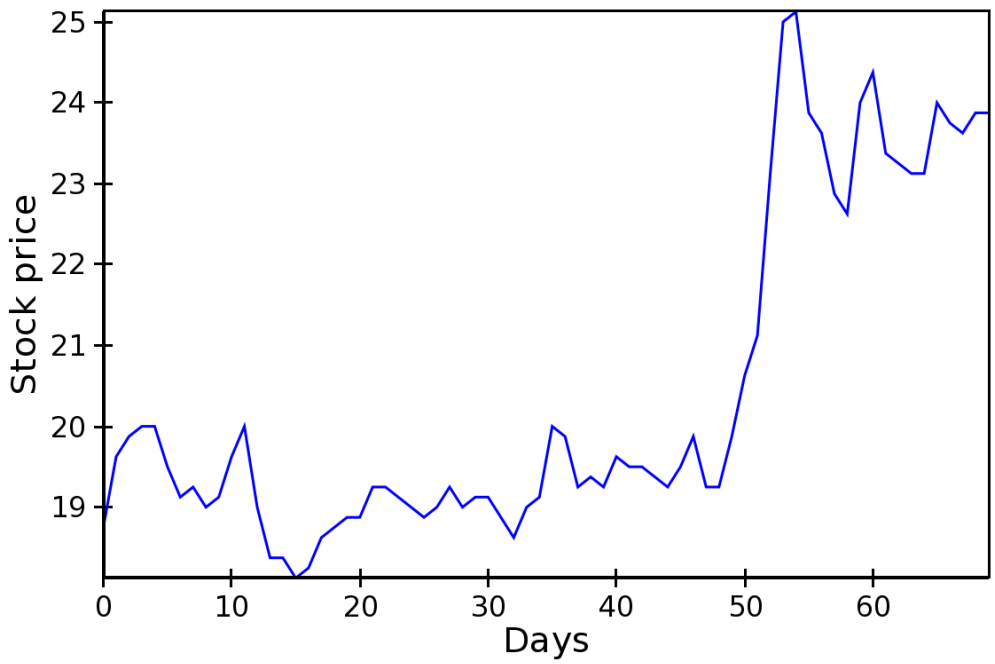
`line_width` The width of the line (default is 1.0)

`line_style` The style of the line, one of 'solid' (default), 'dot dash', 'dash', 'dot', or 'long dash'.

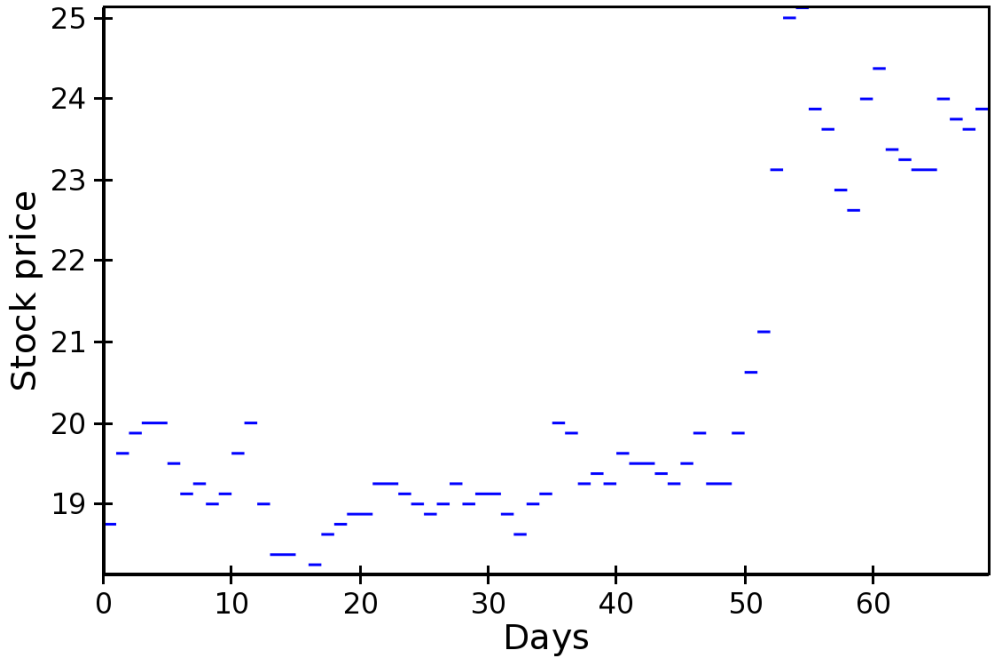
`render_style` The rendering style of the line plot, one of 'connectedpoints' (default), 'hold', or 'connectedhold'

These images illustrate the differences in rendering style:

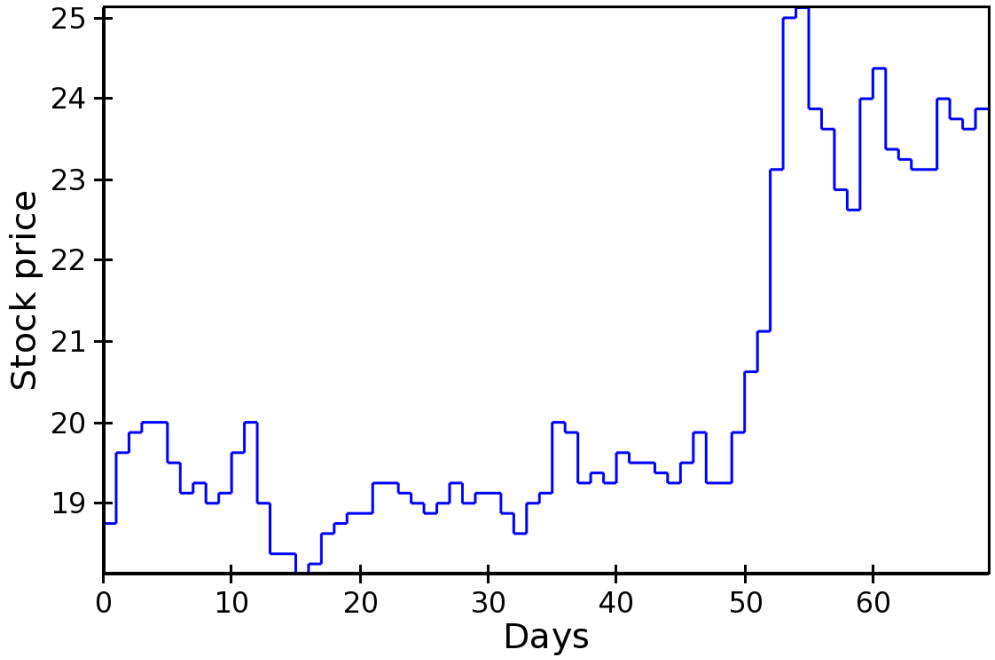
- `renderstyle='connectedpoints'`



- `renderstyle='hold'`



- `renderstyle='connectedhold'`



Scatter Plot

Standard scatter plot implementation. The aspect of the markers is controlled by the parameters

marker The marker type, one of 'square'(default), 'circle', 'triangle', 'inverted_triangle', 'plus', 'cross', 'diamond', 'dot', or 'pixel'. One can also define a new marker shape by setting this parameter to 'custom', and set the `custom_symbol` parameter to a `CompiledPath` instance (see the file `demo/basic/scatter_custom_marker.py` in the Chaco examples directory).

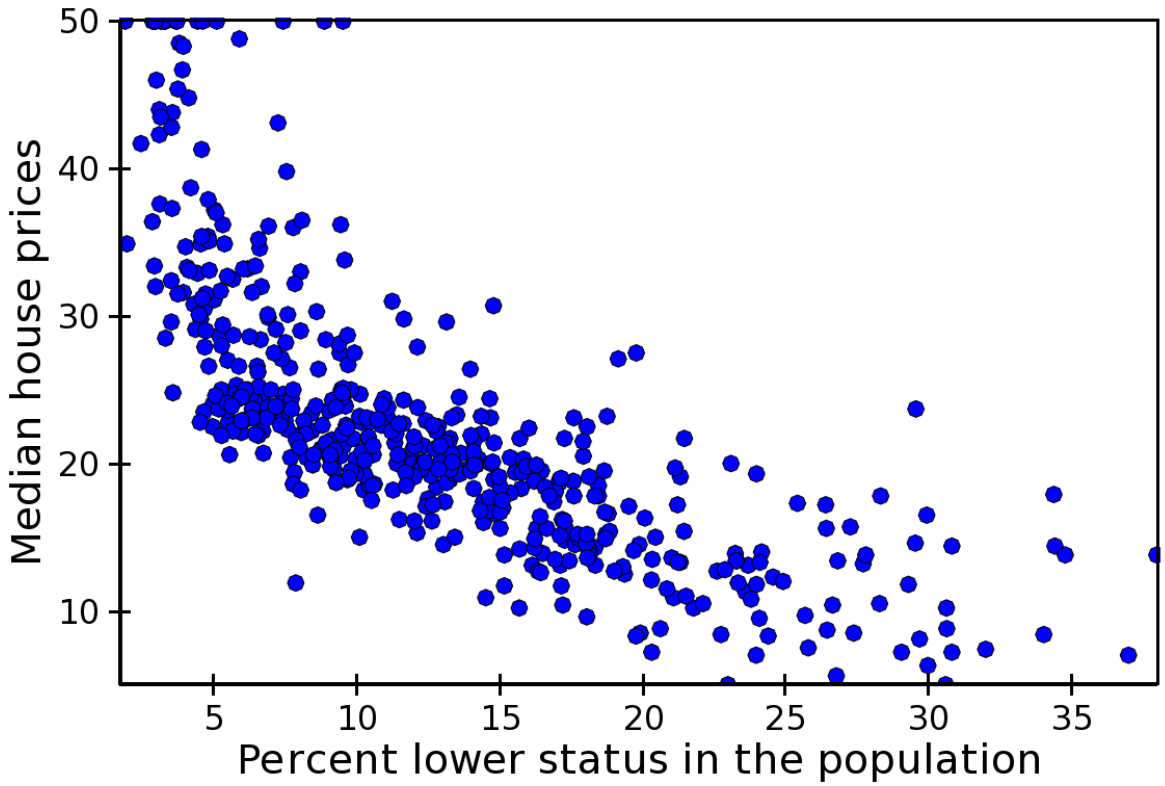
marker_size Size of the marker in pixels, not including the outline. This can be either a scalar (default is 4.0), or an array with one size per data point.

line_width Width of the outline around the markers (default is 1.0). If this is 0.0, no outline is drawn.

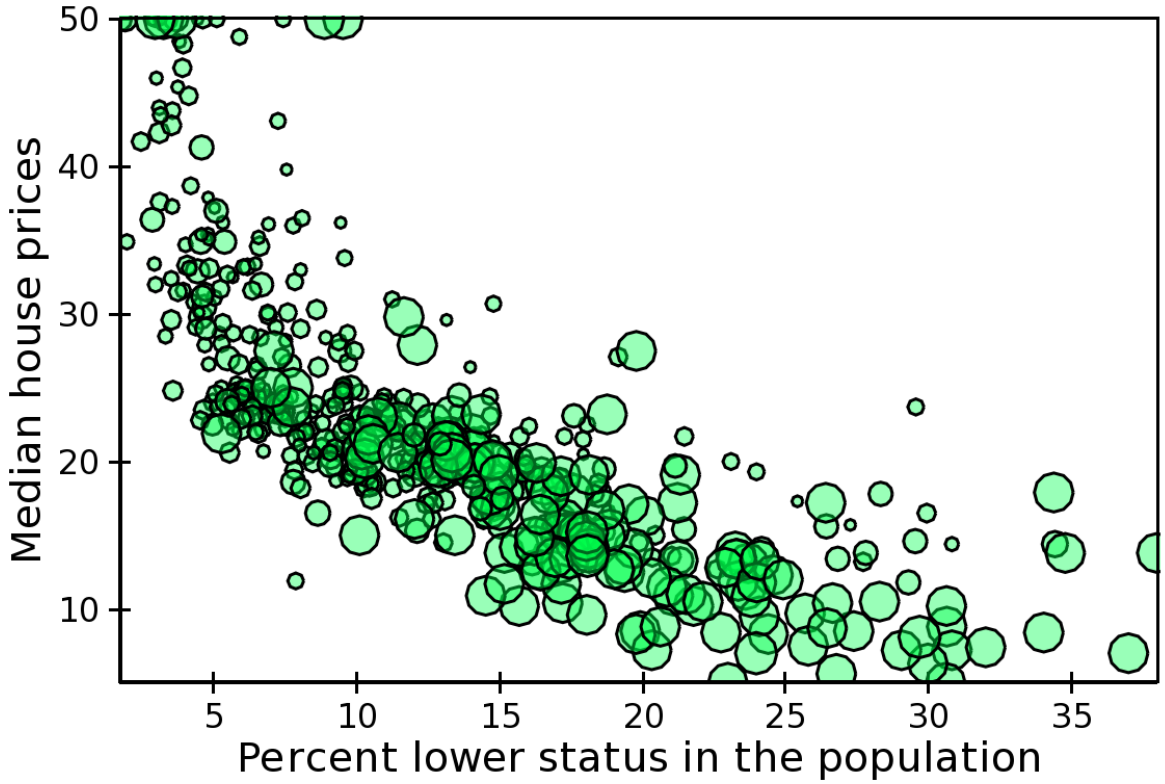
color The fill color of the marker (default is black).

outline_color The color of the outline to draw around the marker (default is black).

This is an example with fixed point size:



The same example, using marker size to map property-tax rate (larger is higher):



Colormapped Scatter Plot

Colormapped scatter plot. Additional information can be added to each point by setting a different color.

The color information is controlled by the `color_data` data source, and the `color_mapper` mapper. A large number of ready-to-use color maps are defined in the module `chaco.default_colormaps`.

In addition to the parameters supported by a *scatter plot*, a colormapped scatter plot defines these attributes:

`fill_alpha` Set the alpha value of the points.

`render_method` Set the sequence in which the points are drawn. It is one of

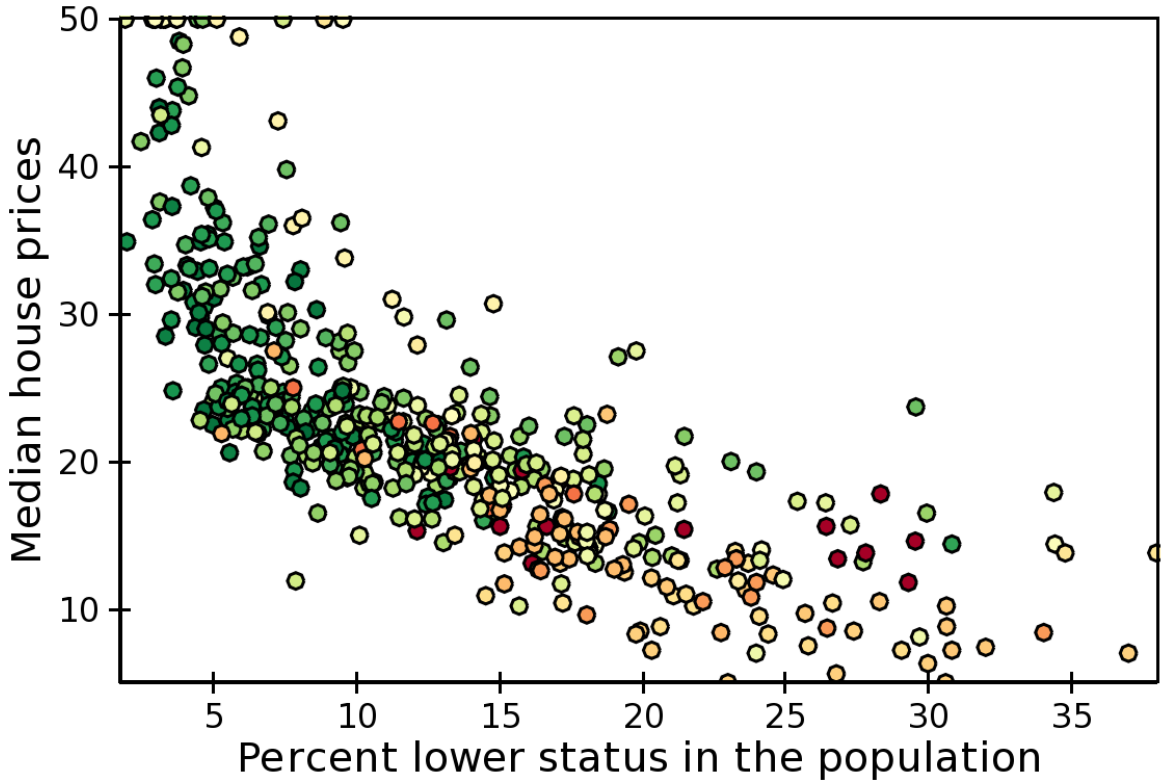
'banded' draw points by color band; this is more efficient but some colors will appear more prominently if there are a lot of overlapping points

'bruteforce' set the stroke color before drawing each marker

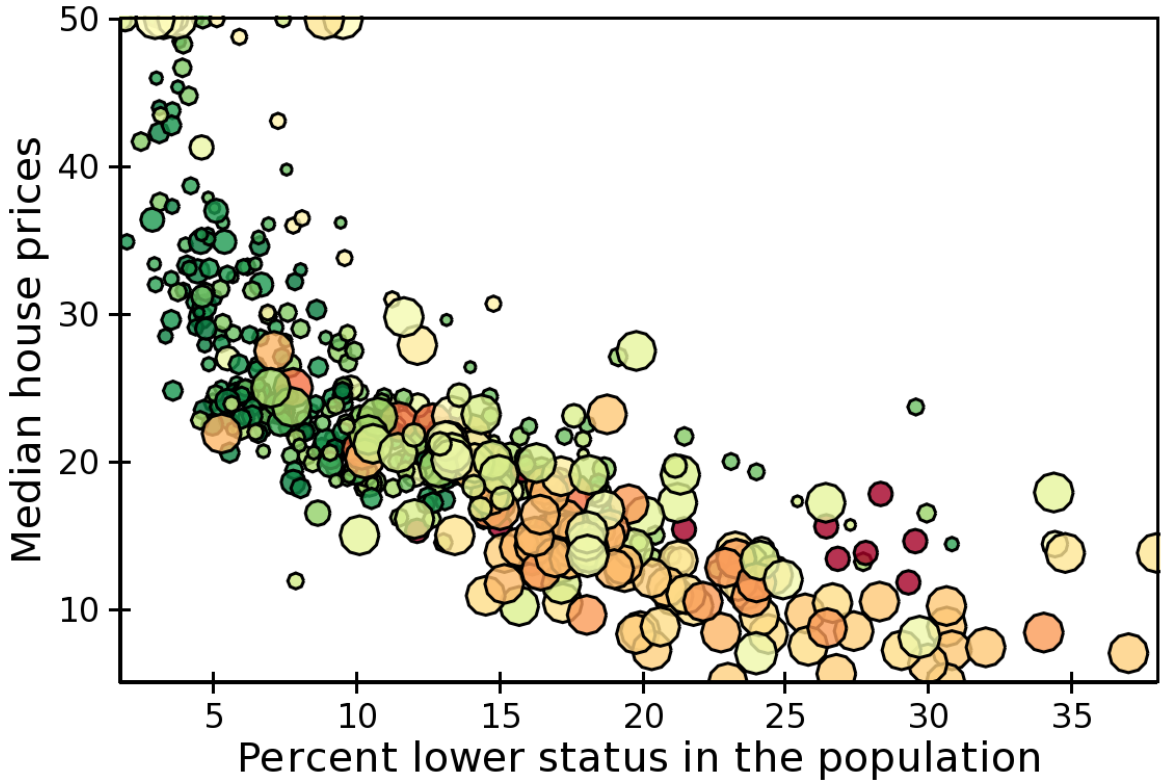
'auto' (default) the approach is selected based on the number of points

In practice, there is not much performance difference between the two methods.

In this example plot, color represents nitric oxides concentration (green is low, red is high):



Using X,Y, color, and size we can display 4 variables at the time. In this example, color is again, and size is nitric oxides concentration:



Candle Plot

A candle plot represents summary statistics of distribution of values for a set of discrete items. Each distribution is characterized by a central line (usually representing the mean), a bar (usually representing one standard deviation around the mean or the 10th and 90th percentile), and two stems (usually indicating the maximum and minimum values).

The positions of the centers, and of the extrema of the bar and stems are set with the following data sources

`center_values` Value of the centers. It can be set to `None`, in which case the center is not plotted.

`bar_min` and `bar_max` Lower and upper values of the bar.

`min_values` and `max_values` Lower and upper values of the stem. They can be set to `None`, in which case the stems are not plotted.

It is possible to customize the appearance of the candle plot with these parameters

`bar_color` (alias of `color`) Fill color of the bar (default is black).

`bar_line_color` (alias of `outline_color`) Color of the box forming the bar (default is black).

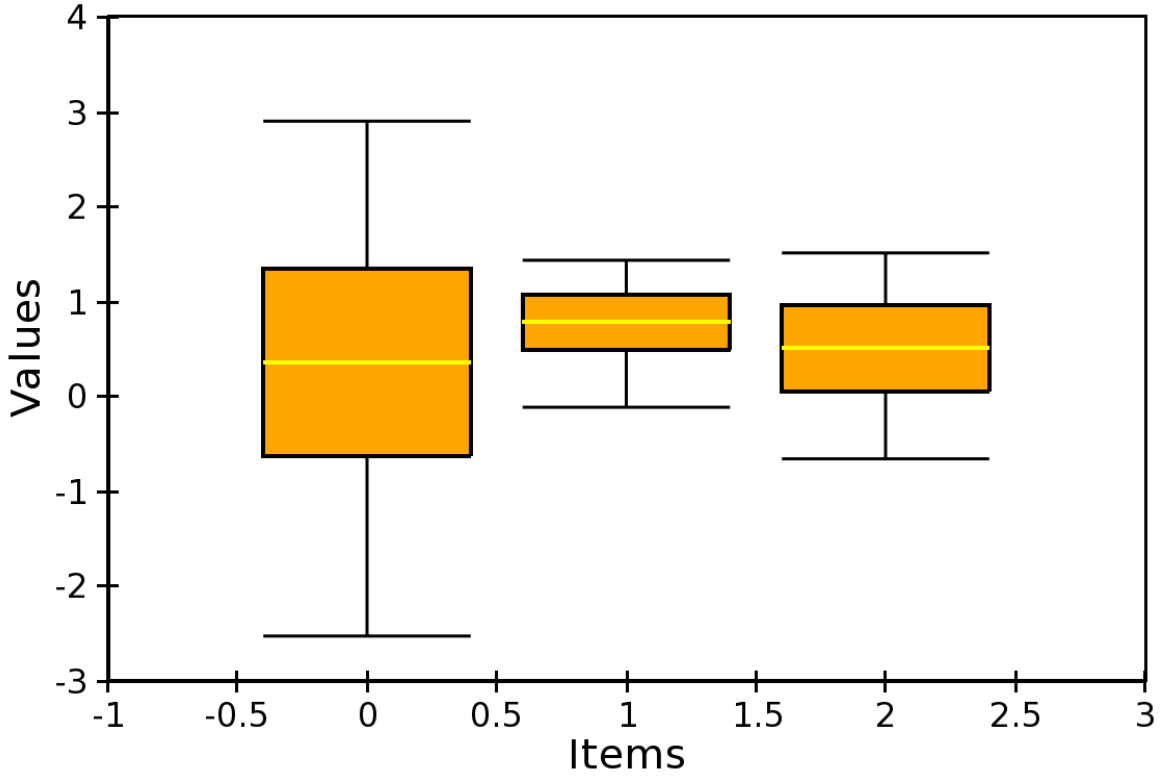
`center_color` Color of the line indicating the center. If `None`, it defaults to `bar_line_color`.

`stem_color` Color of the stems and endcaps. If `None`, it defaults to `bar_line_color`.

`line_width`, `center_width`, and `stem_width` Thickness in pixels of the lines drawing the corresponding elements. If `None`, they default to `line_width`.

`end_cap` If `False`, the end caps are not plotted (default is `True`).

At the moment, it is not possible to control the width of the central bar and end caps.



Errorbar Plot

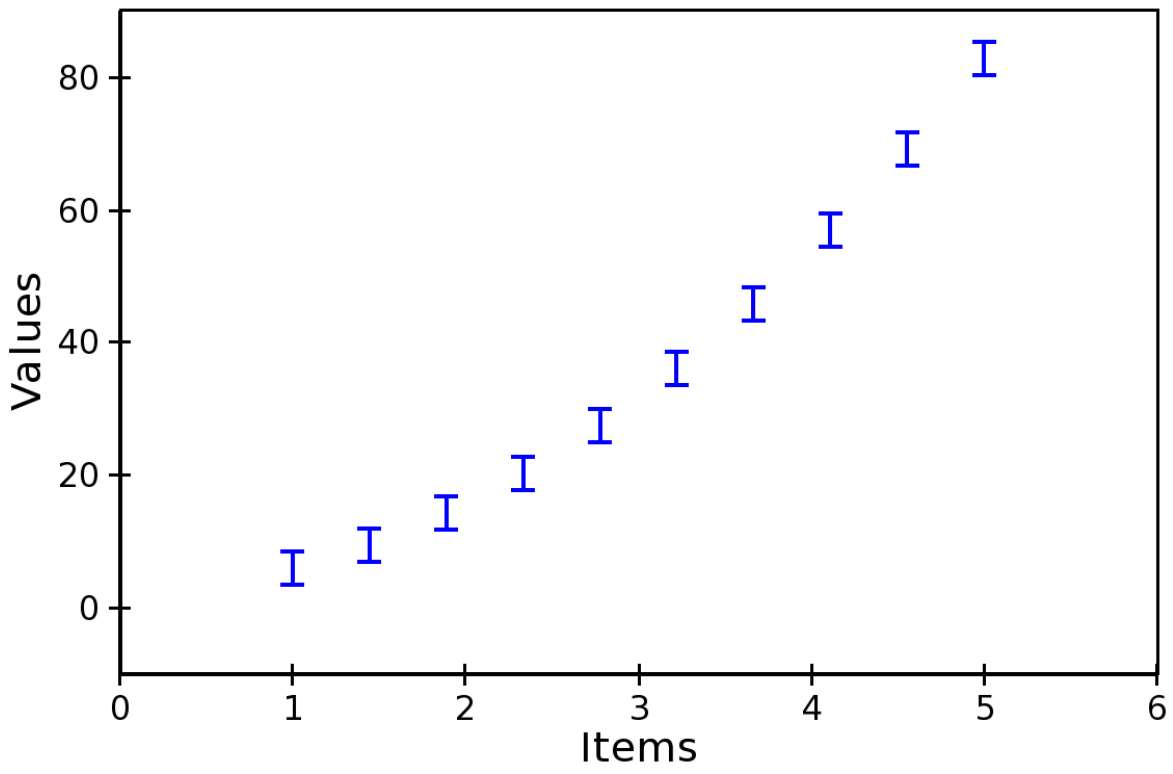
A plot with error bars. Note that `ErrorBarPlot` only plots the error bars, and needs to be combined with a `LinePlot` if one would like to have a line connecting the central values.

The positions of the extrema of the bars are set by the data sources `value_low` and `value_high`.

In addition to the parameters supported by a *line plot*, an errorbar plot defines these attributes:

`endcap_size` The width of the endcap bars in pixels.

`endcap_style` Either 'bar' (default) or 'none', in which case no endcap bars are plotted.



Filled Line Plot

A line plot filled with color to the axis.

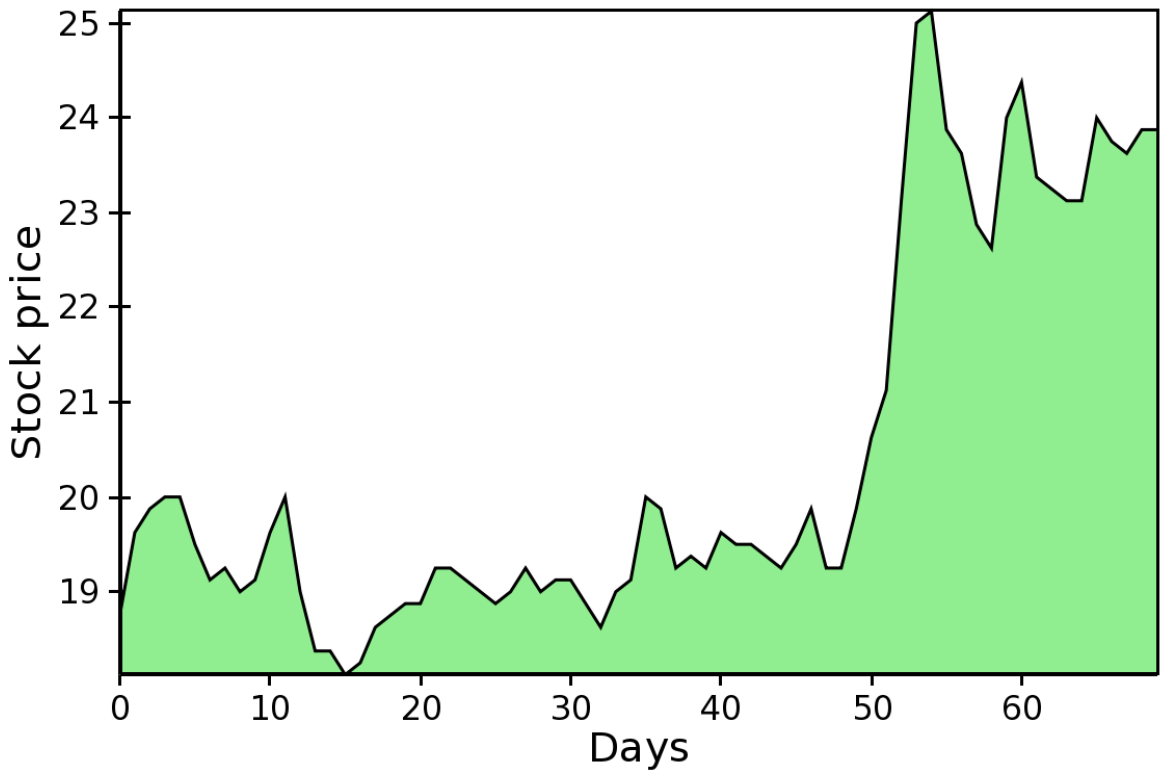
`FilledLinePlot` defines the following parameters:

`fill_color` The color used to fill the plot.

`fill_direction` Fill the plot toward the origin ('down', default) ot towards the axis maximum ('up').

`render_style` The rendering style of the line plot, one of 'connectedpoints' (default), 'hold', or 'connectedhold' (see *line plot* for a description of the different rendering styles).

`FilledLinePlot` is a subclass of `PolygonPlot`, so to set the thickness of the plot line one should use the parameter `edge_width` instead of `line_width`.



Multi-line Plot

A line plot showing multiple lines simultaneously.

The values of the lines are given by an instance of `MultiArrayDataSource`, but the lines are rescaled and displaced vertically so that they can be compared without crossing each other.

The relative displacement and rescaling of the lines is controlled by these attributes of `MultiLinePlot`:

`index`

The usual array data source for the index data.

`yindex`

Array data source for the starting point of each line. Typically, this is set to `numpy.arange(n_lines)`, so that each line is displaced by one unit from the others (the other default parameters are set to work well with this arrangement).

`use_global_bounds`, `global_min`, `global_max`,

These attributes are used to compute an "amplitude scale" which that the largest trace deviation from its base y-coordinate will be equal to the y-coordinate spacing.

If `use_global_bounds` is set to False, the maximum of the absolute value of the full data is used as the largest trace deviation. Otherwise, the largest between the absolute value of `global_min` and `global_max` is used instead.

By default, `use_global_bounds` is set to False and `global_min` and `global_max` to 0.0, which means that one of these value has to be set to create a meaningful plot.

`scale`, `offset`, `normalized_amplitude`

In addition to the rescaling done using the global bounds (see above), each line is individually scaled by `normalized_amplitude` (by default this is -0.5, but is normally it should be something like 1.0). Finally, all the lines are moved by `offset` and multiplied by `scale` (default are 0.0 and 1.0, respectively).

`MultiLinePlot` also defines the following parameters:

`line_width`, `line_style`

Control the thickness and style of the lines, as for *line plots*.

`color`, `color_func`

If `color_func` is None, all lines have the color defined in `color`. Otherwise, `color_func` is a function (or, more in general, a callable) that accept a single argument corresponding to the index of the line and returns a RGBA 4-tuple.

`fast_clip`

If True, traces whose *base* y-coordinate is outside the value axis range are not plotted, even if some of the data in the curve extends into the plot region. (Default is False)

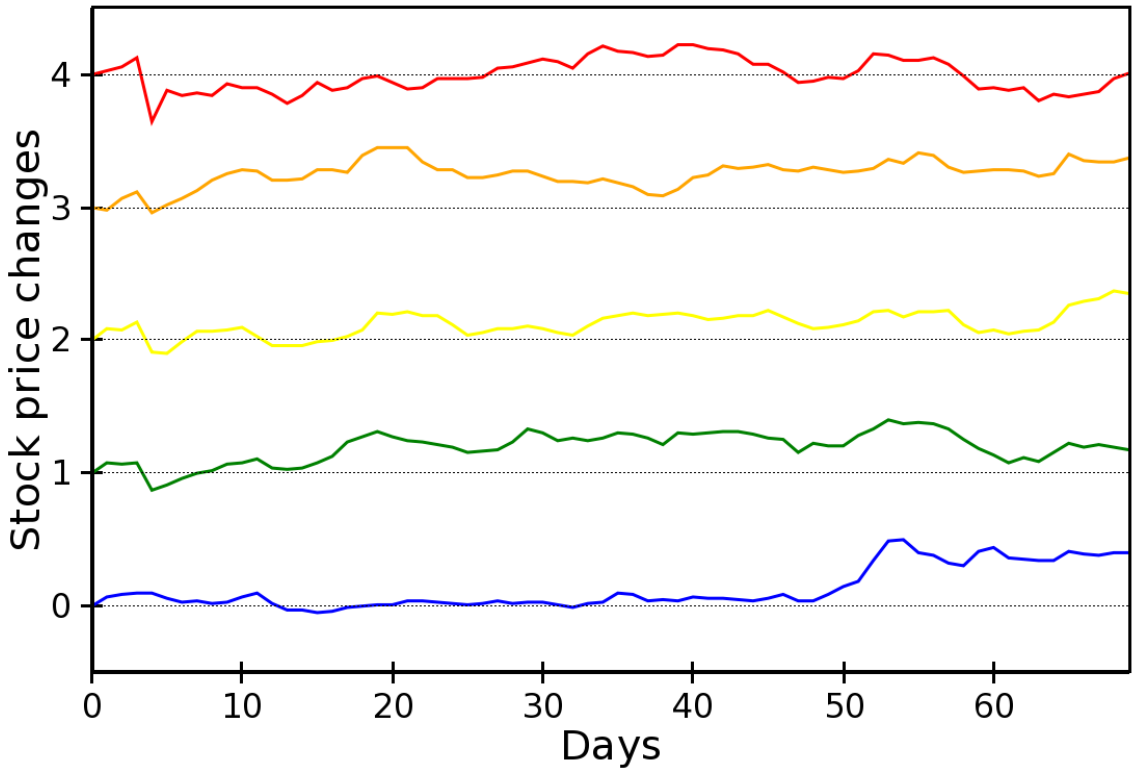


Image and 2D Plots

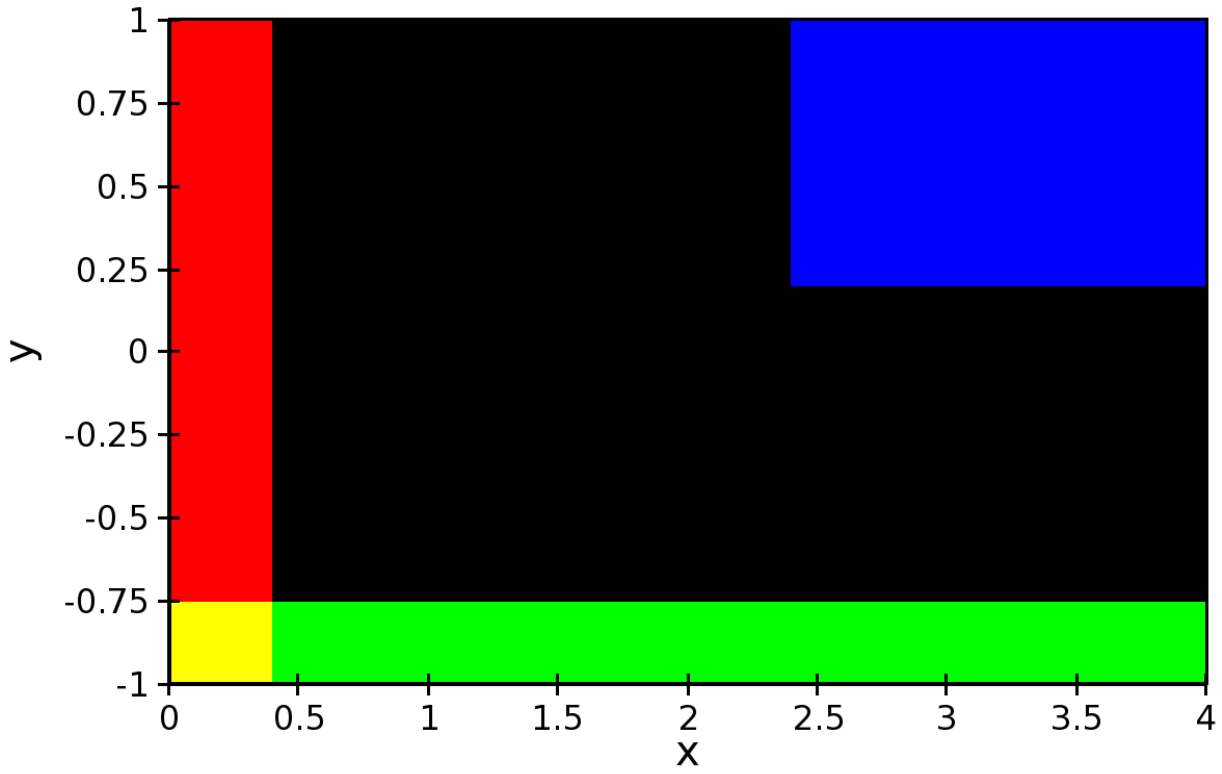
These plots display information as a two-dimensional image. Unless otherwise stated, they are subclasses of `Base2DPlot`.

The common interface for 2D plots is described in *2D Plots interface*.

Image Plots

Plot image data, provided as RGB or RGBA color information. If you need to plot a 2D array as an image, use a *colormapped scalar plot*

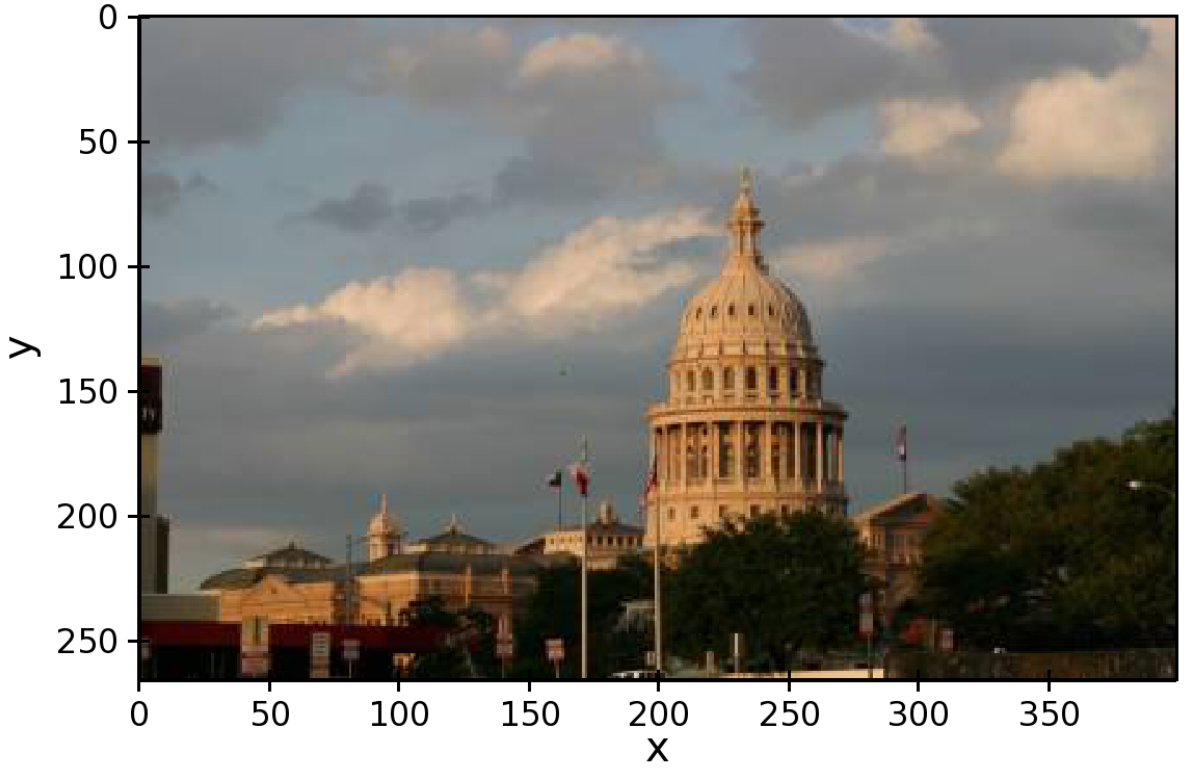
In an `ImagePlot`, the `index` attribute corresponds to the data coordinates of the pixels (often a `GridDataSource`). The `index_mapper` maps the data coordinates to screen coordinates (typically using a `GridMapper`). The *value* is the image itself, wrapped into the data source class `ImageData`.



A typical use case is to display an image loaded from a file. The preferred way to do this is using the factory method `from_file()` of the class `ImageData`. For example:

```
image_source = ImageData.fromfile('capitol.jpg')

w, h = image_source.get_width(), image_source.get_height()
index = GridDataSource(np.arange(w), np.arange(h))
index_mapper = GridMapper(range=DataRange2D(low=(0, 0),
                                            high=(w-1, h-1)))

image_plot = ImagePlot(
    index=index,
    value=image_source,
    index_mapper=index_mapper,
    origin='top left',
    **PLOT_DEFAULTS
)
```

The code above displays this plot:



Colormapped Scalar Plot

Plot a scalar field as an image. The image information is given as a 2D array; the scalar values in the 2D array are mapped to colors using a color map.

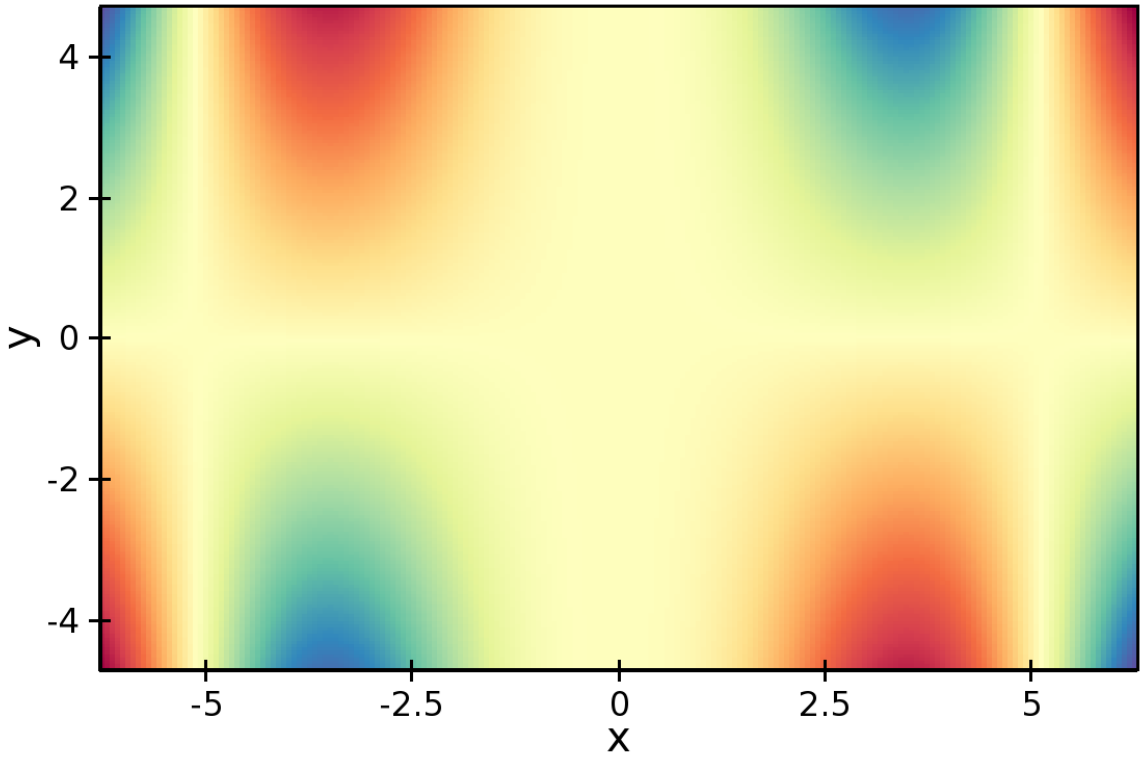
The basic class for colormapped scalar plots is `CMapImagePlot`. As in *image plots*, the `index` attribute corresponds to the data coordinates of the pixels (a `GridDataSource`), and the `index_mapper` maps the data coordinates to screen coordinates (a `GridMapper`). The scalar data is passed through the `value` attribute as an `ImageData` source. Finally, a color mapper maps the scalar data to colors. The module `chaco.default_colormaps` defines many ready-to-use colormaps.

For example:

```
xs = np.linspace(-2 * np.pi, +2 * np.pi, NPOINTS)
ys = np.linspace(-1.5*np.pi, +1.5*np.pi, NPOINTS)
x, y = np.meshgrid(xs, ys)
z = scipy.special.jn(2, x)*y*x

index = GridDataSource(xdata=xs, ydata=ys)
index_mapper = GridMapper(range=DataRange2D(index))

color_source = ImageData(data=z, value_depth=1)
color_mapper = dc.Spectral(DataRange1D(color_source))

cmap_plot = CMapImagePlot(
    index=index,
    index_mapper=index_mapper,
    value=color_source,
```

```
    value_mapper=color_mapper,
    **PLOT_DEFAULTS
)
```

This creates the plot:



Contour Plots

Contour plots represent a scalar-valued 2D function, z = f(x, y), as a set of contours connecting points of equal value.

Contour plots in Chaco are derived from the base class `BaseContourPlot`, which defines these common attributes:

`levels` `levels` is used to define the values for which to draw a contour. It can be either a list of values (floating point numbers); a positive integer, in which case the range of the value is divided in the given number of equally spaced levels; or "auto" (default), which divides the total range in 10 equally spaced levels

`colors` This attribute is used to define the color of the contours. `colors` can be given as a color name, in which case all contours have the same color, as a list of colors, or as a colormap. If the list of colors is shorter than the number of levels, the values are repeated from the beginning of the list. If left unspecified, the contours are plot in black. Colors are associated with levels of increasing value.

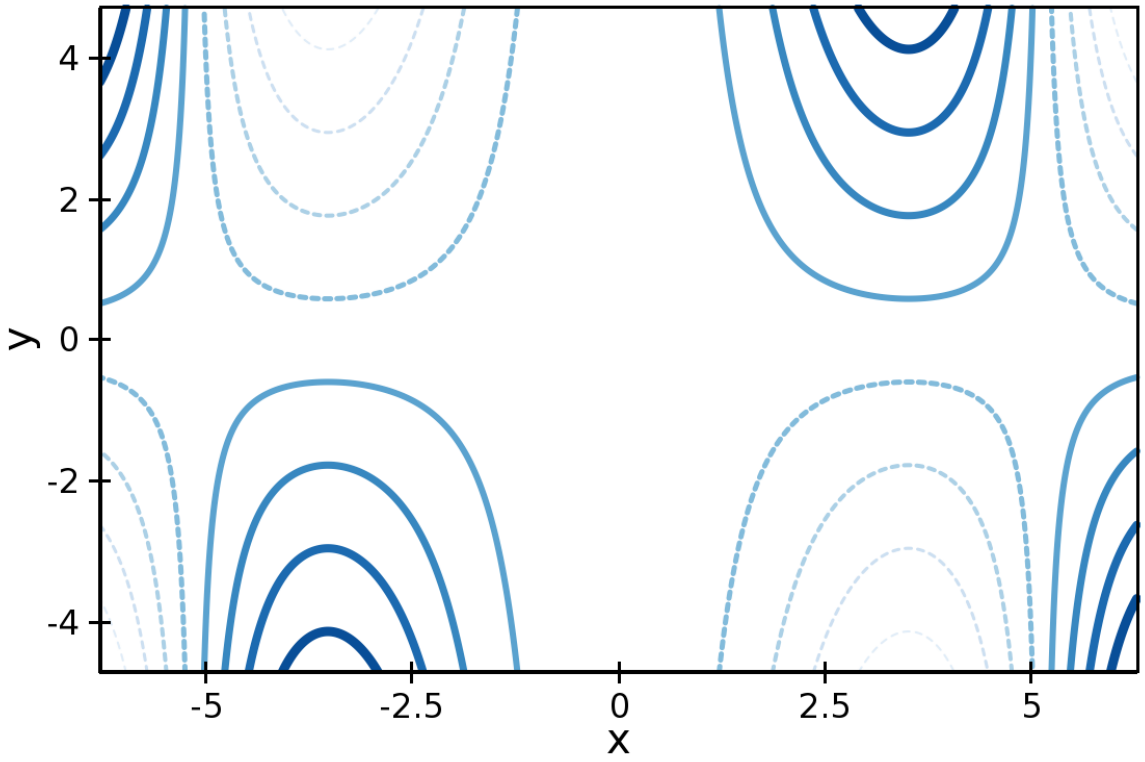
`color_mapper` If present, the color mapper for the colorbar. TODO: not sure how it works

`alpha` Global alpha level for all contours.

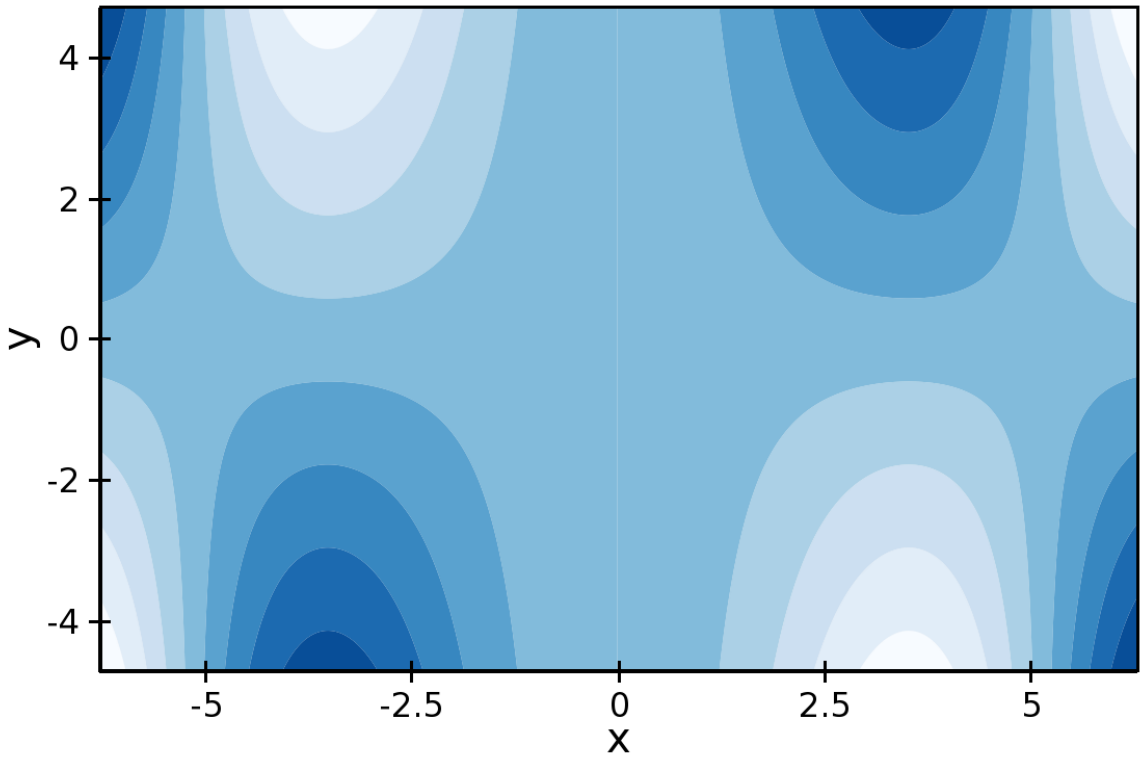
Contour Line Plot Draw a contour plots as a set of lines. In addition to the attributes in `BaseContourPlot`, `ContourLinePlot` defines the following parameters:

widths The thickness of the contour lines. It can be either a scalar value, valid for all contour lines, or a list of widths. If the list is too short with respect to the number of contour lines, the values are repeated from the beginning of the list. Widths are associated with levels of increasing value.

styles The style of the lines. It can either be a string that specifies the style for all lines (allowed styles are 'solid', 'dot dash', 'dash', 'dot', or 'long dash'), or a list of styles, one for each line. If the list is too short with respect to the number of contour lines, the values are repeated from the beginning of the list. The default, 'signed', sets all lines corresponding to positive values to the style given by the attribute `positive_style` (default is 'solid'), and all lines corresponding to negative values to the style given by `negative_style` (default is 'dash').



Filled contour Plot Draw a contour plot as a 2D image divided in regions of the same color. The class `ContourPolyPlot` inherits all attributes from `BaseContourPlot`.



Polygon Plot

Draws a polygon given the coordinates of its corners.

The x-coordinate of the corners is given as the `index` data source, and the y-coordinate as the `value` data source. As usual, their values are mapped to screen coordinates by `index_mapper` and `value_mapper`.

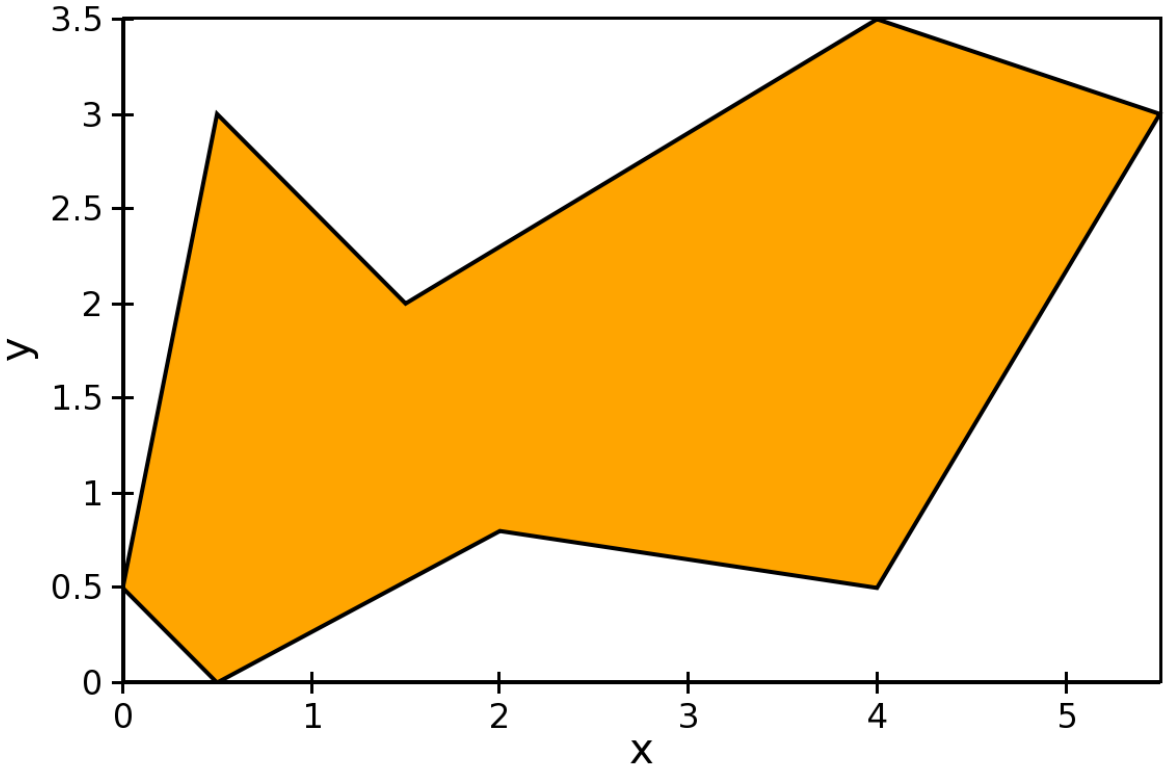
In addition, the class `PolygonPlot` defines these parameters:

`edge_color` The color of the line on the edge of the polygon (default is black).

`edge_width` The thickness of the edge of the polygon (default is 1.0).

`edge_style` The line dash style for the edge of the polygon, one of 'solid' (default), 'dot dash', 'dash', 'dot', or 'long dash'.

`face_color` The color of the face of the polygon (default is transparent).



Other Plot Types

This section collects all plots that do not fall in the previous two categories.

Bar Plot

Draws a set of rectangular bars, mostly used to plot histograms.

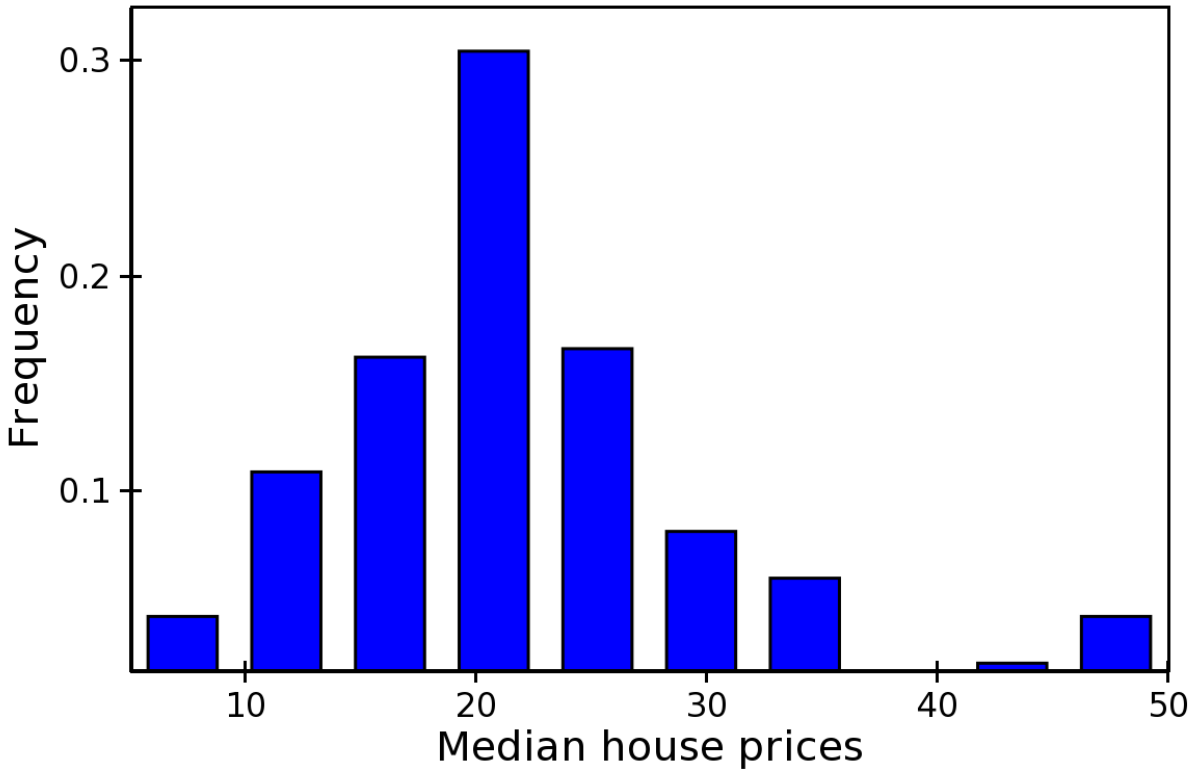
The class `BarPlot` defines the attributes of regular X-Y plots, plus the following parameters:

`sorting_value` While `value` is a data source defining the upper limit of the bars, `sorting_value` can be used to define their bottom limit. Default is 0. (Note: "upper" and "bottom" assume a horizontal for the plot.)

`bar_width_type` Determines how to interpret the `bar_width` parameter. If 'data' (default', the width is given in the units along the index dimension of the data space. If 'screen', the width is given in pixels.

`bar_width` The width of the bars (see `bar_width_type`).

`fill_color` The color of the bars.



Quiver Plot

This is a kind of *scatter plot* which draws an arrow at every point. It can be used to visualize 2D vector fields.

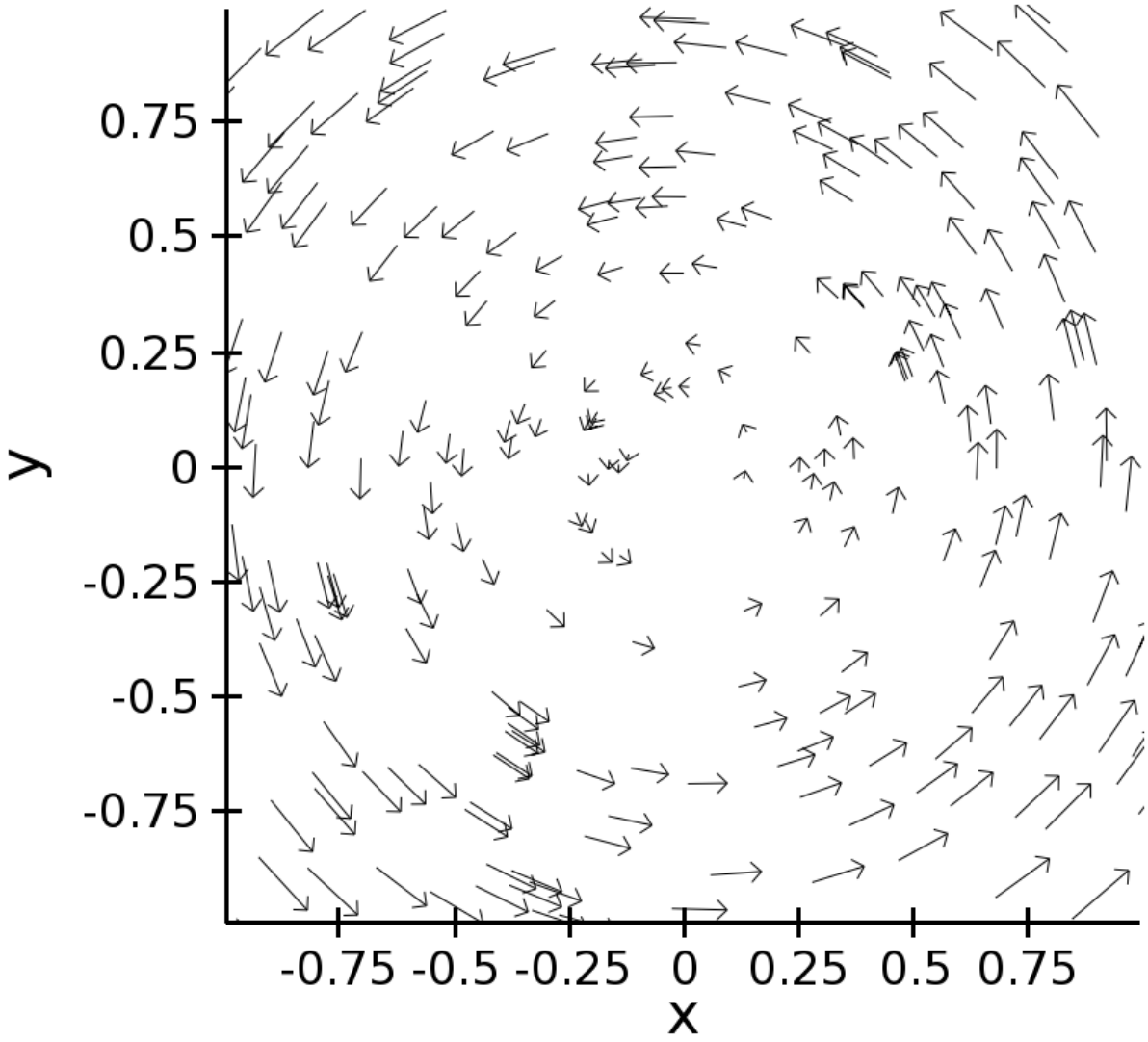
The information about the vector sizes is given through the data source `vectors`, which returns an Nx2 array. Usually, `vectors` is an instance of `MultiArrayDataSource`.

`QuiverPlot` defines these parameters:

`line_width` Width of the lines that trace the arrows (default is 1.0).

`line_color` The color of the arrows (default is black).

`arrow_size` The length of the arrowheads in pixels.



Polar Plot

Display a line plot in polar coordinates.

The implementation at the moment is at a proof-of-concept stage. The class `PolarLineRenderer` relies on `PolarMapper` to map polar to cartesian coordinates, and adds circular polar coordinate axes.

Warning: At the moment, `PolarMapper` does not do a polar to cartesian mapping, but just a linear mapping. One needs to do the transformation by hand.

The aspect of the polar plot can be controlled with these parameters:

`line_width` Width of the polar plot line (default is 1.0).

`line_style` The style of the line, one of 'solid' (default), 'dot dash', 'dash', 'dot', or 'long dash'.

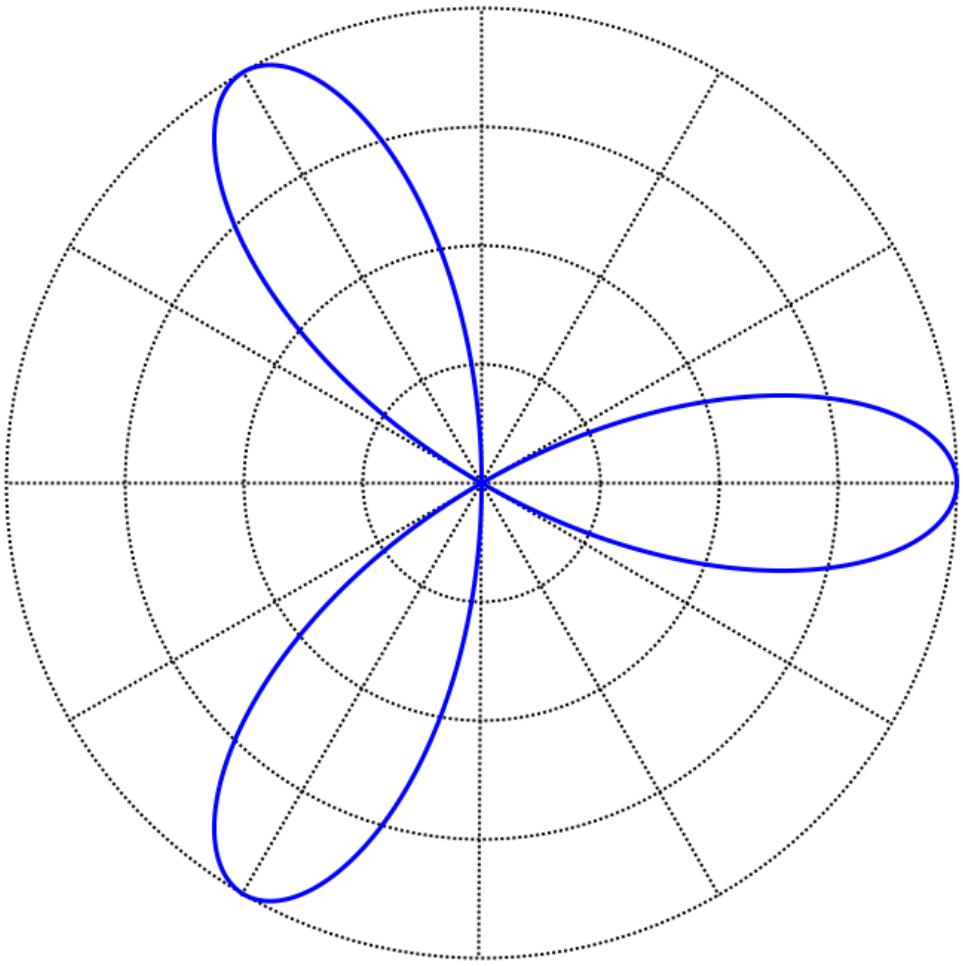
color The color of the line.

grid_style The style of the lines composing the axis, one of 'solid','dot dash', 'dash', 'dot' (default), or 'long dash'.

grid_visible If True (default), the circular part of the axes is drawn.

origin_axis_visible If True (default), the radial part of the axes is drawn.

origin_axis_width Width of the radial axis in pixels (default is 2.0).



Jitter Plot

A plot showing 1D data by adding a random jitter around the main axis. It can be useful for visualizing dense collections of points. This plot has got a single mapper, called `mapper`.

Useful parameters are:

jitter_width The size, in pixels, of the random jitter around the axis.

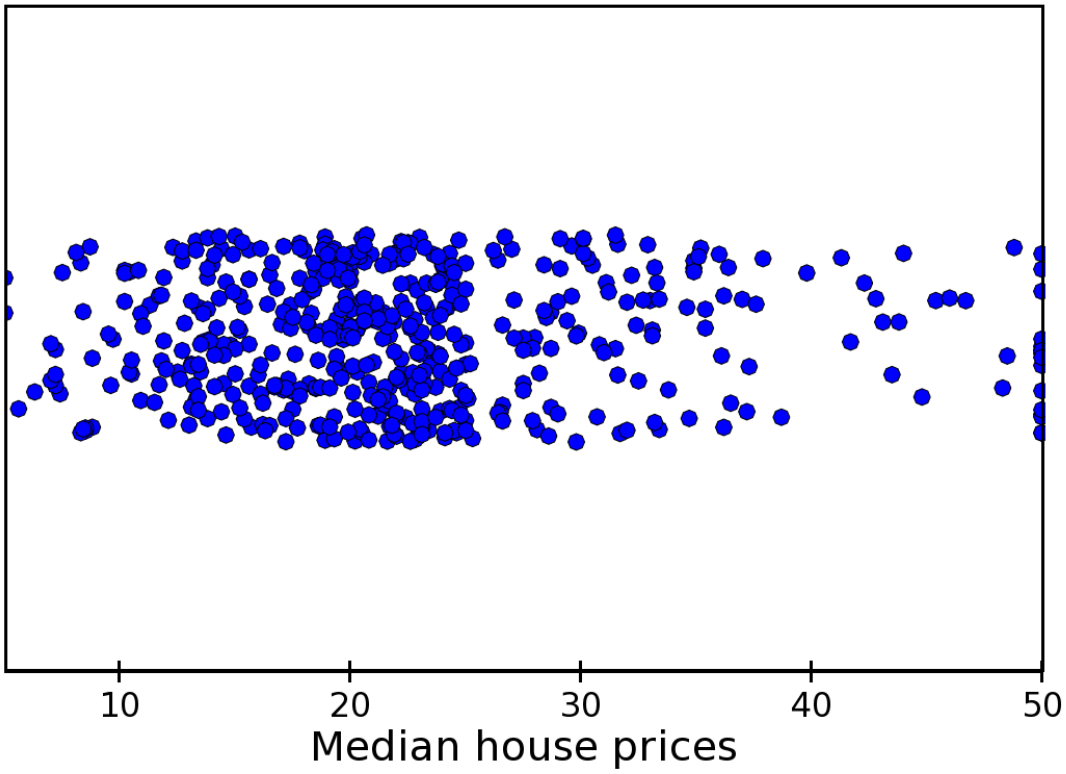
marker The marker type, one of 'square'(default), 'circle', 'triangle', 'inverted_triangle', 'plus', 'cross', 'diamond', 'dot', or 'pixel'. One can also define a new marker shape by setting this parameter to 'custom', and set the `custom_symbol` parameter to a `CompiledPath` instance (see the file `demo/basic/scatter_custom_marker.py` in the Chaco examples directory).

marker_size Size of the marker in pixels, not including the outline (default is 4.0).

line_width Width of the outline around the markers (default is 1.0). If this is 0.0, no outline is drawn.

color The fill color of the marker (default is black).

outline_color The color of the outline to draw around the marker (default is black).



TODO: add description of color bar class

1.3.3 Containers and Layout

Chaco containers

It is quite common to need to display multiple data side by side. In order to arrange plots and other components (e.g., colorbars, legends) in a single panel, Chaco uses *containers* to organize the layout.

Chaco implements 4 different containers: *HPlotContainer and VPlotContainer*, *GridPlotContainer*, and *OverlayPlotContainer*.

All containers are derived from the base class `BasePlotContainer`, and share a common interface:

- `__init__(*components, **parameters)` (constructor of the container object): The constructor of a plot container takes a sequence of components, which are added to the container itself, and a set of keyword

arguments, which are used to initialize the parameters of the container. For example:

```
container = HPlotContainer(scatter_plot, line_plot, spacing=100)
```

creates a container with horizontal layout containing two plots (`scatter_plot` and `line_plot`), with a spacing of 100 pixels between them.

- `add(*components)`: Append ore or more plots to the ones already present in the container. For example, this is equivalent to the code above:

```
container = HPlotContainer(spacing=100)
container.add(line_plot, scatter_plot)
```

- `remove(self, *components)`: Remove a sequence of components from the container
- `insert(index, component)`: Inserts a component at a specific position in the components list

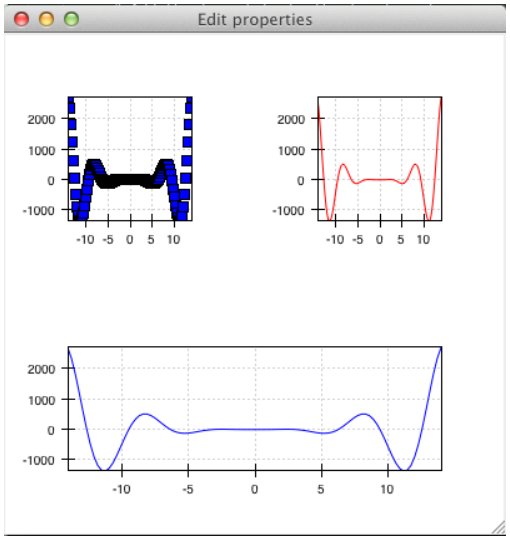
---

Note: **Each plot can have only one container**, so adding the same plot to a second container will remove it from the first one. In the same way, adding the same plot multiple times will not have create multiple copies. Instead, one should create multiple plots objects.

E.g., this code:

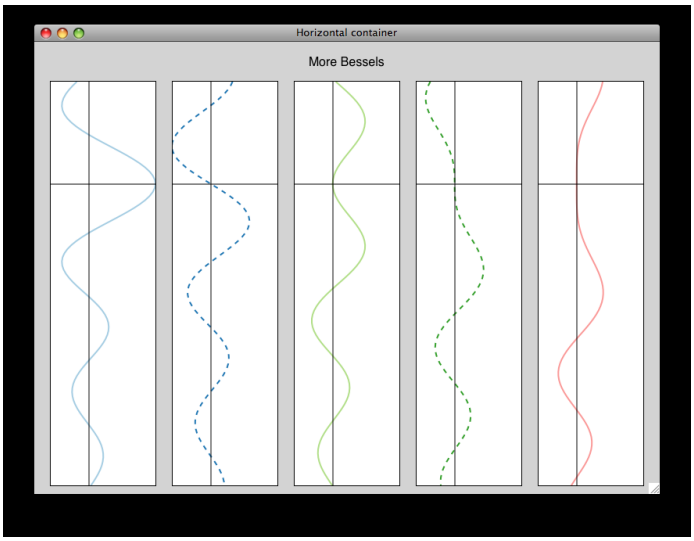
```
# Create a vertical container containing two horizontal containers
h_container1 = HPlotContainer()
h_container2 = HPlotContainer()
outer_container = VPlotContainer(h_container1, h_container2,
                                 stack_order="top_to_bottom")

# Add the three plots to the first container
h_container1.add(scatter_plot, line_plot1, line_plot2)

# Now add the first line plot to the second container => it is removed
# from the first, as each plot can only have one container
h_container2.add(line_plot1)
```

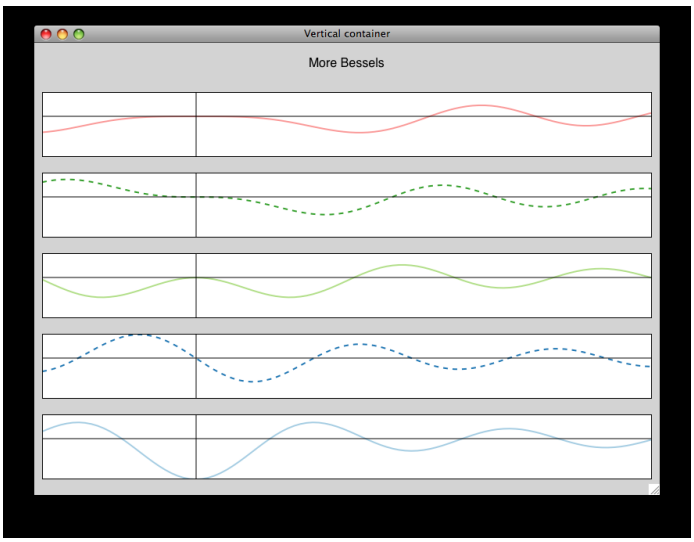
results in this layout:



HPlotContainer and VPlotContainer

`HPlotContainer` and `VPlotContainer` display a set of components in an horizontal and vertical stack, respectively, as shown in these simple examples:



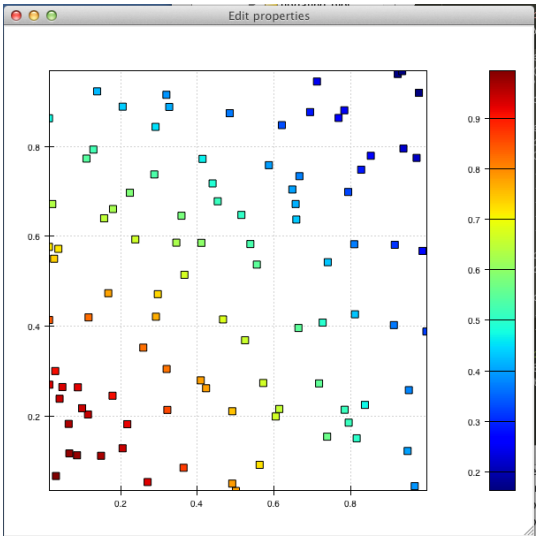


In both cases, a series of line plots and scatter plots is added to an `HPlotContainer` or a `VPlotContainer`:

```
# Create the data and the PlotData object
x = linspace(-14, 14, 100)
y = sin(x) * x**3
plotdata = ArrayPlotData(x = x, y = y)

# Create a scatter plot
scatter_plot = Plot(plotdata)
scatter_plot.plot(("x", "y"), type="scatter", color="blue")

# Create a line plot
line_plot = Plot(plotdata)
line_plot.plot(("x", "y"), type="line", color="blue")

# Create a horizontal container and put the two plots inside it
```

```
container = HPlotContainer(line_plot, scatter_plot)
self.plot = container
```

`HPlotContainer` is also used often to display a colorbar or legend to the side of a plot. For example, this plot



was created using a color-mapped scatter plot and a colorbar inside a horizontal container:

```
# Create the plot
plot = Plot(data)
plot.plot(("index", "value", "color"), type="cmap_scatter",
          color_mapper=jet)

# Create the colorbar, handing in the appropriate range and colormap
colormap = plot.color_mapper
colorbar = ColorBar(index_mapper=LinearMapper(range=colormap.range),
                    color_mapper=colormap,
                    orientation='v',
                    resizable='v',
                    width=30,
                    padding=20)

colorbar.padding_top = plot.padding_top
colorbar.padding_bottom = plot.padding_bottom

# Create a container to position the plot and the colorbar side-by-side
container = HPlotContainer(plot, colorbar)
```

HPlotContainer parameters This is a list of parameters that are specific to `HPlotContainer`

- `stack_order`: The order in which components in the plot container are laid out. The default behavior is left-to-right.

  ```
  stack_order = Enum("left_to_right", "right_to_left")
  ```

- `spacing`: The amount of space to put between components.

  ```
  spacing = Float(0.0)
  ```

- `valign`: The vertical alignment of objects that don't span the full height.

```
valign = Enum("bottom", "top", "center")
```

VPlotContainer parameters This is a list of parameters that are specific to `VPlotContainer`

- `stack_order`: The order in which components in the plot container are laid out. The default behavior is bottom-to-top.

  ```
  stack_order = Enum("bottom_to_top", "top_to_bottom")
  ```

- `spacing`: The amount of space to put between components.:

  ```
  spacing = Float(0.0)
  ```

- `halign`: The horizontal alignment of objects that don't span the full width.:

  ```
  halign = Enum("left", "right", "center")
  ```

See Also:

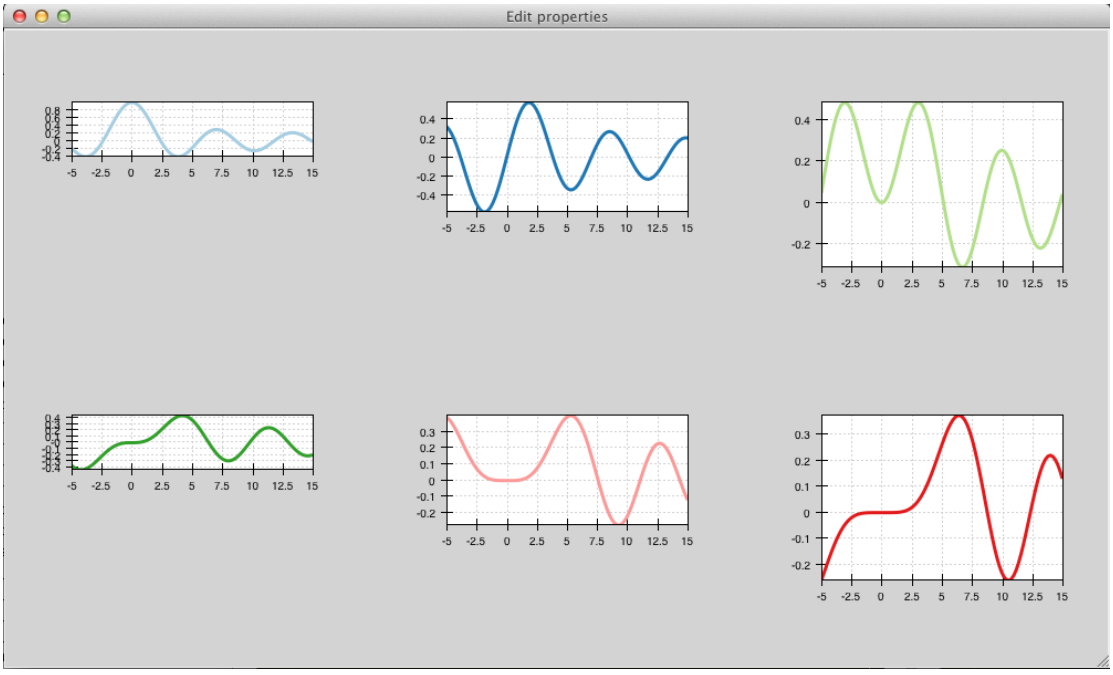
HPlotContainer and VPlotContainer in action. See `demo/financial_plot.py`, `demo/two_plots.py`, `demo/advanced/scalar_image_function_inspector.py`, and `demo/basc/cmap_scatter.py` in the Chaco examples directory.

GridPlotContainer

Just as the name suggests, a `GridPlotContainer` lays out plots in a regular grid.

Unlike the previous containers, one has to specify in advance the number of rows and columns in the plot. Plots with different sizes and/or aspect ratios are aligned according to the parameters `halign` and `valign`.

For example, to generate this plot



one needs to create six plots of fixed height and add them successively (left-to-right, top-to-bottom) to the `GridPlotContainer`. Plots are aligned to the top by setting `valign = 'top'`.

The complete code looks like this:

```
class GridContainerExample(HasTraits):

    plot = Instance(GridPlotContainer)

    traits_view = View(
        Item('plot', editor=ComponentEditor(), show_label=False),
        width=1000, height=600, resizable=True
    )

    def _plot_default(self):
        # Create a GridContainer to hold all of our plots: 2 rows, 3 columns
        container = GridPlotContainer(shape=(2,3),
                                      spacing=(10,5),
                                      valign='top',
                                      bgcolor='lightgray')

        # Create x data
        x = linspace(-5, 15.0, 100)
        pd = ArrayPlotData(index = x)

        # Plot some Bessel functions and add the plots to our container
        for i in range(6):
            data_name = 'y{}'.format(i)
            pd.set_data(data_name, jn(i,x))

            plot = Plot(pd)
            plot.plot(('index', data_name),
                      color=COLOR_PALETTE[i],
                      line_width=3.0)

            # Set each plot's aspect based on its position in the grid
            plot.set(height=((i % 3) + 1)*50,
                     resizable='h')

            # Add to the grid container
            container.add(plot)

        return container
```

GridPlotContainer parameters This is a list of parameters that are specific to `GridPlotContainer`

- `valign`: The vertical alignment of objects that don't span the full height.:

  ```
  valign = Enum("bottom", "top", "center")
  ```

- `halign`: The horizontal alignment of objects that don't span the full width.:

  ```
  halign = Enum("left", "right", "center")
  ```

- `spacing`: A tuple or list of `(h_spacing, v_spacing)`, giving spacing values for the horizontal and vertical direction. Default is (0, 0).

See Also:

GridPlotContainer in action. See `demo/basic/grid_container.py` and `demo/basic/grid_container_aspect_ratio.py` in the Chaco examples directory.

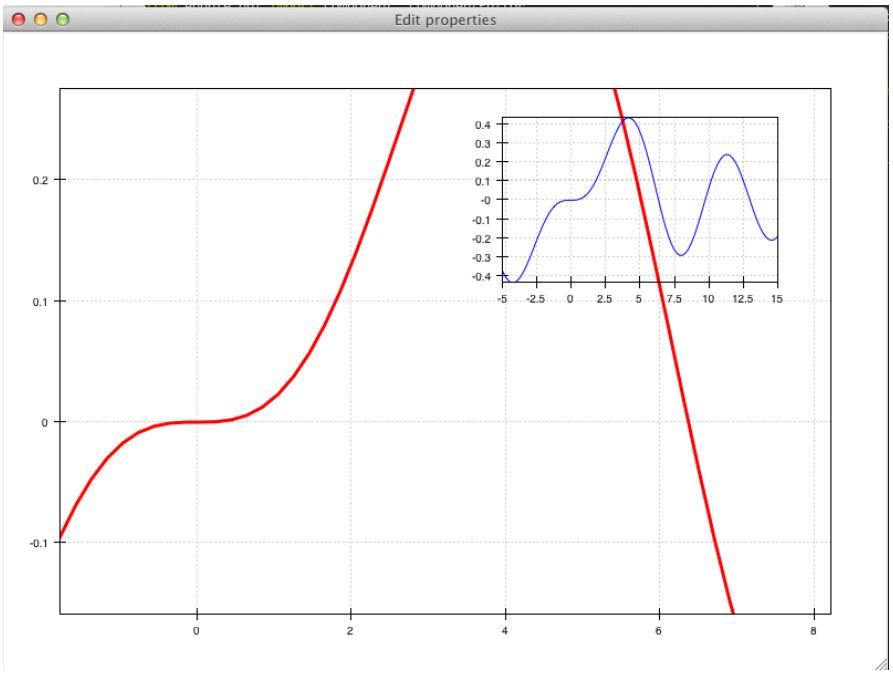
OverlayPlotContainer

Overlay containers `OverlayPlotContainer` lay out plots on top of each other. The `chaco.plot.Plot` class in Chaco is a special subclass of `OverlayPlotContainer`.

Overlay containers can be used to create "inset" plots. In the following code, for instance, we create a zoomable plot with an fixed inset showing the full data:

```
class OverlayContainerExample(HasTraits):

    plot = Instance(OverlayPlotContainer)

    traits_view = View(
        Item('plot', editor=ComponentEditor(), show_label=False),
        width=800, height=600, resizable=True
    )

    def _plot_default(self):
        # Create data
        x = linspace(-5, 15.0, 100)
        y = jn(3, x)
        pd = ArrayPlotData(index=x, value=y)

        zoomable_plot = Plot(pd)
        zoomable_plot.plot(('index', 'value'),
                           name='external', color='red', line_width=3)

        # Attach tools to the plot
        zoom = ZoomTool(component=zoomable_plot,
                        tool_mode="box", always_on=False)
        zoomable_plot.overlays.append(zoom)
        zoomable_plot.tools.append(PanTool(zoomable_plot))

        # Create a second inset plot, not resizable, not zoom-able
        inset_plot = Plot(pd)
        inset_plot.plot(('index', 'value'), color='blue')
        inset_plot.set(resizable = '',
                       bounds = [250, 150],
                       position = [450, 350],
                       border_visible = True
                       )

        # Create a container and add our plots
        container = OverlayPlotContainer()
        container.add(zoomable_plot)
        container.add(inset_plot)
        return container
```

The code above generates this plot:



See Also:

GridPlotContainer in action. See `demo/basic/inset_plot.py` and `demo/advanced/scalar_image_function_inspector.py` in the Chaco examples directory. To learn more about sharing axes on overlapping plots, see `demo/multiaxis.py` and `demo/multiaxis_with_Plot.py`.

Sizing, rendering, events

Containers are responsible for a handling communication with the components it contains, including defining the rendering order, dispatching events, and determining sizes.

Sizing

Containers are the elements that set sizes and do layout. Components within containers declare their preferences, which are taken into account by their container to set their final aspect.

The basic traits that control the layout preferences of a component are:

- `resizable`, a string indicating in which directions the component can be resized. Its value is one of `''` (not resizable), `'h'` (resizable in the horizontal direction), `'v'` (resizable in the vertical direction), `'hv'` (resizable in both, default).
- `aspect_ratio`, the ratio of the component's width to its height. This is used by the component itself to maintain bounds when the bounds are changed independently. Default is `None`, meaning that the aspect ratio is not enforced.
- `padding_left`, `padding_right`, `padding_top`, `padding_bottom` set the amount of padding space to leave around the component (default is 0). The property `padding` allows to set all of them as a tuple (left, right, top, bottom).
- `auto_center`, controls the behavior when the component's bounds are set to a value that does not conform its aspect ratio. If `True` (default), the component centers itself in the free space.

- `fixed_preferred_size`: If the component is resizable, this attribute specifies the amount of space that the component would like to get in each dimension, as a tuple (width, height). This attribute can be used to establish relative sizes between resizable components in a container: if one component specifies, say, a fixed preferred width of 50 and another one specifies a fixed preferred width of 100, then the latter component will always be twice as wide as the former.

You can get access to the actual bounds of the component, (including padding and border) using the `outer` properties:

- `outer_position`, the x,y point of the lower left corner of the padding outer box around the component. Use `set_outer_position()` to change these values.
- `outer_bounds`, the number of horizontal and vertical pixels in the padding outer box. Use `set_outer_bounds()` to change these values.
- `outer_x`, `outer_y`, `outer_x2`, `outer_y2:`, `:attr:'outer_width`, `outer_height`: coordinates of lower-left pixel of the box, coordinates of the upper-right pixel of the box, width and height of the outer box in pixels

See also the documentation of the class `enable.component.Component` for more details about the internal parameters of Chaco components.

The container can set the attribute `fit_components` to control if it should resize itself to fit its components. Allowed values are `''` (do not resize, default), `'h'` (resize in the horizontal direction), `'v'` (resize in the vertical direction), `'hv'` (resize in both).

Rendering order

Every plot component has several layers:

1. `background`: Background image, shading, and borders
2. `underlay`: Axes and grids
3. **`image`: A special layer for plots that render as images. This is in** a separate layer since these plots must all render before non-image plots.
4. `plot`: The main plot area
5. `annotation`: Lines and text that are conceptually part of the "plot" but need to be rendered on top of everything else in the plot.
6. **`overlay`: Legends, selection regions, and other tool-drawn visual** elements

These are defined by `DEFAULT_DRAWING_ORDER`, and stored in the `drawing_order` trait.

Complexity arises when you have multiple components in a container: How do their layers affect each other? Do you want the "overlay" layer of a component to draw on top of all components? Do you want the "background" elements to be behind everything else?

This is resolved by the `unified_draw` trait. The container will draw all layers in succession. If a component sets `unified_draw` to `False` (default), the container will ask it to draw the corresponding layer as it is reached in the loop. If `unified_draw` is `True`, the whole component will draw in one go when the container reaches the layer specified in the attribute `component.draw_layer`, which by default is 'plot'.

For example, if you want a plot to act as an overlay, you could set `unified_draw = True` and `draw_layer = 'overlay'`. These values tell the container to render the component when it gets to the 'overlay' layer.

Set `overlay_border` to True if you want the border to draw as part of the overlay; otherwise it draws as part of the background. By default, the border is drawn just inside the plot area; set `inset_border` to False to draw it just outside the plot area.

Backbuffer A backbuffer provides the ability to render into an offscreen buffer, which is blitted on every draw, until it is invalidated. Various traits such as `use_backbuffer` and `backbuffer_padding` control the behavior of the backbuffer. A backbuffer is used for non-OpenGL backends, such as *agg* and on OS X. If `use_backbuffer` is False, a backbuffer is never used, even if a backbuffer is referenced by a component.

Dispatching events

The logic of event dispatching is defined in the 'enable' library, which defines the superclasses for Chaco's containers and components. In summary, when a component gets an event, it dispatches it to:

1. its overlays, in reverse order that they were added and are drawn
2. itself, so that any event handler methods on itself get called
3. its underlays, in reverse order that they were added and are drawn
4. its listener tools

On each of these elements, Chaco looks for a method of the form `{component_state}_{event_name}`. For example, in response to the user pressing the left mouse button on a tool in state `normal` (the default state, see *Tool states*), Chaco would look for a method called `normal_left_down`.

If this exists, the event is dispatched and the component decides whether to handle the element and set `event.handled = True`, in which case the dispatch chain is interrupted.

Note: If the attribute `auto_handle_event` of the component is set to `True`, calling the event method automatically sets `event.handled = True`.

Possible event names are:

- left_down
- left_up
- left_dclick
- right_down
- right_up
- right_dclick
- middle_down
- middle_up
- middle_dclick
- mouse_move
- mouse_wheel
- mouse_enter
- mouse_leave
- key_pressed
- key_released
- character
- dropped_on
- drag_over
- drag_enter
- drag_leave

Most objects default to having just a single event state, which is the "normal" event state. To make a component that handled a left-click, you could subclass `PlotComponent`, and implement `normal_left_down()` or `normal_left_up()`. The signature for handler methods is just one parameter, which is an event object that is an instance of (a subclass of) `BasicEvent`. Subclasses of `BasicEvent` are `MouseEvent`, `DragEvent`, `KeyEvent`,

and `BlobEvent` and `BlobFrameEvent` (for multitouch). It's fairly easy to extend this event system with new kinds of events and new suffixes (as was done for multitouch).

Events contain a reference to the GUI toolkit window that generated them as `event.window`. A common pattern is for component to call methods on the window to do things like set a tooltip or create a context menu. A draw or update of the window does not actually happen until the next `paint()`. By that time, the component no longer has a reference to the event or the event's window, but uses instead its own reference to the window, `self.window`.

See also the documentation of the enable library, which gives more details about the event dispatching happening at that level.

1.3.4 Tools and Overlays

Overview

Chaco, Enable, and Event Dispatch

A Basic Tool

A Basic Overlay

Interaction Tools

PanTool

ZoomTool

RectZoom

DragZoom

LegendTool

DataLabelTool

MoveTool

Inspector-type Tools

DataPrinter

LineInspector

ScatterInspector

CursorTool

HighlightTool

ImageInspectorTool

TraitsTool

Selection Tools

RangeSelection

LassoSelection

SelectTool

Drawing Tools

DrawPointsTool

Note: This section is currently under active development.

Basics

How do I...

- render data to an image file?

```
def save_plot(plot, filename, width, height):
    plot.outer_bounds = [width, height]
    plot.do_layout(force=True)
    gc = PlotGraphicsContext((width, height), dpi=72)
    gc.render_component(plot)
    gc.save(filename)
```

- integrate a Chaco plot into my WX app?

```
import wx
from scipy import arange
from scipy.special import jn
from chaco.api import HPlotContainer, create_line_plot
from enable.wx_backend.api import Window

class PlotFrame(wx.Frame):
    def __init__(self, *args, **kw):
        kw["size"] = (850, 550)
        wx.Frame.__init__( *(self,) + args, **kw )
        self.plot_window = Window(self, component=self._create_plot())
        sizer = wx.BoxSizer(wx.HORIZONTAL)
        sizer.Add(self.plot_window.control, 1, wx.EXPAND)
        self.SetSizer(sizer)
        self.SetAutoLayout(True)
        self.Show(True)
        return

    def _create_plot(self):
        x = arange(-5.0, 15.0, 20.0/100)
        y = jn(0, x)
        plot = create_line_plot((x,y), bgcolor="white",
                                add_grid=True, add_axis=True)
        container = HPlotContainer(spacing=20, padding=50, bgcolor="lightgray")
        container.add(plot)
        return container

if __name__ == "__main__":
    app = wx.PySimpleApp()
    frame = PlotFrame(None)
    app.MainLoop()
```

- integrate a Chaco plot into my QT app?
- integrate a Chaco plot into my Traits UI?

```
import numpy
from chaco.api import Plot, ArrayPlotData
from enable.component_editor import ComponentEditor
from traits.api import HasTraits, Instance
from traitsui.api import Item, View
```

```
class MyPlot(HasTraits):
    plot = Instance(Plot)

    traits_view = View(Item('plot', editor=ComponentEditor()))

    def __init__(self, index, data_series, **kw):
        super(MyPlot, self).__init__(**kw)

        plot_data = ArrayPlotData(index=index)
        plot_data.set_data('data_series', data_series)
        self.plot = Plot(plot_data)
        self.plot.plot(('index', 'data_series'))

index = numpy.array([1,2,3,4,5])
data_series = index**2

my_plot = MyPlot(index, data_series)
my_plot.configure_traits()
```

- make an application to render many streams of data?

```
def plot_several_series(index, series_list):
    plot_data = ArrayPlotData(index=index)
    plot = Plot(plot_data)

    for i, data_series in enumerate(series_list):
        series_name = "series_%d" % i
        plot_data.set_data(series_name, data_series)
        plot.plot(('index', series_name))
```

- make a plot the right size?

```
def resize_plot(plot, width, height):
    plot.outer_bounds = [width, height]
```

- copy a plot the the clipboard?

```
def copy_to_clipboard(plot):
    # WX specific, though QT implementation is similar using
    # QImage and QClipboard
    import wx

    width, height = plot.outer_bounds

    gc = PlotGraphicsContext((width, height), dpi=72)
    gc.render_component(plot_component)

    # Create a bitmap the same size as the plot
    # and copy the plot data to it

    bitmap = wx.BitmapFromBufferRGBA(width+1, height+1,
                                     gc.bmp_array.flatten())
    data = wx.BitmapDataObject()
    data.SetBitmap(bitmap)

    if wx.TheClipboard.Open():
        wx.TheClipboard.SetData(data)
        wx.TheClipboard.Close()
    else:
```

```
        wx.MessageBox("Unable to open the clipboard.", "Error")
```

Layout and Rendering

How do I...

- put multiple plots in a single window?
- change the background color?

```
def make_black_plot(index, data_series):
    plot_data = ArrayPlotData(index=index)
    plot_data.set_data('data_series', data_series)
    plot = Plot(plot_data, bgcolor='black')
    plot.plot(('index', 'data_series'))

def change_bgcolor(plot):
    plot.bgcolor = 'black'
```

- turn off borders?

```
def make_borderless_plot(index, data_series):
    plot_data = ArrayPlotData(index=index)
    plot_data.set_data('data_series', data_series)
    plot = Plot(plot_data, border_visible=False)
    plot.plot(('index', 'data_series'))

def change_to_borderless_plot(plot):
    plot.border_visible = False
```

Writing Components

How do I...

- compose multiple renderers?
- write a custom renderer?
- write a custom overlay/underlay?
- write a custom tool?
- write a new container?

Advanced

How do I...

- properly change/override draw dispatch?
- modify event dispatch?
- customize backbuffering?
- embed custom/native WX widgets on the plot?

1.3.7 Frequently Asked Questions

Where does the name "Chaco" come from?

It is named after Chaco Canyon, which had astronomical markings that served as an observatory for Native Americans. The original version of Chaco was built as part of a project for the Space Telescope Science Institute. This is also the origin of the name "Kiva" for our vector graphics layer that Chaco uses for rendering.

What are the pros and cons of Chaco vs. matplotlib?

This question comes up quite a bit. The bottom line is that the two projects initially set out to do different things, and although each project has grown a lot of overlapping features, the different original charters are reflected in the capabilities and feature sets of the two projects.

Here is an excerpt from a thread about this question on the enthought-dev mailing list.

Gael Varoquaux's response:

```
On Fri, May 11, 2007 at 10:03:21PM +0900, Bill Baxter wrote:

> Just curious.  What are the pros and cons of chaco vs matplotlib?

To me it seem the big pro of chaco is that it is much easier to use in a
"programatic way" (I have no clue this means something in English). It is
fully traited and rely quite a lot on inversion of control (sorry, I love
this concept, so it has become my new buzz-word). You can make very nice
object oriented interactive code.

Another nice aspect is that it is much faster than MPL.

The cons are that it is not as fully featured as MPL, that it does not
has an as nice interactively useable functional interface (ie chaco.shell
vs pylab) and that it is not as well documented and does not have the
same huge community.

I would say that the codebase of chaco is nicer, but than if you are not
developping interactive application, it is MPL is currently an option
that is lickely to get you where you want to go quicker. Not that I
wouldn't like to see chaco building up a bit more and becoming **the** reference.

Developers, if you want chaco to pick up momentum, give it a pylab-like
interface (as close as you can to pylab) !

My 2 cents,
Gael
```

Peter Wang's response (excerpt):

```
    On May 11, 2007, at 8:03 AM, Bill Baxter wrote:

> Just curious.  What are the pros and cons of chaco vs matplotlib?

You had to go and ask, didn't you? :)  There are many more folks here
who have used MPL more extensively than myself, so I'll defer the
comparisons to them.  (Gael, as always, thanks for your comments and
feedback!)  I can comment, however, on the key goals of Chaco.

Chaco is a plotting toolkit targeted towards developers for building
```

```
interactive visualizations.  You hook up pieces to build a plot that
is then easy to inspect, interact with, add configuration UIs for
(using Traits UI), etc.  The layout of plot areas, the multiplicity
and types of renderers within those windows, the appearance and
locations of axes, etc. are all completely configurable since these
are all first-class objects participating in a visual canvas.  They
can all receive mouse and keyboard events, and it's easy to subclass
them (or attach tools to them) to achieve new kinds of behavior.
We've tried to make all the plot renderers adhere to a standard
interface, so that tools and interactors can easily inspect data and
map between screen space and data space.  Once these are all hooked
up, you can swap out or update the data independently of the plots.

One of the downsides we had a for a while was that this rich set of
objects required the programmer to put several different classes
together just to make a basic plot.  To solve this problem, we've
assembled some higher-level classes that have the most common
behaviors built-in by default, but which can still be easily
customized or extended.  It's clear to me that this is a good general
approach to preserving flexibility while reducing verbosity.

At this point, Chaco is definitely capable of handling a large number
of different plotting tasks, and a lot of them don't require too much
typing or hacking skills.  (Folks will probably require more
documentation, however, but I'm working on that. :)  I linked to the
source for all of the screenshots in the gallery to demonstrate that
you can do a lot of things with Chaco in a few dozen lines of code.
(For instance, the audio spectrogram at the bottom of the gallery is
just a little over 100 lines.)

Fundamentally, I like the Chaco model of plots as compositions of
interactive components.  This really helps me think about
visualization apps in a modular way, and it "fits my head".  (Of
course, the fact that I wrote much of it might have something to do
with that as well. ;)  The goal is to have data-related operations
clearly happen in one set of objects, the view layout and
configuration happen in another, and the interaction controls fit
neatly into a third.  IMHO a good toolkit should help me design/
architect my application better, and we definitely aspire to make
Chaco meet that criterion.

Finally, one major perk is that since Chaco is built completely on
top of traits and its event-based component model, you can call
edit_traits() on any visual component from within your app (or
ipython) and get a live GUI that lets you tweak all of its various
parameters in realtime.  This applies to the axis, grid, renderers,
etc.  This seems so natural to me that I sometimes forget what an
awesome feature it is. :)
```

1.3.8 Annotated Examples

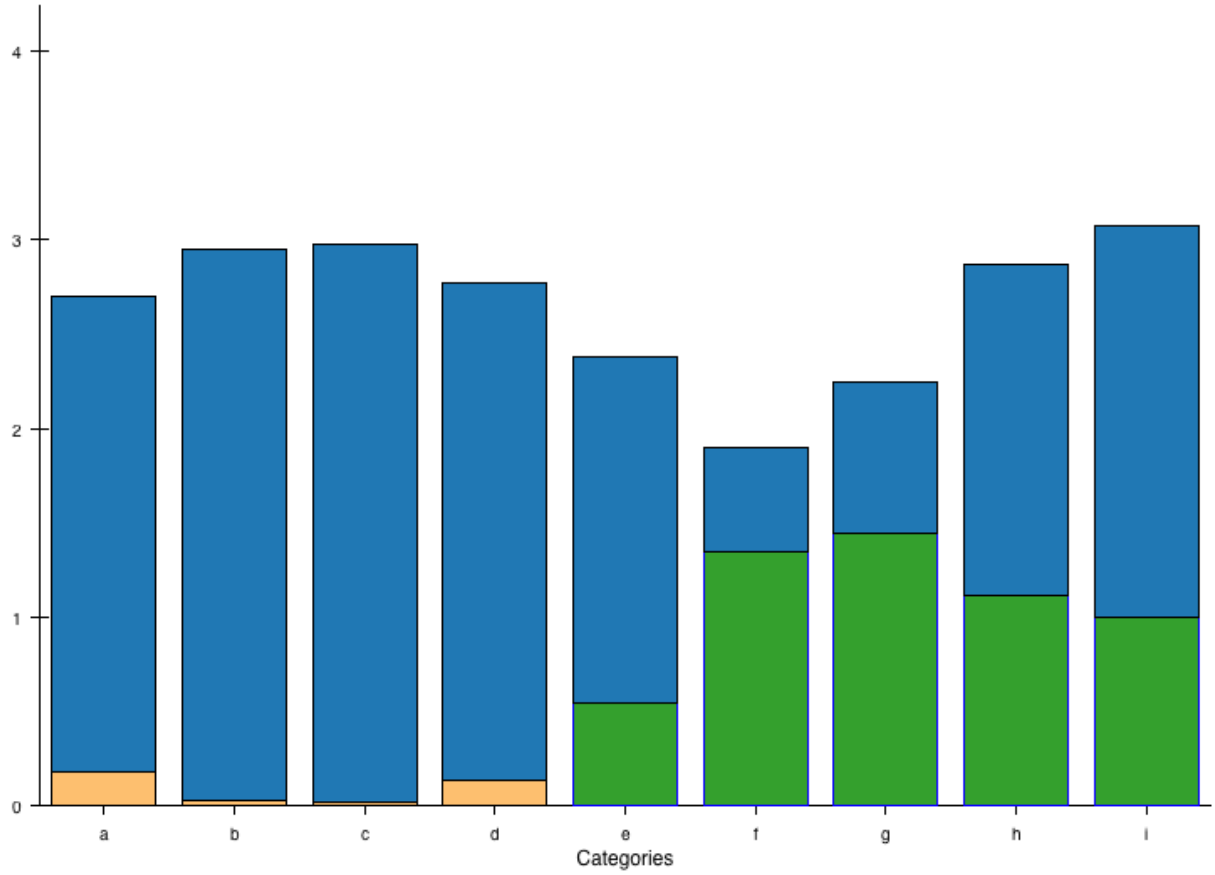
This section describes each of the examples provided with Chaco. Each example is designed to be a stand-alone demonstration of some of Chaco's features. Though they are simple, many of the examples have capabilities that are difficult to find in other plotting packages.

Extensibility is a core design goal of Chaco, and many people have used the examples as starting points for their own applications.

bar_plot_stacked.py

An example showing Chaco's BarPlot class.

source: bar_plot_stacked.py



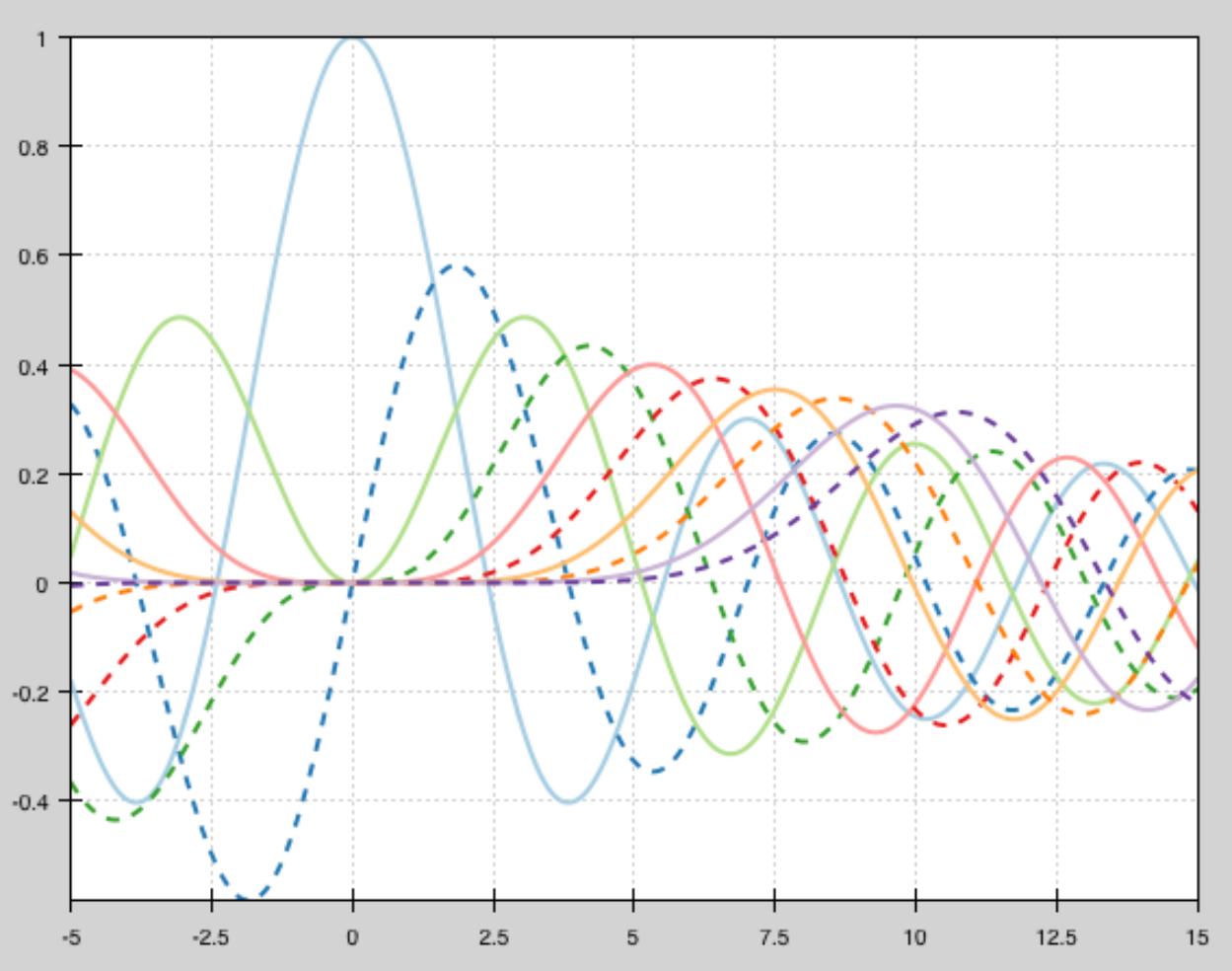
bigdata.py

Demonstrates chaco performance with large datasets.

There are 10 plots with 100,000 points each. Right-click and drag to create a range selection region. The region can be moved around and resized (drag the edges). These interactions are very fast because of the backbuffering built into chaco.

Zooming with the mousewheel and the zoombox (as described in simple_line.py) is also available, but panning is not.

source: bigdata.py

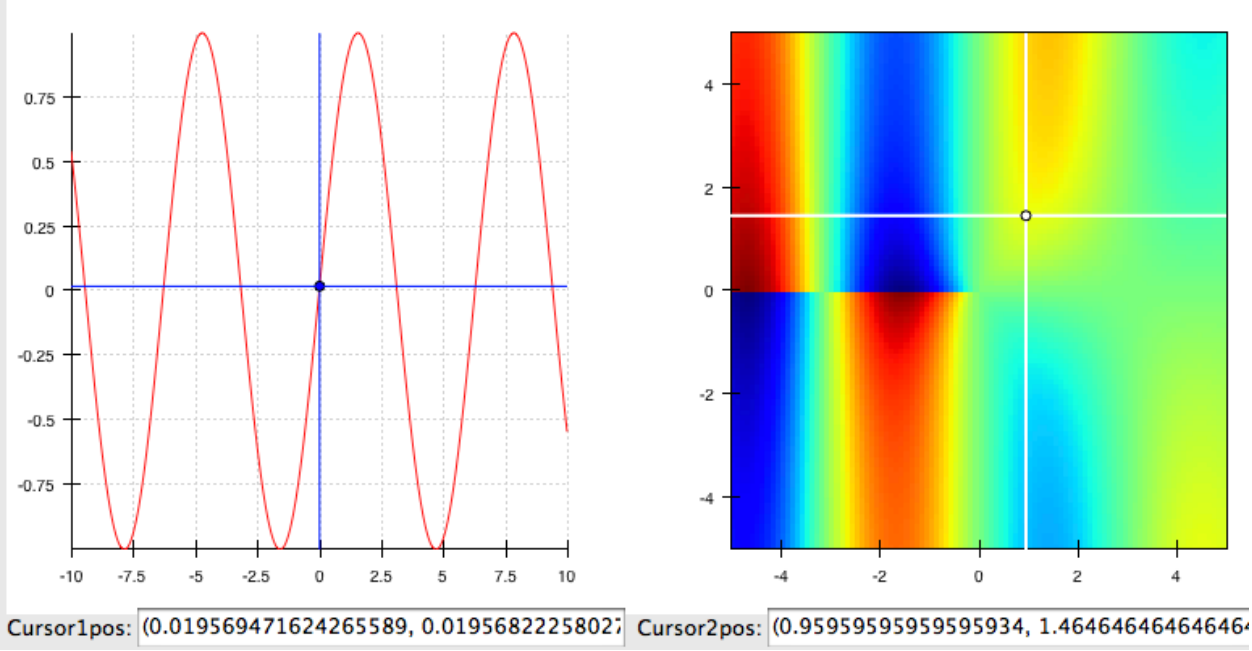


cursor_tool_demo.py

A Demonstration of the CursorTool functionality

Left-button drag to move the cursors round. Right-drag to pan the plots. 'z'-key to Zoom

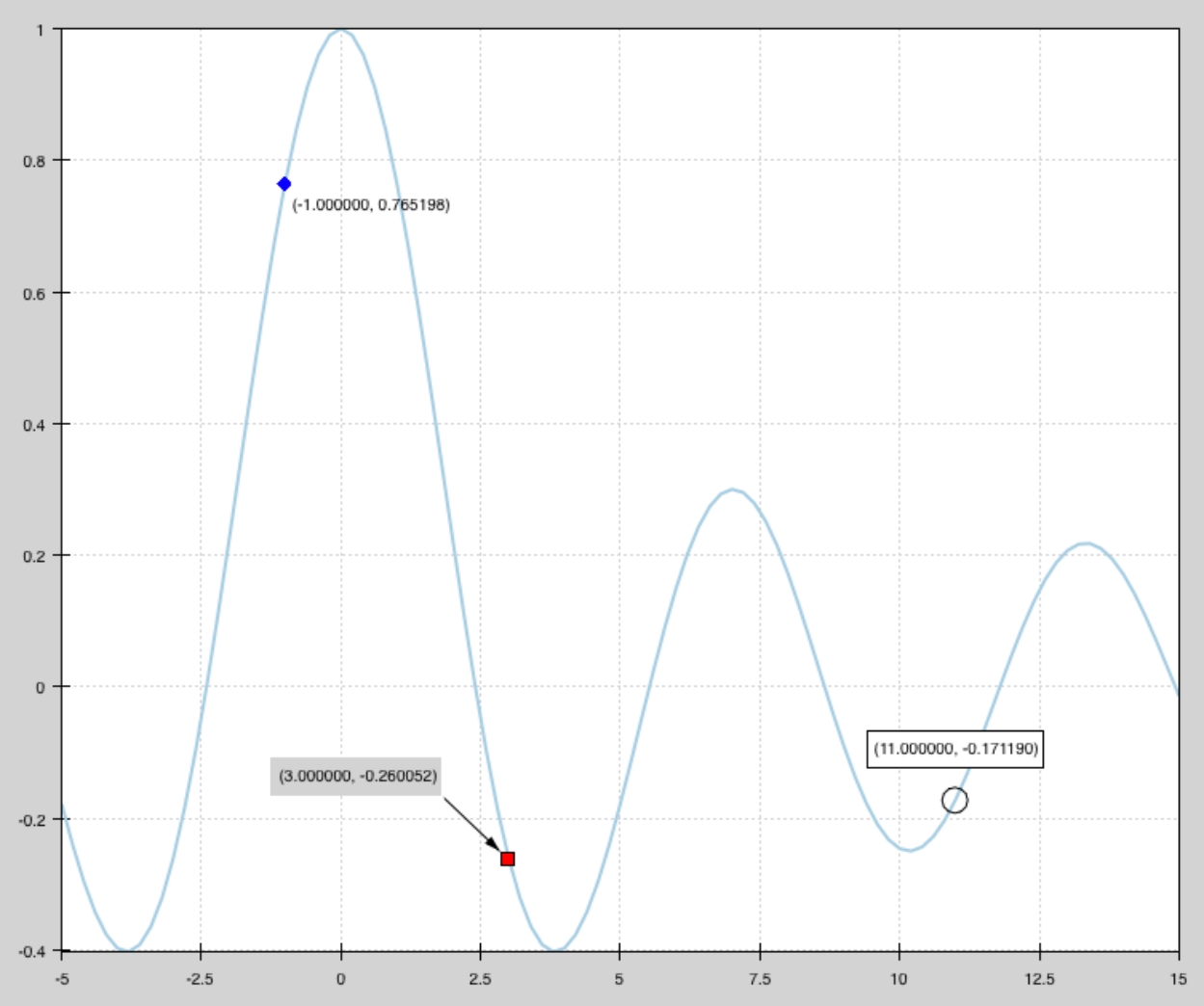
source: cursor_tool_demo.py



data_labels.py

Draws a line plot with several points labelled. Demonstrates how to annotate plots.

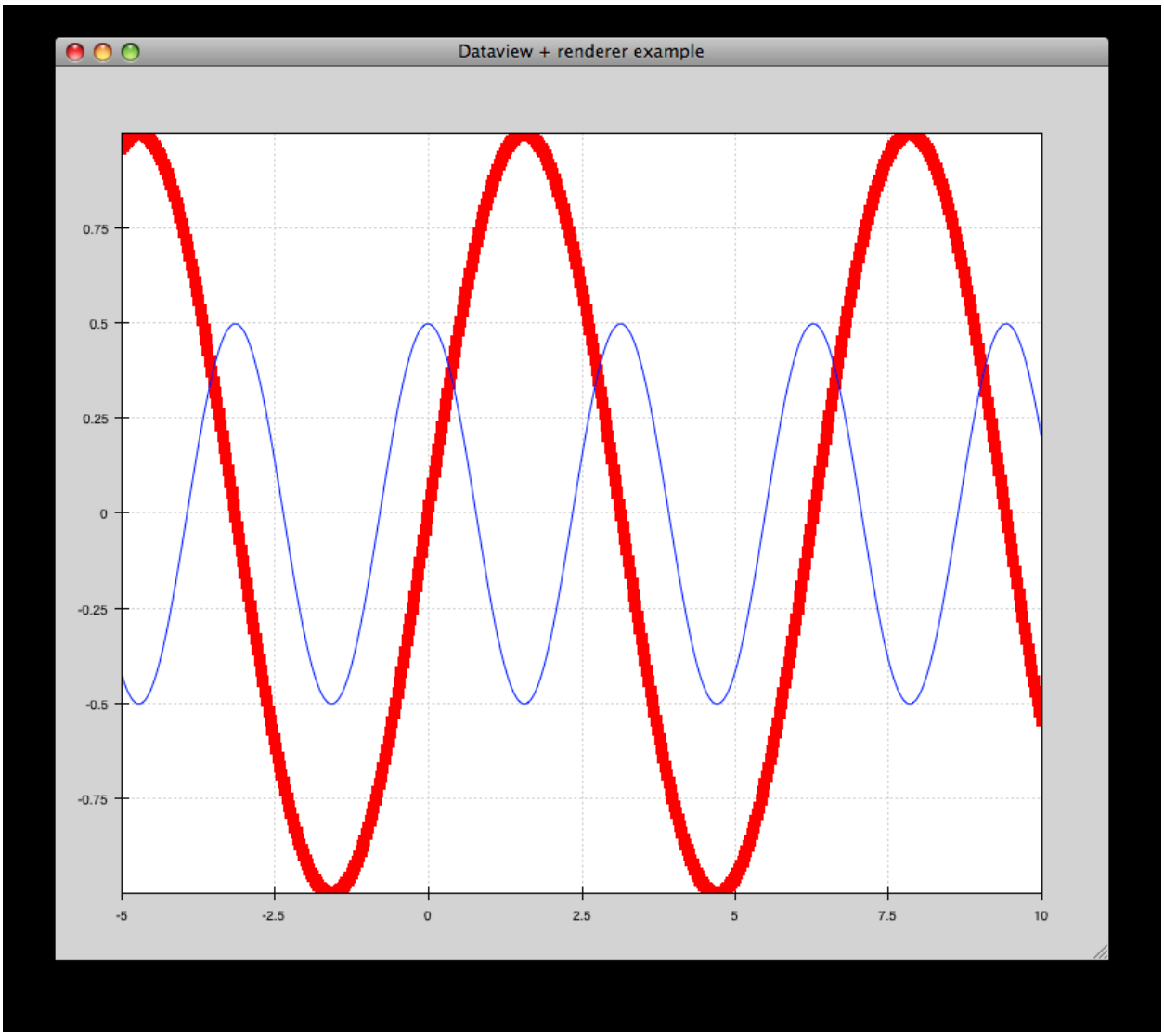
source: data_labels.py



data_view.py

Example of how to use a DataView and bare renderers to create plots.

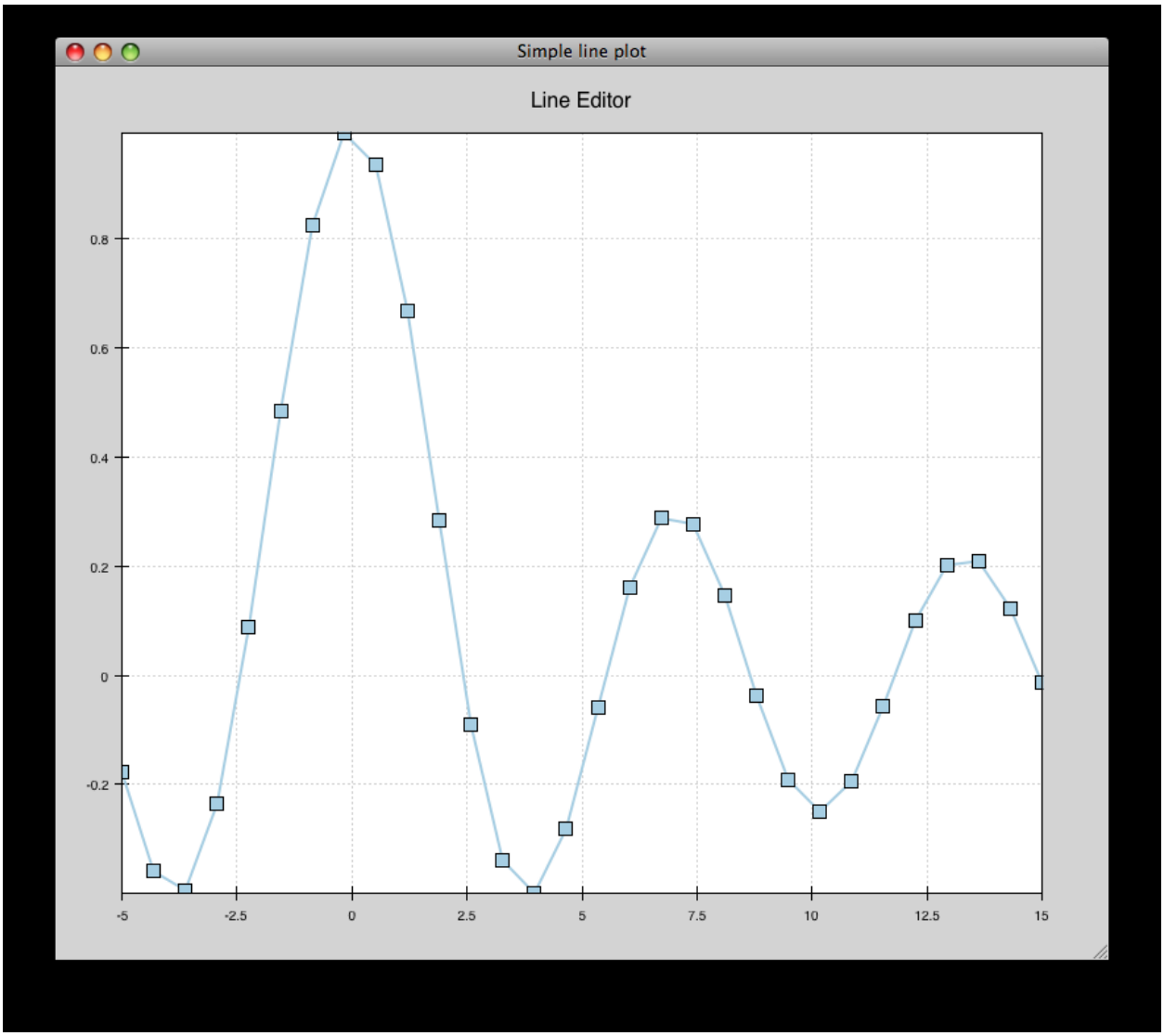
source: data_view.py



edit_line.py

Allows editing of a line plot.

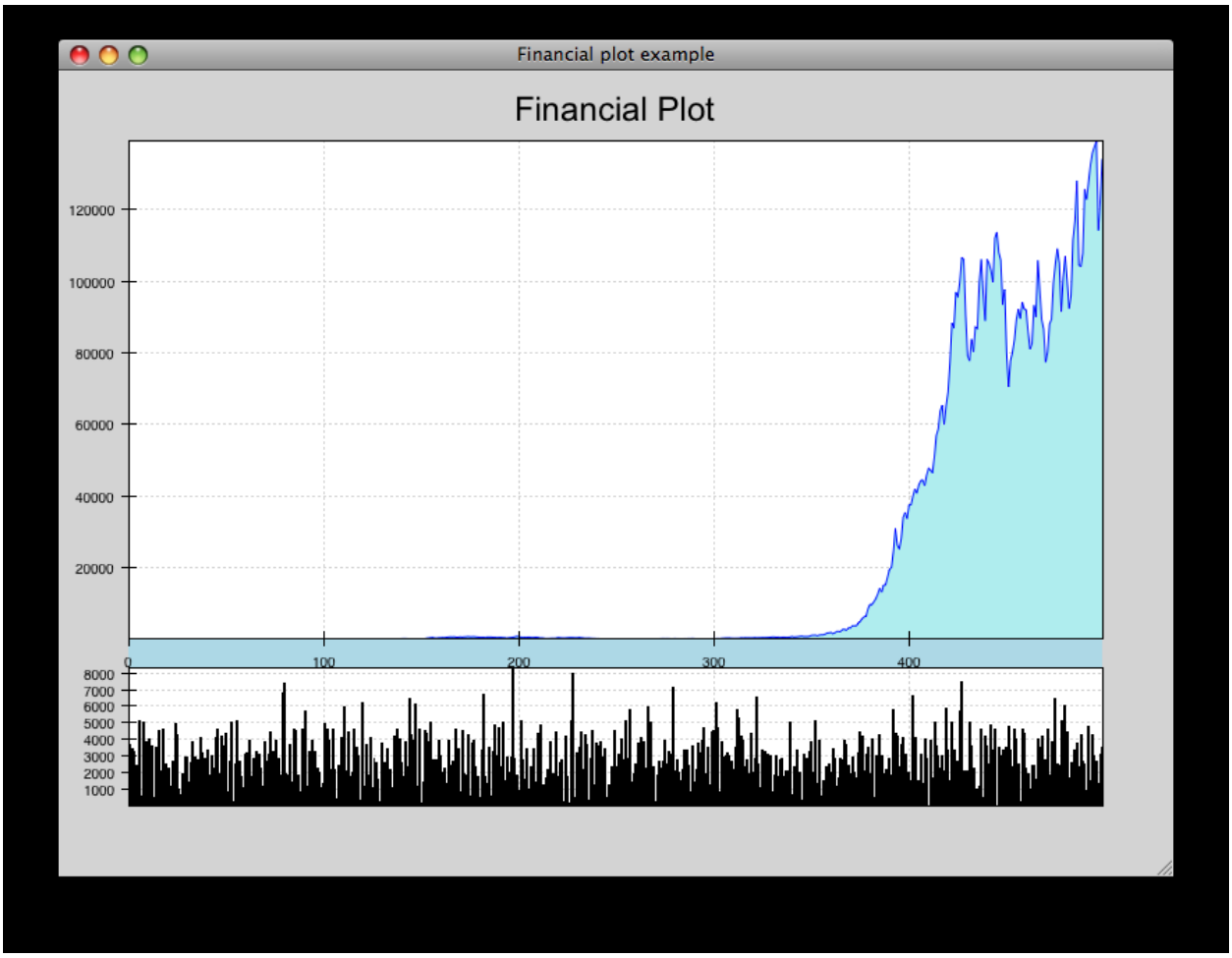
source: edit_line.py



financial_plot.py

Implementation of a standard financial plot visualization using Chaco renderers and scales. Right-clicking and selecting an area in the top window zooms in the corresponding area in the lower window.

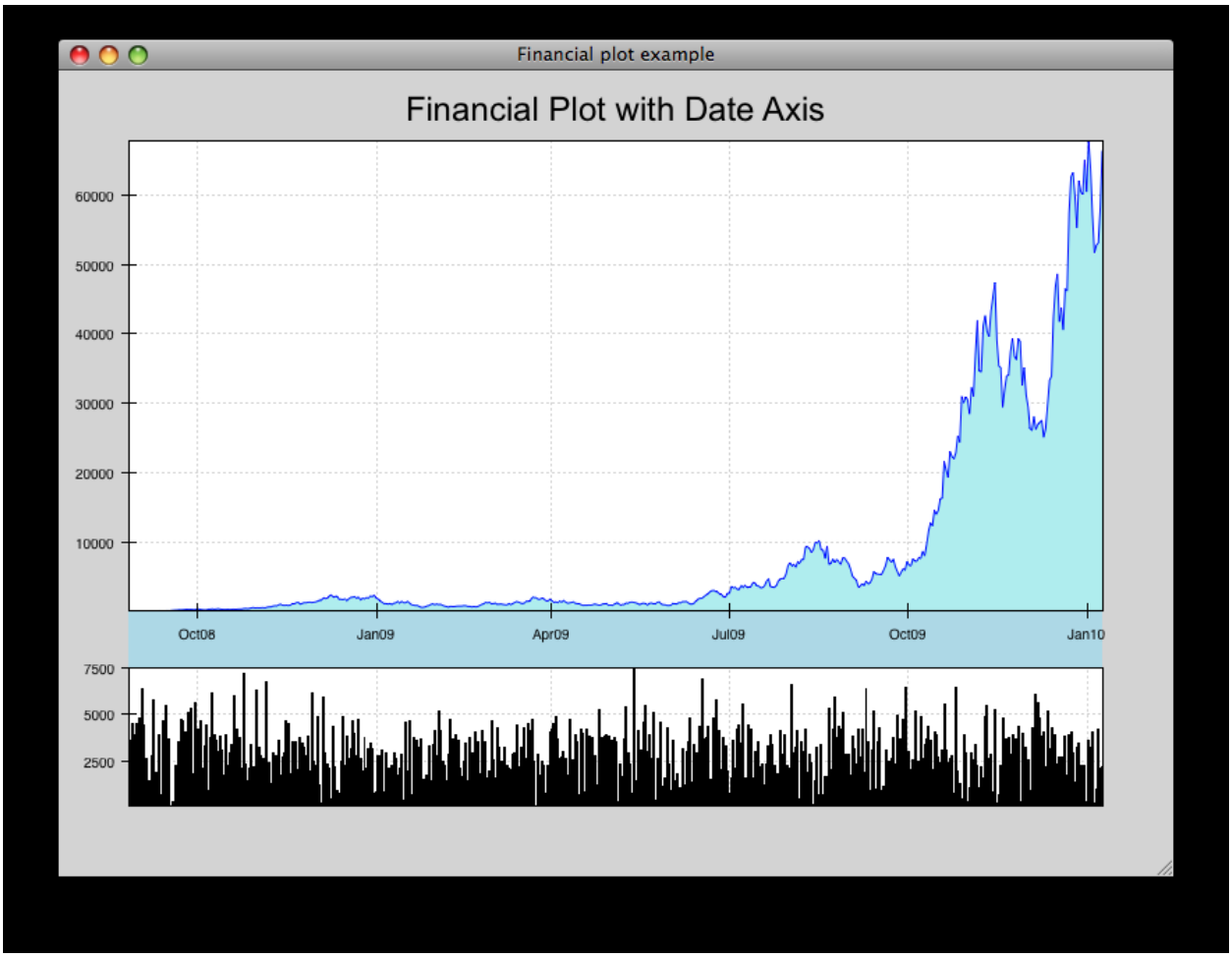
source: financial_plot.py



financial_plot_dates.py

Implementation of a standard financial plot visualization using Chaco renderers and scales. Right-clicking and selecting an area in the top window zooms in the corresopnding area in the lower window. This differs from the financial_plot.py example in that it uses a date-oriented axis.

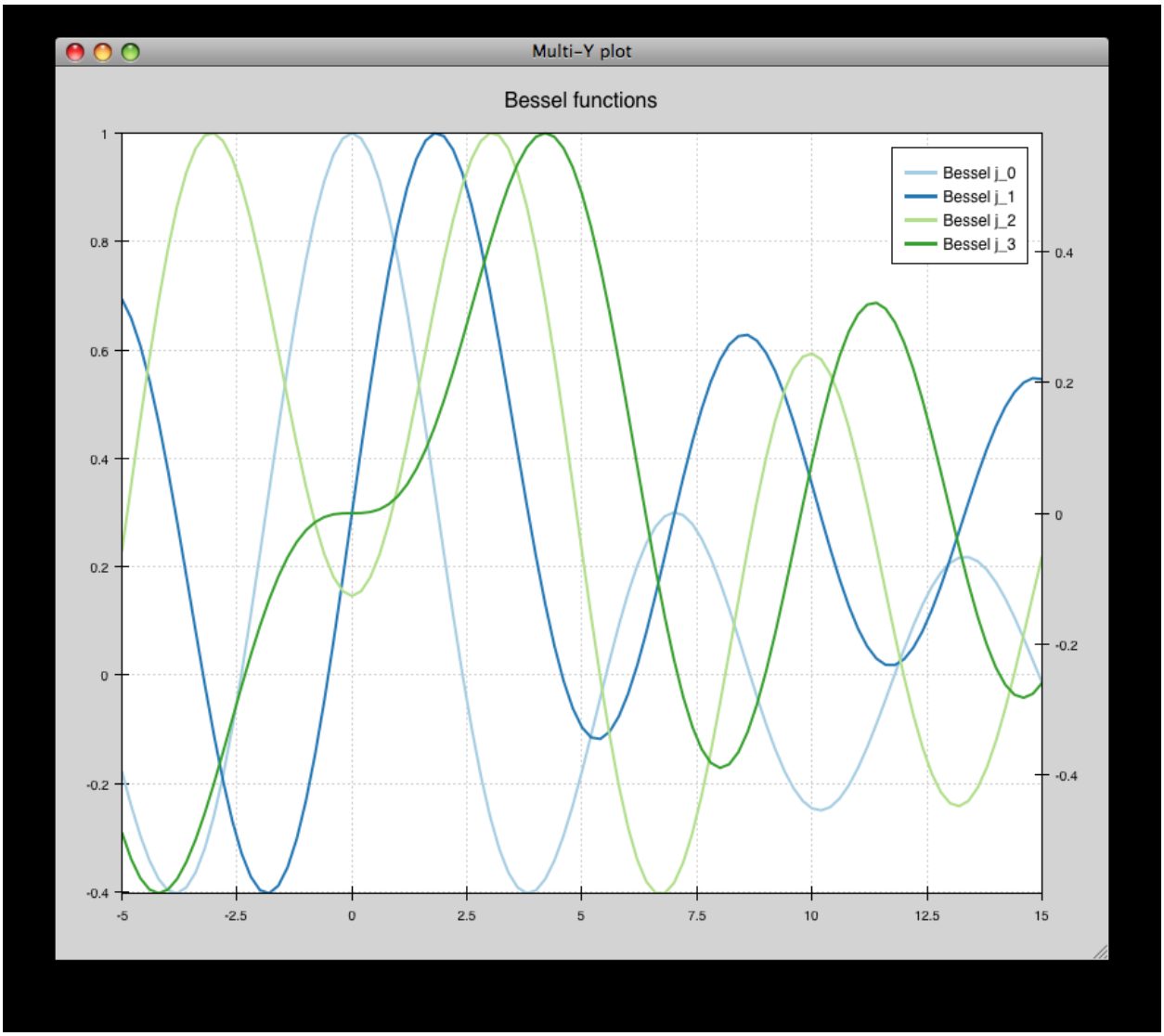
source: financial_plot_dates.py



`multiaxis.py`

Draws several overlapping line plots like simple_line.py, but uses a separate Y range for each plot. Also has a second Y-axis on the right hand side. Demonstrates use of the BroadcasterTool.

source: multiaxis.py

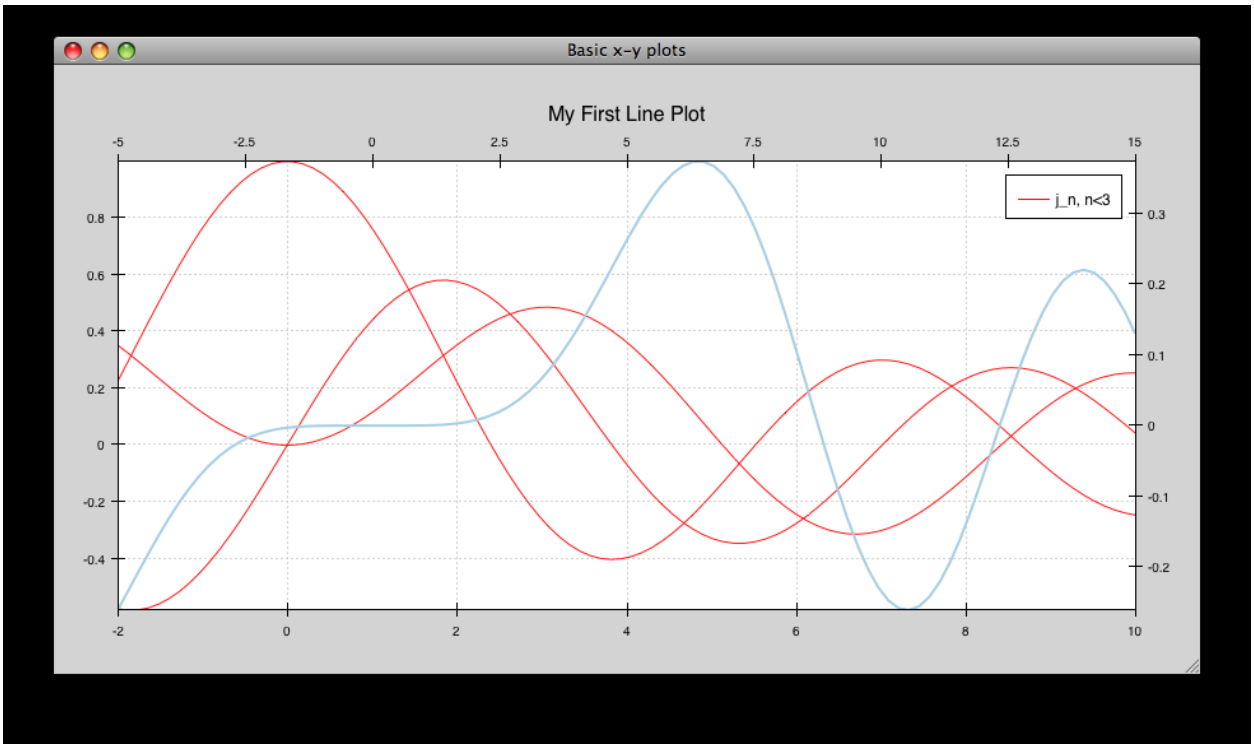


multiaxis_using_Plot.py

Draws some x-y line and scatter plots. On the left hand plot:

- Left-drag pans the plot.
- Mousewheel up and down zooms the plot in and out.
- Pressing "z" opens the Zoom Box, and you can click-drag a rectangular region to zoom. If you use a sequence of zoom boxes, pressing alt-left-arrow and alt-right-arrow moves you forwards and backwards through the "zoom history".

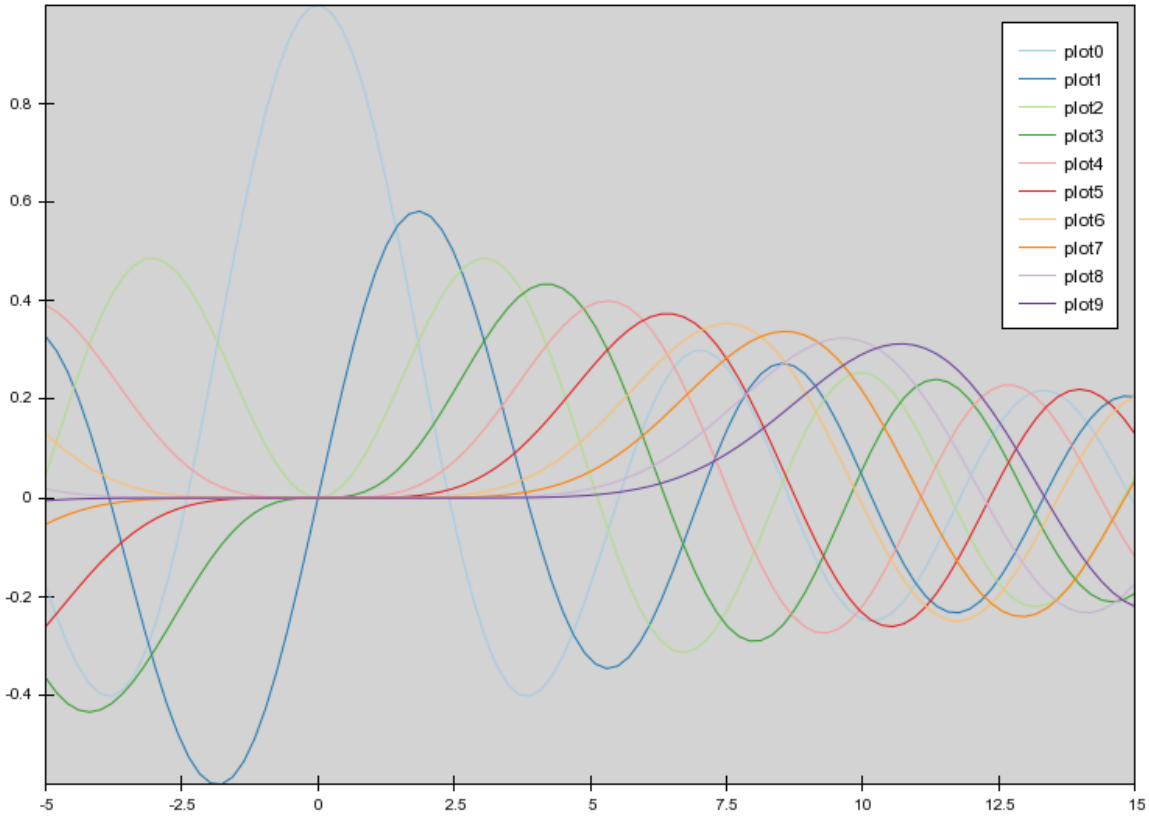
source: multiaxis_using_Plot.py



noninteractive.py

This demonstrates how to create a plot offscreen and save it to an image file on disk. The image is what is saved.

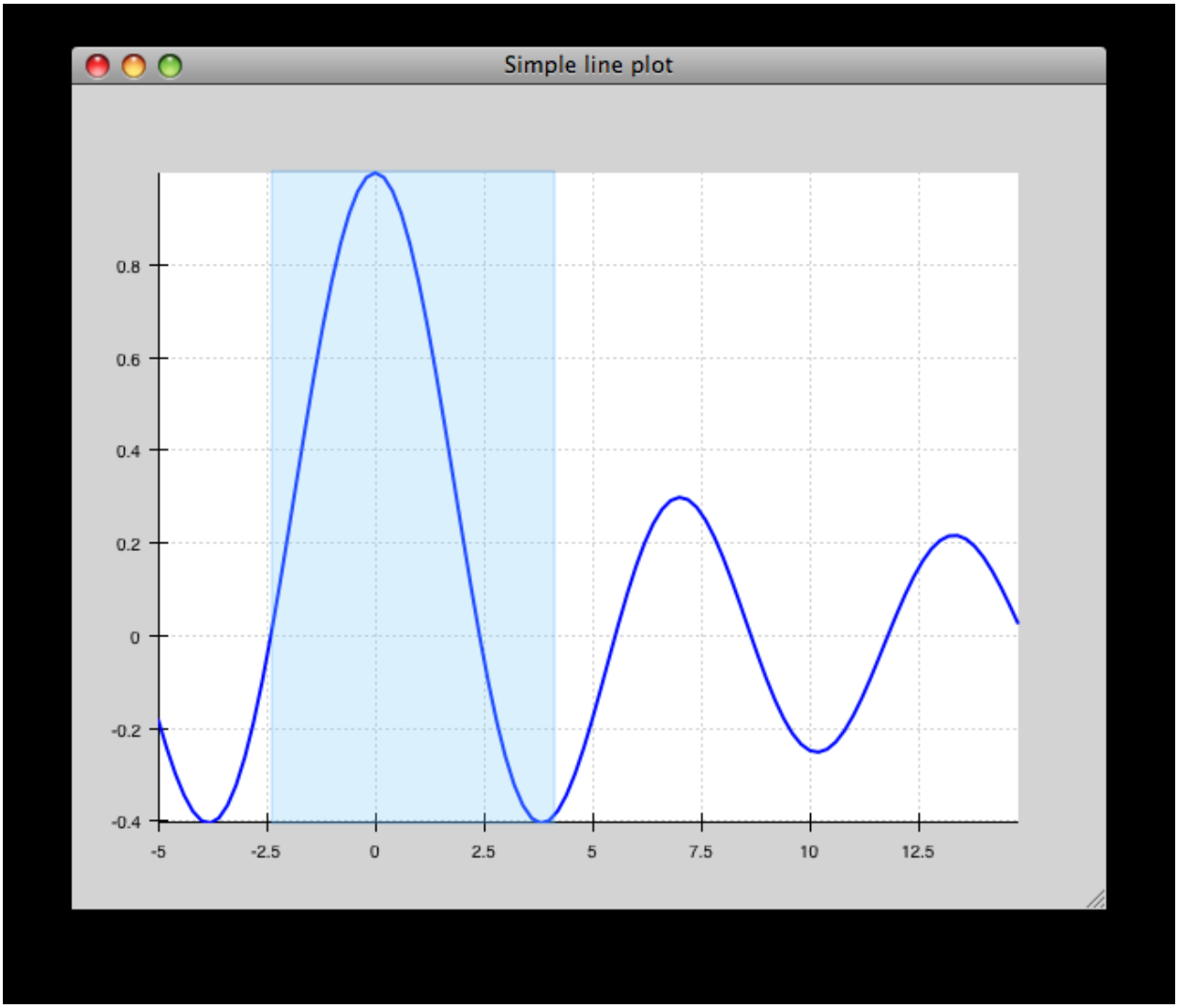
source: noninteractive.py



range_selection_demo.py

Demo of the RangeSelection on a line plot. Left-click and drag creates a horizontal range selection; this selection can then be dragged around, or resized by dragging its edges.

source: range_selection_demo.py

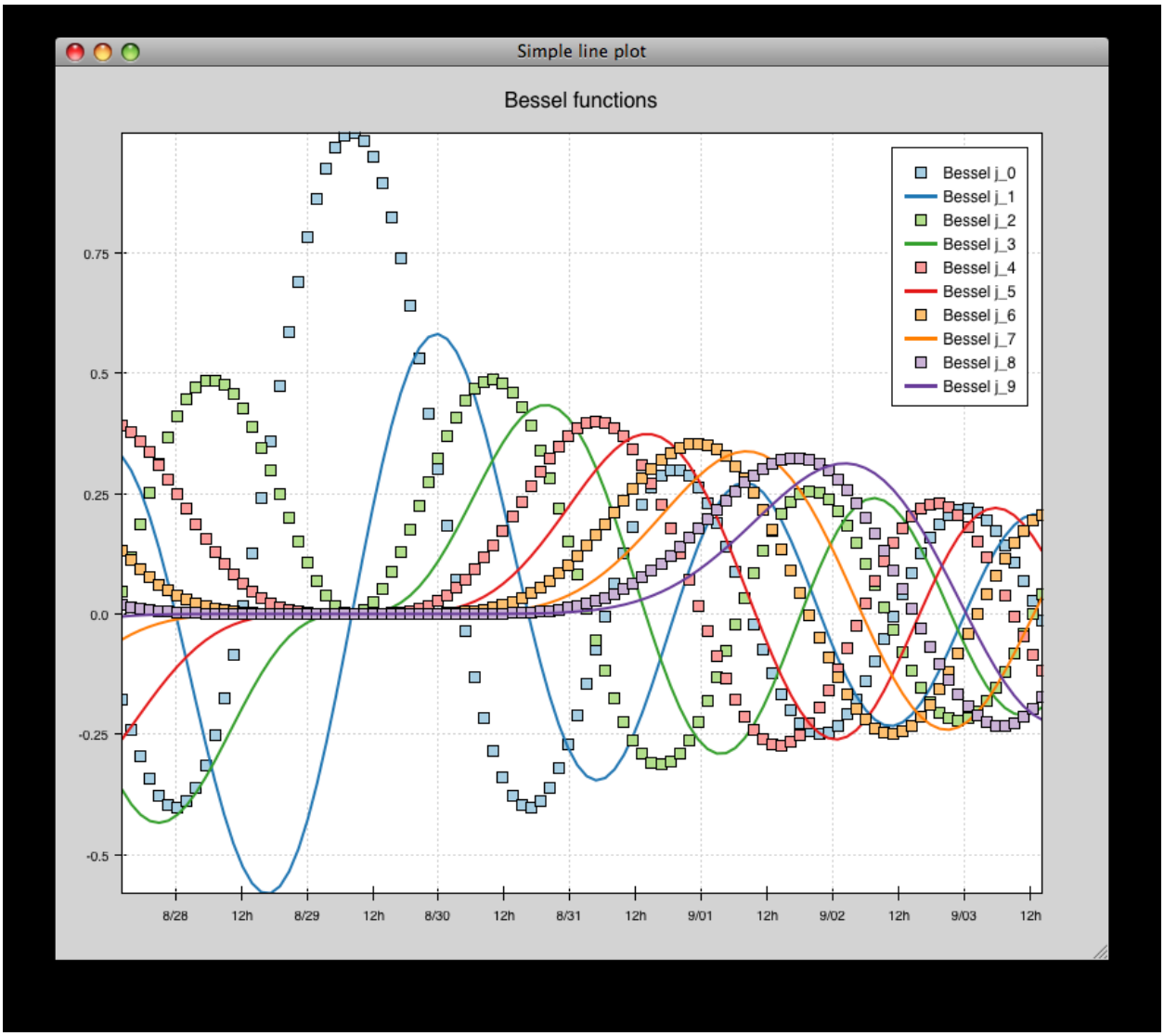


scales_test.py

Draws several overlapping line plots.

Double-clicking on line or scatter plots opens a Traits editor for the plot.

source: scales_test.py

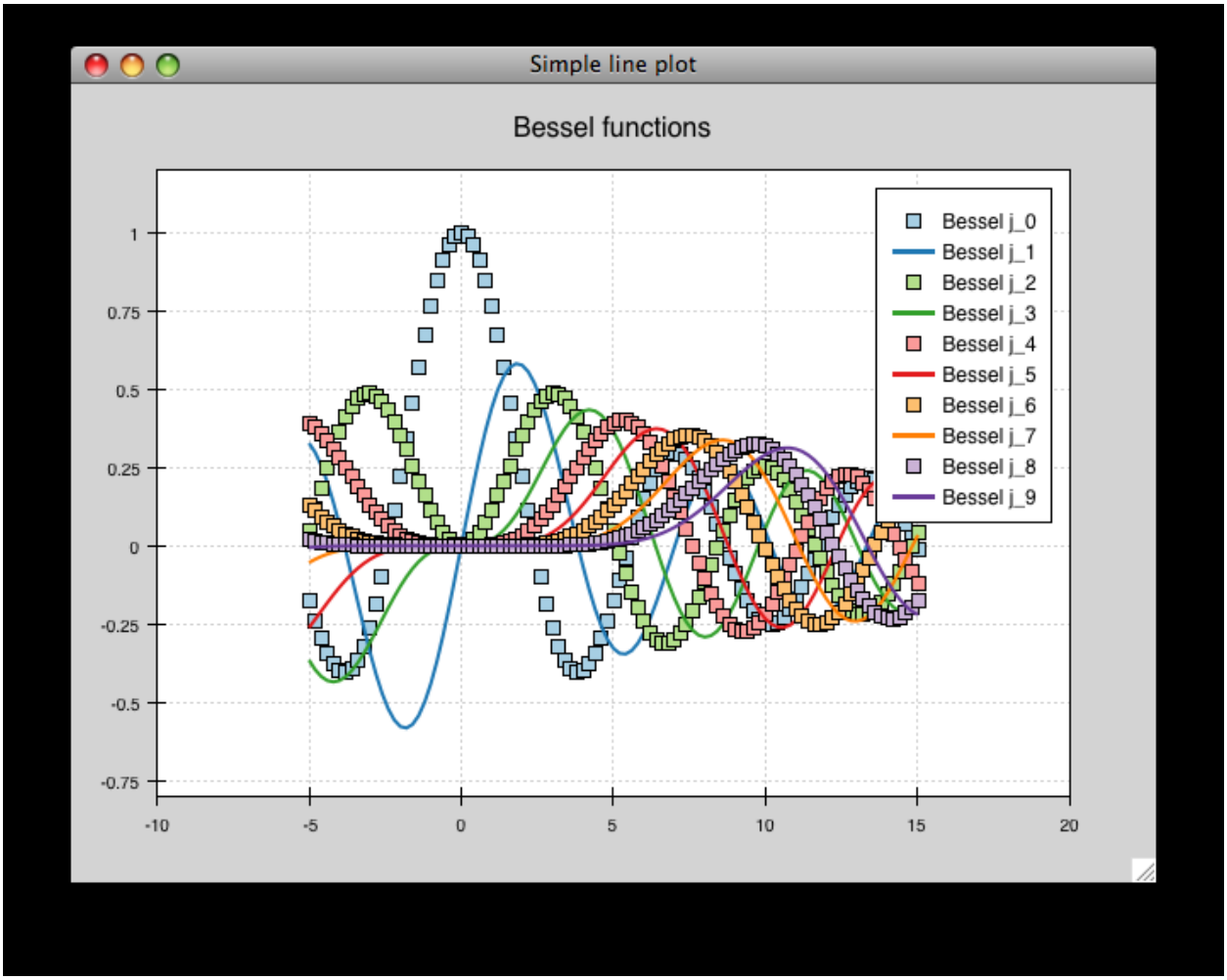


simple_line.py

Draws several overlapping line plots.

Double-clicking on line or scatter plots opens a Traits editor for the plot.

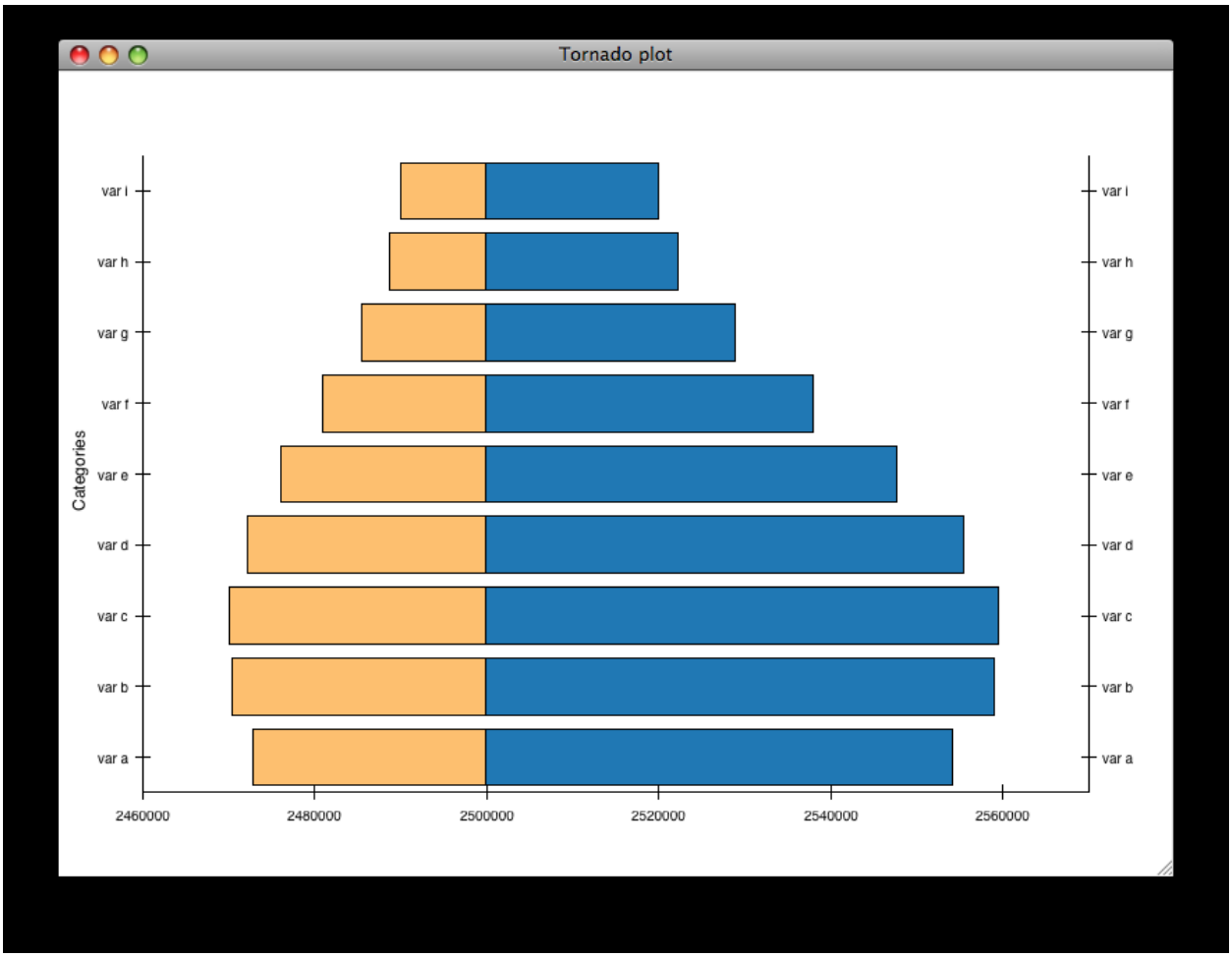
source: simple_line.py



`tornado.py`

Tornado plot example from Brennan Williams.

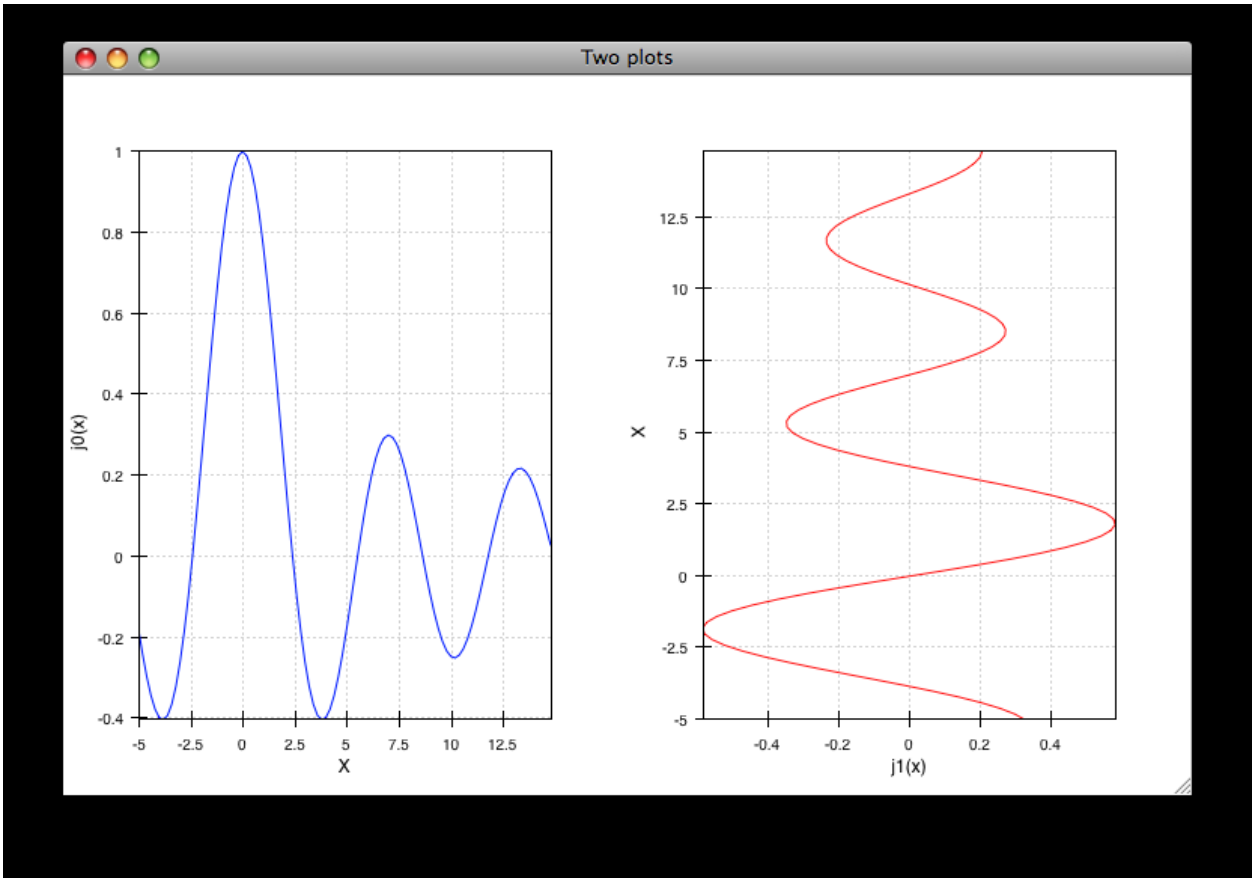
source: tornado.py



two_plots.py

Demonstrates plots sharing datasources, ranges, etc...

source: two_plots.py

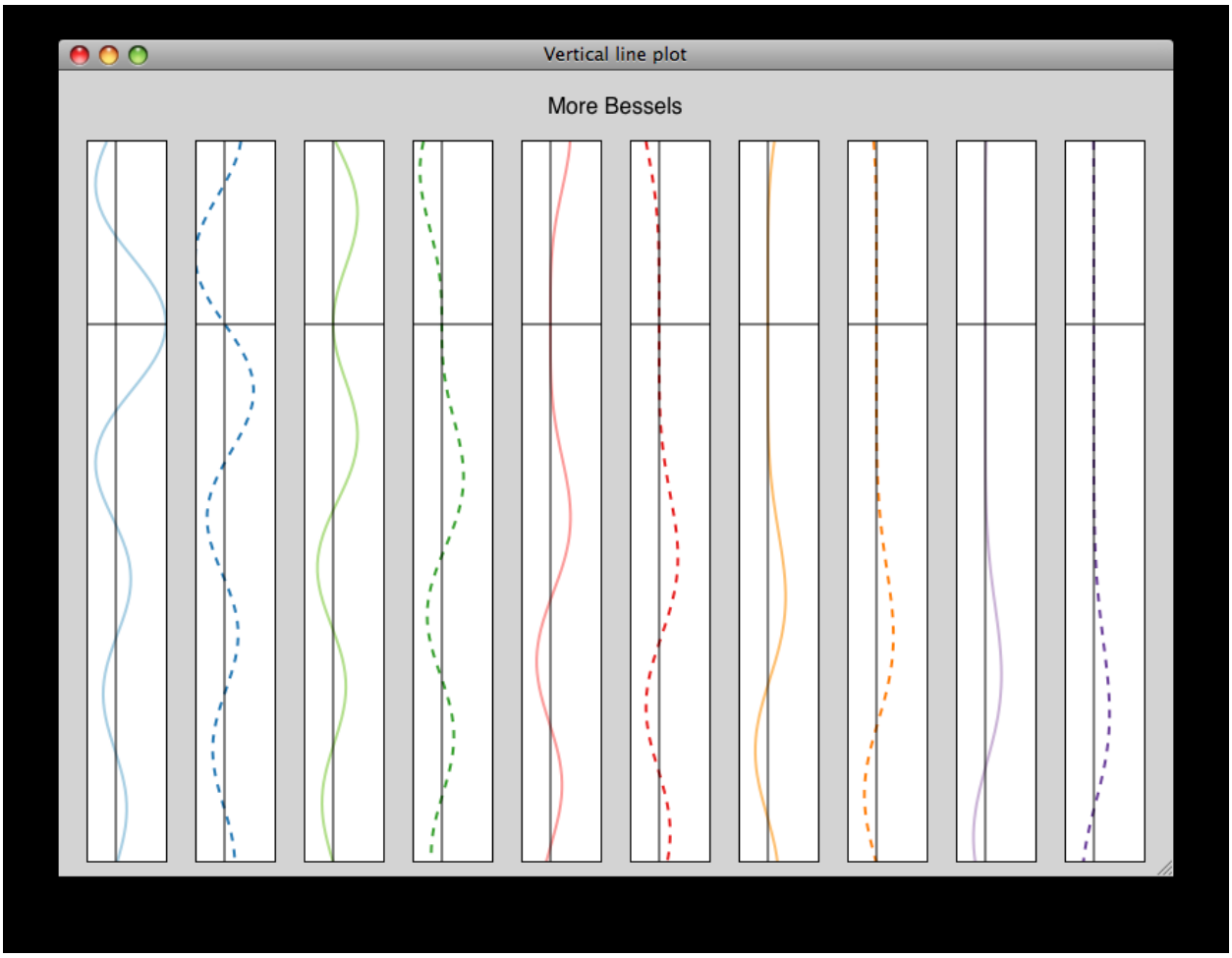


vertical_plot.py

Draws a static plot of bessel functions, oriented vertically, side-by-side.

You can experiment with using different containers (uncomment lines 32-33) or different orientations on the plots (comment out line 43 and uncomment 44).

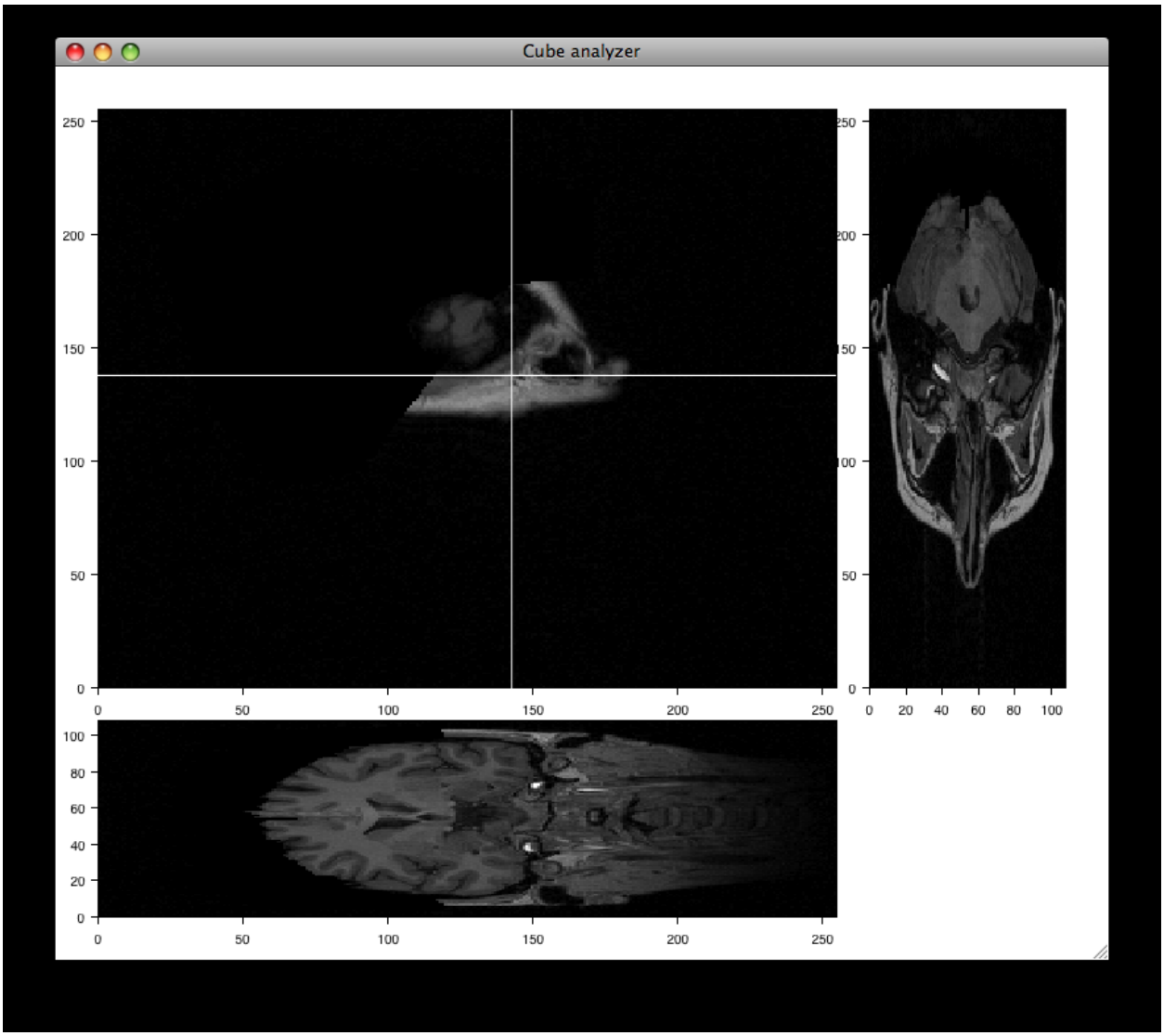
source: vertical_plot.py



data_cube.py

Allows isometric viewing of a 3-D data cube (downloads the necessary data, about 7.8 MB)

source: data_cube.py

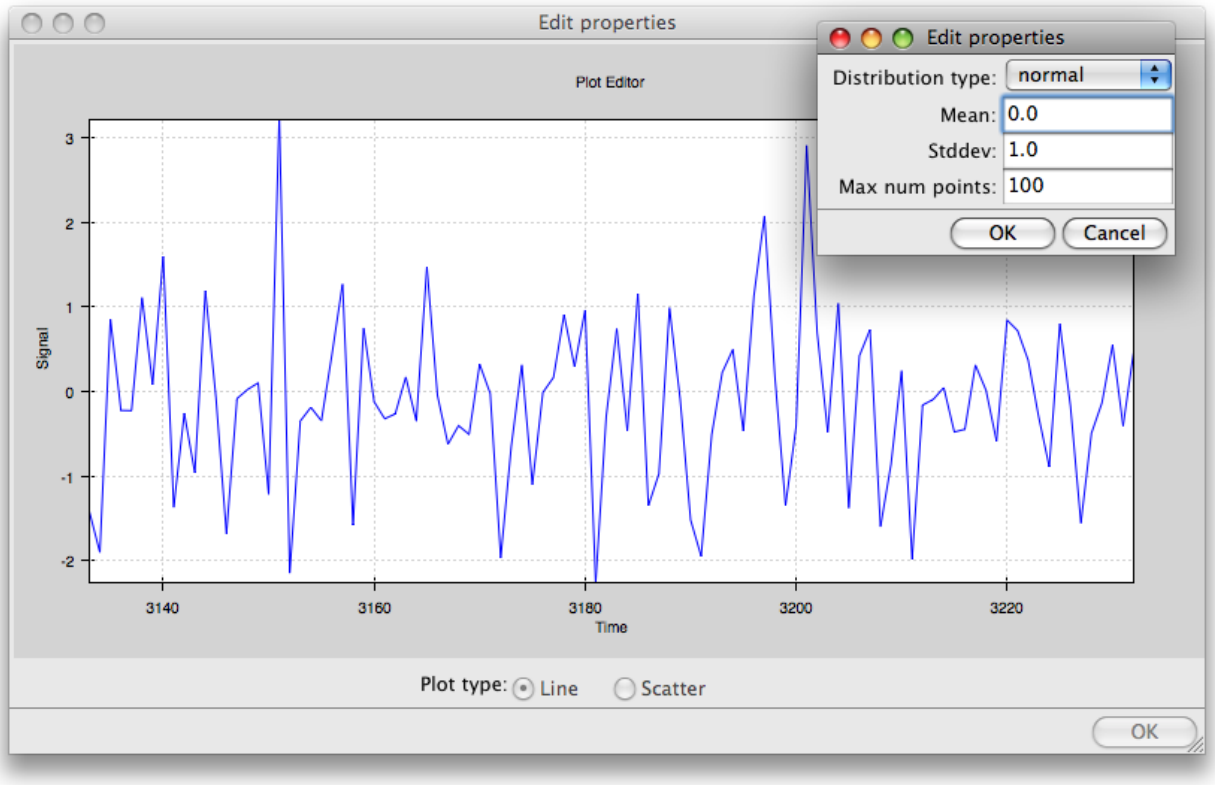


data_stream.py

This demo shows how Chaco and Traits can be used to easily build a data acquisition and visualization system.

Two frames are opened: one has the plot and allows configuration of various plot properties, and one which simulates controls for the hardware device from which the data is being acquired; in this case, it is a mockup random number generator whose mean and standard deviation can be controlled by the user.

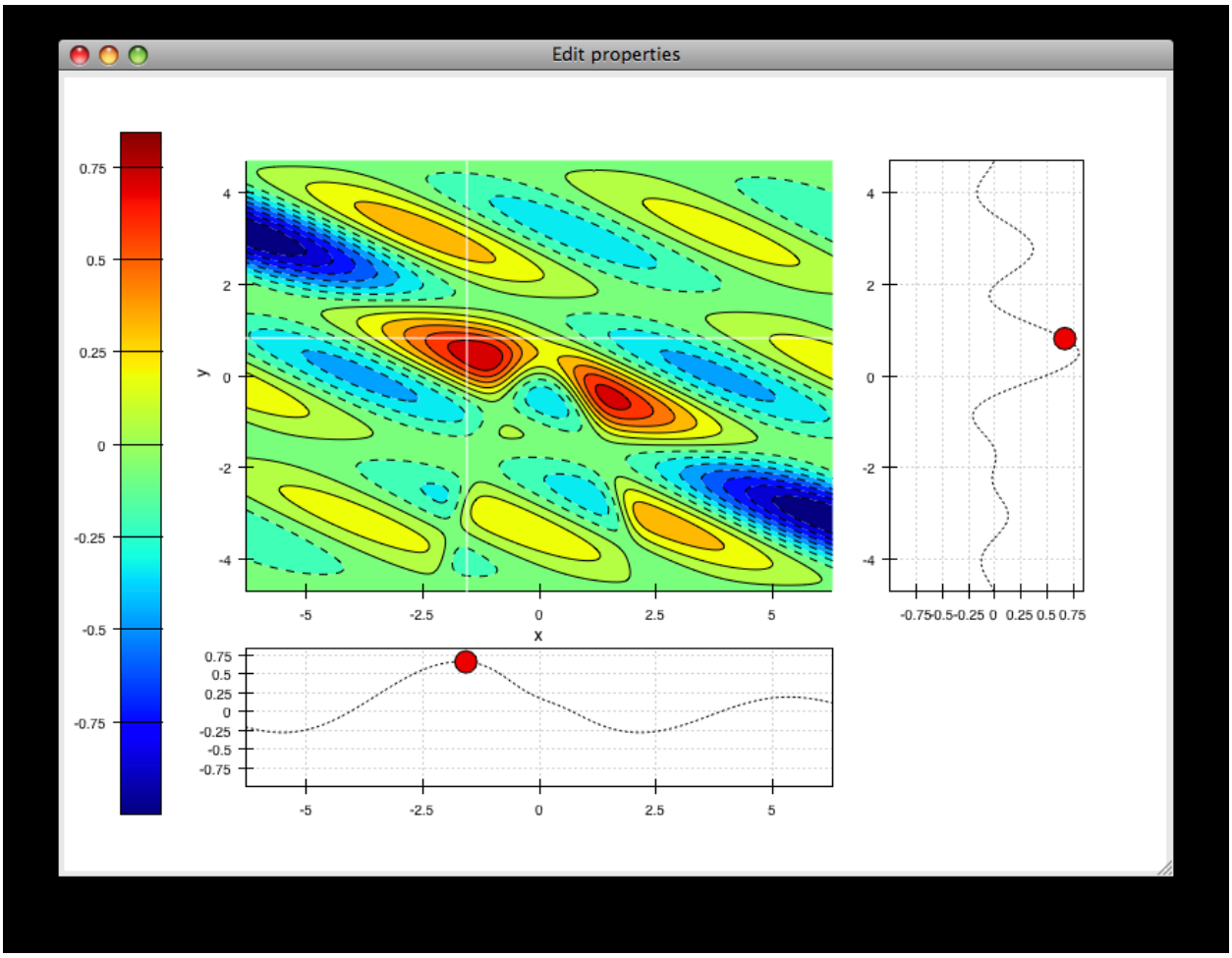
source: data_stream.py



scalar_image_function_inspector.py

Renders a colormapped image of a scalar value field, and a cross section chosen by a line interactor.

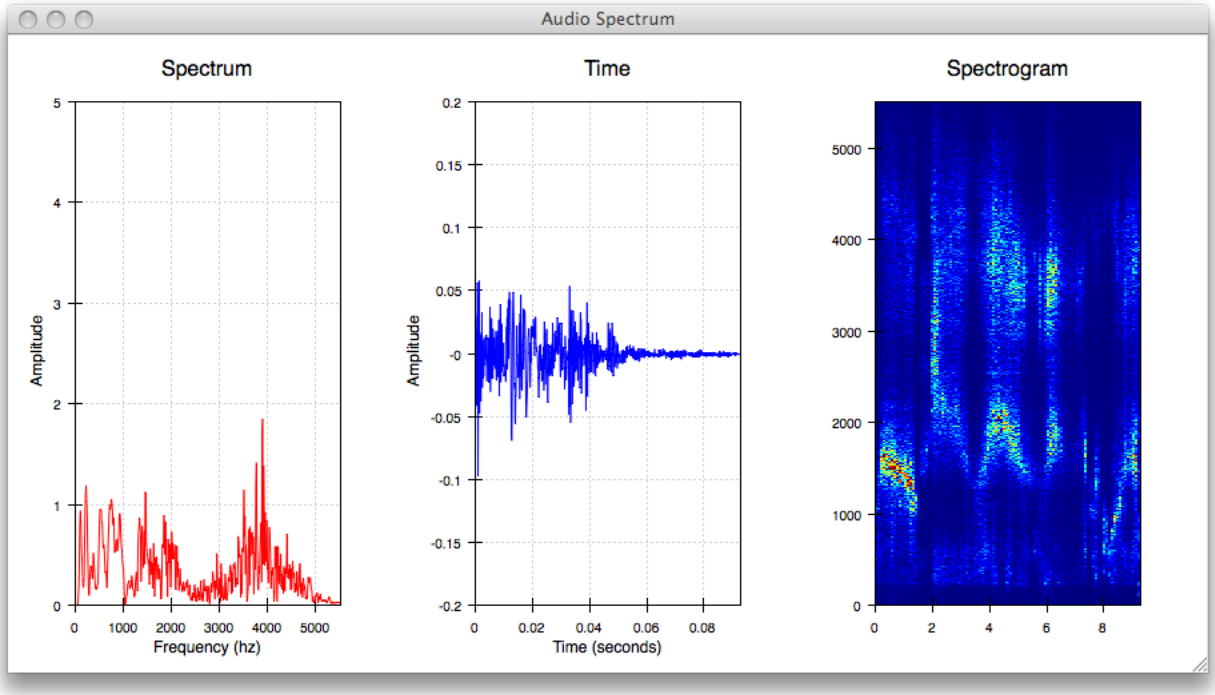
source: scalar_image_function_inspector.py



`spectrum.py`

This plot displays the audio spectrum from the microphone.

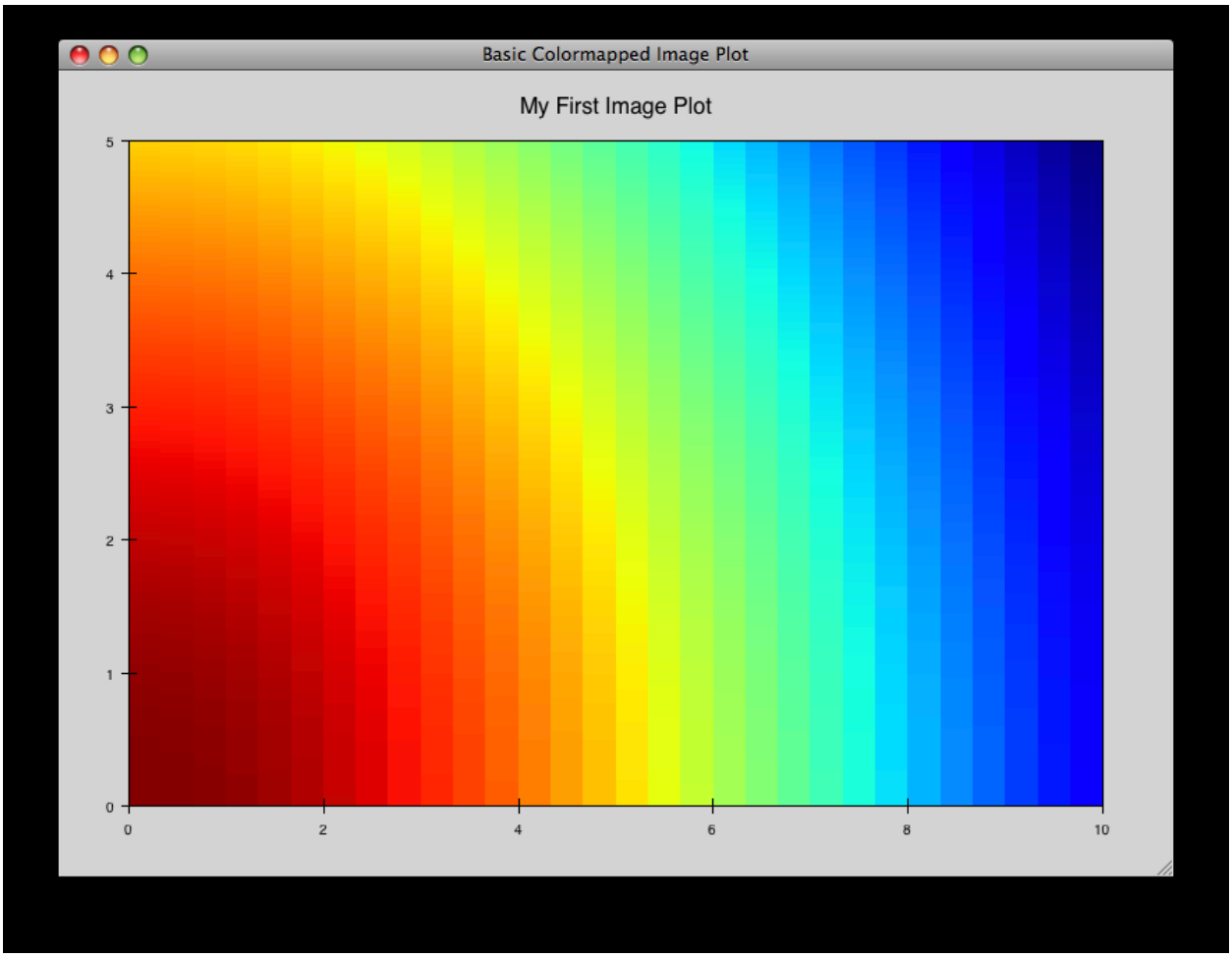
source: spectrum.py



`cmap_image_plot.py`

Draws a colormapped image plot.

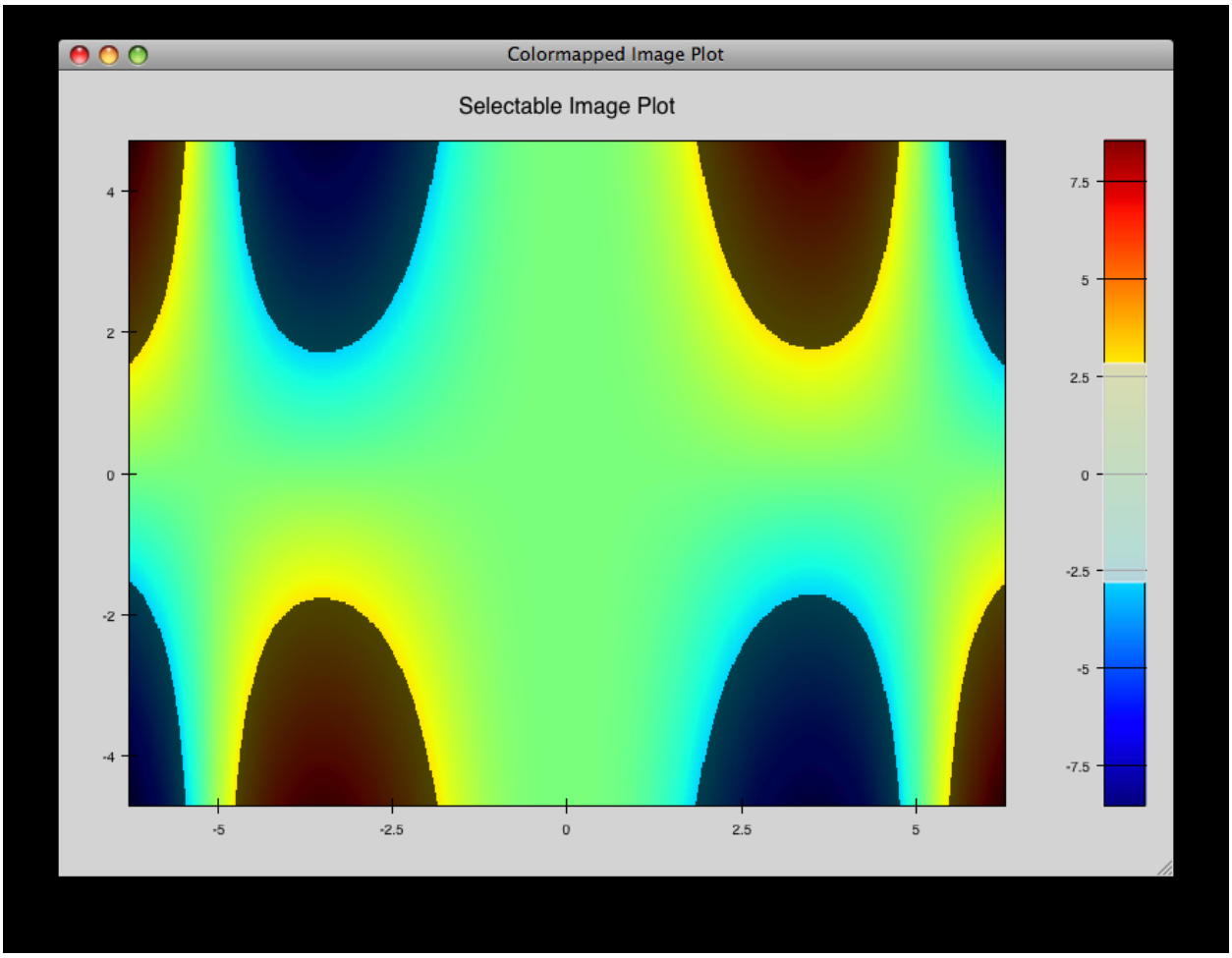
source: cmap_image_plot.py



cmap_image_select.py

Draws a colormapped image plot. Selecting colors in the spectrum on the right highlights the corresponding colors in the color map.

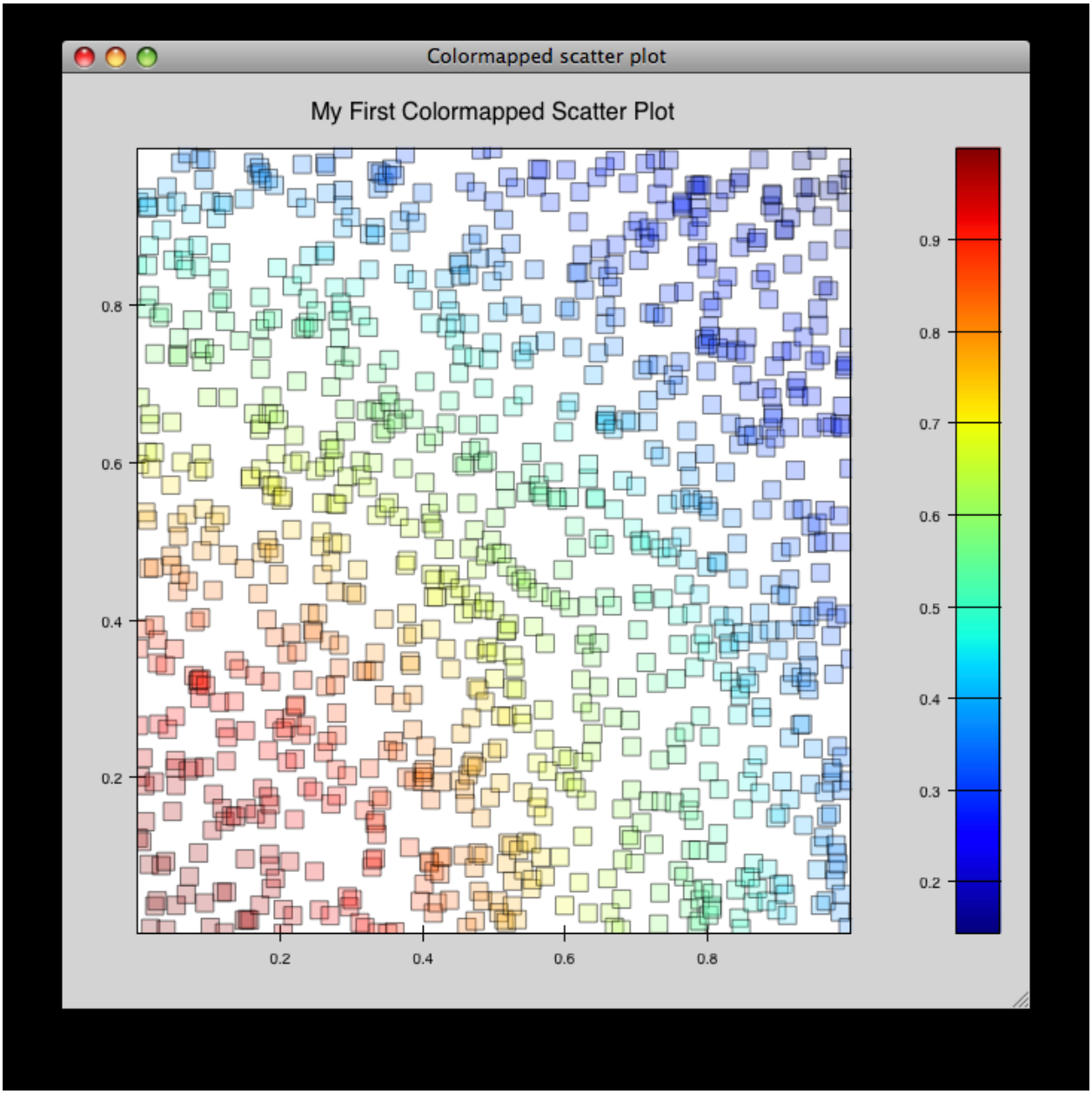
source: cmap_image_select.py



`cmap_scatter.py`

Draws a colormapped scatterplot of some random data. Selection works the same as in cmap_image_select.py.

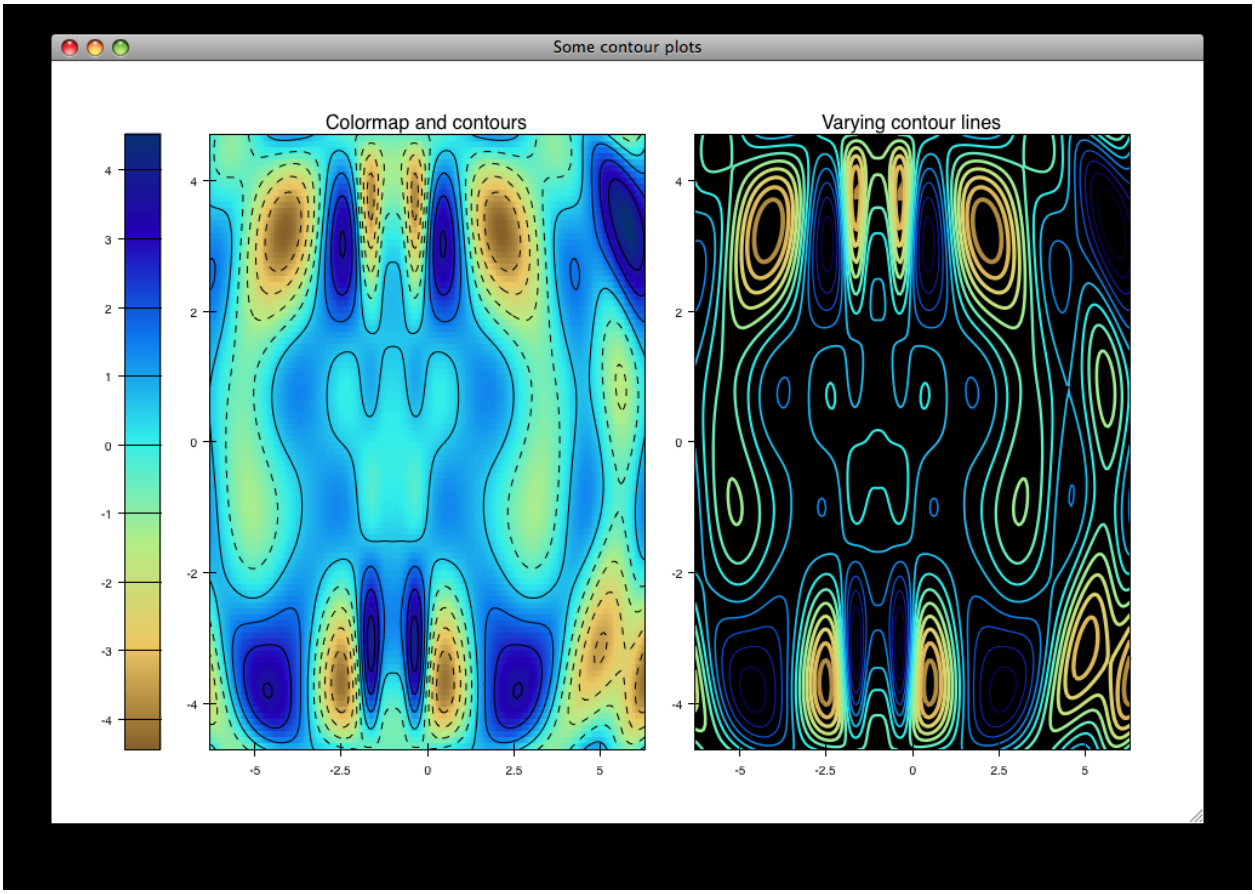
source: cmap_scatter.py



contour_cmap_plot.py

Renders some contoured and colormapped images of a scalar value field.

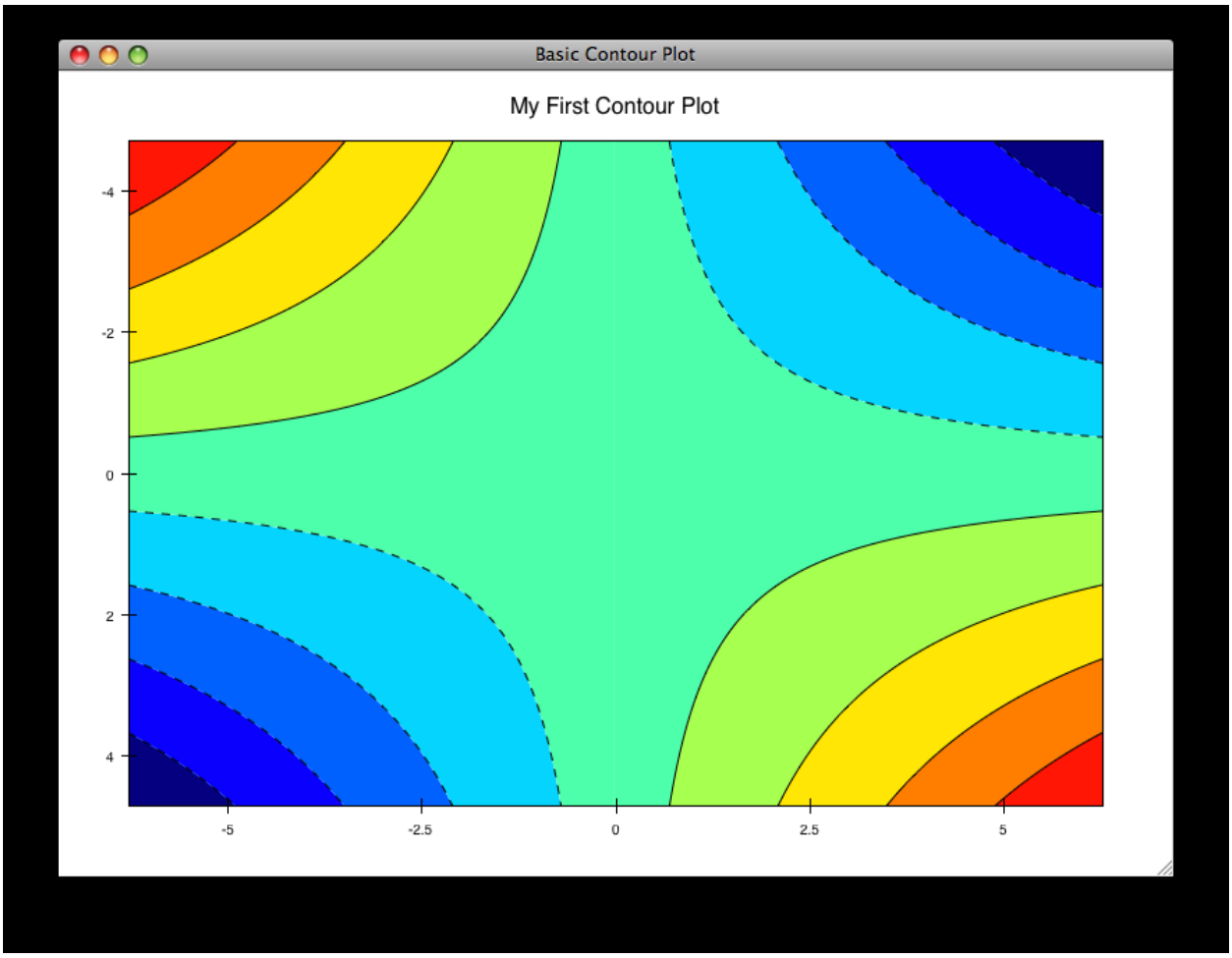
source: countour_cmap_plot.py



contour_plot.py

Draws an contour polygon plot with a contour line plot on top.

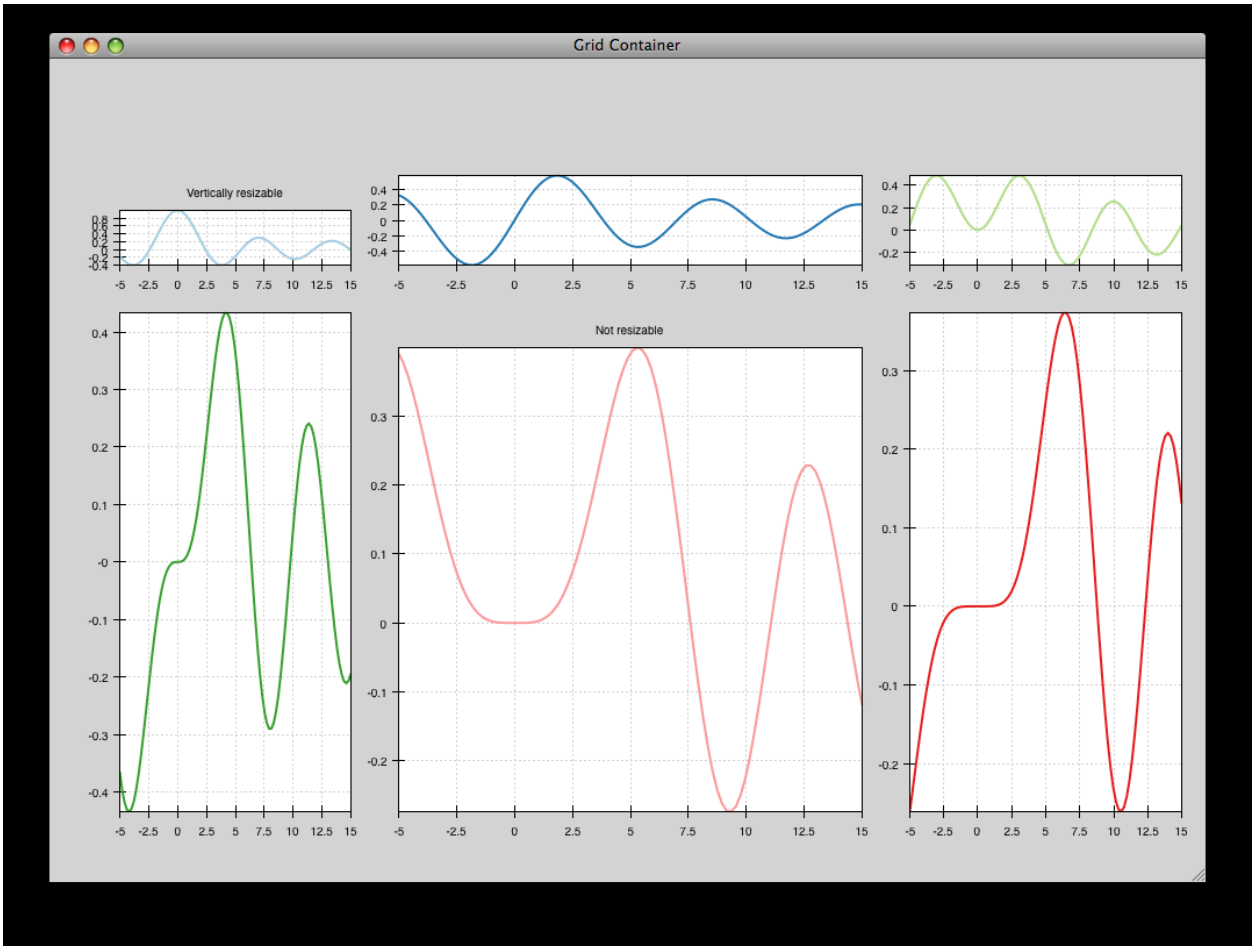
source: countour_plot.py



grid_container.py

Draws several overlapping line plots.

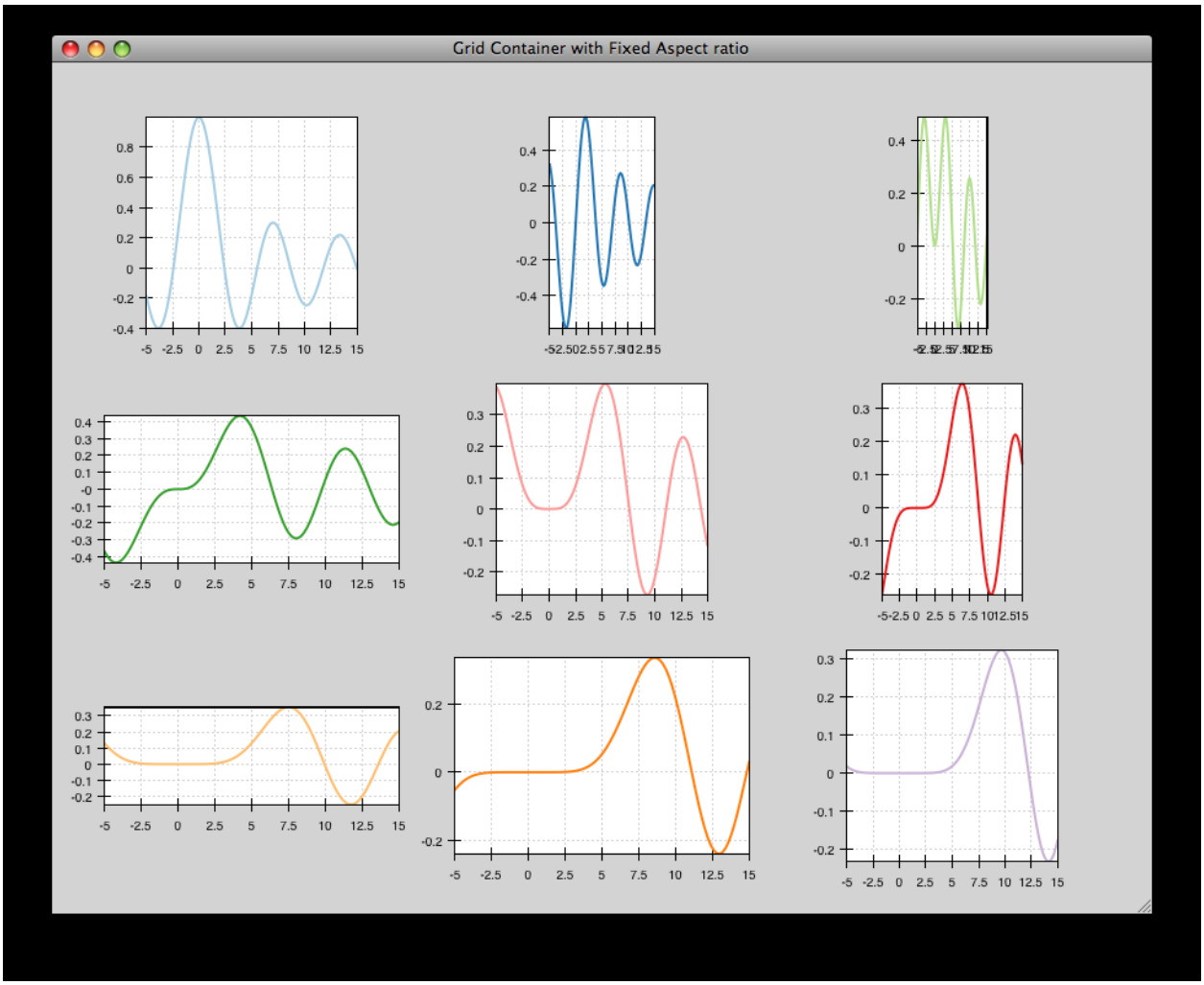
source: grid_container.py



grid_container_aspect_ratio

Similar to grid_container.py, but demonstrates Chaco's capability to used a fixed screen space aspect ratio for plot components.

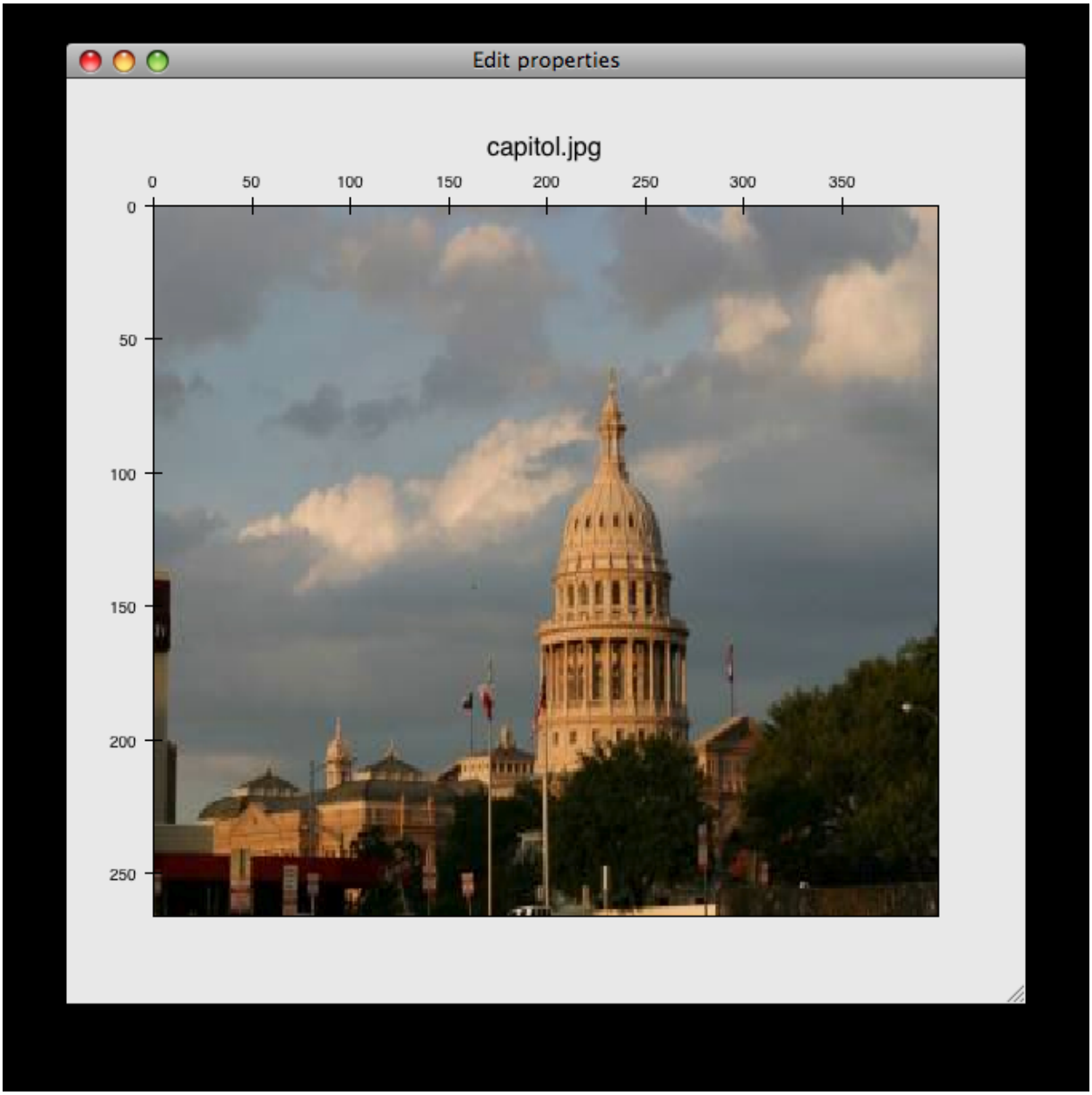
source: grid_container_aspect_ratio.py



image_from_file.py

Loads and saves RGB images from disk.

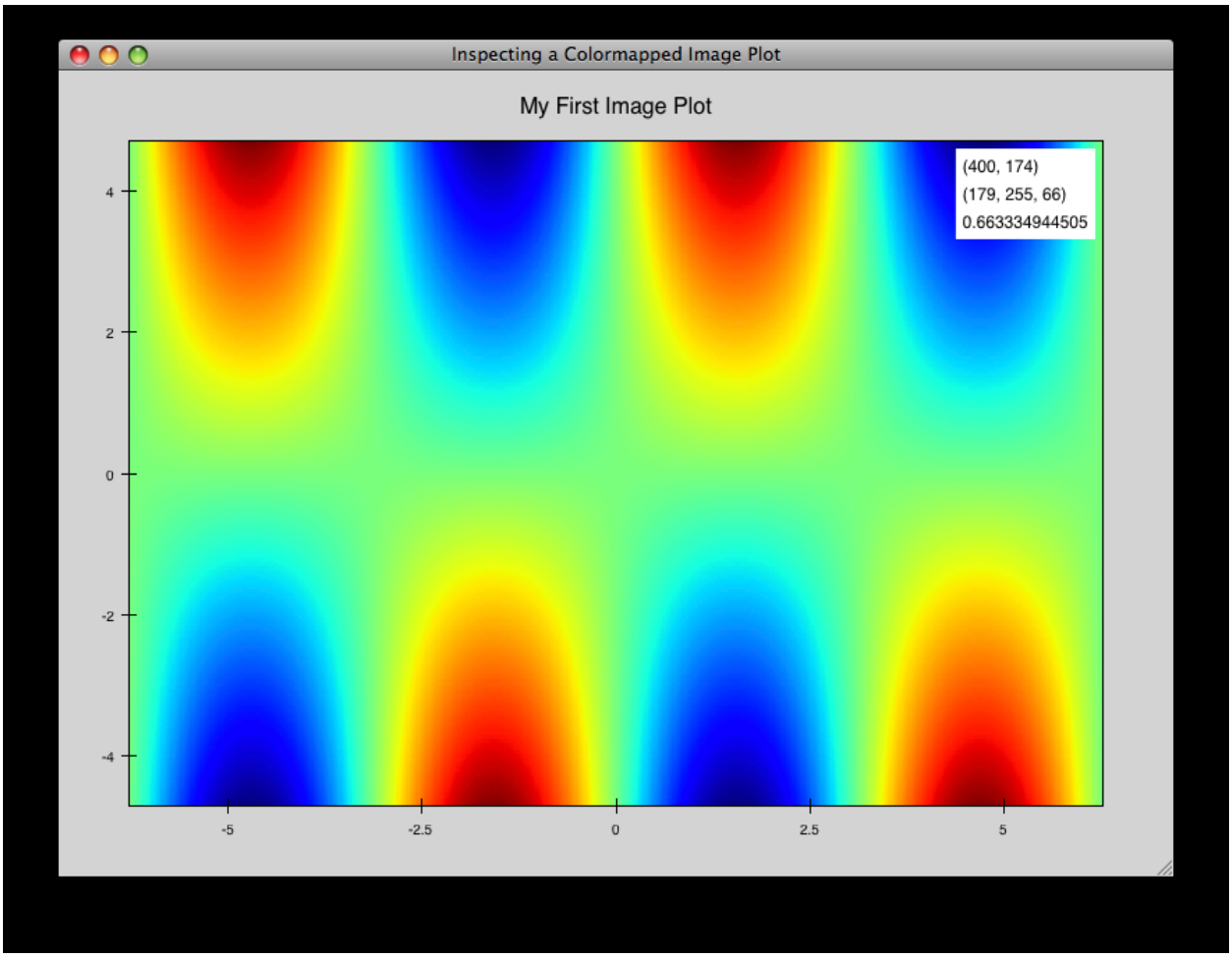
source: image_from_file.py



image_inspector.py

Demonstrates the ImageInspectorTool and overlay on a colormapped image plot. The underlying plot is similar to the one in cmap_image_plot.py.

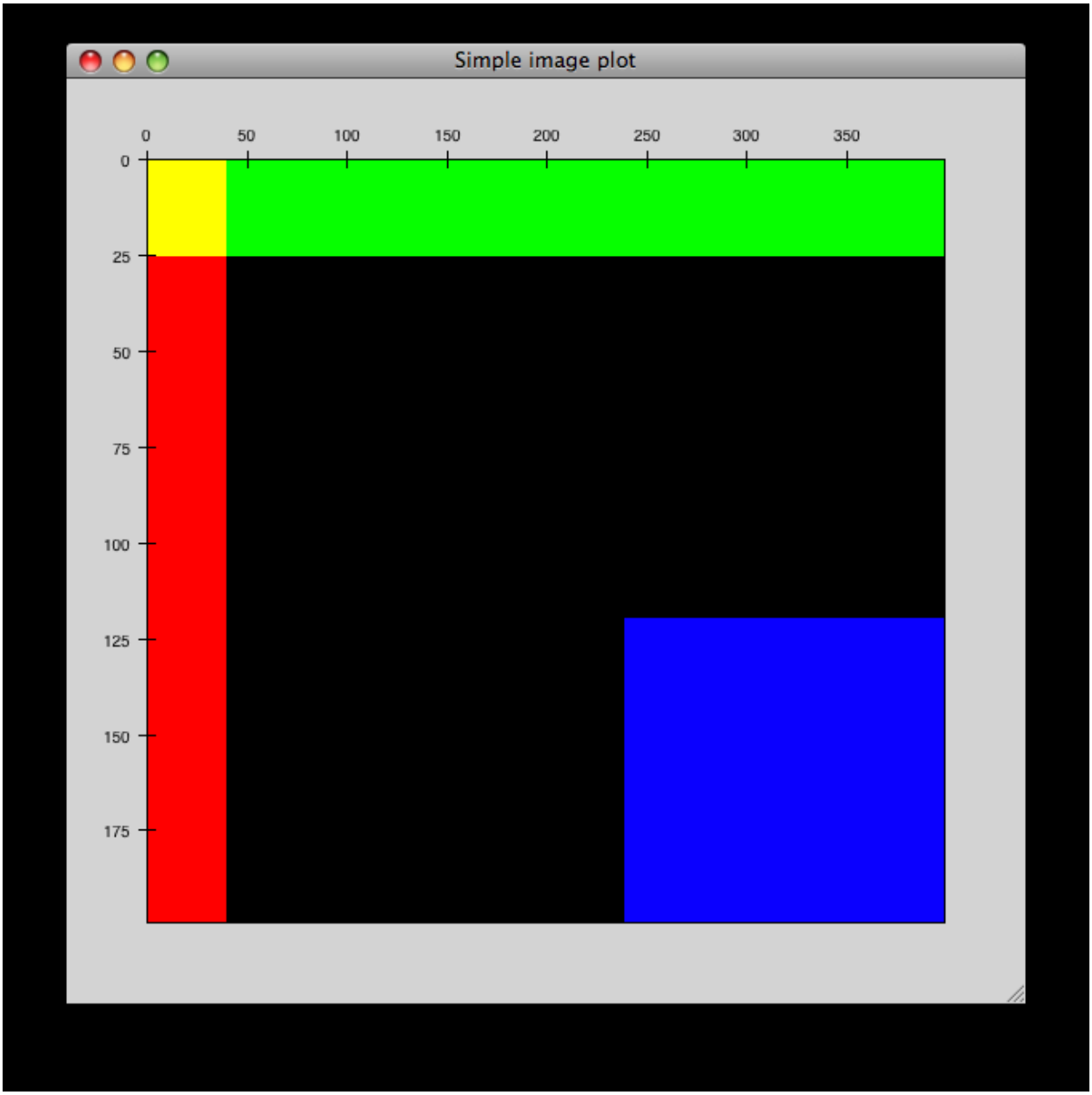
source: image_inspector.py



image_plot.py

Draws a simple RGB image

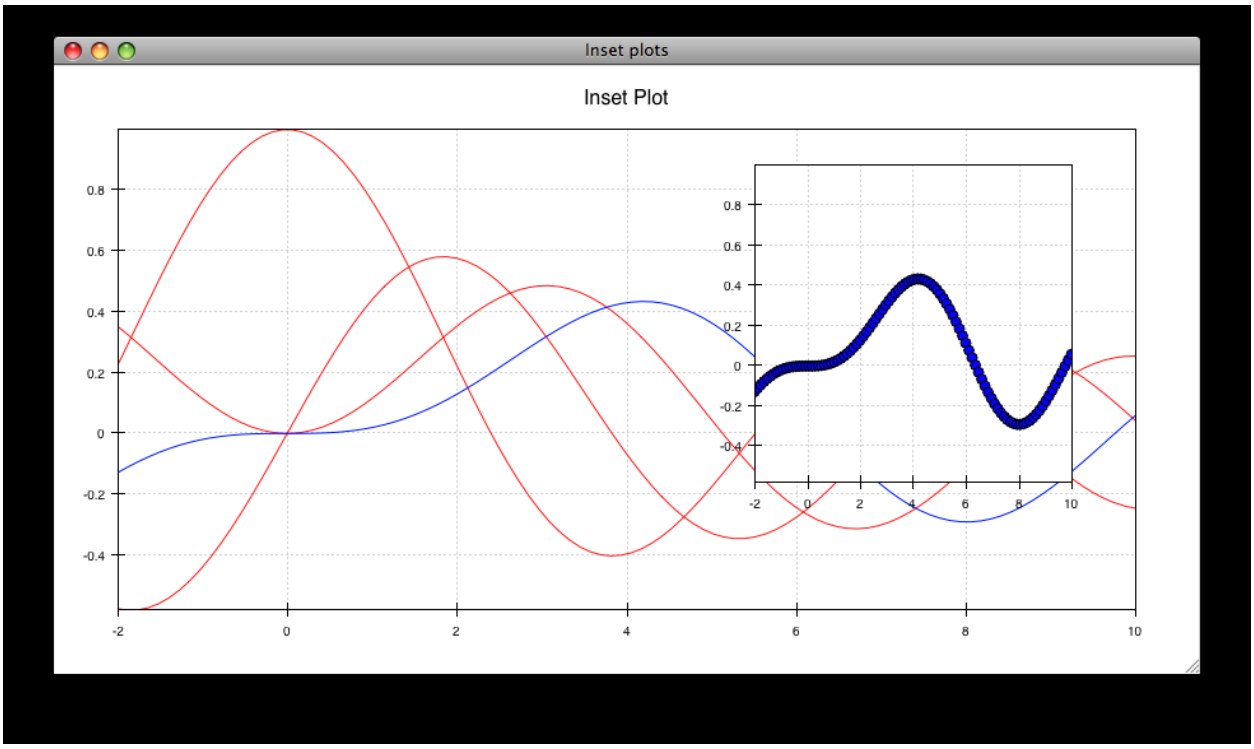
source: image_plot.py



inset_plot.py

A modification of line_plot1.py that shows the second plot as a subwindow of the first. You can pan and zoom the second plot just like the first, and you can move it around my right-click and dragging in the smaller plot.

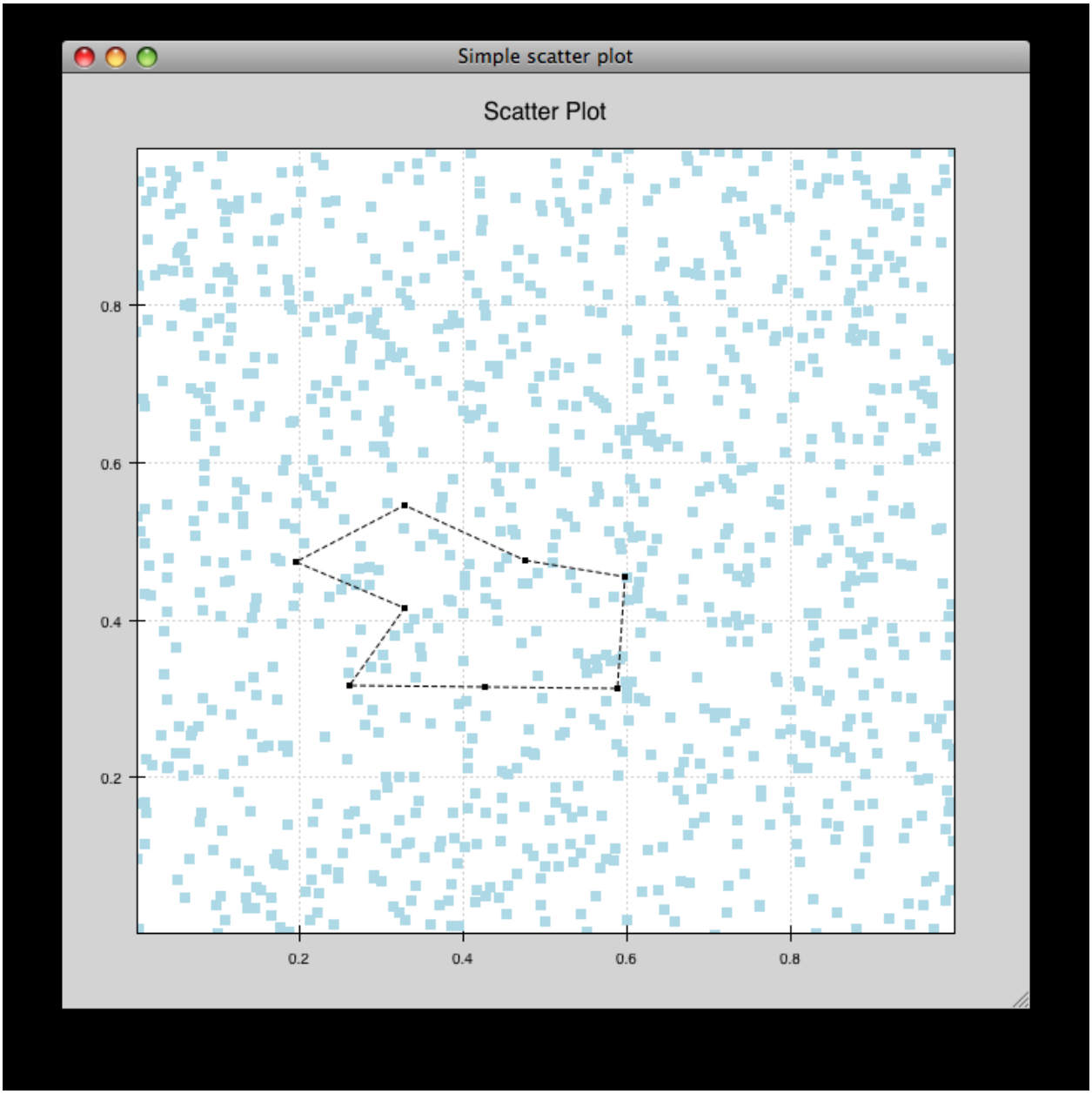
source: inset_plot.py



line_drawing.py

Demonstrates using a line segment drawing tool on top of the scatter plot from simple_scatter.py.

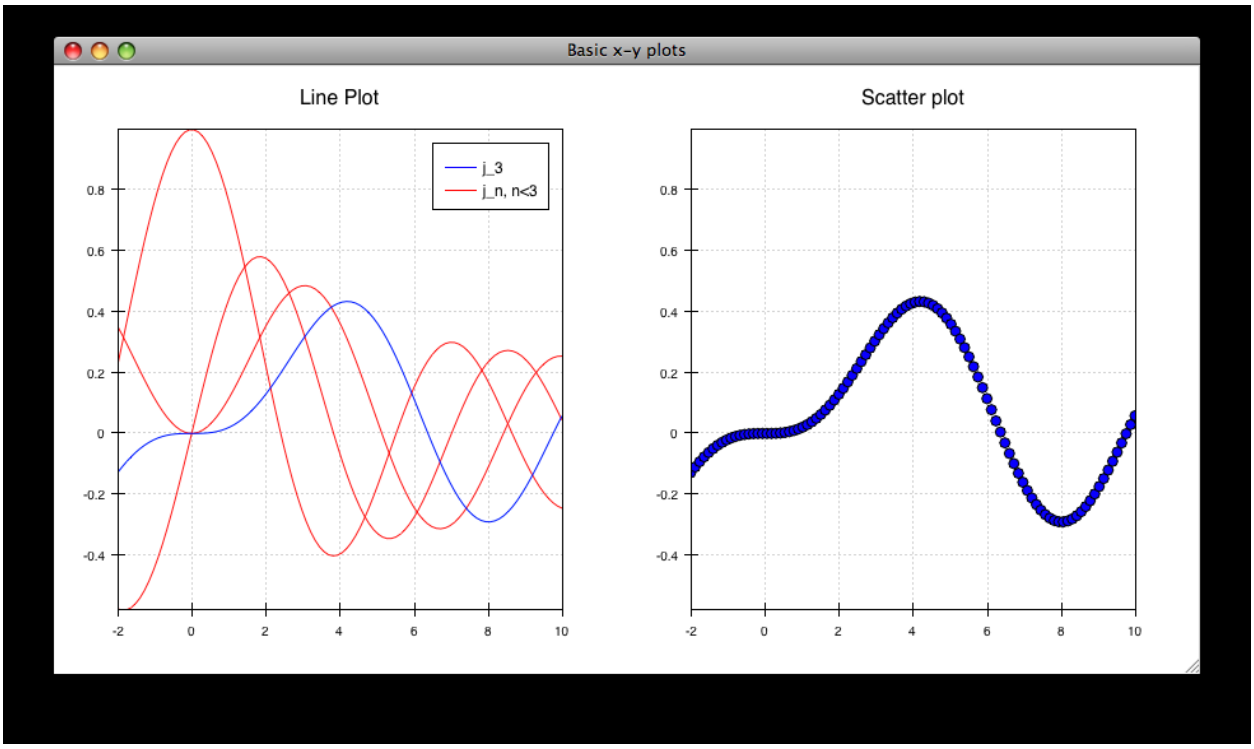
source: line_drawing.py



line_plot1.py

Draws some x-y line and scatter plots.

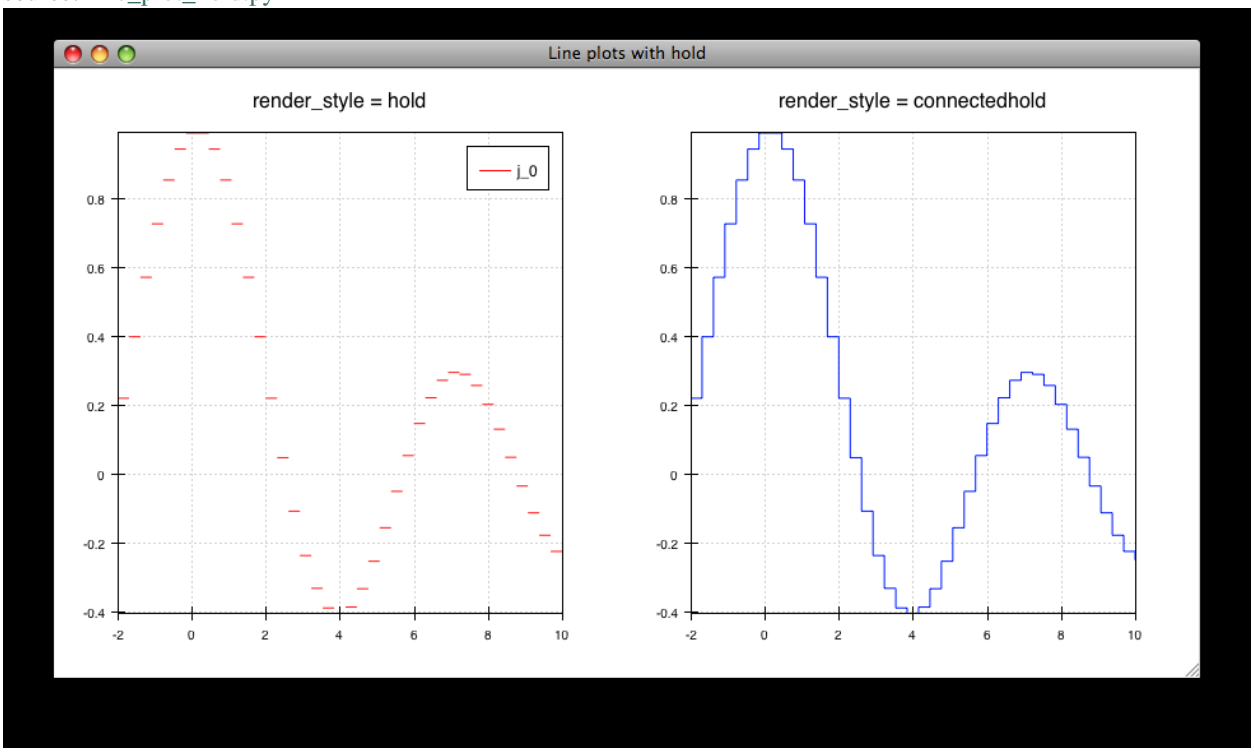
source: line_plot1.py



`line_plot_hold.py`

Demonstrates the different 'hold' styles of LinePlot.

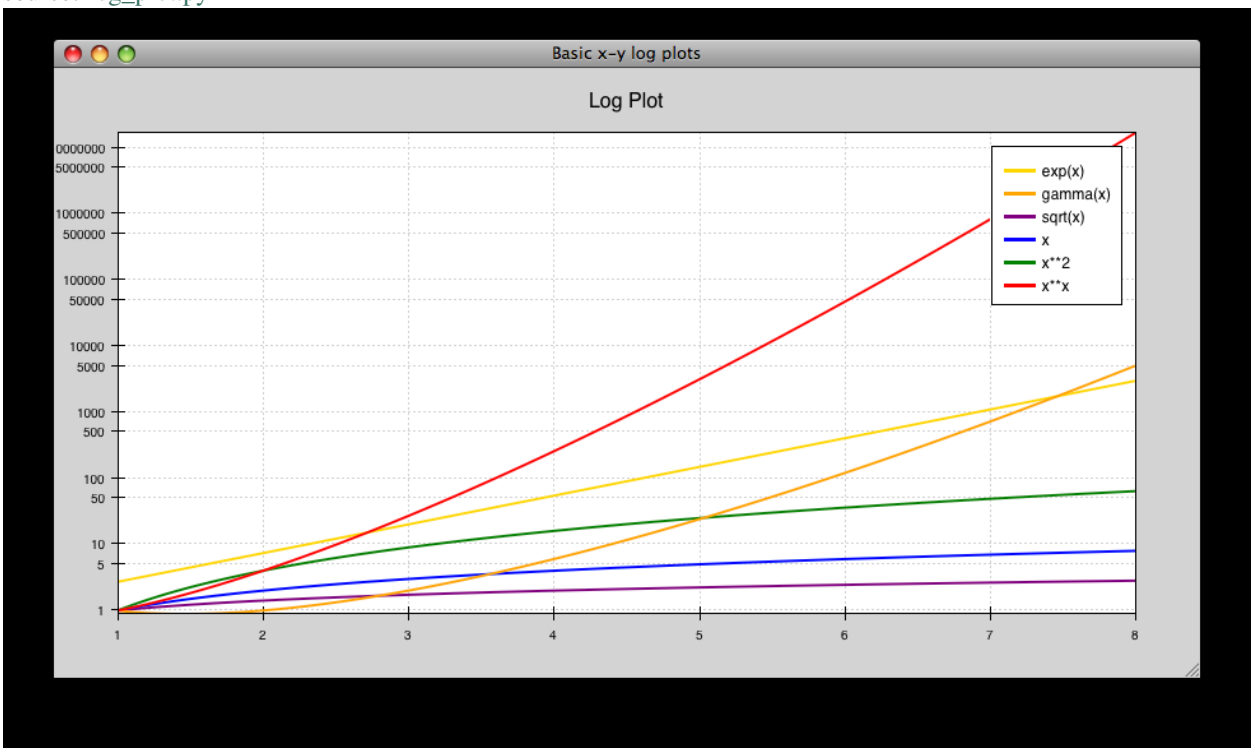
source: line_plot_hold.py



log_plot.py

Draws some x-y log plots. (No Tools).

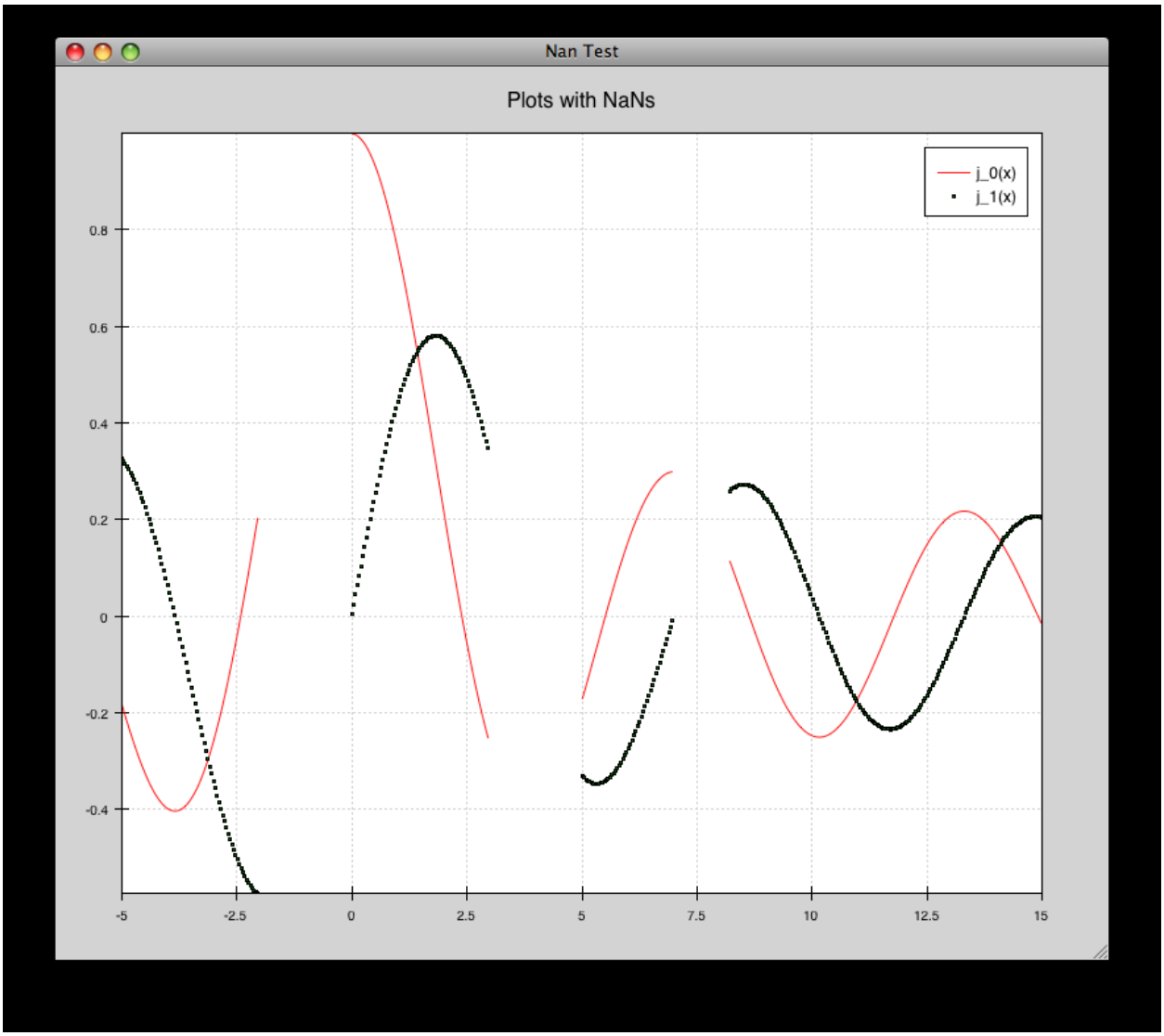
source: log_plot.py



nans_plot.py

This plot displays chaco's ability to handle data interlaced with NaNs.

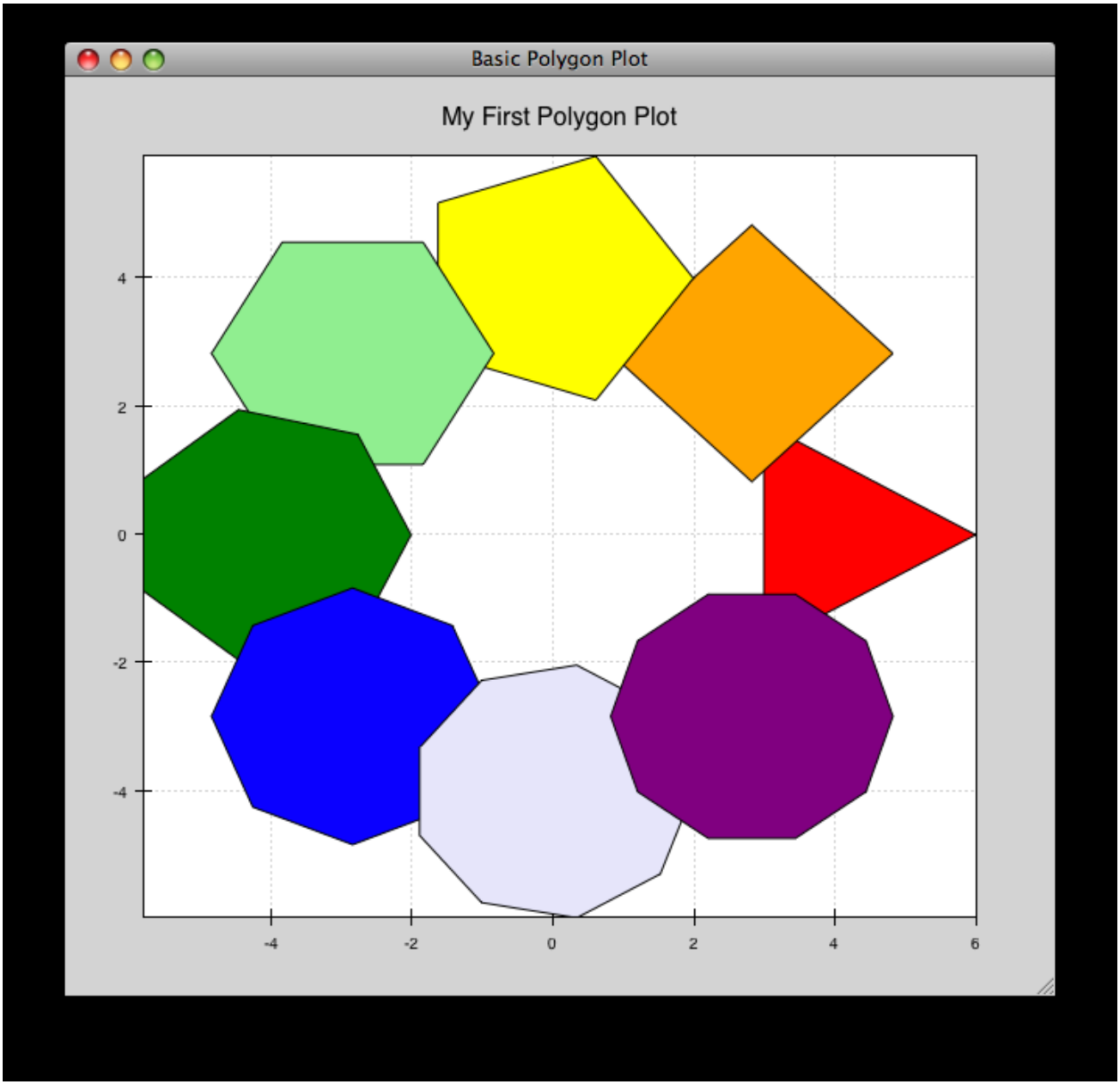
source: nans_plot.py



polygon_plot_demo.py

Draws some different polygons.

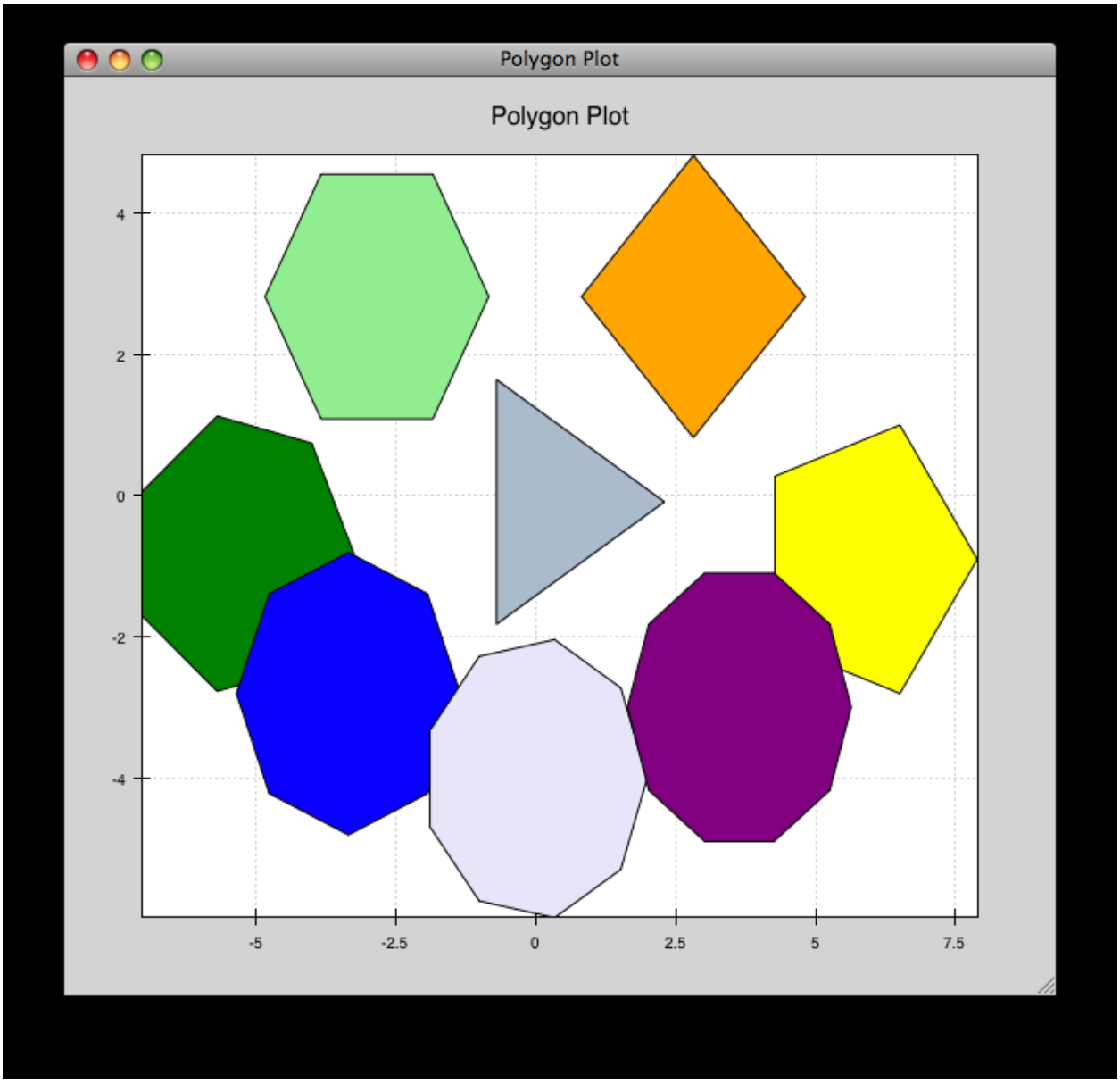
source: polygon_plot_demo.py



polygon_move.py

Shares same basic interactions as polygon_plot.py, but adds a new one: right-click and drag to move a polygon around.

source: polygon_move.py

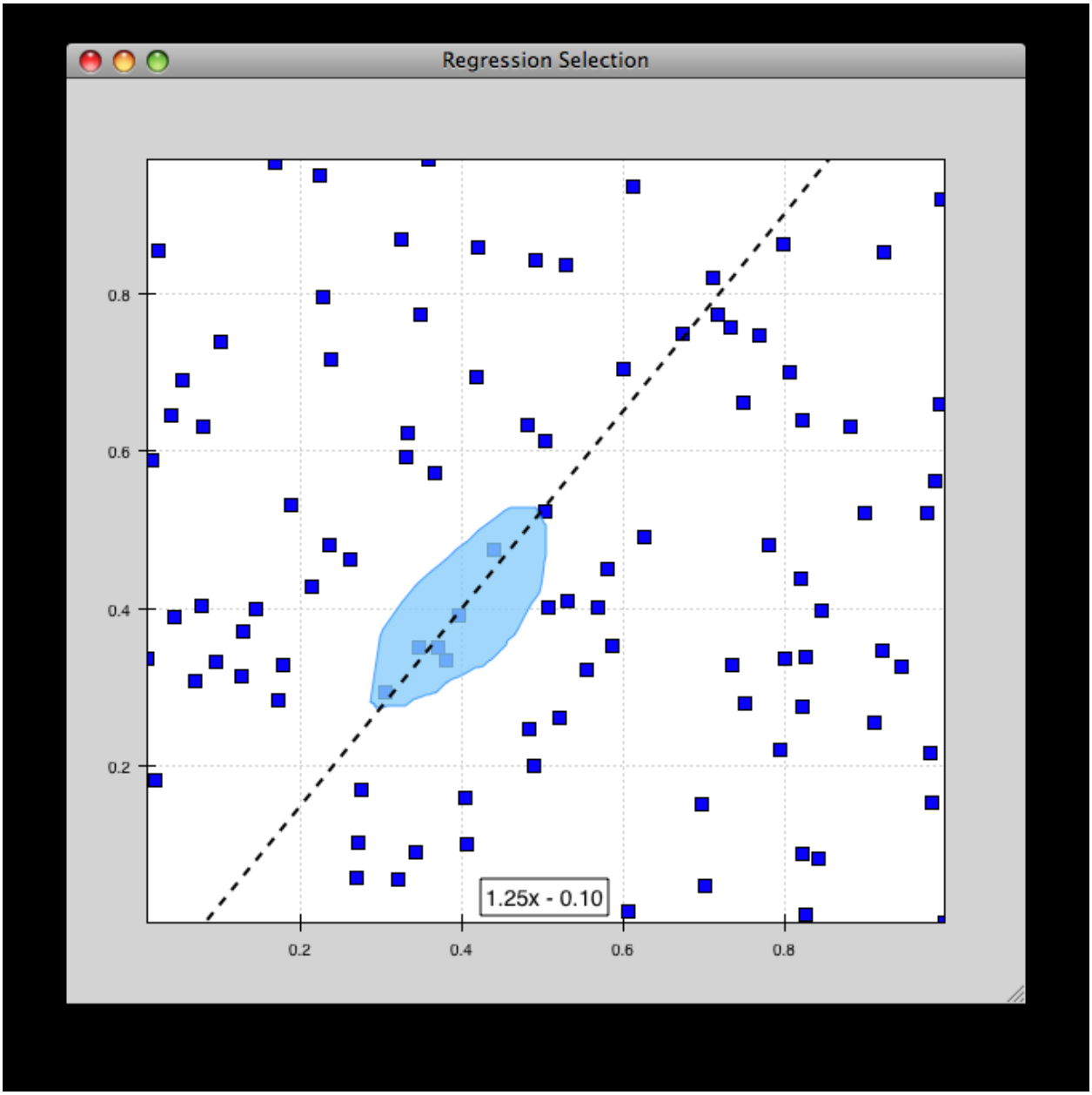


regression.py

Demonstrates the Regression Selection tool.

Hold down the left mouse button to use the mouse to draw a selection region around some points, and a line fit is drawn through the center of the points. The parameters of the line are displayed at the bottom of the plot region. You can do this repeatedly to draw different regions.

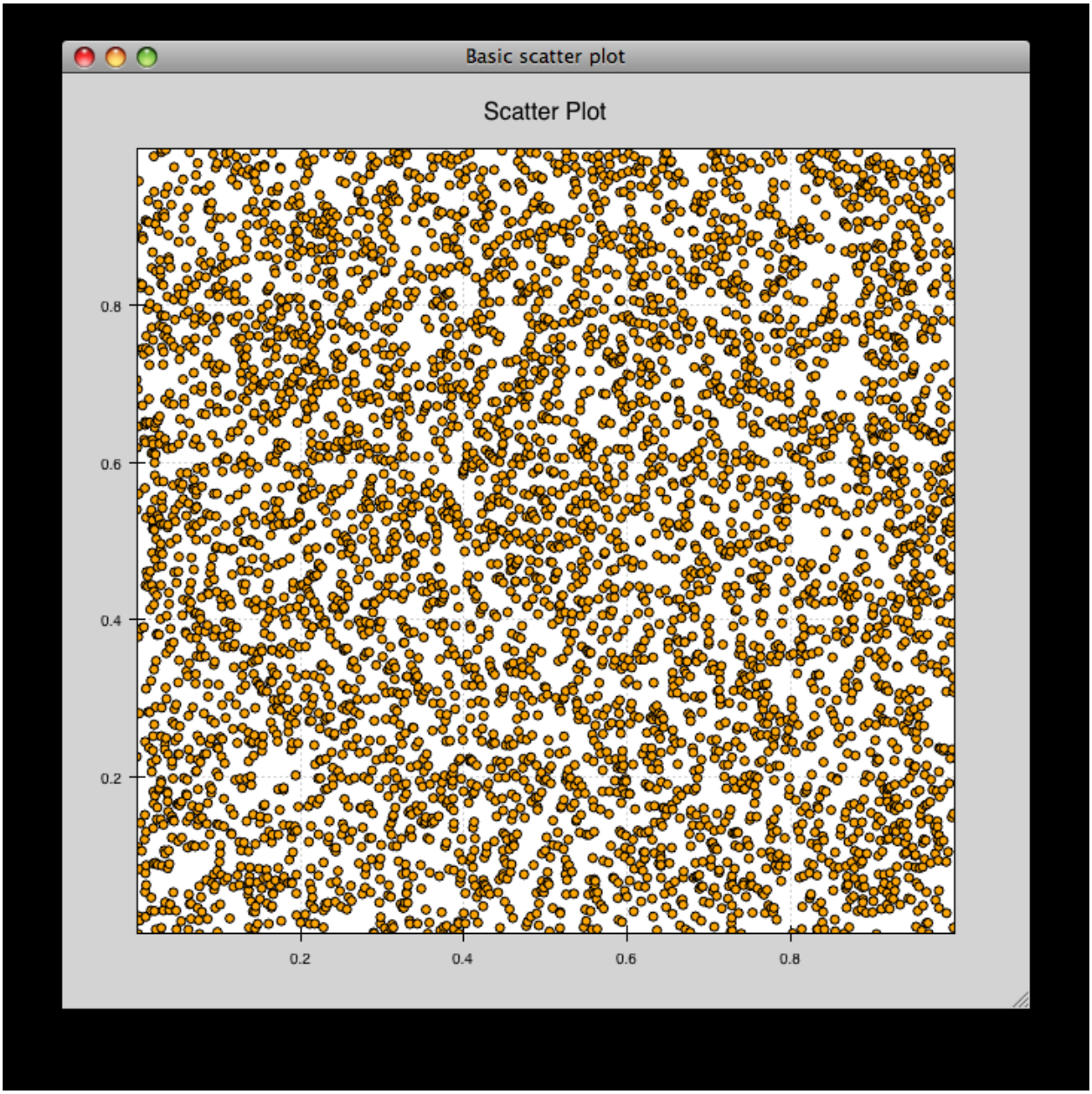
source: regression.py



scatter.py

Draws a simple scatterplot of a set of random points.

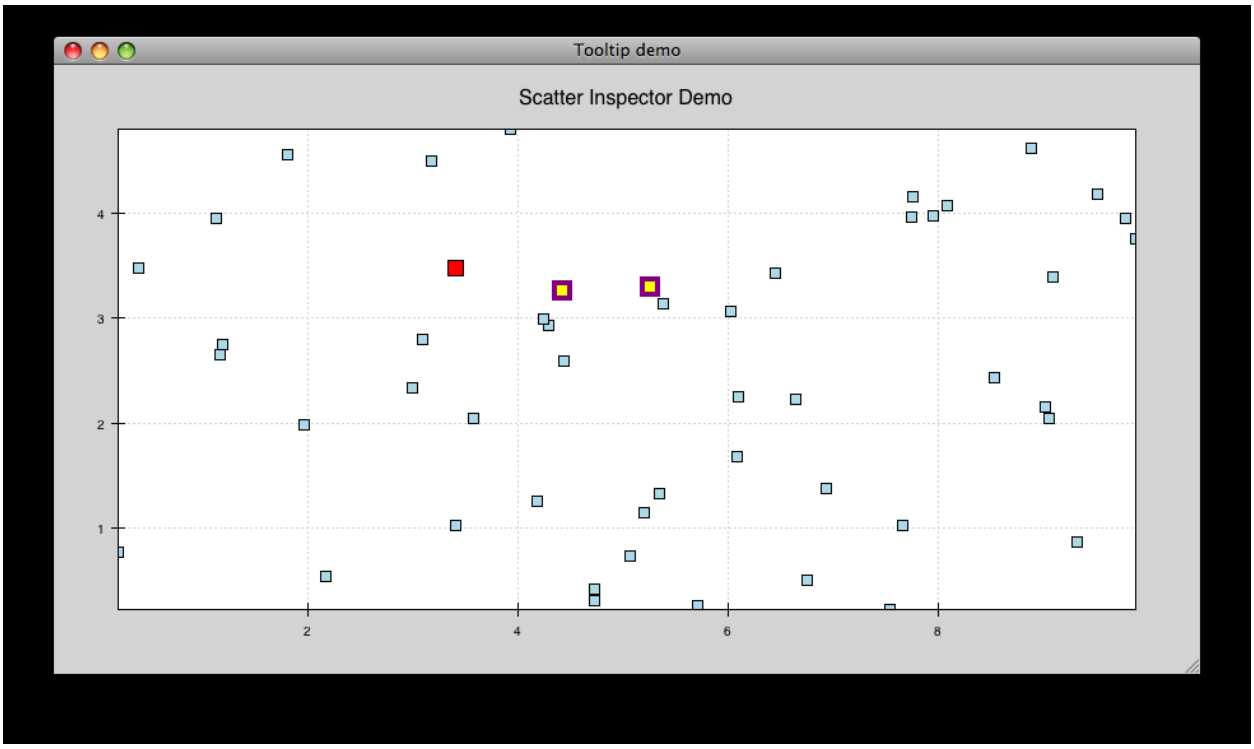
source: scatter.py



scatter_inspector.py

Example of using tooltips on Chaco plots.

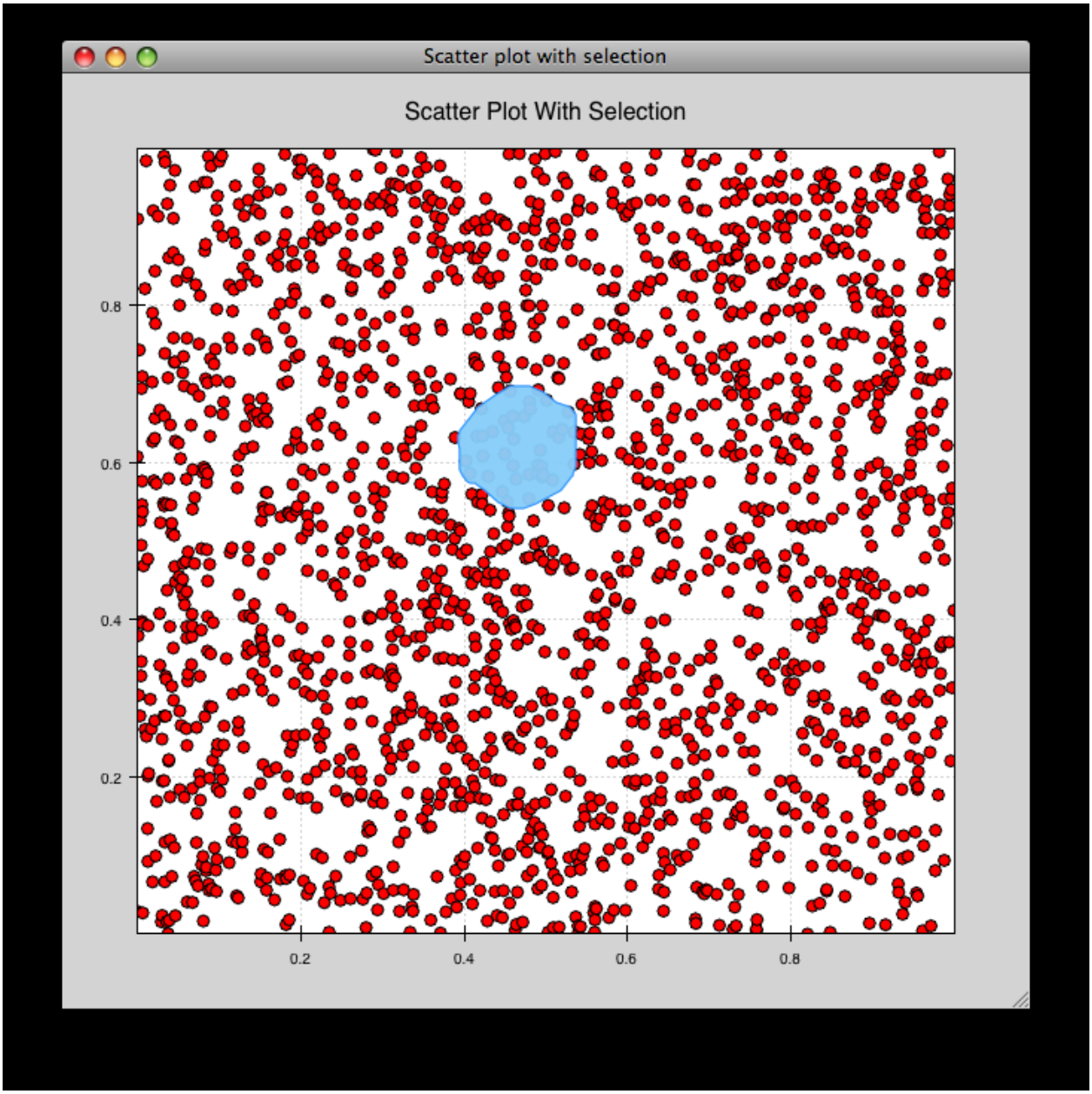
source: scatter_inspector.py



scatter_select.py

Draws a simple scatterplot of random data. The only interaction available is the lasso selector, which allows you to circle a set of points. Upon completion of the lasso operation, the indices of the selected points are printed to the console.

source: scatter_select.py



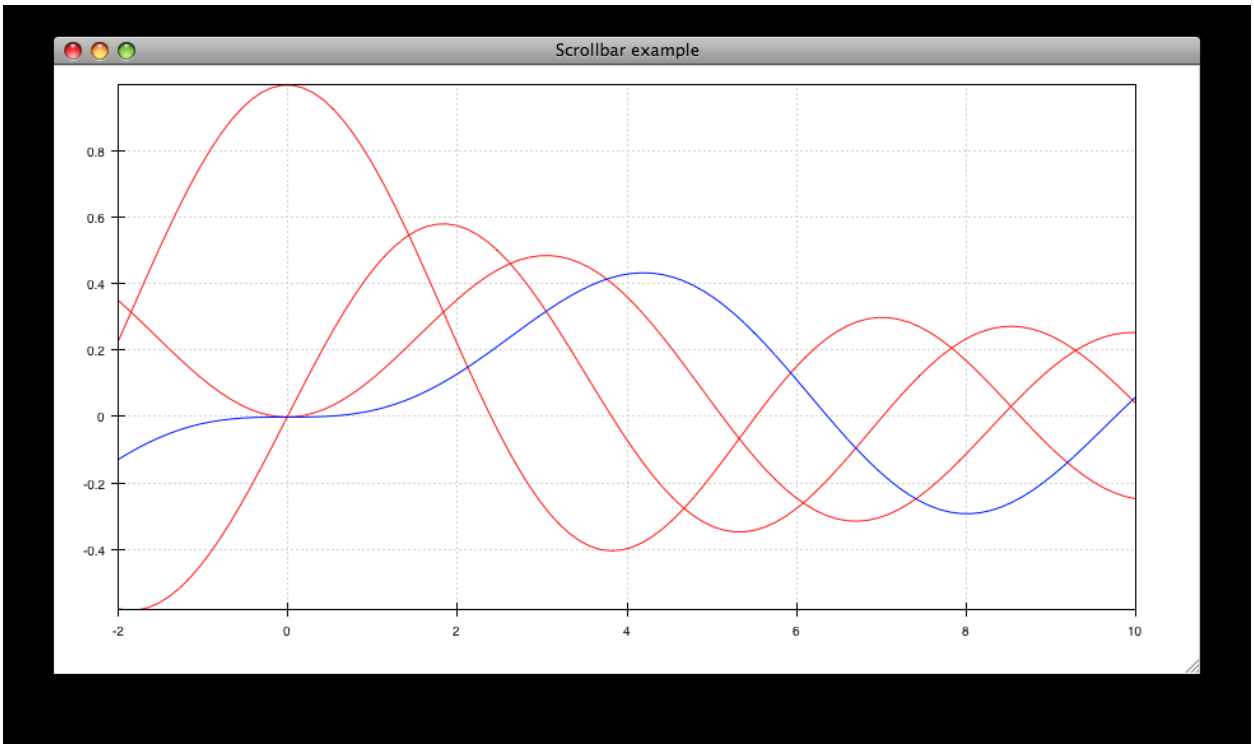
console output:

```
New selection:
    [789  799  819  830  835  836  851  867  892  901  902  909  913  924  929
     931  933  938  956  971  972  975  976  996  999 1011 1014 1016 1021 1030
     1045 1049 1058 1061 1073 1086 1087 1088]
```

scrollbar.py

Draws some x-y line and scatter plots.

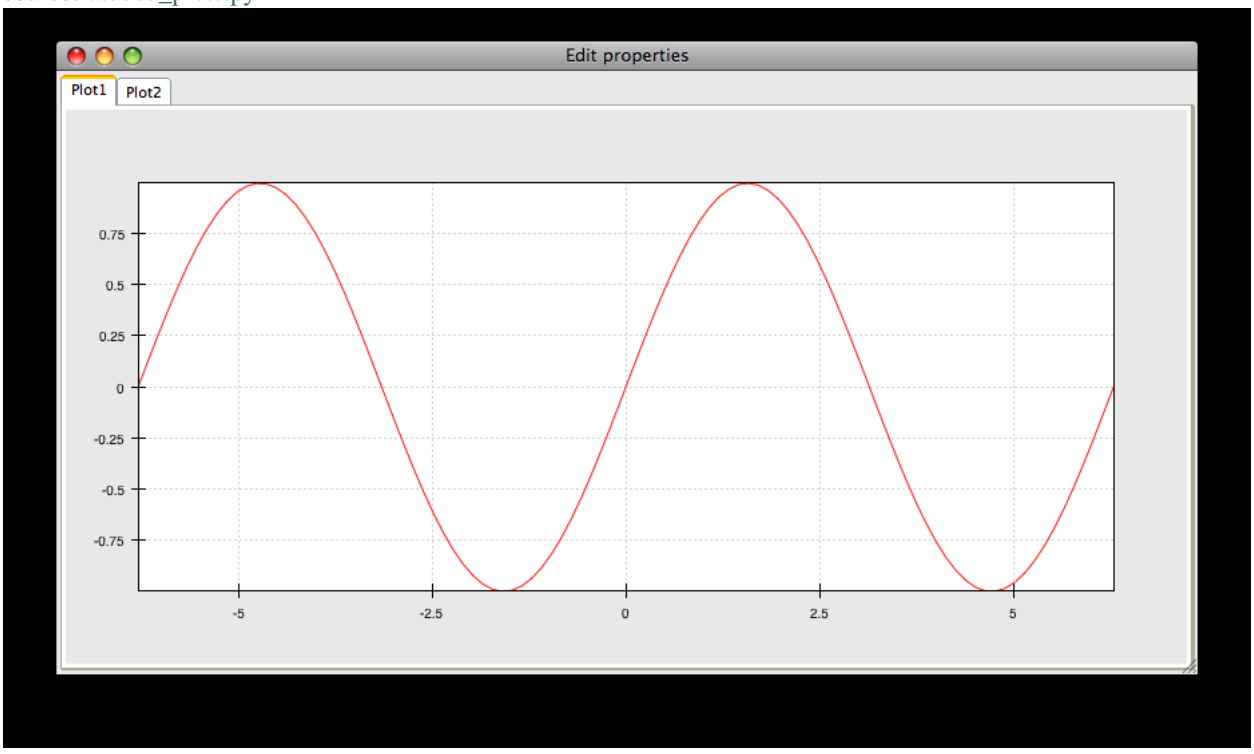
source: scrollbar.py

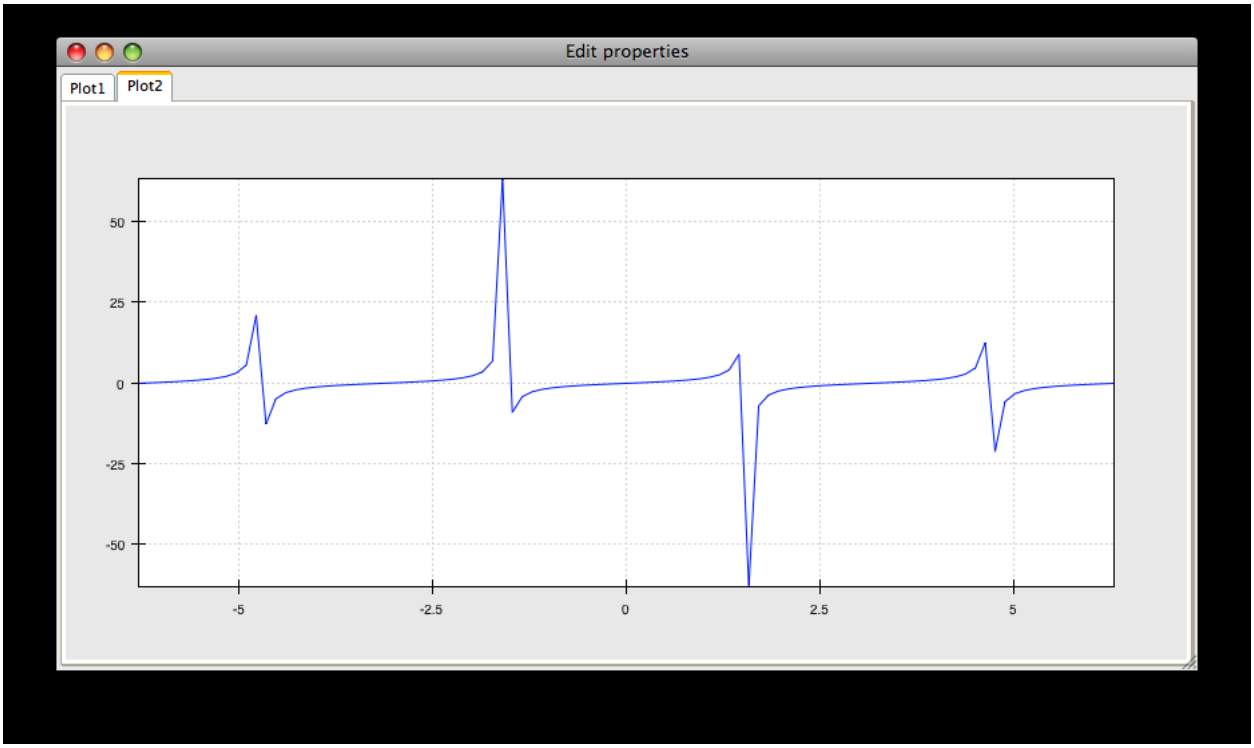


`tabbed_plots.py`

Draws some x-y line and scatter plots.

source: tabbed_plots.py

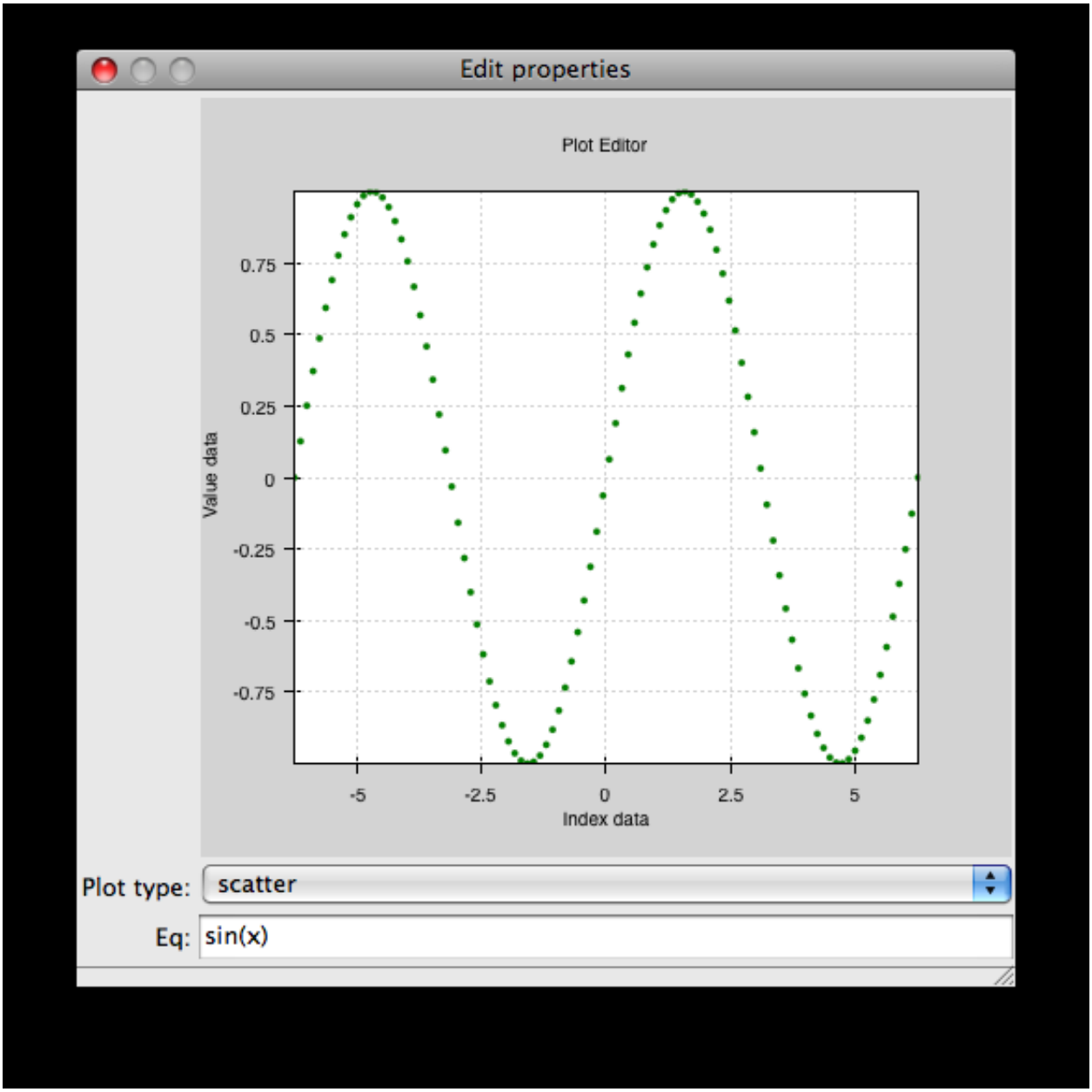




traits_editor.py

This example creates a simple 1-D function examiner, illustrating the use of ChacoPlotEditors for displaying simple plot relations, as well as Traits UI integration. Any 1-D numpy/scipy.special function works in the function text box.

source: traits_editor.py



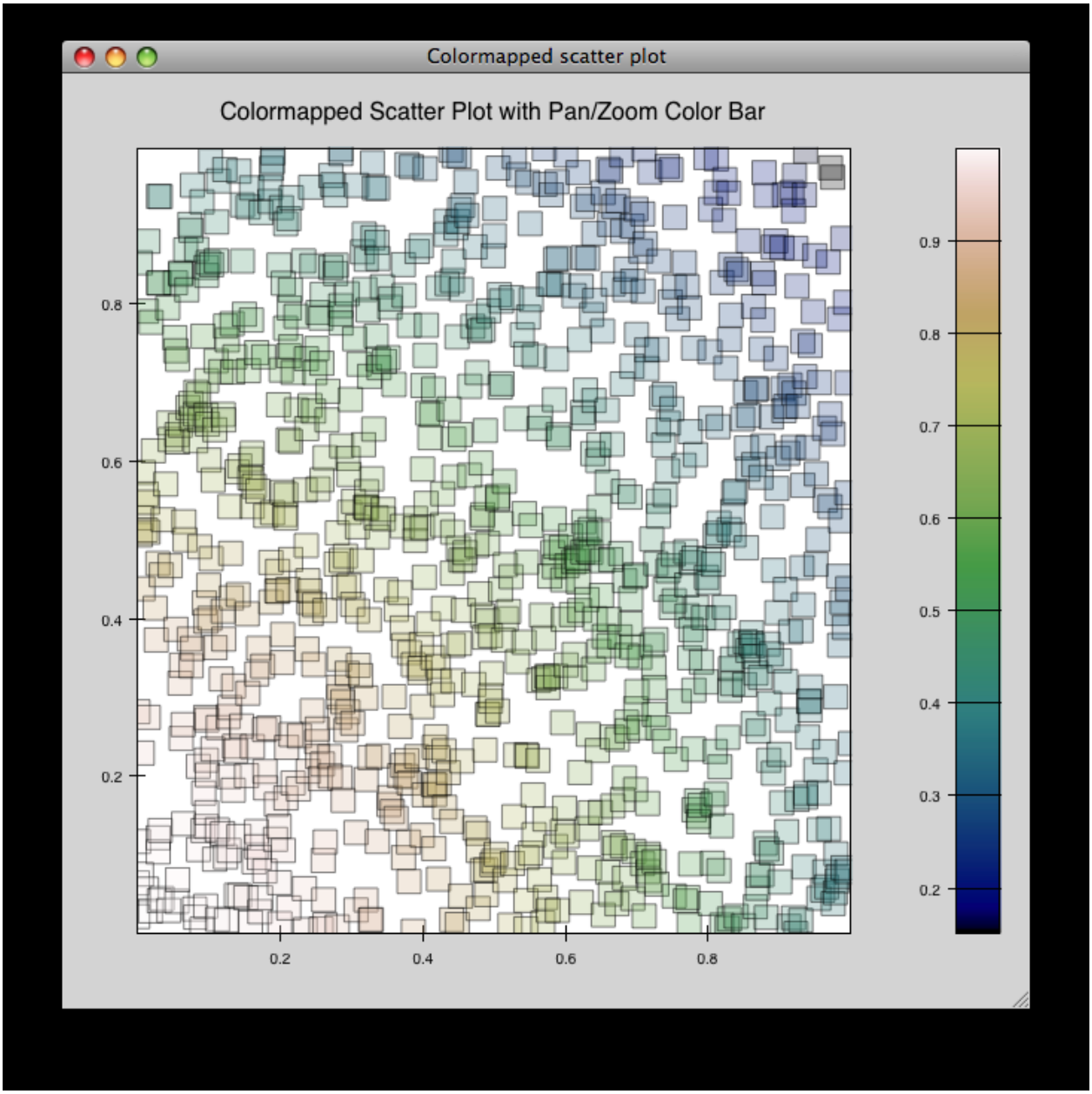
zoomable_colorbar.py

Draws a colormapped scatterplot of some random data.

Interactions on the plot are the same as for simple_line.py, and additionally, pan and zoom are available on the colorbar.

Left-click pans the colorbar's data region. Right-click-drag selects a zoom range. Mousewheel up and down zoom in and out on the data bounds of the color bar.

source: zoomable_colorbar.py

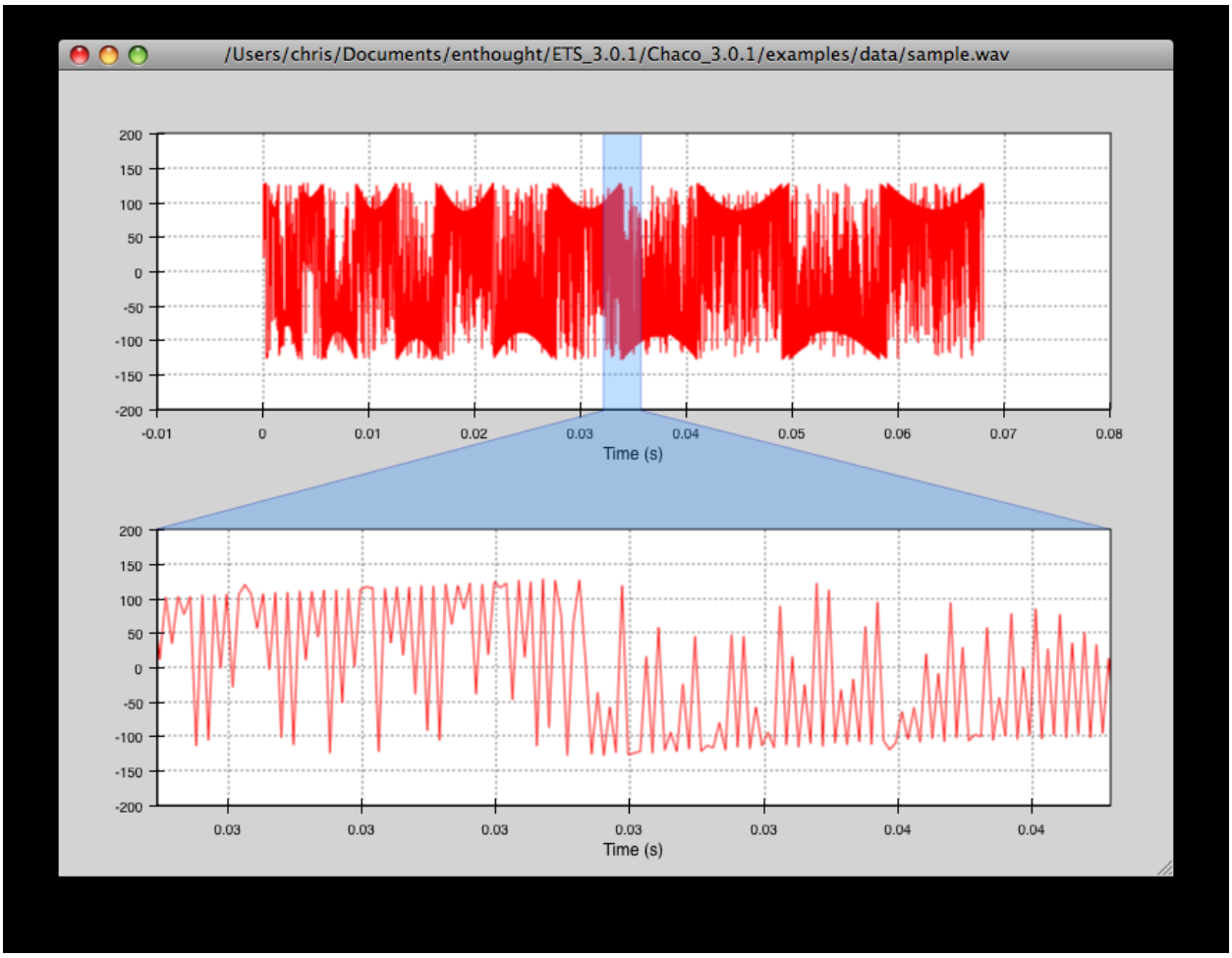


zoomed_plot

The main executable file for the zoom_plot demo.

Right-click and drag on the upper plot to select a region to view in detail in the lower plot. The selected region can be moved around by dragging, or resized by clicking on one of its edges and dragging.

source: zoomed_plot



1.4 Other Chaco resources

1.4.1 Chaco Gallery

Examples of what can be done with Chaco is available in the Chaco gallery.

1.4.2 Further Reading and resources

You can also learn more about Chaco:

- running *the tutorials* included with the Chaco package,
- following *demos of Chaco* given during webinars Enthought to EPD subscribers,
- reading *seminar slides* posted on conference websites,
- reading about *the API* from the developer guide.
- following the Chaco mailing list: chaco-users@enthought.com

Built-in tutorials

For more details on how to use Chaco to embed powerful plotting functionality inside applications, refer to the *Tutorials, webinars, and examples* page. In particular, some tutorial examples were added into the `examples/tutorials/scipy2008/` directory. These examples are numbered and introduce concepts one at a time, going from a simple line plot to building a custom overlay with its own trait editor and reusing an existing tool from the built-in set of tools. You can browse them on the GitHub repository at: https://github.com/enthought/chaco/tree/master/examples/tutorials . Finally, it is recommended to explore the examples (*Annotated Examples* section) as they are regularly updated to reflect the most recent changes and recommended ways to use Chaco.

Enthought webinars

The video webinars given in as part of the Enthought webinar series cover building interactive plotting using Chaco. If you are an EPD user, you can find the video, the slides, and the demo code for each webinar covering Chaco.

- The first one (April 2010) demoes how to use Chaco as your plotting tool (https://www.enthought.com/repo/epd/webinars/2010-04InteractiveChaco/).
- The seconds (October 2010) illustrates how to building interactive 2D visualization (see https://www.enthought.com/repo/epd/webinars/2010-10Building2DInteractiveVisualizations/).

Presentations

There have been several presentations on Chaco at previous PyCon and SciPy conferences:

- Video recording of the latest Chaco presentation at SciPy 2011 at http://conference.scipy.org/scipy2011/tutorials.php#corran
- Follow the tutorial from the Scipy 2006 conference at http://code.enthought.com/projects/files/chaco_scipy06/chaco_talk.html ,
- Follow the presentation of Chaco at the PyCon 2007 at http://code.enthought.com/projects/files/chaco_pycon07/ .
- SciPy 2008 Tutorial slides (pdf)

Developers references and API Docs

For developers and architects,

- more details about the **current architecture and API** can be found in the *Programmer's Reference*,
- the API for Chaco 3.0 (in ETS 3.0) can be found at http://code.enthought.com/projects/files/ETS3_API/enthought.chaco.html ,
- the API for Chaco2 (in ETS 2.7.1) can be found at http://code.enthought.com/projects/files/ets_api/enthought.chaco2.html .

1.5 Programmer's Reference

1.5.1 Architecture Overview

Note: This is an overview of not just Chaco, but also Kiva and Enable.

Contents

Core Ideas

The Chaco toolkit is defined by a few core architectural ideas:

- **Plots are compositions of visual components**

  Everything you see in a plot is some sort of graphical widget, with position, shape, and appearance attributes, and with an opportunity to respond to events.

- **Separation between data and screen space**

  Although everything in a plot eventually ends up rendering into a common visual area, there are aspects of the plot which are intrinsically screen-space, and some which are fundamentally data-space. Preserving the distinction between these two domains allows us to think about visualizations in a structured way.

- **Modular design and extensible classes**

  Chaco is meant to be used for writing tools and applications, and code reuse and good class design are important. We use the math behind the data and visualizations to give us architectural direction and conceptual modularity. The Traits framework allows us to use events to couple disjoint components at another level of modularity.

  Also, rather than building super-flexible core objects with myriad configuration attributes, Chaco's classes are written with subclassing in mind. While they are certainly configurable, the classes themselves are written in a modular way so that subclasses can easily customize particular aspects of a visual component's appearance or a tool's behavior.

The Relationship Between Chaco, Enable, and Kiva

Chaco, Enable, and Kiva are three packages in the Enthought Tool Suite. They have been there for a long time now, since almost the beginning of Enthought as a company. Enthought has delivered many applications using these toolkits. The Kiva and Enable packages are bundled together in the "Enable" project.

Kiva

Kiva is a 2-D vector drawing library for Python. It serves a purpose similar to Cairo. It allows us to compose vector graphics for display on the screen or for saving to a variety of vector and image file formats. To use Kiva, a program instantiates a Kiva `GraphicsContext` object of an appropriate type, and then makes drawing calls on it like `gc.draw_image()`, `gc.line_to()`, and `gc.show_text()`. Kiva integrates with windowing toolkits like wxWindows and Qt, and it has an OpenGL backend as well. For wxPython and Qt, Kiva actually performs a high-quality, fast software rasterization using the Anti-Grain Geometry (AGG) library. For OpenGL, Kiva has a python extension that makes native OpenGL calls from C++.

Kiva provides a GraphicsContext for drawing onto the screen or saving out to disk, but it provides no mechanism for user input and control. For this "control" layer, it would be convenient to have to write only one set of event callbacks

or handlers for all the platforms we support, and all the toolkits on each platform. The Enable package provides this layer. It insulates all the rendering and event handling code in Chaco from the minutiae of each GUI toolkit. Additionally, and to some extent more importantly, Enable defines the concept of "components" and "containers" that form the foundation of Chaco's architecture. In the Enable model, the top-most Window object is responsible for dispatching events and drawing a single component. Usually, this component is a container with other containers and components inside it. The container can perform layout on its internal components, and it controls how events are subsequently dispatched to its set of components.

Enable

Almost every graphical component in Chaco is an instance of an Enable component or container. We're currently trying to push more of the layout system (implemented as the various different kinds of Chaco plot containers) down into Enable, but as things currently stand, you have to use Chaco containers if you want to get layout. The general trend has been that we implement some nifty new thing in Chaco, and then realize that it is a more general tool or overlay that will be useful for other non-plotting visual applications. We then move it into Enable, and if there are plotting-specific aspects of it, we will create an appropriate subclass in Chaco to encapsulate that behavior.

The sorts of applications that can and should be done at the Enable level include things like a visual programming canvas or a vector drawing tool. There is nothing at the Enable level that understands the concept of mapping between a data space to screen space and vice versa. Although there has been some debate about the incorporating rudimentary mapping into Enable, for the time being, if you want some kind of canvas-like thing to model more than just pixel space on the screen, implement it using the mechanisms in Chaco.

The way that Enable hooks up to the underlying GUI toolkit system is via an `enable.Window` object. Each toolkit has its own implementation of this object, and they all subclass from `enable.AbstractWindow`. They usually contain an instance of the GUI toolkit's specific window object, whether it's a `wx.Window` or `Qt.QWidget` or `pyglet.window.Window`. This instance is created upon initialization of the enable.Window and stored as the `control` attribute on the Enable window. From the perspective of the GUI toolkit, an opaque widget gets created and stuck inside a parent control (or dialog or frame or window). This instance serves as a proxy between the GUI toolkit and the world of Enable. When the user clicks inside the widget area, the `control` widget calls a method on the enable.Window object, which then in turn can dispatch the event down the stack of Enable containers and components. When the system tells the widget to draw itself (e.g., as the result of a PAINT or EXPOSE event from the OS), the enable.Window is responsible for creating an appropriate Kiva GraphicsContext (GC), then passing it down through the object hierarchy so that everyone gets a chance to draw. After all the components have drawn onto the GC, for the AGG-based bitmap backends, the enable.Window object is responsible for blitting the rastered off-screen buffer of the GC into the actual widget's space on the screen. (For Kiva's OpenGL backend, there is no final blit, since calls to the GC render in immediate mode in the window's active OpenGL context, but the idea is the same, and the enable.Window object does perform initialization on the GL GraphicsContext.)

Some of the advantages to using Enable are that it makes mouse and key events from disparate windowing systems all share the same kind of signature, and be accessible via the same name. So, if you write bare wxPython and handle a `key_pressed` event in wx, this might generate a value of `wx.WXK_BACK`. Using Enable, you would just get a "key" back and its value would be the string "Backspace", and this would hold true on Qt4 and Pyglet. Almost all of the event handling and rendering code in Chaco is identical under all of the backends; there are very few backend-specific changes that need to be handled at the Chaco level.

The `enable.Window` object has a reference to a single top-level graphical component (which includes containers, since they are subclasses of component). Whenever it gets user input events, it recursively dispatches all the way down the potentially-nested stack of components. Whenever a components wants to signal that it needs to be redrawn, it calls self.request_redraw(), which ultimately reaches the enable.Window, which can then make sure it schedules a PAINT event with the OS. The nice thing about having the enable.Window object between the GUI toolkits and our apps, and sitting at the very top of event dispatch, is that we can easily interject new kinds of events; this is precisely what we did to enable all of our tools to work with Multitouch.

The basic things to remember about Enable are that:

- Any place that your GUI toolkit allows you stick a generic widget, you can stick an Enable component (and this extends to Chaco components, as well). Dave Morrill had a neat demonstration of this by embedding small Chaco plots as cells in a wx Table control.
- If you have some new GUI toolkit, and you want to provide an Enable backend for it, all you have to do is implement a new Window class for that backend. You also need to make sure that Kiva can actually create a GraphicsContext for that toolkit. Once the kiva_gl branch is committed to the trunk, Kiva will be able to render into any GL context. So if your newfangled unsupported GUI toolkit has a GLWindow type of thing, then you will be able to use Kiva, Enable, and Chaco inside it. This is a pretty major improvement to interoperability, if only because users now don't have to download and install wxPython just to play with Chaco.

Chaco

Note: This section provides an overview of the relationships between these classes, and illustrates some sample usages. For a more detailed list of the class hierarchy, please see *Commonly Used Modules and Classes*.

At the highest level, Chaco consists of:

- Visual components that render to screen or an output device (e.g., `LinePlot`, `ScatterPlot`, `PlotGrid`, `PlotAxis`, `Legend`)
- Data handling classes that wrap input data, interface with application-specific data sources, and transform coordinates between data and screen space (e.g., `ArrayDataSource`, `GridDataSource`, `LinearMapper`)
- Tools that handle keyboard or mouse events and modify other components (e.g., `PanTool`, `ZoomTool`, `ScatterInspector`)

Every Chaco plot is composed of these elements. One can think of them as comprising a "display pipeline", although the components form more of a graph.

For example, a simple scatter plot will have:

- Two `ArrayDataSource` objects, one for the array of X data and one for the Y data
- Two `DataRange1D` ranges, one for the X axis and one for the Y axis. If we want the ranges to automatically compute the bounds of the dataset, then they need a reference to the an `ArrayDataSource`.
- Two independent `LinearMapper` mappers, one for X axis and one for the Y axis. The mappers convert from screen space to data space and vice verse, so they need a reference to the `DataRange1D` objects so they know the data space extents.
- A `ScatterPlot` renderer, that has a reference to two mappers, as well as an index and a value `ArrayDataSource`.

This creates *only* the renderer that draws scatter markers in some region of screen space. This does not create an X-axis, a Y-axis, or horizontal and vertical grids. These other visuals are embodied as separate, distinct components: axes are drawn by the `PlotAxis` component, and grids are drawn by the `PlotGrid` component. Both of these overlays require a mapper in order to know where on the screen they should draw.

1.5.2 Commonly Used Modules and Classes

Base Classes

Plot Component

All visual components in Chaco subclass from `PlotComponent`. It defines all of the common visual attributes like background color, border styles and color, and whether the component is visible. (Actually, most of these visual attributes are inherited from the Enable drawing framework.) More importantly, it provides the base behaviors for participating in layout, handling event dispatch to tools and overlays, and drawing various layers in the correct order. Subclasses almost never need to override or customize these base behaviors, but if they do, there are several easy extension points.

PlotComponent is a subclass of Enable `Component`. It has its own default drawing order. It redefines the inherited traits `draw_order` and `draw_layer`, but it doesn't define any new traits. Therefore, you may need to refer to the API documentation for Enable Component, even when you have subclassed Chaco PlotComponent.

If you subclass PlotComponent, you need to implement `do_layout()`, if you want to size the component correctly.

Data Objects

Data Source

A data source is a wrapper object for the actual data that it will be handling. It provides methods for retrieving data, estimating a size of the dataset, indications about the dimensionality of the data, a place for metadata (such as selections and annotations), and events that fire when the data gets changed. There are two primary reasons for a data source class:

- It provides a way for different plotting objects to reference the same data.
- It defines the interface for embedding Chaco into an existing application. In most cases, the standard ArrayDataSource will suffice.

  Interface: `AbstractDataSource`

  Subclasses: `ArrayDataSource`, `MultiArrayDataSource`, `PointDataSource`, `GridDataSource`, `ImageData`

Data Range

A data range expresses bounds on data space of some dimensionality. The simplest data range is just a set of two scalars representing (low, high) bounds in 1-D. One of the important aspects of data ranges is that their bounds can be set to `auto`, which means that they automatically scale to fit their associated datasources. (Each data source can be associated with multiple ranges, and each data range can be associated with multiple data sources.)

Interface: `AbstractDataRange`

Subclasses: `BaseDataRange`, `DataRange1D`, `DataRange2D`

Data Source

A data source is an object that supplies data to Chaco. For the most part, a data source looks like an array of values, with an optional mask and metadata.

Interface: :class:AbstractDataSource‘

Subclasses: `ArrayDataSource`, `DataContextDataSource`, `GridDataSource`, `ImageData`, `MultiArrayDataSource`, `PointDataSource`

The `metadata` trait attribute is a dictionary where you can stick stuff for other tools to find, without inserting it in the actual data.

Events that are fired on data sources are:

- `data_changed`
- `bounds_changed`
- `metadata_changed`

Mapper

Mappers perform the job of mapping a data space region to screen space, and vice versa. Bounds on mappers are set by data range objects.

Interface: `AbstractMapper`

Subclasses: `Base1DMapper`, `LinearMapper`, `LogMapper`, `GridMapper`, `PolarMapper`

Containers

PlotContainer

`PlotContainer` is Chaco's way of handling layout. Because it logically partitions the screen space, it also serves as a way for efficient event dispatch. It is very similar to sizers or layout grids in GUI toolkits like WX. Containers are subclasses of PlotComponent, thus allowing them to be nested. `BasePlotContainer` implements the logic to correctly render and dispatch events to sub-components, while its subclasses implement the different layout calculations.

A container gets the preferred size from its components, and tries to allocate space for them. Non-resizeable components get their required size; whatever is left over is divided among the resizeable components.

Chaco currently has three types of containers, described in the following sections.

Interface: `BasePlotContainer`

Subclasses: `OverlayPlotContainer`, `HPlotContainer`, `VPlotContainer`, `GridPlotContainer`

The listed subclasses are defined in the module `chaco.plot_containers`.

Renderers

Plot renderers are the classes that actually draw a type of plot.

Interface: `AbstractPlotRenderer` *Subclasses*:

- `BarPlot`
- `Base2DPlot`
  - `ContourLinePlot`
  - `ContourPolyPlot`
  - `ImagePlot`: displays an image file, or color-maps scalar data to make an image

  - CMapImagePlot

- BaseXYPlot: This class is often emulated by writers of other plot renderers, but renderers don't *need* to be structured this way. By convention, many have a hittest() method. They *do* need to implement map_screen(), map_data(), and map_index() from AbstractPlotRenderer.
  - LinePlot
    * ErrorBarPlot
  - PolygonPlot
    * FilledLinePlot
  - ScatterPlot
    * ColormappedScatterPlot
  - ColorBar
  - PolarLineRenderer: NOTE: doesn't play well with others

You can use these classes to compose more interesting plots.

The module chaco.plot_factory contains various convenience functions for creating plots, which simplify the set-up.

The chaco.plot.Plot class (called "capital P Plot" when speaking) represents what the user usually thinks of as a "plot": a set of data, renderers, and axes in a single screen region. It is a subclass of DataView.

Tools

Tools attach to a component, which gives events to the tool.

All tools subclass from Enable's BaseTool, which is in turn an Enable Interactor. Do not try to make tools that draw: use an overlay for that.

Some tool subclasses exist in both Enable and Chaco, because they were created first in Chaco, and then moved into Enable.

Interface: BaseTool *Subclasses*:

- BroadcasterTool: Keeps a list of other tools, and broadcasts events it receives to all those tools.
- DataPrinter: Prints the data-space position of the point under the cursor.
- enable.tools.api.DragTool: Enable base class for tools that do dragging.
  - MoveTool
  - ResizeTool
  - ViewportPanTool
- chaco.tools.api.DragTool: Chaco base class for tools that do dragging.
  - BaseCursorTool
    * CursorTool1D
    * CursorTool2D
  - DataLabelTool
  - DragZoom

    - LegendTool
    - MoveTool
- DrawPointsTool
- HighlightTool
- HoverTool
- ImageInspectorTool
- LineInspector
- PanTool
    - TrackingPanTool
- PointMarker
- SaveTool
- SelectTool
    - ScatterInspector
    - SelectableLegend
- enable.tools.api.TraitsTool
- chaco.tools.api.TraitsTool

DragTool is a base class for tools that do dragging.

Other tools do things like panning, moving, highlighting, line segments, range selection, drag zoom, move data labels, scatter inspection, Traits UI.

Overlays

Miscellaneous

1.5.3 Data Sources

AbstractDataSource

ArrayDataSource

MultiArrayDataSource

PointDataSource

GridDataSource

ImageData

1.5.4 Data Ranges

AbstractDataRange

BaseDataRange

DataRange1D

DataRange2D

1.5.5 Mappers

AbstractMapper

Base1DMapper

LinearMapper

LogMapper

GridMapper

ColorMapper

ColorMapTemplate

TransformColorMapper

1.5.6 Containers

BasePlotContainer

OverlayPlotContainer

HPlotContainer

VPlotContainer

GridPlotContainer

1.6.1 About the Chaco Scales package

In the summer of 2007, I spent a few weeks working through the axis ticking and labelling problem. The basic goal was that I wanted to create a flexible ticking system that would produce nicely-spaced axis labels for arbitrary sets of labels *and* arbitrary intervals. The chaco2.scales package is the result of this effort. It is an entirely standalone package that does not import from any other Enthought package (not even traits!), and the idea was that it could be used in other plotting packages as well.

The overall idea is that you create a ScaleSystem consisting of various Scales. When the ScaleSystem is presented with a data range (low,high) and a screen space amount, it searches through its list of scales for the scale that produces the "nicest" set of labels. It takes into account whitespace, the formatted size of labels produced by each scale in the ScaleSystem, etc. So, the basic numerical Scales defined in scales.py are:

- FixedScale: Simple scale with a fixed interval; places ticks at multiples of the resolution
- DefaultScale: Scale that tries to place ticks at 1,2,5, and 10 so that ticks don't "pop" or suddenly jump when the resolution changes (when zooming)
- LogScale: Dynamic scale that only produces ticks and labels that work well when doing logarithmic plots

By comparison, the default ticking logic in DefaultTickGenerator (in ticks.py) is basically just the DefaultScale. (This is currently the default tick generator used by PlotAxis.)

In time_scale.py, I define an additional scale, the TimeScale. TimeScale not only handles time-oriented data using units of uniform interval (microseconds up to days and weeks), it also handles non- uniform calendar units like "day of the month" and "month of the year". So, you can tell Chaco to generate ticks on the 1st of every month, and it will give you non-uniformly spaced tick and grid lines.

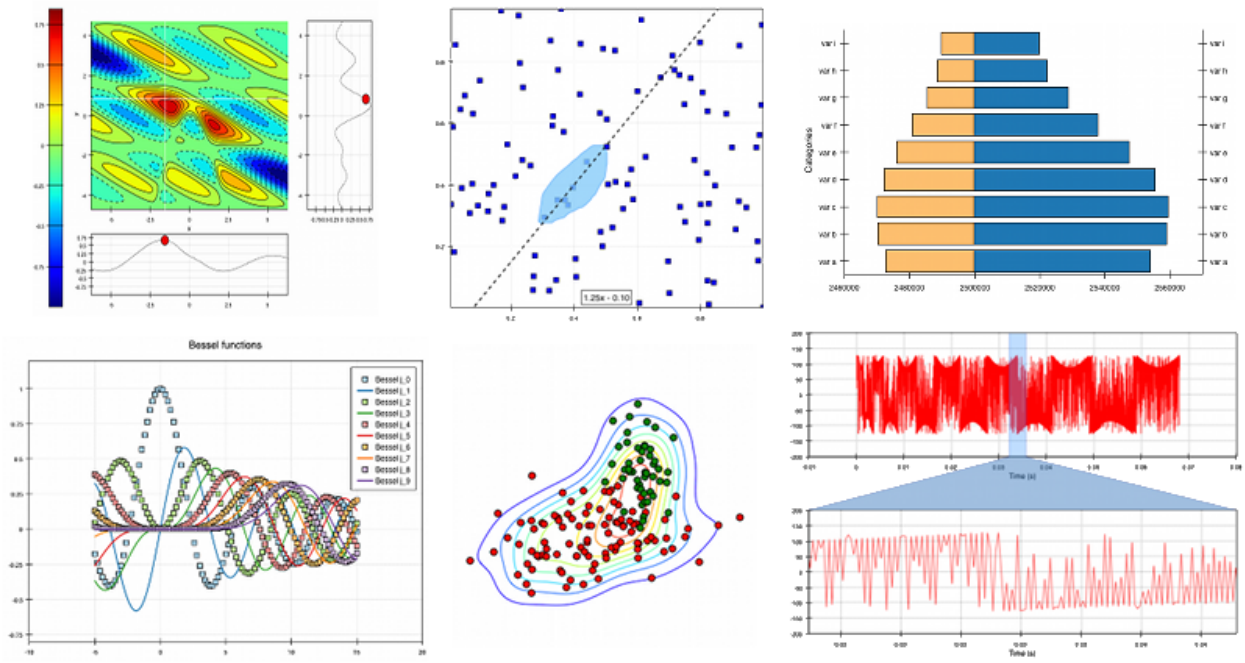
The scale system mechanism is configurable, so although all of the examples use the CalendarScaleSystem, you don't have to use it. In fact, if you look at CalendarScaleSystem.__init__, it just initializes its list of scales with `HMSScales + MDYScales`:

```
HMSScales = [TimeScale(microseconds=1), TimeScale(milliseconds=1)] + \
            [TimeScale(seconds=dt) for dt in (1, 5, 15, 30)] + \
            [TimeScale(minutes=dt) for dt in (1, 5, 15, 30)] + \
            [TimeScale(hours=dt) for dt in (1, 2, 3, 4, 6, 12, 24)]

MDYScales = [TimeScale(day_of_month=range(1,31,3)),
             TimeScale(day_of_month=(1,8,15,22)),
             TimeScale(day_of_month=(1,15)),
             TimeScale(month_of_year=range(1,13)),
             TimeScale(month_of_year=range(1,13,3)),
             TimeScale(month_of_year=(1,7)),
             TimeScale(month_of_year=(1,))]
```

So, if you wanted to create your own ScaleSystem with days, weeks, and whatnot, you could do:

```
ExtendedScales = HSMScales + [TimeScale(days=n) for n in (1,7,14,28)]
MyScaleSystem = CalendarScaleSystem(*ExtendedScales)
```

To use the Scales package in your Chaco plots, just import `PlotAxis` from `chaco2.scales_axis` instead of `chaco2.axis`. You will still need to create a `ScalesTickGenerator` and pass it in. The financial_plot_dates.py demo is a good example of how to do this.



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