
pyqtgraph Documentation

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Contents:

1.1 What is pyqtgraph?

PyQtGraph is a graphics and user interface library for Python that provides functionality commonly required in engineering and science applications. Its primary goals are 1) to provide fast, interactive graphics for displaying data (plots, video, etc.) and 2) to provide tools to aid in rapid application development (for example, property trees such as used in Qt Designer).

PyQtGraph makes heavy use of the Qt GUI platform (via PyQt or PySide) for its high-performance graphics and numpy for heavy number crunching. In particular, pyqtgraph uses Qt's QGraphicsView framework which is a highly capable graphics system on its own; we bring optimized and simplified primitives to this framework to allow data visualization with minimal effort.

It is known to run on Linux, Windows, and OSX

1.2 What can it do?

Amongst the core features of pyqtgraph are:

- Basic data visualization primitives: Images, line and scatter plots
- Fast enough for realtime update of video/plot data
- Interactive scaling/panning, averaging, FFTs, SVG/PNG export
- Widgets for marking/selecting plot regions
- Widgets for marking/selecting image region-of-interest and automatically slicing multi-dimensional image data
- Framework for building customized image region-of-interest widgets
- Docking system that replaces/complements Qt's dock system to allow more complex (and more predictable) docking arrangements
- ParameterTree widget for rapid prototyping of dynamic interfaces (Similar to the property trees in Qt Designer and many other applications)

1.3 Examples

PyQtGraph includes an extensive set of examples that can be accessed by running:

```
import pyqtgraph.examples
pyqtgraph.examples.run()
```

Or by running `python examples/` from the source root.

This will start a launcher with a list of available examples. Select an item from the list to view its source code and double-click an item to run the example.

Note If you have installed pyqtgraph with `python setup.py develop` then the examples are incorrectly exposed as a top-level module. In this case, use `import examples; examples.run()`.

1.4 How does it compare to...

- **matplotlib:** For plotting, pyqtgraph is not nearly as complete/mature as matplotlib, but runs much faster. Matplotlib is more aimed toward making publication-quality graphics, whereas pyqtgraph is intended for use in data acquisition and analysis applications. Matplotlib is more intuitive for matlab programmers; pyqtgraph is more intuitive for python/qt programmers. Matplotlib (to my knowledge) does not include many of pyqtgraph's features such as image interaction, volumetric rendering, parameter trees, flowcharts, etc.
- **pyqwt5:** About as fast as pyqwt5, but not quite as complete for plotting functionality. Image handling in pyqtgraph is much more complete (again, no ROI widgets in qwt). Also, pyqtgraph is written in pure python, so it is more portable than pyqwt, which often lags behind pyqt in development (I originally used pyqwt, but decided it was too much trouble to rely on it as a dependency in my projects). Like matplotlib, pyqwt (to my knowledge) does not include many of pyqtgraph's features such as image interaction, volumetric rendering, parameter trees, flowcharts, etc.

(My experience with these libraries is somewhat outdated; please correct me if I am wrong here)

Mouse Interaction

Most applications that use pyqtgraph's data visualization will generate widgets that can be interactively scaled, panned, and otherwise configured using the mouse. This section describes mouse interaction with these widgets.

2.1 2D Graphics

In pyqtgraph, most 2D visualizations follow the following mouse interaction:

- Left button: Interacts with items in the scene (select/move objects, etc). If there are no movable objects under the mouse cursor, then dragging with the left button will pan the scene instead.
- Right button drag: Scales the scene. Dragging left/right scales horizontally; dragging up/down scales vertically (although some scenes will have their x/y scales locked together). If there are x/y axes visible in the scene, then right-dragging over the axis will `_only_` affect that axis.
- Right button click: Clicking the right button in most cases will show a context menu with a variety of options depending on the object(s) under the mouse cursor.
- Middle button (or wheel) drag: Dragging the mouse with the wheel pressed down will always pan the scene (this is useful in instances where panning with the left button is prevented by other objects in the scene).
- Wheel spin: Zooms the scene in and out.

For machines where dragging with the right or middle buttons is difficult (usually Mac), another mouse interaction mode exists. In this mode, dragging with the left mouse button draws a box over a region of the scene. After the button is released, the scene is scaled and panned to fit the box. This mode can be accessed in the context menu or by calling:

```
pyqtgraph.setConfigOption('leftButtonPan', False)
```

2.2 Context Menu

Right-clicking on most scenes will show a context menu with various options for changing the behavior of the scene. Some of the options available in this menu are:

- Enable/disable automatic scaling when the data range changes
- Link the axes of multiple views together
- Enable/disable mouse interaction per axis
- Explicitly set the visible range values

The exact set of items available in the menu depends on the contents of the scene and the object clicked on.

2.3 3D Graphics

3D visualizations use the following mouse interaction:

- Left button drag: Rotates the scene around a central point
- Middle button drag: Pan the scene by moving the central “look-at” point within the x-y plane
- Middle button drag + CTRL: Pan the scene by moving the central “look-at” point along the z axis
- Wheel spin: zoom in/out
- Wheel + CTRL: change field-of-view angle

And keyboard controls:

- Arrow keys rotate around central point, just like dragging the left mouse button

How to use pyqtgraph

There are a few suggested ways to use pyqtgraph:

- From the interactive shell (python -i, ipython, etc)
- Displaying pop-up windows from an application
- Embedding widgets in a PyQt application

3.1 Command-line use

PyQtGraph makes it very easy to visualize data from the command line. Observe:

```
import pyqtgraph as pg
pg.plot(data)    # data can be a list of values or a numpy array
```

The example above would open a window displaying a line plot of the data given. The call to `pg.plot` returns a handle to the `plot` widget that is created, allowing more data to be added to the same window. **Note:** interactive plotting from the python prompt is only available with PyQt; PySide does not run the Qt event loop while the interactive prompt is running. If you wish to use pyqtgraph interactively with PySide, see the ‘console’ [example](#).

Further examples:

```
pw = pg.plot(xVals, yVals, pen='r')  # plot x vs y in red
pw.plot(xVals, yVals2, pen='b')

win = pg.GraphicsWindow()  # Automatically generates grids with multiple items
win.addPlot(data1, row=0, col=0)
win.addPlot(data2, row=0, col=1)
win.addPlot(data3, row=1, col=0, colspan=2)

pg.show(imageData)  # imageData must be a numpy array with 2 to 4 dimensions
```

We’re only scratching the surface here—these functions accept many different data formats and options for customizing the appearance of your data.

3.2 Displaying windows from within an application

While I consider this approach somewhat lazy, it is often the case that ‘lazy’ is indistinguishable from ‘highly efficient’. The approach here is simply to use the very same functions that would be used on the command line, but from within an existing application. I often use this when I simply want to get a immediate feedback about the state of data in my application without taking the time to build a user interface for it.

3.3 Embedding widgets inside PyQt applications

For the serious application developer, all of the functionality in pyqtgraph is available via *widgets* that can be embedded just like any other Qt widgets. Most importantly, see: `PlotWidget`, `ImageView`, `GraphicsLayoutWidget`, and `GraphicsView`. PyQtGraph’s widgets can be included in Designer’s ui files via the “Promote To...” functionality:

1. In Designer, create a `QGraphicsView` widget (“Graphics View” under the “Display Widgets” category).
2. Right-click on the `QGraphicsView` and select “Promote To...”.
3. Under “Promoted class name”, enter the class name you wish to use (“`PlotWidget`”, “`GraphicsLayoutWidget`”, etc).
4. Under “Header file”, enter “`pyqtgraph`”.
5. Click “Add”, then click “Promote”.

See the designer documentation for more information on promoting widgets. The “`VideoSpeedTest`” and “`ScatterPlotSpeedTest`” examples both demonstrate the use of .ui files that are compiled to .py modules using `pyuic4` or `pyside-uic`. The “`designerExample`” example demonstrates dynamically generating python classes from .ui files (no `pyuic4` / `pyside-uic` needed).

3.4 PyQt and PySide

PyQtGraph supports two popular python wrappers for the Qt library: PyQt and PySide. Both packages provide nearly identical APIs and functionality, but for various reasons (discussed elsewhere) you may prefer to use one package or the other. When pyqtgraph is first imported, it automatically determines which library to use by making the following checks:

1. If PyQt4 is already imported, use that
2. Else, if PySide is already imported, use that
3. Else, attempt to import PyQt4
4. If that import fails, attempt to import PySide.

If you have both libraries installed on your system and you wish to force pyqtgraph to use one or the other, simply make sure it is imported before pyqtgraph:

```
import PySide  ## this will force pyqtgraph to use PySide instead of PyQt4
import pyqtgraph as pg
```

3.5 Embedding PyQtGraph as a sub-package of a larger project

When writing applications or python packages that make use of pyqtgraph, it is most common to install pyqtgraph system-wide (or within a virtualenv) and simply call `import pyqtgraph` from within your application. The main benefit to this is that pyqtgraph is configured independently of your application and thus you (or your users) are free to install newer versions of pyqtgraph without changing anything in your application. This is standard practice when developing with python.

However, it is also often the case, especially for scientific applications, that software is written for a very specific purpose and then archived. If we want to ensure that the software will still work ten years later, then it is preferable to tie the application to a very specific version of pyqtgraph and *avoid* importing the system-installed version of pyqtgraph, which may be much newer (and potentially incompatible). This is especially the case when the application requires site-specific modifications to the pyqtgraph package which may not be present in the main releases.

PyQtGraph facilitates this usage through two mechanisms. First, all internal import statements in pyqtgraph are relative, which allows the package to be renamed or used as a sub-package without any naming conflicts with other versions of pyqtgraph on the system (that is, pyqtgraph never refers to itself internally as ‘pyqtgraph’). Second, a git subtree repository is available at <https://github.com/pyqtgraph/pyqtgraph-core.git> that contains only the ‘pyqtgraph’ subtree, allowing the code to be cloned directly as a subtree of the application which uses it.

The basic approach is to clone the repository into the appropriate location in your package. When you import pyqtgraph from within your package, be sure to use the full name to avoid importing any system-installed pyqtgraph packages. For example, imagine a simple project has the following structure:

```
my_project/
  __init__.py
  plotting.py
      """Plotting functions used by this package"""
      import pyqtgraph as pg
      def my_plot_function(*data):
          pg.plot(*data)
```

To embed a specific version of pyqtgraph, we would clone the pyqtgraph-core repository inside the project:

```
my_project$ git clone https://github.com/pyqtgraph/pyqtgraph-core.git
```

Then adjust the import statements accordingly:

```
my_project/
  __init__.py
  pyqtgraph/
  plotting.py
      """Plotting functions used by this package"""
      import my_project.pyqtgraph as pg # be sure to use the local subpackage
                                         # rather than any globally-installed
                                         # versions.
      def my_plot_function(*data):
          pg.plot(*data)
```

Use `git checkout pyqtgraph-core-x.x.x` to select a specific version of the repository, or use `git pull` to pull pyqtgraph updates from upstream (see the git documentation for more information).

For projects that already use git for code control, it is also possible to include pyqtgraph as a git subtree within your own repository. The major advantage to this approach is that, in addition to being able to pull pyqtgraph updates from the upstream repository, it is also possible to commit your local pyqtgraph changes into the project repository and push those changes upstream:

```
my_project$ git remote add pyqtgraph-core https://github.com/pyqtgraph/pyqtgraph-core.  
↪git  
my_project$ git fetch pyqtgraph-core  
my_project$ git merge -s ours --no-commit pyqtgraph-core/core  
my_project$ mkdir pyqtgraph  
my_project$ git read-tree -u --prefix=pyqtgraph/ pyqtgraph-core/core  
my_project$ git commit -m "Added pyqtgraph to project repository"
```

See the `git subtree` documentation for more information.

CHAPTER 4

Installation

PyQtGraph does not really require any installation scripts. All that is needed is for the pyqtgraph folder to be placed someplace importable. Most people will prefer to simply place this folder within a larger project folder. If you want to make pyqtgraph available system-wide, use one of the methods listed below:

- **Debian, Ubuntu, and similar Linux:** Download the .deb file linked at the top of the pyqtgraph web page or install using apt by putting “deb <http://luke.campagnola.me/debian> dev/” in your /etc/apt/sources.list file and install the python-pyqtgraph package.
- **Arch Linux:** Looks like someone has posted unofficial packages for Arch (thanks windel). (<https://aur.archlinux.org/packages.php?ID=62577>)
- **Windows:** Download and run the .exe installer file linked at the top of the pyqtgraph web page.
- **Everybody (including OSX):** Download the .tar.gz source package linked at the top of the pyqtgraph web page, extract its contents, and run “python setup.py install” from within the extracted directory.

PyQtGraph makes extensive use of Qt for generating nearly all of its visual output and interfaces. Qt's documentation is very well written and we encourage all pyqtgraph developers to familiarize themselves with it. The purpose of this section is to provide an introduction to programming with Qt (using either PyQt or PySide) for the pyqtgraph developer.

5.1 QWidgets and Layouts

A Qt GUI is almost always composed of a few basic components:

- A window. This is often provided by QMainWindow, but note that all QWidgets can be displayed in their window by simply calling widget.show() if the widget does not have a parent.
- Multiple QWidget instances such as QPushButton, QLabel, QComboBox, etc.
- QLayout instances (optional, but strongly encouraged) which automatically manage the positioning of widgets to allow the GUI to resize in a usable way.

PyQtGraph fits into this scheme by providing its own QWidget subclasses to be inserted into your GUI.

Example:

```
from PyQt4 import QtGui # (the example applies equally well to PySide)
import pyqtgraph as pg

## Always start by initializing Qt (only once per application)
app = QtGui.QApplication([])

## Define a top-level widget to hold everything
w = QtGui.QWidget()

## Create some widgets to be placed inside
btn = QtGui.QPushButton('press me')
text = QtGui.QLineEdit('enter text')
listw = QtGui.QListWidget()
```

```
plot = pg.PlotWidget()

## Create a grid layout to manage the widgets size and position
layout = QtGui.QGridLayout()
w.setLayout(layout)

## Add widgets to the layout in their proper positions
layout.addWidget(btn, 0, 0) # button goes in upper-left
layout.addWidget(text, 1, 0) # text edit goes in middle-left
layout.addWidget(listw, 2, 0) # list widget goes in bottom-left
layout.addWidget(plot, 0, 1, 3, 1) # plot goes on right side, spanning 3 rows

## Display the widget as a new window
w.show()

## Start the Qt event loop
app.exec_()
```

More complex interfaces may be designed graphically using Qt Designer, which allows you to simply drag widgets into your window to define its appearance.

5.2 Naming Conventions

Virtually every class in pyqtgraph is an extension of base classes provided by Qt. When reading the documentation, remember that all of Qt's classes start with the letter 'Q', whereas pyqtgraph's classes do not. When reading through the methods for any class, it is often helpful to see which Qt base classes are used and look through the Qt documentation as well.

Most of Qt's classes define signals which can be difficult to tell apart from regular methods. Almost all signals explicitly defined by pyqtgraph are named beginning with 'sig' to indicate that these signals are not defined at the Qt level.

In most cases, classes which end in 'Widget' are subclassed from QWidget and can therefore be used as a GUI element in a Qt window. Classes which end in 'Item' are subclasses of QGraphicsItem and can only be displayed within a QGraphicsView instance (such as GraphicsLayoutWidget or PlotWidget).

5.3 Signals, Slots, and Events

[to be continued.. please post a request on the pyqtgraph forum if you'd like to read more]

Qt detects and reacts to user interaction by executing its *event loop*.

- what happens in the event loop?
- when do I need to use QApplication.exec_() ?
- what control do I have over event loop execution? (QApplication.processEvents)

5.4 GraphicsView and GraphicsItems

More information about the architecture of Qt GraphicsView: <http://qt-project.org/doc/qt-4.8/graphicsview.html>

5.5 Coordinate Systems and Transformations

More information about the coordinate systems in Qt GraphicsView: <http://qt-project.org/doc/qt-4.8/graphicsview.html#the-graphics-view-coordinate-system>

5.6 Mouse and Keyboard Input

5.7 QTimer, Multi-Threading

5.8 Multi-threading vs Multi-processing in Qt

Plotting in pyqtgraph

There are a few basic ways to plot data in pyqtgraph:

<code>pyqtgraph.plot()</code>	Create a new plot window showing your data
<code>PlotWidget.plot()</code>	Add a new set of data to an existing plot widget
<code>PlotItem.plot()</code>	Add a new set of data to an existing plot widget
<code>GraphicsLayout.addPlot()</code>	Add a new plot to a grid of plots

All of these will accept the same basic arguments which control how the plot data is interpreted and displayed:

- `x` - Optional X data; if not specified, then a range of integers will be generated automatically.
- `y` - Y data.
- `pen` - The pen to use when drawing plot lines, or `None` to disable lines.
- `symbol` - A string describing the shape of symbols to use for each point. Optionally, this may also be a sequence of strings with a different symbol for each point.
- `symbolPen` - The pen (or sequence of pens) to use when drawing the symbol outline.
- `symbolBrush` - The brush (or sequence of brushes) to use when filling the symbol.
- `fillLevel` - Fills the area under the plot curve to this Y-value.
- `brush` - The brush to use when filling under the curve.

See the ‘plotting’ [example](#) for a demonstration of these arguments.

All of the above functions also return handles to the objects that are created, allowing the plots and data to be further modified.

6.1 Organization of Plotting Classes

There are several classes involved in displaying plot data. Most of these classes are instantiated automatically, but it is useful to understand how they are organized and relate to each other. PyQtGraph is based heavily on Qt’s Graph-

icsView framework—if you are not already familiar with this, it’s worth reading about (but not essential). Most importantly: 1) Qt GUIs are composed of QWidgets, 2) A special widget called QGraphicsView is used for displaying complex graphics, and 3) QGraphicsItems define the objects that are displayed within a QGraphicsView.

- **Data Classes (all subclasses of QGraphicsItem)**

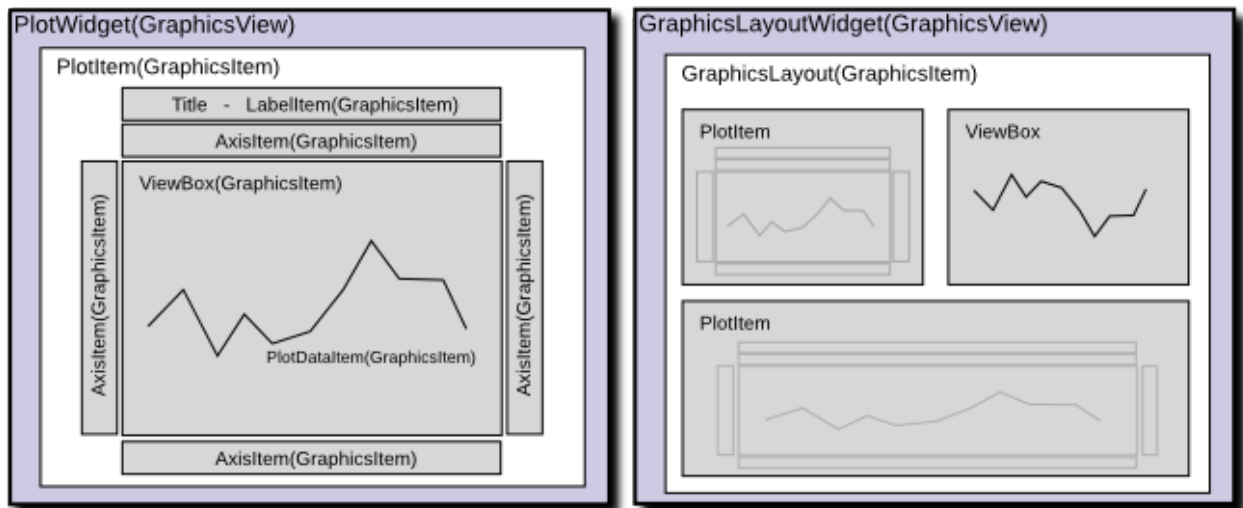
- `PlotCurveItem` - Displays a plot line given x,y data
- `ScatterPlotItem` - Displays points given x,y data
- `PlotDataItem` - Combines `PlotCurveItem` and `ScatterPlotItem`. The plotting functions discussed above create objects of this type.

- **Container Classes (subclasses of QGraphicsItem; contain other QGraphicsItem objects and must be viewed from within a QGraphicsView)**

- `PlotItem` - Contains a `ViewBox` for displaying data as well as `AxisItems` and labels for displaying the axes and title. This is a `QGraphicsItem` subclass and thus may only be used from within a `GraphicsView`
- `GraphicsLayout` - `QGraphicsItem` subclass which displays a grid of items. This is used to display multiple `PlotItems` together.
- `ViewBox` - A `QGraphicsItem` subclass for displaying data. The user may scale/pan the contents of a `ViewBox` using the mouse. Typically all `PlotData/PlotCurve/ScatterPlotItems` are displayed from within a `ViewBox`.
- `AxisItem` - Displays axis values, ticks, and labels. Most commonly used with `PlotItem`.

- **Container Classes (subclasses of QWidget; may be embedded in PyQt GUIs)**

- `PlotWidget` - A subclass of `GraphicsView` with a single `PlotItem` displayed. Most of the methods provided by `PlotItem` are also available through `PlotWidget`.
- `GraphicsLayoutWidget` - `QWidget` subclass displaying a single `GraphicsLayoutItem`. Most of the methods provided by `GraphicsLayoutItem` are also available through `GraphicsLayoutWidget`.



6.2 Examples

See the ‘plotting’ and ‘PlotWidget’ *examples included with pyqtgraph* for more information.

Show x,y data as scatter plot:

```
import pyqtgraph as pg
import numpy as np
x = np.random.normal(size=1000)
y = np.random.normal(size=1000)
pg.plot(x, y, pen=None, symbol='o')  ## setting pen=None disables line drawing
```

Create/show a plot widget, display three data curves:

```
import pyqtgraph as pg
import numpy as np
x = np.arange(1000)
y = np.random.normal(size=(3, 1000))
plotWidget = pg.plot(title="Three plot curves")
for i in range(3):
    plotWidget.plot(x, y[i], pen=(i,3))  ## setting pen=(i,3) automatically creates
↪ three different-colored pens
```

Displaying images and video

PyQtGraph displays 2D numpy arrays as images and provides tools for determining how to translate between the numpy data type and RGB values on the screen. If you want to display data from common image and video file formats, you will need to load the data first using another library (PIL works well for images and built-in numpy conversion).

The easiest way to display 2D or 3D data is using the `pyqtgraph.image()` function:

```
import pyqtgraph as pg
pg.image(imageData)
```

This function will accept any floating-point or integer data types and displays a single `ImageView` widget containing your data. This widget includes controls for determining how the image data will be converted to 32-bit RGBA values. Conversion happens in two steps (both are optional):

1. Scale and offset the data (by selecting the dark/light levels on the displayed histogram)
2. Convert the data to color using a lookup table (determined by the colors shown in the gradient editor)

If the data is 3D (time, x, y), then a time axis will be shown with a slider that can set the currently displayed frame. (if the axes in your data are ordered differently, use `numpy.transpose` to rearrange them)

There are a few other methods for displaying images as well:

- The `ImageView` class can also be instantiated directly and embedded in Qt applications.
- Instances of `ImageItem` can be used inside a `ViewBox` or `GraphicsView`.
- For higher performance, use `RawImageWidget`.

Any of these classes are acceptable for displaying video by calling `setImage()` to display a new frame. To increase performance, the image processing system uses `scipy.weave` to produce compiled libraries. If your computer has a compiler available, `weave` will automatically attempt to build the libraries it needs on demand. If this fails, then the slower pure-python methods will be used instead.

For more information, see the classes listed above and the ‘VideoSpeedTest’, ‘ImageItem’, ‘ImageView’, and ‘HistogramLUT’ *Examples*.

PyQtGraph uses OpenGL to provide a 3D scenegraph system. This system is functional but still early in development. Current capabilities include:

- 3D view widget with zoom/rotate controls (mouse drag and wheel)
- Scenegraph allowing items to be added/removed from scene with per-item transformations and parent/child relationships.
- Triangular meshes
- Basic mesh computation functions: isosurfaces, per-vertex normals
- Volumetric rendering item
- Grid/axis items

See the [API Reference](#) and the Volumetric (GLVolumeItem.py) and Isosurface (GLMeshItem.py) examples for more information.

Basic usage example:

```
## build a QApplication before building other widgets
import pyqtgraph as pg
pg.mkQApp()

## make a widget for displaying 3D objects
import pyqtgraph.opengl as gl
view = gl.GLViewWidget()
view.show()

## create three grids, add each to the view
xgrid = gl.GLGridItem()
ygrid = gl.GLGridItem()
zgrid = gl.GLGridItem()
view.addItem(xgrid)
view.addItem(ygrid)
view.addItem(zgrid)
```

```
## rotate x and y grids to face the correct direction
xgrid.rotate(90, 0, 1, 0)
ygrid.rotate(90, 1, 0, 0)

## scale each grid differently
xgrid.scale(0.2, 0.1, 0.1)
ygrid.scale(0.2, 0.1, 0.1)
zgrid.scale(0.1, 0.2, 0.1)
```

Line, Fill, and Color

Qt relies on its `QColor`, `QPen` and `QBrush` classes for specifying line and fill styles for all of its drawing. Internally, `pyqtgraph` uses the same system but also allows many shorthand methods of specifying the same style options.

Many functions and methods in `pyqtgraph` accept arguments specifying the line style (pen), fill style (brush), or color. For most of these function arguments, the following values may be used:

- single-character string representing color (b, g, r, c, m, y, k, w)
- (r, g, b) or (r, g, b, a) tuple
- single greyscale value (0.0 - 1.0)
- (index, maximum) tuple for automatically iterating through colors (see `intColor`)
- `QColor`
- `QPen` / `QBrush` where appropriate

Notably, more complex pens and brushes can be easily built using the `mkPen()` / `mkBrush()` functions or with Qt's `QPen` and `QBrush` classes:

```
mkPen('y', width=3, style=QtCore.Qt.DashLine)      ## Make a dashed yellow line_
↪ 2px wide
mkPen(0.5)                                          ## solid grey line 1px wide
mkPen(color=(200, 200, 255), style=QtCore.Qt.DotLine) ## Dotted pale-blue line
```

See the Qt documentation for 'QPen' and 'PenStyle' for more line-style options and 'QBrush' for more fill options. Colors can also be built using `mkColor()`, `intColor()`, `hsvColor()`, or Qt's `QColor` class.

9.1 Default Background and Foreground Colors

By default, `pyqtgraph` uses a black background for its plots and grey for axes, text, and plot lines. These defaults can be changed using `pyqtgraph.setConfigOption()`:

```
import pyqtgraph as pg

## Switch to using white background and black foreground
pg.setConfigOption('background', 'w')
pg.setConfigOption('foreground', 'k')

## The following plot has inverted colors
pg.plot([1,4,2,3,5])
```

(Note that this must be set *before* creating any widgets)

Interactive Data Selection Controls

PyQtGraph includes graphics items which allow the user to select and mark regions of data.

10.1 Linear Selection and Marking

Two classes allow marking and selecting 1-dimensional data: `LinearRegionItem` and `InfiniteLine`. The first class, `LinearRegionItem`, may be added to any `ViewBox` or `PlotItem` to mark either a horizontal or vertical region. The region can be dragged and its bounding edges can be moved independently. The second class, `InfiniteLine`, is usually used to mark a specific position along the x or y axis. These may be dragged by the user.

10.2 2D Selection and Marking

To select a 2D region from an image, `pyqtgraph` uses the `ROI` class or any of its subclasses. By default, `ROI` simply displays a rectangle which can be moved by the user to mark a specific region (most often this will be a region of an image, but this is not required). To allow the ROI to be resized or rotated, there are several methods for adding handles (`addScaleHandle`, `addRotateHandle`, etc.) which can be dragged by the user. These handles may be placed at any location relative to the ROI and may scale/rotate the ROI around any arbitrary center point. There are several ROI subclasses with a variety of shapes and modes of interaction.

To automatically extract a region of image data using an ROI and an `ImageItem`, use `ROI.getArrayRegion`. ROI classes use the `affineSlice` function to perform this extraction.

ROI can also be used as a control for moving/rotating/scaling items in a scene similar to most vector graphics editing applications.

See the `ROItypes` example for more information.

PyQtGraph provides a variety of export formats for all 2D graphics. For 3D graphics, see *Exporting 3D Graphics* below.

11.1 Exporting from the GUI

Any 2D graphics can be exported by right-clicking on the graphic, then selecting ‘export’ from the context menu. This will display the export dialog in which the user must:

1. Select an item (or the entire scene) to export. Selecting an item will cause the item to be highlighted in the original graphic window (but this highlight will not be displayed in the exported file).
2. Select an export format.
3. Change any desired export options.
4. Click the ‘export’ button.

11.2 Export Formats

- Image - PNG is the default format. The exact set of image formats supported will depend on your Qt libraries. However, common formats such as PNG, JPG, and TIFF are almost always available.
- SVG - Graphics exported as SVG are targeted to work as well as possible with both Inkscape and Adobe Illustrator. For high quality SVG export, please use PyQtGraph version 0.9.3 or later. This is the preferred method for generating publication graphics from PyQtGraph.
- CSV - Exports plotted data as CSV. This exporter `_only_` works if a `PlotItem` is selected for export.
- Matplotlib - This exporter opens a new window and attempts to re-plot the data using matplotlib (if available). Note that some graphic features are either not implemented for this exporter or not available in matplotlib. This exporter `_only_` works if a `PlotItem` is selected for export.

- Printer - Exports to the operating system's printing service. This exporter is provided for completeness, but is not well supported due to problems with Qt's printing system.

11.3 Exporting from the API

To export a file programatically, follow this example:

```
import pyqtgraph as pg
import pyqtgraph.exporters

# generate something to export
plt = pg.plot([1,5,2,4,3])

# create an exporter instance, as an argument give it
# the item you wish to export
exporter = pg.exporters.ImageExporter(plt.plotItem)

# set export parameters if needed
exporter.parameters()['width'] = 100  # (note this also affects height parameter)

# save to file
exporter.export('fileName.png')
```

11.4 Exporting 3D Graphics

The exporting functionality described above is not yet available for 3D graphics. However, it is possible to generate an image from a `GLViewWidget` by using `QGLWidget.grabFramebuffer` or `QGLWidget.renderPixmap`:

```
glview.grabFramebuffer().save('fileName.png')
```

See the Qt documentation for more information.

[Just an overview; documentation is not complete yet]

PyQtGraph offers several powerful features which are commonly used in engineering and scientific applications.

12.1 Parameter Trees

The parameter tree system provides a widget displaying a tree of modifiable values similar to those used in most GUI editor applications. This allows a large number of variables to be controlled by the user with relatively little programming effort. The system also provides separation between the data being controlled and the user interface controlling it (model/view architecture). Parameters may be grouped/nested to any depth and custom parameter types can be built by subclassing from `Parameter` and `ParameterItem`.

See the [parametertree documentation](#) for more information.

12.2 Visual Programming Flowcharts

PyQtGraph's flowcharts provide a visual programming environment similar in concept to LabView—functional modules are added to a flowchart and connected by wires to define a more complex and arbitrarily configurable algorithm. A small number of predefined modules (called Nodes) are included with `pyqtgraph`, but most flowchart developers will want to define their own library of Nodes. At their core, the Nodes are little more than 1) a Python function 2) a list of input/output terminals, and 3) an optional widget providing a control panel for the Node. Nodes may transmit/receive any type of Python object via their terminals.

See the [flowchart documentation](#) and the flowchart examples for more information.

12.3 Graphical Canvas

The Canvas is a system designed to allow the user to add/remove items to a 2D canvas similar to most vector graphics applications. Items can be translated/scaled/rotated and each item may define its own custom control interface.

12.4 Dockable Widgets

The dockarea system allows the design of user interfaces which can be rearranged by the user at runtime. Docks can be moved, resized, stacked, and torn out of the main window. This is similar in principle to the docking system built into Qt, but offers a more deterministic dock placement API (in Qt it is very difficult to programatically generate complex dock arrangements). Additionally, Qt's docks are designed to be used as small panels around the outer edge of a window. PyQtGraph's docks were created with the notion that the entire window (or any portion of it) would consist of dockable components.

Parameter trees are a system for handling hierarchies of parameters while automatically generating one or more GUIs to display and interact with the parameters. This feature is commonly seen, for example, in user interface design applications which display a list of editable properties for each widget. Parameters generally have a name, a data type (int, float, string, color, etc), and a value matching the data type. Parameters may be grouped and nested to form hierarchies and may be subclassed to provide custom behavior and display widgets.

PyQtGraph's parameter tree system works similarly to the model-view architecture used by some components of Qt: Parameters are purely data-handling classes that exist independent of any graphical interface. A `ParameterTree` is a widget that automatically generates a graphical interface which represents the state of a hierarchy of `Parameter` objects and allows the user to edit the values within that hierarchy. This separation of data (model) and graphical interface (view) allows the same data to be represented multiple times and in a variety of different ways.

For more information, see the 'parametertree' example included with `pyqtgraph` and the API reference

13.1 ParameterTree API Reference

Also see the 'parametertree' example included with `pyqtgraph`

Contents:

13.1.1 Parameter

13.1.2 ParameterTree

13.1.3 Built-in Parameter Types

13.1.4 ParameterItem

Visual Programming with Flowcharts

PyQtGraph's flowcharts provide a visual programming environment similar in concept to LabView—functional modules are added to a flowchart and connected by wires to define a more complex and arbitrarily configurable algorithm. A small number of predefined modules (called Nodes) are included with `pyqtgraph`, but most flowchart developers will want to define their own library of Nodes. At their core, the Nodes are little more than 1) a python function 2) a list of input/output terminals, and 3) an optional widget providing a control panel for the Node. Nodes may transmit/receive any type of Python object via their terminals.

One major limitation of flowcharts is that there is no mechanism for looping within a flowchart. (however individual Nodes may contain loops (they may contain any Python code at all), and an entire flowchart may be executed from within a loop).

There are two distinct modes of executing the code in a flowchart:

1. Provide data to the input terminals of the flowchart. This method is slower and will provide a graphical representation of the data as it passes through the flowchart. This is useful for debugging as it allows the user to inspect the data at each terminal and see where exceptions occurred within the flowchart.
2. Call `Flowchart.process()`. This method does not update the displayed state of the flowchart and only retains the state of each terminal as long as it is needed. Additionally, Nodes which do not contribute to the output values of the flowchart (such as plotting nodes) are ignored. This mode allows for faster processing of large data sets and avoids memory issues which can occur if too much data is present in the flowchart at once (e.g., when processing image data through several stages).

See the flowchart example for more information.

API Reference:

14.1 flowchart.Flowchart

14.2 flowchart.Node

14.3 flowchart.Terminal

14.4 Basic Use

Flowcharts are most useful in situations where you have a processing stage in your application that you would like to be arbitrarily configurable by the user. Rather than giving a pre-defined algorithm with parameters for the user to tweak, you supply a set of pre-defined functions and allow the user to arrange and connect these functions how they like. A very common example is the use of filter networks in audio / video processing applications.

To begin, you must decide what the input and output variables will be for your flowchart. Create a flowchart with one terminal defined for each variable:

```
## This example creates just a single input and a single output.  
## Flowcharts may define any number of terminals, though.  
from pyqtgraph.flowchart import Flowchart  
fc = Flowchart(terminals={  
    'nameOfInputTerminal': {'io': 'in'},  
    'nameOfOutputTerminal': {'io': 'out'}  
})
```

In the example above, each terminal is defined by a dictionary of options which define the behavior of that terminal (see `Terminal.__init__()` for more information and options). Note that Terminals are not typed; any python object may be passed from one Terminal to another.

Once the flowchart is created, add its control widget to your application:

```
ctrl = fc.ctrlWidget()  
myLayout.addWidget(ctrl) ## read Qt docs on QWidget and layouts for more information
```

The control widget provides several features:

- Displays a list of all nodes in the flowchart containing the control widget for each node.
- Provides access to the flowchart design window via the ‘flowchart’ button
- Interface for saving / restoring flowcharts to disk.

At this point your user has the ability to generate flowcharts based on the built-in node library. It is recommended to provide a default set of flowcharts for your users to build from.

All that remains is to process data through the flowchart. As noted above, there are two ways to do this:

1. Set the values of input terminals with `Flowchart.setInput()`, then read the values of output terminals with `Flowchart.output()`:

```
fc.setInput(nameOfInputTerminal=newValue)  
output = fc.output() # returns {terminalName:value}
```

This method updates all of the values displayed in the flowchart design window, allowing the user to inspect values at all terminals in the flowchart and indicating the location of errors that occurred during processing.

2. Call `Flowchart.process()`:


```
output = fc.process(nameOfInputTerminal=newValue)
```

This method processes data without updating any of the displayed terminal values. Additionally, all `Node.process()` methods are called with `display=False` to request that they not invoke any custom display code. This allows data to be processed both more quickly and with a smaller memory footprint, but errors that occur during `Flowchart.process()` will be more difficult for the user to diagnose. It is thus recommended to use this method for batch processing through flowcharts that have already been tested and debugged with method 1.

14.5 Implementing Custom Nodes

PyQtGraph includes a small library of built-in flowchart nodes. This library is intended to cover some of the most commonly-used functions as well as provide examples for some more exotic Node types. Most applications that use the flowchart system will find the built-in library insufficient and will thus need to implement custom Node classes.

A node subclass implements at least:

1. A list of input / output terminals and their properties
2. A `process()` function which takes the names of input terminals as keyword arguments and returns a dict with the names of output terminals as keys.

Optionally, a Node subclass can implement the `ctrlWidget()` method, which must return a `QWidget` (usually containing other widgets) that will be displayed in the flowchart control panel. A minimal Node subclass looks like:

```
class SpecialFunctionNode(Node):
    """SpecialFunction: short description

    This description will appear in the flowchart design window when the user
    selects a node of this type.
    """
    nodeName = 'SpecialFunction' # Node type name that will appear to the user.

    def __init__(self, name): # all Nodes are provided a unique name when they
                              # are created.
        Node.__init__(self, name, terminals={ # Initialize with a dict
                                              # describing the I/O terminals
                                              # on this Node.
                                              'inputTerminalName': {'io': 'in'},
                                              'anotherInputTerminal': {'io': 'in'},
                                              'outputTerminalName': {'io': 'out'},
                                              })

    def process(self, **kwds):
        # kwds will have one keyword argument per input terminal.

        return {'outputTerminalName': result}

    def ctrlWidget(self): # this method is optional
        return someQWidget
```

Some nodes implement fairly complex control widgets, but most nodes follow a simple form-like pattern: a list of parameter names and a single value (represented as spin box, check box, etc..) for each parameter. To make this easier, the `CtrlNode` subclass allows you to instead define a simple data structure that `CtrlNode` will use to automatically generate the control widget. This is used in many of the built-in library nodes (especially the filters).

There are many other optional parameters for nodes and terminals – whether the user is allowed to add/remove/rename terminals, whether one terminal may be connected to many others or just one, etc. See the documentation on the `Node`

and `Terminal` classes for more details.

After implementing a new `Node` subclass, you will most likely want to register the class so that it appears in the menu of Nodes the user can select from:

```
import pyqtgraph.flowchart.library as fclib
fclib.registerNodeType(SpecialFunctionNode, [('Category', 'Sub-Category')])
```

The second argument to `registerNodeType` is a list of tuples, with each tuple describing a menu location in which `SpecialFunctionNode` should appear.

See the `FlowchartCustomNode` example for more information.

14.5.1 Debugging Custom Nodes

When designing flowcharts or custom Nodes, it is important to set the input of the flowchart with data that at least has the same types and structure as the data you intend to process (see [processing methods](#) #1 above). When you use `Flowchart.setInput()`, the flowchart displays visual feedback in its design window that can tell you what data is present at any terminal and whether there were errors in processing. Nodes that generated errors are displayed with a red border. If you select a Node, its input and output values will be displayed as well as the exception that occurred while the node was processing, if any.

14.6 Using Nodes Without Flowcharts

Flowchart Nodes implement a very useful generalization in data processing by combining a function with a GUI for configuring that function. This generalization is useful even outside the context of a flowchart. For example:

```
## We defined a useful filter Node for use in flowcharts, but would like to
## re-use its processing code and GUI without having a flowchart present.
filterNode = MyFilterNode("filterNodeName")

## get the Node's control widget and place it inside the main window
filterCtrl = filterNode.ctrlWidget()
someLayout.addWidget(filterCtrl)

## later on, process data through the node
filteredData = filterNode.process(inputTerminal=rawData)
```

Internals - Extensions to Qt's GraphicsView

- GraphicsView
- GraphicsScene (mouse events)
- GraphicsObject
- GraphicsWidget
- ViewBox

Contents:

16.1 Global Configuration Options

PyQtGraph has several global configuration options that allow you to change its default behavior. These can be accessed using the `setConfigOptions()` and `getConfigOption()` functions:

Op-tion	Type	De-fault	
left-ButtonPan	bool	True	If True, dragging the left mouse button over a ViewBox causes the view to be panned. If False, then dragging the left mouse button draws a rectangle that the ViewBox will zoom to.
fore-ground	See <code>mkColor()</code>	'd'	Default foreground color for text, lines, axes, etc.
back-ground	See <code>mkColor()</code>	'k'	Default background for <code>GraphicsView</code> .
an-tialias	bool	False	Enabling antialiasing causes lines to be drawn with smooth edges at the cost of reduced performance.
im-ageAx-isOr-der	str	'col-major'	For 'row-major', image data is expected in the standard row-major (row, col) order. For 'col-major', image data is expected in reversed column-major (col, row) order. The default is 'col-major' for backward compatibility, but this may change in the future.
editor-Com-mand	str or None	None	Command used to invoke code editor from <code>ConsoleWidget</code> .
exit-Cleanup	bool	True	Attempt to work around some exit crash bugs in PyQt and PySide.
useWeave	bool	False	Use weave to speed up some operations, if it is available.
weaveDe-bug	bool	False	Print full error message if weave compile fails.
useOpenGL	bool	False	Enable OpenGL in <code>GraphicsView</code> . This can have unpredictable effects on stability and performance.
en-able-Exper-imen-tal	bool	False	Enable experimental features (the curious can search for this key in the code).
crash-Warn-ing	bool	False	If True, print warnings about situations that may result in a crash.

16.2 PyQtGraph's Helper Functions

16.2.1 Simple Data Display Functions

16.2.2 Color, Pen, and Brush Functions

Qt uses the classes `QColor`, `QPen`, and `QBrush` to determine how to draw lines and fill shapes. These classes are highly capable but somewhat awkward to use. PyQtGraph offers the functions `mkColor()`, `mkPen()`, and `mkBrush()` to simplify the process of creating these classes. In most cases, however, it will be unnecessary to call these functions directly—any function or method that accepts *pen* or *brush* arguments will make use of these functions for you. For example, the following three lines all have the same effect:

```
pg.plot(xdata, ydata, pen='r')
pg.plot(xdata, ydata, pen=pg.mkPen('r'))
pg.plot(xdata, ydata, pen=QPen(QColor(255, 0, 0)))
```

16.2.3 Data Slicing

16.2.4 Coordinate Transformation

16.2.5 SI Unit Conversion Functions

16.2.6 Image Preparation Functions

16.2.7 Mesh Generation Functions

16.2.8 Miscellaneous Functions

16.3 PyQtGraph's Graphics Items

Since pyqtgraph relies on Qt's QGraphicsView framework, most of its graphics functionality is implemented as QGraphicsItem subclasses. This has two important consequences: 1) virtually anything you want to draw can be easily accomplished using the functionality provided by Qt. 2) Many of pyqtgraph's GraphicsItem classes can be used in any normal QGraphicsScene.

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16.3.2 PlotItem

16.3.3 ImageItem

16.3.4 GraphItem

16.3.5 ViewBox

16.3.6 LinearRegionItem

16.3.7 InfiniteLine

16.3.8 ROI

16.3.9 GraphicsLayout

16.3.10 PlotCurveItem

16.3.11 ScatterPlotItem

16.3.12 IsocurveItem

16.3.13 AxisItem

16.3.14 TextItem

16.3.15 ErrorBarItem

16.3.16 ArrowItem

16.3.17 FillBetweenItem

16.3.18 CurvePoint

16.3.19 CurveArrow

16.3.20 GridItem

16.3.21 ScaleBar

16.3.22 LabelItem

16.3.23 VTickGroup

16.3.24 LegendItem

16.3.25 GradientEditorItem

16.3.26 TickSliderItem

16.4. PyQtGraph's Widgets

16.3.27 HistogramLUTItem

16.3.28 GradientLegend

applications.

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Note 1: pyqtgraph.opengl is based on the deprecated OpenGL fixed-function pipeline. Although it is currently a functioning system, it is likely to be superseded in the future by [VisPy](#).

Note 2: use of this system requires python-opengl bindings. Linux users should install the python-opengl packages from their distribution. Windows/OSX users can download from <http://pyopengl.sourceforge.net>.

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16.5.1 GLViewWidget

16.5.2 GLGridItem

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16.5.9 GLGraphicsItem

16.5.10 GLScatterPlotItem

16.5.11 MeshData

16.6 ColorMap

16.7 GraphicsScene and Mouse Events

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16.7.1 GraphicsScene

16.7.2 HoverEvent

16.7.3 MouseClickEvent

16.7.4 MouseDragEvent

CHAPTER 17

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