Jupyter Qt Console Documentation

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Jupyter Development Team

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Contents

To start the Qt console:

```
$> jupyter qtconsole
```

You can use any Jupyter kernel with this PyQt console GUI. This is a very lightweight widget that largely feels like a terminal, but provides a number of enhancements only possible in a GUI, such as inline figures, proper multiline editing with syntax highlighting, graphical calltips, and much more.

The Qt frontend has hand-coded emacs-style bindings for text navigation. This is not yet configurable.

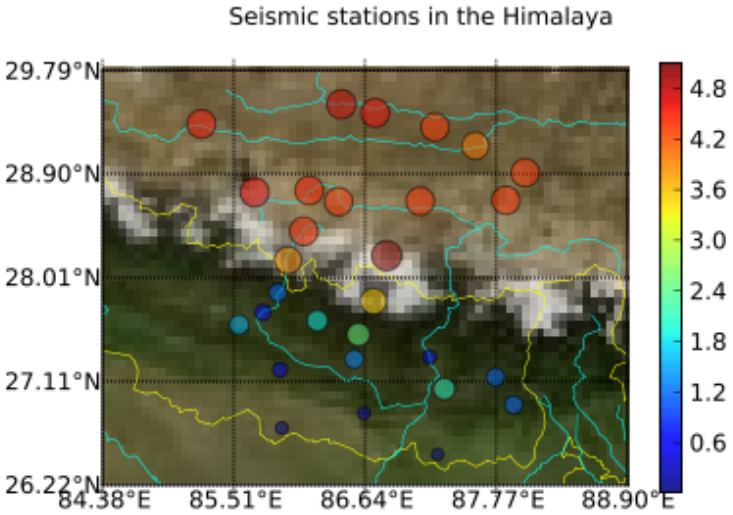
Tip: Since the Qt console tries hard to behave like a terminal, by default it immediately executes single lines of input that are complete. If you want to force multiline input, hit `Ctrl-Enter` at the end of the first line instead of `Enter`, and it will open a new line for input. At any point in a multiline block, you can force its execution (without having to go to the bottom) with `Shift-Enter`.

IPython

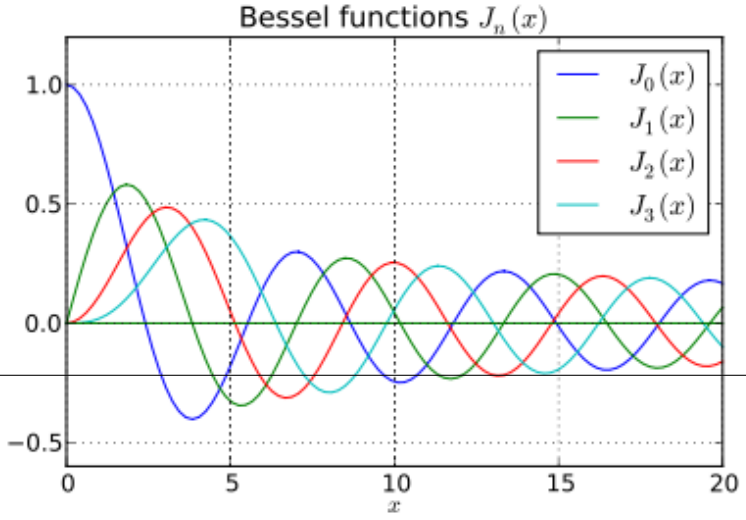
```
Python 2.6.5 (r265:79063, Apr 16 2010, 13:57:41)
Type "copyright", "credits" or "license" for more information.

IPython 0.11.alpha1.git -- An enhanced Interactive Python.
?         -> Introduction and overview of IPython's features.
%quickref -> Quick reference.
help      -> Python's own help system.
object?   -> Details about 'object', use 'object??' for extra details.
%guiref   -> A brief reference about the graphical user interface.

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




```
In [2]: from scipy import special as sp
   ...: x = linspace(0, 20, 100)
   ...: for n in range(4):
   ...:     y = sp.jn(n, x)
   ...:     plot(x, y, label=r'$J_%s(x)$' % n)
   ...: axhline(0, color='green', label='_nolegend_')
   ...: grid()
   ...: legend()
   ...: xlabel('$x$')
   ...: title(r'Bessel functions $J_n(x)$')
Out[2]: <matplotlib.text.Text object at 0x7fcddc1795d0>
```



CHAPTER 1

Installation

See also:

Installing Jupyter The Qt console is part of the Jupyter ecosystem.

You can install the Qt console with:

```
pip install qtconsole
# OR
conda install qtconsole
```

If you're new to Python, we recommend installing Anaconda, a Python distribution which includes the Qt console and the other Jupyter components.

1.1 Qt

The Qt console requires PyQt or PySide, which can't be installed with pip.

If you install the Qt console using conda, it will automatically install PyQt as well.

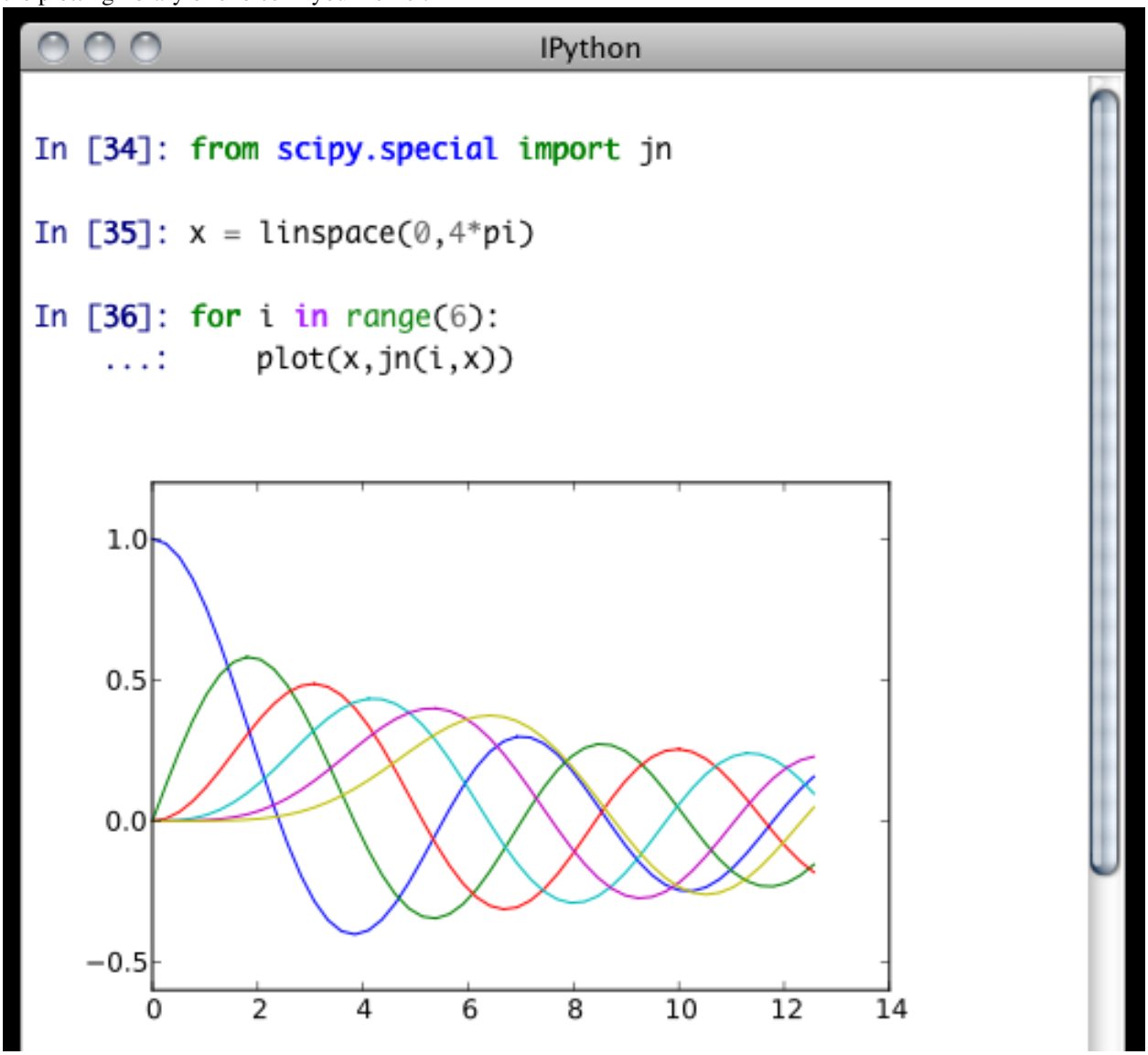
Otherwise, you can download PyQt manually, or install it using your system package manager, e.g.:

```
sudo apt-get install python3-pyqt5
```

CHAPTER 2

Inline graphics

One of the most exciting features of the QtConsole is embedded figures. You can plot with matplotlib in IPython, or the plotting library of choice in your kernel.



CHAPTER 3

Saving and Printing

QtConsole has the ability to save your current session, as either HTML or XHTML. Your inlinke figures will be PNG in HTML, or inlined as SVG in XHTML. PNG images have the option to be either in an external folder, as in many browsers' "Webpage, Complete" option, or inlined as well, for a larger, but more portable file.

Note: Export to SVG+XHTML requires that you are using SVG figures, which is *not* the default. To switch the inline figure format in IPython to use SVG, do:

```
In [10]: %config InlineBackend.figure_format = 'svg'
```

Or, you can add the same line (c.Inline... instead of %config Inline...) to your config files.

This will only affect figures plotted after making this call

The widget also exposes the ability to print directly, via the default print shortcut or context menu.

See these examples of `png/html` and `svg/xhtml` output. Note that syntax highlighting does not survive export. This is a known issue, and is being investigated.

CHAPTER 4

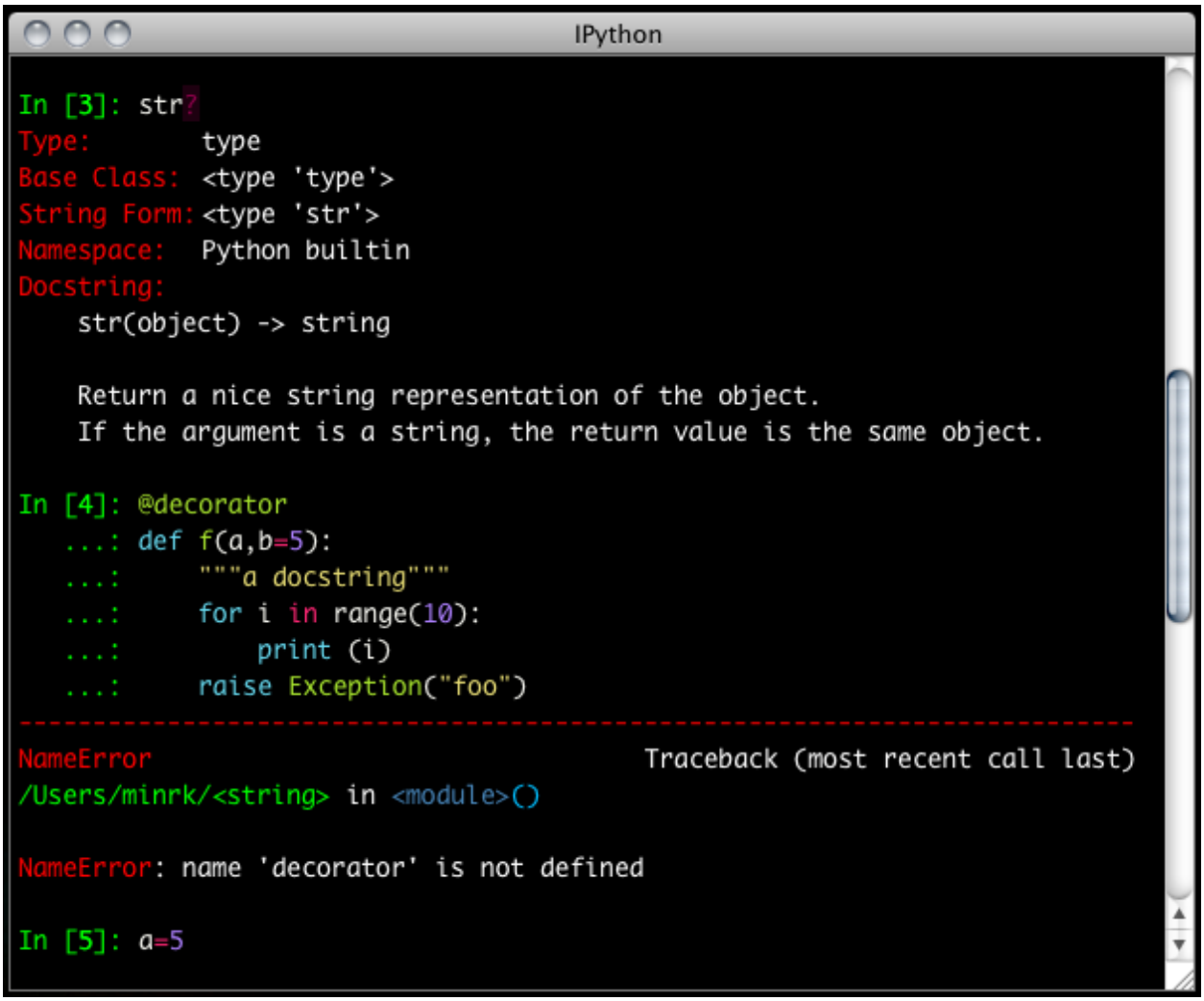
Colors and Highlighting

Terminal IPython has always had some coloring, but never syntax highlighting. There are a few simple color choices, specified by the `colors` flag or `%colors` magic:

- LightBG for light backgrounds
- Linux for dark backgrounds
- NoColor for a simple colorless terminal

The Qt widget, however, has full syntax highlighting as you type, handled by the pygments library. The `style` argument exposes access to any style by name that can be found by pygments, and there are several already installed.

Screenshot of `jupyter qtconsole --style monokai`, which uses the 'monokai' theme:



Note: Calling `jupyter qtconsole -h` will show all the style names that pygments can find on your system.

You can also pass the filename of a custom CSS stylesheet, if you want to do your own coloring, via the `stylesheet` argument. The default LightBG stylesheet:

```
QPlainTextEdit, QTextEdit { background-color: white;
        color: black ;
        selection-background-color: #ccc}
.error { color: red; }
.in-prompt { color: navy; }
.in-prompt-number { font-weight: bold; }
.out-prompt { color: darkred; }
.out-prompt-number { font-weight: bold; }
/* .inverted is used to highlight selected completion */
.inverted { background-color: black ; color: white; }
```

CHAPTER 5

Fonts

The QtConsole has configurable via the ConsoleWidget. To change these, set the `font_family` or `font_size` traits of the ConsoleWidget. For instance, to use 9pt Anonymous Pro:

```
$> jupyter qtconsole --ConsoleWidget.font_family="Anonymous Pro" --ConsoleWidget.font_size=9
```

CHAPTER 6

Process Management

With the two-process ZMQ model, the frontend does not block input during execution. This means that actions can be taken by the frontend while the Kernel is executing, or even after it crashes. The most basic such command is via 'Ctrl-.', which restarts the kernel. This can be done in the middle of a blocking execution. The frontend can also know, via a heartbeat mechanism, that the kernel has died. This means that the frontend can safely restart the kernel.

6.1 Multiple Consoles

Since the Kernel listens on the network, multiple frontends can connect to it. These do not have to all be qt frontends - any Jupyter frontend can connect and run code.

Other frontends can connect to your kernel, and share in the execution. This is great for collaboration. The `--existing` flag means connect to a kernel that already exists. Starting other consoles with that flag will not try to start their own kernel, but rather connect to yours. `kernel-12345.json` is a small JSON file with the ip, port, and authentication information necessary to connect to your kernel. By default, this file will be in your Jupyter runtime directory. If it is somewhere else, you will need to use the full path of the connection file, rather than just its filename.

If you need to find the connection info to send, and don't know where your connection file lives, there are a couple of ways to get it. If you are already running a console connected to an IPython kernel, you can use the `%connect_info` magic to display the information necessary to connect another frontend to the kernel.

```
In [2]: %connect_info
{
  "stdin_port":50255,
  "ip":"127.0.0.1",
  "hb_port":50256,
  "key":"70be6f0f-1564-4218-8cda-31be40a4d6aa",
  "shell_port":50253,
  "iopub_port":50254
}

Paste the above JSON into a file, and connect with:
    $> ipython <app> --existing <file>
or, if you are local, you can connect with just:
    $> ipython <app> --existing kernel-12345.json
or even just:
    $> ipython <app> --existing
if this is the most recent kernel you have started.
```

Otherwise, you can find a connection file by name (and optionally profile) with `jupyter_client.find_connection_file()`:

```
$> python -c "from jupyter_client import find_connection_file;\
print(find_connection_file('kernel-12345.json'))"
/home/you/Library/Jupyter/runtime/kernel-12345.json
```

6.2 Security

Warning: Since the ZMQ code currently has no encryption, listening on an external-facing IP is dangerous. You are giving any computer that can see you on the network the ability to connect to your kernel, and view your traffic. Read the rest of this section before listening on external ports or running a kernel on a shared machine.

By default (for security reasons), the kernel only listens on localhost, so you can only connect multiple frontends to the kernel from your local machine. You can specify to listen on an external interface by specifying the `ip` argument:

```
$> jupyter qtconsole --ip=192.168.1.123
```

If you specify the ip as 0.0.0.0 or '*', that means all interfaces, so any computer that can see yours on the network can connect to the kernel.

Messages are not encrypted, so users with access to the ports your kernel is using will be able to see any output of the kernel. They will **NOT** be able to issue shell commands as you due to message signatures.

Warning: If you disable message signatures, then any user with access to the ports your kernel is listening on can issue arbitrary code as you. **DO NOT** disable message signatures unless you have a lot of trust in your environment.

The one security feature Jupyter does provide is protection from unauthorized execution. Jupyter's messaging system will sign messages with HMAC digests using a shared-key. The key is never sent over the network, it is only used to generate a unique hash for each message, based on its content. When the kernel receives a message, it will check that the digest matches, and discard the message. You can use any file that only you have access to to generate this key, but the default is just to generate a new UUID.

6.3 SSH Tunnels

Sometimes you want to connect to machines across the internet, or just across a LAN that either doesn't permit open ports or you don't trust the other machines on the network. To do this, you can use SSH tunnels. SSH tunnels are a way to securely forward ports on your local machine to ports on another machine, to which you have SSH access.

In simple cases, Jupyter's tools can forward ports over ssh by simply adding the `--ssh=remote` argument to the usual `--existing...` set of flags for connecting to a running kernel, after copying the JSON connection file (or its contents) to the second computer.

Warning: Using SSH tunnels does *not* increase localhost security. In fact, when tunneling from one machine to another *both* machines have open ports on localhost available for connections to the kernel.

There are two primary models for using SSH tunnels with Jupyter. The first is to have the Kernel listen only on localhost, and connect to it from another machine on the same LAN.

First, let's start a kernel on machine **worker**, listening only on loopback:

```
user@worker $> ipython kernel
[IPKernelApp] To connect another client to this kernel, use:
[IPKernelApp] --existing kernel-12345.json
```

In this case, the IP that you would connect to would still be 127.0.0.1, but you want to specify the additional `--ssh` argument with the hostname of the kernel (in this example, it's 'worker'):

```
user@client $> jupyter qtconsole  --ssh=worker --existing /path/to/kernel-12345.json
```

Which will write a new connection file with the forwarded ports, so you can reuse them:

```
[JupyterQtConsoleApp] To connect another client via this tunnel, use:
[JupyterQtConsoleApp] --existing kernel-12345-ssh.json
```

Note again that this opens ports on the *client* machine that point to your kernel.

Note: the ssh argument is simply passed to openssh, so it can be fully specified `user@host:port` but it will also respect your aliases, etc. in `.ssh/config` if you have any.

The second pattern is for connecting to a machine behind a firewall across the internet (or otherwise wide network). This time, we have a machine **login** that you have ssh access to, which can see **kernel**, but **client** is on another network. The important difference now is that **client** can see **login**, but *not* **worker**. So we need to forward ports from client to worker *via* login. This means that the kernel must be started listening on external interfaces, so that its ports are visible to `login`:

```
user@worker $> ipython kernel --ip=0.0.0.0
[IPKernelApp] To connect another client to this kernel, use:
[IPKernelApp] --existing kernel-12345.json
```

Which we can connect to from the client with:

```
user@client $> jupyter qtconsole --ssh=login --ip=192.168.1.123 --existing /path/to/kernel-12345.jso
```

Note: The IP here is the address of worker as seen from *login*, and need only be specified if the kernel used the ambiguous 0.0.0.0 (all interfaces) address. If it had used 192.168.1.123 to start with, it would not be needed.

6.4 Manual SSH tunnels

It's possible that Jupyter's ssh helper functions won't work for you, for various reasons. You can still connect to remote machines, as long as you set up the tunnels yourself. The basic format of forwarding a local port to a remote one is:

```
[client] $> ssh <server> <localport>:<remoteip>:<remoteport> -f -N
```

This will forward local connections to **localport** on client to **remoteip:remoteport** *via* **server**. Note that remoteip is interpreted relative to *server*, not the client. So if you have direct ssh access to the machine to which you want to forward connections, then the server *is* the remote machine, and remoteip should be server's IP as seen from the server itself, i.e. 127.0.0.1. Thus, to forward local port 12345 to remote port 54321 on a machine you can see, do:

```
[client] $> ssh machine 12345:127.0.0.1:54321 -f -N
```

But if your target is actually on a LAN at 192.168.1.123, behind another machine called **login**, then you would do:

```
[client] $> ssh login 12345:192.168.1.16:54321 -f -N
```

The `-f -N` on the end are flags that tell ssh to run in the background, and don't actually run any commands beyond creating the tunnel.

See also:

A short discussion of ssh tunnels: http://www.revsys.com/writings/quicktips/ssh-tunnel.html

6.5 Stopping Kernels and Consoles

Since there can be many consoles per kernel, the shutdown mechanism and dialog are probably more complicated than you are used to. Since you don't always want to shutdown a kernel when you close a window, you are given the option to just close the console window or also close the Kernel and *all other windows*. Note that this only refers to all other *local* windows, as remote Consoles are not allowed to shutdown the kernel, and shutdowns do not close Remote consoles (to allow for saving, etc.).

Rules:

- Restarting the kernel automatically clears all *local* Consoles, and prompts remote Consoles about the reset.
- Shutdown closes all *local* Consoles, and notifies remotes that the Kernel has been shutdown.
- Remote Consoles may not restart or shutdown the kernel.

CHAPTER 7

Qt and the QtConsole

An important part of working with the QtConsole when you are writing your own Qt code is to remember that user code (in the kernel) is *not* in the same process as the frontend. This means that there is not necessarily any Qt code running in the kernel, and under most normal circumstances there isn't.

A common problem listed in the PyQt4 Gotchas is the fact that Python's garbage collection will destroy Qt objects (Windows, etc.) once there is no longer a Python reference to them, so you have to hold on to them. For instance, in:

```
def make_window():
    win = QtGui.QMainWindow()

def make_and_return_window():
    win = QtGui.QMainWindow()
    return win
```

`make_window()` will never draw a window, because garbage collection will destroy it before it is drawn, whereas `make_and_return_window()` lets the caller decide when the window object should be destroyed. If, as a developer, you know that you always want your objects to last as long as the process, you can attach them to the QApplication instance itself:

```
# do this just once:
app = QtCore.QCoreApplication.instance()
app.references = set()
# then when you create Windows, add them to the set
def make_window():
    win = QtGui.QMainWindow()
    app.references.add(win)
```

Now the QApplication itself holds a reference to `win`, so it will never be garbage collected until the application itself is destroyed.

7.1 Embedding the QtConsole in a Qt application

In order to make the QtConsole available to an external Qt GUI application (just as `IPython.embed()` enables one to embed a terminal session of IPython in a command-line application), there are a few options:

- First start IPython, and then start the external Qt application from IPython, as described above. Effectively, this embeds your application in IPython rather than the other way round.
- Use `qtconsole.rich_jupyter_widget.RichJupyterWidget` in your Qt application. This will embed the console widget in your GUI and start the kernel in a separate process, so code typed into the console cannot access objects in your application.

- Start a standard IPython kernel in the process of the external Qt application. See `examples/Embedding/ipkernel_qtapp.py` for an example. Due to IPython's two-process model, the QtConsole itself will live in another process with its own QApplication, and thus cannot be embedded in the main GUI.
- Start a special IPython kernel, the `IPython.kernel.inprocess.ipkernel.InProcessKernel`, that allows a QtConsole in the same process. See `examples/Embedding/inprocess_qtconsole.py` for an example. While the QtConsole can now be embedded in the main GUI, one cannot connect to the kernel from other consoles as there are no real ZMQ sockets anymore.

CHAPTER 8

Regressions

There are some features, where the qt console lags behind the Terminal frontend:

- !cmd input: Due to our use of pexpect, we cannot pass input to subprocesses launched using the '!' escape, so you should never call a command that requires interactive input. For such cases, use the terminal IPython. This will not be fixed, as abandoning pexpect would significantly degrade the console experience.