Julia Tools and Editors

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1 Contents

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While Jupyter notebooks are a great way to get started with the language, eventually you will want to use more powerful tools.

We'll discuss a few of them here, such as

- Text editors like Atom, which come with rich Julia support for debugging, documentation, git integration, plotting and inspecting data, and code execution.
- The Julia REPL, which has specialized modes for package management, shell commands, and help.

Note that we assume you've already completed the getting started and interacting with Julia lectures.

2 Preliminary Setup

Follow the instructions for setting up Julia on your local computer.

3 The REPL

Previously, we discussed basic use of the Julia REPL ("Read-Evaluate-Print Loop").

Here, we'll consider some more advanced features.

3.1 Shell Mode

Hitting `;` brings you into shell mode, which lets you run bash commands (PowerShell on Windows)

```
In [1]: ; pwd
```

```
/home/ubuntu/repos/lecture-source-jl/_build/jupyterpdf/executed/more_julia
```

You can also use Julia variables from shell mode

```
In [2]: x = 2
```

```
Out[2]: 2
```

```
In [3]: ; echo $x
```

```
2
```

3.2 Package Mode

Hitting `]` brings you into package mode.

- `] add Expectations` will add a package (here, `Expectations.jl`).
- Likewise, `] rm Expectations` will remove that package.
- `] st` will show you a snapshot of what you have installed.
- `] up` will (intelligently) upgrade versions of your packages.
- `] precompile` will precompile everything possible.
- `] build` will execute build scripts for all packages.
- Running `] preview` before a command (i.e., `] preview up`) will display the changes without executing.

You can get a full list of package mode commands by running

```
In [4]: ] ?
```

```
  Welcome to the Pkg REPL-mode. To return to the julia> prompt,
either press
  backspace when the input line is empty or press Ctrl+C.

  Synopsis

  pkg> cmd [opts] [args]

  Multiple commands can be given on the same line by interleaving a ;
between
  the commands.

  Commands

  activate: set the primary environment the package manager manipulates
```

```
add: add packages to project

build: run the build script for packages

develop: clone the full package repo locally for development

free: undoes a pin, develop, or stops tracking a repo

gc: garbage collect packages not used for a significant time

generate: generate files for a new project

help: show this message

instantiate: downloads all the dependencies for the project

pin: pins the version of packages

precompile: precompile all the project dependencies

redo: redo the latest change to the active project

remove: remove packages from project or manifest

resolve: resolves to update the manifest from changes in dependencies of
developed packages

status: summarize contents of and changes to environment

test: run tests for packages

undo: undo the latest change to the active project

update: update packages in manifest

registry add: add package registries

registry remove: remove package registries

registry status: information about installed registries

registry update: update package registries
```

On some operating systems (such as OSX) REPL pasting may not work for package mode, and you will need to access it in the standard way (i.e., hit `]` first and then run your commands).

3.3 Help Mode

Hitting `?` will bring you into help mode.

The key use case is to find docstrings for functions and macros, e.g.

```
? print
```

Note that objects must be loaded for Julia to return their documentation, e.g.

```
? @test
```

will fail, but

```
using Test
```

```
? @test
```

will succeed.

4 Atom

As discussed previously, eventually you will want to use a fully fledged text editor.

The most feature-rich one for Julia development is Atom, with the Juno package.

There are several reasons to use a text editor like Atom, including

- Git integration (more on this in the next lecture).
- Painless inspection of variables and data.
- Easily run code blocks, and drop in custom snippets of code.
- Integration with Julia documentation and plots.

4.1 Installation and Configuration

4.1.1 Installing Atom

1. Download and Install Atom from the Atom website.
2. (Optional, but recommended): Change default Atom settings

- Use `Ctrl-,` to get the `Settings` pane
- Choose the `Packages` tab
- Type `line-ending-selector` into the Filter and then click "Settings" for that package
  - Change the default line ending to `LF` (only necessary on Windows)
- Choose the Editor tab
  - Turn on `Soft Wrap`
  - Set the `Tab Length` default to `4`

4.1.2 Installing Juno

1. Use `Ctrl-,` to get the Settings pane.
2. Go to the `Install` tab.
3. Type `uber-juno` into the search box and then click Install on the package that appears.
4. Wait while Juno installs dependencies.
5. When it asks you whether or not to use the standard layout, click `yes`.

At that point, you should see a built-in REPL at the bottom of the screen and be able to start using Julia and Atom.

4.1.3 Troubleshooting

Sometimes, Juno will fail to find the Julia executable (say, if it's installed somewhere non-standard, or you have multiple).

To do this 1. `Ctrl-,` to get Settings pane, and select the Packages tab. 2. Type in `julia-client` and choose Settings. 3. Find the Julia Path, and fill it in with the location of the Julia binary.

    - To find the binary, you could run `Sys.BINDIR` in the REPL, then add in an additional `/julia` to the end of the screen.

- e.g. `C:\Users\YOURUSERNAME\AppData\Local\Julia-1.0.1\bin\julia.exe` on Windows as `/Applications/Julia-1.0.app/Contents/Resources/julia/bin/julia` on OSX.

See the setup instructions for Juno if you have further issues.

If you upgrade Atom and it breaks Juno, run the following in a terminal.

```
apm uninstall ink julia-client
apm install ink julia-client
```

If you aren't able to install `apm` in your PATH, you can do the above by running the following in PowerShell:

```
cd $ENV:LOCALAPPDATA/atom/bin
```

Then navigating to a folder like `C:\Users\USERNAME\AppData\Local\atom\bin` (which will contain the `apm` tool), and running:

```
./apm uninstall ink julia-client
./apm install ink julia-client
```

4.1.4 Upgrading Julia

To get a new release working with Jupyter, run (in the new version's REPL)

```
] add IJulia
] build IJulia
```

This will install (and build) the `IJulia` kernel.

To get it working with Atom, open the command palette and type "Julia Client: Settings."

Then, in the box labelled "Julia Path," enter the path to yor Julia executabe.

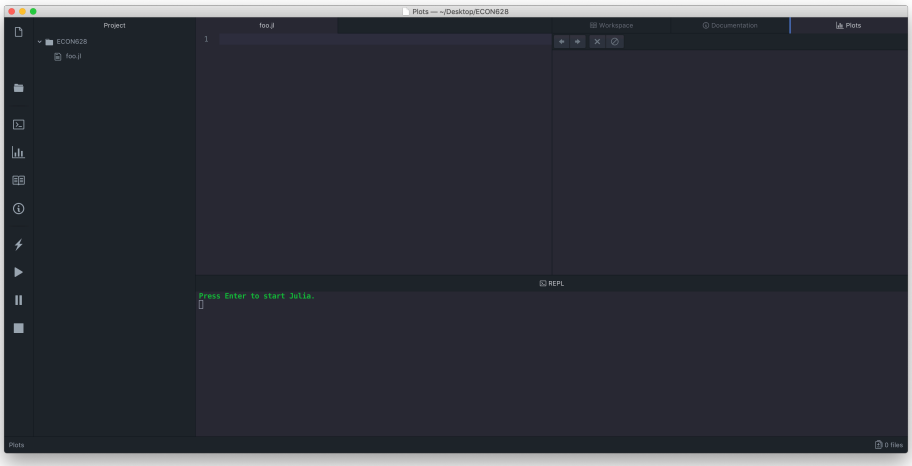
You can find the folder by running `Sys.BINDIR` in a new REPL, and then add the `/julia` at the end to give the exact path.

For example:

4.2 Standard Layout

If you follow the instructions, you should see something like this when you open a new file.

If you don't, simply go to the command palette and type "Julia standard layout"



The bottom pane is a standard REPL, which supports the different modes above.

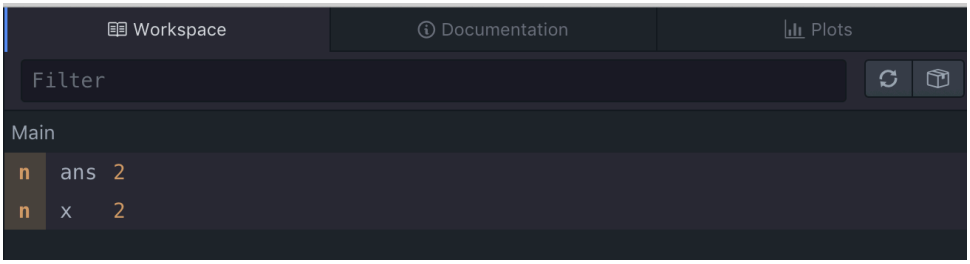
The "workspace" pane is a snapshot of currently-defined objects.

For example, if we define an object in the REPL

```
In [5]: x = 2
```

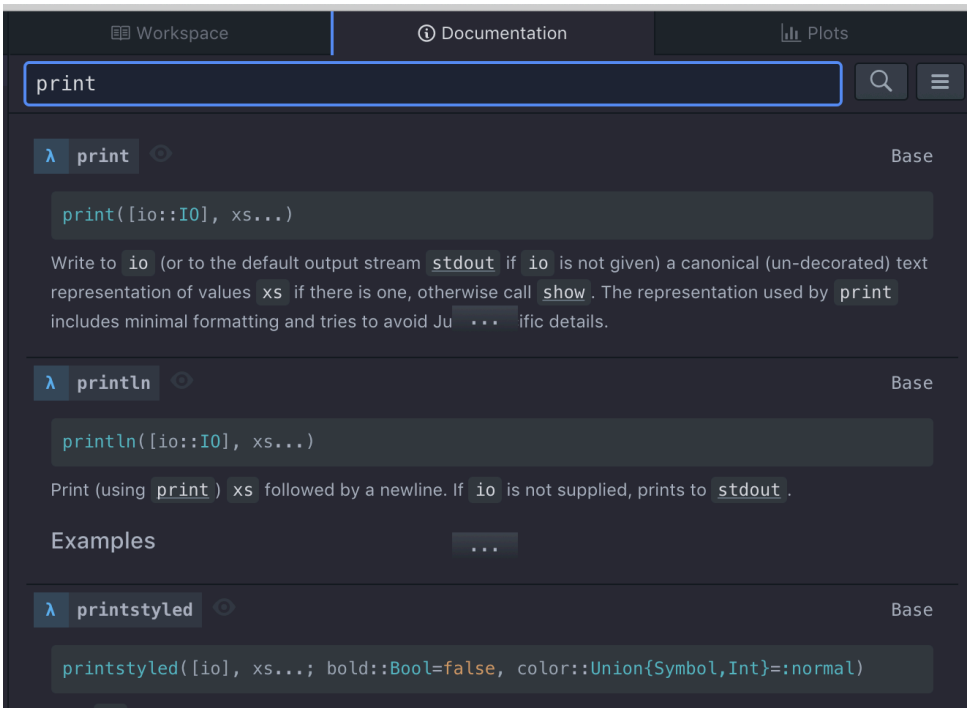
```
Out[5]: 2
```

Our workspace should read



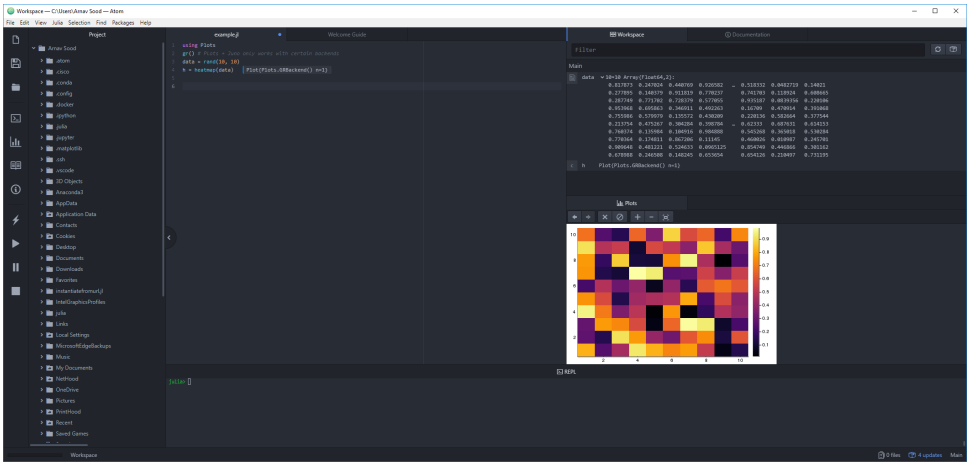
The `ans` variable simply captures the result of the last computation.

The `Documentation` pane simply lets us query Julia documentation



The `Plots` pane captures Julia plots output (the code is as follows)

```
using Plots
gr(fmt = :png);
data = rand(10, 10)
h = heatmap(data)
```



Note: The plots feature is not perfectly reliable across all plotting backends, see the Basic Usage page.

4.3 Other Features

- `Shift + Enter` will evaluate a highlighted selection or line (as above).

- The run symbol in the left sidebar (or `Ctrl+Shift+Enter`) will run the whole file.

See basic usage for an exploration of features, and the FAQ for more advanced steps.

5 Package Environments

Julia's package manager lets you set up Python-style "virtualenvs," or subsets of packages that draw from an underlying pool of assets on the machine.

This way, you can work with (and specify) the dependencies (i.e., required packages) for one project without worrying about impacts on other projects.

- An `environment` is a set of packages specified by a `Project.toml` (and optionally, a `Manifest.toml`).
- A `registry` is a git repository corresponding to a list of (typically) registered packages, from which Julia can pull (for more on git repositories, see version control).
- A `depot` is a directory, like `~/.julia`, which contains assets (compile caches, registries, package source directories, etc.).

Essentially, an environment is a dependency tree for a project, or a "frame of mind" for Julia's package manager.

- We can see the default (`v1.1`) environment as such

```
In [6]: ] st
```

```
    Status `~/repos/lecture-source-
jl/_build/jupyterpdf/executed/more_julia/Project.toml`
  [2169fc97] AlgebraicMultigrid v0.2.2
  [28f2ccd6] ApproxFun v0.11.13
  [7d9fca2a] Arpack v0.4.0
  [aae01518] BandedMatrices v0.15.7
  [6e4b80f9] BenchmarkTools v0.5.0
  [a134a8b2] BlackBoxOptim v0.5.0
  [ffab5731] BlockBandedMatrices v0.8.4
  [324d7699] CategoricalArrays v0.8.0
  [34da2185] Compat v2.2.0
  [a93c6f00] DataFrames v0.21.0
  [1313f7d8] DataFramesMeta v0.5.1
  [39dd38d3] Dierckx v0.4.1
  [9fdde737] DiffEqOperators v4.10.0
  [31c24e10] Distributions v0.23.2
  [2fe49d83] Expectations v1.1.1
  [a1e7a1ef] Expokit v0.2.0
  [d4d017d3] ExponentialUtilities v1.6.0
  [442a2c76] FastGaussQuadrature v0.4.2
  [1a297f60] FillArrays v0.8.9
  [9d5cd8c9] FixedEffectModels v0.10.7
  [c8885935] FixedEffects v0.7.3
  [587475ba] Flux v0.10.4
  [f6369f11] ForwardDiff v0.10.10
  [38e38edf] GLM v1.3.9
  [28b8d3ca] GR v0.49.1
  [40713840] IncompleteLU v0.1.1
  [43edad99] InstantiateFromURL v0.5.0
  [a98d9a8b] Interpolations v0.12.9
  [b6b21f68] Ipopt v0.6.1
  [42fd0dbc] IterativeSolvers v0.8.4
```

```
  [4076af6c] JuMP v0.21.2
  [5ab0869b] KernelDensity v0.5.1
  [ba0b0d4f] Krylov v0.5.1
  [0b1a1467] KrylovKit v0.4.2
  [b964fa9f] LaTeXStrings v1.1.0
  [5078a376] LazyArrays v0.16.9
  [0fc2ff8b] LeastSquaresOptim v0.7.5
  [093fc24a] LightGraphs v1.3.3
  [7a12625a] LinearMaps v2.6.1
  [5c8ed15e] LinearOperators v1.1.0
  [961ee093] ModelingToolkit v3.6.4
  [76087f3c] NLopt v0.6.0
  [2774e3e8] NLsolve v4.3.0
  [429524aa] Optim v0.20.1
  [1dea7af3] OrdinaryDiffEq v5.38.1
  [d96e819e] Parameters v0.12.1
  [14b8a8f1] PkgTemplates v0.6.4
  [91a5bcdd] Plots v1.2.5
  [f27b6e38] Polynomials v1.0.6
  [af69fa37] Preconditioners v0.3.0
  [92933f4c] ProgressMeter v1.2.0
  [1fd47b50] QuadGK v2.3.1
  [fcd29c91] QuantEcon v0.16.2
  [1a8c2f83] Query v0.12.2
  [ce6b1742] RDatasets v0.6.8
  [d519eb52] RegressionTables v0.4.0
  [295af30f] Revise v2.6.6
  [f2b01f46] Roots v1.0.1
  [47a9eef4] SparseDiffTools v1.8.0
  [684fba80] SparsityDetection v0.3.1
  [90137ffa] StaticArrays v0.12.3
  [2913bbd2] StatsBase v0.32.2
  [3eaba693] StatsModels v0.6.11
  [f3b207a7] StatsPlots v0.14.6
  [789caeaf] StochasticDiffEq v6.20.0
  [a759f4b9] TimerOutputs v0.5.5 #master
 (https://github.com/KristofferC/TimerOutputs.jl)
  [112f6efa] VegaLite v2.1.3
  [e88e6eb3] Zygote v0.4.20
  [37e2e46d] LinearAlgebra
  [9a3f8284] Random
  [2f01184e] SparseArrays
  [10745b16] Statistics
  [8dfed614] Test
```

- We can also create and activate a new environment

In [7]:
```
] generate ExampleEnvironment
```

```
  Generating  project ExampleEnvironment:
ExampleEnvironment/Project.toml
ExampleEnvironment/src/ExampleEnvironment.jl
```

- And go to it

In [8]:
```
; cd ExampleEnvironment
```

```
    /home/ubuntu/repos/lecture-source-
jl/_build/jupyterpdf/executed/more_julia/ExampleEnvironment
```

- To activate the directory, simply

```
In [9]: ] activate .
```

```
     Activating environment at `~/repos/lecture-source-
jl/_build/jupyterpdf/executed/more_julia/ExampleEnvironment/Project.toml`
```

where "." stands in for the "present working directory".

- Let's make some changes to this

```
In [10]: ] add Expectations Parameters
```

```
      Updating registry at `~/.julia/registries/General`
```

```
      Updating git-repo
`https://github.com/JuliaRegistries/General.git`
```

```
     Resolving package versions…
    Updating `~/repos/lecture-source-
jl/_build/jupyterpdf/executed/more_julia/ExampleEnvironment/Project.toml`
  [2fe49d83] + Expectations v1.5.0
  [d96e819e] + Parameters v0.12.1
    Updating `~/repos/lecture-source-
jl/_build/jupyterpdf/executed/more_julia/ExampleEnvironment/Manifest.toml`
  [34da2185] + Compat v3.15.0
  [e66e0078] + CompilerSupportLibraries_jll v0.3.3+0
  [9a962f9c] + DataAPI v1.3.0
  [864edb3b] + DataStructures v0.18.4
  [31c24e10] + Distributions v0.23.11
  [2fe49d83] + Expectations v1.5.0
  [442a2c76] + FastGaussQuadrature v0.4.2
  [1a297f60] + FillArrays v0.9.6
  [e1d29d7a] + Missings v0.4.4
  [efe28fd5] + OpenSpecFun_jll v0.5.3+3
  [bac558e1] + OrderedCollections v1.3.0
  [90014a1f] + PDMats v0.10.0
  [d96e819e] + Parameters v0.12.1
  [1fd47b50] + QuadGK v2.4.1
  [79098fc4] + Rmath v0.6.1
  [f50d1b31] + Rmath_jll v0.2.2+1
  [a2af1166] + SortingAlgorithms v0.3.1
  [276daf66] + SpecialFunctions v0.10.3
  [2913bbd2] + StatsBase v0.33.1
  [4c63d2b9] + StatsFuns v0.9.5
  [3a884ed6] + UnPack v1.0.2
```

```
  [2a0f44e3] + Base64
  [ade2ca70] + Dates
  [8bb1440f] + DelimitedFiles
  [8ba89e20] + Distributed
  [b77e0a4c] + InteractiveUtils
  [76f85450] + LibGit2
  [8f399da3] + Libdl
  [37e2e46d] + LinearAlgebra
  [56ddb016] + Logging
  [d6f4376e] + Markdown
  [a63ad114] + Mmap
  [44cfe95a] + Pkg
  [de0858da] + Printf
  [3fa0cd96] + REPL
  [9a3f8284] + Random
  [ea8e919c] + SHA
  [9e88b42a] + Serialization
  [1a1011a3] + SharedArrays
  [6462fe0b] + Sockets
  [2f01184e] + SparseArrays
  [10745b16] + Statistics
  [4607b0f0] + SuiteSparse
  [8dfed614] + Test
  [cf7118a7] + UUIDs
  [4ec0a83e] + Unicode
```

Note the lack of commas

- To see the changes, simply open the `ExampleEnvironment` directory in an editor like Atom.

The Project TOML should look something like this

```
name = "ExampleEnvironment"
uuid = "14d3e79e-e2e5-11e8-28b9-19823016c34c"
authors = ["QuantEcon User <quanteconuser@gmail.com>"]
version = "0.1.0"

[deps]
Expectations = "2fe49d83-0758-5602-8f54-1f90ad0d522b"
Parameters = "d96e819e-fc66-5662-9728-84c9c7592b0a"
```

We can also

```
In [11]: ] precompile
```

```
    Precompiling project…
┌ Info: Precompiling Expectations [2fe49d83-0758-5602-8f54-1f90ad0d522b]
└ @ Base loading.jl:1260
┌ Warning: Package Expectations does not have LinearAlgebra in its dependencies:
│ - If you have Expectations checked out for development and have
│   added LinearAlgebra as a dependency but haven't updated your primary
│   environment's manifest file, try `Pkg.resolve()`.
│ - Otherwise you may need to report an issue with Expectations
└ Loading LinearAlgebra into Expectations from project dependency, future warnings
  ↪for
Expectations are suppressed.
```

```
┌ Info: Precompiling ExampleEnvironment [d87746dc-3dde-4a18-a403-77e9d69e748a]
└ @ Base loading.jl:1260
```

Note The TOML files are independent of the actual assets (which live in `~/.julia/packages`, `~/.julia/dev`, and `~/.julia/compiled`).

You can think of the TOML as specifying demands for resources, which are supplied by the `~/.julia` user depot.

- To return to the default Julia environment, simply

```
In [12]: ] activate
```

```
     Activating environment at `~/repos/lecture-source-
jl/_build/jupyterpdf/executed/more_julia/Project.toml`
```

without any arguments.

- Lastly, let's clean up

```
In [13]: ; cd ..
```

```
/home/ubuntu/repos/lecture-source-jl/_build/jupyterpdf/executed/more_julia
```

```
In [14]: ; rm -rf ExampleEnvironment
```

5.1 InstantiateFromURL

With this knowledge, we can explain the operation of the setup block

```
In [15]: using InstantiateFromURL
         # optionally add arguments to force installation: instantiate = true,
↪precompile = true
         github_project("QuantEcon/quantecon-notebooks-julia", version = "0.8.0")
```

What this `github_project` function does is activate (and if necessary, download, instantiate and precompile) a particular Julia environment.