SKILLPILLS

Skill Pill: Julia

Lecture 2: Data Processing and Plotting

Juan Polo { material taken/based on Ankur Dhar & James Schloss }

juan.polo@oist.jp

ankurd@oist.jp

james.schloss@oist.jp

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1. Arrays

2. Data Handling

3. Plotting

Creating Arrays

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```
x = [1 2 3 4]        # 1x4 Array{Int64,2}
y = collect(1:4)     # 4-element Array{Int64,1}
z = [1, 2, 3, 4]     # 4-element Array{Int64,1}
m = [1 2; 3 4]       # 2x2 Array{Int64,2}
w=x'                 # 4x1 {Int64,Array{Int64,2}}
array = Int64[]      # 0-element Array{Int64,1}
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Please try to create a vector from 0 to 0.9 in steps of 0.1

Array Generation Functions

zeros(S) Makes an array of size S filled with zeros

ones(S) Makes an array of size S filled with ones

repeat(A,c,r) Repeats array A column-wise c times and row-wise r times

rand(S) Generates array of size S with random numbers between 0 and 1

Type[] Creates empty array of type Type

Array Operations

Arrays can be indexed by using square brackets after the array. For multidimensional arrays, the first dimension is the row, followed by column and so on. Output of indexing arrays is by default a column. This is crucial when it comes to multiplying arrays by each other.

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data = rand(50,50)
data[1,:]
data[:,1]
inner = x*y
outer = y*x
square = x .* x
```

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```
2 .* x
```

Broadcasting

It is sometimes useful to perform element-by-element binary operations on arrays of different sizes. Dotted operators such as `.+` and `.*` are equivalent to broadcast calls

```
data = collect(0:.1:1)
round.(data)
f(x) = x+2
f.(data)
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```

Extra cool things

`data[data .< 0.5]`

Data Handling

File Structure

To begin working with files, you must know where your working directory is. When launching Julia from an application menu (Windows/MacOS), the default directory is predefined. For Linux it will be the home directory.

```julia
pwd()
# cd("C:\\Users\\M\\Documents\\JuliaStuff")
readdir()
```

You can use `pwd()` to print your working directory, and `cd()` to change it to whichever new directory you would like. Once you are in the directory you want, you can list the files within using `readdir()`.

Delimited text

The simplest data files are often delimited text files or CSV files, which can be manipulated like any other variable in Julia. To load any general delimited file, load the DelimitedFiles package. Reading in these files will automatically generate 1D or 2D arrays depending on the data being read in.

```
julia> using DelimitedFiles
julia> data = rand(50,50)
julia> writedlm("Random.txt",data)
julia> randData = readdlm("Random.txt")
```

Similarly, any 1D or 2D can be written to a file, with the actual delimiter being based on the file extension used (txt for space and csv for comma).

CSV files

Typical CSV files are a bit more complex than standard delimited files, with headers or labels. For this use case the CSV package is recommended. When reading in a file, the first row will be taken as the header row, but this can be explicitly defined.

```
using CSV, DataFrames
data =
    DataFrame(CSV.File("simplemaps-worldcities-basic.csv"))
names(data)
populations = data[:,:pop]
populations = data.pop
data[5677,:]
```

Small trick, you can write “`data.`” and press "TAB" twice to see the available columns

```
data[data.city .== "Barcelona",:]
findall(x->x=="Barcelona",data.city)
```

Exercises

Exercise 1

Creates a file `squares.txt` consisting of the first 5 square numbers

Exercise 2

Write a script which creates a new file called `large_cities.txt`. The file should contain one line for each of the cities which have a population larger than 10,000,000., formatted as follows:

Buenos Aires, Argentina: population 11862073
Sao Paulo, Brazil: population 14433147.5
...

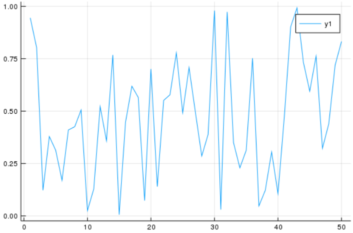
Fast way to look at data using Dataframes `data[data.pop .> 10^7,:]`

Plots

Plots in a Nutshell

To start with, let's add and load the general Plots package

```
# inside pkg>
add Plots
# inside REPL
using Plots
# plot(Plots.fakedata(50))
```



This will let us call the general Plot commands, in this case `plot` plots 1D data as a line plot.

More information can be found at `https://docs.juliaplots.org/latest/`

Plotting Commands

scatter(X,Y)	Scatter plot data with XY coordinates
bar(x,y)	Bar plot following similar rules to plot
histogram(x,bins=n)	Plots histogram of 1D data in n bins.
plot(θ,r,proj=:polar)	Polar plot of data following r and θ
heatmap(x,y,z)	Plots heatmap following XY axes with intensity array z
fakedata(L,S)	Generates random S numbers of series data of length L
savefig(filename)	Saves a generated plot as an image file

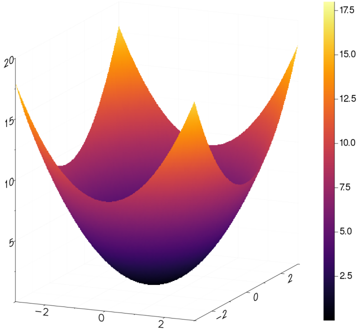
Plotting 3D Data

There are a couple of additional options for plotting 3D data:

surface(x,y,z) Draws surface in 3D space

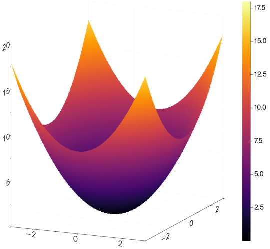
contour(x,y,z) Draws contours on 2D plane

The plotting commands `plot`,`scatter`,`bar`, and `heatmap` also can accept 3D data.



Plotting 3D examples

```
using Plots
x = y = collect(-1:0.01:1)
#surface(x,y,(x,y)->x^2+y^2)
#heatmap(x,y,(x,y)->x^2+y^2)
f(x,y) = x^2 + y^2
surface(x,y,f.(x,y'))
contour(x,y,f.(x,y'))
```



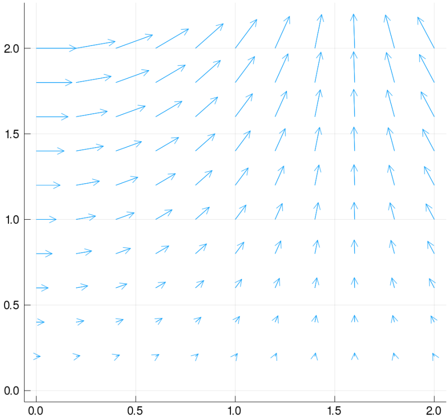
Plotting Vector Data

For vector data the current option is quiver:

```
help?> quiver
search: quiver quiver!

quiver(x,y,quiver=(u,v))
quiver!(x,y,quiver=(u,v))

Make a quiver (vector field)
    plot. The ith vector
    extends from (x[i],y[i])
    to (x[i] + u[i], y[i] +
    v[i]).
```



Plotting Backends

These commands are agnostic to the plotting backend, meaning they will work with a number of plotting engines in similar fashion. Each backend has pros and cons, but most commonly used are GR and PyPlot.

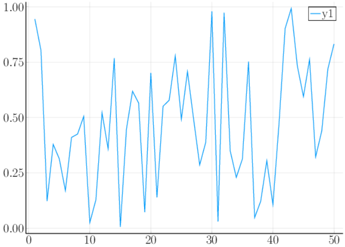


Figure: PGFPlots

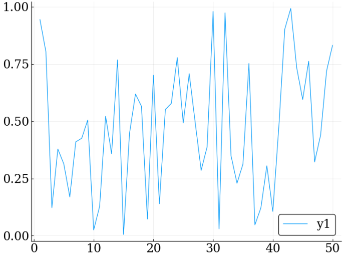
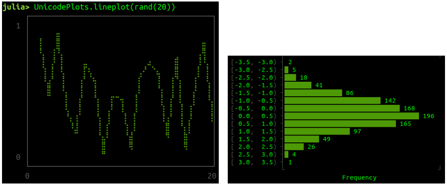


Figure: PyPlot

using PyPlot; PyPlot.plot(rand(10))



```
julia> UnicodePlots.lineplot(rand(20))
```

```
[-3.5, -3.0) ┤ 2
[-3.0, -2.5) ┤ 5
[-2.5, -2.0) ┤ 18
[-2.0, -1.5) ┤ 41
[-1.5, -1.0) ┤ 86
[-1.0, -0.5) ┤ 142
[-0.5,  0.0) ┤ 168
[ 0.0,  0.5) ┤ 196
[ 0.5,  1.0) ┤ 165
[ 1.0,  1.5) ┤ 97
[ 1.5,  2.0) ┤ 49
[ 2.0,  2.5) ┤ 26
[ 2.5,  3.0) ┤ 4
[ 3.0,  3.5) ┤ 1
                   Frequency
```

Figure: UnicodePlots

using UnicodePlots; UnicodePlots.lineplot(rand(10))
`UnicodePlots.histogram(randn(1000),nbins=15,closed=:left)`

Formatting Commands

Each of these commands can be expressed in-line with the plotting command or beforehand within a call to the plotting backend.

font(fontname,size) Defines a Font object with a given size

size=(X,Y) Sets size of plot to X by Y pixels

xlabel=string Sets X-Y labels to string, also ylabel

title=string Sets title to string, also colorbar_title for heatmap.

xtickfont=font Sets the font of x tick marks, also ytickfont,titlefont,guidefont

left_margin=length Sets margin for left side of plot, also top_margin, bottom_margin, and right_margin

xscale=:log10 Sets x scale to log10, also yscale

Exercises

Exercise 3

Read data.txt given in the Public Folder and plot the results. What do you see?

Exercise 4

Plot a histogram of the longitudes of the world's cities. What is the mean and median longitude?

```
using Plots, DataFrames, CSV
data = DataFrame(CSV.File("simplemaps-worldcities-basic.csv"))
```

Exercise 4 solution

```
using Plots, Images, ImageMagick, DataFrames, CSV

data =
    DataFrame(CSV.File("simplemaps-worldcities-basic.csv"))

histogram(data.lng,bins=200)
histogram(data.lat)
```

My image

```
using Plots, Images, ImageMagick, DataFrames, CSV,Shapefile

data =
    DataFrame(CSV.File("simplemaps-worldcities-basic.csv"))

shp =
    Shapefile.shapes(Shapefile.Table("ne_110m_coastline.shp"));

p3 = histogram(data.lng,bins=200,xticks = (-200:25:200));
p2 = plot(shp,xlim=(-200,200),ylim=(-100,100));
p2_size = p2.attr.explicit[:size];

p1 = histogram(data.lat,bins=200,ylim = (-100,100),
   orientation=:horizontal,aspect_ratio=p2_size[1]/p2_size[2]);

plot(p1,p2,p3,p3,
   layout= layout=@layout [[a{0.2w} b{0.8h}]; [c d]])
```

What is next?

Last Session Problem Sets with James

Also next week Advanced Topics with Valentin!