



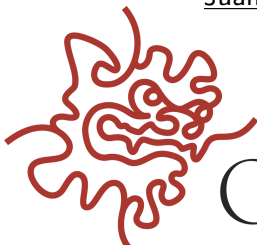
SKILLPILLS

Mini Course: Julia Lecture 2: Data Processing and Plotting

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material
taken/based on
Ankur Dhar &
James Schloss }

March 3rd, 2021



OIST

1 Arrays

2 Data Handling

3 Plotting

Plots and Pyplot

```
] add Plots  
] add PyPlot  
using Plots  
import PyPlot
```

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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}
array2 = Array{Int64}(undef, 2, 2, 2) # 2×2×2 Array{Int64,3}
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?range This allows you to create a range without thinking too much. You can combine stop, step and length `collect(range(0,stop=10,length=10))`

`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`

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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`

Element-by-element binary operations on arrays of different sizes are possible. Dotted operators, `.+` or `.*`, are equivalent to broadcast calls

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

```
data[data .< 0.5]
```

Data Handling

To print you current working directory `pwd()`

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

Change you current directory `cd("String")`

List the files within using `readdir()`

The simplest data files are delimited text files or CSV files

Requires to load a library `DelimitedFiles`

```
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).

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Hierarchical Data Format (HDF5) can be an interesting format to save arrays and data.

CSV files are a bit more complex than standard delimited files, including headers or labels.

A specific library can be loaded **CSV**.

The first row will be taken as the header row (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)
```

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

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Exercise 1

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Fast way to look at data using Dataframes `data[data.pop .> 107,:]`

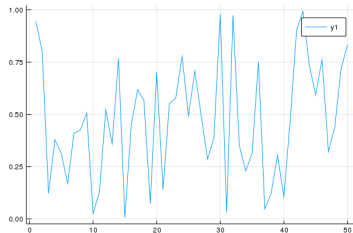
Plots

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/>



`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

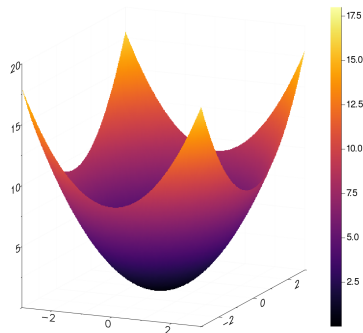
There are a couple of additional options for plotting 3D data:

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

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

`heatmap(x,y,z)` Draws a heatmap on 2D plane

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

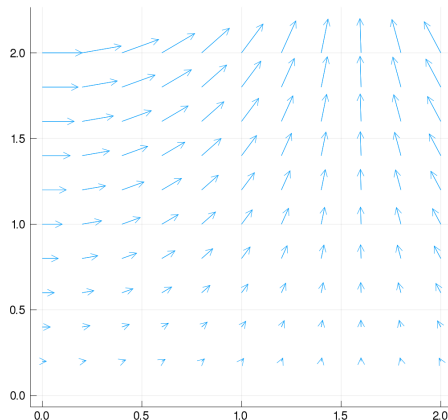


For vector data the current option is
quiver:

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

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

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



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**.

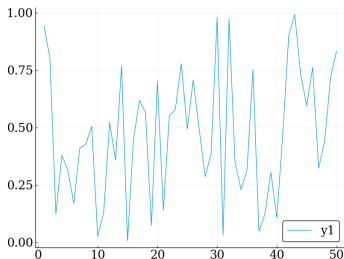


Figure: PyPlot
using PyPlot; PyPlot.plot(rand(10))

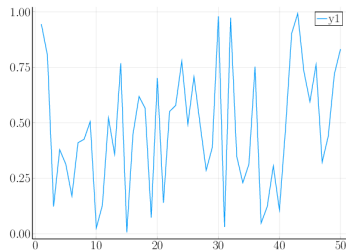


Figure: PGFPlots

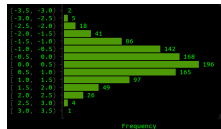
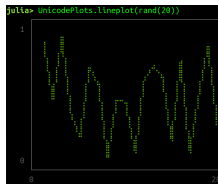


Figure: UnicodePlots
using UnicodePlots; UnicodePlots.lineplot(rand(10))
UnicodePlots.histogram(randn(1000), nbins=15, closed=:left)

You can load one or multiple plot libraries but they might have conflicts. Using “Plots.plot” or “PyPlot.plot” will force a particular library.

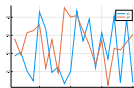
The default backend can be changed by “backend(:gr)” or “backend(:pyplot)”

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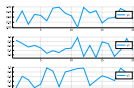
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```
using Plots; import PyPlot; plt = PyPlot;  
# Import avoids conflicts, however PyPlot.XXX or plt.XXX is  
# need to use that library
```

```
plot(rand(20))      # generates a plot  
plot(rand(20))      # generates a new plot  
plot!(rand(20))     # add line to previous plot
```

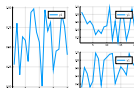


```
p1 = plot(rand(20)); # the semicolon will prevent plotting  
p2 = plot(rand(20));  
p3 = plot(rand(20));  
plot(p1,p2,p3) # Automatically generates a layout
```



```
# Manually generating a layout
```

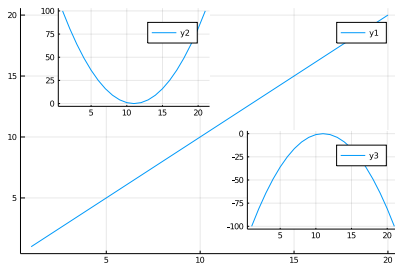
```
plot(p1,p2,p3, layout = @layout grid(3,1))  
plot(p1,p2,p3, layout = @layout [a [b; c]])
```




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```

Plot with two insets

```
plot(1:20)  
plot!((-10:10).^2, inset = (1, bbox(0.1,0.0,0.4,0.4)),  
      subplot = 2)  
plot!((-10:10).^2, inset = (1, bbox(0.6,0.5,0.4,0.4)),  
      subplot = 3)
```

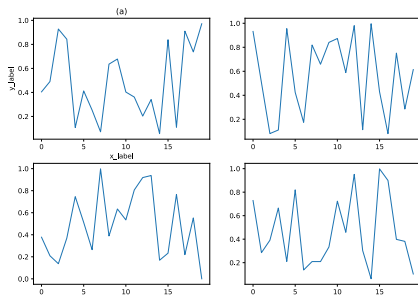


```
using Plots; import PyPlot; plt = PyPlot;  
# we have to use plt.XXX for the main commands
```

```
fig, axs = plt.subplots(ncols=2,nrows=2);
```

```
axs[1,1].plot(rand(20));  
axs[1,2].plot(rand(20));  
axs[2,1].plot(rand(20));  
axs[2,2].plot(rand(20));
```

```
axs[1,1].set_title("(a)")  
axs[1,1].set_xlabel("x_label")  
axs[1,1].set_ylabel("y_label")
```



```
plt.clf(); # this will clear the figure
```

```
using Plots
```

```
x = y = collect(-1:0.01:1)
```

```
#surface(x,y,(x,y)->x^2+y^2)
```

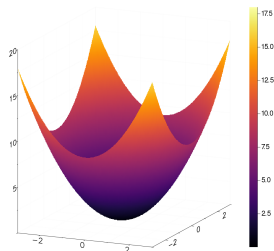
```
#heatmap(x,y,(x,y)->x^2+y^2)
```

```
f(x,y) = x^2 + y^2
```

```
surface(x,y,f.(x,y'))
```

```
contour(x,y,f.(x,y'))
```

```
heatmap(x,y,f.(x,y'))
```



```
using Plots;

ENV["GKSwstype"]="nul" #Plots.backends()

anim = Animation()

x = range(0,stop=20*pi,length=200)

p(w) = plot(x,[cos.(x) + cos.(w .* x)], xlims = (0, 20π),
            ylims = (-2, 2))

for i in range(1,stop=1.25,length=100)
    p(i)
    frame(anim)
end

gif(anim, "myanimation.gif", fps=15)
```

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`, `guidelfont`

`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`

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 and latitudes of the world's cities.

using `Plots`, `DataFrames`, `CSV`

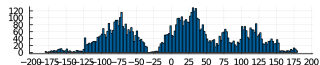
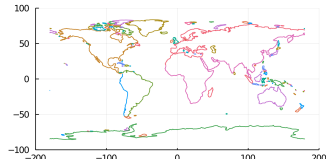
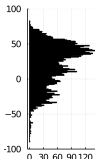
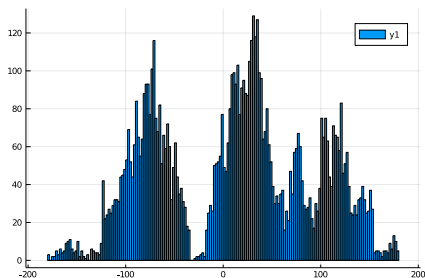
```
data = DataFrame(CSV.File("simplemaps-worldcities-basic.csv"))
```

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

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

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

```
histogram(data.lat)
```



```
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), label=false);
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], label=false);

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


Last Session (Gaston) IDEs, Data Structures, Coding Practices, and Algorithms