SKILLPILLS

Skill Pill: Julia

Lecture 2: Data Processing and Plotting

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material taken/based on Ankur Dhar & James Schloss

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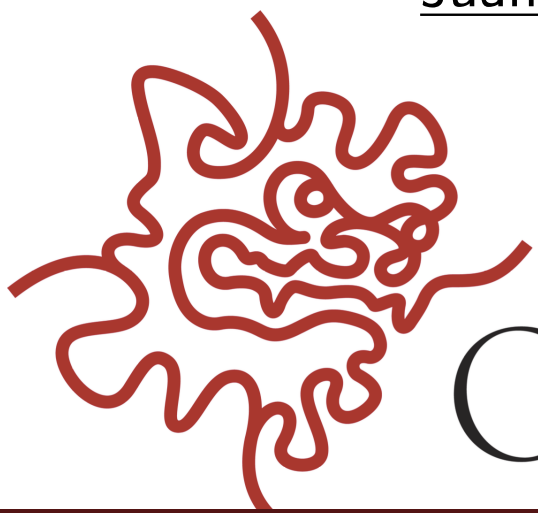

OIST

Installing the plotting packages

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}
array3 = [[1,2],[3,4,"5"]] # 2-element Array{Array{Int64,1},1}
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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))

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

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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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To execute scalar operations on an array, **you can use a . to the operator**. This is also applicable to functions as well.

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Broadcasting

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

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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 **p**rint you current **w**orking **d**irectory pwd()

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

Change you current directory `cd("String")`
List the files within using `readdir()`

Delimited text

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

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)
```

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
...

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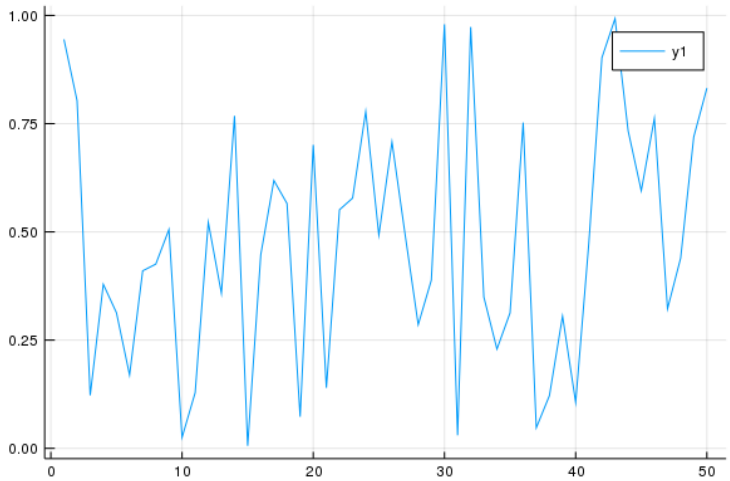
Fast way to look at data using Dataframes `data[data.pop .> 10^7,:]`

Plots

Plots in a Nutshell

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

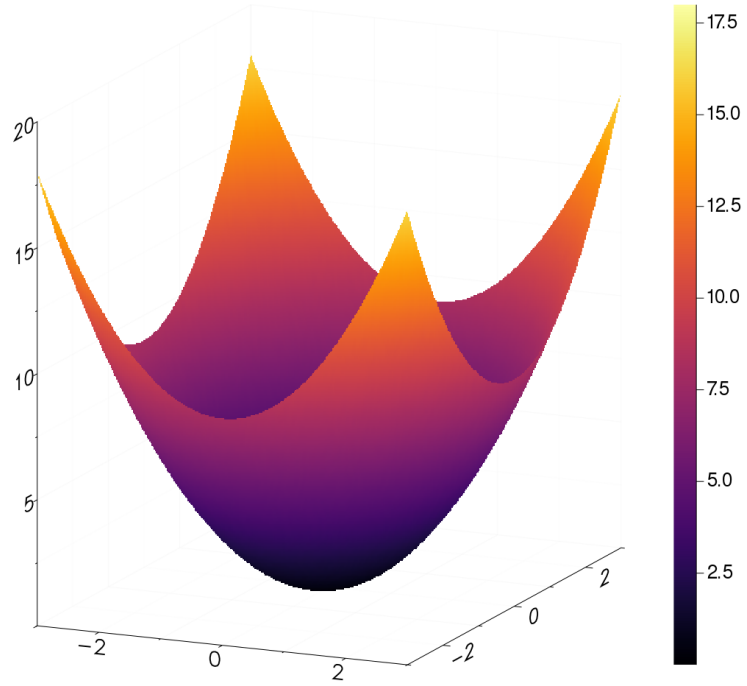
There are a couple of additional options for plotting 3D data:

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

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

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

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



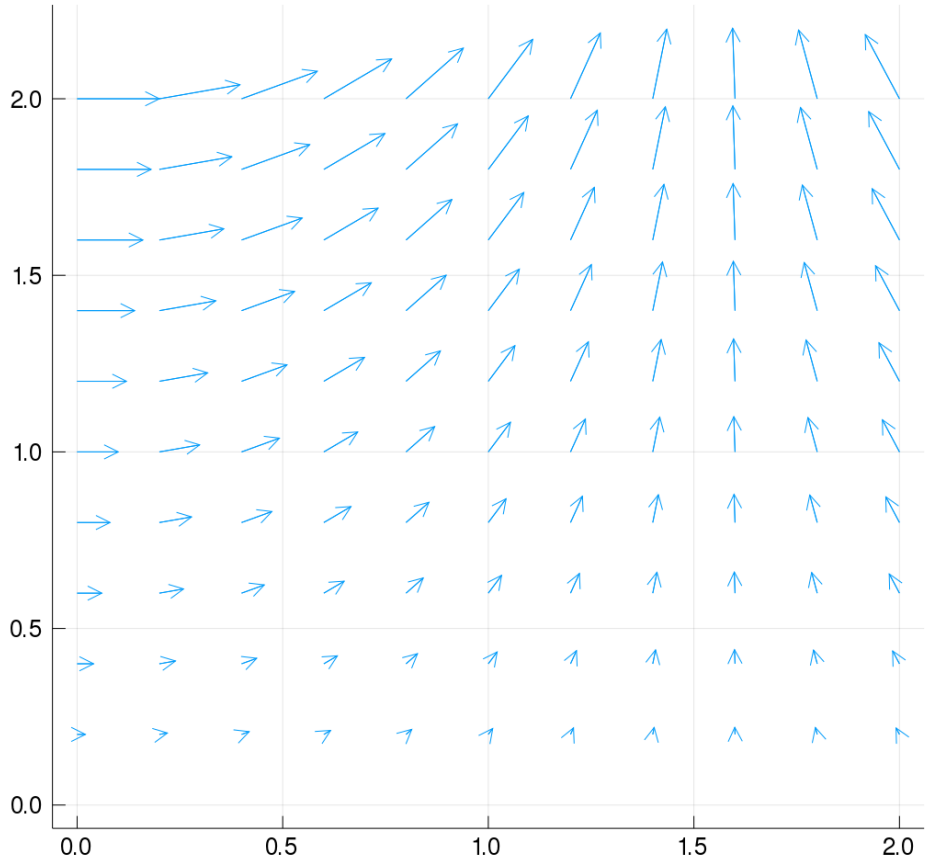
Plotting Vector Data

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.

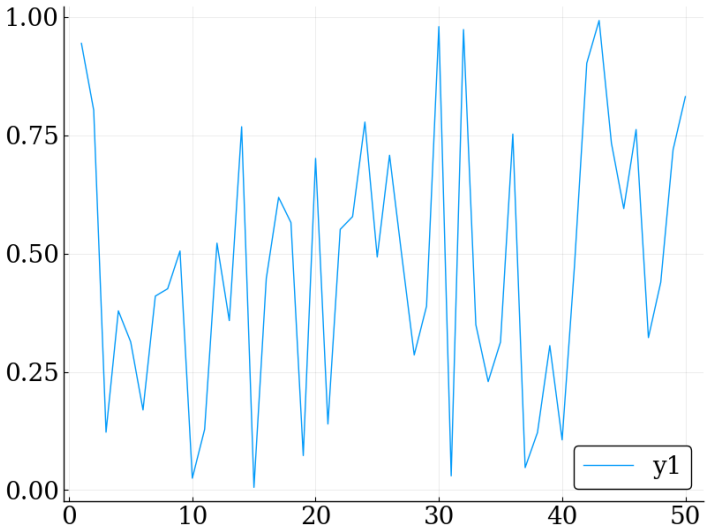


Figure: PyPlot

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

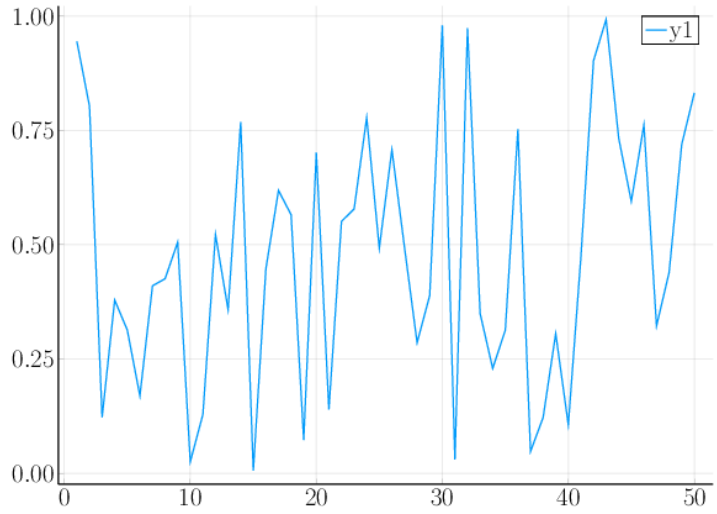
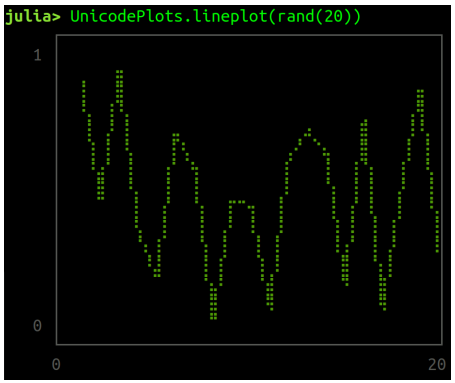


Figure: PGFPlots



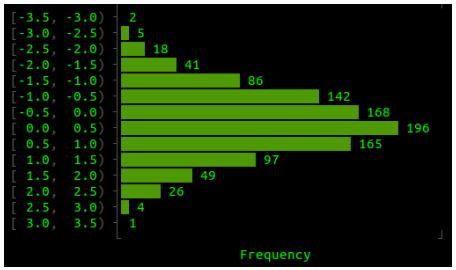


Figure: UnicodePlots

using UnicodePlots; UnicodePlots.lineplot(rand(10))

UnicodePlots.histogram(randn(1000),nbins=15,closed=:left)

Examples of plots

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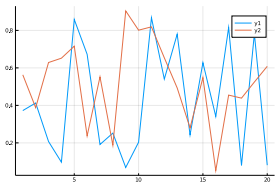
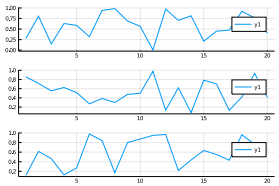
```
using Plots; import PyPlot; plt = PyPlot;
# Import avoids conflicts, however PyPlot.XXX or plt.XXX is
    need to use that library

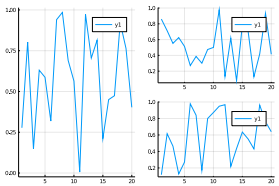
plot(rand(20))     # generates a plot
plot(rand(20))     # generates a new plot
plot!(rand(20))    # add line to previous plot
```



```
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)
```
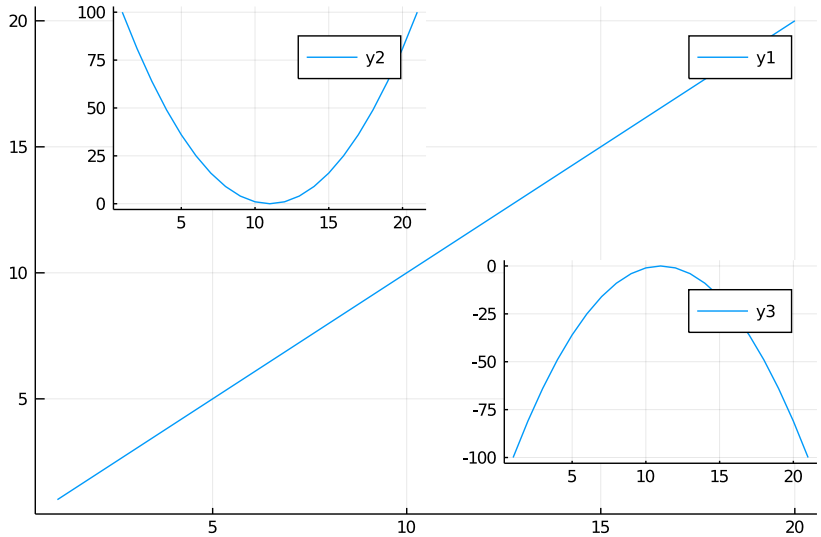
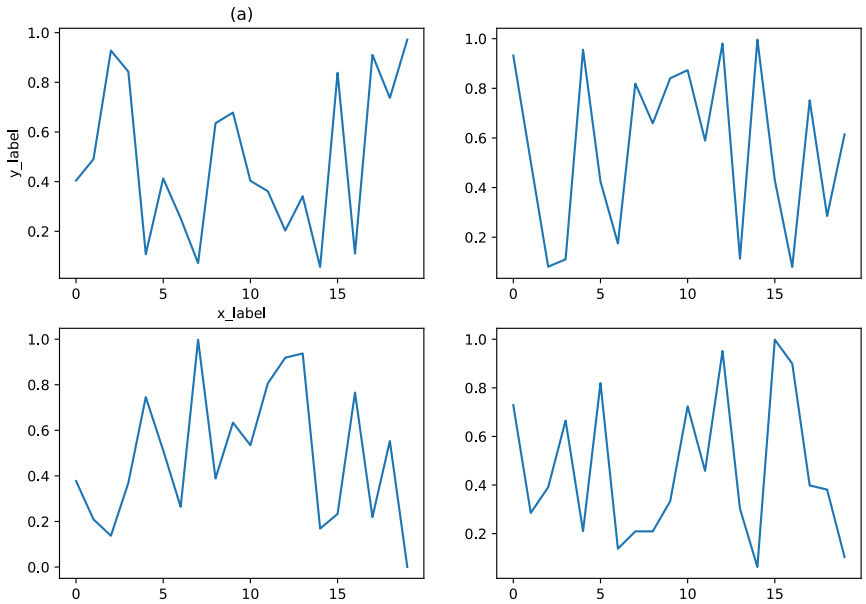



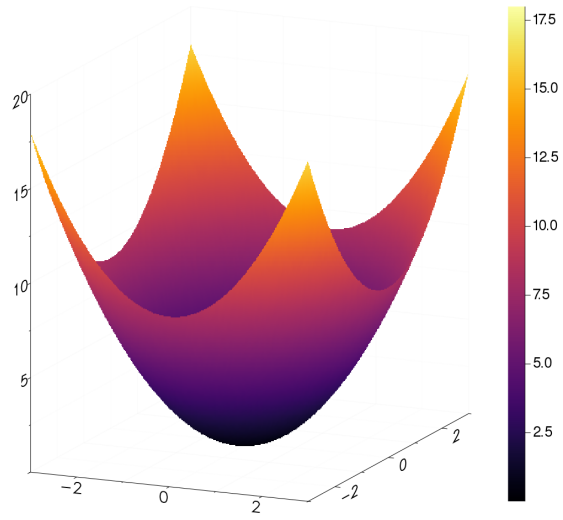
Examples of plots with PyPlot

```
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
```



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



Examples

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

Animations

```
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)
```

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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?

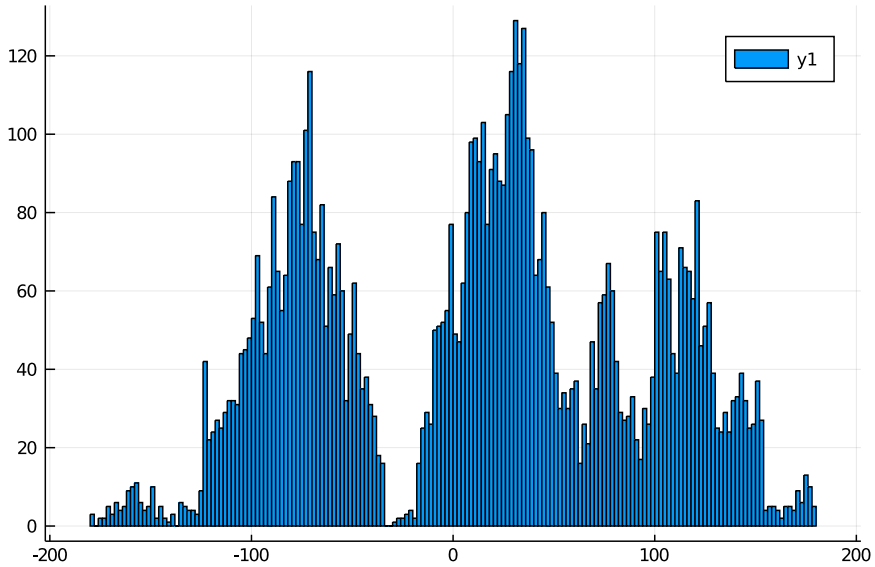
Exercise 4

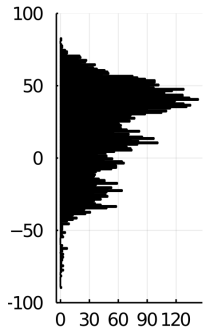
Plot a histogram of the longitudes and latitudes of the world's cities.

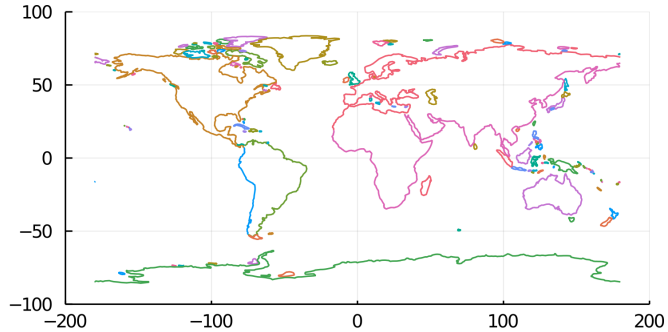
```
using Plots, DataFrames, CSV
data = DataFrame(CSV.File("simplemaps-worldcities-basic.csv"))
```

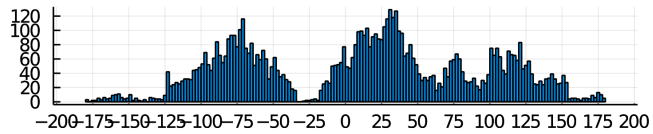
Exercise 4 solution

```
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),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]])
```

What is next?

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