

CS636 Data Analytics with R Programing

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Course Logistics

- Basic information
- Requirements
- Goal

Requirements

- Homework & computing lab exercise (10%)
- Quiz (20%)
- Term Project (20%)
- Midterm (20%)
- Final (30%)

Homework (10 %)

- Homework assignments
 - Only use R in homework
 - Try to do it independently, discussions allowed, but **copying is forbidden.**
- Homework Grading Policy
 - Your homework: may have several homework assignments, but pick only one (the worst one) to grade. Namely, if you miss one assignment, you get 0.
- Late homework policy
 - 25% penalization per late day;
 - Not accepted more than 3 days late

Lab exercise

- Have a lab session every week
- Lab exercises
 - Focus on R computing exercises
 - We will solve some simple problems
 - Post your answers by replying on canvas
 - Some answers may be selected for discussion by the end of lab session.
 - Some problems may become part of homework

Two Term Projects (20%)

- You can choose R or Python for your projects
- Use Jupyter
- Submit code and report to summarize what you have done and results you obtained.
- Prepare for presentation and demo.
- 1~4 students a group.
- More details to be announced soon
- Cheating/Copying is strictly prohibited. I will report to Dean and you will get F in this course.
- If you think your group members don't make contribution, talk to me.

Quiz (20%)

- Focus on course materials.
- Every other week
- Only R is allowed

Two Exams (50%)

- One midterm and one Final (20%+30%)
 - In-class
 - Open book
 - Final is cumulative
 - Only R

Some tips

- Set up your dev environment for exams. It may require to write code.
- Prior to quiz/exam, restudy the slides and Jupyter sample code
- If I discover cheating, I will report the incident to the Dean of Student's office Re: Academic Integrity. (TAs report the incident to the course instructor)

Goal

- We use R to teach this class but the content is for generic data science
- Focus on the skills that can be transferred to Python
- Familiarize you with the commonly used analytical techniques in Data Science
- Develop the way of data science thinking
 - Learn how to preprocess, explore and interpret real data
 - Learn how to model real problems using computational techniques

Prerequisites

- Basic programming skills
- Linear algebra
- Probability
- Statistics

Tentative course topics

(Subject to changes according to progress)

- R libraries for data science. The most common knowledge that you can easily apply to Python.
- Big Data and Graph Analytics
- Visualization with probability and statistics basics
- Regular Expression and NLP for text processing
- Machine learning algorithms (a lot of math)
- Model/Feature Selection (more math)
- May cover advanced big data and deep learning

Intro to R

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What is R?

- Statistical computer language similar to S-plus
- Interpreted language (like Matlab)
- Has many built-in (statistical) functions
- Easy to build your own functions
- Good graphic displays
- Extensive help files

Strengths

- Many built-in functions
- Can get other functions from the internet by downloading libraries
- Relatively easy data manipulations

Weaknesses

- ❑ Not as commonly used by non-statisticians
- ❑ Not a compiled language, language interpreter can be very slow, but allows to call own C/C++ code

R packages

- Packaging: a crucial infrastructure to efficiently produce, load and keep consistent software libraries from (many) different sources / authors
- Statistics
 - most packages deal with statistics and data analysis
 - State of the art: many statistical researchers provide their methods as R packages

A sample job opening

- Experience using Statistical and Machine Learning algorithms on real data, in commercial environments. Experience in the Telecom Domain is a big plus.
- Excellent and wide ranging experience in supervised and unsupervised learning. Reinforcement learning a plus.
- Experienced in the use and design of logistic regression, support vector machines, ensemble trees, and neural networks. Optimization problems a plus
- Familiarity and experience with the standard machine learning packages, such as numpy, scipy scikit-learn, TensorFlow, keras and Theano
- Experience in data munging, data cleansing etc.
- Experience in feature selection, feature engineering and development of recommender systems.
- Very Good Knowledge on one and more Statistical Tool like R/Python
- Excellent communication and interpersonal skills, with proven ability to take initiative and build strong, productive relationships.
- Good to have experience in Network Analytics. Building a strong intuitive understanding of the problem domain (Next Generation Access Networks).
- Influence and transform the end-to-end delivery process to maximize the value Customers gain from Analytics
- Should be able to handle multiple projects and liaison with customer different teams to bring overall value add.
- Should have strong people skills and good team management experience.
- Identify testable hypotheses to explain interesting phenomena in this domain
- Constructing an automated system test framework
- Develop and communicate goals, strategies, tactics, project plans, timelines, and key performance metrics to reach goals
- Experience with public cloud (AWS) desirable
- Great communication skills
- Proficiency in using query languages such as SQL
- Good scripting and programming skills, such as R, Python, or Spark

When to use R?

- When
 - Requires standalone computing or analysis on individual servers.
 - Great for exploratory work: it's handy for almost any type of data analysis because of the huge number of packages and necessary tools to get up and running quickly
 - R can even be part of a big data solution.

How to use/learn R?

- How
 - (optional) Install and Use Rstudio IDE
 - (optional) Install Jupyter with R kernel
 - Getting started with R (Basic grammars)
 - Get to use/learn those popular packages
 - dplyr, plyr and reshape2 for data manipulation
 - stringr for string operation
 - ggplot2 for data visualization
 - ...
 - Do (a lot of) practices including real projects

Install RStudio

- An integrated development environment (IDE) available for R
 - a nice editor with syntax highlighting
 - there is an R object viewer
 - there are a number of other nice features that are integrated
- How to install
 - <https://www.youtube.com/watch?v=9-RrkJQQYqY>

Install Jupyter with R kernel

1. Install R and Rstudio
2. Download and install the latest Anaconda at <https://www.anaconda.com/download/>
3. In windows, add your R bin path and Anaconda3 Scripts path to your environmental variable "Path"
 - In my computer the R bin path is C:\Program Files\R\R-3.5.1\bin
 - Anaconda3 Scripts path is C:\ProgramData\Anaconda3\Scripts, the paths in your computer may vary.
 - How to set the path and environment variables in Windows
<https://www.computerhope.com/issues/ch000549.htm>
 - Install R kernel to Jupyter (PLEASE DO THIS STEP IN R CONSOLE, not in Rstudio or RGui)
<https://irkernel.github.io/installation/>
<https://stackoverflow.com/questions/44056164/jupyter-client-has-to-be-installed-but-jupyter-kernelspec-version-exited-wit>
 - Then you can start "Jupyter Notebook" from the start menu.

Starting and stopping R

- Starting
 - Windows: Double click on the R icon
 - Unix/Linux: type R (or the appropriate path on your machine)
- ▣ Stopping
 - Type `q()`
 - `q()` is a function execution
 - Everything in R is a function
 - `q` merely returns the content of the function

Writing R code

- Can input lines one at a time into R
- Can write many lines of code in any of your favorite text editors (including Rstudio) and run all at once
 - Simply paste the commands into R
 - Use function `source("path/yourscript")`, to run in batch mode the codes saved in file "yourscript" (use `options(echo=T)` to have the commands echoed)

R as a Calculator

```
> log2(32)
```

```
[1] 5
```

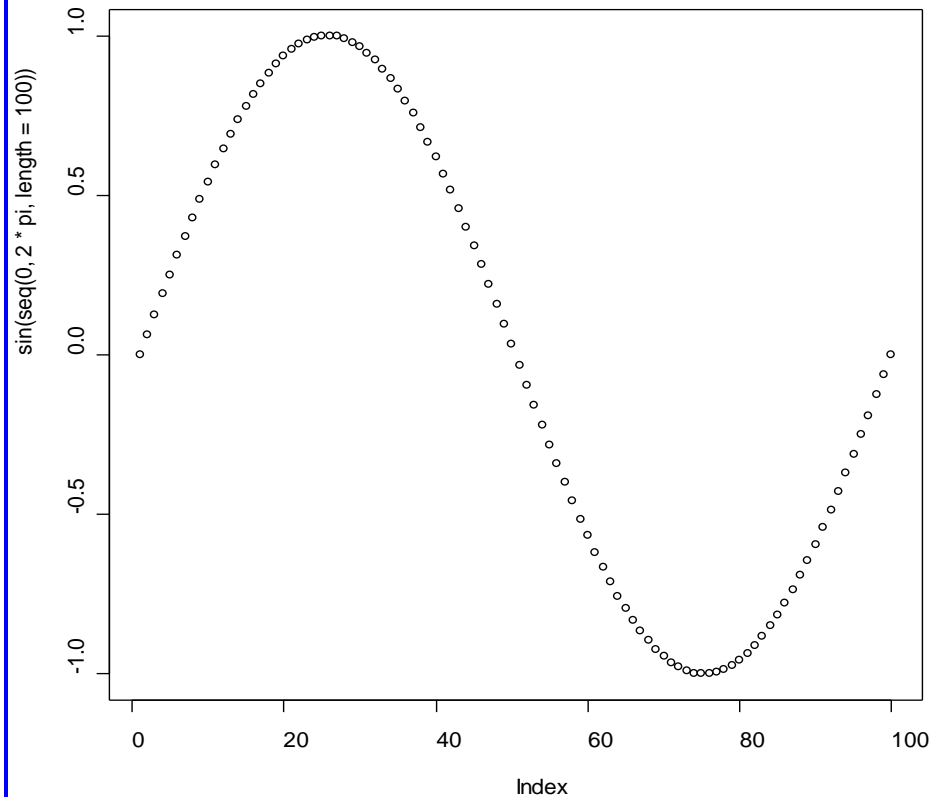
```
> sqrt(2)
```

```
[1] 1.414214
```

```
> seq(0, 5, length=6)
```

```
[1] 0 1 2 3 4 5
```

```
> plot(sin(seq(0, 2*pi, length=100)))
```



Recalling Previous Commands

- In WINDOWS/UNIX one may use the **arrow up key** or the **history** command under the menus
- Given the history window then one can copy certain commands or else past them into the console window

Language layout

- Three types of statement
 - expression: it is evaluated, printed, and the value is lost (3+5)
 - assignment: passes the value to a variable but the result is not printed automatically (out<-3+5)
 - comment: (#This is a comment)

Naming conventions

- Any roman letters, digits, underline, and '.' (non-initial position)
- Avoid using system names: c, q, s, t, C, D, F, I, T, diff, mean, pi, range, rank, tree, var
- Hold for variables, data and functions
- Variable names are case sensitive

Arithmetic operations and functions

- Most operations in R are similar to Excel and calculators
- Basic: + (add), - (subtract), * (multiply), / (divide)
- Exponentiation: ^
- Remainder or modulo operator: %%
- Matrix multiplication: %*%
- sin(x), cos(x), cosh(x), tan(x), tanh(x), acos(x), acosh(x), asin(x), asinh(x), atan(x), atan(x,y) atanh(x)
- abs(x), ceiling(x), floor(x)
- exp(x), log(x, base=exp(1)), log10(x), sqrt(x), trunc(x) (the next integer closer to zero)
- max(), min(), mean(), median()

Defining new variables

- Assignment symbol, use "`<-`" (shortcut: alt -) or `=`
- Scalars
 - `>scal<-6`
 - `>value<-7`
- Vectors; using `c()` to enter data
 - `>whales<-c(74,122,235,111,292,111,211,133,16,79)`
 - `>simpsons<-c("Homer", "Marge", "Bart", "Lisa", "Maggie")`
- Factors
 - `>pain<-c(0,3,2,2,1)`
 - `>fpain<-factor(pain,levels=0:3)`
 - `>levels(fpain)<-c("none", "Mild", "medium", "severe")`

Use functions on a vector

- Most functions work on vectors exactly as we would want them to do
 - > `sum(whales)`
 - > `length(whales)`
 - > `mean(whales)`
 - `sort()`, `min()`, `max()`, `range()`, `diff()`, `cumsum()`
- Vectorization of (arithmetic) functions
 - > `whales + whales`
 - > `whales - mean(whales)`
 - Other arithmetic funs: `sin()`, `cos()`, `exp()`, `log()`, `^`, `sqrt()`
 - Example: calculate the standard deviation of whales

$$SD(X) = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (X_i - \bar{X})^2}.$$

Functions that create vectors

- Simple sequences

```
> 1:10  
> rev(1:10)  
> 10:1  
> c(1:10, 10:1)  
> fractions(1/(2:10))  
> library(MASS) #to have fractions()
```

- Arithmetic sequence

- $a+(n-1)*h$: how to generate 1, 3, 5, 7, 9?

```
> a=1; h=2; n=5  
> a+h*(0:(n-1))  
OR  
> seq(1,9,by=2)  
> seq(1,9,length=5)
```

- Repeated numbers

```
> rep(1,10)  
> rep(1:2, c(10,15))  
– getting help: ?rep or help(rep)  
– help.search( "keyword" ) or ??keyword
```