Introduction to Data Science

Vanderbilt University

Human and Organizational Development

Course Number HOD 3200

Fall 2019

William R. Doyle

Office: 207D Payne

Office Hours: Tuesdays and Thursdays, 2:30-5 (https://wdoyle42.youcanbook.me) or by appointment

Email: w.doyle@vanderbilt.edu

Twitter: @wdoyle42

Phone: (615) 322-2904

Introduction

We have entered a time in which vast amounts of data are more widely available than ever before. At the same time, a new set of tools has been developed to analyze this data and provide decision makers with information to help them accomplish their goals. Those who engage with data and interpret it for organizational leaders have taken to calling themselves data scientists, and their craft data science. Other terms that have come into vogue are "Big Data," "Predictive Analytics" and "Data Mining." These can seem to be mysterious domains. The point of this class is to demystify much of this endeavor for individuals who will be organizational leaders.

The class is structured around developing students' skills in three areas: getting data, analyzing data to make predictions, and presenting the results of analysis. For each area, the subtopics are as follows:

Getting Data Topics

- Tools of the Trade: R and Rstudio, git and Github
- Working with pre-processed data and flat files
- Getting data from the web: webscraping, using forms, using Application Programming Interfaces
- Using databases

Analyzing Data Topics

- Descriptives and conditional means
- Regression
- Supervised learning: classification
- Unsupervised learning: K-means and nearest neighbors clustering
- Evaluating multiple models/ Cross Validation

Presenting Data Analysis Topics

- Descriptives: histograms, density plots, bar plots, dot plots
- Scatterplots
- Plots for Classification
- Interactive Graphics

Evaluation

Students will be evaluated based in two areas: weekly assignments and the final project.

- Problem sets: 65% Each week I will assign a problem set for students to complete. These problem sets will be assigned on Monday, and will be due the next Sunday night at 11:59:59 pm. No late assignments will be accepted. Each assignment will be graded on a 100 point scale. Your lowest grade will be dropped.
- Final Project 35%: During the course of the semester you will work on a final assignment utilizing your skills as a data analyst. We will discuss this assignment and my expectations in detail during the course of the semester. There will be four progress reports due for the final project, each of which will be worth 12.5% of the final grade for the project. No late progress reports will be accepted. The final product will account for the remaining 50%. No late final products will be accepted.

Texts

Required Texts

We will have two texts for the course. The first is Hadley Wickham's book, R for Data Science. Wickham is generously making this book available for free. However, I strongly encourage you to buy this book from O'Reilly.

Amazon

The other text is Nate Silver's *Signal and the Noise*.

Silver,N. (2012). *The signal and the noise: Why so many predictions fail-but some don't*. New York: Penguin.

Amazon

Half.com

Your local bookseller

Reserve

I've placed three books by Edward Tufte on reserve for you. These are masterpieces in the area of visualizing quantitative information. You should take a look at these for ideas and inspiration–I've noted the sections that are most helpful in various parts of the syllabus.

Tufte, E. R. (1990). Envisioning information. Cheshire, CT: Graphics Press.

Tufte, E. R. (1997) Visual explanations. Cheshire, CT: Graphics press.

Tufte, E. R.(2001). The visual display of quantitative information (2nd Edition). Cheshire, CT: Graphics press.

Lecture Notes

My lecture notes include both code and notes for the week. They will be available in your private github repository.

Web Resources

When appropriate for each week, web resources are linked directly from the syllabus. You will find a wealth of resources online, including other versions of this class offered as Massive Online Open Courses. I encourage you to take full advantage of the wealth of online materials that are available. Stack Overflow is your friend, but search carefully for your question. It is VERY likely that your question has already been asked.

Software

We will use only free, open source software in this course.

We will use R, an open-source data analytic platform for all analysis. R appears to be the most widely used data analysis software in data science. We will utilize Rstudio as our integrated development environment (IDE) for R.

We will also use git, a distributed version control program, and Github, an online hosting platform. Github Desktop will serve as our Graphical User Interface to git and GitHub. RStudio is fully integrated with git and Github, making it an ideal IDE for these purposes. Class assignments will be distributed through GitHub and will be collected and graded through GitHub as well.

Communication

My office is in 207D Payne, and my phone number is (615) 322-2904. Please always feel free to stop by during office hours or to call. You can book my office hours at: (wdoyle42.youcanbook.me) If my office hours don't work for you, please make an appointment. Student communications, including emails are my priority. However, due to the volume of email I receive, I may miss your message. To help with this problem, please place the phrase "HOD 3200" in your subject line. I will search for these messages every time I access my email. You can also use Brightspace's email function, which will automatically do this for you. If you have a general question that I can answer for the whole class, send me a message on twitter at @wdoyle42, tagged #hoddatasci, or you can send a direct message.

The Tedious Stuff

This class will be impossible if you don't show up. It's reasonable to contact me if for some reason you can't make it for a given class session.

We must use laptops in this class, despite the substantial body of evidence that laptop use in classrooms hinders learning. To mitigate this problem, the following standards will ALWAYS apply in class. You may have RStudio open. You may also have a web browser open to a web page that is relevant to course content. You MUST turn off all notifications and messaging programs. If your web browser is open to Facebook, Instagram or other purely social sites, or if you are responding to messaging apps, I will ask you to leave class for the day.

Mobile phone use is never appropriate in class. I will ask you to leave if you are using your mobile phone at any time. Exceptions are to be arranged BEFORE class, not when I observe you using your mobile phone.

Honor Code Statement

All assignments for this class, including weekly assignments and the final project, are to be conducted under the obligations set out in Vanderbilt's Honor Code. Please click hereto review the honor code.

There will be two quite different standards for completing the assignments and the final project.

Assignments You may collaborate with anyone and you may utilize any resource you wish to complete these assignments.

Final Project All of the work on the final assignment must be your own. Anyone's work that you reference should be cited, as usual. All data that you do not personally collect must be cited, as with any other resource.

If you have any questions at all about the honor code or how it will be applied, ask me right away.

Schedule

Thursday, August 22 Topic for the Week: Getting Data 1– Tools of the Trade

Resources

Wickham: Introduction, Explore: Introduction, Workflow: basics, Workflow: projects

Silver, Chapters 1-4

R Intro and Resources

Download R

R Basics

Download Rstudio You want the "Desktop" version, free license

Rstudio Intro and Resources

Download git

Download GitHub Desktop

Github Intro and Resources

Tuesday, August 27 Getting Data 1: Tools of the Trade

Subtopics: "verbs" of data wrangling, file types, working with git and GitHub.

Lesson Notes

`01-intro.Rmd`.

Thursday, August 29 Getting Data 1: Tools of the Trade

Standing meeting

Lab Practical R Basics, "verbs" of data wrangling

Tuesday, September 3 Topic for the Week: Analyzing Data 1– Conditional Means

Resources

Wickham: Data transformation
Silver, Chapters 5-9, 12-13

Lecture Notes

Condtional Means: `02-conditional_means.Rmd`.

Assignments

Assignment 1 Due Midnight, Monday, September 3

Thursday, September 5 Conditional Means, continued

Standing Meetings

Lab Practical: Conditional Means

Tuesday, September 10 Topic for the Week: Presenting Data 1– Descriptives

Subtopics: bar plot, density plot, dot plots, histograms

Resources

Wickham: Data visualization

Data transformation

Cookbook for R:Bar and Line Graphs

Cookbook for R: Plotting Distributions

Lecture Notes

Plotting Distributions and Condtional Means: `03-plot_means.Rmd`.

Assignments

Assignment 2 Due Midnight Monday, September 10

Thursday, September 12 Descriptive Graphics, Continued

Standing Meeting Progress Report 1 Due

Lab Practical: Presenting results in graphical format: barplots, density plots, dot plots, histograms

Tuesday, September 17 Topic for the Week: Getting Data 2–pre-processed data, flat files, basic concepts of "tidy data"

Resources

Wickham: Data import, Tidy data

Lecture Notes

Flat Data `04-flat_data.Rmd`

Assignments

Assignment 3 Due Midnight Monday, September 17

Thursday, September 19 Pre-processed data, continued

Standing Meeting

Lab Practical: working with various data formats

Tuesday, September 24 Topic for the Week: Analyzing Data 2–linear regression

Resources

Wickham: Model: Introduction, Model Basics, Model Building

Lecture Notes

Linear Regression `05-regression.Rmd`

Assignments

Assignment 4 Due Midnight Monday, September 24

September Thursday, September 26 Linear Regression, continued

Standing Meetings

Lab Practical: linear regression

Tuesday, October 1 Topic for the Week: Analyzing Data 2–Linear Regression

Training and Testing Models

September Thursday, October 3 Linear Regression, continued

Second Progress Report for Final Project Due

Tuesday, October 8 Topic for the Week: Presenting data 2–scatterplots

Resources

Wickham: Data Visualization, Graphics for Communication

Tufte, Visual Display chapters 4 and 5.

Tufte, Envisioning Information, chapter 2

Lecture Notes

Scatterplots `06-scatterplots.Rmd`

Assignments

Assignment 5 Due Midnight Monday, October 8

Thursday, October 10 Scatterplots, continued

Standing Meetings

Lab Practical: Presenting Data via Scatterplots

Tuesday, October 15 Topic for the week: Getting Data 3– Getting data from the web

Resources

Rvest Vignette: https://cran.r-project.org/web/packages/rvest/vignettes/selectorgadget.html

Reed College rvest introduction

rvest tutorial

Lecture Notes

Web Scraping and APIs, `07-webscraping.Rmd`

Assignments

Assignment 6 Due Midnight Monday, October 15

Thursday, October 17 Web data, continued

Standing Meetings

Lab Practical

Tuesday, October 22 Topic for the Week: Analyzing Data 3–Classification

Resources

James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). An introduction to statistical learning (Vol. 6). New York: Springer. Chapter 4 , Chapter 4 Lab R Code

Althoff, T., Danescu-Niculescu-Mizil, C., & Jurafsky, D. (2014, May). How to Ask for a Favor: A Case Study on the Success of Altruistic Requests. In ICWSM. (Available Here)[http://www.aaai.org/ocs/index.php/ICWSM/ICWSM14/paper/download/8106/8101]

Lecture Notes

Classification, `08-classification.Rmd`

Assignments

Assignment 7 Due Midnight Monday, October 22

##Thursday, October 24 Classification, continued

Standing Meetings

Lab Practical

Classifying behavior via text analysis: random acts of pizza.

Tuesday, October 29 Topic for The Week: Presenting Data 3– Plots for Classification

Resources

Lecture Notes

Plots for Classification `09-plots_classification.Rmd`

Assignments

Assignment 8 Due Midnight Monday, October 29

##Thursday, October 31 Plots for Classification, continued

Standing Meetings

Third Progress Reports Due

Lab Practical

Plots for understanding classification

Tuesday, November 5 Topic for the Week: Training and testing multiple models, Cross Validation

Resources

Wickham Many Models

Lecture Notes

`10-cross_validation.Rmd`

Assignments

Assignment 9 Due Midnight Monday, November 5

Thursday, November 7 Cross Validation, continued

Standing Meeting

Lab Practical

Lab Practical: Cross Validation

Tuesday, November 12 Topic for the Week: Getting Data 4–databases and relational data

Resources Wickham Relational Data

Working with Databases in R, available: https://cran.r-project.org/web/packages/dplyr/vignettes/databases.html

Lecture Notes

Chapter 11, Databases `11-databases.Rmd`

Assignments

Assignment 10 Due Midnight Monday, November 12

Thursday, November 14 Databases, continued

Standing Meetings

Lab Practical Databases and relational data, collaborating via github

Tuesday, November 19 Thanksgiving Break: No Class

Check out the lecture notes on interactive graphics, `13-interactive_graphics.Rmd`

Thursday, November 21 Thanksgiving Break

No Standing meetings, but feel free to talk about Data Science at dinner

Tuesday, November 26 Topic for the Week: Analyzing Data 4–Unsupervised learning

Subtopics: k-means, nearest neighbor clustering

Resources

James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). An introduction to statistical learning (Vol. 6). New York: Springer. Chapter 10 , Chapter 10 Lab R Code

Lecture Notes

Chapter 12, Unsupervised Learning `12-unsupervised.Rmd`

Assignments

Assignment 12 Due Midnight Monday, November 26

Thursday, November 28 Unsupervised Learning, continued

Standing Meetings

Fourth Progress Reports Due

Lab Practical: K-means clustering, nearest neighbor classification

Tuesday, December 3 Class Presentations

Group 1

Assignments

Assignment 13 Due Midnight Monday, December 3

Thursday, December 5 Class Presentations

Group 2

Final Projects Due Tuesday, December 10, midnight