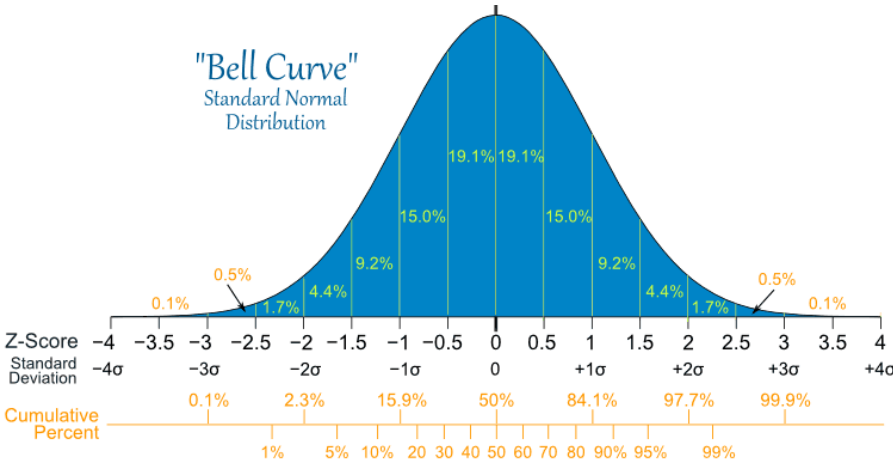
UNIVERSITY of WASHINGTON

Data Science UW Methods for Data Analysis

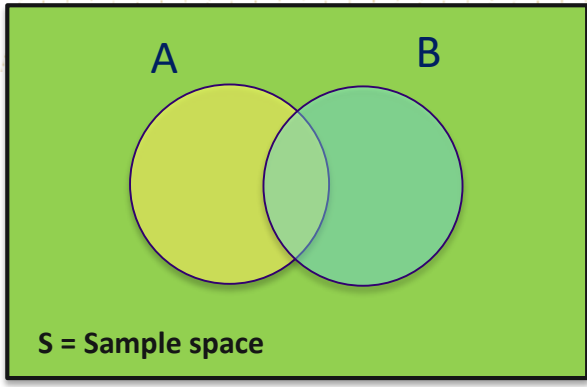
Class Review
Lecture 10
Nick McClure

Lecture 1

- R review
- Discrete Distributions
  - Bernoulli, Binomial, Poisson
- Continuous Distributions
  - Uniform, Normal, Students-T, Beta
- Covariance: Expected value of the differences between x,y and their corresponding means.
- Correlation: Normalized Covariance.
- Variable Transformations (must be monotonic)



Lecture 2

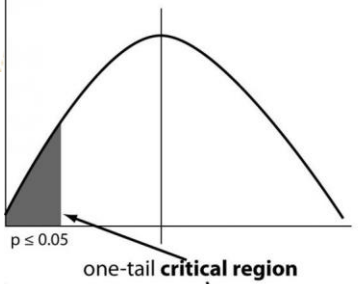


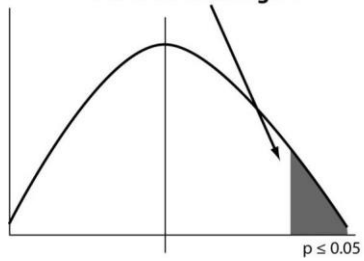
- Counting
  - Multiplication Principle, Factorial, Combinations, Permutations, expand.grid()
- Probability
  - 3 axioms: $0 \leq P(A) \leq 1$

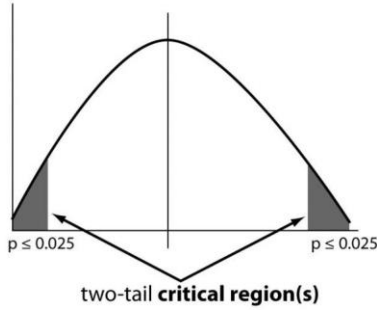
    $P(S) = 1$

    $P(A \cup B) = P(A) + P(B)$ If A and B are M.E.
  - Venn Diagrams
- Conditional Probability
- Mutually Exclusive $P(A \cap B) = 0$
- Independence $P(A|B) = P(A)$
- Simulations in R
- Imputation
  - Multiple Imputation: Amelia package

Lecture 3

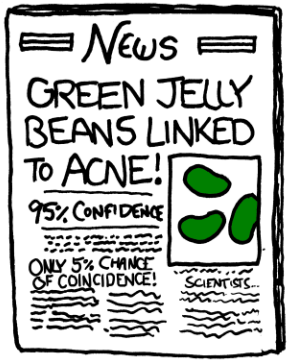






- Conditional Probability Trees
  - Rare disease testing
- Sampling Data
- Law of Large Numbers
- Standard Deviation: Measure of variability in a sample or population.
- Standard Error: Measure of variability in the statistics of the sample.
- Hypothesis Testing
  - Normal curve, one tailed vs two tailed, interpreting the p-value
- Student's T-test: Test differences of means of two populations with known variance.
- Welch's T-test: Test differences of means of two populations with *unknown* variance.
- Chi-Squared Test: Test difference in Counts, needs larger sample.
- Fisher's Exact Test: Same as above, but exact (Stricter).
- Testing for outliers

Lecture 4



- K-S Statistic
- Shapiro-Wilk test for normality
- ANOVA: analysis of variants, i.e., is at least one mean of the groups different?
- Bonferroni correction: If you test n hypotheses, significance level should be alpha/n.
- Central Limit Theorem: The distribution of summary statistics is normally distributed:

$$\bar{X} \sim N(mean, \frac{variance}{\sqrt{n}})$$

- Confidence Intervals
- Introduction to Regression:

$$y_i = mx_i + b + \varepsilon_i$$

$$\varepsilon_i \sim N(0, \sigma)$$

Lecture 5

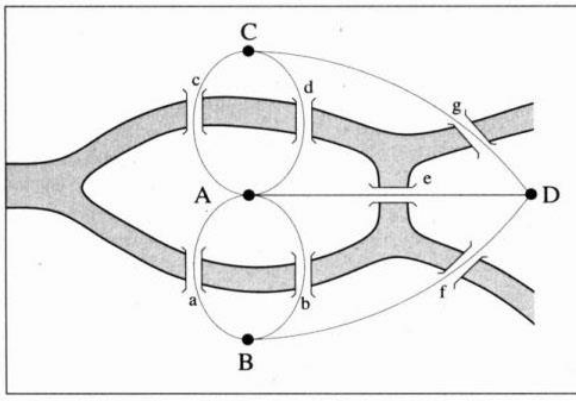
DayOfWeek
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday
…

DayOfWeek
1
2
3
4
5
6
7
…

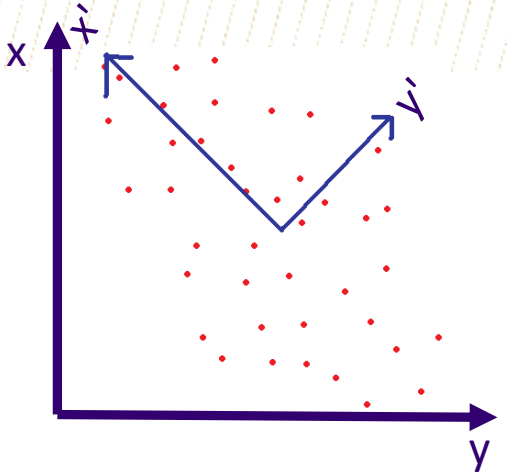
Eye Color
Brown
Brown
Blue
Green
Green
Blue
Brown
…

Brown	Blue
1	0
1	0
0	1
0	0
0	0
0	1
1	0
…	…

- More on Regression:
  - MSE, R^2, Least Squares Fitting.
- Homoscedasticity
  - Errors are random, heteroscedastic otherwise.
- Leverage and Cook's Distance
- Prediction and Confidence bands
- Encoding categorical variables
- Multiple linear regression
- Introduction to graph theory with python:
  - Triangle completions
  - Centrality
  - Graph labeling
  - Clustering
- Gephi
- Testing for Degree Distributions



Lecture 6



- Matrix operations/Linear algebra
- Singular Value Decomposition (SVD)
- SVD as regression (Deming regression or Total least squares)
- Using SVD to compress information.
- SVD as a way of clustering data.
- Ridge Regression
  - Regularize partial slopes with a squared term in the loss function:

$$\min \sum (y - y_i)^2 + \alpha \sum \beta^2$$

- Lasso Regression
  - Regularize partial slopes to have total sum less than a value:

$$\min \sum (y - y_j)^2 \quad \text{Such that} \quad \sum |\beta_i| < \lambda$$

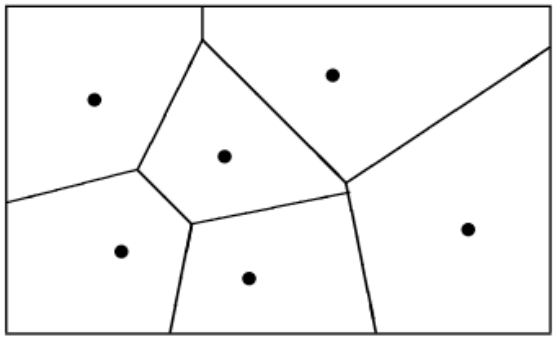
- Logistic Regression

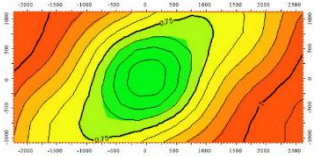
Lecture 7

$$X_k = \frac{1}{N}\sum_{n=0}^{N-1} x_n e^{i2\pi k \frac{n}{N}}$$

To find the energy at a particular frequency, spin your signal around a circle at that frequency, and average a bunch of points along that path.

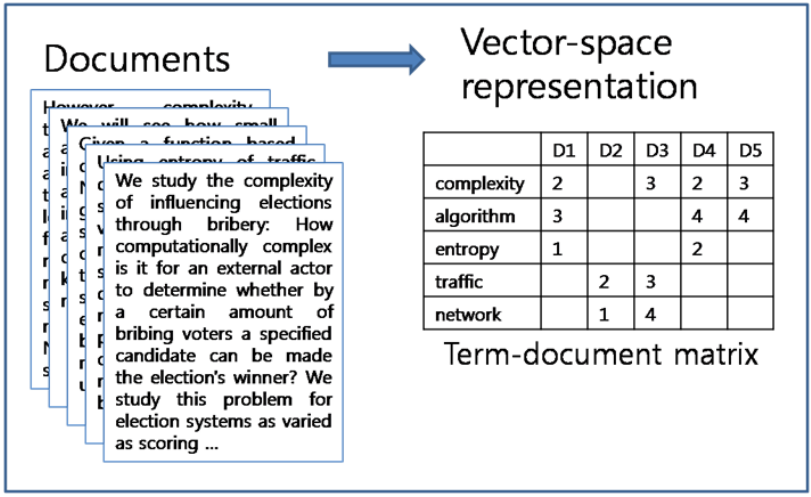
- Time Series
- Moving Averages
- Seasonality
  - Fourier Transform
- ARIMA models
  - Auto-regressive Integrated Moving Average
- Spatial Statistics
- Moving Windows
- Median Polish
  - Removes spatial trends
- Point estimate
  - Weighted Averages: weighted by voronoi polygon area
- Global estimation
  - Kriging: weight prediction at any spot by spatial dependence or variance.
- Clustering
  - Ripley's K



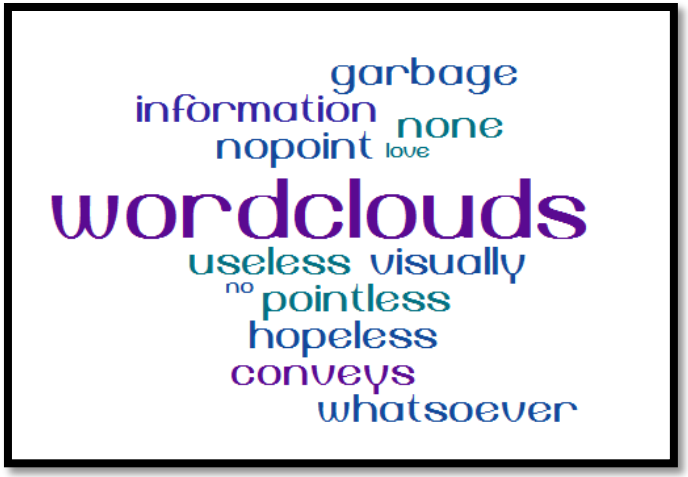


Lecture 8

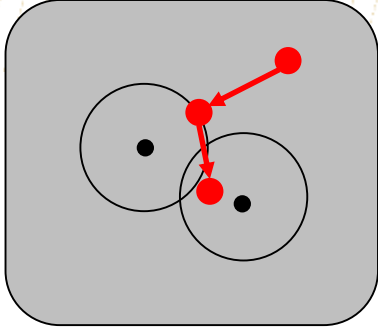
- Natural Language Processing
- Text Normalization
- Word Clouds
- Text Distances
- Corpus/Dictionaries
- Naïve Bayes
- Word Frequencies (TF-IDF)



	D1	D2	D3	D4	D5
complexity	2		3	2	3
algorithm	3			4	4
entropy	1			2	
traffic		2	3		
network		1	4		



Lecture 9



- Guest Lecture
- Bayesian Statistics
  - Prior, Likelihood, and Posterior

$$Posterior = Likelihood \frac{Prior}{P(data)}$$

- Bayesian Inference
  - Estimating p(heads)
  - Estimating linear regression parameters
- Monty Carlo Markov Chain Estimation
  - Accepting/Rejecting points to estimate a distribution.
- Computational Statistics
  - Simulate the Null Hypothesis, and find p-value.
- Bootstrapping
  - Bootstrapping for small samples and getting errors on linear regression.

Class Overview: Important Themes

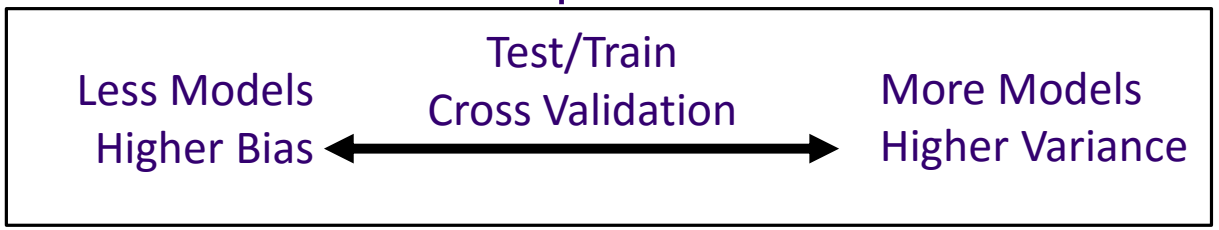
> Hypothesis Testing

> Linear Regression

- Ordinary Linear Regression, Multiple Linear Regression, Logistic Regression, Ridge Regression, Lasso Regression, SVD and total regression

* Feature reduction techniques

> Bayesian Statistics and Computational Statistics



Next Class: Deriving Knowledge from Data at Scale

- More in depth machine learning techniques
- Supervised vs unsupervised learning
- More data prep and feature engineering
- Linear vs nonlinear models
- Classification, clustering, and dimensionality reduction
- Decision trees, random forests, and boosted models
- More on neural networks and deep learning
- Support Vector Machines

- Group project: Submit a solution to a Kaggle contest.

To learn more about statistics…

- There are some free resources out there:
  - https://www.openintro.org/ (free introductory stats textbook)
  - https://www.datacamp.com/courses/data-analysis-and-statistical-inference_mine-cetinkaya-rundel-by-datacamp (data camp course) (most similar to this course)
  - https://www.coursera.org/course/introstats (somewhat similar to this course)
  - http://stats.stackexchange.com/ (stack overflow for statistics)
  - http://datascience.stackexchange.com/ (stack overflow for data science)

  - Have not checked out but heard of:
  - http://bookboon.com/en/statistics-ebooks
  - http://www.mv.helsinki.fi/home/jmisotal/BoS.pdf

To learn more about R programming…

- https://www.coursera.org/learn/r-programming (Good reviews)
- https://www.edx.org/course/introduction-r-data-science-microsoft-dat204x-0 (introductory R)
- http://adv-r.had.co.nz/ (Hadley W., Advanced R Programming)
- http://slides.com/treycausey/pydata2015#/ (unit testing for D.S.)

- Start answering ‘R’ tagged questions on Stack Overflow.

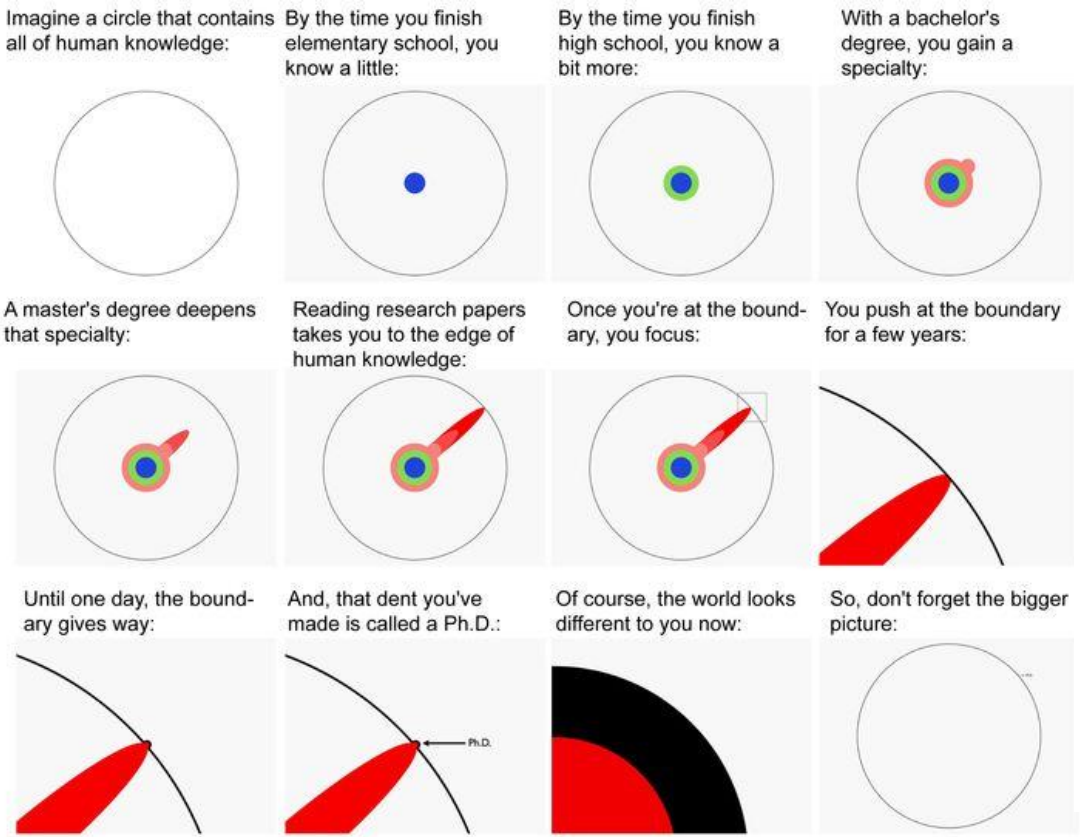
To Stay Current…

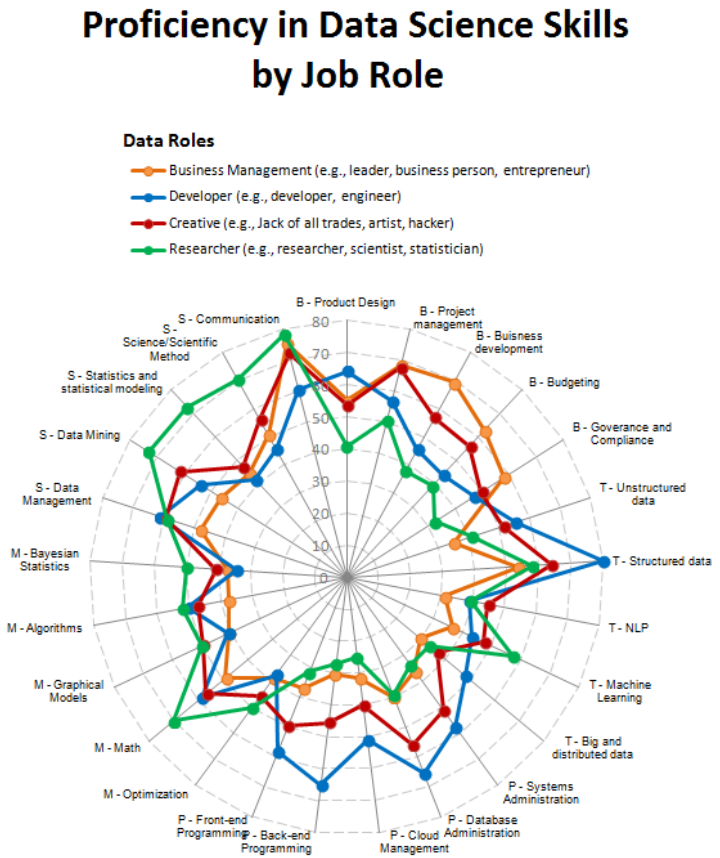
- The Data Science, analytics, and machine learning fields are moving faster than journals or even periodicals can keep up.
- Have to take a different strategy…
  - Google News alert for keywords
  - http://arxiv.org/ is a faster journal review site by Cornell
  - Twitter is nice for instantaneous glimpse into news. (https://tweetdeck.twitter.com/ is a nice instant dashboard you can setup)

Do I need an advanced degree?

> If you're asking 'need', then the answer is usually no.

> Advanced degrees should be something you *want* to pursue.





http://matt.might.net/articles/phd-school-in-pictures/

For the Data Science field…

- Employers used to hire only people with advanced degrees because there were no courses, certifications, or masters degrees in D.S.
- Now, since there are ways to get degrees and certifications in D.S. (and even resources to learn on your own), having an advanced degree isn't required any more.

Job Search Resources

- www.indeed.com
- https://angel.co/seattle
- https://anthology.co
- http://www.jobsfornewdatascientists.com/
- http://www.becomingadatascientist.com/

Getting an Interview

- Persistence is key.
- A company may be required to post a public job description despite knowing they will fill the position internally.
- A data scientist for company A is not a data scientist for company B.
  - Skills vary, and companies are looking for specific skills. Despite what HR wrote on the job description.
- Even if you do well in an interview, there are internal mechanisms that may prevent you from getting the job.
  - Job funding/opening may have changed.
  - HR doesn't want to pay a moving bonus.
  - Workplace politics.
- Always negotiate! You are probably worth more than you think.

My Personal Experience

- I’ve given a many interviews for D.S. positions. (And have recently taken a few as well).
- The education and location of a degree doesn’t mean much.
- What really matters is:
  - Can this person program at the level we need?
  - Does this person understand the basic level of statistics we need?
  - Does this person like solving problems?
  - Is this person a good culture fit?

Class Overview

- Remember this class is an overview of many methods.
- Hopefully you will know what and where to lookup subjects that you may need for work, projects, dinner party jokes, etc…
- This certification class is a great step in the right direction.
  - It shows employers and colleagues that you are serious about the analytical field and have had formal training.
- You are now (and have been) a resource for others.
- Last piece of advice:
  - Don’t ever stop learning. The day we stop learning for/at our jobs is the day we should be looking for a new job.

Please remember to take the class survey, we need your feedback!