Introduction

CSC 461: Machine Learning

Fall 2021

Prof. Marco Alvarez
University of Rhode Island

Course Logistics

Welcome

- Instructor
  - ✓ Prof. Marco Alvarez
- TAs
  - ✓ Mikel Gjergji
  - ✓ Derek Jacobs
- Lectures
  - ✓ MW 3 - 4:15p
- Office Hours
  - ✓ TBA
- Course Website
  - ✓ https://homepage.cs.uri.edu/~malvarez/teaching/csc-461/

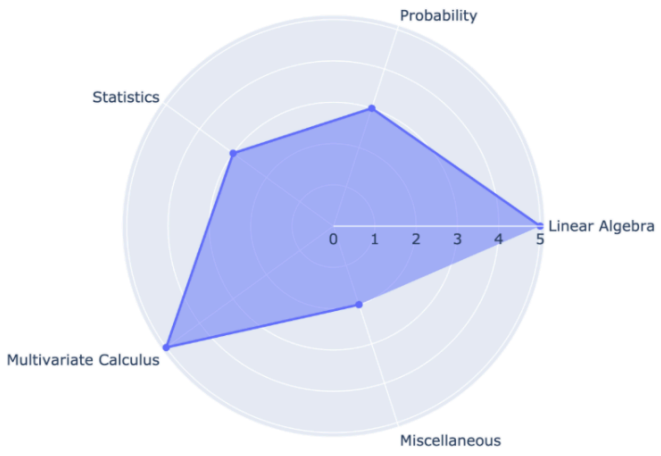
Course goals

- Understand how ML algorithms work
  - ✓ the **learning** problem and limitations
  - ✓ theoretical foundations of major techniques
- Be able to develop ML applications
  - ✓ problem design, algorithm/platform choice
- Be able to read ML papers

Should I take this class?

- Requires more math than traditional CS courses
- Programming experience is required

  consider taking this course at a later time if necessary
- Little emphasis on 'how to use this library'
  - ✓ focus on implementing major algorithms
- High grades require high effort
  - ✓ long and challenging assignments



Machine Learning

https://www.analyticsvidhya.com/blog/2019/10/mathematics-behind-machine-learning/

Math resources

- Linear Algebra Review and Reference
  - ✓ http://cs229.stanford.edu/summer2019/cs229-linalg.pdf
- Review of Probability Theory
  - ✓ http://cs229.stanford.edu/summer2019/cs229-prob.pdf
- Computational Linear Algebra for Coders
  - ✓ https://github.com/fastai/numerical-linear-algebra
- Mathematics for Machine Learning
  - ✓ https://gwthomas.github.io/docs/math4ml.pdf

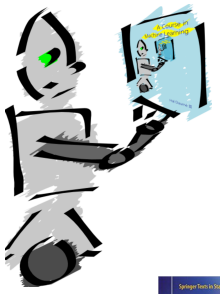
Python/Numpy resources

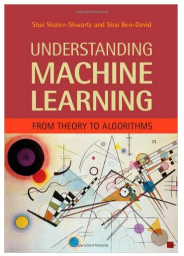
- Google's Python Class
  - ✓ https://developers.google.com/edu/python/
- From Python to Numpy
  - ✓ https://www.labri.fr/perso/nrougier/from-python-to-numpy/
- Python Numpy Tutorial
  - ✓ http://cs231n.github.io/python-numpy-tutorial/

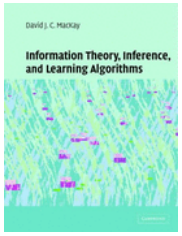
Tentative topics (order not relevant)

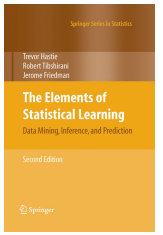
Introduction, Supervised Learning	Bagging, Boosting
Linear Regression, Linear Classifiers, Loss Functions	Maximum Likelihood Estimation, Naive Bayes
Logistic Regression, Gradient Descent	k-Means, Hierarchical Clustering
Generalization, Bias/Variance, Overfitting/ Underfitting, Model Selection	PCA, SVD, Matrix Factorization
Linear SVM, Empirical Risk Minimization, Regularization, Kernels	Reinforcement Learning
K-NN, Curse of Dimensionality	Neural Networks
Decision Trees, Regression Trees	Convolutional Networks

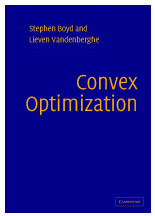
Free textbooks

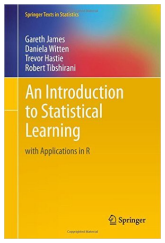


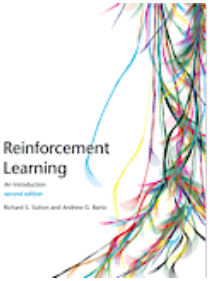


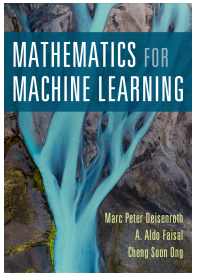




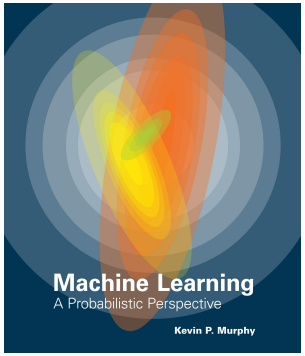


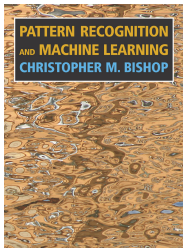


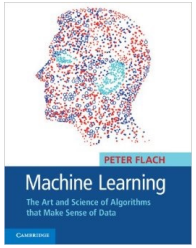


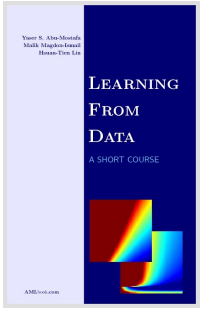


More textbooks









Grading

- Assignments (35%)
  - ✓ ~6 Homework Assignments
- Technical Presentation (25%)
  - ✓ groups of 2
- Final Project
  - ✓ progress report (10%)
  - ✓ final report (15%)
  - ✓ presentation (15%)

Final Project

- Find some new data/problem or find new approach to old data/problem
  - ✓ 2-3 students per group
- Deliverables
  - ✓ progress report (mid October)
  - ✓ final report (end of semester)
  - ✓ presentation (end of semester)

Logistics

Your job

- Attend lectures (**synchronous**)
- Participate
  - ✓ in-class and also on Ed
- Work hard
  - ✓ read textbooks and papers (schedule is ambitious)
  - ✓ work on your assignments (focus on **excellence** rather than just "getting a good grade")
    - ✓ this is about developing highly-sought skills and competencies

The badges game

Badges data

- COLT conference 1994
  - ✓ attendees received badges labeled as positive or negative
- The author (Haym Hirsh) knew the function that generated the labels
- Challenge: look at the names and find the hidden function
- https://www.seas.upenn.edu/~cis519/fall2019/assets/lectures/lecture-0/game.html

Subset of the original dataset

+ Naoki Abe	- Myriam Abramson	+ David W. Aha
+ Kamal M. Ali	- Eric Allender	+ Dana Angluin
- Chidanand Apte	+ Minoru Asada	+ Lars Asker
+ Javed Aslam	+ Haralabos Athanassiou	+ Jose L. Balcazar
+ Timothy P. Barber	+ Michael W. Barley	- Cristina Baroglio
+ Peter Bartlett	- Eric Baum	+ Welton Becket
- Shai Ben-David	+ George Berg	+ Neil Berkman
+ Malini Bhandaru	+ Bir Bhanu	+ Reinhard Blasig
- Avrim Blum	- Anselm Blumer	+ Justin Boyan
+ Carla E. Brodley	+ Nader Bshouty	- Wray Buntine
- Andrey Burago	+ Tom Bylander	+ Bill Byrne
- Claire Cardie	+ Richard A. Caruana	+ John Case
+ Jason Catlett	+ Nicolo Cesa-Bianchi	- Philip Chan
+ Mark Changizi	+ Pang-Chieh Chen	- Zhixiang Chen
+ Wan P. Chiang	- Steve A. Chien	+ Jeffery Clouse
+ William Cohen	+ David Cohn	- Clare Bates Congdon
- Antoine Cornuejols	+ Mark W. Craven	+ Robert P. Daley
+ Lindley Darden	- Chris Darken	- Bhaskar Dasgupta
- Brian D. Davidson	+ Michael de la Maza	- Olivier De Vel
- Scott E. Decatur	+ Gerald F. DeJong	+ Kan Deng
- Thomas G. Dietterich	+ Michael J. Donahue	+ George A. Drastal
+ Harris Drucker	- Chris Drummond	+ Hal Duncan
- Thomas Ellman	+ Tapio Elomaa	+ Susan L. Epstein
+ Bob Evans	- Claudio Facchinetti	+ Tom Fawcett
- Usama Fayyad	+ Aaron Feigelson	+ Nicolas Fiechter
+ David Finton	+ John Fischer	+ Paul Fischer
+ Seth Flanders	+ Lance Fortnow	- Ameur Foued
+ Judy A. Franklin	+ Yoav Freund	+ Johannes Furnkranz
+ Merrick L. Furst	+ Jean Gabriel Ganascia	+ William Gasarch
+ Ricard Gavalda	+ Melinda T. Gervasio	+ Yolanda Gil
+ David Gillman	- Attilio Giordana	+ Kate Goelz
+ Paul W. Goldberg	+ Sally Goldman	+ Diana Gordon
+ Geoffrey Gordon	+ Jonathan Gratch	+ Leslie Grate
+ William A. Greene	+ Russell Greiner	+ Marko Grobelnik
+ Tal Grossman	+ Margo Guertin	+ Tom Hancock
+ Earl S. Harris Jr.	+ David Haussler	+ Matthias Heger
+ Lisa Hellerstein	+ David Helmbold	+ Daniel Hennessy
+ Haym Hirsh	+ Jonathan Hodgson	+ Robert C. Holte
+ Jiarong Hong	- Chun-Nan Hsu	+ Kazushi Ikeda
+ Masayuki Inaba	- Drago Indjic	+ Nitin Indurkhya
+ Jeff Jackson	+ Sanjay Jain	+ Wolfgang Janko
- Klaus P. Jantke	+ Nathalie Japkowicz	+ George H. John
+ Randolph Jones	+ Michael I. Jordan	+ Leslie Pack Kaelbling
+ Bala Kalyanasundaram	- Thomas E. Kammeyer	- Grigoris Karakoulas
+ Michael Kearns	+ Neela Khan	+ Roni Khardon
+ Dennis F. Kibler	+ Jorg-Uwe Kietz	- Efim Kinber
- Jyrki Kivinen	- Emanuel Knill	- Craig Knoblock
+ Ron Kohavi	+ Pascal Koiran	+ Moshe Koppel
+ Daniel Kortenkamp	+ Matevz Kovacic	- Stefan Kramer
+ Martinch Krikis	+ Martin Kummer	- Eyal Kushilevitz
- Stephen Kwek	+ Wai Lam	+ Ken Lang
- Steffen Lange	+ Pat Langley	+ Mary Soon Lee
+ Wee Sun Lee	+ Moshe Leshno	+ Long-Ji Lin

Lets play …

- Analyze the training data …
- Lets calculate your accuracy on these names …

```
Brian Tester
Lyle H. Ungar
Paul Vitanyi
Gary Weiss
Bradley L. Whitehall
Janusz Wnek
Holly Yanco
Jean-Daniel Zucker
```

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Chen K. Tham
Paul Utgoff
Xuemei Wang
Sholom Weiss
Alma Whitten
Kenji Yamanishi
John M. Zelle
Darko Zupanic
```

Can we use a computer?

- We could extract features (attributes/characteristics) then use ML
  - ✓ length
  - ✓ number of vowels
  - ✓ number of consonants
  - ✓ number of dots
  - ✓ number of words
  - ✓ number of whitespaces
  - ✓ vowel/consonant ratio
  - ✓ length even/odd?
  - ✓ starts with a vowel?
  - ✓ is second letter a vowel?
  - ✓ …

Features and Data

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO	B	LSTAT	MEDV
0	0.00632	18.0	2.31	0.0	0.538	6.575	65.2	4.0900	1.0	296.0	15.3	396.90	4.98	24.0
1	0.02731	0.0	7.07	0.0	0.469	6.421	78.9	4.9671	2.0	242.0	17.8	396.90	9.14	21.6
2	0.02729	0.0	7.07	0.0	0.469	7.185	61.1	4.9671	2.0	242.0	17.8	392.83	4.03	34.7
3	0.03237	0.0	2.18	0.0	0.458	6.998	45.8	6.0622	3.0	222.0	18.7	394.63	2.94	33.4
4	0.06905	0.0	2.18	0.0	0.458	7.147	54.2	6.0622	3.0	222.0	18.7	396.90	5.33	36.2

https://towardsdatascience.com/feature-selection-with-pandas-e3690ad8504b