

Assignment Project Exam Help

Machine learning lecture slides

COMS 4771 Fall 2020

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Overview

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- ▶ Please use Piazza Live Q&A

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- ▶ A “bird’s eye view” of machine learning
- ▶ About COMS 4771

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Figure 1: Predict the bird species depicted in a given image.

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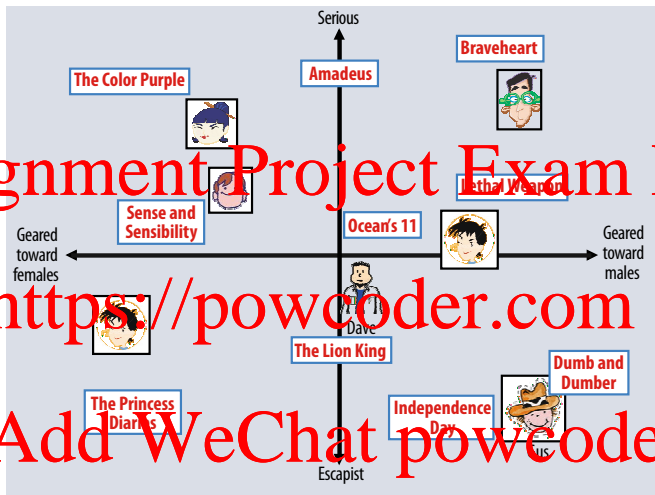
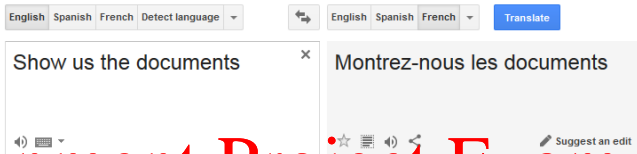


Figure 2: Predict how a given user would rate a given movie.



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Figure 3: Predict the French translation of a given English sentence.

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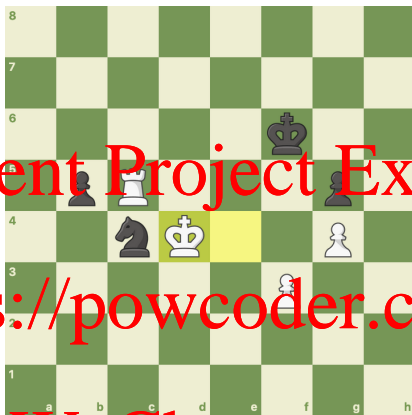


Figure 4: Predict the 'win probability' of a given move in a given game state.

How to “solve” problems without ML?

- ▶ Image classification:
 - ▶ Recruit a “bird expert” to teach you about different birds features (e.g., beak shape, feather color, typical environment)
 - ▶ Recognize these features in a given image, and then come up with a best guess of the bird species
- ▶ Recommender system:
 - ▶ Ask user to self-report specific movie genres of interest (e.g., horror, sci-fi)
 - ▶ Ask movie suppliers to categorize movies into the same genres
 - ▶ Predict a high rating for any movie in a user’s genre-of-interest; low rating for all other movies
- ▶ Machine translation: ...
- ▶ Chess: ...

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- ▶ Applied ML
 - ▶ Collect/prepare data, build/train models, analyze performance/errors, etc
- ▶ ML developer
 - ▶ Implement ML algorithms and infrastructure
- ▶ ML research
 - ▶ Design/analyze models and algorithms

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Note: These roles are not mutually exclusive!

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Mathematical and computational prerequisites

- ▶ Math

- ▶ Linear algebra, probability, multivariable calculus

- ▶ Understand and reason about the concepts (not just calculations)

- ▶ Software/programming

- ▶ Much ML work is implemented in python with libraries such as numpy and pytorch

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Basic setting: supervised learning

- ▶ Training data: dataset comprised of labeled examples
 - ▶ Labeled example: a pair of the form (input, label)
 - ▶ Input: what you see before you make a prediction (a.k.a. context, side-information, features, etc.)
 - ▶ Label: output value (a.k.a. output, response, target, etc.)
- ▶ Goal: learn predictor (i.e., prediction function) to predict label from input for new examples

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```
1: if age  $\geq$  40 then  
2:   if genre = western then  
3:     return 4.3  
4:   else if release date > 1998 then  
5:     return 2.5  
6:   else  
7:      $\vdots$   
8:   end if  
9: else if  $\vdots$  then  
10:   $\vdots$   
11: end if
```

Figure 5: Decision tree

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```
1: if  $0.335 \cdot x_1 + 2.5 \cdot x_2 + \dots + 6.35 \cdot x_{10^6} > 4.3$  then  
2:   return spam  
3: else  
4:   return not spam  
5: end if
```

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Figure 6: Linear classifier ("Perceptron")

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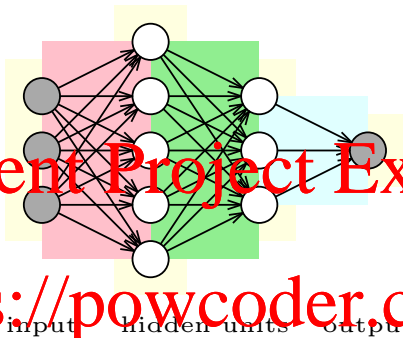


Figure 7: Neural network

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Types of prediction problems

- ▶ Binary classification
 - ▶ Given an email, is it spam or not?
 - ▶ (What's the probability that it is spam?)
- ▶ Multi-class classification
 - ▶ Given an image, what animal is depicted?
 - ▶ (Or which animals are depicted?)
- ▶ Regression
 - ▶ Given clinical measurements, what is level of tumor antigens?
 - ▶ (In absolute level? Log-scale?)
- ▶ Structured output prediction
 - ▶ Given a sentence, what is its grammatical parse tree?
 - ▶ (Or dependency tree?)
- ▶ ...

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Template of supervised learning pipeline

- ▶ Get data
- ▶ Determine representation of and predictive model for data
- ▶ Train the predictor (a.k.a. model fitting, parameter estimation)
- ▶ Evaluate predictor (test the “goodness of fit”)
- ▶ Deploy predictor in application

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- ▶ What is the core prediction problem?

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- ▶ What features (i.e., predictor variables) are available?

- ▶ Will these features be available at time of prediction?

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- ▶ Is there enough information (e.g., training data, features) to learn the relationship between the input and output?

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- ▶ What are the modeling assumptions?
- ▶ Is high-accuracy prediction a useful goal for the application?

- ▶ Form of the prediction function

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- ▶ Choice of features

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- ▶ Choice of training data

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- ▶ Choice of learning algorithm
 - ▶ Choice of objective function and constraints

- ▶ Might not have the “right” data

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- ▶ Might not have the “right” model

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- ▶ Data might be corrupted, noisy, ...

- ▶ Plug-in principle

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- ▶ Inductive bias

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- ▶ Linearity

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- ▶ Mathematical optimization

- ▶ Basic principles and methods of supervised machine learning
 1. Appetizer: nearest neighbor rules (a “non-parametric” method)
 2. Statistical model for prediction
 3. Regression
 - ▶ Why? Clean, simple, and illustrates important concepts (linearity, inductive bias, regularization, kernels)
 4. Classification
 5. Optimization methods for machine learning
 - ▶ Convex optimization, neural networks
 6. Maybe one other topic if time permits ...
- ▶ This is not a course about how to use sklearn, tensorflow, etc.
- ▶ Also not about latest nonsense on arXiv
- ▶ Good stuff beyond COMS 4771:
 - ▶ COMS 4252, 4773: Mathematical theory of learning
 - ▶ COMS 4774: Unsupervised learning
 - ▶ COMS 4775: Causal inference
 - ▶ ...

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- ▶ Professor Daniel Hsu
 - ▶ Okay to call me “Daniel”!
 - ▶ “Professor Hsu” also okay
 - ▶ “Professor Daniel” is a little weird
 - ▶ At Columbia since 2013
 - ▶ Previously at Microsoft Research, Rutgers, UPenn, UC San Diego, UC Berkeley
 - ▶ Research interests: algorithms, statistics, & combining the two
 - ▶ Good at: \LaTeX -hacking
 - ▶ Bad at: making slides

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About you

- ▶ I assume you have fluency in
 - ▶ multivariable calculus,
 - ▶ linear algebra, and
 - ▶ elementary probability (no measure theory needed)
- ▶ I also assume you can read and write programs in Python
 - ▶ (and read online documentation to learn, e.g., how to do I/O with CSV files)
 - ▶ See Courseworks for a “Python basics” Jupyter notebook to brush up on Python, Numpy, etc.
- ▶ Let me know why you are interested in ML!
 - ▶ Part of HW 1.

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- ▶ Website: <https://www.cs.columbia.edu/~djhsu/ML>
 - ▶ Schedule for office hours/lectures/homework/quizzes/exam
 - ▶ Syllabus
- ▶ Course format:
 - ▶ Lecture/recitation: online over Zoom
 - ▶ “On Campus” people: check email about in-person lectures
- ▶ Course assistants (CAs):
 - ▶ Andy, Andrea, Wonjun, Serena
 - ▶ Links for online office hours will be posted on Courseworks
- ▶ Technology:
 - ▶ Piazza: communicate with course staff (live Q&A and offline)
 - ▶ Courseworks: retrieve assignments, quizzes, data files, etc.
 - ▶ Gradescope: submit homework write-ups, code
 - ▶ Slack: discussion with fellow classmates
- ▶ Disability services:
 - ▶ Please make arrangements with disability services ASAP

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Academic rules of conduct

- ▶ See syllabus
- ▶ **Cheating**: don't do it
 - ▶ If unsure about something, ask!
 - ▶ Consequence is automatic fail

- ▶ **Cheating out of desperation** is also cheating

- ▶ Instead: get help early

- ▶ We are here to help

- ▶ Okay to work on homework in groups of ≤ 3

- ▶ No collaboration across groups

- ▶ No diffusion of responsibility

- ▶ No collaboration at all on quizzes or exams

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Reading assignments

- ▶ There are some required reading assignments (mostly from handouts posted on website)
- ▶ Unfortunately, most textbooks on ML are not appropriate for this course
 - ▶ Closest is “A Course in Machine Learning” by Daumé
 - ▶ I have selected some optional reading assignments from a few books that may be used to supplement the lectures
 - ▶ All books available online

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