Syllabus

L665 Applying Machine Learning Techniques in Computational Linguistics & CSCI-B 659 Topics in Artificial Intelligence: Machine Learning, Neural Networks, Deep Learning for CL/NLP

Instructor: Prof. Damir Cavar <dcavar@indiana.edu> (http://damir.cavar.me/)
Location: Ballantine Hall 118
Times: Tuesday and Thursday 9:30-10:45 AM
Material: Canvas, online
Office hours: Ballantine Hall 850 Tuesday and Thursday 11 AM - 12 PM
Teaching Assistant: Atreyee Mukherjee <atremukh@indiana.edu>

LING-L 665 / CSCI-B 659 is a graduate course that focuses on the introducing of machine learning techniques that are used in Computational Linguistics and Natural Language Processing. Machine learning problems in CL are rather non-typical for machine learning because natural language includes a significant level of exceptions. The course will provide an overview of the most important machine learning algorithms, but it will mostly focus on how to apply machine learning to CL/NLP problems such as co-reference resolution, morphological analysis, parsing, and word sense disambiguation.

In addition to the numerous underlying tasks in ML for CL (and NLP) applications, we will discuss Deep Learning approaches. We will work with Neural Network models applied to traditional CL and NLP problems

Among others, we will cover word vector representations, window-based neural networks, recurrent neural networks, long-short-term-memory models, recursive neural networks, convolutional neural networks, etc. The course is a series of lectures and hands-on programming exercises.

I recommend reading the textbooks in the Literature section. We will discuss selected chapters during class.

The course is a series of lectures and hands-on programming exercises.

The course is using material provided by:

- Stanford University: CS224n: Natural Language Processing with Deep Learning
- The Deep Learning textbook (MIT Press) by Ian Goodfellow, Yoshua Bengio and Aaron Courville
- Dan Jurafsky and James H. Martin. Speech and Language Processing (3rd ed. draft)
- University of Oxford: Deep Learning for Natural Language Processing: 2016-2017 by Phil Blunsom et al.
  https://github.com/oxford-cs-deepnlp-2017/lectures

- Coding the Matrix, Philip Klein, Brown University
  http://codingthematrix.com/

These courses are accompanied by videos, slides, research papers, links to supplemental material and tutorials, and other very valuable information. Please make use of these excellent resources during our course.

Literature

- Ian Goodfellow and Yoshua Bengio and Aaron Courville (2016) *Deep Learning*. MIT Press.
  http://www.deeplearningbook.org/
  https://www.amazon.com/Deep-Learning-Adaptive-Computation-Machine/dp/0262035618/
- Dan Jurafsky and James H. Martin (2017) *Speech and Language Processing* (3rd ed. draft)
  https://web.stanford.edu/~jurafsky/slp3/
- Yoav Goldberg. *A Primer on Neural Network Models for Natural Language Processing*.
  http://u.cs.biu.ac.il/~yogo/nnlp.pdf

In the schedule and during class we will provide more articles and publications to read and discuss in class. Each class one student will be responsible to present, summarize, and lead the discussion of one paper. You have to read the papers to be able to follow the discussion.

Additional Literatur

Bender, Emily M. (2013) *Linguistic Fundamentals for Natural Language Processing: 100 Essentials from Morphology and Syntax*. Synthesis Lectures on Human Language Technologies #20. Morgan & Claypool Publishers.

Bird, Steven, Ewan Klein, Edward Loper (2009) *Natural Language Processing with Python*. O'Reilly Media.

Hogg, Robert V., Elliot A. Tanis (2001) *Probability and statistical inference*. 6th ed. Upper Saddle River, NJ: Prentice Hall.

Manning, Christopher D., Hinrich Schütze 1999. Foundations of statistical natural language processing. Cambridge, Mass.: MIT Press.

Pilgrim, Mark (2009) *Dive into Python 3*. Apress. (Free access online)

Coding and Computational Experiments

Students are encouraged to bring their laptops or other computational devices to class.

The readings and exercises will be accompanied by practical examples using:

- Python 3 or Go
- NLTK, Numpy, Tensorflow module for Python 3

I recommend to consider the Python distribution Anaconda for your local machine installation, because it contains all the necessary modules prepackaged.

Once you have Python 3, NLTK, Numpy, Tensorflow installed on your computer, use these instructions to set up the necessary corpora/data for NLTK.

Prerequisites and Requirements

I expect that you are able or acquire the skills to code examples in Python or Go. If you have no programming experience, follow the different links here and on the mentioned course sites and learn Python and Numpy.

Recommended:

- Learn Python or Go; if you have never programmed before, learn Python first; I recommend using Python 3.x or the most recent distribution of Go.
- Install and learn about TensorFlow, Word2vec.
- Refresh your knowledge of Calculus and Linear Algebra.
- Update your knowledge of Probability Theory.
- Refresh your knowledge of common Machine Learning approaches.
- Familiarize yourself with common Linguistic concepts and theories, in particular lexical properties, syntax, semantics, speech; for basic introductions consult Jurafsky and Martin (2017, draft, 3rd ed.) or Bender (2013).

Assignments

There will be bi-weekly assignments throughout the semester. They will generally not be overbearingly long, and they will provide you with exercises to demonstrate that you grasp the material. Homework assignments are due by the beginning of each class, as indicated on Canvas. If the assignment allows that, you can work together with others on the problem, but write out your own answers. Your grade will be based on both quality and effort.

- B659 students may occasionally have more of a programming component required for their assignments.
- Additionally, there will periodically be in-class exercises which count towards your participation grade.

- After conferring with the grader, I will let you know whether electronic or hard copies of assignments are preferred.

Final project

Your last assignment will be more in-depth than the previous ones, allowing you to work more closely with a problem. Since it will be about twice as long as the others, it will be worth twice as many points.

Grading

Participation	10%
Assignments	50% (=5@10% each)
Presentations	10% (at least 1 per person)
Final presentation	10%
Final project	20%

If you feel that I have graded anything incorrectly or improperly, please contact me outside of class. I will be happy to address your concerns.

Attendance policy: Poor attendance has a strong negative impact on your performance, slows down the class pace, and consequently affects other students' learning. You can miss up to two classes without further consequences but for any further unexcused absence, 2% will be deducted from the final grade. This is independent of the reasons why you might have to miss a class.

Collaboration and citation policy: You are encouraged to work with your fellow students on assignments, but **you must do your write-up individually, and list the names of the people you worked with**. It is **not acceptable** to write up materials that the group worked on that you don't understand. If you consult any reference materials other than course readings and handouts, you must list them in your write-up. Acknowledging help won't hurt your grade, but failing to do so can be catastrophic. Plagiarism will result in penalties in the range from a zero for that portion of your work, an F for the course, transcript citation, or more severe consequences. To see IU's policies on academic misconduct, see http://www.iu.edu/~code/code/responsibilities/academic/index.shtml.

Late assignment policy: As a general rule, **no late assignments will be accepted for credit.** Exceptions may be made if (1) you got **advance** permission from me to hand in an assignment late or (2) you couldn't come to campus on the day the assignment is due because of a serious illness or unexpected emergency. All assignments will be submitted online and you will be given

enough time to prepare them and submit them under normal circumstances. In case you were not able to submit an assignment in time and you had the permission to hand it in late, you will need to turn in the assignment at the earliest possible opportunity with a written explanation of the situation.

Additional Opportunities

I would encourage you to check out the weekly colloquium series on Computational Linguistics (CLingDing): see http://cl.indiana.edu/wiki/, and within Informatics, Cognitive Science, and in other divisions at Indiana University. Note, too, that there is an email listserv (COMPLING-L) which has announcements for talks, internships, etc. The LINGUIST List at Indiana University is a list and social media information service that provides information about jobs, internships, publications, conferences, and other relevant issues that are of interest to computational linguists and natural language processing.

We are organizing different extra-curricular activities, including programming of NLP technologies and High Performance Computing for NLP. The topics discussed at these meetings might help you understand the course material better, or you might get ideas for final projects that would be in the domain of open source HPNLP, Deep Learning, and speech and language processing in general. Please contact me, if you would be interested in participating in these meetings outside of class.

Disclaimer

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Schedule

Date	Topic	Readings
Jan. 09	Introduction Syllabus and Schedule	
Jan. 11	Introduction to NLP and CL	• Bender 2013 for Linguistics • Manning & Schuetze: Ch. 1
Jan. 16	Probability Review	• Maleki & Do: Review of Probability Theory • Manning & Schuetze: Ch. 2 • Goodfellow et al.: Ch. 3
Jan. 18	Linear Algebra Review	• Kolter (and Do) Linear Algebra

		Review and References • Goodfellow et al.: Ch. 2
Jan. 23	Optimization Python, NLTK, WordNet, spaCy	• Convex Optimization Review • More Optimization (SGD) Review • Jurafsky & Martin: Ch. 17 • Bird et al (2009) • Pilgrim (2009)
Jan. 25	Vectors and Word2vec	• Jurafsky & Martin: Ch. 15 & 16 • Word2Vec Tutorial - The Skip-Gram Model • Distributed Representations of Words and Phrases and their Compositionality • Efficient Estimation of Word Representations in Vector Space
Jan. 30	Numpy and Word2vec applied	• Online tutorial • See previous session
Feb. 1	Word Window Classification and Neural Networks	• Jurafsky & Martin: Ch. 8
Feb. 6	Word Window Classification and Neural Networks	• Jurafsky & Martin: Ch. 8
Feb. 8	Advanced Word Vector Models	• Jurafsky & Martin: Ch. 16
Feb. 13	Advanced Word Vector Models	• Jurafsky & Martin: Ch. 16
Feb. 15	Neural Networks, Single Layer Networks	• Jurafsky & Martin: Ch. 8 • Goodfellow et al.: Ch. 6
Feb. 20	Backpropagation	• UFLDL tutorial • Learning Representations by Backpropogating Errors
Feb. 22	Backpropagation, NNs, QA, Semantics	• Natural Language Processing (almost) from Scratch • A Neural Network for Factoid Question Answering over Paragraphs • Grounded Compositional Semantics for Finding and Describing Images with Sentences • Deep Visual-Semantic Alignments for Generating Image Descriptions • Recursive Deep Models for

		Semantic Compositionality Over a Sentiment Treebank
Feb. 27	Gradients, Overfitting, Activation Function	• Practical recommendations for gradient-based training of deep architectures • UFLDL page on gradient checking
Mar. 1	Tensorflow	• TensorFlow: Large-Scale Machine Learning on Heterogeneous Distributed Systems • Tensorflow tutorials
Mar. 6	Tensorflow	• See above
Mar. 8	Recurrent Neural Networks and Language Models	• Recurrent neural network based language model • Extensions of recurrent neural network language model • Opinion Mining with Deep Recurrent Neural Networks
Mar. 20	Gated Feedback Recurrent NNs, Long Short-Term Memory for Machine Translation	• Long Short-Term Memory • Gated Feedback Recurrent Neural Networks • Empirical Evaluation of Gated Recurrent Neural Networks on Sequence Modeling
Mar. 22	Gated Feedback Recurrent NNs, Long Short-Term Memory for Machine Translation	• See above
Mar. 27	Recursive Neural Networks, Parsing	• Goodfellow et al.: Ch. 10 • Parsing with Compositional Vector Grammars • Subgradient Methods for Structured Prediction • Parsing Natural Scenes and Natural Language with Recursive Neural Networks
Mar. 29	Recursive Neural Networks, Sentiment Analysis	• Recursive Deep Models for Semantic Compositionality Over a Sentiment Treebank • Dynamic Pooling and Unfolding Recursive Autoencoders for Paraphrase Detection

		• Improved Semantic Representations From Tree-Structured Long Short-Term Memory Networks
Apr. 3	Convolutional Neural Networks, Sentence Classification	• Goodfellow et al.: Ch. 9 • Arxiv paper
Apr. 5	General topics: ML, Speech Recognition	• Oxford DL Course: Speech Recognition chapter • Deep Neural Networks for Acoustic Modeling in Speech Recognition
Apr. 10	General topics: Dynamic Memory Networks	• Ask me anthing: Dynamic Memory Networks for NLP
Apr. 12	Discussion and Practical Experiments	• TBA
Apr. 17	Issues with Deep Learning and NLP	• Marcus 2017
Apr. 19	Issues with Deep Learning and NLP	• Marcus 2018
Apr. 24	Project presentations	
Apr. 26	Project presentations	

Policies and Other Agreements

Academic Integrity (from the Dean for Academic Standards and Opportunities)

As a student at IU, you are expected to adhere to the standards and policies detailed in the *Code of Student Rights, Responsibilities, and Conduct* (*Code*) studentcode.iu.edu. When you submit an assignment with your name on it, you are signifying that the work contained therein is yours, unless otherwise cited or referenced. Any ideas or materials taken from another source for either written or oral use must be fully acknowledged. All suspected violations of the *Code* will be reported to the Dean of Students and handled according to University policies. Sanctions for academic misconduct may include a failing grade on the assignment, reduction in your final course grade, and a failing grade in the course, among other possibilities. If you are unsure about the expectations for completing an assignment or taking a test or exam, be sure to seek clarification beforehand.

Students with Disabilities

Students who need an accommodation based on the impact of a disability should contact me to arrange an appointment as soon as possible to discuss the course format, to anticipate needs, and to explore potential accommodations.

I rely on Disability Services for Students for assistance in verifying the need for accommodations and developing accommodation strategies. Students who have not previously contacted Disability Services are encouraged to do so (812 855-7578; http://www.indiana.edu/~iubdss/).

CAPS

One benefit of a school like IU is that there are many, many resources available to you. School and life can be intense at times, and if your academic responsibilities or other personal concerns are distracting or weighing on you this semester, I encourage you to contact Counseling and Psychological Services (CAPS) (812) 855-5711, http://healthcenter.indiana.edu/counseling/). The people there can be a resource and a source of support, not just in times of crisis, but also when you need an extra ear or a little extra support. I'm happy to be a listening ear, as well, but I have no counseling training and the folks at CAPS do. Note, too, that I am required to report certain things (e.g., reports of sexual assault, suicidal thoughts).

Note Selling

Several commercial services have approached students regarding selling class notes/study guides to their classmates. Selling the instructor's notes/study guides in this course is not permitted. Violations of this policy will be reported to the Dean of Students as academic misconduct (violation of course rules). Sanctions for academic misconduct may include a failing grade on the assignment for which the notes/study guides are being sold, a reduction in your final course grade, a failing grade in the course, among other possibilities. Additionally, you should know that selling a faculty member's notes/study guides individually or on behalf of one of these services using IU email, or via Canvas may also constitute a violation of IU information technology and IU intellectual property policies and additional consequences may result.

Sexual Misconduct Policies at IU

As your instructor, one of my responsibilities is to create a positive learning environment for all students. Title IX and IU's **Sexual Misconduct Policy** prohibit sexual misconduct in any form, including sexual harassment, sexual assault, stalking, and dating and domestic violence. If you have experienced sexual misconduct, or know someone who has, the University can help. If you are seeking help and would like to speak to someone confidentially, you can make an appointment with:

- The Sexual Assault Crisis Services (SACS) at (812) 855-8900 (counseling services)

- Confidential Victim Advocates (CVA) at (812) 856-2469 (advocacy and advice services)
- IU Health Center at (812) 855-4011 (health and medical services)

It is also important that you know that Title IX and University policy *require me to share any information brought to my attention about potential sexual misconduct, with the campus Deputy Title IX Coordinator or IU's Title IX Coordinator*. In that event, those individuals will work to ensure that appropriate measures are taken and resources are made available. Protecting student privacy is of utmost concern, and information will only be shared with those that need to know to ensure the University can respond and assist.

I encourage you to visit stopsexualviolence.iu.edu to learn more.

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