Course Number and Name: CS 584 Natural Language Processing

Credits and Contact Hours: 3 credits; 3 contact hours (3 lecture)

Instructor or Course Coordinator's Name: Yue Ning

Textbook, Title, Author, and Year:

[1] Yoav Goldberg. *Neural Network Methods for Natural Language Processing. 2017.* Morgan and Claypool publishers. [NNLP]

[2] Ian Goodfellow, Yoshua Bengio, and Aaron Courville. *Deep Learning*. MIT Press. 2016. [DL]

[3] Dan Jurafsky and James H. Martin. Speech and Language Processing (3rd ed. draft). 2018. [SLP]

Catalog Description:
Natural language processing (NLP) is one of the most important technologies in the era of information. Comprehending human language is also a crucial and challenging part of artificial intelligence. People communicate almost everything in language: conferences, emails, customer service, language translation, web searches, reports, etc. There are a large variety of underlying tasks and machine learning models behind NLP applications. Recently, deep learning approaches have achieved high performance in many different NLP tasks. Instead of traditional and task-specific feature engineering, deep learning can solve tasks with single end-to-end models. The course provides an introduction to machine learning research applied to NLP. This course will cover topics including word vector representations, neural networks, recurrent neural networks, convolutional neural networks, semi-supervised models, reinforcement learning for NLP, as well as some attention-based models.

Pre and/or Co-requisites: Pre-requisite: undergraduate: MA 222 or MA 232; graduate: CS 556 or CS559

Required, Elective, or Selected Elective:
Selected Elective. This course can be taken as a machine learning elective.

Course Learning Outcomes:
1. [Gradient Descent] - Implement gradient descent (GD) and stochastic gradient descent (SGD) techniques for learning problems and understand the theory behind them.
2. [Vector Semantics] - Apply word2vec models in real-world text corpora.
3. [Neural Networks] - Understand the neural networks models and backpropagation optimization. Implement neural network models in platforms such as TensorFlow.
4. [Dependency Parsing]- Understand dependency parsing, recurrent neural networks and their application in NLP.

5. [Convolutional Neural Networks] – Understand convolutional neural networks and their application in NLP.
6. [Sequence to Sequence models] - Understand sequence to sequence models and attention in NLP deep neural networks.

Coursework:

Submissions: All assignments (homework problems and project milestones) must be submitted on Canvas by the start of the class on the due dates.

- Homework (50%): There will be bi-weekly homework assignments with both written and programming parts. Each assignment is centered around an application and will also deepen your understanding of the theoretical concepts.
- Midterm Exam (20%): The midterm exam is to evaluate your understanding of the course so far.
- Project (20%): The final project provides an opportunity for you to use the tools from class to build something interesting of your choice. You need to submit a report with code.
- Participation (5%): Discussions on Canvas and attending classes.
- Quizzes (5%): Online pop quizzes.

Student outcomes addressed by this course:

The student outcomes addressed by this course's learning outcomes are described at the beginning of this appendix.

List of Topics:

	Topic(s)	**Reading(s)**	**HW**
Week 1	Introduction to NLP, deep learning, python, tensor flow	SLP chapter 1-3; NNLP chapter 1	
Week 2	Machine learning basics and neural networks	DL chapter 2-5; NNLP chapter 3-5	
Week 3	Vector semantics (skip-gram, Glove) and matrix operations, probability theory, numerical computations	DL chapter 2-5; SLP book chapter 6-8; NJNLP chapter 10-11	Vector operations; Gaussian distribution; gradient descent

Week 4	Deep feedforward networks; regularization for deep learning	DL book chapter 6-8	Implement regularized neural networks; experiments on different activation functions for real-world tasks
Week 5	Language Modeling	DL book chapter 11	
Week 6	Recurrent neural networks(RNN)	SLP book chapter 13, DL book chapter 10	Implement back propagation for basic neural networks; different activation functions; develop RNN models on text translation
Week 7	Vanishing gradients and more on RNNs	DL chapter 10; NNLP chapter 15-16	
Week 8	Convolutional neural networks (CNN)	DL book chapter 9; NNLP chapter 13	Implement CNNs on text classification;
Week9	Sequence to sequence models and machine translation; Attention models	DL book chapter 10; NNLP chapter 17	
Wee 10	Tree recursive neural networks and constituency parsing	SLP book chapter 22; NNLP chapter 18	Implement sequence to sequence models for machine translation
Week 11	Dependency Parsing	SLP chapter 13	
Week 12	Advanced architectures (e.g., BERT) and memory networks	SLP book chapter 24	
Week 13	Semi-supervised learning for NLP	[Semi-Supervised Sequence Learning] [Learned in Translation: Contextualized Word Vectors]	
Week 14	Future of NLP, Multi-task learning		