جـــامـــعـــة مـحـمـد بـــن زايـــد
للـــذكـــاء الاصـــطـــنـــاعـــي
MOHAMED BIN ZAYED UNIVERSITY
OF ARTIFICIAL INTELLIGENCE

Core Courses Syllabi

NLP701 - Natural Language Processing

Title	Natural Language Processing
Code	NLP701
Loading	4 Credit-hours
Prerequisites	• Basic Concepts in Linear Algebra, Calculus, Probability and Statistics • Programming in Python or similar language
Catalog Description	This course provides a comprehensive introduction to Natural Language Processing. It builds upon fundamental concepts in Mathematics, specifically probability and statistics, linear algebra, and calculus, and assumes familiarity with programming.
Goal	This graduate level course aims to familiarize students with the foundations of core Natural Language Processing algorithms.
Content	The course covers the following major modules: **(I)** Sequence Tagging, **(II)** Parsing, **(III)** Text Categorization **(IV)** Sequential Modelling and **(V)** Machine Translation
Recommended Textbooks	1. Chris Manning et al, *Foundation of statistical natural language processing*, MIT Press (1999) ISBN: 0262133601 2. Ian Goodfellow, Yoshua Bengio, and Aaron Courville. *Deep Learning*. MIT Press. ISBN: 9780262035613
Recommended References & Supplemental Material	Relevant research papers, technical reports, and surveys for each topic, where needed, are identified in the teaching plan ahead. In addition, the following textbooks may be useful: Dan Jurafsky and James H. Martin, *Speech and Language Processing*, Prentice Hall, 2009. ISBN: 9780131873216

Teaching Week	Topics
1	**Introduction to Natural Language Processing (NLP)** **Lecture** • What is NLP and its motivations • Stages of language processing • Challenges of NLP **Lab** • Get familiar with Python programming • Practice NLTK and Numpy library
2	**Language Modeling** **Lecture** • The language modeling problem • Trigram model • Evaluation of language models **Lab** • Text processing practice: sentence segmentation, word tokenization, stemming and lemmatization, preparation of dictionary, etc. • Implement a tri-gram model
3	**Tagging, and Hidden Markov Model** **Lecture** • Understanding tagging problems: PoS tagging, chunking and NER tagging • Hidden Markov Model (HMM) • Parameter estimation of HMM • Using HMM for tagging problems **Lab** • Programming exercises on employing HMM for PoS tagging • Assignment 1
4	**Log-Linear Models** **Lecture** • Motivation for the log-linear model • Generative vs Discriminative model • Log-linear model • Feature templates • Features for the language modelling and Named Entity Recognition (NER) • Maximum likelihood estimation **Lab** • Programming exercises to implement log-linear model for PoS tagging problem • Compare the performance of log-linear model with HMM's performance

Teaching Week	Topics
5	**Maximum Entropy Markov model and conditional random field** **Lecture** • Maximum-Entropy Markov models (MEMMs) • Conditional random field (CRF) • MEMMs and CRF for PoS tagging/NER **Lab** • Programming exercises for employing CRF on NER tasks • Improve the performance of the model using domain specific features
6	**Parsing and Context-free Grammars** **Lecture** • An introduction to the parsing problem • Context-free grammars (CFG) • Syntax of English • Examples of ambiguous structures • Probabilistic context-free grammars (PCFG) • The CKY algorithm for parsing with PCFGs • Weaknesses of PCFGs **Lab** • Programming exercises for using existing NLP tools (CoreNLP/NLTK) and obtaining the syntactic parsing of the text.
7	**Lexicalized Context-free Grammar** **Lecture** • Lexicalization of a treebank • Lexicalized PCFG • Parameter estimation in lexicalized PCFG **Lab** • Problem-solving related to PCFG
8	**Revision** **Lecture and Lab** • Review and Exam Preparation

Teaching Week	Topics
9	**Feedforward Neural Networks** **Lecture** • Neural network • Recall log-linear model • Introducing learned representations • Single-layer feedforward network • Multi-layer feedforward network **Lab** • Demonstration and familiarization with deep learning libraries • Assignment 2
10	**Computational Graphs, and Backpropagation** **Lecture** • Introduction to multi-layer neural network • Chain rule • Computation graph for the feedforward network • Backpropagation algorithms • Regularization and weight initialization of the neural network **Lab** • Programming exercises for employing a multi-layer feedforward network on PoS tagging and NER tasks • Assignment 3
11	**Word Embeddings in Feedforward Networks** **Lecture** • Neural probabilistic language model (NPL) • Word embedding • Application of word embedding • Limitation of NPL **Lab** • Programming exercises for implementing NPL • Employ the learned word embedding in existing neural NER model
12	**Tagging and Dependency Parsing using Feedforward Networks** **Lecture** • Neural CRF model for tagging problem • Dependency parsing using a shift-reduce neural-network model **Lab** • Programming exercises for employing CRF on the existing neural NER models

Teaching Week	Topics
13	**Recurrent Networks, and LSTMs, for NLP** **Lecture** • A simple recurrent network • Exploding and vanishing gradients problem • LSTM and GRU network • Application of RNNs in NLP **Lab** • Programming exercises for using LSTM in text classification task • Assignment 4
14	**Convolution Neural Networks for NLP** **Lecture** • A simple Convolution Neural Network (CNN) • From RNNs to CNNs • Attention method • Applications of CNNs in NLP **Lab** • Programming exercises for employing CNN on the text classification task
15	**Neural Machine Translation** **Lecture** • Introduction to the machine translation problem • Sequence to sequence model • LSTM for encoding and decoding a sequence • Incorporating the attention mechanism for decoding a sequence **Lab** • Programming exercises for using a sequence to sequence model on machine translation tasks