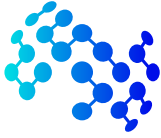


## Core Courses Syllabi

### NLP701 - Natural Language Processing

<b>Title</b>	Natural Language Processing
<b>Code</b>	NLP701
<b>Loading</b>	4 Credit-hours
<b>Prerequisites</b>	<ul style="list-style-type: none"><li>• Basic Concepts in Linear Algebra, Calculus, Probability and Statistics</li><li>• Programming in Python or similar language</li></ul>
<b>Catalog Description</b>	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.
<b>Goal</b>	This graduate level course aims to familiarize students with the foundations of core Natural Language Processing algorithms.
<b>Content</b>	The course covers the following major modules: <b>(I)</b> Sequence Tagging, <b>(II)</b> Parsing, <b>(III)</b> Text Categorization <b>(IV)</b> Sequential Modelling and <b>(V)</b> Machine Translation
<b>Recommended Textbooks</b>	<ol style="list-style-type: none"><li>1. Chris Manning et al, <i>Foundation of statistical natural language processing</i>, MIT Press (1999) ISBN: 0262133601</li><li>2. Ian Goodfellow, Yoshua Bengio, and Aaron Courville. <i>Deep Learning</i>. MIT Press. ISBN: 9780262035613</li></ol>
<b>Recommended References &amp; Supplemental Material</b>	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, <i>Speech and Language Processing</i> , Prentice Hall, 2009. ISBN: 9780131873216



Teaching Week	Topics
1	<b>Introduction to Natural Language Processing (NLP)</b> <b>Lecture</b> <ul style="list-style-type: none"><li>• What is NLP and its motivations</li><li>• Stages of language processing</li><li>• Challenges of NLP</li></ul> <b>Lab</b> <ul style="list-style-type: none"><li>• Get familiar with Python programming</li><li>• Practice NLTK and Numpy library</li></ul>
2	<b>Language Modeling</b> <b>Lecture</b> <ul style="list-style-type: none"><li>• The language modeling problem</li><li>• Trigram model</li><li>• Evaluation of language models</li></ul> <b>Lab</b> <ul style="list-style-type: none"><li>• Text processing practice: sentence segmentation, word tokenization, stemming and lemmatization, preparation of dictionary, etc.</li><li>• Implement a tri-gram model</li></ul>
3	<b>Tagging, and Hidden Markov Model</b> <b>Lecture</b> <ul style="list-style-type: none"><li>• Understanding tagging problems: PoS tagging, chunking and NER tagging</li><li>• Hidden Markov Model (HMM)</li><li>• Parameter estimation of HMM</li><li>• Using HMM for tagging problems</li></ul> <b>Lab</b> <ul style="list-style-type: none"><li>• Programming exercises on employing HMM for PoS tagging</li><li>• Assignment 1</li></ul>
4	<b>Log-Linear Models</b> <b>Lecture</b> <ul style="list-style-type: none"><li>• Motivation for the log-linear model</li><li>• Generative vs Discriminative model</li><li>• Log-linear model</li><li>• Feature templates</li><li>• Features for the language modelling and Named Entity Recognition (NER)</li><li>• Maximum likelihood estimation</li></ul> <b>Lab</b> <ul style="list-style-type: none"><li>• Programming exercises to implement log-linear model for PoS tagging problem</li><li>• Compare the performance of log-linear model with HMM's performance</li></ul>



Teaching Week	Topics
5	<b>Maximum Entropy Markov model and conditional random field</b> <b>Lecture</b> <ul style="list-style-type: none"><li>• Maximum-Entropy Markov models (MEMMs)</li><li>• Conditional random field (CRF)</li><li>• MEMMs and CRF for PoS tagging/NER</li></ul> <b>Lab</b> <ul style="list-style-type: none"><li>• Programming exercises for employing CRF on NER tasks</li><li>• Improve the performance of the model using domain specific features</li></ul>
6	<b>Parsing and Context-free Grammars</b> <b>Lecture</b> <ul style="list-style-type: none"><li>• An introduction to the parsing problem</li><li>• Context-free grammars (CFG)</li><li>• Syntax of English</li><li>• Examples of ambiguous structures</li><li>• Probabilistic context-free grammars (PCFG)</li><li>• The CKY algorithm for parsing with PCFGs</li><li>• Weaknesses of PCFGs</li></ul> <b>Lab</b> <ul style="list-style-type: none"><li>• Programming exercises for using existing NLP tools (CoreNLP/NLTK) and obtaining the syntactic parsing of the text.</li></ul>
7	<b>Lexicalized Context-free Grammar</b> <b>Lecture</b> <ul style="list-style-type: none"><li>• Lexicalization of a treebank</li><li>• Lexicalized PCFG</li><li>• Parameter estimation in lexicalized PCFG</li></ul> <b>Lab</b> <ul style="list-style-type: none"><li>• Problem-solving related to PCFG</li></ul>
8	<b>Revision</b> <b>Lecture and Lab</b> <ul style="list-style-type: none"><li>• Review and Exam Preparation</li></ul>



Teaching Week	Topics
9	<b>Feedforward Neural Networks</b> <b>Lecture</b> <ul style="list-style-type: none"><li>• Neural network</li><li>• Recall log-linear model</li><li>• Introducing learned representations</li><li>• Single-layer feedforward network</li><li>• Multi-layer feedforward network</li></ul> <b>Lab</b> <ul style="list-style-type: none"><li>• Demonstration and familiarization with deep learning libraries</li><li>• Assignment 2</li></ul>
10	<b>Computational Graphs, and Backpropagation</b> <b>Lecture</b> <ul style="list-style-type: none"><li>• Introduction to multi-layer neural network</li><li>• Chain rule</li><li>• Computation graph for the feedforward network</li><li>• Backpropagation algorithms</li><li>• Regularization and weight initialization of the neural network</li></ul> <b>Lab</b> <ul style="list-style-type: none"><li>• Programming exercises for employing a multi-layer feedforward network on PoS tagging and NER tasks</li><li>• Assignment 3</li></ul>
11	<b>Word Embeddings in Feedforward Networks</b> <b>Lecture</b> <ul style="list-style-type: none"><li>• Neural probabilistic language model (NPL)</li><li>• Word embedding</li><li>• Application of word embedding</li><li>• Limitation of NPL</li></ul> <b>Lab</b> <ul style="list-style-type: none"><li>• Programming exercises for implementing NPL</li><li>• Employ the learned word embedding in existing neural NER model</li></ul>
12	<b>Tagging and Dependency Parsing using Feedforward Networks</b> <b>Lecture</b> <ul style="list-style-type: none"><li>• Neural CRF model for tagging problem</li><li>• Dependency parsing using a shift-reduce neural-network model</li></ul> <b>Lab</b> <ul style="list-style-type: none"><li>• Programming exercises for employing CRF on the existing neural NER models</li></ul>



Teaching Week	Topics
13	<b>Recurrent Networks, and LSTMs, for NLP</b> <b>Lecture</b> <ul style="list-style-type: none"><li>• A simple recurrent network</li><li>• Exploding and vanishing gradients problem</li><li>• LSTM and GRU network</li><li>• Application of RNNs in NLP</li></ul> <b>Lab</b> <ul style="list-style-type: none"><li>• Programming exercises for using LSTM in text classification task</li><li>• Assignment 4</li></ul>
14	<b>Convolution Neural Networks for NLP</b> <b>Lecture</b> <ul style="list-style-type: none"><li>• A simple Convolution Neural Network (CNN)</li><li>• From RNNs to CNNs</li><li>• Attention method</li><li>• Applications of CNNs in NLP</li></ul> <b>Lab</b> <ul style="list-style-type: none"><li>• Programming exercises for employing CNN on the text classification task</li></ul>
15	<b>Neural Machine Translation</b> <b>Lecture</b> <ul style="list-style-type: none"><li>• Introduction to the machine translation problem</li><li>• Sequence to sequence model</li><li>• LSTM for encoding and decoding a sequence</li><li>• Incorporating the attention mechanism for decoding a sequence</li></ul> <b>Lab</b> <ul style="list-style-type: none"><li>• Programming exercises for using a sequence to sequence model on machine translation tasks</li></ul>