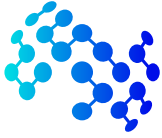


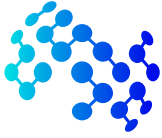
## Core Courses Syllabi

### NLP703 - Speech Processing

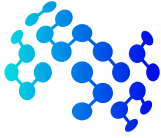
<b>Title</b>	Speech Processing
<b>Code</b>	NLP703
<b>Loading</b>	4 Credit-hours
<b>Prerequisites</b>	<ul style="list-style-type: none"> <li>• Basic Concepts in Linear Algebra, Calculus, Probability and Statistics</li> <li>• Programming in Python or similar language</li> </ul>
<b>Catalog Description</b>	This course provides a comprehensive introduction to Speech Processing. It builds upon fundamental concepts in Speech Processing and assumes familiarization with Mathematical and Signal Processing concepts.
<b>Goal</b>	This graduate level course aims to equip students with deep understanding of foundations of core speech processing algorithms.
<b>Content</b>	The course covers the following major modules: <b>(I)</b> Speech Recognition, <b>(II)</b> Speech Synthesis and <b>(III)</b> Dialogue and Conversational System
<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:</li> </ol>
<b>Recommended References &amp; Supplemental Material</b>	<p>Relevant research papers, technical reports, and surveys for each topic, where needed, are identified in the teaching plan ahead. In addition, the following textbook may be useful:</p> <p>C. Bishop, <i>Pattern Recognition and Machine Learning</i>, Berlin: Springer-Verlag, 2006. ISBN: 0387310738</p>



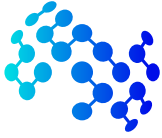
Teaching Week	Topics
1	<p><b>Course Overview</b></p> <p><b>Lecture</b></p> <ul style="list-style-type: none"><li>• Introduction to speech processing, digitization and recording of the speech signal.</li><li>• Overview of speech processing applications</li></ul> <p><b>Lab</b></p> <ul style="list-style-type: none"><li>• Demonstration of the development platform and libraries used for speech and language processing (e.g. Tensorflow, PyCharm, Pure Data)</li><li>• Warm-up exercise for Python and Jupyter Notebook</li><li>• Start <b>Project</b></li></ul>
2	<p><b>Speech Processing: Basics</b></p> <p><b>Lecture</b></p> <ul style="list-style-type: none"><li>• Acoustic phonetics and articulatory phonetics (The International Phonetic Alphabet, IPA)</li><li>• The syllable</li><li>• Consonants and vowels</li><li>• Phonetic transcription</li><li>• Machine-readable phonetic alphabets</li></ul> <p><b>Lab</b></p> <ul style="list-style-type: none"><li>• Assignment 1</li></ul>
3	<p><b>Speech Processing: Human Speech Production System</b></p> <p><b>Lecture</b></p> <ul style="list-style-type: none"><li>• Introduction of the human speaking system, including the vocal tract, the palate and lips etc.</li><li>• Introduce Uniform Tube Modeling in speech production</li><li>• Introduce voiced and unvoiced segments, first and second formant</li></ul> <p><b>Lab</b></p> <ul style="list-style-type: none"><li>• Assignment 1</li></ul>
4	<p><b>Speech Processing: Human Speech Perception System</b></p> <p><b>Lecture</b></p> <ul style="list-style-type: none"><li>• Introduction of the basic mechanisms of human hearing, including the ear canal, eardrums and pinna, etc</li><li>• Description of action of the cochlea</li></ul> <p><b>Lab</b></p> <ul style="list-style-type: none"><li>• Basic programming exercises for using tools for speech synthesis (e.g. implementing the Holmes parallel formant synthesizer)</li></ul>



Teaching Week	Topics
5	<p><b>Speech Signal Analysis: Forms of the Speech Signal</b></p> <p><b>Lecture</b></p> <ul style="list-style-type: none"><li>• Describe the different forms of signals</li><li>• Discrete/continuous signal</li><li>• Signal Processing</li><li>• Sensors/transducers</li><li>• Microphones</li><li>• Periodic signals (sines &amp; cosines)</li><li>• White noise</li><li>• Stationarity</li></ul> <p><b>Lab</b></p> <ul style="list-style-type: none"><li>• Assignment 2</li></ul>
6	<p><b>Speech Signal Analysis: Feature Representation</b></p> <p><b>Lecture</b></p> <ul style="list-style-type: none"><li>• Overview of techniques for representing speech Signal as features</li><li>• Feature extraction, extraction of the fundamental frequency</li><li>• Harmonics</li><li>• The spectrum</li><li>• The complex spectrum</li><li>• Impulse response</li><li>• The source-filter model of speech</li></ul> <p><b>Lab</b></p> <ul style="list-style-type: none"><li>• Programming exercise for feature extraction from the speech signal</li><li>• Assignment 2</li></ul>
7	<p><b>Speech Signal Analysis: Models</b></p> <p><b>Lecture</b></p> <ul style="list-style-type: none"><li>• Overview of different techniques used for speech signal analysis</li><li>• Waveform analysis</li><li>• Spectrographic analysis</li><li>• Binaural processing</li><li>• Fourier Transform</li></ul> <p><b>Lab</b></p> <ul style="list-style-type: none"><li>• Programming exercises for implementation of Fourier Transform</li></ul>



Teaching Week	Topics
8	<b>Revision</b> <b>Lecture and Lab</b> <ul style="list-style-type: none"><li>• Project Work</li><li>• Assignment 2</li></ul>
9	<b>Speech recognition: Basics</b> <b>Lecture</b> <ul style="list-style-type: none"><li>• Introduction of basic speech recognition models</li><li>• Noisy Channel Model</li><li>• Hidden Markov Models</li><li>• Word error rate (evaluation method)</li></ul> <b>Lab</b> <ul style="list-style-type: none"><li>• Programming exercises for implementation of Hidden Markov Model</li></ul>
10	<b>Speech Recognition: Advanced</b> <b>Lecture</b> <ul style="list-style-type: none"><li>• Introduction to advanced speech recognition models</li><li>• Forward and backward Viterbi</li><li>• Advanced decoding</li><li>• Finite State Transducers</li><li>• Gaussian mixture model</li></ul> <b>Lab</b> <ul style="list-style-type: none"><li>• Programming exercises for implementation of the Forward and backward Viterbi decoding algorithm</li></ul>
11	<b>Neural Speech Recognition: Basics</b> <b>Lecture</b> <ul style="list-style-type: none"><li>• Introduction to neural network acoustic modellings</li><li>• Multi-layer Feedforward Neural Network</li><li>• Recurrent Neural Networks (RNNs)</li><li>• Convolutional Neural Networks</li></ul> <b>Lab</b> <ul style="list-style-type: none"><li>• Programming exercises for implementation of MLP</li></ul>



Teaching Week	Topics
12	<p><b>Neural Speech Recognition: End-to-end Neural Network Speech Recognition</b></p> <p><b>Lecture</b></p> <ul style="list-style-type: none"><li>• Description of the processing pipeline used in practical speech recognition systems, covering neural models used in individual modules in the pipeline, from signal extraction to speech recognition</li></ul> <p><b>Lab</b></p> <ul style="list-style-type: none"><li>• Assignment 3</li></ul>
13	<p><b>Conversational Agents System: Introduction and Frame-based Dialogue</b></p> <p><b>Lecture</b></p> <ul style="list-style-type: none"><li>• Overview of different conversational systems (e.g. goal oriented v.s conversation systems)</li><li>• Description of the techniques used for frame extraction and recognition in corpora</li><li>• Semantic Parsing</li><li>• Conditional Random Field</li></ul> <p><b>Lab</b></p> <ul style="list-style-type: none"><li>• Programming exercises for implementation of semantic parser</li></ul>
14	<p><b>Conversational Agents System: Utterance Understanding, Dialogue Management and Response Generation</b></p> <p><b>Lecture</b></p> <ul style="list-style-type: none"><li>• Models for dialog act classification (e.g. statement, rephrase, questions, etc.)</li><li>• Frameworks for dialogue management</li><li>• Markov Decision Processes</li><li>• Information state</li><li>• Reinforcement learning</li></ul> <p><b>Lab</b></p> <ul style="list-style-type: none"><li>• Programming exercises for implementation of dialog act classifier</li></ul>
15	<p><b>Conversational Agents System: Neural Approaches used in Conversational Agents System</b></p> <p><b>Lecture</b></p> <ul style="list-style-type: none"><li>• Introduction to neural networks models used in conversational agents systems</li><li>• Sequence to sequence neural models</li></ul> <p><b>Lab</b></p> <ul style="list-style-type: none"><li>• Review and exam preparation</li><li>• Assignment 4</li></ul>