Intelligent Signal Processing

Introduction to the course

Angelo Ciaramella

The course

- 6 training credits (CFU)
  - Part 1 (3 CFU)
    - Teacher – Angelo Ciaramella
  - Part 2 (3 CFU)
    - Teacher – Danilo Greco

- Theoretical part
  - Frontal lectures
  - Practices
    - theoretical
    - laboratory

The course

- Examination
  - Practical project
    - Topic chosen by the student
    - Term paper
  - Oral interview
    - Presentation
    - Project simulation

Lecture timetable

- Lecture Timetable
  - Tuesday
    - 4:00 p.m. - 6:00 p.m. – Lab 2
  - Wednesday
    - 2:00 p.m. - 4:00 p.m. – Lab 1
- Office hours
  - Tuesday
    - 2:00 p.m. - 4:00 p.m.
  - "On demand"
    - via e-mail

Objectives of the course

- The course provides the basic theoretical and practical foundations for Signal Processing (SP) using Artificial Intelligence based methodologies

  - Signal Processing
    - Audio, Images and Video processing
    - Information theory

  - Advanced Signal Processing
    - Signal denoising
    - Sparse coding and Compressive Sensing
    - Blind Source Separation
    - Acoustic beamforming
    - Direction of Arrival

  - Artificial Intelligence
    - Machine Learning, Deep Learning and Computational Intelligence based models

Teaching materials

- Recommended books
  - Signal Processing
    - Discrete-time signal processing, Alan V. Oppenheim, R. W. Schafer; J.R. Buck, Upper Saddle River, N.J., Prentice Hall, 1999, ISBN 0-13-754920-2
    - Probability, Random Variables and Stochastic Processes, Papoulis, Athanasios; Pillai, S. Unnikrishna (4° ed.) (2002), Boston: McGraw Hill. ISBN 0-07-366011-6
    - Information Theory, Inference and Learning Algorithms, MacKay, David J. C., Cambridge: Cambridge University Press., 2003, ISBN 9780521642989
  - Artificial Intelligence
    - Fuzzy Logic with Engineering Applications, T. J. Ross, 4th Edition, 2016
    - Pattern Recognition and Machine Learning, C. M. Bishop, Springer, 2006
    - Deep Learning, I. Goodfellow, Y. Bengio, A. Courville, MIT Press, 2016
  - Further readings will be suggested later
- Lecture notes
  - e-learning material

Syllabus

- Introduction to Multimedia
  - Basics of Audio, Image and Video
  - Data representations
- Signal processing
  - Signal Digitization
  - Signal Frequency Transforms
  - Filtering
  - Audio Sound Effects
  - Audio Synthesis

Syllabus

- Stochastic Processes
  - Spectral estimation
  - Filtering and prediction
  - Kalman filters

- Information theory
  - Basics of Information Theory and Inference
  - Integrated information theory
  - Brief hint on
    - Shannon's Source Coding Theorem
    - Shannon's Noisy-Channel Coding Theorem

Syllabus

- Basics of Compression
  - JPEG compression for Images
  - MPEG compression for Audio and Video

- Advanced Signal Processing
  - AI based Denoising
    - ECG and EEG
  - Sparse coding and Compressive Sensing
    - Packet Loss in Streaming
    - Bioinformatics
  - Blind Source Separation
  - Acoustic beamforming
  - Direction of Arrival

Syllabus

- Soft Computing based Methodologies
  - Fuzzy Logic for Information Retrieval
  - Neuro-Fuzzy based Systems for DSP
  - Music Emotion Recognition
- Practical applications
  - Python
    - scipy.signal
  - Colab