MSE | MASTER OF SCIENCE IN ENGINEERING

Module Description

Analysis of Sequential Data

General Information

Number of ECTS Credits

3

Module code

TSM_AnSeqDa

Responsible of module

Giorgio Corani, SUPSI

Language

Explanations regarding the language definitions for each location:

- Instruction is given in the language defined below for each location/each time the module is held.
- Documentation is available in the languages defined below. Where documents are in several languages, the percentage distribution is shown (100% = all the documentation).
- The examination is available 100% in the languages shown for each location/each time it is held.

	Berne	Lausanne			Lugano	Zurich		
Instruction	☐ E 100%	☐ E 100%		☐ F 100%	☐ E 100%	☑ E 100%		☐ D 100%
Documentation	☐ E 100%	☐ E 100%	☐ E %	☐ F %	☐ E 100%	☑ E 100%	☐ E %	☐ D %
Examination	☐ E 100%	☐ E 100%	☐ E 100%	☐ F 100%	☐ E 100%	☑ E 100%	☐ E 100%	☐ D 100%

Module category

FTP Fundamental theoretical principles

☑ TSM Technical/scientific specialization module

CM Context module

Lessons

2 lecture periods and 1 tutorial period per week.

Entry level competencies

Prerequisites, previous knowledge

Basic knowledge in statistics and signal processing.

Programming skills (preferably R and Python).

Brief course description of module objectives and content

Many data sets are temporal by nature, i.e. time series. Typical tasks faced by data scientists are: analyzing time series in different domains and developing statistical models based on the data, in order to forecast future values or classify the time series into predefined categories.

This course provides a comprehensive introduction to analysis, forecasting and classification of sequential data. The course adopts a practical approach: theoretical concepts are illustrated and applied in specific case studies. Students will also learn to identify the tools best suited for a given task.

The first part of the course presents a survey of the state-space approach to exponential smoothing, which currently achieves state-of-the-art performance in time series forecasting. It starts from the simpler exponential smoothing model and makes it more realistic by adding trend components, seasonal components, and so on. The techniques are applied to real data set containing hundreds of related time series.

In the second part of the course students learn how to analyze digital signals in different domains, i.e. time and spectral domain; they learn how to extract meaningful features from digital signals suitable for classification. Finally, they learn how to set up and learn statistical models, such as HMMs or DNNs, for recognizing and classifying time series.

Aims, content, methods

Learning objectives and acquired competencies

- Students know how to model trends, seasonalities and non-stationarities in time series based on state-space model exponential smoothing.
- Students know the overlapping between exponential smoothing and ARIMA models.
- Students know how to perform model estimation, model selection and prediction (including prediction intervals) with these models.

- Students know how to visualize time series and forecasts, and how to evaluate forecast accuracy
- Students know different methods to analyse digital signals in different domains
- Students know how to extract important features used in speech processing
- Students learn to apply Bayes rule for classifying digital signals.
- Students can apply modern deep learning approaches to classify digital signals

Contents of module with emphasis on teaching content

Part 1: Forecasting sequential data (7 weeks)

- Exponential smoothing: the state-space approach
    - Model identification and model selection
    - Overlapping with ARIMA models
    - Predictive distribution and assessment of the predictions.
- Analysis of hierarchical time series

Part 2: Analysis and classification of digital signals (7 weeks)

- Analysis of digital signals in different domains (1 week)
- Feature extraction (1 week)
- Modelling, classification & recognition of digital signals (5 weeks)
    - Classic Approaches: Dynamic Time Warping, Vector Quantization
    - Statistical modelling: Hidden Markov Models
    - Deep Learning Approaches

The contents are illustrated and applied in practical case studies using computational environments such as R or Python.

Teaching and learning methods

- Ex cathedra
- Self study of literature / publications
- Practical exercises with computer

Literature

Slides will be available covering the topics of the course.

In addition, recommended books are:

R. Hyndman et al., Forecasting with Exponential Smoothing, Springer, 2008

A. V. Oppenheim and R. W. Schafer, Discrete-time signal processing. Prentice Hall International Inc., 1989.

L. R. Rabiner und B.-H. Juang, Fundamentals of Speech Recognition. Prentice Hall, 1993.

D. Yu und L. Deng, Automatic Speech Recognition: A Deep Learning Approach. Springer London, 2014.

Assessment

Certification requirements for final examinations (conditions for attestation)

None.

Basic principle for exams:
All the standard final exams for modules are written exams.
The repetition exams can be either written or oral.

Standard final exam for a module and written repetition exam

Kind of Exam	Written
Duration of exam	120 minutes
Permissible aids	Handwritten summary pages

Special case: Repetition exam as an oral exam

If an oral exam is set (only possible for ≤ 4 students), the following applies:

Kind of Exam	oral
Duration of exam	30 minutes
Permissible aids	closed book = no aids