

**Module Description, available in: EN**

## *Analysis of Sequential Data*

### General Information

**Number of ECTS Credits**

3

**Module code**

TSM\_AnSeqDa

**Valid for academic year**

2024-25

**Last modification**

2023-11-12

**Coordinator of the module**

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**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.

	Lausanne	Lugano	Zurich
<b>Instruction</b>	X E 100%		
<b>Documentation</b>	X E 100%		
<b>Examination</b>	X E 100%		

**Module Category**

TSM Technical scientific module

**Lessons**

2 lecture periods and 1 tutorial period per week

### Entry level competences

**Prerequisites, previous knowledge**

Basic knowledge in statistics.  
Programming with scripting languages.

### Brief course description of module objectives and content

Many data sets are temporal by nature.

The first part of the course presents techniques for analysis of time series. It starts from visualization techniques; then it shows techniques for characterizing trend and seasonality; eventually it present structured statistical approaches based on exponential smoothing and arima techniques. Several examples referring to real data sets are shown.

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.

The course adopts a practical approach: theoretical concepts are illustrated and applied in specific case studies.

A probabilistic approach is emphasized throughout the course.

The labs are done using environments for scientific programming such as R or Matlab or Python.

## Aims, content, methods

### Learning objectives and acquired competencies

- Students know how to visualize time series and how to characterize their main features.
- Students know how to evaluate forecast accuracy.
- Students know how to model trends, seasonalities and non-stationarities adopting exponential smoothing and ARIMA models.
- Students know how to perform model estimation, model selection and probabilistic prediction with these models.
- 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

- Time series graphics.
- Main features of time series.
- Assessment of the predictions.
- Exponential smoothing
- ARIMA models

Practical case studies.

#### Part 2: Analysis and classification of digital signals

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

Practical case studies.

### Teaching and learning methods

- Ex cathedra
- Self study
- Practical exercises with computer
- Graded homeworks / project.

### Literature

Slides will be available covering the topics of the course.

In addition, recommended books are:

*For forecasting:*

R. Hyndman and G. Athanasopoulos., Forecasting: Principles and Practice, Springer, 2018 (online free textbook at <https://otexts.org/fpp2/>)

*For digital signal processing:*

X. Huang, A. Acero, H.-W. Hon: Spoken Language Processing, Prentice Hall, 2001, ISBN 0-13-22616-5

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

Module uses certification requirements

### Certification requirements for final examinations (conditions for attestation)

The students will be required to do a small project and some graded homeworks. Such activities will determine 20% of the final grade.

### Basic principle for exams

**As a rule, all the standard final exams for modules and also all resit exams are to be in written form**

### Standard final exam for a module and written resit exam

#### Kind of exam

written

#### Duration of exam

120 minutes

#### Permissible aids

*Aids permitted as specified below:*

#### Permissible electronic aids

Scientific calculator

#### Other permissible aids

2 Handwritten summary sheets

### Special case: Resit exam as oral exam

#### Kind of exam

oral

#### Duration of exam

30 minutes

#### Permissible aids

No aids permitted