

# SYLLABUS

**Name:** Models With Hidden Data (MakAu-DS>SM2MWHD19)

**Name in Polish:**

**Name in English:** Models With Hidden Data

## Information on course:

**Course offered by department:** Faculty of Automatic Control, Electronics and Computer Science

**Course for department:** Silesian University of Technology

## Default type of course examination report:

ZAL

## Language:

English

## Short description:

The aim of the course is making students familiar with issues related to statistical models with hidden variables.

## Description:

ECTS: 2

Total hours: 60h (contact: 30h / self-study: 30h)

\* lecture: 15h

\* laboratories: 15h

## Student's self-study work:

Reviewing the literature and preparing for the laboratories.

## Lectures:

1. Introductory issues. Notions of missing, latent, hidden variables in data analyses. Examples of problems involving latent variables in science, engineering, optimization, parameter estimation.
2. Mixtures of Gaussian distributions. Parameters. Gaussian components. Component parameters. Component index as latent variable. Bayesian formula for computing conditional distribution of latent variables. Intuitive derivation of estimates of component parameters.
3. General expectation maximization algorithm for iterative likelihood maximization. Complete observations, incomplete observations, latent observations. Conditional distribution of hidden variables given data and parameters guess. Integral formula for log likelihood. Expectation step. Maximization step. Jensen's inequality. Properties of the EM algorithm.
4. EM algorithm for mixtures of distributions. EM algorithm for censored data.
5. Probabilistic latent semantic analysis. Co-occurrence tables. Aspect model. Latent semantic analysis. Application of the EM algorithm.
6. Markov models with latent states. Hidden Markov models. Baum – Welch algorithm.
7. Mixtures of Markov models and hidden Markov models.

## Laboratories:

1. Mixtures of normal distributions
2. Probabilistic latent semantic analysis
3. Mixtures of Markov models and hidden Markov models.

## Bibliography:

G.J. McLachlan, T Krishnan, (2008), The EM Algorithm and Extensions, Wiley

G.J. McLachlan, D. Peel, (2000), Finite Mixture Models, Wiley

C.M. Bishop, (2006), Pattern Recognition and Machine Learning, Springer

## Learning outcomes:

### Knowledge – the student:

- Knows and understands the concepts of missing, latent, and hidden variables, and can explain their role in parameter estimation, optimization, and probabilistic modeling tasks. (K2A\_W05)
- Possesses advanced knowledge of mixture models, the EM algorithm, Markov models, and hidden Markov models, as well as their applications in data analysis. (K2A\_W05)
- Knows advanced programming tools and methods of computer simulation used for analyzing mixture models, PLSA, and Markov models, including numerical techniques applied in the implementation of the EM algorithm.(K2A\_W12)

### Skills – the student:

- Is able to appropriately select sources of theoretical and practical knowledge concerning mixture models, PLSA, and HMMs, critically analyze them, and present conclusions in a creative and synthetic manner. (K2A\_U01)
- Can select and apply appropriate computational methods and tools, including advanced information and communication technologies, for implementing EM, PLSA, and Markov model algorithms. (K2A\_U01, K2A\_W12)
- Is capable of formulating and solving complex data analysis problems involving latent variables, particularly through proper construction of probabilistic models and parameter estimation. (K2A\_U01)
- Can communicate effectively with diverse audiences on topics related to probabilistic models, their interpretation, and their applications in data analysis. (K2A\_U02)
- Is able to plan and conduct numerical experiments, including simulations of mixture models, PLSA, and Markov models, analyze obtained results, and draw well-founded conclusions. (K2A\_U07, K2A\_W12)
- Can implement EM algorithms for various models (mixtures, PLSA, HMMs) and assess their effectiveness based on computational experiments. (K2A\_U01, K2A\_U07)

## Assessment methods and assessment criteria:

During the last lecture session, a test is held, and its result constitutes the lecture grade. A report must be prepared for each laboratory class, and each report is graded. The laboratory grade is the arithmetic mean of all the grades obtained for the laboratory classes. The

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final grade is the average of the lecture grade and the laboratory grade.

This syllabus is valid from the academic year 2025/26. Its content is not subject to modification during the semester.

**Course credits in various terms:**

**<without a specific program>**

Type of credits	Number	First term	Last term
European Credit Transfer System (ECTS)	2	2020/2021-Z	