02433 – Course overview

General information

Description
The course introduces the basics of hidden Markov models and enables the student to apply the methodology to time series problems. The methods presented in the course are illustrated with exercises and examples from the real world.

Scope and form
Web-based course relying on self study by the student. There will be no face to face confrontation with a teacher. Instead the student is expected to read the book and the supplementary slides uploaded to the course web-page (www.imm.dtu.dk/courses/02433). The student is furthermore expected to solve exercises related to each chapter, some of which have solutions provided on the course web-page. Questions related to the course should be emailed to the teacher. If the teacher finds that the question is relevant to all students it is posted on campusnet along with the response.

The student is expected to solve three larger written assignments given during the course and hand in the solutions as written reports. These will be the basis for the final oral exam. Assigment questions marked with a "$\star$" are voluntary, unless you are taking the Ph.D. version of the course, or you are working in a group with two or more students, in which case the $\star$-questions are mandatory.

In determining the final grade of the student the three reports will weigh 60% (20% each) and the oral examination will weigh 40%.

Duration of course
13 weeks.

Examination
The examination will be held at the DTU main campus in Lyngby. The student will draw one of the three written reports, and the examination will begin immediately (no preparation time). The student should then in advance have prepared a small presentation of the report (5-10 min) where the purpose of the report is discussed, the approaches taken to solve the questions are explained, and findings are presented. In discussing the report the student should be aware of possible alternative approaches to solve the questions. It is recommended to present the key results and figures in a slide show (beamer, power point or similar). The bring their own laptop (a screen will be available), or alternatively bring the presentation on a USB stick. Toward the end of the examination if time permits the student may be asked a couple of questions in the remaining curriculum. The total examination time will be 15-20 mins including time for deliberations.

Evaluation
The Danish 7-step scale. Grades in order of decreasing evaluation: 12, 10, 7, 4, 02, 00, -3.

Qualified prerequisite DTU courses

02417 - Time series analysis.

Optional/recommended prerequisite DTU courses
02407 - Stochastic processes.

Textbook
Zucchini W. and MacDonald I.L. – 2009 (referred to as Zucchini09).
Home-page: http://134.76.173.220/hmm-with-r/
The home-page contains (among other things) all the R scripts found in the appendix of the book, and all data sets used in the book.

Course responsible
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Curriculum

Chapters 1-6, 8 in Zucchini09 including supplementary slides, all additional notes and examples uploaded to the course website, written reports 1-3.

- Week 1

Chapter 1: Preliminaries: mixtures and Markov chains.
Suggested exercises: 3, 6, 8, 10 (12, 15). Numbers in parentheses have no provided solution.

- Week 2

Chapter 2: Hidden Markov models: definition and properties.
Suggested exercises: 1, 2, 6, 9, 11

- Week 3

Chapter 3: Estimation by direct maximization of the likelihood.
Suggested exercises: 2, 5, 7, 8

First of three larger exercises is handed out – report to be handed in at the beginning of course week 7.

- Week 4

Chapter 4: Estimation by the EM algorithm.
Suggested exercises: 5, 6

- Week 5

Chapter 5: Forecasting, decoding and state prediction.
Suggested exercises: 1, 4, 6

- Week 6

Chapter 6: Model selection and checking.
Suggested exercises: 1, 4, 5

- Week 7

Section 13.3.1 and course notes about analysing state-space models with HMMs.

Second of three larger exercises is handed out – report to be handed in at the beginning of course week 11.

- Week 8

Chapter 8: Extensions of the basic hidden Markov model.
Suggested exercises: 3, 5, 9

- Week 9

An example where HMMs are used to analyse DNA copy number data.

- Week 10

An example where HMMs are used to analyse data from the wind power production of the offshore wind farm Horns rev 1.
Suggested exercises: See end of week 10 example slides.

- Week 11

Chapter 12: Wind direction at Koeberg. **Focus:** HMMs with covariate information.

Third and final of three larger exercises is handed out – report to be handed in by the week after course week 13.

- Week 12

Chapter 16: A model for animal behaviour which incorporates feedback. Cursory reading: Altman, R.M. (2007). *Mixed hidden Markov models: An extension of the hidden Markov model to the longitudinal data setting.* JASA, 102, 201-210. **Focus:** Feedback and mixed HMM.

- Week 13

An example where HMMs are used to estimate the geographical location of fish from indirect observations.