Weekly Learning Plan — MATH20802

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Overview

General plan

This module is taught based on the concept of "flipped learning":

1) First, you study the asynchronous material by yourself:
   i) read the lecture notes,
   ii) watch the lecture videos and
   iii) try to solve the questions and problems given in the worksheets and study their solutions.

For each of the semester weeks 1–12 the following pages provide a detailed list which material you will need to study in a specific week.

2) Subsequently, you attend the live synchronous sessions:
   i) the review lecture and
   ii) the tutorial session.

The review lecture recapitulates the key content from the lecture notes and videos each week. The tutorial session discuss the questions and problems in an interactive fashion.

Links

You can find the course material both on Blackboard and on the MATH20802 course homepage. There can also find the scheduled times and locations for the two weekly live sessions.

Workload

For this course you will need to spend about 6-8 hours study each week:

- 2-3h watching videos, reading and understanding lecture notes
- 2-3h working on the problems in the worksheets
- 2h attending live sessions

The in-semester assessment in Week 6 will be a 40 minute online test.

Week 1 (from 8 February 2021)

LN: lecture notes — view online
Video: lecture videos — view online
Worksheets: download worksheets

Topics:

In this week first a broad overview over the course content and course organisation is given. Next, we provide a refresher of the statistical concepts required as foundation for this module.

Study:

Video 1 Introduction to the course
LN Chapter 1

Video 2 Refresher of statistics
LN Appendix

Problem solving:

No worksheet this week

There are no tutorials in the first week of the course.

Week 2 (from 15 February 2021)

LN: lecture notes — view online
Video: lecture videos — view online
Worksheets: download worksheets

Topics:

In this week we study entropy and its close link to maximum likelihood. Specifically, we discuss the properties of relative entropy, also known as Kullback-Leibler (KL) divergence, and show how it gives rise to the method of maximum likelihood. We also introduce the expected Fisher information as local approximation of the KL divergence.

Study:

Video 3 Entropy and Kullback-Leibler divergence
Video 4 Expected Fisher information
Video 5 Entropy learning and maximum likelihood
LN Chapter 2

Problem solving:

Worksheet 1

Week 3 (from 22 February 2021)

LN: lecture notes — view online
Video: lecture videos — view online
Worksheets: download worksheets

Topics:

In this week we study maximum likelihood estimation in more detail and illustrate the approach by a number of worked examples. Furthermore, the observed Fisher information is introduced.

Study:

Video 6 Principles of maximum likelihood estimation
Video 7 Observed Fisher information
LN Chapter 3

Problem solving:

Worksheet 2

Week 4 (from 1 March 2021)

LN: lecture notes — view online
Video: lecture videos — view online
Worksheets: download worksheets

Topics:

In this week we introduce the covariance and correlation matrix as well as the multivariate normal distribution. Subsequently, we investigate second order approximation of the log-likelihood function and the asymptotic normality of maximum likelihood estimates. Furthermore, we demonstrate how the normal approximation can be used to construct corresponding confidence intervals, and also discuss a case where the quadratic approximation is not available.

Study:

Video 8 Quadratic approximation and normal asymptotics
Video 9 Normal-approximation interval estimation
Video 10 Non-regular models
LN Chapter 4

Problem solving:

Worksheet 3

Week 5 (from 8 March 2021)

LN: lecture notes — view online
Video: lecture videos — view online
Worksheets: download worksheets

Topics:

In this week we show how to compute likelihood-based confidence intervals, a generalisation of normal-based intervals. We also introduce the likelihood ratio and likelihood ratio tests, and also discuss generalised likelihood ratio statistics. Finally, we discuss optimality properties of maximum likelihood. This concludes Part I of the module about maximum likelihood estimation and inference.

Study:

Video 11 Likelihood ratio and likelihood-based interval estimation
Video 12 Generalised likelihood ratio test
LN Chapter 5

Video 13 Optimality properties of maximum likelihood and summary
LN Chapter 6

Problem solving:

Worksheet 4

Week 6 (from 15 March 2021)

LN: lecture notes — view online
Video: lecture videos — view online
Worksheets: download worksheets

Topics:

In this week this week we begin with Part II of the module on Bayesian statistics and provide an overview over the elements of Bayesian learning. As a first example we study how to estimate a proportion in the Bayesian statistical framework using a Binomial likelihood and a Beta prior distribution. In this week there is also the midterm test about the contents of Part I of the module.

Study:

Video 14 Introduction to Bayesian learning
LN Chapter 7

Video 15 Bayes model for a proportion
LN Chapter 8

Problem solving:

No worksheet this week

There are no tutorials this week.

In-semester assessment:

The online midterm test takes place this week. Further details are found on Blackboard.

Week 7 (from 22 March 2021)

LN: lecture notes — view online
Video: lecture videos — view online
Worksheets: download worksheets

Topics:

In this week we continue with the study of Bayesian statistics and first discuss general properties of Bayesian learning as illustrated by the Beta-Binomial model. Subsequently we introduce two further standard Bayesian models: i) for estimating the mean using a Normal likelihood and a Normal prior distribution and ii) for estimating the variance using a Normal likelihood and an Inverse Gamma prior distribution. Furthermore, we discuss the James-Stein estimator, an empirical Bayes estimator related to the Normal-Normal model of the mean.

Study:

Video 16 Properties of Bayesian learning
LN Chapter 9

Video 17 Bayes models for the mean and the variance
LN Chapter 10

Video 18 Shrinkage estimation and James-Stein estimator
LN Chapter 11

Problem solving:

Worksheet 5

Week 8 (from 12 April 2021)

LN: lecture notes — view online
Video: lecture videos — view online
Worksheets: download worksheets

Topics:

In this week we consider two Bayesian ways of conducting statistical test: the Bayes factor and its BIC approximation, and (local) false discovery rates. Finally, we give a summary of the optimality properties of Bayesian learning.

Study:

Video 19 Bayes factor and BIC approximation
LN Chapter 12

Video 20 False discovery rates
LN Chapter 13

Video 21 Optimality of Bayesian learning and summary
LN Chapter 14

Problem solving:

Worksheet 6

Week 9 (from 19 April 2021)

LN: lecture notes — view online
Video: lecture videos — view online
Worksheets: download worksheets

Topics:

In this week we first provide an overview over the problem of regression in general and then introduce the linear regression model.

Study:

Video 22 Introduction to regression models
LN Chapter 15

Video 23 Linear regression model
LN Chapter 16

Problem solving:

Worksheet 7

Week 10 (from 26 April 2021)

LN: lecture notes — view online
Video: lecture videos — view online
Worksheets: download worksheets

Topics:

In this week we discuss how to estimate coefficients of the linear regression model from data.

Study:

Video 24 Estimating regression coefficients by least squares and maximum likelihood
Video 25 Three further ways to estimate regression coefficients
LN Chapter 17

Problem solving:

Worksheet 8

Week 11 (from 3 May 2021)

LN: lecture notes — view online
Video: lecture videos — view online
Worksheets: download worksheets

Topics:

In this week we introduce the squared multiple correlation and its use in linear regression. In particular, we show how the decomposition into explained and unexplained variance is linked to squared multiple correlation. Furthermore, we discuss ways how to assign variable importance to predictor variables and how to select variables most relevant for prediction.

Study:

Video 26 Squared multiple correlation
Video 27 Variance decomposition in regression
LN Chapter 18

Video 28 Prediction and variable selection
LN Chapter 19

Problem solving:

Worksheet 9

Week 12 (from 10 May 2021)

LN: lecture notes — view online
Video: lecture videos — view online
Worksheets: download worksheets

Topics:

This week is revision week with no new content. Revisit the lecture videos and worksheets of Weeks 1–11.

Study:

No videos this week

Problem solving:

No worksheet this week

The tutorial this week is a revision Q & A.