

14D001

Statistical Modelling and Inference

6 ECTS

## Course Outline

### Topic: Fundamentals of regression

- Likelihood Inference, features and numerics
- Residuals, leverage, bias-variance tradeoff, overfitting
- Classification (pt 1), GLMs and survival models

### Topic: Variable selection & penalized likelihood

- Bias-variance tradeoff for regression inference and prediction
- Penalized likelihood: best subset selection, convex penalties (e.g. lasso), sparsity
- Optimization algorithms for penalized likelihood

### Topic: Bayesian regression

- Foundations of Bayesian inference and the Bayesian linear model
- Bayesian shrinkage priors
- Bayesian variable selection and model averaging
- The computational challenge

### Topic: Bayesian computation

- Deterministic approximations and variational inference
- Monte Carlo methods and MCMC

### Topic: Probabilistic supervised and unsupervised learning

- Discrete latent variables, mixture models, topic models for text mining, inference and computation
- Continuous latent variables, probabilistic PCA (including connections to SVD, PCA), factor models, matrix factorisation, independent component analysis
- Generative models (Bayes classifiers, inverse regression etc)

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- Spectral clustering and semi-supervised learning

### Topic: Graphical models

- Bayesian networks
- Conditional independence, d-separation
- Markov random fields & elements of computations on graphs (e.g. belief propagation)

### Topic: Gaussian processes for regression and classification

- Kernel methods, connection to Bayesian regression, GP formulation for nonparametric regression
- Computational aspects
- Connections to spectral clustering and semi-supervised learning

### Topic: Intro to multilevel and hierarchical models

- Multilevel data structures and regression
- Case studies

## Required Activities

Weekly exercises, projects

## Evaluation

Final exam 50%, weekly homework 30%, project 20%

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### Materials

#### Main refs

- [Bishop] Bishop, Pattern Recognition and Machine Learning
- [Hastie et al.] Hastie, Tibshirani, Friedman, The elements of statistical learning
- [Gelman&Hill] Gelman and Hill, Data analysis using regression and multilevel/hierarchical models

#### Supplementary refs

- Wasserman, All of Statistics
- Hoff: A First Course in Bayesian Statistical Methods
- Venables & Ripley: Modern Applied Statistics with S
- Strang: Linear Algebra and its applications
- Bernardo and Smith: Bayesian theory