Fundamentals of Estimation and Detection

- Lectures: Michael Lentmaier (Wed., 6th DS, BAR 106)
- Exercises: Vinay Suryaprakash (Thu., 6th DS, BAR 218)
- Exam: oral, date to be fixed in February/March

Additional literature:
- James L. Massey: lecture notes (german), ETH Zürich
  - “Mathematische Grundlagen der Nachrichtentechnik”
  - “Zeitdiskrete Systeme und stochastische Signale”

(available at http://www.isiweb.ee.ethz.ch/archive/massey_scr/)
Content of the lectures

- **Introduction**
  - Motivation
  - Mathematical preliminaries: probability theory

- **Detection Theory**
  - Introduction / Structure of detection problems
  - Detection methods: starting with a single measurement
    - Maximum likelihood (ML) rule
    - Neyman-Pearson Theorem/ Receiver Operating Characteristic
    - Maximum a posteriori probability (MAP) rule
    - General Bayesian problem / (Log) Likelihood Ratio
    - Min-Max criterion
    - Application to M hypotheses
  - Detection in systems with memory
    - FIR-systemes / hidden state Markov chains
    - Tree-based search algorithms
    - Maximum Likelihood Sequence Estimation (Viterbi algorithm)
    - Symbol-by-symbol MAP (BCJR algorithm, logMAP, maxLogMAP)
  - Iterative detection methods
    - The “turbo-principle"
    - Application examples: turbo codes, iterative equalization
Content of the lectures

- **Estimation Theory**
  - Introduction: motivation, properties of estimators
  - Bayesian estimation of parameters
    - Bayesian MMSE estimation
    - General Bayesian estimation problem
    - Maximum a posteriori probability (MAP) rule
    - Maximum likelihood (ML) rule
  - Design of unbiased estimators of minimum variance
    - Fisher information
    - Cramer-Rao bound, efficiency
    - Rao-Blackwell theorem, Neyman-Fisher factorization
  - Estimation of vector parameters
    - MAP, ML and MMSE for the vector case
    - Linear models: BLUE, Linear-Least-Squares, linear MMSE
  - Filtering of stochastic signals
    - Introduction to linear time-discrete systems
    - Wiener filtering
    - Basic principles of Kalman filtering