MVE135 Random Processes with Applications, Q.1, 2009/2010

Purpose

The purpose of the course is to provide the students with a fundamental theoretical framework for processing of signals with random variation. The course starts with basic probability and proceeds to stochastic processes which are relevant in signal processing. It gives techniques for manipulating and study of random signals, together with practical methods for analysis and filtering of these signals.

Learning outcomes

After completion of the course the students should be able to

- define and explain fundamental probability tools used in the design and analysis of communication systems, with emphases on multidimensional joint distributions, the Gaussian one in particular, conditional expectation and conditional variance, convergence of random variables and limit theorems for sums of independent and identically distributed random variables
- describe the basic statistical principles involved in estimation
- identify basic models of random processes and explain their use for the designing of components in communication systems and analysis of their effect on system performance. These models include the Poisson process, Gaussian processes, white noise, and stationary stochastic processes
- use wide-sense stationary processes for modeling systems involving random signals and noise. In particular the students should have got a firm grasp on the important class of ARMA processes
- estimate second-order characteristics from data, including non-parametric estimation of the power spectral density, and understand the statistical properties of these estimates
- explain the mathematical techniques for design of optimal linear systems for signal processing, with emphasis on match filtering and the Wiener filter.

Course topics

Basic Probability Theory: Review and Extension

Axioms of Probability. Conditional Probability. Independence of Events. Probability Distributions. Expectation and Variance.

Random Variables
Functions of Random Variables. Multiple Random Variables. Conditional Distribution, Expectation, and Variance. Multidimensional Gaussian Distribution.

Series of Random Variables
Convergence. Limit Theorems for Sums of Random Variables.

Mathematical Statistics
Estimation. Maximum Likelihood.

Random Processes with Application in Statistical Signal Processing
Definition of a Random Process. Autocorrelation Functions. Some Special Random Processes: Poisson Process, Wiener process, White Gaussian Noise. Wide-Sense Stationary Random Processes. Spectral Representation. Autoregressive Moving Average Processes. Analysis and Processing of Random Signals Through a Linear System. Cross-Correlation and Cross-Spectrum. Optimum Linear Systems.

Statistical Signal Processing
Non-Parametric Spectrum Estimation. Windowing and Frequency Resolution. Welch and Blackman-Tukey Methods. Optimum Linear Systems. Prediction, Filtering and Smoothing. Wiener Filter.

Teachers
Lectures: Rossitza Dodunekova and Mats Viberg.
Exercises: Sima Shahsavari.

Organization
The course comprises lectures, classes with exercises and discussions, two compulsory computer laborations (with Mats), two optional home assignments (with Rossitza), providing bonus points to the written examination, and consultation sessions with all teachers.

Course book
Scott L. Miller, Donald G. Childers, *Probability and Random Processes With Application to Signal Processing and Communications*, available at Cremona.

Course information
Internet access by Chalmers Students Portal or by http://www.math.chalmers.se/∼rossitza

Recommended additional literature:
Alberto Leon Garsia, *Probability and Random Processes for Electrical Engineering.*