UCLouvain

linma1731

2026

Stochastic processes : Estimation and prediction

5.00 credits	30.0 h + 30.0 h	Q2

Teacher(s)	Vandendorpe Luc ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Prerequisites	Basic understanding of probability theory and static estimation (as covered in LEPL1109 or an equivalent course), as well as foundational knowledge of signals and systems (as taught in LEPL1106 or an equivalent)
Main themes	The course provides an in-depth exploration of advanced concepts related to stochastic processes and their use in engineering, including their mathematical modeling, key statistical properties, and behavior over time. The course also focuses on the derivation and analysis of widely used estimation techniques for such processes, most notably the Wiener Filter and the Kalman Filter. These estimators are presented in the context of optimal filtering theory, and their practical relevance is illustrated through examples involving signal processing and dynamic system state estimation.
Learning outcomes	**At the end of this learning unit, the student is able to :** • AA1.1, AA1.2, AA1.3 • AA3.1, AA3.2, AA3.3 • AA4.2 At the end of this course, the students will be able to : • Demonstrate a solid understanding of random variables and stochastic processes, and apply them effectively in engineering contexts; • Characterize stable stochastic processes and analyze their spectral properties; • Apply key estimation techniques, understand their theoretical properties, and assess their performance; • Design and implement predictors, filters, and smoothers within both the Wiener and Kalman filtering frameworks; • Analyze the impact of noise and uncertainty on dynamic systems and estimation strategies; • Interpret and simulate stochastic models using computational tools; • Critically assess the assumptions and limitations underlying classical estimation methods; • Connect theoretical developments to real-world applications in areas such as signal processing, control systems, and communications.
Evaluation methods	• A project carried out during the semester, accounting for 40% of the final grade. • A final exam, contributing 60% of the final grade. • Additional activities, such as quizzes and homework exercises, may be incorporated into the project evaluation. • In the event of a second examination session, the project grade from the first session is retained and cannot be resubmitted or redone. Additional details are specified in the course outline available on Moodle.
Teaching methods	• Lecture sessions conducted according to the modalities set by the EPL. • Assignments/projects to be completed individually or in groups. • Organizational details are specified each year in the course syllabus on Moodle. • Finally, certain activities may be conducted remotely.
Content	• Part 1 - Estimation: probability theory (reminder), Fisher and Bayesian estimation, bias, covariance, mean square error, Cramér--Rao bound, asymptotic properties, classical estimators (maximum likelihood, best linear unbiased, maximum a posteriori, conditional mean...), hidden Markov model, nonlinear filtering, particle filtering, Kalman filter. • Part 2 - Stochastic Processes and LTI Filters: complex random variables, stochastic processes, stationarity, ergodism, autocovariance, power spectral density, transformation by LTI systems, white noise, spectral factorization, finite-dimensional models (AR, MA, ARMA...), Wiener filter.
Inline resources	https://moodle.uclouvain.be/course/view.php?id=714
Bibliography	Les notes de cours des co-titulaires sont disponibles.

Faculty or entity in charge	MAP

Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Learning outcomes
Specialization track in Applied Mathematics	FILMAP	5		🔍
Mineure Polytechnique	MINPOLY	5		🔍