**ELEC-E8107 Stochastics models, estimation and control D, 5 op**
Autumn 2022
Lectures: DSc Arto Visala                    Exercises: MSc Issouf Ouattara
Study material: The following chapters and sections of the book
        Yaakov Bar-Shalom, Xiao-Rong Li & T. Kirubarajan: Estimation with applications to
        tracking and navigation (2001)
are required. Notes on duality between estimation and control. Slides cover the whole area
Exam + home assignments (75% + 25%)

**Content**
Basics of statistics and stochastic processes. Basic concepts in estimation, ML, MAP, LS,
MMSE; unbiased estimators. Linear estimation in static systems. Optimal state estimation in
discrete linear dynamic systems, Kalman filter and information filter. Optimal State
estimation in nonlinear dynamic systems, recursive functional relationship. Approximation of
optimal nonlinear state estimation, particle filter, extended Kalman filters, 1st and 2nd order.
Adaptive estimation. Duality of estimation and control. Main approaches in stochastic
control.

**Timetable**

*September 6*
1. INTRODUCTION
        Basics of statistics and stochastic processes, the whole chapter is not required; only
        such methods, which are used later in this course. Particularly
                1.3.5 The Gradient, Jacobian and Hessian
                1.3.6 Eigenvalues, Eigenvectors, and Quadratic Forms
                1.4.13 Gaussian Random Variables
                1.4.14 Joint and Conditional Gaussian Random Variables
                1.4.21 Markov Processes
                1.4.22 Random Sequences, Markov Sequences and Markov Chains
*September 20, 27*
2. BASIC CONCEPTS IN ESTIMATION 2.1-2.6
        In the section 2.7 CONSISTENCY AND EFFICIENCY OF ESTIMATORS only
        main ideas, subsections 2.7.1-2.7.2 are useful to understand, but not required.
3. LINEAR ESTIMATION IN STATIC SYSTEMS 3.1-3.4
*September 27*
4. LINEAR DYNAMIC SYSTEMS WITH RANDOM INPUTS 4.1-4.3
Section 4.3.5 not required
5. STATE ESTIMATION IN DISCRETE TIME LINEAR DYNAMIC SYSTEMS 5.1-5.3,
5.5. The subsection 5.4 CONSISTENCY OF STATE ESTIMATORS is not required
6. ESTIMATION FOR KINEMATIC MODELS the whole chapter not required
*October 4*
7. COMPUTATION ASPECTS OF ESTIMATION 7.2
        In this chapter only section 7.2 THE INFORMATION FILTER is required
8. EXTENSIONS OF DISCRETE TIME LINEAR ESTIMATION not required
9. CONTINUOUS TIME LINEAR STATE ESTIMATION 9.2
        Only the section 9.2 THE CONTINUOUS TIME LINEAR STATE ESTIMATION
        FILTER is required
*October 11*
10. STATE ESTIMATION FOR NONLINEAR DYNAMIC SYSTEMS 10.1-10.3
        No sections 10.4-10.8
*October 25*
Examples of EKF for localization of ATVs, Particle filter, only slides

*November 1*

11. ADAPTIVE ESTIMATION AND MANEUVERING TARGETS 11.6, 11.9

      In this chapter, only the main ideas in 11.6 THE MULTIPLE MODEL APPROACH, subsections 11.6.1-3, and section 11.9 USE OF EKF FOR SIMULTANEOUS STATE AND PARAMETER ESTIMATION are required.

*November 8*

WIENER AND VOLTERRA NONLINEAR DYNAMIC MODELS

Wiener and Volterra nonlinear dynamic models, approximation with Neural Networks, parameter output error (OE) estimation with Extended Kalman Filter, only slides

NOTES ON DUALITY BETWEEN ESTIMATION AND CONTROL

Slides, from a book by Torsten Söderström

*December*

Exam, no registration required

**It is allowed to use the collection of main equations, available in mycourses, in the exam.**