



UNIVERSITÀ DI PISA  
**DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE**  
**Dottorato di Ricerca in Ingegneria dell'Informazione**

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Doctoral Course

**“Linear and nonlinear Kalman filtering: theory and applications”**

Prof. Luigi Chisci

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**Short Abstract:** This course aims to provide both theoretical and practical tools to tackle estimation problems encountered in several areas of engineering and science. In particular, it is shown how to formulate such estimation problems as instances of a general dynamical system state estimation problem and how to derive the mathematical solution of the latter problem. Then it is shown that, for a linear Gaussian system, such a solution yields the well-known Kalman filter. Further, approximate techniques (e.g. extended and unscented Kalman filters, particle filter, etc.) are presented for the case of nonlinear and/or non-Gaussian systems, for which an exact closed-form solution cannot be found. To conclude the theoretical part, theoretical limitations (i.e. the Cramer-Rao lower bound) on the quality of estimation are discussed. In the second part of the course, we illustrate some applications of linear/nonlinear Kalman filtering (e.g., tracking, robotic navigation, environmental data assimilation).

**Course Contents in brief:**

- A general dynamic estimation problem in state-space form
- Recursive Bayesian filtering
- Kalman filter as recursive Bayesian filter in the linear Gaussian case
- Beyond the Kalman filter: nonlinear filters for nonlinear and/or non-Gaussian estimation problems (extended Kalman filter, unscented Kalman filter, particle filter, Gaussian sum filter).
- Theoretical limits on the quality of estimation
- Applications to surveillance, robotic navigation and environmental data assimilation.

**Total # of hours of lecture: 16**

## References:

- [1] B.D.O. Anderson, J.B. Moore: Optimal Filtering, Prentice Hall, 1979.
- [2] Y. Bar-Shalom, X. R. Li, T. Kirubarajan: Estimation with Applications to Tracking and Navigation – Theory, Algorithms and Software, J. Wiley & Sons, 2001.
- [3] B. Ristic, S. Arulampalam, N. Gordon: Beyond the Kalman Filter – Particle Filters for tracking Applications, Artech House, 2004.
- [4] Notes provided by the teacher.

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## CV of the Teacher

Luigi Chisci was born in Florence, Italy, in 1959. He got a degree in Electronic Engineering at the University of Florence in 1984 and a Ph.D. in Control Engineering in 1989. Currently, he is a full professor of Control Engineering since December 2004 at the University of Firenze. He has been an associate professor since 1992, until 1993 at the University of Pisa and then at the University of Florence. From 1990 to 1992 he has been research associate of Control Engineering at the University of Florence. His scientific activity from 1987 until now has produced over 200 publications, of which about 80 on international journals, on various research themes of control engineering including: parallel algorithms and architectures for control and digital signal processing, adaptive filtering and control, identification, predictive control, control of constrained systems, control of telecommunication networks. Currently his main research interests are in networked estimation, sensor networks and data fusion, multitarget tracking and robotic navigation. In July 2004 he organized a course on "Modeling and control for telecommunication networks" within the Italian Summer School for Ph.D. students in Control Engineering. He has been coordinator of the PhD Program in Information Engineering at the University of Firenze from 2013 to 2018. He has been Associate Editor of the Conference Editorial Board of the IEEE Control Systems Society from 2000 to 2008. He is Associate Editor of the International Journal of Adaptive Control and Signal Processing (Wiley).

## Room and Schedule

Room: *From remote by using Microsoft Teams.*

Schedule:

January 12, 2021 – 9:30-12:45

January 14 2021 – 9:30-12:45

January 19, 2021 – 9:30-12:45

January 21, 2021 – 9:30-12:45