# ECE 286 - Bayesian Machine Perception

## Spring 2020 - Syllabus

Situation-aware sensing technologies such as high-resolution radar and lidar are key to innovative products and services that are profoundly changing various aspects of our daily life. For example, the safe navigation of autonomous terrestrial, aerial, or underwater vehicles is only possible if a clear picture of the environment is available. Machine perception is the task of localizing and tracking relevant features of the environment from measurements provided by one or more potentially heterogeneous sensors.

In this research-oriented course, machine perception will be investigated from a statistical-inference perspective. We will introduce factor graphs as an economical representation within which to formulate high-dimensional nonlinear Bayesian estimation problems. This representation sets the stage for the subsequent development of practical algorithmic solutions for machine perception. We also will explore how deep learning techniques can be used to infer unknown factors of the graph. Specific topics of this course include sequential Bayesian estimation, probabilistic graphical models, data association, and Monte Carlo techniques. Some of the discussed methodologies will be evaluated in a final research project.

**Time and place:** Lectures are Mondays and Wednesdays 11AM-12:20PM, EBU1 2315.

**Instructor:**

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e-mail: flmeyer@ucsd.edu
(Office hours are by appointment.)

**Prerequisites:** The minimal suggested prerequisites for the course are linear algebra, basic probability, and optimization (e.g., ECE 109, ECE 174) as well as Matlab programming experience in algorithm development. Some familiarity with graphical models and estimation theory (e.g., ECE 175A, ECE 275B) is helpful, but not required.

**Bibliography:** A main reference is the textbook

- *Probabilistic Graphical Models: Principles and Techniques*, Daphne Koller and Nir Friedman, MIT Press, 2009.

This book will be on reserve at the campus library. In addition, a variety of book chapters and research papers will be used, which will be posted on the course website. Additional, optional references are listed at the end of this syllabus.

**Course Website:** All handouts, including homework, will be posted on the Canvas website of the course.

**Grades:** Research Project 50 %, Homework 50 %

**Research Project:** This course includes a research project in which students work in groups to address one of three possible topics that will be outlined at the beginning of the class. A one-page document describing the approach the students plan to take is due midway through the quarter. Final presentations are during the last two lectures of the course and a final write-up of the project of 6-8 pages is due during finals week.

**Homework:** Problems to be solved in Matlab will be posted approximately every 2-3 weeks on the course website, and will be due one week later. It is expected that all completed problems are turned in on time. Late homework *will not be accepted*, unless there is a prior arrangement.

**Collaboration Policy:** The goal of homework is to give you practice in mastering the course material. Consequently, you are encouraged to form study groups to discuss the course material and problem sets.

However, the developed Matlab solutions you hand in, should reflect your own understanding of the course material. It is not acceptable to copy a solution that somebody else has written. You must develop each problem solution by yourself without assistance.

**Additional References:** The following references are relevant for the topics covered in this course.


1. B. D. O. Anderson and J. B. Moore. *Optimal Filtering*. Prentice-Hall, 1979.
2. Y. Bar-Shalom and X.-R. Li. *Multitarget-Multisensor Tracking: Principles and Techniques*, Yaakov Bar-Shalom, 1995.
3. B. Ristic, S. Arulampalam, and N. Gordon. *Beyond the Kalman Filter: Particle Filters for Tracking Applications*, Artech House, 2004.
4. S. Thrun, W. Burgard, and D. Fox. *Probabilistic Robotics*, MIT Press, 2006.
5. F. Dellaert and M. Kaess. *Factor Graphs for Robot Perception*, Now Publishers, 2017.