A tutorial for the 2020 IEEE International Radar Conference

Title: Radar Tracking, State Estimation and Association

Course Outline: Will follow a similar outline of the tutorial given in the 2019 Radar Conference in Boston (see attached abstract) with some updates, a four hour four-lectures series:

1- Fundamentals of Trajectory Estimation
2- Dealing with Real World Problems
3- Multiple Target Tracking
4- Multiple Sensor Systems and Current Trends in Radar Tracking

Audience: Radar engineers and algorithm designers that want to learn how to design algorithms to track a single target or targets in dense environment with a radar or a system of radars.

Presenters: Dr. Chaw-Bing Chang, MIT Lincoln Laboratory
Dr. Keh-Ping Dunn, MIT Lincoln Laboratory

Prerequisites: Familiar with basic probability theory, linear algebra, and differential equations.

Textbook: Chaw-Bing Chang and Keh-Ping Dunn, *Applied State Estimation and Association*, The MIT Press, Cambridge, MA 2016

Estimate of Attendance: 15-20

Other Tutorial: "Radar Tracking Using State Estimation and Association," *2019 IEEE Radar Conference Tutorial Session I*, *Boston, 22 April 2019*. (16 registered, 2 walk-ins)

Presenter Biography:

Chaw-Bing Chang received his BS degree from National Cheng Kung University, Taiwan, and MS and PhD degrees from the State University of New York at Buffalo, all in electrical engineering. He joined Lincoln Laboratory in 1974, and his initial project was on radar signal processing and trajectory estimation for ballistic missile defense (BMD). He became an Assistant Group Leader in 1984 to lead projects in air defense (AD) technology development for the US Navy. He was appointed Group Leader of the Air Defense and Sensor Technology Group in 1998, and was responsible for technology development for the Navy's airborne surveillance radar system. During this time, he led a multiyear data collection and experimentation campaign supporting the Navy's Mountaintop Program. As part of the Navy AD program, he contributed to algorithm development and performance evaluation for both surface and airborne radar systems. Upon returning to the Laboratory's BMD program in 2004, he participated in advanced algorithm development and phenomenology research for radar and optical sensors and led an airborne optical sensor technology program for BMD. He has published more than 70 journal articles, conference papers, and Lincoln Laboratory reports. He is currently a senior staff member of the BMD System Integration Group.

Keh-Ping Dunn received his BS degree in control system engineering from the National Chiao Tung University in Taiwan, and MS and DSc degrees in systems science and mathematics from Washington University in St. Louis, Missouri. Before joining the Laboratory in 1976, he was with the Electronic System Laboratory of MIT in charge of a NASA project on a multiple model adaptive control system for the F-8C aircraft. At Lincoln Laboratory, he has worked in many areas of ballistic missile defense (BMD). He became the Group Leader of Systems Testing and Analysis in 1992, managing the first two campaigns of the Theater Missile Defense (TMD) Critical Measurement Program (TCMP) that conducted a series of live missile tests in the Pacific in the 1990s. He won the Missile Defense Agency's (MDAs) 2010 Technology Achievement Award for his effort on this project. He consequently managed Theater Missile Defense (1999−2003), Advanced Concepts and Technology (2003−2008), and Missile Defense Elements (2008−2010) groups, all for MDA projects. He chaired the Panel of Tracking Parameters of the SDI Tracking Panels in the late 1980s for the Strategic Defense Initiative Organization (SDIO). He has worked on multiple target/multiple sensor tracking, target identification, and sensor fusion and decision architecture for various BMD sensor (both optics and radar) systems at the Laboratory. He is currently a senior staff member in the BMD System Integration Group.

A tutorial for 2019 Radar Conference

Radar Tracking Using State Estimation and Association

Dr. Chaw-Bing Chang and Dr. Keh-Ping Dunn

Abstract

State estimation is to determine target's motion dynamics, association is to identify measurements of the same target in a multiple target environment for estimation. Put them together, it is known as target tracking. The purpose of this tutorial is to introduce the audience with techniques of state estimation and association for tracking. Theory and application of different estimation and association algorithms will be discussed. Applicability of recursive and batch processing algorithms will be compared. Specific attentions will be given to practical filter designs as well as their estimation performance prediction and evaluation. A variety of adaptive techniques for tracking maneuvering targets including multiple model estimation algorithms will be presented. Methods for mitigating radar biases will be discussed. Integrating multiple radar collections in a network can improve tracking accuracy, enhance surveillance coverage, and achieve a variety of additional advantages. Architectures and algorithms for integrating multiple radars will be presented with the pros and cons of different approaches compared. A real world challenge in multiple target tracking is the presence of dense target environment, hence the problem of association. A variety of association techniques will be presented including nearest neighbor, global nearest neighbor, probabilistic data association, multidimensional assignment, multiple hypothesis tracking, etc. Several approaches for jointly solving estimation and association problems in a multiple radar system with measurement biases will be compared using examples. Numerical examples representing tracking of air and ballistic targets will be included throughout the lecture to help the audience to understand practical aspects of applying state estimation and association to target tracking. Open issues and further areas of research together with more recent approaches such as "particle filters" will be briefly discussed at the end.

Text Book

Chaw-Bing Chang and Keh-Ping Dunn, *Applied State Estimation and Association*, The MIT Press, Cambridge, MA, 2016