• TITLE: Radar Resource Management and Meta-level Tracking

• PRESENTERS:
  
  – Professor Vikram Krishnamurthy, Department of Electrical & Computer Engineering, University of British Columbia, Vancouver, V6T 1Z4, Canada. email: vikramk@ece.ubc.ca
  

Short Bio of Presenters:

  – Vikram Krishnamurthy is a professor and holds the Canada Research Chair in statistical signal processing at the Department of Electrical Engineering, University of British Columbia, Canada. His current research interests include statistical signal processing and controlled sensing with applications in sensor and social networks. Dr Krishnamurthy has served as Distinguished lecturer for the IEEE signal processing society and Editor in Chief of IEEE Journal Selected Topics in Signal Processing. He has published widely in the signal processing, automatic control, information theory and operations research literature. He received an honorary doctorate from KTH Stockholm Sweden in 2013. He is coauthor of the monograph *Interactive Sensing and Decision Making in Social Networks* published in 2014.
  
  – Martie Goulding is the Chief Radar Engineer for the Airborne Systems Group at MDA Systems Ltd. Dr. Goulding has over 20 years of industrial experience in the design, implementation, deployment and test of airborne and spaceborne Ground Moving Target Indicator and Synthetic Aperture Radar Systems. He has worked closely with Defence Research and Development Canada Ottawa in several radar projects, as well as collaborating with the University of British Columbia.

• TOPIC AND DESCRIPTION: The tutorial will provide a comprehensive review of sensor management and meta-level tracking along with sanitized models of real radar systems. The key mathematical tools of Bayesian filtering, stochastic context free grammars and stochastic dynamic programming will be introduced together with structural results that yield efficiently computable scheduling policies. The techniques presented will be illustrated in several practical examples involving radars and electronic warfare.

The tutorial is for 3 hours and will comprise of 3 sub-parts:

1. *Introduction and Examples*: Several examples involving state-of-the-art resource management in multifunction radars and meta-level tracking will be be introduced. Models and examples of real-life AESA radars will be introduced.

2. *Meta-level Tracking*: How can target tracks be interpreted to assist a human operator? How to parameterize trajectories that are anomalous to infer intent of a target? Such meta-level tracking forms the human-sensor interface. State space Markovian models are unsuitable for such meta-level tracking problems. A tutorial description of reciprocal stochastic processes and stochastic context free grammars for modelling target trajectories will be given. Also associated statistical signal processing algorithms will be described. We will address questions such as: Given tracks from a GMTI radar, how can an automated algorithm infer if multiple vehicles are moving in a convoy or a vehicle is departing from a convoy? How can a radar...
be used for perimeter surveillance to detect suspicious trajectories such as a vehicle circling a building or a restricted area? How can a digital map of the road system be exploited to track multiple moving vehicles?

3. **Adaptive Radar and Stochastic Control**: A tutorial on partially observed Markov decision processes (POMDPs) will be given and stochastic dynamic programming will be introduced for partially observed stochastic dynamical systems. The objective is to devise sophisticated stochastic feedback control algorithms that enable a radar to adapt dynamically to its environment. Flexible multi-mode radars are capable of switching between various measurement modes, e.g., radar transmit waveforms, beam pointing directions, so that the tracking system is able to tell the radar which mode to use at the next measurement epoch. How can an automated mode control algorithm dynamically switch between the multiple modes to track targets with sufficient precision and resolution?

- **AUDIENCE**: Researchers in industry and academia + graduate students working in sensor resource management, target tracking, and scheduling; including operations research. Some prior background in Bayesian filtering for target tracking is assumed.

- **RELEVANCE**: Controlled Sensing and meta level target tracking are important and timely areas. Both these aspects were traditionally controlled by human radar operators in a highly regulated manner. For the full potential of next-generation radars to be harnessed there are compelling reasons to automate these procedures.

Radar resource management goes beyond classical signal processing to address the deeper question of how to schedule signal processing resources in real time to achieve a trade off between estimation accuracy and measurement costs.

Meta level target tracking goes beyond physical sensor based tracking and seek to use the tracks from conventional trackers to interpret the targets intent. It can be viewed as middleware forming the human-sensor interface since the aim is to interpret information from a tracker to assist a human operator.

Therefore a tutorial that summarizes state-of-the-art mathematical tools in these areas should useful to researchers and graduate students. The material in this tutorial is based on several recent research papers published by the presenters. The combination of a professor (Krishnamurthy) and industrial expert (Goulding) should provide the audience with a useful mix of analytical/modelling tools with practical considerations.

- **PREVIOUS EDITIONS**:

  Previous versions were offered at 2 Fusion conferences. In each case the presentation has been improved. The meta-level tracking material is new and we believe of significant importance.

- **EQUIPMENT** None – apart from the standard LCD projector, a single projection screen and microphones.