Recent Developments in Maritime Radar Detection

Luke Rosenberg and Simon Watts, September 3, 2019

Tutorial Outline

Traditional maritime radar is based on non-coherent detection, mainly due to the complexities of implementing coherent detectors in sea clutter. Over the past decade, there has been significant new research into the characterisation and modelling of sea clutter and how to improve maritime target detection. The use of models has also led to techniques for predicting the performance of many new radar detection schemes. This tutorial will include a comprehensive coverage of new research in three key areas. The first is sea clutter modelling for both monostatic and active bistatic radar systems. The second area looks at a number of detection schemes which have been proposed for detection of targets in sea clutter. These include both non-coherent techniques based on constant false alarm rate (CFAR) schemes, coherent single and multichannel techniques and approaches based on time-frequency analysis and sparse signal separation. The final part of the tutorial links these two areas by showing how sea clutter models can be used to determine the expected detection performance of both non-coherent and coherent detection schemes.

Intended Audience

The intending audience includes students, researchers, radar systems engineers, radar users and radar procurers. The topics will be presented at different levels ranging from introductory to advanced, in a manner that will aim to encourage interest and further reading.

Learning Outcomes

Over the past 5-10 years, there have many new developments in maritime radar detection. Many of these are based on exploiting knowledge of the underlying clutter statistics. The development of methods to model clutter and constant false alarm rate (CFAR) detection schemes for targets in clutter are still at the forefront of radar research, as evidenced by the numbers of papers on these topics in the radar journals and at the radar conferences. This tutorial will help attendees to understand the impact of clutter on radar design and performance, and how new detection schemes have exploited this knowledge. This is achieved by describing how performance prediction modelling can be used to understand the average performance of a detection scheme and can provide detailed insight into the practical application of the detection algorithms. This insight is relevant not only to radar system engineers but also to those responsible for specifying and procuring new radar systems for operational use.

Suggested Prerequisites

An undergraduate Electrical and Electronic Engineering degree is sufficient to understand the majority of topics in the tutorial.

Presenters Biography

Dr. Luke Rosenberg, Defence Science and Technology Group, patriot176@gmail.com
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Prof. Simon Watts graduated from the University of Oxford in 1971, obtained an MSc and DSc from the University of Birmingham in 1972 and 2013, respectively, and a PhD from the CNAA in 1987. He was deputy Scientific Director and Technical Fellow in Thales UK until 2013 and is a Visiting Professor in the department of Electronic and Electrical Engineering at University College London. He joined Thales (then EMI Electronics) in 1967 and since then has worked on a wide range of radar and EW projects, with a particular research interest in maritime radar and sea clutter. He is author and co-author of over 60 journal and conference papers, a book on sea clutter and several patents. He was chairman of the international radar conference RADAR-97 in Edinburgh UK. Professor Watts received the IEE JJ Thomson Premium Award in 1987 and the IEE Mountbatten Premium Award in 1991. He has served as an Associate Editor for Radar for the IEEE Transactions AES and is a member of the Editorial Board of IET Radar, Sonar & Navigation. He was appointed MBE in 1996 for services to the UK defence industry and is a Fellow of the Royal Academy of Engineering, Fellow of the IET, Fellow of the IMA and Fellow of the IEEE.

Dr. Luke Rosenberg received the Bachelor of Electrical and Electronic Engineering in 1999, the Masters in Signal and Information Processing in 2001 and the Ph.D. in 2007, all from the University of Adelaide, Australia. In 2016, he completed the Graduate Program in Scientific Leadership at the University of Melbourne, Australia. He is currently a Discipline Lead for Maritime Airborne Radar in the Defence Science and Technology Group, Australia. His work covers the areas of radar image formation, adaptive filtering, detection theory, and radar and clutter modelling. He is an adjunct Senior Lecturer at the University of Adelaide, and in 2014 spent 12 months at the U.S. Naval Research Laboratory (NRL) working on algorithms for focusing moving scatterers in synthetic aperture radar imagery. Dr. Rosenberg has jointly received the best paper awards at international radar conferences in 2014 and 2015 and has presented a number of tutorials at the IEEE American (national) and international radar conferences. In 2016, he received the prestigious Defence Science and Technology Achievement Award for Science and Engineering Excellence and in 2017, the NRL ARPAD award with colleagues from the NRL, and in 2018, the IEEE AESS Fred Nathanson award for 'Fundamental Experimental and Theoretical Work in Characterizing Radar Sea Clutter'.

Proposed Schedule

1. **Introduction**
   - Scope of the tutorials and typical applications
   - Problems encountered in practical systems
2. **Sea clutter models**
   - Clutter characteristics – reflectivity, amplitude statistics, Doppler spectra, spatial correlation.
   - Survey of models and new developments (including models for active and passive bistatic applications, different amplitude distribution and Doppler spectrum models etc.)
3. **Target detection techniques**
   - Non-coherent – pulse-to-pulse and scan to scan integration, binary integration, CFAR techniques and the use of frequency agility.
   - Coherent – post-Doppler and pre-Doppler methods for single and multi-channel radar systems.
   - Alternative techniques – time/frequency techniques (wavelets); sparse detection including techniques based on basis pursuit denoising, morphological component analysis and orthogonal matching pursuit; single snapshot coherent detection
   - Coherent multi-static detection
4. **Performance of detectors in sea clutter**
   - Problems with time-varying and range-varying Doppler spectra
   - Estimation of clutter statistics
   - Comparison of coherent and non-coherent methods.
   - Use of models to predict performance
   - Examples of CFAR detector performance.

Prior Presentations

Simon Watts has presented or co-presented different aspects of this subject in over 15 tutorials since Radar ’97, most recently at Radar 2012 (jointly with Keith Ward), Radar 2013, Radar 2014 , Radar 2015, RadarConf 2015, RadarConf 2016, Radar 2017, RadarConf 2017, RadarConf 2018 and Radar 2019. This specific tutorial has been presented jointly with Luke Rosenberg at the Radar 2019 conference. Some of the background sections on clutter modelling are also covered in the book: K.D.Ward, R.J.A.Tough and S.Watts, “Sea Clutter: Scattering, the K Distribution and Radar Performance”, 2nd Edition, IET, 2013.

Luke Rosenberg presented a tutorial on high resolution land and sea clutter at Radar 2015, Washington DC, jointly with Maria Greco, and some of that material will be used here also. He has also presented tutorials on clutter modelling with Simon Watts at RadarConf 2015, RadarConf 2016, RadarConf 2017, Radar 2017, RadarConf 2018, Radar 2018 and Radar 2019. The content of this tutorial has only been presented once previously at the Radar 2019 conference.

Estimate of numbers

Previous tutorials have always attracted at least 10-20 participants. As this is a newer tutorial, we expect the number to be higher.