Sensor Signal Processing for Defence
SSPD 2022

13th - 14th September  London

IET London: Savoy Place

This conference is organised by the University Defence Research Collaboration (UDRC) in Signal Processing and it is sponsored by the Defence Science and Technology Laboratory (Dstl) and the Engineering and Physical Sciences Research Council (EPSRC).
Welcome

Dear Colleagues,

We warmly welcome you to this year’s SSPD Conference, our second hybrid conference. This event is the 11th conference of the Sensor Signal Processing for Defence series and provides a chance to present, listen to and discuss the latest scientific findings in signal processing for defence.

We are privileged to have our two keynote speakers, Frédéric Barbaresco from Thales Land & Air Systems, France and Lieutenant General Tom R Copinger-Symes CBE, Deputy Commander UK Strategic Command. The SSPD 2022 conference also welcomes our invited speakers; Lance M. Kaplan, ARL, Simon Godsill, University of Cambridge and Jon Spencer, Dstl.

A welcome also extends to our panel speakers from Defence, Industry and Academia and the presenters of scientific papers presenting their novel research through live oral presentations. We look forward to some interesting debate and discussion throughout the conference.

We would like to take this opportunity to thank the speakers, reviewers, session chairs and the technical committee for their contribution to this event.

We hope you enjoy our conference.

Mike Davies
Steve McLaughlin
Jordi Barr
Gary Heald
SSPD 2022  Tuesday 13th September 2022

8:30 to 9:00 Refreshments

Session 1 – Applications and Implementation – Chair – Mike Davies, University of Edinburgh

9:00 Introduction and Welcome to Day 1/Session 1 – Mike Davies, University of Edinburgh.


10:10 – 10:40 Invited Speaker: Dealing with Epistemic Uncertainty in Information Fusion Systems, Lance Kaplan, ARL.

10:40 – 11:05 Automatic Approximation for 1-Dimensional Feedback-Loop Computations: a PID Benchmark, Yun Wu¹, Yun Zhang¹, Anis Hamadouche¹, Joao Mota¹, Andrew M Wallace¹, ¹Heriot-Watt University.

11:05 – 11:35 Refreshments

11:35 – 12:00 Efficient Joint Surface Detection and Depth Estimation of Single-photon Lidar Data using assumed Density Filtering, Kristofer Drummond¹, Dan Yao¹, Agata Pawlikowska², Robert Lamb², Steve McLaughlin¹, Yoann Altmann¹, ¹Heriot-Watt University, ²Leonardo.

Session 2 – Panel Discussion and Lightning Posters – Chair – Jordi Barr - Dstl

12:00 Introduction and Welcome to Session 2 – Jordi Barr, Dstl

12:00 – 13:00 Panel Discussion: Open Source intelligence

13:00 – 13:30 Lightning Poster Presentations

P1. An Extension to the Frenet-Serret and Bishop Invariant Extended Kalman Filters for Tracking Accelerating Targets, Joe Gibbs¹, David Anderson¹, Matt MacDonald², John Russell², ¹University of Glasgow, ²Leonardo.

P2. Joint Undervolting and Overclocking Power Scaling Approximation on FPGA, Yun Wu¹, Joao Mota¹, Andrew M Wallace¹, ¹Heriot-Watt University.


P4. Optimal Bernoulli Point Estimation with Applications, Alexey Narykov¹, Murat Uney¹, Jason F. Ralph¹, ¹University of Liverpool.

P5. High Resolution DOA Estimation for Contiguous Target with Large Power Difference, Murtiza Ali¹, Karan Nathwani¹, ¹Indian Institute of Technology.

P6. Compressive Self-Noise Cancellation in Under water Acoustics, Pawan Kumar¹, Karan Nathwani¹, Vinayak Abrol², Suresh Kumar³, ¹Indian Institute of Technology,
SSPD 2022

2University of Oxford, 3DRDO, India.


P8. Unsupervised Expectation Propagation Method for Large-Scale Sparse Linear Inverse Problems, Dan Yao, Steve McLaughlin, Yoann Altmann, 1Heriot-Watt University.

P9. Movement Classification and Segmentation Using Event-Based Sensing and Spiking Neural Networks, Paul Kirkland, Gaetano Di Caterina, 1University of Strathclyde.

P10. Enhanced Space-Time Covariance Estimation Based on a System Identification Approach, Faizan Khattak; Ian Proudler, Stephan Weiss, 1University of Strathclyde.

13:30 – 14:45 Lunch and Poster Presentations – There will be an opportunity to view posters either online or at Savoy Place (Q & A will use https://www.sli.do)

Session 3 Networking and Communications – Chair – Steve McLaughlin, Heriot-Watt University

14:45 Introduction and Welcome to Session 3 – Steve McLaughlin, Heriot-Watt University

14:45 OMASGAN: Out-of-distribution Minimum Anomaly Score GAN for Anomaly Detection, Nikolaos Dionelis, Sotirios Tsaftaris, Mehrdad Yaghoobi, 1University of Edinburgh.

15:10 Refreshments

15:45 Fast Trajectory Forecasting With Automatic Identification System Broadcasts, Yicheng Wang, Murat Uney, 1University of Liverpool.


16:35 Closing remarks

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19:30 Conference Reception Drinks - IET Savoy Place

20:00 Conference Dinner
8:30 to 9:00 Refreshments

Session 4 Machine Learning – Chair – James Hopgood, University of Edinburgh

9:00 Introduction and Welcome to Day 2/Session 4 – Machine Learning – James Hopgood, University of Edinburgh


10:35 – 11:00 Robust DOA Estimation Based on Deep Neural Networks in Presence of Array Phase Errors, Xuyu Gao\(^2\), Aifei Liu\(^2\), Yutao Xiong\(^2\), \(^1\)Harbin Engineering University, \(^2\)Northwestern Polytechnical University.

11:00 – 11:25 Refreshments

Session 5 – Panel Discussion – Chair – Jordi Barr - Dstl

11:25 Introduction and Welcome to Session 5 – Jordi Barr, Dstl

11:25 – 12:25 Panel Discussion: Should defence be more university friendly or should universities be more defence friendly?

12:25 – 13:25 Lunch

Session 6 – Radar Sonar and Acoustics – Chair – Gary Heald, Dstl

13:25 Introduction and Welcome to Session 6 – Gary Heald, Dstl


13:55 – 14:20 A Polynomial Subspace Projection Approach for the Detection of Weak Voice Activity, Vincent W Neo\(^1\), Stephan Weiss\(^2\), Patrick A Naylor\(^1\), \(^1\)Imperial College London, \(^2\)University of Strathclyde.

14:20 – 14:45 Optimizing Sonobuoy Placement using Multiobjective Machine Learning, Christopher M Taylor\(^1\), Simon Maskell\(^1\), Jason F. Ralph\(^1\), \(^1\)University of Liverpool.

14:45 – 15:10 Refreshments

15:10 – 15:35 Image Quality SAR Refocus of Moving Targets undergoing Complicated Rolling Maneuvers, David A. Garren\(^1\), \(^1\)Naval Postgraduate School.
15:35 – 16:00 Learning Low-Rank Models From Compressive Measurements for Efficient Projection Design, Fraser K Coutts\textsuperscript{1}, John Thompson\textsuperscript{1}, Bernard Mulgrew\textsuperscript{1}, \textsuperscript{1}University of Edinburgh.

16:00 – 16:25 LoRaWAN Performance Evaluation and Resilience under Jamming Attacks, Vaia Kalokidou\textsuperscript{1}, Manish Nair\textsuperscript{1}, Mark Beach\textsuperscript{1}, \textsuperscript{1}University of Bristol.

\textbf{16:25 Closing remarks}
General Chairs
Mike Davies - University of Edinburgh
Stephen McLaughlin - Heriot-Watt University
Jordi Barr - Dstl
Gary Heald - Dstl

Publicity and Local Arrangements Chair
Janet Forbes - University of Edinburgh

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Abderrahim Halimi - Heriot-Watt University
Alasdair Hunter - Dstl
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Andy Stove - Stove Specialties
Athanasiou Gkelias - Imperial College London
Augusto Aubry - Universita degli studi di Napoli
Bernard Mulgrew - University of Edinburgh
Brian Barber - Dstl
Bruno Clerckx - Imperial College London
Carmine Clemente - University of Strathclyde
Chris Baker - University of Birmingham
Christoph Wasserzier - Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR
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James Hopgood - University of Edinburgh
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Suresh Jacob - Dstl
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Wenwu Wang - University of Surrey
Wolfgang Koch - Fraunhofer FKIE
Yoann Altmann - Heriot-Watt University
Keynote Speakers

Frédéric Barbaresco


Abstract: Lie Groups Statistics and Machine Learning for Military Sensors based on Symplectic Structures of Information Geometry

In a first part, we will present pioneering THALES Sensors/Radars algorithms: Geometric Matrix CFAR based on Jean-Louis Koszul’s Information Geometry and its extension for STAP, Complex-Valued Convolutional Neural Networks and Covariance-Matrix-Valued HPDNet for Micro-Doppler ATDR, Lie Group-based Convolutional Equivariant Neural Network from Geometric Deep Learning for Doppler clutter map, IEKF (Invariant Extended Kalman Filter) Frenet-Serret Tracker based on Lie Groups for hyper-maneuvering targets, Tracker parameters tuning by Deep Learning and finally, Multi-Agent Reinforcement Learning for Radar Task Scheduling and Active-Track/TWS collaborative Resources Management. In a second part, we will present Avant-Garde tools using statistics on Lie Groups for different sensors applications (detection, tracking and recognition). From French Jean-Marie Souriau’s Symplectic Model of Statistical Physics and Russian Kirillov’s Representation Theory of Lie Groups, we will introduce Gaussian statistical density for Lie Groups defined as Maximum Entropy Gibbs density on coadjoint orbits though moment map. This Symplectic model of Information gives new geometric foundation for Entropy, defined purely geometrically (and no longer axiomatically) as Casimir Invariant Function in Coadjoint Representation. We will conclude with new perspectives opened by this new Symplectic Theory of Heat and Information.
Keynote Speakers

Lieutenant General T R Copinger-Symes

Tom spent his early career with The Rifles on operations in Northern Ireland, Bosnia, Kosovo, Iraq and Afghanistan, and in operational and strategy posts at the Permanent Joint Headquarters and the Ministry of Defence.

For the past 10 years he has focused on how the Army and Defence can make better use of its data and information, whether in supporting traditional warfighting or employed as a weapon in its own right - especially in the context of ‘sub-threshold’ competition. This has included command at brigade (1 ISR Bde) and divisional levels (Force Troops Command - now 6th (UK) Div), as well as, in his last post as Director of Military Digitisation, leading Defence’s Digital Transformation portfolio.

In May 2022 Tom was promoted to Lieutenant General, on appointment as the Deputy Commander of UK Strategic Command.

Title: Information Challenges in Multi-Domain Integration
Invited Speakers

Lance M. Kaplan, ARL

Lance M. Kaplan received his undergraduate degree at Duke University in 1989 and a PhD degree from the University of Southern California in 1994, all in Electrical Engineering. He held a National Science Foundation Graduate Fellowship and a USC Dean’s Merit Fellowship from 1990–1993. Dr. Kaplan previously worked at the Georgia Tech Research Institute (1987-1990) and the Hughes Aircraft Company (1994-1996). He was a faculty member in the Department of Engineering at Clark Atlanta University from 1996-2004. Currently, he is a team leader in the Context Aware Processing branch of the DEVCOM Army Research Laboratory (ARL). Dr. Kaplan serves as VP Publications for the IEEE Aerospace and Electronic Systems (AES) Society (2021-Present) and as VP Conferences for the International Society of Information Fusion (ISIF) (2014-Present). Previously, he served as Editor-In-Chief for the IEEE Transactions on AES (2012-2017), on the Board of Governors for the IEEE AES Society (2008-2013, 2018-2020) and on the Board of Directors of ISIF (2012-2014). He is a Fellow of IEEE and of ARL. His current research interests include information/data fusion, reasoning under uncertainty, network science, resource management and signal and image processing.

Abstract: Dealing with Epistemic Uncertainty in Information Fusion Systems

Information fusion is basically the weighted averaging of data from different sources where the weights are inversely proportional to the uncertainty for the data sources. Generally, the uncertainty is aggregated from likelihood models to characterize the probability of the unknown states in light of the observations. In many fusion systems, the likelihood functions are presumed to be known, but in practice they must be machine learned via a calibration process. In Army applications, there can be little training data to accurately learn these likelihoods. This talk will address the epistemic uncertainty as a second-order uncertainty about the likelihoods in cases where very little training exists. Specifically, the talk will highlight new methods to compute error bars around probabilistic outputs of Bayesian and neural networks. Furthermore, it enables new paradigms for establishing prediction sets of feasible hypotheses rather than the most likely hypothesis, which can be very misleading in cases of imbalance of epistemic uncertainty.
Simon Godsill is Professor of Statistical Signal Processing in the Engineering Department at Cambridge University. He is also a Professorial Fellow and tutor at Corpus Christi College Cambridge. He coordinates an active research group in Signal Inference and its Applications within the Signal Processing and Communications Laboratory at Cambridge, specializing in Bayesian computational methodology, multiple object tracking, audio and music processing, and financial time series modeling. A particular methodological theme over recent years has been the development of novel techniques for optimal Bayesian filtering and smoothing, using Sequential Monte Carlo or Particle Filtering methods. Prof. Godsill has published extensively in journals, books and international conference proceedings, and has given a number of high profile invited and plenary addresses at conferences such as the Valencia conference on Bayesian Statistics, the IEEE Statistical Signal Processing Workshop and the Conference on Bayesian Inference for Stochastic Processes (BISP). He co-authored a seminal Springer text Digital Audio Restoration with Prof. Peter Rayner in 1998. He was technical chair of the successful IEEE NSSPW workshop in 2006 on sequential and nonlinear filtering methods, and has been on the conference panel for numerous other conferences/workshops. Prof. Godsill has served as Associate Editor for IEEE Tr. Signal Processing and the journal Bayesian Analysis. He was Theme Leader in Tracking and Reasoning over Time for the UK’s Data and Information Fusion Defence Technology Centre (DIF-DTC) and Principal Investigator on many grants funded by the EU, EPSRC, QinetiQ, General Dynamics, MOD, Microsoft UK, Citibank and Mastercard. In 2009-10 he was co-organiser of an 18 month research program in Sequential Monte Carlo Methods at the SAMSI Institute in North Carolina. He is a Director of CEDAR Audio Ltd. (which has received numerous accolades over the years, including a technical Oscar).

Abstract: Points, particles and positions: recent advances in distributed processing of agile objects

In this talk I will discuss models developed under the SIGNeTS project for agile motion of objects. I will describe new motion and observation models based on point process theory and Levy processes, as well as new advances in Gaussian process models for nonparametric modelling of motion, and will further discuss methods for distributed processing of sensor data using these models, as well as inference about target detection rates and clutter rates. The methodology is probabilistic and implemented using combinations of particle filtering and variational methods.
Invited Speakers

Jon Spencer CPhys FInstP, Dstl

Jon is the Chief Communications and Networks Scientist at the Defence Science and Technology Laboratory (Dstl), part of the UK Ministry of Defence. Jon leads the delivery of communications research spanning all military domains from subsea to space, focusing on development of next-generation and generation-after-next resilient systems to enable information driven operations in the most challenging environments.

As lead scientist for the Communications and Networks programme Jon coordinates research to develop and demonstrate the advanced concepts that will enable Information Advantage in the contested environments of the future. Working with allies and partners from UK industry and academia we are investing in research both to bring forward the military capabilities essential for future operations and to stimulate the development of skills and facilities in the supply chain.

The work is wide ranging. It stretches from fundamental physical research into the propagation environment; maturing novel communications concepts such as Quantum communications; developing new ideas for networking in very congested and dynamic environments through to developing the architectures needed to enable rapid integration and adaptation.

Jon has been active in the development of tactical communications and networking capabilities for 25 years, both in government research and in industry where he led a number of successful product developments. Jon is a Fellow of the Institute of Physics.

Abstract: Multi-Spectral and Multi-Modal Underwater Acoustic Imaging

Communications and Networks are fundamental enablers to military capability. This talk will explain some of the fundamental threats and technical challenges faced when delivering communications and networks capability for military operations. UK Ministry of Defence has recently announced a significant investment in communications and networks research to address these challenges and an overview of that programme will be presented along with opportunities to contribute. Access to appropriate signal processing techniques is essential to this and the talk will discuss some of the signal processing challenges to enable covert and overt communications.
Delegate List

<table>
<thead>
<tr>
<th>Name</th>
<th>Affiliation</th>
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<td>Abderrahim Halimi</td>
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Janet Forbes
Joe Gibbs
John Thompson
Jon Spencer
Jordi Barr
Julian Deeks
Kaiyu Zhang
Karan Nathwani
Kate Hocking
Kristofer Drummond
Lamia Alyami
Lance Kaplan
Lauren Jeeves
Lt Gen Tom Copinger-Symes CBE
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Samuel Waterfall
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California Institute of Technology
Fraunhofer
University of Bath
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Dstl
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Steven Horstmann  Leonardo
Taha Selim
Thomas Bassett  MBDA Systems
Thomas Eddleston  Dstl
Thomas Fraser  Heriot-Watt University
Thomas Short  Atlas Elektronik
Vincent Neo  Imperial College London
Vladimir Stankovic  University of Strathclyde
Wenwu Wang  University of Surrey
Yicheng Wang  University of Liverpool
Yoann Altmann  Heriot-Watt University
Yun Wu  Heriot-Watt University
Zach Gazak  USA Space Systems Command
Sensor Signal Processing for Defence Conference

Important Dates:
Submission of Papers: 16th April 2023
Notification of Paper Acceptance: 30th June 2023
Final version of Paper Due: 30th July 2023
Date of conference: 12 to 13 September 2023
Online / Royal College of Physicians Edinburgh

International Conference in Sensor Signal Processing for Defence: from Sensor to Decision

Signal Processing for Defence Conference is organised by the University Defence Research Collaboration (UDRC) in Signal Processing. SSPD 2023 aims to bring together researchers from academia, industry and government organisations interested in Signal Processing for Defence.

Papers are solicited from the following areas:
- Array Signal Processing
- Image Processing
- Radar, Sonar and Acoustic
- Multimodal Signal Processing
- Multi-Target Tracking
- Signal Acquisition and Sensor Management
- Multiple-input and multiple-output (MIMO)
- Deep Learning, Machine Learning
- Information/Data Analysis
- Data Fusion
- Source Separation
- Anomaly Detection
- Distributed Signal Processing
- Low Size Weight & Power Solutions
- Target Detection and Identification
- Electro-Optic Sensing

All submitted papers will be peer reviewed. Technical sponsorship is provided by the IEEE Signal Processing Society and proceedings will be submitted to the Xplore Digital Library.

www.sspdconference.org
This summer school is delivered under the University Defence Research Collaboration (UDRC) in Signal Processing in the Information Age and is funded by EPSRC and Dstl.

**Summer School Programme**

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<td>Source Separation and Beamforming</td>
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**www.mod-udrc.org**

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