

Welcome to UDRC-EURASIP Summer School 2022

27th June to 30th June 2022



University Defence Research Collaboration in Signal Processing

[a partnership between government, industry and academia]

Mike Davies, UDRC Director
University of Edinburgh



The UDRC

Collaborative Centre of Excellence for Signal Processing

Aims

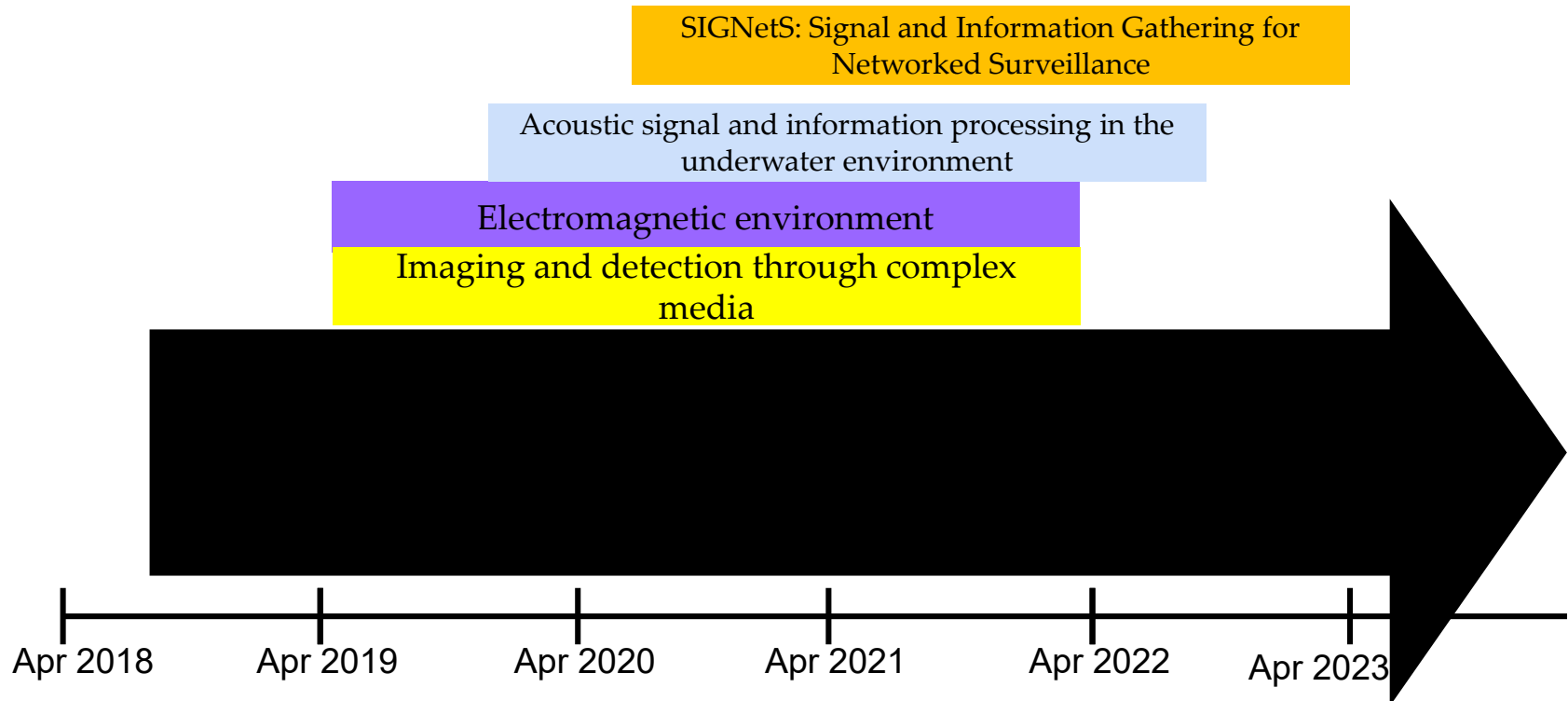
- World-class research
- Long-term sustainable skills
- Community of practice

Approach

- Joint funding with EPSRC
- Dstl technical leadership
- Close, early engagement with industry



Phase 3 UDRC



USP Grant:

£4M over 5 years
= £800k per year
= £400k MOD + £400k EPSRC per year

AT Grants:

£1M approx. over 2-3 years
funding sources vary

Fostering the signal processing community

Annual Conference



Educating the next generation



Website



Special journal editions, books, articles, theme meetings



Sensor Signal Processing for Defence Conference 2022

Conference – 13th – 14th September 2022

Location: IET London:Savoy Place

www.sspdconference.org

- **Academic Keynote - F. Barbaresco, Thales**
- **Industry/Defence Sessions**

Invited speakers

- Simon Godsill, University of Cambridge
- Lance M. Kaplan, ARL

Registration is open and the conference will be face to face in London and also online

Sensor Signal Processing for Defence Conference
13th - 14th September
Hybrid Conference
IET London: Savoy Place / Online

Important Dates:
Submission of Papers: **Extended deadline 29th April 2022**
Notification of Paper Acceptance: 1 July 2022
Final version of Paper Due: 31 July 2022

Papers are selected 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-SNR 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



Welcome to UDRC-EURASIP Summer School 2022

- 8th Summer School (since 2013)
- 75 people registered over 4 days
- 25 different organisations (industry and academia)
- Funded by EPSRC, Dstl and EURASIP

Experts from:

- University of Edinburgh
- Heriot-Watt University
- University of Strathclyde
- University of Liverpool
- Dstl
- Leonardo

UDRC-EURASIP Summer School

Summer School Packs:

- Programme, notebook, pen, WIFI instructions, welcome letter and details of bus routes/maps

Presentation/Lecture Notes: www.mod-udrc.org/resources

Evaluation forms will be emailed to you

SSPD2022 conference flyer

Certificate of attendance – on request

Programme

- Refreshment breaks – tea/coffee/snacks and Lunch
- All lectures in this room

Networking activities

- Monday evening – Ghost Tour (Meet at 7pm at Mercat Cross, High Street). Tours will be split into three groups and will leave at intervals from 7pm.
- Wednesday evening – Dinner at the Salisbury Arms (Meet at 7pm at restaurant).

Summer School Programme

	Monday 27 th June -Statistical Signal Processing	Tuesday 28 th June – Tracking and Sensing	Wednesday 29 th June - Machine Learning	Thursday 30 th June - Source Separation and Beamforming
08:30	Coffee	Coffee	Coffee	Coffee
09:00	Introduction: Introducing exemplar application areas that use statistical signal processing concepts, such as target localization, blind source separation, and other timely topics. Probability and Random Variables: Axioms of probability and classic paradoxes; scalar and vector random variables; probability transformations and applications; statistical descriptors; central limit theorem.	State estimation and multi-target tracking: introduction: Mathematical foundations of tracking and state estimation – transition models, sensor models; Recursive state estimation (Bayes filtering). Single target tracking; the Kalman filter, extended Kalman filter (EKF), unscented Kalman filter (UKF) and particle filter (PF). <i>Jordi Barr, Dstl</i>	Introduction to Machine Learning: Basic concepts; problem formulation: data, labels, objective function, constraints, regularization; examples in pattern classification; kernel PCA and KDA, support vector machines, neural networks (NN). Deep Neural Networks I: Introduction; simple feed forward neural network architecture; how to train neural network; backpropagation theory; introduction to convolutional neural networks. <i>Sotirios Tsafaris, University of Edinburgh</i>	Introduction to Array Processing: Discussion of applications, signal model, and assumptions. Narrowband array processing: steering vectors, angle or arrival (AoA) estimation, and beamforming. broadband processing via tap delay lines: broadband AoA estimation via coherent signal subspace methods; formulation of constraints for broadband beamforming and beamforming solutions. <i>Stephan Weiss, University of Strathclyde</i>
10:00	Classical Estimation Theory: Basic concepts; properties of estimators; maximum likelihood; least squares. The theory will be linked to a “breakdown” of the localization problem. <i>James Hoggood, University of Edinburgh</i>	Single target tracking: Introduction to Stone Soup Practicals on Kalman filter, EKF, UKF and PF <i>James Wright, Dstl</i>		
10:30	Refreshments / Informal Networking	Refreshments / Informal Networking	Refreshments / Informal Networking	Refreshments / Informal Networking
11:00	Further Estimation Theory and Examples: Cramér–Rao lower bounds and Examples; Generative modelling, physical modelling, and Bayesian Estimation Theory. Overview of Monte-Carlo Methods: Applications for integration and optimization, generating random variables, accept-reject and importance sampling, MCMC techniques. <i>James Hoggood</i>	Multiple targets, clutter and data association: The issues introduced by ambiguous association, combinatorics; Absolute assignment schemes (nearest neighbour); Probabilistic assignment schemes. <i>Jordi Barr Multiple target tracking: practical session.</i> Data association, multiple targets, PDA and JPDA. <i>James Wright</i>	Deep neural networks II: Deep learning architectures; key factors behind deep learning; residual neural networks; latest developments in neural network architectures. Some applications as examples of deep learning. <i>Sen Wang, Heriot-Watt University</i>	Source Separation and Beamforming Background: Application of linear algebra to array problems, including subspace decompositions, and robust beamforming. Adaptive signal processing for beamforming, with application to minimum variance distortion less response beamformer. <i>Ian Proudler, University of Strathclyde</i>
12:00				
12:30	Lunch / Informal Networking	Lunch / Informal Networking	Lunch / Informal Networking	Lunch / Informal Networking
13:30	Random Processes: Ensembles, statistical descriptors; input-output system statistics; PSDs; Bayesian Recursions <i>James Hoggood</i> Application: Expectation Propagation (EP) for Scalable Inverse Imaging Problems: introduction to expectation propagation, approximate Bayesian inference, message passing, factor graphs, scalable image restoration, uncertainty quantification, photon-limited imaging. <i>Dan Yao, Heriot-Watt University</i>	Practical aspects and simulation – Initiators/Deleters Metrics. Bringing all components together. Practical sessions on initiation/deletion/metrics and complete simulations. <i>James Wright</i>	Deep Neural Networks III: Deep learning on sparse data using meta-learning and self-supervised learning. Robust deep learning for adversarial defense and domain-shift. Some practical examples in vision, language and control. <i>Tim Hospedales, University of Edinburgh</i>	Introduction to Polynomial Matrix Algebra and Applications: Formulation of broadband array problems using polynomial matrix notation; polynomial matrix factorisations; broadband AoA estimation via polynomial matrix techniques; broadband MVDR adaptive beamforming. <i>Stephan Weiss and Ian Proudler</i>
14:00				
15:00	Refreshments / Informal Networking	Refreshments / Informal Networking	Refreshments / Informal Networking	Refreshments / Informal Networking
15:30	Decision theory: Risk, optimal decisions, likelihood ratio test, connections with MAP and maximum likelihood estimation, types of errors, and Neyman-Pearson lemma. <i>João Mota, Heriot-Watt University</i> Summary and Conclusions of Key Points from the Day. <i>João Mota and James Hoggood.</i>	Demonstrations and Advanced Topics – Tracking in video, AIS-based tracking. <i>Lyudmil Vladimirov, University of Liverpool; David Cormack, Leonardo; James Wright</i>	Resource Constrained Embedded Deep Learning: deployment complexities, optimised models, quantised DNNs, hardware accelerator architectures, real-word examples and demos. <i>Mehrdad Yaghoobi, University of Edinburgh</i>	Exploring the Underwater Environment: applications of beamforming and Bayesian inference to sonar array processing. <i>Lyudmil Vladimirov, University of Liverpool</i> Close 16:30
17:00	Close			

Any Questions?