

UDRC-EURASIP Summer School Programme – 2021

	Monday 28 th June -Statistical Signal Processing	Tuesday 29 th June – Tracking and Sensing	Wednesday 30 th June - Machine Learning	Thursday 1 st July - 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 Tsiftaris, 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>Steve Hiscocks, 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</i> Multiple target tracking: practical session. Data association, multiple targets, PDA and JPDA. <i>Steve Hiscocks</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; spectral representations. Short talks on Advanced topics: Including: Bayesian Recursions and Particle Filtering Methods; Introduction to Hypothesis Testing and Detection Theory. <i>James Hoggood and João Mota, 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>Steve Hiscocks</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	Advanced topics: Sparsity in Signal Processing; Lasso, generalisations, and applications <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; Steve Hiscocks</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>Jason Ralph, University of Liverpool</i>
16:30	Meet the Lecturer / Networking using Spatial Chat (until 17:30).			
17:00	Close			

Timings will be UK time. The Summer School lectures will run in MS Teams and Networking will be run using Spatial Chat. There are informal networking session throughout the week during the refreshment breaks. There is one networking event which the lecturers will attend and will take place on Monday at 16:30 until 17:30. Links will be sent a few days before the event.