

UDRC-EURASIP Summer School Programme – 2022

	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 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 Hopgood, 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 Hopgood</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>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 Hopgood</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 Hopgood.</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			

We have arranged an Edinburgh Ghost Tour on Monday evening at 19:00 and a Summer School dinner at the Salisbury Arms on Wednesday at 19:00.