UDRC-EURASIP Summer School Programme – 2019

	Statistical Signal Processing **Monday 24th June**	**Tracking and Sensing** **Tuesday 25th June**	**Machine Learning** **Wednesday 26th June**	**Source Separation and Beamforming** **Thursday 27th June**
08:30	Coffee	Coffee	Coffee	Coffee
09:00	**Introduction and Target Localisation:** Discussion of active and passive target localisation as exemplar application for the day's material. **Probability and Random Variables:** Axioms of probability and classic paradoxes; scalar and vector random variables; probability transformations and applications; statistical descriptors; central limit theorem. **Classical Estimation Theory**: Basic concepts; properties of estimators; Cramér–Rao lower bounds; maximum likelihood; Bayes theorem; least squares. The theory will be linked to a "breakdown" of the localization problem. ***James Hopgood, University of Edinburgh***	**Overview of Multi-Target Tracking (MTT):** Examples of detection methods, including matched filter. Sensor bias and registration issues. Discussion of typical assumptions used in MTT, observation models, motion models, state-space formulations. ***Murat Uney, David Cormack, Heriot-Watt University, and James Hopgood***	**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. ***Sotirios Tsaftaris, University of Edinburgh***	**Introduction to Array Processing:** Discussion of applications, signal model, and assumptions. Narrowband array processing: steering vectors, angle or arrival (AoA0estimation, 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. ***Stephan Weiss, University of Strathclyde***
10.00		**Single-Target Tracking:** Introduction to the Chapman-Kolgomorov equation, Kalman filtering and its extensions (such as EKF, UKF), particle filtering. ***David Cormack, Murat Uney, James Hopgood***		
10:30	Refreshments	Refreshments	Refreshments	Refreshments
11:00	**Introduction to Random Processes:** Ensembles, statistical descriptors; input-output system relationships; system identification; introduction to spectral representations. **Monte-Carlo Methods:** Applications for integration and optimization, generating random variables, accept-reject and importance sampling, MCMC techniques. ***Murat Uney (NATO) and James Hopgood***	**Single Target Tracking using Stone Soup:** A Practical workshop for investigating and implementing single-target tracking using an open-source platform. ***Jordi Barr, Steve Hiscocks, Dstl*** **Wrap-up Session on Single-Target Tracking** ***Jordi Barr, James Hopgood***	**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. ***Sen Wang, Heriot-Watt University***	**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 distortionless response beamformer. ***Ian Proudler, University of Strathclyde***
12:30	Lunch	Lunch	Lunch	Lunch
13:30	**Introduction to Hypothesis Testing and Detection Theory:** Using the results from the first session, considers classic hypothesis testing, parameter detection. **Optimal Detection of Signals:** Application examples, Optimal tests in the white and colored (non-white) noise cases; detection in active sensing (coherence, long-time integration). ***Murat Uney and João Mota, Heriot-Watt University***	**Classic Data Association for Multi-Target Tracking:** Overview of classic data association techniques, including PDA and JPDA. **Stone Soup for Data Association** A Practical workshop for investigating data association using an open-source platform. ***Jordi Barr, Steve Hiscocks***	**Deep Neural Networks III**: Recurrent neural networks (RNN) and applications in vision and language processing; Deep learning on sparse data; Some practical examples using PyTorch. ***Tim Hospedales, University of Edinburgh***	**Introduction to Polynomial Matrices:** Formulation of broadband array problems using polynomial matrix notation, and motivation of polynomial matrix factorisations; polynomial matrix eigenvalue decomposition algorithms their characteristics. ***Fraser Coutts, University of Edinburgh***
15:00	Refreshments	Refreshments	Refreshments	Refreshments
15:30 – 17:00	**Sparsity in Signal Processing:** L1 optimisation problems, techniques for optimisation, including convexity, stochastic gradient descent. Applications of sparse signal processing. ***João Mota, Heriot-Watt University*** **Summary and Conclusions of Key Points from the Day.** ***João Mota and James Hopgood.***	**Random Finite Set and Vector Based Methods**: A tour of modern multi-target tracking techniques, including recent advances in message passing methods, multi-scan techniques, and group tracking. ***Murat Uney and David Cormack***	**Hands on with Deep Learning in MATLAB, Abstract** ***Martina Sciola, Mathworks***	**Polynomial Matrix Applications:** Broadband AoA estimation via polymomial matrix techniques; polynomial matrix-based broadband MVDR adaptive beamforming. ***Stephan Weiss and Ian Proudler***

Monday 24th June 2017 at 5:30pm: Whisky Tasting

****Wednesday 26th June 2017 at 8pm: Summer school dinner at the Bridge Inn, Ratho (coach pick up at 7:30pm)**