

UDRC Summer School Programme – 2020

	Statistical Signal Processing Monday 22nd June	Tracking and Sensing Tuesday 23rd June	Machine Learning Wednesday 24th June	Source Separation and Beamforming Thursday 25th June
08:30	Coffee	Coffee	Coffee	Coffee
09:00	<p>Introduction: Introducing exemplar application areas that use statistical signal processing concepts, such as target localization, blind source separation, and other timely topics.</p> <p>Probability and Random Variables: Axioms of probability and classic paradoxes; scalar and vector random variables; probability transformations and applications; statistical descriptors; central limit theorem.</p> <p>Classical Estimation Theory: Basic concepts; properties of estimators; maximum likelihood; least squares. The theory will be linked to a “breakdown” of the localization problem.</p> <p><i>James Hopgood, University of Edinburgh</i></p>	<p>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.</p> <p><i>David Cormack, Leonardo</i></p>	<p>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).</p> <p>Deep Neural Networks I: Introduction; simple feed forward neural network architecture; how to train neural network; backpropagation theory; introduction to convolutional neural networks.</p> <p><i>Sotirios Tsafaris, University of Edinburgh</i></p>	<p>Introduction to Array Processing: Discussion of applications, signal model, and assumptions.</p> <p>Narrowband array processing: steering vectors, angle or arrival (AoA) estimation, and beamforming.</p> <p>broadband processing via tap delay lines: broadband AoA estimation via coherent signal subspace methods; formulation of constraints for broadband beamforming and beamforming solutions.</p> <p><i>Stephan Weiss, University of Strathclyde</i></p>
10:00	<p>Classical Estimation Theory: Basic concepts; properties of estimators; maximum likelihood; least squares. The theory will be linked to a “breakdown” of the localization problem.</p> <p><i>James Hopgood, University of Edinburgh</i></p>	<p>Single-Target Tracking: Introduction to the Chapman-Kolmogorov equation, Kalman filtering and its extensions (such as EKF, UKF), particle filtering.</p> <p><i>David Cormack, Mengwei Sun, James Hopgood</i></p>		
10:30	Refreshments	Refreshments	Refreshments	Refreshments
11:00	<p>Further Estimation Theory and Examples: Cramér–Rao lower bounds and Examples; Generative modelling, physical modelling, and Bayesian Estimation Theory.</p> <p>Overview of Monte-Carlo Methods: Applications for integration and optimization, generating random variables, accept-reject and importance sampling, MCMC techniques.</p> <p><i>James Hopgood and Colleagues</i></p>	<p>Single Target Tracking using Stone Soup: A Practical workshop for investigating and implementing single-target tracking using an open-source platform.</p> <p><i>Jordi Barr, Steve Hiscocks, Dstl</i></p> <p>Wrap-up Session on Single-Target Tracking</p> <p><i>Jordi Barr, James Hopgood</i></p>	<p>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.</p> <p><i>Sen Wang, Heriot-Watt University</i></p>	<p>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.</p> <p><i>Ian Proudler, University of Strathclyde</i></p>
12:30	Lunch	Lunch	Lunch	Lunch
13:30	<p>Random Processes: Ensembles, statistical descriptors; input-output system statistics; spectral representations.</p> <p>Short talks on Advanced topics: Including:</p> <ul style="list-style-type: none"> Bayesian Recursions and Particle Filtering Methods Introduction to Hypothesis Testing and Detection Theory. <p><i>James Hopgood and Joño Mota, Heriot-Watt University</i></p>	<p>Classic Data Association for Multi-Target Tracking: Overview of classic data association techniques, including PDA and JPDA.</p> <p>Stone Soup for Data Association</p> <p>A Practical workshop for investigating data association using an open-source platform.</p> <p><i>Jordi Barr, Steve Hiscocks</i></p>	<p>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.</p> <p><i>Tim Hospedales, University of Edinburgh</i></p>	<p>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.</p> <p><i>Stephan Weiss and Ian Proudler</i></p>
15:00	Refreshments	Refreshments	Refreshments	Refreshments
15:30 – 17:00	<p>Short talks on Advanced topics: Including:</p> <ul style="list-style-type: none"> Sparsity in Signal Processing Optimal Detection of Signals and other Applications <p><i>Joño Mota, Heriot-Watt University</i></p> <p>Summary and Conclusions of Key Points from the Day.</p> <p><i>Joño Mota and James Hopgood.</i></p>	<p>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.</p> <p><i>David Cormack</i></p>	<p>Resource Constrained Embedded Deep Learning:</p> <p><i>Mehrdad Yaghoobi, University of Edinburgh</i></p>	<p>Exploring the Underwater Environment: applications of beamforming and Bayesian inference to sonar array processing.</p> <p><i>Jason Ralph, University of Liverpool</i></p>

*Monday 22nd June 2020 at 6:45 pm: Ghost Tour – Meet at Mercat Cross, High Street, Edinburgh

**Wednesday 24th June 2017 at 7:30pm: Summer School dinner at the Salisbury Arms, 58 Dalkeith Rd, Edinburgh EH16 5AD