University Defence Research Collaboration in Signal Processing
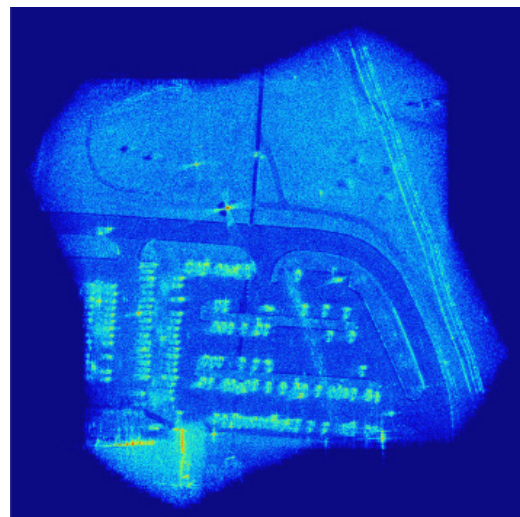## From academic research to military capability

The UDRC provides MOD with direct access to an academic signal processing talent pool deployable on MOD problems at short notice. Twenty researchers in the UDRC have Security Clearance (SC) and a further two have Developed Vetting (DV) clearance.

Exploitation Outputs

Compressed sensing algorithms for producing Low Frequency-Synthetic Aperture Radar (LF-SAR) images developed under the UDRC by the University of Edinburgh, have been adopted by SEA. The fast back projection algorithms are now being evaluated by Selex ES. The technology allows an order-of-magnitude speed up in SAR image formation, which will lead to more rapid situation awareness for SAR operators.

UDRC research at the University of Edinburgh and Dstl has demonstrated rapid and sensitive analysis of mixtures of chemicals in explosives detection using a sparse signal decomposition. Further work is now underway (through MOD-directed funding) to implement the algorithm on a handheld platform, and improve sensitivity for specific mixtures. This task will result in a demonstration of a mixture analysis system at TRL 6 (technology system/subsystem prototype demonstration in a relevant environment). Further permission has been sought from the University of Edinburgh to release code to a third party for integration onto a handheld Raman spectrometer for demonstration at Dstl.

Wide area SAR image formed through Edinburgh fast back projection algorithm.

The UDRC has developed and released an open-source Polynomial Matrix Eigenvalue Decomposition (PEVD) software toolbox. By virtue of its openness, this benefits the whole of the UK academic and industrial signal processing community. The toolbox was developed from UDRC work at Strathclyde and Loughborough and will allow access to sophisticated methods for source separation for technologists working in the field of large and distributed sensor arrays. It is currently being used in support of a UDRC secondee into Thales UK working on algorithms for detection and tracking of difficult to-detect targets using large sonar arrays.

HMS Ambush - an Astute Class submarine, on the Clyde. Crown Copyright 2013.

Outputs of LSSCN consortium work on sparsity and source separation are being directed toward improving underwater situation awareness.

Example handheld Raman spectrometer-target platform for Edinburgh spectral deconvolution software.

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dstl

Enhancing the quality of radar and sonar imaging has also been addressed within the UDRC at the Universities of Surrey and Newcastle through the development of techniques which exploit sparsity, such as analysis model-based dictionary learning, together with sequential Bayesian methods. This technology provides substantial uplift in target definition and potentially overcomes failure in sensors and missing data. It is informing research that the University of Surrey is conducting on the benefits of sparse array techniques for sonar applications under a contract with Atlas Elektronik Ltd. and the Maritime Collaborative Enterprise.

UDRC algorithms for quantifying the trust an operator can place in an automated classifier were used in a project on assured naval mine countermeasures (MCM) under the Maritime Collaborative Enterprise (MarCE) programme. This work was undertaken jointly by SeeByte UK Ltd, Heriot-Watt University and BAE Systems. The outputs from this project will inform other research to design the MCM and Hydrographic Capability (MHC), the successor to the Hunt and Sandown class MCM vessels.

Hunt-class minehunter HMS Brocklesby. Crown Copyright 2013.

UDRC algorithms will help to inform the procurement of the next generation of mine countermeasure capability.

Collaborations

The UDRC has built collaborations with similar, relevant defence-academic ventures, which are essential steps to facilitate exploitation of the UDRC work into MOD programmes. In 2014 the UDRC held a joint meeting with the UK/US International Technology Alliance in Network and Information Sciences (NIS-ITA) and a themed meeting on signal processing for autonomous systems was held jointly with researchers from the Autonomous Systems Underpinning Research (ASUR) programme.

The UDRC phase 2 has made notable contributions toward its objective of developing a world-class UK skills base in signal processing for defence. It ran the UDRC Summer Schools in June 2014 and July 2015 for signal processing engineering research students and industrial practitioners. The UDRC has organised themed meetings on source separation, anomaly detection, signal processing for autonomous systems, advanced radar applications and hardware implementations. These are designed to bring UDRC researchers and industry together to address a common signal processing problem. Since 2010 the UDRC has organised the Sensor Signal Processing for Defence (SSPD) conferences – the only open-access international academic conference in this research area.

Structure

Phase 2 of the UDRC follows the successful UDRC Phase 1 which ran from 2009 to 2013. This was administered through Imperial College London and delivered £4.8M of signal processing research at 12 universities. The current phase is a 5-year, £11.5M programme centred on an £8M joint venture between MOD and EPSRC. UDRC phase 2 is a collaboration between 7 leading universities, the MOD and defence industry (ten primes and SMEs currently serve on each consortiums' advisory group). The personnel comprise a team of 38 researchers and 15 PhD students. This collaboration is unique in terms of an integrated programme of research, with engagement from strategic industrial partners who provide commercial driving force to bring research outputs closer to exploitation.

What is the UDRC?

- The UDRC is an ongoing joint venture between MOD and the Engineering and Physical Sciences Research Council (EPSRC). The UDRC Phase 2, which began in 2013, addresses the topic of "Signal Processing in a Networked Battlespace".

- The aims of the programme are to:
  - Develop signal processing science and technology to address military challenges;
  - Develop a world class UK skills base in signal processing for defence;
  - Form a key component of the wider community of practice in defence signal processing;
  - Facilitate the rapid exploitation of science and technology in the signal processing domain to address military requirements.

- Phase 2 Collaborating Universities: University of Edinburgh, Heriot-Watt University, Loughborough University, University of Surrey, University of Strathclyde, Cardiff University and Newcastle University.

Working with academia

The Universities involved are all international leaders, working at the cutting edge of signal processing theory, applying innovative theory by developing and testing advanced algorithms. A number of instances of UDRC research have already been applied directly to MOD signal processing problems for the benefit of the UK and our international partners. There are over 100 publications in phase 2, examples of significant breakthroughs are found in fields such as low frequency synthetic aperture radar imaging, micro Doppler technologies for target detection and multi-target tracking algorithms. This outstanding research can be found published in the most significant peer reviewed journals such as IEEE Transactions.