

UDRC Highlights on activities, exploitation and training the next generation of defence signal processors

Consortium Directors

Prof. Mike Davies,
Edinburgh Consortium

- University of Edinburgh
- Heriot-Watt University
- Queen's University Belfast

Prof. Jonathon Chambers,
LSSCN Consortium

- Loughborough University
- University of Surrey
- Strathclyde University
- Cardiff University
- Newcastle University

Structure of Presentation

Communication, engagement and education

- Publicity and marketing
- UDRC Summer School
- SSPD Conference
- Related Events
- PhD Studentships
- Awards
- People

Defence and industry

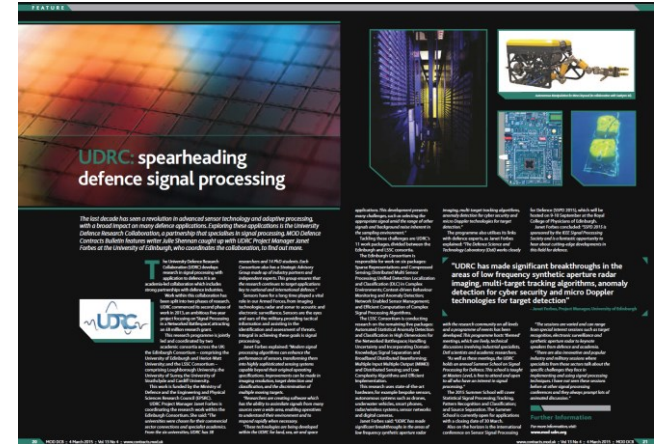
- Strategic Partners
- Industry Days / Workshops
- UDRC Themed Meetings and Challenge Competitions
- Funding Streams - an overview
- Highlights
- Data

Conclusions

Publicity and Marketing

Two websites - www.mod-udrc.org
www.sspdconference.org

18 Articles (Including Financial Times, The Herald, Forbes, MOD Defence Contracts Bulletin, BBC).



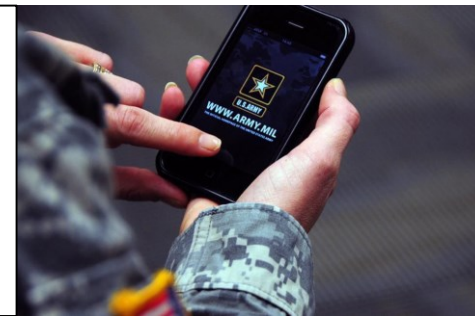
[FT Magazine](#)

Science: Interpreting the theatre of war



Forbes

Academics Launch Bid to Lift The Digital Fog Of War



BBC New sonar device mimics dolphins

Communication, engagement and education: – UDRC Summer School

4 day school

- Statistical signal processing
 - Radar processing and tracking
 - Machine learning
 - Source separation and beamforming
- } Edinburgh led
- } LSSCN led

In 2017

- 95 people registered over 4 days
- 19 different countries represented
- 29 separate organisations

In phase 2 - delivered 5 summer schools and graduated
360 students

Experts from:

UDRC Universities, Czech Technical University Prague,
Hellenic Air Force, Leonardo, Seebyte, UCL.



The poster for the UDRC Summer School 2017, held at the University of Surrey from June 26-29, 2017. It features a silhouette of a human head filled with gears and a brain, symbolizing cognitive and technical processes. The text on the poster includes the school's title, dates, location, and a table of the four-day program. It also lists important dates for applications and notifications, and provides contact information for expressions of interest.

UDRC Summer School
26 - 29 June, 2017
University of Surrey

IMPORTANT DATES

- Application for UDRC Summer School 2017 Open: 19 January 2017
- Deadline for Application: 31 March 2017
- Notification of Application: 11 April 2017

This four day school is for researchers in industry, defence and academia with an interest in Signal Processing for Defence and a knowledge of Mathematics/Statistics at Masters level.

Summer School Programme

Monday 26 June	Statistical Signal Processing
Tuesday 27 June	Radar Processing and Tracking
Wednesday 28 June	Machine Learning
Thursday 29 June	Source Separation and Beamforming

This summer school is delivered under the University Defence Research Collaboration (UDRC) in Signal Processing for a Networked Battlespace and is funded by IPARC and Dstl.

Expressions of Interest – email jane.lorbert@ucl.ac.uk
More information – www.uosd.sus.ac.uk/info/2017/summer-school

Communication, engagement and education: – Sensor Signal Processing for Defence Conference Series (SSPD)

- Annual conference
- 7 successful to-date
- 100 – 120 people in attendance
- Industrial and military panels
- Academic and defence keynotes
- Invited speakers on specific topics; radar, tracking and sonar.
- Peer reviewed papers
- Best paper award
- Sponsored by;
 - IEEE Signal Processing Society,
 - IEEE Aerospace and Electronic Systems Society.

Next SSPD - 9th to 10th May 2019 in Brighton

Sensor Signal Processing for Defence Conference
22 - 23 September
Royal College of Surgeons
Edinburgh
SSPD 2016

Sensor Signal Processing for Defence Conference
6 - 7 December, 2017
IET: Savoy Place
London
WC2R 0BL
SSPD 2017

Sensor Signal Processing for Defence Conference 2014
4th - 6th September 2014
John McIntyre Conference Centre, Pollock Halls,
University of Edinburgh

Sensor Signal Processing for Defence Conference (SSPD 2015)
September 9 - 10, 2015
Royal College of Physicians
9 Queen Street
Edinburgh
EH2 1JQ

Important Dates:
Submission of Papers: 22nd April 2016
Notification of Paper Acceptance: 24th June 2016
Final version of Paper Due: 29th July 2016

Important Dates:
Submission of Papers: 22nd June 2017
Notification of Paper Acceptance: 22nd August 2017
Final version of Paper Due: 30th September 2017

Important Dates:
Submission of Paper Deadlines:
4th April 2014
Notification of Paper Acceptance:
6th June 2014
Final version of Paper Due:
27th July 2014
Conference Dates:
8th and 9th September 2014

Important Dates:
Submission of Papers:
14th - 16th April 2015
1st May 2015
Paper Acceptance:
11th June 2015
Final version of Paper Due:
8th July 2015

Call for papers: www.sspdconference.org

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Technical sponsorship is provided by the IEEE Signal Processing Society and the IEEE Aerospace and Electronic Systems Society.

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Communication, engagement and education: – Related Events

- Warfare in the information age (WitIA) event
 - UDRC presented work on:
 - anomaly detection in networks and WAMI
 - compressed sensing and sparsity
 - tracking and sensor management
 - efficient implementation
- Int. Symposium on communications control and signal processing (ISCCSP)
 - UDRC presented special sessions featuring:
 - Analysis dictionary learning based on Nesterov's gradient with application to SAR image despeckling;
 - Reuse of fractional waveform libraries for MIMO radar and electronic countermeasures.
- Keynotes
 - Int. Conference on Pattern Recognition Methods 2014
 - Electronic Warfare Symposium 2015
 - SPAWC 2016
 - International workshop on compressed sensing theory
 - IMA conference on mathematics in signal processing

Impact – Years 1-4 UDRC II

- Royal Society, Kavli International Research Centre, Chicheley Hall, 25th – 26th August 2016



“Workshop on Polynomial Matrix Decompositions and their Applications” Professor John McWhirter FRS & Dr Stephen Weiss



Overview PART I Basics PEVD Iter. Toolbox PART II MIMO AoA MVDR Material



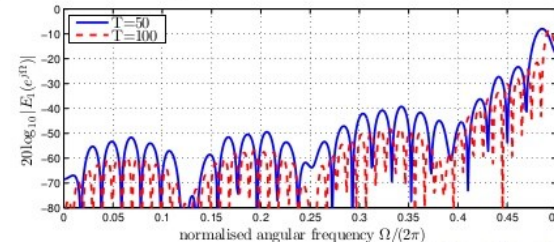
Polynomial Matrix MVDR Formulation

- ▶ Power spectral density of beamformer output:
 $R_e(z) = \tilde{\mathbf{w}}(z)\mathbf{R}(z)\mathbf{w}(z)$
- ▶ proposed broadband MVDR beamformer formulation:

$$\min_{\mathbf{w}(z)} \oint_{|z|=1} R_e(z) \frac{dz}{z} \quad (26)$$

$$\text{s.t. } \tilde{\mathbf{a}}(\vartheta_s, z)\mathbf{w}(z) = F(z) . \quad (27)$$

- ▶ precision of broadband steering vector, $|\tilde{\mathbf{a}}(\vartheta_s, z)\mathbf{a}(\vartheta_s, z) - 1|$, depends on the length T of the fractional delay filter:



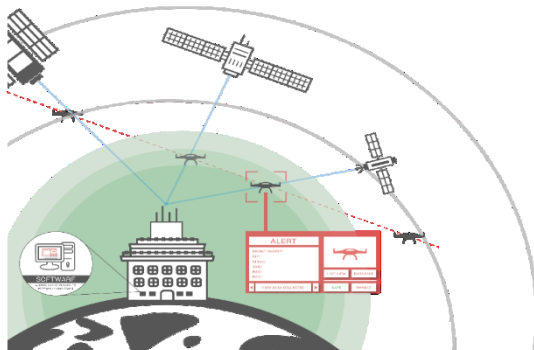
Communication, engagement and education: – PhD studentships

- 20 additional studentships provided by UDRC Universities to work on UDRC problems
- 9 industrially sponsored studentships funded by industry (Leonardo, Roke Manor, Seebyte, ST Microelectronics, Mathworks, Thales)

Communication, engagement and education: - Awards

Highlight: Dr Carmine Clemente and his team at Strathclyde won the overall European Satellite Navigation Competition.

- Development of satellite-based, early detection system capable of early drone detection and tracking.
- The project will receive an extensive package to support further development and market entry.



Drone appears at 00:00, 00:23 & 00:37



Communication, engagement and education: - People

PHASE 2 UDRC

25 academics, 26 Postdoctoral Researcher Associate (PDRA), 20 PhD students

PhD students who have graduated:

- Lecturer, Nanjing Technical Univ., China
- PDRA, Loughborough University x 2
- Research Scientist, State Key Lab of Space-Ground Integrated Information Tech, Beijing, China
- PDRA, Kings College London
- NATO, CMRE, La Spezia, Italy
- PDRA, Surrey University
- PDRA, Strathclyde University
- Engineer, Aveillant.
- Engineer, AnyVision
- Researcher, Fraunhofer FKIE
- Robotics Engineer, I Robot
- CEO, Autuo.ai

PDRAs who have moved on:

- NATO, CMRE, La Spezia, Italy x 2
- Academic, University of Edinburgh
- Researcher, International Council for the Exploration of the Sea.
- Academic, Dublin University x 2
- Academic, Lincoln University
- PDRA, Cambridge University
- Engineer, AnyVision
- Software Engineer, Blackmagic Design
- Software Developer, ARM
- Engineer, NCTech

Defence and Industry: – Strategic Partners

Strategic Meetings

- provide feedback on research
 - **timely and relevant**
- advise on the programme strategy
 - **change of direction as required (mid-term review)**
- identify current knowledge gaps
 - **from industrial viewpoint**
- create potential exploitation opportunities
 - **consultancy/PhD research**



Roke

Part of the
Chemring Group

THALES

SYSTEMS

INSPIRED WORK

QINETIQ

ATLAS ELEKTRONIK




Innovation deployed
Kaon



Defence and Industry: – UDRC Industrial Days / Workshops

- UDRC Industrial Day – showcase joint collaborations
- UDRC Aim Day – companies submit a question or commercial challenge which gets addressed by UDRC academics
- Specific topic workshops
 - Polynomial matrix workshop
 - Advanced processing for sonar workshop
 - Space surveillance and tracking
 - AFRL and US Army scoping meetings
- Presenting case studies explaining challenges and successes of the research
- Knowledge transfer and exploitation opportunities



AIM DAY Sensor Signal Processing & Imaging

Would you like some of the UK's most innovative minds working on your company's challenges?

Why not join us at AIMDay* Sensor Signal Processing & Imaging on 27th September 2016 in Edinburgh which will tackle company needs for new knowledge in sensor systems from many disciplines to specialist high-value sensors.


The UDRC, a consortium of seven leading universities funded by Dstl and EPSRC develops research into signal processing for defence. This is an ideal opportunity to benefit from the transfer of these skills to other sectors to tackle technical challenges in sensor signal processing and imaging.

What is AIMDay?
AIMDay stands for Academic Industry Meeting day. It is a one day event at which companies submit a question or commercial challenge within the chosen AIMDay topic. Multi-disciplinary academics, with knowledge on how to address the specific company challenges they self-select the questions which they believe they can add most value to. On the day itself, the academics attend a one hour workshop face to face with the company to discuss possible pathways to a solution. There is no limit to the number of questions each company can pose.

What AIMDay Sensor Signal Processing & Imaging offers:

- Meet with academics who can contribute to solving your company challenges.
- Find out about the latest cutting edge research from academics, which could be applied to your specific challenge.
- Explore new opportunities for product and business development through collaboration with academic researchers.
- Meet representatives from other companies/organisations.

Register your attendance and questions at www.aimday.org/sensors-edinburgh-2016



UDRC Industrial Day

Friday 27th June 2014

Postgraduate Centre - Heriot-Watt University

The University Defence Research Collaboration is a leading partnership between industry and defence. The research is academia led and focuses on Sensor Signal Processing for defence.

The UDRC is inviting all those interested in the development of Signal Processing for the defence industry.

Industrial Day
Come along and hear about the research in Signal Processing for Defence where a number of case studies are presented explaining the challenges, successes of the research and exhibit the outputs through a series of practical demonstrations. These case studies will showcase the collaborations between academia and industry. There will also be an opportunity to discuss research at interactive poster sessions throughout the day and find out more from the Knowledge Transfer Networks and the Centre for Defence and Enterprise.

The Industry Day is an excellent opportunity to network and stimulate new collaborations in the Signal Processing field.

Registration Is Now Open!

The University Defence Research Collaboration (UDRC) is funded by EPSRC and Dstl

Postgraduate Centre
Heriot-Watt University
Riccarton Campus
Edinburgh
EH14 4AS

Register:
www.udrc.org/industry

For More Information:
www.udrc.org
Contact: post@heriot-watt.ac.uk

Defence and Industry: – UDRC Themed Meetings

Lively meetings with industry, defence and academia where there is the opportunity to enter defence challenges.

Technical meetings have been held on:

- Source separation and sparsity
- Network and Information Sciences International Technology Alliance
- Autonomous systems and signal processing
- Hardware and implementation
- Image and video processing
- MIMO and radar signal processing
- Space surveillance and tracking
- Underwater sensing, signal processing and communications
- Data science and signal processing (with Alan Turing Institute)

Defence and Industry: – UDRC Challenge Competitions

- 1-2 per meeting
- Run during themed meetings
- Addresses current signal processing challenge
- Well-constrained
- Comes with data
- Short horizon
- Prize
- 11 challenges in total
- ~100 data sets distributed
- 7 winners
- 3 entries attracted further funding from MOD
- 1 ended up in a commercial product
- at least 6 entries have ended up making their way into Dstl research projects



GPR Anomaly
Detection



Temporal Anomaly Detection



Underwater ATR



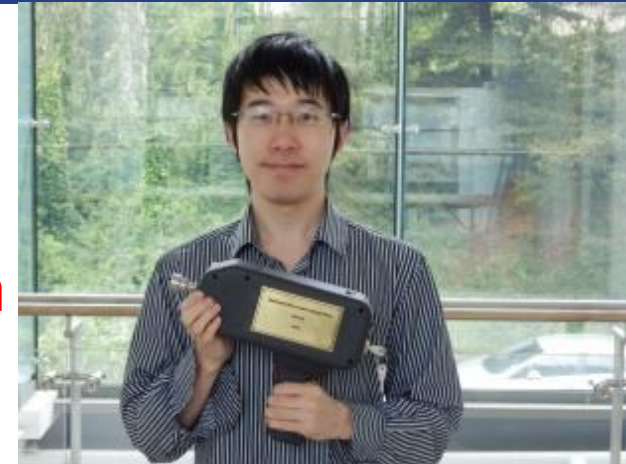
WAMI Anomaly detection

Defence and Industry: – Challenge Competition

Highlight: fast Raman spectral deconvolution

- Themed meeting Challenge
 - Enabling agreement
 - baseline correction
 - complexity reduction
 - Enabling agreement 2
 - prototyping
 - Industry involvement
 - Enabling agreement 3
 - technical refinement
 - Contract with industrial supplier
 - Licensing agreement

< 3yrs



Fast Sparse Raman Spectral Unmixing for Chemical Fingerprinting and Quantification

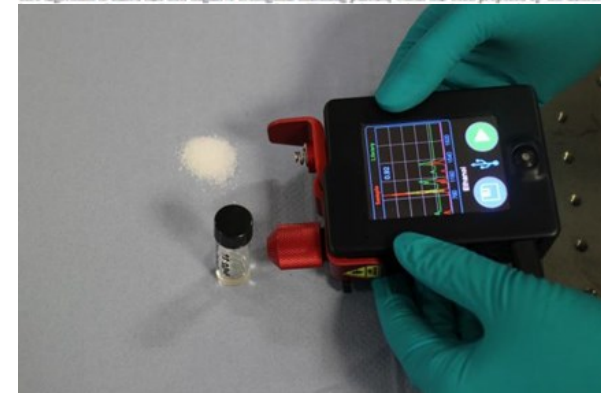
Mehrdad Yaghoobi^a, Di Wu^a, Rhon J. Clives^b, and Mike E. Davies^a

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Mayfield Road, Edinburgh EH9 3JL, UK
^bCBR Devision, Dstl, SP4 0JQ, UK

ABSTRACT

Raman spectroscopy is a well-established spectroscopic method for the detection of condensed phase chemicals. It is based on scattered light from exposure of a target material to a narrow-band laser beam. The information generated enables presumptive identification from measuring correlation with library spectra. Whilst this approach is successful in identification of chemical information of samples with one component, it is more difficult to apply to spectral mixtures. The capability of handling spectral mixtures is crucial for defence and security applications as hazardous materials may be present as mixtures due to the presence of degradation, interferences or precursors. A novel method for spectral unmixing is proposed here. Most modern decomposition techniques are based on the sparse decomposition of mixture and the application of extra constraints to preserve the sum of concentrations. These methods have often been proposed for passive spectroscopy, where spectral baseline correction is not required. Most successful methods are computationally expensive, e.g. convex optimisation and Bayesian approaches.

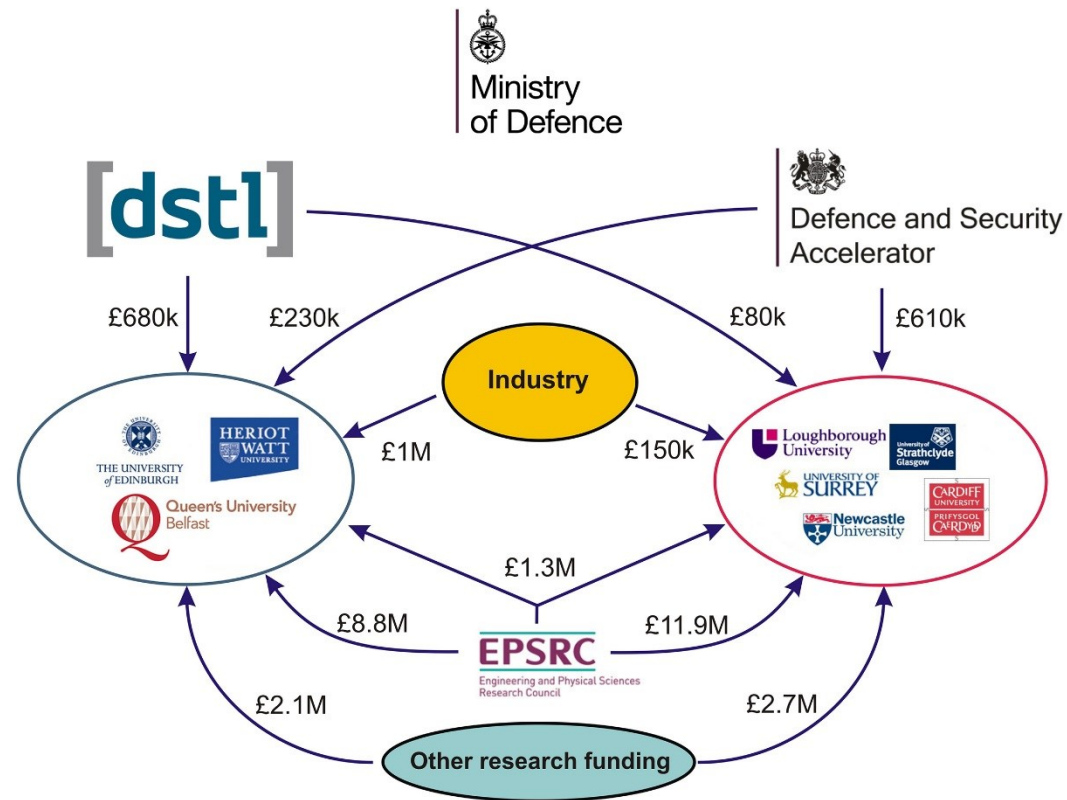
We present a novel low complexity sparsity based method to decompose the spectra using a reference library of spectra. It can be implemented on a hand-held spectrometer in near to real-time. The algorithm is based on iteratively subtracting the contribution of selected spectra and updating the contribution of each spectrum. The core algorithm is called fast non-negative orthogonal matching pursuit, which has been proposed by the authors.



Defence and Industry: – An Overview

In addition to main UDRC Grant, the consortia secured the following related funding streams

- Related EPSRC funding - £21M
- Other (EU/ERC/Royal Society) - £4.8M
- Industrial Contributions (Studentships and consultancy) - £1.1M
- Dstl Enabling Contracts - £760K
- Defence and Security Accelerators - £840K



Defence and Industry: – Highlights

UDRC have provided signal processing expertise to people and projects in MOD, wider Government and industry.

- from exploratory workshops covering a broad range of topics
- to more focussed and in-depth work which looks at a particular defence need.

Secondments

› Strathclyde	➡	Thales
› Heriot-Watt	➡	Roke Manor
› Heriot-Watt	➡	Dstl, Porton Down
› Heriot-Watt	➡	Purdue University
› Edinburgh	➡	Aalto University

Visiting Positions

› Dstl	➡	HWU
› Dstl	➡	Strathclyde

Total £760K in associated enabling contracts on MOD problems and challenges including work in:

- Underwater tracking and motion analysis
- Space surveillance and tracking
- Temporal anomaly detection
- Mobile Ad-Hoc Sensor Network (MASNET) Modelling
- Algorithms for the Detection of Advanced Radar Signals (DARS) testbed
- Raman Spectral Analysis

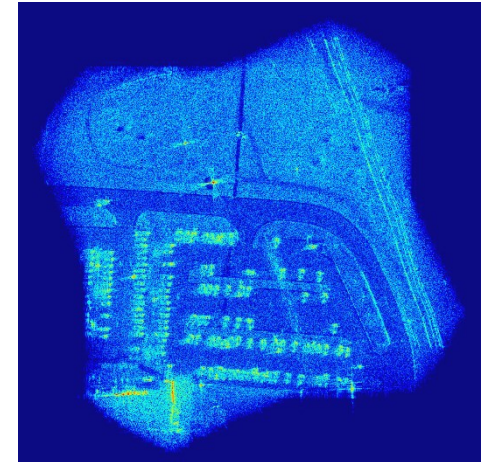
Defence and Industry: – Data

Working with **Dstl's** data to improve research

- Dstl - Application of novel tracking and association methods for Space Situational Awareness
- (Processed raw data from ground-based radars and optical sensor systems)

Working with **industrial partners** and use their data to test and evaluate algorithms and models

- Roke Manor - How to reliably count the number of co-channel signals in the presence of spatially correlated noise
- Cubica Technologies - Rapid multi-sensor deployment using automatic calibration.
- Thales - Application of polynomial matrix decompositions in broadband processing for underwater systems
- Atlas Elektronik - Sparse sensor arrays for conformal arrays on submarines



Defence and Industry: – Joint International Defence Trials

UDRC Data collection - Joint trials between UDRC and NATO Centre for Maritime Research & Experimentation

- Broadband sonar data was collected with the Hydrason BioSonar ultra-wideband sonar array. This novel hardware relies in part on research outputs from the UDRC phase 2.
- The trials delivered a vital data set which addresses fundamental questions about coherence as well as material to develop recognition algorithms based on coherence processing.



Defence and Industry: – Spin-outs and Companies

Anyvision

- A visual security company focussing on face recognition in surveillance started in 2015
- As of 2018 AnyVision employs 85 people in UK, Israel and the USA and partners with major players including Bosch, Almativa, NVIDIA and Verint.

AutuoAI

- An early-stage startup company - developing technology that gives machines variable perception in complex environments
- Developing ultra-sensitive LiDAR systems and Deep Learning solutions for the CUAV, autonomous vehicles (AV) and autonomous rail (AR) market
- Enables autonomous systems to operate safely in harsh environmental conditions, e.g. heavy fog or rain and snow
- Developing new software solutions that allows machines to perceive and interact in any complex environment using multiple sensors

University of Strathclyde

- Development of satellite-based detection system capable of early drone detection and tracking.
- The project received an extensive package to support further development and market entry.



AUTUO
— Making autonomy safer

Puneet Chhabra (Heriot-Watt) and Jameel Marafie (Imperial College London)

Conclusions

A unique combination of research, exploitation, engagement and communication

Signal processing community of interest of 1150 active members. Over 300 UDRC publications published.

Register your interest at www.mod-udrc.org

More information can be found at:
Research / White papers / Videos
www.mod-udrc.org/research/

Publications
www.mod-udrc.org/publications

Any Questions?