

PROCEEDINGS OF SPIE

# **Counterterrorism, Crime Fighting, Forensics, and Surveillance Technologies III**

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**Robert J. Stokes**, Agilent Technologies (United Kingdom)
- 2 Spectroscopy, Raman/LIBS and Hyperspectral  
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- 3 Remote Surveillance and Autonomous Sensors  
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- 5 Image Enhancement, Detection and Tracking (Joint Session 2)  
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- JS7 Segmentation (Joint Session 7)  
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## Introduction

This conference brings together emerging technologies for countering terrorism and crime fighting, providing support to forensics, surveillance, security and defence forces. It addresses the big issues of maintaining security and safety by detecting hidden dangerous materials, identifying people, authenticating travel documents, and recognizing suspicious behaviour from video imagery.

### **Session 1: Detection and Identification of CBRNE**

For the first session on the detection and identification of CBRNE, there were four technical talks. The first talk was from Dr. Gennadii Kotkovskii (National Research Nuclear University MEPhI, Russian Federation) who presented the need for concentrating microparticles of TNT before detection and the use of cyclone to enhance the concentration of the explosive samples before detection. He compared the collection efficiency of this approach with the traditional wiping method which showed substantially high efficiency.

This presentation was followed by a talk from Dr. Artem Akmalov (National Research Nuclear University MEPhI) on laser ionisation assisted, explosive vapour detection using in mobility spectrometry. A Nd:YAG laser ( $\lambda=266\text{nm}$ ) was used to detect explosives like RDX, NG, PETN, TNT. For this investigation, the field asymmetric ion mobility spectrometry (FAIMS) method was used. He presented results on the effect of changes in laser power levels on the detected signal.

Dr. Igor Martynov (National Research Nuclear University MEPhI) presented interesting research on use of dye embedded inside porous microcavities for the detection of nitroaromatic compounds. Dye (5-triphenylamino-4-(triphenylaminothiophen-2-yl)-pyrimidine) was embedded into the substrate through high pressure and capillary action of the pores, and the sensitivity of the obtained structures was examined for the nitroaromatic compounds detection.

This was followed by a second presentation from Dr. Gennadii Kotkovskii on a prototype instrument development for aerosol collection with liquid phase re-circulation and pre-concentration of explosive particles (especially for biosecurity). The collected samples seem to maintain viability of the collected microorganisms and the sampler is compact and portable.

### **Session 2: Spectroscopy, RAMAN/LIBS and Hyperspectral Imaging**

This session started with a student presentation by Mr. Marwan Abu Leil (Ben-Gurion University of the Negev, Israel) on image quality enhancement with the help of liquid crystal waveplates (LCW), including both computational and experimental results. He demonstrated the effect of LCW in imaging, for different spectral bands and low light levels for various applications like tissue imaging, fingerprint imaging and remote sensing.

This was followed by another interesting talk from Ms. Agnieszka Jenerowicz (Military University of Technology, Poland) on use of hyperspectral imaging for the evaluation of camouflage fabric deterioration. Spectral indices were applied in order to determine the degree of ageing/deterioration. Again, the material samples were subjected to a classification process using spectral reflectance characteristics of brand new materials to find the divergence between the samples and determining the degree of destruction of samples, depending on the ageing processes.

After this, Dr. Radhakrishna Prabhu (Robert Gordon University, United Kingdom) presented the use of rare-earth doped waveguides for enhancing the security of passports and travel documents. He discussed the use of fluorescent multi-spectral bands as spectral barcodes and their integration into the passports. He explained the use of time resolved spectroscopy (fluorescence decay) along with the multi-spectral bands to enhance the security.

This was closely followed by a talk from Dr. Federico Angelini (ENEA, Italy) on Raman spectroscopy to maximise the signal for stand-off detection keeping the power levels for eye safe operation. He highlighted the signal-to-noise aspect of the very weak Raman signal during the detection.

This was followed on to the use of reflective THz radiation generated using photoconductive antenna, for the detection of traces of explosives, by Dr. Artem Akmalov (National Research Nuclear University MEPhI), in which he used a femtosecond laser along with a microarray lens on a substrate to generate the radiation (0.5-2.6 THz). Cotton fabrics with traces of explosives of trinitrotoluene (TNT), cyclotrimethylenetrinitramine (RDX) and pentaerythritol tetranitrate (PETN) were investigated. Detection of trace amounts of explosives around 100 µg/mg was possible with this approach.

### **Session 3: Remote Surveillance and Autonomous Sensors**

Thomas Mueller (Fraunhofer IOSB, Germany) presented a system for drone detection using visible and short-wave infrared cameras. The method is based on temporal median computation for background extraction, structural adaptive image differencing, phase and codebook-based background learning, local density computation, and shape analysis of foreground structures to perform an improved near range change detection for UAVs.

Henri Bouma (TNO, The Netherlands) presented their study on the design and development of a fully functional autonomous system, consisting of sensors, observation processing and behaviour analysis, information database, knowledge base, communication, planning processes, and actuators. The system behaves as a teammate of a human operator and can perform tasks independently with minimal interaction. The simulation is based on the Robotic Operating System (ROS) with fully modelled sensors and actuators and the 3D graphics-enabled physics simulation software Gazebo.

Philip Engstrom (Swedish National Forensic Center) presented a work related to 3D modelling of indoor and outdoor crime scenes and the development of a prototype system to use telepresence for witness walkthrough. Recent progress even led to the development of telepresence in autonomous vehicles on the public road.

Jaroslav Krejci (University of Defence, Czech Republic) focused on comparison of two methods for UAV distance measurement: active (impulse laser rangefinder) and passive (triangulation method). Mathematical modelling showed that the active measurement is possible, and the maximum distance can be identified. The accuracy of the passive method depends on the squared of the UAV distance. There are two significant advantages of the passive method: measurements can be made continuously and multiple objects in the field of view can be measured at the same time.

#### **Session 4: Unmanned Sensors and Systems**

The unmanned sensors and systems session was chaired by Markus Mueller (Fraunhofer IOSB, Germany).

Albertus van den Broek (TNO, The Netherlands) studied of border surveillance systems for automatic threat estimation. This study is linked to the H2020 project ALFA, which focuses on the detection and threat evaluation of low flying objects near the strait of Gibraltar. Several fusion methods are discussed, including Fuzzy Reasoning, Bayesian Reasoning, and Dempster-Shafer Theory. These fusion methods give two output values for each track: a suspect probability and an uncertainty value.

Alexander Borghgraef (Royal Military Academy, Belgium) presented his work on acoustic detection of UAV threats. The characteristic drone sound is detected with MFCC features and microphones that are similar to what humans can hear.

Gunter Grasemann (Fraunhofer IOSB, Germany) presented the system for defense of danger through UAVs.

Ivo Buske (German Center for Aeronautics on Space) presented his work on UAV detection by using a camera with telephoto lens on a pan-tilt unit on the floor and a helium filled balloon with a convex spherical mirror in the air.

Steve Sykes (Thales, United Kingdom) was not focusing on countermeasures against UAVs, but on a sensor tasking algorithm which chooses a sequence of tasks for an EO/IR camera located on the UAV. The tasking algorithm must offer a low latency to target reports. A decentralized approximate solution based on Gittins indices is described to make the problem tractable.

Dongmin Sun (Zhejiang University, China) described a multi-modal vision sensor for autonomous driving. The sensor consists of a stereo camera, polarization camera

and panoramic camera. A cross-modal enhancement is achieved by registering multiple sensors for a water hazard.

### **Session 5: Image Enhancement, Detection, and Tracking**

Hidetoshi Kakuda (National Research Institute of Police Science, Japan) presented three types of image enhancement by pre-processing fingerprints. The first method uses the transformation of a color model, the second is a PCA-based method applied to the color data, and the third is uses FFT to remove the spatial periodic pattern in the background.

Vanessa Buhrmester (Fraunhofer IOSB, Germany) augmented data from a visual camera to train better CNN detectors in the infrared camera. The best performing color augmentation method has been the transformation of RGB to inverse Luminance with added Gaussian blur.

Ibrahim Batuhan Akkaya (ASELSAN, Turkey) used a light-weight Mobile-Net network for visual recognition. The conditional generative adversarial network (CGAN) is utilized in the proposed method. This network can generate more photo-realistic pictures that are balanced in the sense of class distribution. The perceptual loss is utilized in training of the generator network and the effect on performance is evaluated on MNIST, CIFAR10 and SVHN datasets.

Stephane Vujasinovic (Fraunhofer IOSB, Germany) compared several traditional trackers with recent DNN-based trackers. The results showed that even the worst DNN-based tracker outperformed the best traditional tracker.

### **Session 6: Privacy Enhancing Surveillance Techniques**

Ann-Kristing Grosselfinger (Fraunhofer IOSB, Germany) performed anonymization of faces in images by using the OpenPose body-pose detector. She reached nearly human performance, with almost no human resources spent.

Rebekka Peter (Fraunhofer IOSB, Germany) performed anonymization of license plates by using two YOLOv3 detectors in a hierarchical way: one for vehicle detection and one for license plate detection. The model was trained using a specifically composed dataset that included synthesized images, the usage of low-quality or non-annotated datasets as well as data augmentation methods. Rebekka Peter received the student award for the SPIE conference Counterterrorism, Crime Fighting, Forensics and Surveillance Technologies 2019 for her excellent research, presentation and response to the questions.

Henri Bouma (TNO, The Netherlands) presented a utility-driven autonomous surveillance approach to trade-off privacy (anonymization) and security. A methodology for constructing a goal-function was described that reflected the operators' preferences. This goal function was combined with an image-processing system that provided tracking and threat assessment functionality and a decision-making framework that assessed the potential value gained by providing the operator with de-anonymized images.

### **Session 7: Action and Behaviour Recognition**

Maria Andersson (FOI, Sweden) presented her work on deep-learning for behaviour recognition in surveillance. The recurrent LSTM network was used with a sequence input layer, an LSTM layer, a fully connected layer, a softmax layer and a classification output layer. The optimal number of hidden units is a trade-off between accuracy and computation time.

Yitzhak Yitzhaky (Ben-Gurion University of the Negev, Israel) presented his work on action localization and classification in long-distance surveillance. The long distance is challenging because the size of the activity is often small in the image and the turbulence distortions add false motions. The method used optic flow and a modified the I3D-method to perform action recognition.

### **Poster Session:**

The poster session was a joint session with all conferences in Security and Defence and Remote Sensing. From this conference, four papers were selected for poster presentation to allow intensive interaction with the audience.

Wenka Schweikert (Fraunhofer ICT, Germany) presented a poster about trace level detection of explosives by surface-enhanced Raman spectroscopy. Different substrates enhance different molecular vibrations and have varying enhancement factors. The selected explosives could be detected with most of the tested Surface-enhanced Raman Spectroscopy (SERS) plates. The expected enhancement between a SERS substrate, an explosive and the excitation laser wavelength is not always given. There appears to be an immense influence of the size, the species and the arrangements of the metal nano particles on surfaces with the exciting wavelengths of the lasers.

Frank Schnürer (Fraunhofer ICT, Germany) presented a poster to standardize characterization of inkjet-printed explosive trace samples. The automatic segmentation of particles is based on a threshold, which can easily lead to an overestimation or underestimation of particle size and area coverage.

Ippe Asahi (Shikoku Research Institute, Japan) presented a poster about an experimental study for the development of remote sensing technology of hazardous substances by resonance Raman effect. Many hazardous substances exhibit ultraviolet absorption in the deep ultraviolet wavelength region of 300 nm or less. Therefore, resonance Raman-spectrum measuring device was constructed capable of wavelength sweeping in the deep ultraviolet wavelength range, selected SO<sub>2</sub> and NH<sub>3</sub>, typical corrosive gases, as target substance, and verified experimentally the enhancement of Raman signal intensity by resonance Raman effect.

Radhakrishna Prabhu (Robert Gordon University, United Kingdom) presented a poster about Nile-dye based analysis of synthetic fibers for forensic applications. The dye binds to polymer fibers. The selectivity of the dye for fibers makes the

identification of fibers lot easier and less time-consuming in forensic samples when compared to the more commonly used optical microscopy. Microplastics fluoresced in several wavelengths, but fluorescence was best in the green emission.

***Joint Sessions about AI***

AI and machine learning always have been an important component in the SPIE conference on Counterterrorism, Crimefighting, Forensics and Surveillance technologies. To avoid conflicts in the schedule, this conference organized several joint sessions with the new SPIE conference on Artificial Intelligence and Machine Learning in Defence applications, which worked out well for the audience. Besides the earlier mentioned papers, there were joint sessions about AI in ISR, object detection, and semantic segmentation.

We hope you enjoy reading the proceedings!

**Henri Bouma  
Radhakrishna Prabhu  
Robert J. Stokes  
Yitzhak Yitzhaky**