PROCEEDINGS OF SPIE

Counterterrorism, Crime Fighting, Forensics, and Surveillance Technologies II

Henri Bouma
Radhakrishna Prabhu
Robert James Stokes
Yitzhak Yitzhaky
Editors

10–11 September 2018
Berlin, Germany

Sponsored by
SPIE

Cooperating Organisations
European Optical Society
Cranfield University (United Kingdom)

Published by
SPIE

Volume 10802

Proceedings of SPIE 0277-786X, V. 10802

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

Counterterrorism, Crime Fighting, Forensics, and Surveillance Technologies II, edited by Henri Bouma, Radhakrishna Prabhu, Robert James Stokes, Yitzhak Yitzhaky, Proc. of SPIE Vol. 10802, 1080201

The papers in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. Additional papers and presentation recordings may be available online in the SPIE Digital Library at SPIEDigitalLibrary.org.

The papers reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from these proceedings:
Author(s), "Title of Paper," in *Counterterrorism, Crime Fighting, Forensics, and Surveillance Technologies II*, edited by Henri Bouma, Radhakrishna Prabhu, Robert James Stokes, Yitzhak Yitzhaky, Proceedings of SPIE Vol. 10802 (SPIE, Bellingham, WA, 2018) Seven-digit Article CID Number.

ISSN: 0277-786X
ISSN: 1996-756X (electronic)

ISBN: 9781510621879
ISBN: 9781510621886 (electronic)

Published by
SPIE
P.O. Box 10, Bellingham, Washington 98227-0010 USA
Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445
SPIE.org

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.

SPIE. DIGITAL LIBRARY
SPIEDigitalLibrary.org

Paper Numbering: *Proceedings of SPIE* follow an e-First publication model. A unique citation identifier (CID) number is assigned to each article at the time of publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online and print versions of the publication. SPIE uses a seven-digit CID article numbering system structured as follows:

- The first five digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B … 0Z, followed by 10-1Z, 20-2Z, etc. The CID Number appears on each page of the manuscript.

Contents

POSTER SESSION

Authors

Numbers in the index correspond to the last two digits of the seven-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first five digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Conference Committee

Symposium Chair

Ric Schleijpen, TNO Defence, Security and Safety (Netherlands)

Symposium Co-chair

Karin Stein, Fraunhofer-Institut für Optronik, Systemtechnik und Bildauswertung (Germany)

Conference Chairs

Henri Bouma, TNO (Netherlands)
Radhakrishna Prabhu, The Robert Gordon University (United Kingdom)
Robert James Stokes, Cobalt Light Systems Ltd. (United Kingdom)
Yitzhak Yitzhaky, Ben-Gurion University of the Negev (Israel)

Conference Programme Committee

Maria Andersson, FOI-Swedish Defence Research Agency (Sweden)
Stefan Becker, Fraunhofer-Institut für Optronik, Systemtechnik und Bildauswertung (Germany)
Felicity Carlysle-Davies, University of Strathclyde (United Kingdom)
Brian E. Foulger, Ministry of Defence (United Kingdom)
Pengda Hong, Lehigh University (United States)
Gillian F. Marshall, QinetiQ Ltd. (United Kingdom)
David Muench, Fraunhofer-Institut für Optronik, Systemtechnik und Bildauswertung (Germany)
Niamh Nic Daeid, University of Dundee (United Kingdom)
Salman Rosenwaks, Ben-Gurion University of the Negev (Israel)
Neil C. Shand, Defence Science and Technology Laboratory (United Kingdom)
Berkan Solmaz, ASELSAN A.S. (Turkey)
Piotr Szynkarczyk, Industrial Research Institute for Automation and Measurements (Poland)
Paul A. Thomas, Defence Science and Technology Laboratory (United Kingdom)

Session Chairs

1 Detection and Identification of CBRNE
Radhakrishna Prabhu, The Robert Gordon University (United Kingdom)
Robert James Stokes, Cobalt Light Systems Ltd. (United Kingdom)

2 Spectroscopy, Raman/LIBS, and Hyperspectral
Radhakrishna Prabhu, The Robert Gordon University (United Kingdom)
Robert James Stokes, Cobalt Light Systems Ltd. (United Kingdom)

3 Surveillance Systems and Autonomous Sensors
Henri Bouma, TNO (Netherlands)
Yitzhak Yitzhaky, Ben-Gurion University of the Negev (Israel)

4 Biometrics
Radhakrishna Prabhu, The Robert Gordon University (United Kingdom)
Robert James Stokes, Cobalt Light Systems Ltd. (United Kingdom)

5 Action and Behaviour Recognition in Video Images
Henri Bouma, TNO (Netherlands)
Yitzhak Yitzhaky, Ben-Gurion University of the Negev (Israel)

6 Deep Learning and Video Content Analysis
Henri Bouma, TNO (Netherlands)
Yitzhak Yitzhaky, Ben-Gurion University of the Negev (Israel)

Introduction

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

Session 1: Detection and identification of CBRNE

Yifan Chen, Tongji University (China), showed the development of an energy dispersive X-ray diffraction system for the identification of dangerous materials at room temperature. At a nominal diffraction angle of 5 degrees, the energy resolution of the system was approximately 6-9%. The system can identify paracetamol even when the sample was hidden inside parcels and sucrose was tested within several backgrounds.

Xin Wang, Tongji University (China), presented a study on the X-ray backscattering of different materials using a Monte Carlo simulation model. The study indicates that the energy from 100 keV to 150 keV is appropriate for dangerous inspection using X-ray backscatter imaging, and higher energies are not beneficial for improving imaging contrast and it would enlarge radiation safety issues.

Vyacheslav Trofimov, M.S. Lomonosov State University (Russian Federation), studied the problem of induced false absorption frequencies of the broadband THz pulse on substance. These false absorption frequencies can appear due to the bound spectral width of absorption lines of molecules and due to dependency of the frequency conversion process on spectral intensity.

Igor Martynov, National Research Nuclear University (Russian Federation), presented the results of a study of optimization of structure and temperature of porous silicon microcavities with embedded conjugated polymers for explosives detection. The thickness of front and rear Bragg mirrors was varied to optimize its structure. The optimal thickness is from 4 to 5 pairs of low and high porosity layers for the front mirror and 15 pairs for the rear mirror.

Session 2: Spectroscopy, RAMAN/LIBS and Hyperspectral Imaging

Angela Flack, University Strathclyde (United Kingdom), showed how vibrational spectroscopy can be used as a high throughput technique for bacterial biological warfare agents, as highlighted by the 2001 Anthrax letters.

Jaana Kuula, University of Jyväskylä (Finland), studied the capability and competitiveness of hyperspectral imaging in crime fighting by evaluating how well

this technology fits with the common capability requirements of professional detection methods at the different stages of responding to emerging CBRNE risks.

Jason Guicheteau, United States Army ECBC (United States), presented a smaller and faster Raman imaging system to detect energetic materials and illicit drugs located within residual latent fingerprints.

Radhakrishna Prabhu, Robert Gordon University (United Kingdom), presented a novel rare earth doped dual waveguide fluorescence security feature to enhance travel documents and avoid document fraud at border crossings. The low-cost validation system consisting of an LED and an array photodetector.

Artem Akmalov, National Research Nuclear University (Russian Federation), investigated the optimization of the parameters for laser radiation to increase the efficiency of explosive-vapor ionization in a laser field asymmetric ion mobility spectrometer. It is shown that defocusing of laser radiation and expansion of the ionization region increase the TNT signal if the radiation intensity remains at the optimum level. And it is shown that repetition rate should be such that the interval between pulses is shorter than the time of diffusion of non-ionized molecules into the laser irradiation region.

Gennadii Kotkovskii, National Research Nuclear University (Russian Federation), investigated the use of dopants – substances enhancing ion formation – to increase the sensitivity of a laser field asymmetric ion mobility spectrometer for detection of explosives. Three different dopants were studied as enhancers for the formation of negative trinitrotoluene (TNT) ions in gas phase under laser ionization with a wavelength of 266 nm. It has been shown that the most effective dopant is toluene, which acts as an electron generator in two-quantum ionization, less effective is naphthalene, and the use of chloroform to improve the effectiveness of ion formation is contraindicated, because it is an absorber of electrons.

Session 3: Surveillance Systems and Autonomous Sensors

Krzysztof Lech (Warsaw Univ. Techn., Poland) presented a system for 3D documentation of a crime scene. They developed an active structure-from-motion approach, which uses special light sources to project a random pattern on the scene and controllers that are compatible with off-the-shelf cameras. The structured light enhances the 3D model at featureless surfaces.

Paul Thomas (DSTL, UK) presented a modular system architecture (SAPIENT) for detection, classification and localization of Unmanned Aerial Systems (UAS/drones). The SAPIENT architecture consists of intelligent autonomous sensor modules (ASMs) and a high level decision making module (HLDMM). The SAPIENT Counter-UAS system was successfully demonstrated in a live trial against a range of UAS targets flown in a variety of attack trajectories. The system was able to steer

a narrow field of view camera, leading to eyes on the aerial threat without operator intervention.

Niels Neumann, TNO (Netherlands), presented a data-driven approach to reduce uncertainty of detection events in full-motion video from airborne platforms. They devised a classifier to separate the correct and erroneous detections. The classifier is trained on features describing possible sources of uncertainty identified by domain experts. The features relate to both raw data properties (e.g., image quality) and video content properties (e.g., detection confidence).

Almuth Hoffmann, Fraunhofer IOSB (Germany), presented the Coalition Shared Data (CSD) concept, which supports operational processes within Joint ISR (Intelligence, Surveillance and Reconnaissance) and the Intelligence Cycle by defining standardized interfaces, data models, services and workflows. A system architecture is introduced for ISR analytics that is based on the new edition of NATO standard STANAG-4559 Edition 4 that implements the CSD concept and connects it to operational processes.

Session 4: Biometrics

Agnieszka Jenerowicz, Warsaw University Technology (Poland), examined the utility of hyperspectral imagery for personal identification based on the fusion of hand geometry and hand palms veins biometrics. Experiments showed that the data should be acquired in the near infrared range (at 900 nm).

Radhakrishna Prabhu, Robert Gordon University (United Kingdom), also inspected the hand vein biometrics, but focused on the dorsal side of the hand and used a regular RGB camera from a smartphone. The pattern of the dorsal hand vein is exploited for generating a unique ID for preventing identity theft of the valuable documents. From the vein pattern, features are extracted, encrypted and converted into a QR code and is imprinted on the valuable document. This QR code can be verified for authentication of a valuable document possessed by the end user.

Pierre Bonazza, Université de Bourgogne (France), performed face authentication with binary classifiers. He compared a light deep learning approach (MobileNet-CNN v1 and v2) with two other classifiers: Support Vector Machines (SVM) and Random Forest (RF). The other classifiers were combined with Sobel and TanTriggs filters and data reduction with PCA. A near real-time implementation was created on the Raspberry Pi 3. These implementations were trained and tested on various databases, including: LFW, AT&T-ORL, ESSEX-Face94, and Le2i. The RF and SVM implementations could train in less than three seconds, while transfer learning with the lightest of CNNs cannot even achieve training times less than one hour. The trend remains the same between these techniques for the authentication task. Although each method can achieve 90% of authentication accuracy for a particular configuration, classical machine learning prediction on one image

never exceeds 200 microseconds while CNNs go over a second. Pierre Bonazza won the Best Student Paper Award 2018 for his thorough research and clear presentation of the work described in the paper called "Comparative study of deep learning and classical methods: smart camera implementation for face authentication".

Kaan Karaman, ASELSAN (Turkey), performed face recognition based on ResNet-101. The network is trained on the Yale-B face dataset. The performance is improved approx. 3% with a novel training policy that utilizes quadruplet pairs and a new loss function.

Session 5: Action and Behavior Recognition in Videos

Berkan Solmaz, ASELSAN (Turkey), proposed a method for video-based detection of abnormal crowd activities. This method first computes crowd specific motion representations, utilizing motion features such as optical flow, gradients of optical flow, divergence, vorticity (curl) and principal invariants of gradient tensor. Next, normal behavior is learned. The distributions of motion representations are inspected and abrupt changes in the distributions of motion representations, occurring in several parts of the scenes are labelled as anomalies. Experiments, conducted on the publicly available UCSD Anomaly Detection Dataset reveal that the proposed method is effective in detecting abnormal activities.

Louis Clift, University Essex (United Kingdom) and Leonardo (United Kingdom), presented an approach to address the autonomous identification of human behaviours derived from human pose. With the aid of OpenPose, human skeletons are extracted from live camera sources. A type-2 Fuzzy logic classifier then converts the skeleton into a set of base atomic poses (standing, walking, etc.), after which a Markov-chain model is used to order a pose sequence.

Maria Andersson, FOI (Sweden), presented a method for detection of abnormal behaviors related to violent events in urban environments. The anomaly detection method, which is based on the hidden Markov model (HMM), fuses information that is derived from the tracker. The information contains a number of persons, their positions and velocities. The method is evaluated on recorded scenarios such as normal situations, a person loitering, a person shooting and people escaping from sudden smoke development. The results indicate that the person detection method in combination with the tracker can produce robust and accurate observations to the HMM, which in turn provides good conditions for accurate anomaly detection.

Henri Bouma, TNO (Netherlands), developed a demonstrator for the recognition of suspicious activity that allows users to easily define new alerts based on their expert knowledge. Basic modules are developed for the computation of object detections, tracking and action recognition to generate features. The user is able to specify complex behavior with Symbols and Sentences. Symbols are low-level

descriptions to analyze combinations of features and Sentences are high-level descriptions to analyze temporal ordering.

Viacheslav Voronin, Don State Technology University (Russian Federation), presented a framework for action recognition based on 3D Gabor filtering and 3D dense micro-block differences with Fisher Vectors and an SVM classifier. The method was evaluated on UCF50, HMDB51 and UCF101 datasets.

Session 6: Deep Learning and Video Content Analysis

Moritz Blum, Diebold Nixdorf (Germany), showed that it is possible to perform optical skimming and recognize the pressed content on touchscreen devices by automatic analysis of the "pop-up" feature of common smartphone keyboards.

Konrad Moren, Fraunhofer IOSB (Germany), showed an approach for real-time fusion of TV and IR video using NVIDIA Tegra TX2. The algorithm is based on second-generation wavelets (lifting scheme), Cohen-Daubechies-Feauveau 9/7 wavelet, and in-place calculations to avoid auxiliary memory.

Henri Bouma, TNO (Netherlands), gave an overview of flexible image analysis tools to extract information about the: where, what and who. The work contains five contributions: (1) image-based geo-localization to estimate the origin of an image, (2) fine-grained concept detection to distinguish not only generic classes (e.g., firearm) but also subclasses within the generic class (e.g., AK47), (3), recognition of person attributes (e.g., glasses, moustache), (4) an annotation tool to learn novel concepts with minimal interaction, and (5) query expansion to map user queries to known and detectable concepts.

Natalia Shepeleva, SCCH (Austria), improves the robustness and reliability of surveillance systems without storing or inspecting the video, except one frame per camera to understand the scene. A novel scene analysis approach based on hypergraph-based trajectories is introduced for reducing the false-positive rate. The conception of hypergraph-based trajectories relaxes the notion of point-based trajectories by allowing multiple incidences between subsequent points in time. The approach is validated over a two-year non-stop recording on protecting critical infrastructure. The results show substantial reduction of irrelevant false alarms, hence improving the overall system's performance.

David Münch, Fraunhofer IOSB (Germany), proposed the fusion of different object detectors that are each optimal in their own environment. Probabilities are assigned to object, non-object and the uncertain object-or-non-object. An optimal fusion of the individual detections can be carried out with the combination rule of Dempster-Shafer.

Viacheslav Voronin, Don State Technology University (Russian Federation), presented a method that detects deleted frames in a video, which is a form of

video forgery or manipulation to skip content from the original video. The method uses 3D Gabor filters and CNNs.

Poster Session:

The papers that were selected for the poster session received large interest from many attendants.

Frank Schnürer, Fraunhofer ICT (Germany), investigated the production of standardized chemically contaminated test materials with inkjet printing technology to test and validate optical stand-off explosive detection technologies. The contaminated materials must be produced with high accuracy, precision, scalability, and flexibility to allow for the inexpensive, high-throughput production. Test samples with contaminations ranging from nanogrammes to microgrammes have been prepared and analysed over several weeks of storage and the influence of plot parameters on the morphology and durability of printed samples of various common explosives have been investigated on different substrates.

Michael Wittek, Fraunhofer ICT (Germany), proposed the use of inert particles coated with explosives to test explosive trace detection systems. A powder pipette was developed that is able to perform a dry transfer which can place a required number of particles on a target area to guarantee a reproducible generation of traces on different surfaces.

"Cyberdog", Warsaw University Technology (Poland), is a monitoring and control system to support K-9 police dogs during different special activities. According to the law-enforcement operational procedures, the system has been designed basing on three different modules: dogs electronic vest with navigation (GNSS, IMU) and sensing (RGB, NIR) technologies, mobile command center and supporting UAV (Unnamed Airborne Vehicle) platform.

We hope that you will enjoy reading the proceedings of 2018.

Henri Bouma
Radhakrishna Prabhu
Robert James Stokes
Yitzhak Yitzhaky