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Book of Abstracts

Forensic Imaging and Biometrics: Roadblocks, Enablers and Advancements

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Invited Talks

The rocky road to acceptance of soil as a tool in criminal investigations

Lorna Dawson
Environmental and Biochemical Sciences Group, James Hutton Institute, UK

In my talk I will discuss the development of the discipline of forensic soil science and how our work has contributed to a rapid evolution from a 'cottage industry' to a trusted quantitative accredited system within the UK. I will show how new developments and innovations are invaluable in forensic applications but require funding, experimentation, validation, cooperation, collaboration, peer review, many sleepless nights .....and they all require to be fully tested before being 'field ready' ..... never mind what is required for that innovative and exciting scientific approach (and of course you) to be 'court ready'. This high level of testing varies across the legal systems of the world, but the attributes of curiosity, integrity, honesty and adherence to good ethical principles is fundamental in all nations and legal systems of the world, and is vitally important across all disciplines.

Forensic Pattern Recognition: Challenges and Opportunities

Anil K. Jain
Department of Computer Science and Engineering, Michigan State University, USA

Forensic science entails the application of scientific principles to analyze evidence at a crime scene in order to reconstruct and describe past events in a legal setting. It has been deeply influenced by Locard's exchange principle which states that the perpetrator of a crime will bring something into the crime scene and leave with something from it, and that both can be used as forensic evidence. A number of sources of impression evidence are used in forensic investigations, including fingermarks, tire marks, shoe marks, tool marks, and handwriting. Additionally, other types of evidence such as voice and face are also used. One of the principal objectives of a forensic investigation is to associate an item of evidence (e.g., a partial and smudgy fingerprint) with a source (e.g., an individual). In this talk I will present some of the research conducted in my lab that has made an impact in forensics: tattoo matching, face sketch (composite) matching, altered fingerprint detection, and latent fingerprint matching.

Unsolved Problems in Forensic Science: History and Future

Joseph Almog

Casali Institute of Applied Chemistry, Hebrew University of Jerusalem, Israel

Our first forensic R&D program was prepared in 1976. As a preliminary step, we disseminated among the academic community in Israel a list of topics in forensic science which required scientific and technological solutions. The problems were selected by two factors: How pressing they were – Israel has its own order of priorities - and the prospect of reaching solutions, based on the level of existing manpower and budget.

I will present some of the topics which constituted that list; among them: deciphering indented writing, shooter identification, fingerprint visualization on problematic surfaces, and what happened to them worldwide since that time. I will also briefly discuss an ongoing biometrics research which is carried out under the concept of “proactive forensic science”.

Biometrics, Forensics and Identity Science: Can gait, ear and soft biometrics be used in forensics?

Mark Nixon

School of Electronics and Computer Science, University of Southampton, UK

Many biometrics can be used in forensics, as that is largely where biometrics started as a subject. This keynote concentrates on gait, ear and soft biometrics. We will describe how gait has been presented as evidence, and the limitations and advantages it has provided. We shall also describe how the ear itself can be used as identification evidence, as people can hide their faces but are usually less concerned with hiding their ears. We shall also discuss how soft biometrics are used already as evidence, and how they can be learned from video data. Any consideration for use of biometrics in forensics must consider the provision of evidence. Procedures are described for handcrafted approaches in gait and in ear, though the emergence of deep learning complicates the provision od evidence for newer biometrics and newer implementations. Overall it is likely that biometrics has a rich potential future, and as well as describing the current state of art this talk describes some of the considerations that must be made for generating and using gait, ear and soft biometrics in forensics.

Understanding face representations in Deep convolutional Neural networks: Turning the black box white

Alice J. O'Toole

School of Behavioral and Brain Sciences at the University of Texas at Dallas, USA

Computer-based face recognition has improved markedly in recent years with the advent of deep learning and convolutional neural networks (DCNNs). These networks are trained with large numbers of uncontrolled, “in-the-wild” face images The primary accomplishment of DCNNs over previous algorithms is that they can identify faces in relatively unconstrained viewing conditions (e.g., over changes in viewpoint, illumination, appearance). Although these networks perform with accuracy unimaginable just a decade ago, the face representations they generate are not well understood, making it challenging to anticipate and mitigate identification errors. In this talk, I will present a series of computational experiments aimed at dissecting face codes generated by DCNNs. The experiments indicate that DCNN-generated face descriptors retain detailed information about face identity and about the actual image processed by the network. This representation is highly structured by the types of image-based variation encountered in the training, and is remarkably robust against network damage. In summary, DCNN face codes present a fundamentally new solution to the problem of identifying faces in uncontrolled viewing environments.

Redefining possibilities: The development of latent fingermarks from cartridge casings and (cleaned) metals using a novel vapour phase technique

Roberto King

Foster+Freeman Forensic Science Innovation, UK

In 2019, the culmination of a decade of research, resulted in the introduction of RECOVER Latent Fingerprint Technology to the worldwide forensic community. The last year has been pivotal in establishing this process within laboratories and learning about new applications and opportunities for this revolutionary fuming technique. Requiring only a small amount of chemical reagent, and a typical processing time of less than 40 minutes, this cost-effective, and automated, technology serves as the only plausible method of recovering latent fingermarks from exhibit types that have previously been regarded as 'impossible' or 'once in a lifetime'. The development of fingermarks from serious crime exhibit types (fired/unspent ammunition casings, knife blades, IED fragments) will be discussed, with attention given to the importance and lessons learned regarding the imaging of such evidence types. Peripheral imaging, non-visible imaging and episcopic imaging will all be discussed, with relevant examples shown. Comments will also be made regarding casework success in both recent and cold case investigations.

Abstracts

A Spectral Multimodal Microscope for the Automated Recognition of Traces: The SMMART forensics toolkit

Charalambos Boras[1,2], Christos Housos[1,2], Nikolaos Kaminakis[1], Nathanail Kortsalioudakis[1,2], Christos Rossos[1], Gerasimos Stefatos[1,2], Panagiotis Takas[1,2], Athanasios Tsapras[1,2], Christos Tsiaousis[1,2], Panagiotis Tsopelas[1], Costas Balas[1,2]

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Keywords: hyperspectral imaging, forensics traces imaging, high throughput imaging.

Exhaustive collection and thorough analysis of all visible and invisible traces present in a crime field would comprise a paradigm shift in crime investigation. The problem with this approach is that it will generate an enormous number of samples that will require unrealistic examination times. In the framework of the SHUTTLE PCP Project*, participated by forensics institutes across Europe, we have developed a high-throughput screening microscope and a toolkit for the collection and the automated analysis of crime scene traces. The toolkit includes an adhesive non-birefringent, non-fluorescing, optically clean tape that is used to collect both visible and invisible traces, when it comes in contact with crime field surfaces. It further includes a multimodal microscope integrating a hybrid, tunable filter-based hyperspectral camera acquiring color, multispectral, hyperspectral and combined spectral/polarization images. All these image acquisition options are available in all the supported operation modes, namely: the transmission, the reflection, the fluorescence (with two laser line excitations) and the polarization imaging modes. The spectral range of the hyperspectral imager is very broad, spanning the range 320-1100nm at 5-10nm spectral resolution. Spectral images are selected and displayed in real time, while, in the spectroscopy domain the six million spectra, one per

image pixel, are acquired within less than 30s spectral scanning time. The integrated sample illumination sources include unpolarized, linearly polarized and circularly polarized, broad- and narrow- band light sources, which are synchronized with the operated imaging mode (s). The microscope is built on an ultra large sample area (60X40cm), allowing for the direct upload of several collected trace lifting tapes that are examined in a single scan. The object's spatial resolution is less than 1 μm in a single frame, with all frames being stitched together to form large area overviews in all imaging and acquisition modes. Scanning is carried out in a fully automated fashion, implementing scenarios selected by the user. The SMMART system's image handling suite includes the data viewer, the data base and the data analysis software modules, that can be operated independently or in connection. The data analysis module comprises an advanced machine learning/AI platform, offering automated analysis of the acquired multimodal imaging data and outputting trace identification labels. Upon completing a scanning/analysis session, light markings are projected pinpointing the physical location of important traces identified, for facilitating manual sampling for subsequent destructive analyses. The SMMART toolkit improves the workflow and removes subjectivity in crime investigation, comprising also an indispensable research tool for further developing forensics science.

SHUTTLE Project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 786913".

Multi-modal Hyperspectral Microscopy Imaging as a Forensic Tool in Trace Evidence Detection

John Gilchrist[1], Yingwang Gao[1], Stephen Campbell[2], Natalie Smyth[2], Susan Toal[2]

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Keywords: hyperspectral imaging, forensic applications.

The aim of this study is to apply a new development that couples the power of hyperspectral imaging with microscopy for the detection of forensic trace evidence such as body fluids, fibres, gun-shot residues, and other evidential materials collected from tape-lifts or directly on materials.

This paper describes the development of a specially designed multi-modal microscope system that provides hyperspectral imaging from 300 to 1,700nm with a spatial resolution as high as 1µm in each of its optical measurement modes, i.e. reflectance, transmission, luminescence, and polarisation. The microscope system is fully automated and can handle large area samples from tape-lifts.

Demonstration of performance using tape-lift evidence samples that were seeded and studied to mimic real-life crime evidence collections at scene will be shown. In addition, body fluids were analysed directly on a range of challenging, yet typical, substrates at different levels of concentration (i.e. neat, 1:10, 1:50) to investigate limits of detection.

The recorded images from each optical mode were pre-processed using Smoothing and SNV (Standard Normal Variate) before implementing PCA (Principal Component Analysis) for exploratory analysis and dimension reduction. Extracted features (i.e. full spectral features, and dimensional-reduced spectral features) were introduced to SVM (Support Vector Machine) to build classification models. Different optical modes were compared in classification performances, and also combined to create a multi-modal feature set for final evidence classifications.

Results were stored in a database for later retrieval and comparison. This work indicated that a multi-modal hyperspectral microscopy imaging system provides a significant enhancement in visualisation, localisation, and identification of trace evidence. Further work will develop the instrument and signal processing to enhance its effectiveness as a tool in forensic investigation.

Visual Spectroscopy in Reflection as a forensic tool for ink identification

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Keywords: visual spectroscopy, ink identification.

Visible light spectra in reflection were taken by Ocean Optics USB4000-UV-VIS spectrometer and PC with installed "SpectraSuite" software from signatures that were written with 5 different ink products originating from 6 different pens. The ink analysis procedure consisted of recording 10 visible spectra in reflection using the reflection probe holder, from each signature, whereas the spot size partly covers the ink-line of the signature along with the white background (paper). The repeatable typical spectra were obtained and plotted with Origin Pro from each ink of different producer, and only two of each were graphically presented. Typical extrema and features of the spectra were used for comparison of the different inks. The method can be used as a non-destructive tool for ink identification for forensic purposes.

Improving the Quality of Crime Scene Investigations across Yorkshire and Humber with Mobile Technology; a key enabler for the Remote Transmission of Fingerprints

Peter Arnold, Andrew Rowley

Yorkshire and Humber Scientific Support Services, UK

Keywords: forensics, fingerprints, mobile, transmission, digital.

Keypoints are:

- Delivering a regional CSI service from a dedicated forensic control room.
- Implementing technology on the frontline to improve efficiency of CSI operations.
- At-scene and real time searching of national fingerprint databases to identify unknown persons.
- Remote transmission of digital evidence including fingermarks from the crime scene for rapid suspect identification.
- Digital management of fingerprint casework and processing of fingerprint cases
- Developing fingerprint comparison on screen

Methodological round robin studies - lessons we have learned so far

Thomas Fischer

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Keywords: method comparison, MULTIFORESEE deliverables.

The typical round robin study is part of the external quality assurance and aims at the comparability of results obtained in different laboratories, often also specifying analytical methods and normatives. Traditional round robin studies are not intended as benchmarking studies to determine which machine or system performs best. However, MULTIFORESEE is precisely a project that pursues the approach of testing the feasibility and reliability of innovative methods, which is why the round robin study carried out in the project was intended as a method comparison instead of a laboratory comparison. For this reason, no methodological specifications were made in our round robin study; instead, the laboratories were to use the methods of their choice to address a series of tasks relating to document forgery and the usability of fingerprints. In order to facilitate the evaluation of the results, a standard report form was provided by the organizer, in which the methodological specifications were to be given in addition to the answers to the questions asked. Another requirement for participation in the study was that at least one of the methods used should follow a multimodal imaging approach.

When evaluating the study, we found that a number of reports were submitted after the deadline or that corrected reports were submitted after the correct results were announced, and that not all participants used the report form (which made comparison with other reports difficult). Furthermore, some reports did not use imaging methods. Since methods and not

laboratories were benchmarked, the review process raised the question of the laboratories' qualifications to participate in the study. The reviews also questioned to what extent a multimodal approach was actually followed, i.e. an approach that involves the combination of imaging data from different modalities (techniques/methods) in one single image.

From these observations we can draw the following conclusions for multimodal comparative method studies.

1. Organisational requirements (deadlines, formal reporting) should be strictly adhered to. Incomplete reports should be excluded.
2. It should be determined in advance which laboratory would like to participate with which methods. This would help to classify available methods in advance, in particular to facilitate factorial designs or ruggedness testing. At the same time, it could be examined in this context whether multimodality can be achieved or whether multichannel imaging methods should be evaluated independently of each other.

Multi-modal Hyperspectral Microscopy Imaging as a Forensic Tool in Trace Evidence Detection

Simona Francese[1], Katie Kennedy[1], Cameron Heaton[1], Laura Cole[1], Matthias Witt[2], Jason Eyre[3], Simon Tazzyman[3], Richard McColm[4], Michal Levin[5], Ravell Bengiat[5], Carla Oz[5], Yael Herman[5]

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Keywords: blood, fingermarks, imaging, MALDI.

The reliable detection of blood at the scene of violent crimes is paramount to indicate the nature of the crime and its dynamics. The possibility to visualise blood onto the ridges of a fingermark provides associative evidence to further inform investigations. However, as blood is a rich biological matrix, additional intelligence can potentially be derived to narrow down the pool of suspects. The MALDI MS Imaging based methods illustrated here aimed to (i) visualise blood in older marks (useful for investigation of cold cases); (b) mapping Haemoglobin variants (the low incidence of which can be used as a means to narrow down the pool of suspects); (c) integrating blood imaging capabilities in an operational forensic workflow. Building from previously published work, we demonstrated, for the first time, the opportunity to visualise blood in marks as old as 4 years as well as mapping markers of animal and human blood[1]. Six most common (but still low incidence) haemoglobin variants were successfully detected, identified and mapped onto the ridge detail of blood marks[2]. Finally, MALDI MSI provided

molecular images of blood distribution from blood fingermarks deposited on simulated painted walls. Crucially, the methodology was compatible with the prior application of a common crime scene investigation blood enhancement technique as well as with the subsequent application of DNA profiling which enabled the matching with the reference DNA of the donor[3].

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Iris recognition accuracy dependency on the degrees of freedom when information is selected with similar density

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Keywords: iris recognition, degrees of freedom, template, information density.

Iris recognition is a very accurate method to detect imposters from authentic individuals when security is an issue. The effectiveness of this biometric technique is based on successful segmentation of the iris, the information selection across the iris, and then the template extraction from this information. The extracted templates from a pair of different iris images are compared using different metrics. The procedure of analyzing the information constitutes an excellent testbed for the statistical analyses. The possibility to obtain a true positive or a true negative relies on the degrees of freedom (DOF) in one template. DOF is the key ingredient in the overall analysis of iris recognition and that is related with the randomness of the information. Templates are commonly obtained as rectangular shapes while the density of the used pixels is not uniform across the iris. Recent work has focused on templates that are acquired while selecting pixels with equal density across the iris. In this work we report the relation between the DOF and overall accuracy when information is obtained with uniform and nonuniform density. The accuracy is found to be higher in the former configuration.

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Towards Real-World Presentation Attack Detection

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Keywords: face presentation attack, face anti-spoofing, liviness, dataset, deep learning.

Various biometrics systems have been widely deployed in real-world applications such as border controls, biometric passports, and smartphone-based authentication in recent years. For these systems, face biometrics was one of the most preferred biometrics due to its massive advantage over other biometrics. As it is widely used in so many different applications, it becomes the primary target of intruders. In order to bypass face recognition systems, subversive users try to capture authorized user's face image and give this captured face image to the biometric system. This kind of attack on biometric systems is called Presentation Attack (PA). An ideal system should accept all the genuine or live samples presented and reject all the false samples or impersonation attempts successfully. Presentation Attack Detection (PAD) systems use both handcrafted and deep neural network-based approaches to detect presentation attacks correctly. Although PAD systems give high performances on datasets that are trained on, they poorly perform when they are tested on other datasets. This problem is common in systems that use convolutional neural networks. Most publicly available datasets contain images captured in controlled environments with small varieties of lighting and background. Even facial pose variations are limited in many benchmark datasets. Our work focuses on PAD system generalization by improving both model and data. First, we propose a training method that combines small face patches to distinguish attack images from live images. Our proposed method improves the generalization performance of a convolutional neural network by utilizing pixel-wise supervision with combined face patches. Our model uses

small face patches to distinguish spoof without memorizing background or data-specific traces. Secondly, we create an uncontrolled PA dataset that mimics the real-world scenario of a PAD system. Unlike the datasets in the literature, we do not limit presentation attack instruments (PAI), lighting, background, expressions, and facial pose. It allows us to inspect the performance of our algorithm under a challenging real-world scenario. Most uncontrolled datasets create protocols to test models under unknown PAI by leaving one PAI out each time. Creating an uncontrolled dataset would allow us to test models on various unknown PAI, which is infinitely many in the real world. We tested the proposed method both on benchmark PAD datasets and on a real-world dataset. Our method shows its superiority on the most challenging protocols of OULU-NPU and on inter-dataset real-world experiments.

Detection of Adversarial Attacks against Face Recognition systems

Fabio Valerio Massoli

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Keywords: deep learning, adversarial attacks, face recognition .

In the last decades, Deep Convolutional Neural Networks (DCNNs) have shown impressive performances on computer vision-related tasks such as Face Recognition (FR) (Wang, 2018). In FR, a pre-trained DCNN is typically used to extract the so-called deep features from face images that can then be used for the final recognition task, e.g., forensic purposes (Galea, 2017) and surveillance (Cheng, 2018). Unfortunately, the existence of adversarial attacks (Goodfellow, 2015) can pose a significant threat to the outspread of such a technology in real-world applications.

Usually, adversarial samples are crafted by exploiting classes' labels, while FR algorithms exploit deep representations extracted from pre-trained models. Thus, to threaten such systems, one has to consider such characteristics while designing an attack.

In our study, we tackled the problem of detecting such attacks against FR systems and proposed a deep learning model able to spot the malicious inputs by exploiting the representation generated at different layers of the threatened network. Moreover, we proposed an attack algorithm based on the k-NN classifier. We tested our approach concerning “impersonation” and “evading” attacks within the face verification protocol. According to the measurements, we observed that on the one side, attacks based on deep representations rather than on class labels are more effective in fooling an FR system, while on the other side, we prove that our detector reached very high performance in detecting such attacks. Finally, to

show the robustness of our detection scheme, we tested it against the white-box attack setting by giving the attacker full knowledge about the defensive system.

Real World Occluded Faces Dataset and Benchmark

Mustafa Ekrem Erakın, Uğur Demir, Hazım Kemal Ekenel

Department of Computer Engineering, Istanbul Technical University, Turkey

Keywords: face recognition, face occlusion, deep learning, real-world occluded faces.

State-of-the-art face recognition models perform well on benchmark datasets. However, one of the main challenges remains to be facial appearance variations due to facial occlusions. In our study, we propose an occluded face dataset that contains both real-world upper face and lower face occluded images, due to sunglasses and masks, respectively. We conducted experiments using the state-of-the-art face recognition models on the proposed real-world dataset and synthetically generated samples. We observed that real-world occluded faces have a much higher performance impact compared to synthetically generated samples. To illustrate further the impact of using real-world occluded faces, we participated in the IJCB-MFR-2021 competition () and received first place among the academic submissions.

Adaptive Computational Graph-enabled Deep Learning for Face Verification

Nikolaos Passalis, Anastasios Tefas

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Keywords: face verification; deep learning; adaptive computational graphs.

Deep Learning (DL) provided powerful tools for various forensic imaging and biometrics applications, even suppressing humans in some cases. However DL methods are computationally intensive, which limits their applicability in various applications that involve processing enormous amounts of data. A typical example of such an application is face verification, which often involves processing a huge amount of information that is collected through CCTV cameras installed in various locations. Therefore, the need for accurate, yet fast and lightweight DL models that can promptly process all this amount of information is evident. Furthermore, surveillance applications might also impose additional privacy concerns, which limit the amount of information that can be transferred to the cloud for further processing. In these *inference-on-the-edge* scenarios the processing power is even more limited. In this presentation will go through the challenges involved in deploying DL models in the aforementioned scenarios and we will delve into DL models with adaptive *computational graphs*, which allow for easily adapting the computations both to the available resources, as well as to the environmental conditions by selecting the most appropriate computational path. Indeed, adaptive computational graphs are increasingly used for DL models under classification settings, however, little work has been done so far for adapting them for use in metric learning applications, such as those that typically arise in face verification applications. Therefore, we present a metric-learning oriented early exit methodology for DL models that

despite the unique challenges that arise in such metric learning setups can achieve remarkable performance This method employs the Bag-of-Features model to efficiently extract lightweight representations from any layer of a DL model. Then, this representation can be used with efficient linear regressors to match the final representation of the model, which allows for estimating the final output of a complex DL model without having to feedforward the whole computational graph. It is also worth noting that such an approach does not require re-training the model. Instead, it can be directly used using any pre-trained DL model, without the additional cost that arises from training such models from scratch. Finally, we provide experimental evidence that such an approach is effective using various face verification datasets.

Potential of modified Beer-Lambert law for skin bruise analysis

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Keywords: Beer-Lambert law, bruises, chromophore mapping, laser illumination.

Beer-Lambert law is a widely used approach for absorbers concentration calculation in various media. This method requires less computational power as compared to other models, such as hyperspectral imaging 1 or diffusion approximation 2, and its calculation time is significantly shorter. Therefore, we consider the Beer-Lambert law as the basis for analyzing bruises. We present four approaches to calculate relative chromophore concentrations in case of bruises with different additional parameters. For clinical measurements we use a special illumination device with three different wavelength lasers and smartphone camera 3. Four Beer-Lambert law models are compared to determine their usefulness and effectiveness for bruises analysis. Also attenuation coefficient graphs for clinical data for three wavelengths are examined. Although Beer-Lambert law extended versions didn't show promising results with white reference for calculations, using healthy skin as the reference, results seem to be more reliable.

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Comparison of optical and ion beam techniques in determining deposition order between different writing tools

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Keywords: questioned documents, crossing lines, optical non-destructive techniques, IBA techniques.

In the forensic investigation of questioned documents, it is often very important to know the deposition order of two different writing tools at their intersection on a paper. In the present work, intersections of several writing tools were studied using optical non-destructive techniques that are standardly applied for questioned documents examination in the Forensic Science Centre “Ivan Vučetić”, and two accelerator-based Ion Beam Analysis (IBA) techniques - Secondary Ion Mass Spectrometry using MeV ions (MeV SIMS) and Particle Induced X-Ray Emission (PIXE) that are applied at the Ruđer Bošković Institute. MeV SIMS provides chemical and PIXE elemental information about the studied writing tools, which is an added value and can be also applied to determine deposition order, but so far both IBA techniques were relatively rarely used for forensic studies. Results obtained using optical and IBA techniques were compared and discussed.

Towards the Concept of SmileID

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Keywords: biometric, fuzzy commitment, concatenated RS-codes.

A person's smile, which is a key factor in determining a person's psychological state, can also be used as a behavioral biometric identification element. Recently, several applications have appeared that implement the concept of SmileID (www.electronicid.eu/en/solutions/smileid) related to the face biometrics where identity is verified remotely. In recent years, facial biometry has become one of the most preferred biometric methods both in video surveillance and in digital banking due to the fact that it does not require precision equipment and uses a non-contact data processing method. In this study, we consider the use of artificial neural networks (ANN) such as an autoencoder to extract soft biometric information from a person's smile and use it for authentication to provide access to digital services. As a result, we will propose an error correction method for creating biometric templates for authentication with the use of Juels and Wattenberg (JW) fuzzy commitment scheme (FCS) based on Helper Data that can be revoked if compromised. To handle the variability inherent in biometric authentication we applied so-called stacked autoencoder (SAE) that is a ANN including several layers of sparse autoencoders, and constructed FCS with the application of error correcting codes (ECC). The use of SAE provided to achieve the suitable separation of classified classes controlled by a receiver operator characteristic (ROC) that demonstrates how a genuine acceptance rate (GAR), determining a correctly received genuine imprint, depends on a change in a false accept rate (FAR). Video frames of 3 main smile phases (onset, apex and offset) were used to obtain biometric data on the basis of SAE consisting of 2 inner layers and trained with the use of smile videos of 400 subjects taken randomly from UvA-NEMO database. The real

data of the output layer was quantized and encoded by the concatenated ECC based on Reed-Solomon (RS) codes and linear ECC. The false rejection rate (FRR) estimation for the investigated ECC structures at FAR=0 allowed to obtain FRR value less than 0.5%. The use of RS codes with lengths of 31, 63 symbols from fields GF(32) and GF(64) concatenated with binary linear codes made it possible to obtain a SmileId of length from 120 to 135 bits when capturing 3-8 frames of video with the user smiling face.

Luminescent and Biocompatible Calcium Phosphate Nanoparticles. Structural Properties for Fingerprint Imaging

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Keywords: fingerprints, photoluminescence, calcium phosphate.

Fingerprint analysis is one of the most explored biometric recognition approaches in forensic science for personal identification. Usually, fingerprints left on surfaces cannot be observed by naked eyes, and a post processing step is often necessary, such as powder dusting and chemical fuming[1]. On the other hand, the use of photoluminescent nanoparticles (NPs) are gaining importance due to their resistance to photobleaching and the ability to produce high resolution and sensitive fingermarks when illuminated under UV radiation[2]. In this study, we propose the use of chemically precipitated, activators-free luminescent NPs[3], based on calcium orthophosphate (CaP) as a new material for fingerprint analysis. The CaP NPs were characterized by transmission electron microscopy (TEM), X-ray powder diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and X-ray photoelectron spectroscopy (XPS). When excited at l_{exc} = 405 nm, the CaP NPs exhibited a defect-related broad band emission with the maximum centered at 522 nm, as determined by photoluminescence spectroscopy. Fingerprint images were obtained on the surface of tweezers and successfully validated by the 3M Cogent CAFIS system used by Scientific Police in Spain. The potential *in vitro* cytotoxicity of the NPs was evaluated with cultures of Human Dermal Fibroblast neonatal (HDFn) cells via MTT assay. Cell viabilities superior to 95% were found in all concentrations of NPs, from 20 to

320 mg/mL, after incubation for 24 and 48h. The present results evidence the potential of the luminescent CaP NPs to be used as safe material for forensics purposes.

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Multi-elemental composition as a potential tool for the tobacco products discrimination

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Keywords: tobacco, trace elements, ICP, PCA, multivariate analysis.

It is a well-known fact that tobacco products are fortified in toxic heavy metals since elements are preferentially enriched in the tobacco leaves during the plant growth. The elemental signature of tobacco will be correlated with parameters such as soil characteristics, climatic conditions and plant variety. Moreover, some elements can be incorporated as a result of the processing of the finished product. Thus, the consumption of tobacco products by both smoking and non-smoking ways may strongly affect the health of potential consumers. This is the main reason for which studies including tobacco products are continuously performed, primarily in the field of environmental research and health sciences. Recently, the determination of the levels of trace metals has also been conducted in the aspect of distinguishing original products from counterfeit ones (i.e. authentication). It is postulated as well that the brand of cigarettes can be positively linked with the concentration of trace metals in the ash after combustion of tobacco products. In the context of forensic research, this information seems to be extremely valuable, e.g. from the profiling of the perpetrator's preferences perspective. One of the first to become interested in this subject was Edmund Locard, who in 1929 published a paper entitled "The Analysis of Dust Traces" and devoted to this issue. Nowadays, the incorporation of the modern analytical instruments gives a chance to

collect almost the whole elemental fingerprint of tobacco products, which can be successfully used to characterize the studied sample in a detailed way[1].

The main aim of this study was to investigate the possible differences in the elemental composition of various brands of tobacco products, which were commonly available in Polish market. In this work some crucial parameters were included such as product type (snuff, cigarette, etc.) or its origin. Analyzed tobacco samples before the analysis were decomposed using the mixture of concentrated nitric acid and hydrogen peroxide in the microwave closed system. The concentration of selected metals was determined by ICP-MS technique. The study has proven that elemental content was influenced e.g. by smoking/non-smoking product type or sample origin (country) and to a lesser extent by the brand. The projection of objects was performed using multivariate analysis. The employment of PCA made it possible to discriminate for instance tobacco-free snuff made in Germany from other samples and to distinguish snuff samples originated from India, which formed a separate cluster. The observed differences in the levels of studied metals were additionally investigated among the studied groups using statistical tests, which enabled them to compare the specific intra-cluster variations.

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Application of MeV-SIMS and PIXE in the authentication of paintings

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Keywords: MeV-SIMS, PIXE, pigments, binders, painting authentication.

In the framework of the IAEA CRP Project F11021: "Enhancing Nuclear Analytical Techniques to Meet the Needs of Forensic Sciences" an old, conserved painting dating from the 18th – 19th century was studied with two Ion Beam Analysis (IBA) techniques: Secondary Ion Mass Spectrometry using MeV primary ions (MeV-SIMS) and Particle-Induced X-ray Emission (PIXE). One of the objectives of the ongoing project is to highlight the benefits of emerging accelerator-based methods for the authentication of paintings which have potential interest in the heritage application domain of forensic science. For this purpose, a relatively homogeneous region of the acquired painting, containing only the original (non-restored) materials, was sampled, and divided into approximately 2 cm^2 size coupons which were distributed to participating laboratories. One of these coupons was received for analysis along with two mock-up reference samples that contained lead white pigment mixed with linseed oil and egg yolk. The coupon consisted of three distinct paint layers: i) the yellow surface layer (topcoat) with red and orange pigment grains, ii) thick intermediate gray layer, and iii) red ground layer. Small fragments from the three paint layers and the reference mock-up samples were cut and pressed into pure indium (in tear drops) for measurements that were performed at the Ruđer Bošković Institute accelerator facility in Zagreb, Croatia. MeV-SIMS spectra were collected in the

positive- and negative-ion modes with 5 MeV Si^{4+} ion microbeam, while 2 MeV proton microbeam was used for the PIXE elemental analysis at the same sample areas as with MeV-SIMS. An oil-based binding medium was identified with MeV-SIMS in all three paint layers through detection of fatty acids in both positive and negative-ion modes as well as fatty acid lead soaps in the positive-ion mode. Lead and lead oxide species were identified in the positive-ion mode mass spectra, confirming the presence of an inorganic lead pigment. Results of the PIXE analysis showed that several inorganic pigments are present in the three layers of the studied painting: i) Naples yellow, iron oxide reds, orpiment, and lead white in the yellow surface layer, ii) lead white and aluminosilicates in the intermediate ground layer, and iii) iron oxide reds and aluminosilicates in the red ground layer. The information of the painting composition obtained with IBA techniques could contribute significantly to the painting authentication process in an integrated analytical approach, which similar studies also demonstrated[1–3].

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