

MULTIFORESEE 2019

MULTI-modal Imaging of FOREnsics SciEnce Evidence
tools for Forensics Science

16-18 September 2019, Catania, Italy

BOOKLET

*“Interdisciplinary Forensics; government academia
and industry interaction”*

SCIENTIFIC ORGANIZING COMMITTEE

Sebastiano Battiato, Università degli Studi di Catania, Italy

Ivančica Bogdanović Radović, Ruđer Bošković Institute, Croatia

Hazım Kemal Ekenel, Istanbul Technical University, Turkey

Ron Heeren, Maastricht University, Nederland

Jose Luis Lerma, Universitat Politècnica de València, Spain

Alessandro Ortis, Università degli Studi di Catania, Italy

Nicolas Sklavos, University of Patras, Greece

Biljana Škrbić, University of Novi Sad, Serbia

Chiara Villa, University of Copenhagen, Denmark

INVITED SPEAKERS

Giovanni Tessitore (Polizia Scientifica, Rome IT)

Aldo Mattei (RIS Carabinieri, Messina, IT)

Weakness of PNU in Source Camera Identification

Bruno Andrea, Cattaneo Giuseppe

Università degli Studi di Salerno, Dipartimento di Informatica

{andbruno, cattaneo}@unisa.it

Keywords: PNU, Source camera Identification, Digital video, Digital photo.

The use of PRNU-based techniques for Source Camera Identification is a de -facto standard for photo. Digital videos presents an increasing difficulties caused in first place by the effects of digital video stabilization process and the different encoding formats.

In the recent years several papers shown some weakness of the PNU in particular related to the digital video stabilization process (Taspinar 2016) and the uses of different encoding formats, in articular when speaking of the most recent formats like AV1 and H.265 (Bruno 2018, Bruno 2019).

In the field of digital photography we are investigating the effects on PNU of the images elaborated by AI chipset and/or obtained by combining images from multiple sensors in common new generation smartphones like iPhone X and Samsung 9.

References

Taspinar, S., Mohanty, M. and Memon, N., 2016, December. Source camera attribution using stabilized video. In 2016 IEEE International Workshop on Information Forensics and Security (WIFS) (pp. 1-6). IEEE.

Bruno, A. and Cattaneo, G., 2018, October. Effects of H. 265 encoding on PNU and source camera identification. In Proceedings of the 2018 Conference on Research in Adaptive and Convergent Systems (pp. 279-284). ACM.

Bruno, A. and Cattaneo, G., 2019 (Accepted, under publication). An experimental estimate of the impact produced on PNU by new generation video codecs. In Internation Journal on Embedded Systems (IJES), Inderscience

Chemical Imaging of Human Fingerprint by X-ray Photoelectron Spectroscopy

Ayşegül Erdoğan^a, Meral Esen^a, Robin Simpson^b

^aEge University Application and Research Center For Testing and Analysis (EGE MATAL), Turkey

^bThermo Fisher Scientific, United Kingdom

{aysegul_erdogan@live.com, karaca_meral@hotmail.com, robin.simpson@thermofisher.com}

Keywords: XPS, chemical imaging, fingerprint, PCA, surface chemistry.

X-ray Photoelectron Spectroscopy (XPS) has been extensively used to characterize the surface chemistry of materials. It plays a unique role in giving access to qualitative and quantitative information and the presence of chemical functional groups on the surface of any material (Van der Heide, 2011).

Current forensic methods for detecting and identifying the elements and compounds are mostly destructive, so evidence cannot be re-analyzed. However, XPS allows for rapid analysis without any destruction of samples. Recently, more and more forensic researchers have begun to examine specific chemical information in fingerprints. Human fingerprints have been one of the most powerful types of forensic evidence available because they are often left at a crime scene after a suspect has touched a surface (Wei et al., 2016).

In this study, the authors aimed to present the applicability and strength of XPS imaging in fingerprint analysis. Due to the powerful feature of imaging XPS, scientists could achieve the information of both organic compounds and metallic compounds of any sample. XPS imaging can provide spatially specific information on fingerprint chemical composition. A simple discussion was made on how the scanned survey spectra and elemental snapshot spectra were used for the identification of different components on a fingerprint of a scanned surface area. At the end of the analysis; a fingerprint pattern contaminated with caffeine, TiO₂ and PbO could be chemically mapped and imaged by using XPS (Figure 1).

In the detection of specific components in fingerprints, there is still a gap between forensic research in the lab and forensic practice at a crime scene. Therefore, in future, more efforts should be made on latent fingerprints using rapid chemical imaging since there has been a great demand on this research area.

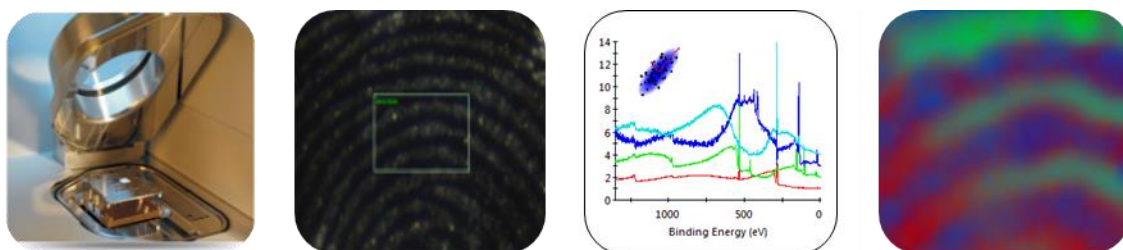


Figure 1. Chemical imaging of fingerprint by XPS using PCA

References

Wei, Q., Zhang, M., Ogorevc, B., & Zhang, X. 2016. Recent advances in the chemical imaging of human fingerprints (a review). *Analyst*, 141(22), 6172-6189.

Van der Heide, P. (2011). *X-Ray photoelectron spectroscopy. An Introduction to Principles and Practices*.

Performance of Convolutional Neural Networks in Biometrics for Noisy Iris Images

Oktay Koc, Orges Balla, Arban Uka

Computer Engineering Department, Epoka University, Tirana, Albania

okoc12@epoka.edu.al, oballa16@epoka.edu.al, auka@epoka.edu.al

Keywords: iris recognition, non-cooperative conditions, degrees of freedom, deep learning.

Iris recognition is one of the most reliable and accurate biometric identification system that uses statistical analysis of the iris image features. The accuracy of the system strongly depends on segmentation process and encoding schemes. The convolutional neural networks have been proven to be very sensitive to noise and result even in miss-classification. We have added artificial noises to the iris database for measuring accuracy of the system under non-cooperative conditions with our state-of-art segmentation and encoding algorithms. We conclude that our algorithms performed better than the classical segmentation and encoding algorithms in terms of accuracy. We have also tested our algorithms by changing the radial and angular resolution that effects the accuracy and equal error rate of resized images as well as adding artificial noises. For the resized images, the well-known techniques of encoding and segmentation were also tested. We have used deep learning techniques with two different architectures and implement them on iris images with and without noises. We get the accuracy results as 96.9% and 87.8% with respect to non-noisy and noisy iris images.

References

- Nguyen, K. at all, 2018. Iris Recognition With Off-the-Shelf CNN Features: A Deep Learning Perspective, IEEE Access, Special Section On Visual Surveillance and Biometrics: Practices, Challenges, and Possibilities
- Uka, A., Roci, A., Koc, O., 2017. Improved Segmentation Algorithm and Further Optimization for Iris Images, In *IEEE EUROCON 2017-17th International Conference on Smart Technologies* (pp. 85-88). IEEE. 10.1109/EUROCON.2017.8011082
- Koc, O., Uka, A., 2016. A New Encoding of Iris Images Employing Eight Quantization Level, *Journal of Image and Graphics*, 4(2), 78-83, 10.18178/joig.4.2.78-83.
- Koc, O., Roci, A., Uka, A., 2016. Iris Recognition and A New Approach in Encoding, *Journal of Natural and Technical Sciences*, 2016(1), 89-101.
- Daugman, J. G., 2007. New methods in iris recognition. *IEEE Transactions on Systems, Man, and Cybernetics, Part B (Cybernetics)*, 1167-1175.
- Liu, Bowyer, and Flynn., 2005. *Experiments with an improved iris segmentation algorithm*. Fourth IEEE Workshop on Automatic Identification Advanced Technologies
- Daugman, J. G., 1993. High confidence visual recognition of persons by a test of statistical independence. *IEEE transactions on pattern analysis and machine intelligence*, 1148-1161.
- Field, D. J., 1987. Relations between the statistics of natural images and the response properties of cortical cells., *J. Opt. Soc. Am. A* 4, 2379-2394.

Multimodal person identification data management in a Smart Elevator project

Andres Udal, Uljana Reinsalu, Mairo Leier, Andri Riid, Rene Pihlak, Risto Heinsar

School of Information Technology, Tallinn University of Technology, Estonia

{andres.udal, uljana.reinsalu, mairo.leier, andri.riid, rene.pihlak, risto.heinsar}@taltech.ee

Keywords: multi-modal information fusion, face recognition, voice control, personal data management.

We describe the ongoing Smart Elevator project between Tallinn University of Technology and the KONE company. Project includes user detection and identification by face recognition technologies, 3D cameras and RFID readers, as well the possibility for the voice control and dialogue. The problems of physical installation, realization of the ROS/Linux based data architecture including local and remote person identification databases, distribution of the computing power, implementing of local/remote control loops and the aspects of the personal data security will be discussed.

For face recognition we use a rather standard pipeline containing of the face detection, feature extraction, grouping (30 photos per person) and person identification from comparison with a local database. The software is based on C++ Dlib toolkit (King, 2009) and on the very deep convolutional neural network ResNet-34 model (He, 2016) trained on dataset of about 3 million faces. Accuracy up to 98% was observed in our preliminary tests.

References

King, D.E., 2009. Dlib-ml: A Machine Learning Toolkit, J. of Machine Learning Res., vol. 10, pp. 1755-1758.

He, K., Zhang, X., Ren, S., Sun, J., 2016. Deep Residual Learning for Image Recognition, Proc. 2016 IEEE Conf. on Comp. Vision and Pattern Recognition, pp. 770-778.

Recognition a Posed Smile from a Genuine and Smile-Index Evaluation

Boris Assanovich, Yury Veretilo

YK State University of Grodno, National Anti-Doping Laboratory

bas@grsu.by, y.veretilo@antidoping.by

Keywords: genuine and posed smile, FACS, Action Unit, k-nearest neighbors, Smile-Index, QoS

1. Introduction

The classification of facial emotional expressions has been an active research area since the Facial Action Coding system (FACS) proposed by Ekman (Ekman, 1978). FACS operates with so-called Action Units (AU), combinations of which can describe any facial expression of a human face.

A smile, as one of the basic emotional states have studied by psychologists for a long time. One of the known researchers from mid-nineteenth century Guillaume Duchenne claimed that so-called genuine smiles are characterized by the presence of AU6 and in the posed smiles it couldn't be controlled voluntarily (Duchenne, 1990). However, later Ekman calculated that only 10% people can fake the enjoyment of a smile and initiate the element AU6 spontaneously, thus having the ability to fake a smile or to produce the posed smile. Several researchers reported observing high proportions of posed smiles that fit the Duchenne smile criteria.

In terms of dynamics, smiles can be composed of three non-overlapping phases; the onset (neutral to expressive), apex, and offset (expressive to neutral), respectively. Previous studies have reported differences in duration for the various phases of genuine and deliberate expressions (Dibeklioglu, 2015). In that work authors calculated maximum and mean amplitude, speed, acceleration, duration, etc. of eyelid, cheek, and lip corner movements to find the difference between genuine and posed smiles. However, many of these features correlated with each other and are difficult to explain from a psychological point of view. In this paper, we will perform an analysis of the temporal characteristics of two smiles types by the lip corner displacement calculation, and perform their classification with the use of well-known k-nearest neighbors algorithm (k-NN) based on a person's intensity of face Action Units, which describe the physiological dynamics of a human smile.

The analysis is performed with FaceAnalyzer Platform (FAP) (Assanovich, 2017) that implements recognition of human biometric data, elements of his emotions by capturing images and video, features extraction and data processing. FAP uses the OpenFace toolkit that perform 68 Facial Landmark detection and tracking with the help of pre-trained models based on Conditional Local Neural Fields (CLNF) (Baltrusaitis, 2016).

In this study we have used FAP and the UvA-NEMO Smile Database (Dibeklioglu, 2015) to perform the classification of posed and genuine smiles with the use of k-nearest neighbors algorithm and the Smile-Index calculation applied for QoS evaluation. Also the calculation of so-called *happiness threshold* as an estimated weighted average considering the contribution of the intensity of each Action Unit in each frame over the whole Database with deliberate and spontaneous (posed and genuine) has been done.

2. Recognition of a Posed Smile from a Genuine

Despite the fact that OpenFace uses both 2D and 3D face elements representation, we chose a simpler 2D model for face tracking and defining the landmarks on it. By determining the lengths of the displacement vectors of the lips extreme points, Landmarks 48 and 54 in accordance with Baltrusaitis numbering (Baltrusaitis, 2016), it is possible to obtain a discrete time signal corresponding to the average displacement during the appearance of a smile. In our work we have performed the displacement normalization and obtained a modified formula for its average value that depends on the position of the analysed landmark at time instants t and $t + 1$ relative to the initial size of lips.

Smile database UvA-NEMO was prepared (Dibeklioglu, 2015) to analyze the dynamics of genuine and posed smiles. The database consists of 1240 smiling videos with approximately the same ratio derived from 400 subjects (185 women and 215 men, in the age range of 8-76 years). Color videos at a rate of 50 frames per second were recorded at a resolution of 1920×1080 pixels with controlled lighting. It is necessary to note that a number of subjects in the process of a smile were “shaking” their heads, which led to significant “jumps” in the calculated of the lips displacement value relative to the initial frame. To compensate this factor, in our study, a correction was made by the use of 2D rotation matrices similar to (Guo, 2018).

Using FAP and recorded data in csv file, we were able to capture the discrete signals corresponding to the state of a smile. Hence FAP allowed to calculate the intensity of the Action Units values, involved in the “smile creation” simultaneously with the visualization of the signal timing (see Fig.1).

To perform the classification, the timing smile signals were segmented into three phases: 1. Onset (neutral to expressive) phase; 2. Apex; and 3. Offset phase (expressive to neutral) describing the state of a smiling person's face, as it was described in the work (Guo, 2018). In each frame of analyzed smile, the intensities of the AU measurements were made, averaged over all frames, and a vector with nonzero intensity values $X=[x_1 \dots x_n]$ was formed for learning and classification purposes. The k-NN classification algorithm for the different values of k has been applied in the experimental setup.

The results showed that the classification error does not exceed 5% and weakly depends on the k-parameter. The improvement of the results is possible due by the increase in the dimension of the data vector with the use of the intensity averaging nonzero AUs in the intervals of three smile phases.

3. Smile-Index Calculation

Consider the application of service quality assessment and the Smile-Index (SI) calculation on the example of supermarkets. It is known that the more customers smile, the higher the quality of service is expected. Measuring the proportion of time during which customers smile at the point of contact, we get an indicator of customer-oriented staff, which is also an integral indicator of the quality of customer service. An example of such an indicator is the SI parameter, supported by the decision of Emotion Monitor (Emotion Monitor, 2019).

We can calculate the SI value as a ratio of time when customers are happy and neutral to the time of recording their emotions. Or in more detail we will consider the following time intervals: T_g (happy) - a period of time during which the level of happiness caused by genuine smile was greater than the value of some threshold Th ; $T(\text{neutral})$ - a period of time during which the level of happiness was less than the value of Th , but greater than $Th/4$; $T(\text{total})$ - the period of time for which the measured values of the level of happiness exist.

For managing the quality of customer service, not only the SI value is necessary, but also the thresholds themselves are important, because on the basis of them Smile-Index is calculated. Generally, to find the appropriate Th values and determine the dependence of threshold value on the positive emotions of a customer, the necessary statistics is required, which we have obtained from UvA-NEMO Smile database. Considering

that a spontaneous smile demonstrates true happiness, we selectively experimented with video recordings, containing spontaneous smiles. With assistance of FAP tool, we have performed preprocessing of selected video records with extracting the intensities of AU parameters for each frame. Using this data, we were able to calculate the desired *happiness threshold* as an estimated weighted average considering the contribution of the intensity of each action unit AU in each frame where they are present during the whole smile signal (see Fig.2). The results showed that the main contribution to the value of the weighted intensity (threshold) has been done by the following values of AU types: AU6, AU7, AU12, AU14.

The proposed approach to genuine and posed classification and calculation of Smile-Index and its components over time allow to control the quality of customers' satisfaction with trade services without involving specialized equipment and personnel and optimize the structure of diversified companies working in the retail and services sector.

References

- Ekman, P., Friesen W. V., 1978. The Facial Action Coding System: A Technique for the Measurement of Facial Movement, Consulting Psychol. Press Inc. San Francisco, CA.
- Duchenne, B., 1990. The Mechanism of Human Facial Expression, Cambridge. U.K. Cambridge Univ. Press.
- Assanovich, B., Veretilo Yu., 2017. Biometric Database Based on HOG Structures and BCH Codes. In Proc. Information Techn. and Syst. BSUIR, pp. 286-287.
- Baltrusaitis, T., Morency, L.-P., Robinson, P., 2013. OpenFace: An open source facial behavior analysis toolkit. In Proc. Conf. WACV, pp. 1-10.
- Dibeklioglu, H., Salah, A. A., and Gevers, T., 2015. Recognition of Genuine Smiles. In IEEE Trans. Multimed. V. 17, No 3, March 2015. pp.279-294.
- Guo, H., Zhang, X.H., Liang, J., and Yan, W.J., 2018. The Dynamic Features of Lip Corners in Genuine and Posed Smiles. In Journal Front. Psychol.
- Emotion Monitor. Available Online: <https://911.prolan.ru/applying/emotionsmonitor.html>

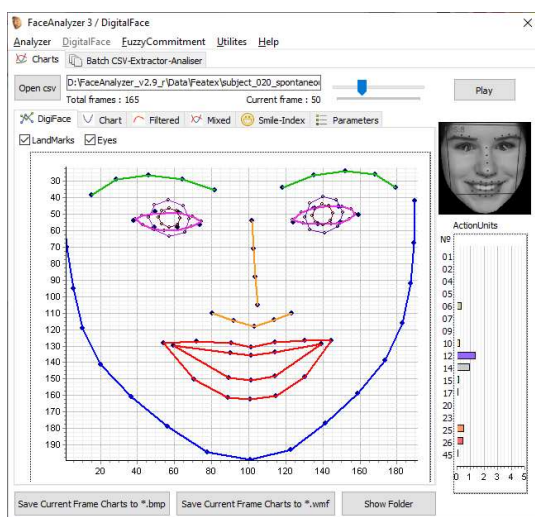


Fig.1 – Digital Face and its Action Units registration

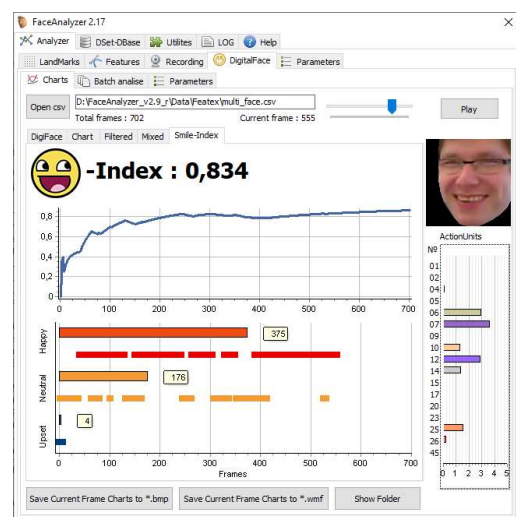


Fig.2 – Smile-Index and diagrams of its components

Hemodynamics in traumatic bruises studied by photothermal radiometry and diffuse reflectance spectroscopy

Boris Majaron, Ana Marin, Nina Verdel, Matija Milanič

Jožef Stefan Institute, Ljubljana, Slovenia

Faculty of Mathematics and Physics, University of Ljubljana, Slovenia

boris.majaron@ijs.si, ana.marin@fmf.uni-lj.si, nina.verdel@ijs.si, matija.milanic@fmf.uni-lj.si

Keywords: bruise aging, photothermal radiometry, diffuse reflectance spectroscopy.

Assessment of bruise age in forensic investigations is based on discoloration of human skin due to dynamical processes involving extravasated hemoglobin (Hb) and products of its biochemical decomposition. However, the current protocol relies on visual inspection and subjective assessment by an expert in forensic medicine. Many uncontrolled factors, such as intensity and spectrum of ambient light, skin thickness and pigmentation of the injured site, depth of blood spillage, thus contribute to limited accuracy of the assessed time of injury. We are aiming at development of a more objective approach by utilizing two noninvasive optical techniques: Diffuse reflectance spectroscopy (DRS) and pulsed photothermal radiometry (PPTR)(Verdel et al., 2019).

The study involves healthy human volunteers with bruises incurred accidentally at a known time point. Diffuse reflectance spectra in visible spectral range are obtained from visually uniform lesion sites using an integrating sphere. PPTR measurements involve irradiation with a millisecond laser pulse at 532 nm and recording of the resulting transient change of mid-infrared emission with a fast infrared camera (FLIR SC7500).

Our analyses clearly show a rapid and substantial increase of the Hb content in the dermis and reduction of its oxygenation level, resulting from blood extravasation. This is followed by a delayed rise of the bilirubin content. Parameters of an earlier proposed dynamical model of hemodynamics in a self-healing bruise (Randeberg et al., 2006) are then assessed by fitting the experimental data with predictions of a dedicated numerical simulation of light and heat transport in intact and bruised human skin (Verdel et al., 2019; Marin et al., 2018). The results correctly indicate, e.g., a rapid rise and subsequent decrease of the Hb decomposition rate as the inflammatory response subsides.

References

- Marin A., Milanič M., Verdel, N., Vidovič L. and Majaron B. (2018) 'Dynamics of controllably induced bruises assessed by diffuse reflectance spectroscopy and pulsed photothermal radiometry', *Proc. SPIE*, 10467, 104670N.
- Randeberg L., Haugen, O., Haaverstad R. and Svaasand L. (2006) 'A novel approach to age determination of traumatic injuries by reflectance spectroscopy', *Lasers Surg. Med.*, 38(4), 277–289.
- Verdel, N., Marin, A., Milanič, M. and Majaron B. (2019) 'Physiological and structural characterization of human skin in vivo using combined photothermal radiometry and diffuse reflectance spectroscopy', *Biomed. Opt. Express*, 10(2), 944-960.

Anti-spoofing Face Authentication Using Corneal Reflections

Bowen Zhang^{1,2}, Xixiang Lv¹

¹School of Cyber Engineering, Xidian University, Xi'an 710126, China

²Department of Information Engineering and Mathematics, University of Siena, Siena 53100, Italy

bowenzhang.psnl@outlook.com, xxlv@xidian.edu.cn

Keywords: anti-spoofing, face authentication, eye reflection.

Spoofing attacks have caused great concern to face authentication techniques, since an attacker can fool most systems by simply presenting a printed photo to the camera. Massive face information that are easily accessible from online social networks further exacerbate this threat (Li, 2014).

Among the methods that have been proposed as countermeasures, those using user's response to a specially designed challenge to distinguish real persons from spoofed images (challenge-based methods) are usually very effective and has reasonable generalizability (Li, 2015; Owczarek, 2012; Wang, 2013). Their drawbacks, however, are also clear, given that these methods are usually user-intrusive and time-consuming. In addition, they can't cope with replay video attacks (Ramachandra, 2017).

In this paper, we investigate one novel user-friendly challenge-based method that can resist both spoofing and replay attacks. By taking the displayed image as a challenge and its corneal reflection as the response, the anti-spoofing mechanism is automatically embedded within the normal face authentication process. We demonstrate, the effectiveness of the proposed method in resisting both 2D spoofing and replay attacks. We also carried out a possible 2.5D mask attack to such an eye-reflection mechanism to test its security. Given the success of such an attack, results reveal more profoundly the current difficulties in designing anti-spoofing methods thus highlighting possible future research directions.

References

- Li, Yan, et al., 2014. "Understanding OSN-based facial disclosure against face authentication systems." Proceedings of the 9th ACM symposium on Information, computer and communications security. ACM.
- Li, Yan, et al., 2015. "Seeing your face is not enough: An inertial sensor-based liveness detection for face authentication." Proceedings of the 22nd ACM SIGSAC Conference on Computer and Communications Security. ACM.
- Owczarek, A., & Ślot, K., 2012. "Lipreading procedure for liveness verification in video authentication systems." International Conference on Hybrid Artificial Intelligence Systems. Springer, Berlin, Heidelberg.
- Wang, Tao, et al., 2013. "Face liveness detection using 3D structure recovered from a single camera." 2013 International Conference on Biometrics (ICB). IEEE.
- Ramachandra, R., & Busch, C. (2017). Presentation attack detection methods for face recognition systems: a comprehensive survey. ACM Computing Surveys (CSUR), 50(1), 8.

Multimodal imaging approach for 3D documenting mummies: our experience with the Llullaillaco child mummies

Chiara VILLA^{1,2}, Tom SPARROW², Andrew HOLLAND², Mario BERNASKI³, Gabriella RECAGNO³,
Johan REINHARD⁴, Tim TAYLOR⁵, Niels LYNNERUP¹ and Andrew S. WILSON²

1 Department of Forensic Medicine, University of Copenhagen, Denmark - Chiara.villa@sund.ku.dk;

2 School of Archaeological & Forensic Sciences, Faculty of Life Sciences, University of Bradford, UK;

3 Museo de Arqueología de Alta Montaña, Salta, Argentina;

4 National Geographic Society Explorer, USA;

5 Vienna Institute of Archaeological Science, Austria.

Keywords: CT scanning, Photogrammetry, mummies.

Mummies are silent witnesses to ancient cultures and represent unique opportunities to shed light on health conditions, disease and cultural rites. As such, they merit preservation and accurate documentation. Computed Tomography (CT) scanning and structure from motion (SFM) photogrammetry offer complementary non-invasive, non-destructive imaging for 3D digital documentation. CT scanning is often used in mummy studies, enabling 3D documentation of both the internal and external aspects of the body. However, colour texture information is not acquired and the resolution of CT imagery is not adequate for recording fine skin details (e.g. tattoos, superficial lesions). SFM Photogrammetry offers high-resolution 3D colour texture models of the external aspect of mummies and related clothing/ artefactual evidence by means of overlapping 2D photographs. Here, we present the combined results of CT scanning and photogrammetry on the Llullaillaco child mummies. The frozen bodies of three children, ritually killed as part of the Inca capacocha rite 500 years ago, were discovered close to the summit of Volcán Llullaillaco, one of South America's highest mountains (6739m) in 1999 (Wilson et al., 2013). Given their exceptional state of preservation, these frozen mummies are curated at a constant temperature of -20⁰ Celsius. We present some of the challenges and sensitivities of working with such a unique assemblage and also highlight the potential utility of combining the data from the two modalities - both to help with conservation in monitoring the preservation of the mummies and with the potential use of 3D models for interpretation and understanding.

References

WILSON, A. S., BROWN, E. L., VILLA, C., LYNNERUP, N., HEALEY, A., CERUTI, M. C., REINHARD, J., PREVIGLIANO, C. H., ARAOZ, F. A., DIEZ, J. G. & TAYLOR, T. 2013. Archaeological, radiological, and biological evidence offer insight into Inca child sacrifice. *Proc Natl Acad Sci U S A*, 110, 13322-7.

Retrofitting Surveillance Systems using Deep Learning Technologies

Cătălin Daniel Căleanu, Florin Alexa

University Politehnica Timișoara

{catalin.caleanu, florin.alexu}@upt.ro

Keywords: IP Camera, Deep Learning Computer Vision, Deep Neural Networks, Embedded Systems.

Steps toward the development of an embedded system been capable to enhance the capabilities of a surveillance camera are described within the proposed paper. The hardware support for our solution is based on newly introduced Google Coral development board having as a prominent feature the on-board Edge TPU coprocessor, capable of execute state-of-the-art mobile vision models such as MobileNet v2 at 100+ FPS, in a power efficient manner (Google Coral Dev Board, 2019). The software part includes some deep learning-based modules for video analytics such as detection, classification and tracking objects, including people, using Faster-RCNN, YOLO and SSD DNN architectures. The system supports video equipment by any manufacturer by interfacing to it using RTSP/ONVIF connections.

References

Google Coral Dev Board, 2019, <https://coral.withgoogle.com/>

Ren, S., He, K., Girshick, R.B., & Sun, J. 2015. Faster R-CNN: Towards Real-Time Object Detection with Region Proposal Networks. IEEE Transactions on Pattern Analysis and Machine Intelligence, 39, 1137-1149.

Redmon J., FarhadiA., 2018. YOLOv3: An Incremental Improvement, <https://arxiv.org/abs/1804.02767>

Liu W. et al., 2016, SSD: Single Shot MultiBox Detector, <https://arxiv.org/abs/1512.02325>

Huang J. et al., 2017. Speed/Accuracy Trade-Offs for Modern Convolutional Object Detectors, 2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), Honolulu, HI, 2017, pp. 3296-3297.

A new study on wood fiber texture: documents authentication through LBP fingerprint

Francesco Guarnera, Dario Allegra, Oliver Giudice, Filippo Stanco, Sebastiano Battiato

Department of Mathematics and Computer Science, University of Catania, Italy

francesco.guarnera@unict.it, {allegra, giudice, fstanco, battiato}@dmi.unict.it

Keywords: Paper fingerprint, Retrieval, Secure document.

The authentication of printed material based on textures is a critical and challenging problem in many contexts: valuable documents, banknotes or rare collectible cards are often targets for forgery. This motivates the study of low-cost, fast and reliable approaches for documents authenticity analysis. The manufacturing process of paper involves the use of wood particles as a base; this process introduces random imperfections, which makes the paper sheet unique and allow to build a fingerprint. The translucent of the paper, is a visible representation of the random texture that have to be mathematically described in order to be employed in automatic processing. A fingerprint can be obtained by computing a Local Binary Pattern, more simple respect Gabor filter used in [1]. LBP guarantees high quality results in the presence of small differences due to input image variabilities. Computing LBP on an entire image means computing it for each pixel of the image. However, using this approach on the entire image produces an histogram where most of the spatial information is lost. Thus, the image can be divided into non-overlapping square patches and the fingerprint can be generate as the concatenation of the LBP histograms of every single patch. To authenticate a document is necessary that its fingerprint have been extracted previously and saved in a database. Given a test image, the authenticity test can be done through the differences on fingerprints, using a distance measure.

References

[1] Toreini E., Shahandashti SF., Hao F., 2017. Texture to the rescue: Practical paper fingerprint based on texture patterns, ACM Transactions on Privacy and Security, vol. 20, no, 3, pp. 1-29, 2017.

Deep Learning Approach for Cross Resolution Face Recognition

Fabio Valerio Massoli¹, Giuseppe Amato¹, Fabrizio Falchi¹, Claudio Gennaro¹ and Claudio Vairo¹

¹Institute of Information Science and Technologies of the National Research Council of Italy (ISTI-CNR),
via G. Moruzzi 1, 56124 Pisa, Italy
{fabio.massoli, giuseppe.amato, fabrizio.falchi, claudio.gennaro, claudio.vairo}@isti.cnr.it

Keywords: Face Recognition, Cross Resolution, Deep Learning, Surveillance, Security.

In the last few years, Deep Learning (DL) models, Convolutional Neural Networks (CNNs) particularly, have shown impressive performances on computer vision related tasks such as Face Recognition (FR) (Wang, 2018). The power of these models leverages on their ability to extract, from face images, discriminative informations called deep features, which can then be used for identification. This capability is especially relevant for forensic purposes (Galea, 2017) and surveillance systems (Cheng, 2018) applications. Interestingly, it has been observed that the performance of DL models typically degrades when tested against low resolution images (Abdollahi, 2019), declining even more critically with images at very different resolutions, as it might be the case of the aforementioned applications. In our study we propose a new training procedure in order to teach a model to extract resolution-robust deep features. We tested our models against the face verification task, relevant to access control systems, and the face identification protocol, applicable to forensic usage and surveillance systems. In order to train the model we used the VGGFace2 dataset (Cao, 2018) while for the tests we adopted high resolution datasets such as IJB-B (Whitelam, 2017) and IJB-C (Maze, 2018) and low resolution surveillance datasets such as QMUL-SurvFace (Cheng, 2018). Moreover, in order to test the cross resolution performances of our models, we synthesized different resolution versions of the IJB-B/C dataset. According to our measurements, we observed that our models reached very high accuracy on high resolution images as well as on low and cross resolution scenarios.

References

- Wang, M. and Deng, W., 2018. Deep face recognition: A survey. *arXiv preprint arXiv:1804.06655*.
- Galea, C. and Farrugia, R.A., 2017. Forensic face photo-sketch recognition using a deep learning-based architecture. *IEEE Signal Processing Letters*, 24(11), pp.1586-1590.
- Cheng, Z., Zhu, X. and Gong, S., 2018. Surveillance face recognition challenge. *arXiv preprint arXiv:1804.09691*.
- Abdollahi Aghdam, O., Bozorgtabar, B., Kemal Ekenel, H. and Thiran, J.P., 2019. Exploring Factors for Improving Low Resolution Face Recognition. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition Workshops* (pp. 0-0).
- Cao, Q., Shen, L., Xie, W., Parkhi, O.M. and Zisserman, A., 2018, May. Vggface2: A dataset for recognising faces across pose and age. In *2018 13th IEEE International Conference on Automatic Face & Gesture Recognition (FG 2018)* (pp. 67-74). IEEE.
- Whitelam, C., Taborsky, E., Blanton, A., Maze, B., Adams, J., Miller, T., Kalka, N., Jain, A.K., Duncan, J.A., Allen, K. and Cheney, J., 2017. Iarpa janus benchmark-b face dataset. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition Workshops* (pp. 90-98).
- Maze, B., Adams, J., Duncan, J.A., Kalka, N., Miller, T., Otto, C., Jain, A.K., Niggel, W.T., Anderson, J., Cheney, J. and Grother, P., 2018, February. IARPA janus benchmark-c: Face dataset and protocol. In *2018 International Conference on Biometrics (ICB)* (pp. 158-165). IEEE.

Chemical imaging approaches to analyse gunshot residue (GSR) from heavy metal free (HMF) primers.

Francesco Saverio Romolo,¹ Ph.D.; Ken Mason,² M.Sc.; and Ph.D. Matteo Donghi,³

¹ Department of Law, Università degli Studi di Bergamo, Bergamo, Italy.

² Ardenne Analytique Hungary Kft, Szőce, Hungary.

³ Arma dei Carabinieri, Parma, Italy.

francescosaverio.romolo@unibg.it, masonkn@skynet.be, matteo.donghi@carabinieri.it.

Keywords: Gunshot Residue (GSR), Firearms Discharge Residue (FDR), Heavy Metal Free (HMF) particles, chemical imaging.

The explosion of a cartridge for firearm produces a heterogeneous population of Gunshot Residue (GSR) particles having varying chemical composition. GSR particles contain elements from the primer mixture, from the propellant charge, from the cartridge case, from the bullet and from the firearm. Finding GSR particles on a suspect frequently provides crucial information in criminal investigations in shooting cases. Scanning Electron Microscope equipped with an Energy Dispersive X-ray Spectrometer (SEM-EDS) is used worldwide to visualise micro-metric particles constituting GSR and to analyse their elemental composition. The ASTM Standard guide for gunshot residue analysis by scanning electron microscopy/energy dispersive X-ray spectroscopy refers that “particles characteristic of GSR (that is, most likely associated with the discharge of a gun) will have the following elemental composition: lead, antimony and barium” [1, 2].

Some innovative priming mixtures, called heavy metal free (HMF), produce residue composed of elements with atomic number lower than 21, urgently demanding new detecting solutions. Due to the HMF primers increasing their presence on the ammunition market, innovative approaches in chemical imaging to detect and analyse GSR are needed.

Inorganic analysis of GSR particles from two HMF primers, Sellier & Bellot Nontox and CBC/Magtech Cleanrange[®], demonstrated for the first time to emit visible light under beam stimulation in a SEM. Cathodoluminescence emission can be used to both detect and characterize residues in forensic cases involving HMF primers, with minor changes to traditional analytical apparatus.

References

1. American Society for Testing and Materials, 2016. E1588–16, Standard guide for gunshot residue analysis by scanning electron microscopy/energy dispersive X-ray spectroscopy. In Annual Book of ASTM Standards, ASTM International, West Conshohocken, PA, USA.
2. O. Dalby, D. Butler, J.W. Birkett, 2010. Analysis of Gunshot Residue and Associated Materials - a Review, Journal of Forensic Sciences 55, 924-943.

Utilizing Profile Face and Ear Images for Age and Gender Classification

F. Irem Eyiokur, Dogucan Yaman, Hazım Kemal Ekenel
Istanbul Technical University
{eyiokur16, yamand16, ekenel}@itu.edu.tr

Keywords: deep learning, multimodality, ear images, profile face images, age and gender.

Estimating soft biometric traits is a very popular research area in computer vision (Jain, 2014; Jain 2009; Vaquero, 2018; Saeed 2018). Previous work has shown that the soft biometric traits help to describe subjects more effectively and also improve the identification performance of the systems (Jain, 2014; Jain 2009; Ozbulak, 2016). In biometric research area, age and gender are the most popular and important soft biometric traits.

In the previous works, deep convolutional neural network (CNN) based methods have been utilized in order to perform automatic age and gender classification. Frontal or close to frontal face images have been used in many of these works (Levi, 2015; Ozbulak, 2016; Zhang, 2018; Rothe, 2018). On the other hand, there are some studies that ear images and profile face images have been used in order to predict age and gender of the subjects (Yaman, 2018; Emersic, 2017; Bukar, 2017).

In this work, we presented an end-to-end multimodal deep learning framework. In the proposed multimodal deep network, we employed separate deep convolutional neural networks for each modality in order to learn individual representations. For this purpose, we benefited from VGG-16 (Simonyan, 2014) and ResNet-50 (He, 2016) deep convolutional neural network architectures, which are powerful and popular deep CNN models in deep learning research area. In order to increase representation and discrimination capability of the deep convolutional neural network, we utilized domain adaptation and center loss (Wen, 2016) besides softmax loss. With center loss, the model can learn more discriminative features than softmax loss. Afterwards, we combined the individual representations and fed them to the classification layers. Besides, for domain adaptation, we employed Multi-PIE ear dataset (Eyiokur, 2017), which is a large scale ear dataset generated from Multi-PIE face dataset and contains around 17000 ear images. Using this dataset, we performed fine-tuning in order to learn ear domain specific features by the deep CNN model. Then, we further fine-tuned this model over FERET (Phillips, 2000), UND-F (Yan, 2005), and UND-J2 (Yan, 2005) datasets separately.

In the experiments, gender classification is a binary classification that contains male and female classes. On the other hand, for age estimation, there are 5 different classes which are 18-28, 29-38, 39-48, 49-58, and 59-68+. We conducted many experiments on the UND-F, UND-J2, and FERET datasets for age and gender classification. For preprocessing, we benefited from off-the-shelf ear detector (Bradski, 2000) and dlib face detector (King, 2009) to obtain ear and profile face images, that don't include ear part. After that, we obtained 942 images for UND-F, 2430 images for UND-J2, and 1397 images for FERET dataset. Although we utilized all three datasets for gender classification, we only used FERET dataset for age classification since age information is only available for FERET dataset. For the experiments, we splitted datasets into three parts, which are train, validation, and test sets. The sizes of train, validation, and test sets are 80%, 10%, and 10% respectively. According to the experimental results, we showed that ear and profile face images contain significantly important features to estimate age and gender. Moreover, using combination of ear and profile face images performed better than unimodal approach. We achieved 66.33% age classification accuracy using ear images. With profile face, 65.73% age classification accuracy is obtained. For gender

classification, 98% and 94% accuracies are achieved using ear and profile face images separately. With the multimodal approach, we achieved 67.28% age classification accuracy and 98.16% gender classification accuracy, which are better than the accuracies achieved by the unimodal approaches.

We also compare the results obtained by the profile views with the ones that are attained using frontal face images. We achieved 70.90% age classification accuracy and 98% gender classification accuracy using frontal face images. These results indicate that the presented multimodal system achieves very high age and gender classification accuracies, matching the ones obtained by using frontal face images.

References

- A. K. Jain, S. C. Dass, and K. Nandakumar, 2014. Soft biometric traits for personal recognition systems. In *Biometric Authentication*, pages 731–738. Springer.
- A. K. Jain and U. Park, 2009. Facial marks: Soft biometric for face recognition. In *International Conference on Image Processing*, pages 37–40. IEEE.
- U. Saeed and M. M. Khan, 2018. Combining ear-based traditional and soft biometrics for unconstrained ear recognition. *Journal of Electronic Imaging*, 27(5):051220.
- D. A. Vaquero, R. S. Feris, D. Tran, L. Brown, A. Hampapur, and M. Turk, 2018. Attribute-based people search in surveillance environments. In *Workshop on Applications of Computer Vision*, pages 1–8. IEEE.
- G. Ozbulak, Y. Aytar, and H. K. Ekenel, 2016. How transferable are CNN-based features for age and gender classification? In *International Conference of the Biometrics Special Interest Group*, pages 1–6. IEEE.
- G. Levi and T. Hassner, 2015. Age and gender classification using convolutional neural networks. In *Computer Vision and Pattern Recognition Workshops*, pages 34–42.
- R. Rothe, R. Timofte, and L. Van Gool, 2018. Deep expectation of real and apparent age from a single image without facial landmarks. *International Journal of Computer Vision*, 126(2-4):144–157.
- D. Yaman, F. I. Eyiokur, N. Sezgin, and H. K. Ekenel, 2018. Age and gender classification from ear images. In *International Workshop on Biometrics and Forensics*. IEEE.
- K. Zhang, N. Liu, X. Yuan, X. Guo, C. Gao, and Z. Zhao, 2018. Fine-grained age estimation in the wild with attention LSTM networks. *arXiv preprint arXiv:1805.10445*.
- A. M. Bukar and H. Ugail, 2017. Automatic age estimation from facial profile view. *IET Computer Vision*, 11(8):650–655.
- Z. Emersic, V. Struc, and P. Peer, 2017. Ear recognition: More than a survey. *Neurocomputing*, 255:26–39.
- K. Simonyan and A. Zisserman, 2014. Very deep convolutional networks for large-scale image recognition. *arXiv preprint arXiv:1409.1556*.
- K. He, X. Zhang, S. Ren, and J. Sun, 2016. Deep residual learning for image recognition. In *Computer Vision and Pattern Recognition*, pages 770–778. IEEE.
- P. J. Phillips, H. Moon, S. A. Rizvi, and P. J. Rauss, 2000. The FERET evaluation methodology for face-recognition algorithms. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 22(10):1090–1104.
- P. Yan and K. W. Bowyer, 2005. Empirical evaluation of advanced ear biometrics. In *Computer Vision and Pattern Recognition Workshops*, page 41. IEEE.
- F. I. Eyiokur, D. Yaman, and H. K. Ekenel, 2017. Domain adaptation for ear recognition using deep convolutional neural networks. *IET Biometrics*, 7(3):199–206.
- Y. Wen, K. Zhang, Z. Li, and Y. Qiao, 2016. A discriminative feature learning approach for deep face recognition. In *European Conference on Computer Vision*, pages 499–515. Springer.
- G. Bradski and A. Kaehler, 2000. OpenCV. *Dr. Dobbs Journal of Software Tools*, 3.
- D. E. King, 2009. Dlib-ml: A machine learning toolkit. *Journal of Machine Learning Research*, 10(Jul):1755–1758.

Use of IBA techniques for forensic document examination

Katherine L. Moore^{a,b}, Marko Barac^a, Marko Brajković^a, Melanie Bailey^b, Zdravko Siketić^a and Iva Bogdanović Radović^{a*}

^a Ruđer Bošković Institute, Zagreb, Croatia

^b University of Surrey, Guildford, Surrey, UK

**iva@irb.hr*

Keywords: MeV SIMS, PIXE, questioned documents, intersecting lines

In the present work two Ion Beam Analysis (IBA) techniques, Secondary Ion Mass Spectrometry with MeV ions (MeV SIMS) and Proton Induced X-Ray Emission (PIXE) were used to reveal the deposition order for several writing tools such as blue ballpoint pens, laser printer toners and inkjet printer ink. Imaging of the intersection regions was performed using ion beams; protons for PIXE and heavier ions for MeV SIMS, both focused to micron dimensions.

As MeV SIMS is a surface sensitive technique, giving 2D molecular images from the uppermost layers of the sample, it is perfect for determining the deposition order. MeV SIMS solely was successful to solve correctly all cases where ballpoint pen and laser toners were involved. However, in cases where inkjet ink was used, all molecular maps showed a break in the inkjet ink line, regardless of the deposition order. To resolve this ambiguity (which comes from the penetration and adhering properties of inkjet ink), PIXE was applied to give 2D elemental maps from larger depths. From those maps, the characteristic X-rays could be used to establish the deposition order in cases involving inkjet ink.

Imaging techniques for ink analysis

Ivo Safarik ^{1,2}, Kristyna Pospiskova ²

¹ Department of Nanobiotechnology, Biology Centre, ISB, Czech Academy of Sciences, Na Sadkach 7, 37005 Ceske Budejovice, Czech Republic

² Regional Centre of Advanced Technologies and Materials, Palacky University, Slechtitelu 27, 78371 Olomouc, Czech Republic

ivosaf@yahoo.com; kristyna.pospiskova@seznam.cz

Keywords: ink analysis, hand-written documents, imaging techniques.

Paper documentation fully or partially hand-written with ink is often an important material for forensic investigation. There are usually several questions to be solved, namely identification of the source of the tested ink, the ink identity on various places of one document or between several documents and the age of ink written text. Extremely important is the determination of correct order of crossing ink lines and discrimination between homogeneous and heterogeneous intersections. Such analysis allows the determination of whether entries have been added or altered in the document(s) tested (Agarwal et al., 2016, Menzyk et al., 2015, Li, 2016).

Several ink types can be distinguished, based mainly on the character of a colorant (dye or pigment), type of solvent (water or organic solvents) and consistency (liquid or paste). Many inks contain also additional chemicals enabling e.g. their strong adhesion to the substrate. Typical writing instruments comprehend fountain, ballpoint, rollerball, felt-tip, gel, ruling or brush pens.

Many procedures have been already developed for inks identification and comparison, including visual examination, thin layer chromatography (TLC), high performance thin layer chromatography (HPTLC), high performance liquid chromatography (HPLC) and gas chromatography (GC) (Menzyk et al., 2015).

In this presentation we will summarize the imaging techniques including spectroscopic techniques (Fourier-transform infrared spectroscopy (FTIR), Raman or UV-VIS spectroscopy and mass spectroscopy) which are efficiently used to analyze forensic evidences including inks in questioned document in a non-destructive way (Menzyk et al., 2015). These procedures for ink analysis can provide a very high degree of discrimination between tested documents, can be applied to very small areas, are usually non-destructive, require minimal or no sample preparation, are rapid, and produce both qualitative and quantitative data (Buzzini and Suzuki, 2016).

References

Agarwal, A., Sharma, N., Negi, Y.S., 2016. Review: Techniques for the characterization of inks. *IOSR Journal of Applied Chemistry*, 9, 76-96.

Buzzini, P., Suzuki, E., 2016. Forensic applications of Raman spectroscopy for the in situ analyses of pigments and dyes in ink and paint evidence. *Journal of Raman Spectroscopy*, 47, 16-27.

Li, B., 2016. An examination of the sequence of intersecting lines using microspectrophotometry. *Journal of Forensic Sciences*, 61, 809-814.

Menzyk, A., Zadora, G., Sajewicz, M., 2015. Physicochemical analysis of inks and methods of evidence evaluation – a review. *Problems of Forensic Sciences*, 104, 245-278.

Multi-spectral-line imaging for forensics: recent developments

Janis Spigulis, Ilze Oshina, Zigmars Rupenheits and Margarita Matulenko

Institute of Atomic Physics and Spectroscopy, University of Latvia

janis.spigulis@lu.lv

Keywords: spectral imaging technology, coloured counterfeit detection.

Recent results related to forensic applications of the snapshot multi-spectral-line imaging technology (SMSLI, [1]) and progress in development of this technology will be presented. A smartphone with add-on triple laser line illuminator (448nm, 532nm, 659nm) [2] has been previously used for comparative studies of authentic and counterfeit 20 EUR and 50 EUR banknotes [3,4]. Extended studies related to 500 EUR banknotes have been carried out. Besides, additional results with this equipment for coloured signature analysis (in frame of the RRS-1) have been obtained.

Our tests of the imaging technique exploiting three laser line illumination have confirmed essentially improved spectral selectivity to compare with traditional multi-spectral imaging approaches (e.g. by means of multi-LED illumination or a set of narrowband spectral filters). Spectral line images and their ratios are well suited for coloured counterfeit (banknotes, documents) detection. They can be also used for high performance mapping of chromophore distribution over the target area. In this case the number of chromophores to be mapped is equal to the number of illumination spectral lines. To enable mapping of four different chromophores, a new prototype imaging device operating at wavelengths 450nm, 523nm, 638nm and 850nm is under development. The main features of the new prototype will be discussed in details.

The support from Latvian Council of Science (grant #lzp-2018/2-0006) for development of the new prototype is highly appreciated.

References

1. WO 2013135311 (A1), 2012. Method and device for imaging of spectral reflectance at several wavelength bands.
2. J.Spigulis, I.Oshina, A.Berzina, A.Bykov, 2017. "Smartphone snapshot mapping of skin chromophores under triple-wavelength laser illumination", *J.Biomed.Opt.*, **22**(9), 091508.
3. P.Potapovs, I.Oshina, J.Spigulis, 2018. "Snapshot triple spectral line imaging for counterfeit detection", *Abstr. of 2nd COST 16101-Multiforesee conf.*, Dubrovnik, pp.43-44.
4. J.Spigulis, I.Oshina, P.Potapovs, K. Lauberts, 2019. "Snapshot multi-spectral-line imaging for applications in dermatology and forensics", *Proc.SPIE*, **10881**, 1088114.

Siamese Ballistics Neural Network

Luca Guarnera, Oliver Giudice, Antonino Paratore, Sebastiano Battiato

University of Catania - iCTLab

luca.guarnera@unict.it antonino.paratore@ictlab.srl {giudice, battiato}@dmi.unict.it

Keywords: Siamese Neural Network, Forensics Ballistics.

This contribution presents new possibilities in digital forensic ballistics analysis. The crime scene often contains traces left by firearms in terms of bullets and cartridges. In general, a weapon through some mechanical components performs three different phases: loading the weapon, shot and ejecting the cartridge. The traces impressed on cartridges and bullets after the shot, can be associated to a specific firearm and are considered as a unique fingerprint among the different weapons.

The possibility to represent cartridges as 2D images, topography images or 3D point-clouds has opened new research challenges as well as the opportunity to make from manual optical comparison techniques, to more sophisticated semi-automatic or fully automatic digital techniques with the aim of obtaining objective assessments.

We have employed a fully automated technique for Forensic Ballistics cartridge comparison, based on neural network called Siamese Ballistics Neural Network. The technique exploits a cartridge pairs as input represented as a 3D point-clouds, trained and tested on the NIST Ballistics Toolmark Research Database (NBTRD) (Zheng, 2016). In a first set of experiments the goal is to recognize the model of the gun. Then we identified of the specific gun which fired a cartridge (gun identification), that is the most important information for scientific ballistic investigations. Retrieval tests have been accomplished in order to evaluate the effectiveness of the proposed technique. For each class a single point-cloud has been randomly selected as query and the remaining ones as samples to be used to perform the retrieval test. To further evaluate the proposed solution w.r.t. state-of-the-art methods (Morris, 2017), (Vorburger, 2007), (Roth, 2015), (Banno, 2004), (Tai, 2018) we reproduced the Top-10-List for the gun identification test. The results achieved demonstrated the power of the techniques.

References

- Xiaoyu A Zheng, Johannes A Soons, and Robert M Thompson, "Nist ballistics toolmark research database," Tech. Rep., 2016
- Keith B Morris, Eric F Law, Roger L Jefferys, Elizabeth C Dearth, and Emily B Fabyanic, "An evaluation of the discriminating power of an integrated ballistics identification system® heritage system with the nist standard cartridge case (standard reference material 2461)," Forensic science international, vol. 280, pp. 188–193, 2017
- Theodore V Vorburger, James H Yen, B Bachrach, Thomas B Renegar, Li Ma, Hyug-Gyo Rhee, Xiaoyu A Zheng, Jun-Feng Song, and Charles D Foreman, "Surface topography analysis for a feasibility assessment of a national ballistics imaging database," Tech. Rep., 2007.
- Joseph Roth, Andrew Carriveau, Xiaoming Liu, and Anil K Jain, "Learning-based ballistic breech face impression image matching," in Biometrics Theory, Applications and Systems (BTAS), 2015 IEEE 7th International Conference on. IEEE, 2015, pp. 1–8.
- Atsuhiko Banno, Tomohito Masuda, and Katsushi Ikeuchi, "Three dimensional visualization and comparison of impressions on fired bullets," Forensic science international, vol. 140, no. 2-3, pp. 233–240, 2004.



Xiao Hui Tai and William F Eddy, "A fully automatic method for comparing cartridge case images," Journal of forensic sciences, vol. 63, no. 2, pp. 440–448, 2018.

Overview of computational methods for processing MeV TOF SIMS spectra and 2D images at RBI

Marko Barac^{1,3}, Marko Brajković¹, Katherine L. Moore^{1*}, Zdravko Siketić¹, Iva Bogdanović Radović¹,
Marijana Popovic Hadžija², Mirko Hadžija²

¹Laboratory for Ion Beam Interactions, Ruđer Bošković Institute, Bijenička 54, HR-10000 Zagreb, Croatia

²Laboratory for mitochondrial bioenergetics and diabetes, Ruđer Bošković Institute, Bijenička 54, HR-10000 Zagreb, Croatia

³International postgraduate school Jožef Stefan, Jamova 39, 1000 Ljubljana, Slovenia

*Permanent address: Department of Chemistry, University of Surrey, Guildford, Surrey, UK

marko.barac@irb.hr, marko.brajkovic@irb.hr, katherine.moore@irb.hr, zdravko.siketic@irb.hr, ivancica.bogdanovic.radovic@irb.hr, marijana.popovic.hadzija@irb.hr, mirko.hadzija@irb.hr

Keywords: MeV SIMS, PCA, k-means, MEBA, forensics

Complex, multivariate nature of MeV time-of-flight secondary ion mass spectroscopy (TOF SIMS) datasets requires the use of advanced statistical methods for proper data interpretation (identification, classification or prediction). Such fast and efficient methods minimize subjectivity during analysis and use all the information available in the dataset. They improve signal to noise ratio and are able to remove potential bias. On the other hand, there are numerous different procedures to choose from, and some can be difficult to understand and interpret. Appropriate selection of data pre-processing and analysis method are critical for accurate interpretation of MeV TOF SIMS data. MeV TOF SIMS is a fairly new technique in use at heavy ion microprobe installed at the 45° beam line of the 6 MV Tandem Van de Graaff accelerator at Ruđer Bošković Institute. So far it has been used in the analysis of forensic samples (mapping intersections of inks and toners, spectra of signatures and stamps, mapping and spectra of fingerprints etc.) and biological samples (mouse serum and urine, liver tissue, biological cells etc.). The need arises to correctly draw conclusions from the studies and to maximize the amount of data used in the process, as well as to try to visualize variations in more complex datasets. For that purpose, several multivariate statistical methods such as Principle Component Analysis (PCA) and k-means clustering, commonly used for the analysis of the keV TOF-SIMS mass spectra and images, can also be applied in the MeV TOF-SIMS. Several examples of PCA analysis of 2d images in the study of deposition order of different writing tools is presented. K-means clustering algorithm is applied on generated principal components (PC's) to reconstruct the complete 2D image of the sample in terms of deposition order. Another example is presented involving a temporal study investigating potential biomarkers for diabetes type 2 from mice urine. Temporal datasets containing mass spectra from urine of several mice, together with blood glucose monitoring, were analyzed with Multivariate empirical Bayes analysis (MEBA), a common analysis algorithm used in proteomics experiments.

Controlling Frontal Person Close-up Shooting using Deep Reinforcement Learning

Nikolaos Passalis and Anastasios Tefas
Aristotle University of Thessaloniki
{passalis, tefas}@csd.auth.gr

Keywords: Autonomous Control, Surveillance, Unmanned Aerial Vehicles, Gimbal Control, Deep Reinforcement Learning

Controlling the shooting process for various cameras, from fixed cameras mounted on gimbals to cameras on Unmanned Aerial Vehicles (UAVs), can significantly improve the quality of the collected footage for various surveillance and/or forensic applications. However, manually controlling an enormous amount of cameras is not feasible, reducing the quality of the collected videos, often rendering them useless. To overcome this limitation, intelligent control methods can be employed for automating the control process (Passalis & Tefas, 2019). To this end, we provide a generic way for formulating various visual control objectives, that can be used for training reinforcement learning (RL) agents to efficiently perform the camera control process, as well as control the vehicle on which the camera is mounted, e.g., a drone. A hint-based reward function is also used to further increase the convergence speed and learn more accurate deep RL agents. The proposed method is evaluated using two different simulation environments, one for controlling the gimbal of a camera and one for controlling a UAV. It is worth noting that the proposed method can be used to perform both discrete control as well as continuous control. Finally, it is experimentally demonstrated that the proposed method can significantly improve the control accuracy over both handcrafted control techniques, as well as other baseline deep RL models.

References

Passalis, N., & Tefas, A. (2019). Deep reinforcement learning for controlling frontal person close-up shooting. *Neurocomputing*, 335, 37-47.

Digital Forensics: Video Manipulation Detection Techniques and Security Systems

Irene Ioannidou, Nicolas Sklavos

SCYTALE Group,
Computer Engineering & Informatics Department,
University of Patras, Hellas

e-mails: {eioannidou, nsklavos}@upatras.gr

Keywords: digital forensics, video manipulation, detection techniques, security systems

The digital forensics landscape has drastically altered during the last decade as a result of the massively increasing number of cybercrimes that expand to the field of multimedia content (Lillis et al. 2016). Online image and video sharing are growing faster than ever (Milani et al. 2012). Especially, video editing tools are available to everyone, allowing simple users to create and edit video content on their own (Guttmann et al. 2011). Media manipulating for deceiving purposes has become incredibly easy and traces are very hard to detect. Images and videos have become unreliable and issues like security, confidentiality and integrity of data are arising (Kot and Cao, 2012).

This brings to the surface the importance of video forgery detection (Bruno et al. 2015) as well as video steganography techniques (Böhm and Kirchner, 2016). Internet of Things (IoT) paradigm enabled portable hardware solutions for video processing in Raspberry Pi devices (Arva and Fryza, 2017; Mand and Lakhe, 2018). Deep Learning paradigm added even more challenge to forensic video investigations and introduced the prediction of manipulation existence with a sample of as few as 2 seconds (Guera and Delp, 2018). Researchers have proposed many different solutions in hardware level, such as a low power consumption FPGA watermarking system (Roy et al. 2013) and ENF signal extracting at the edge device for video surveillance systems (Nagothu et al. 2019).

This work focuses on video manipulation and introduces a comparative analysis of up-to-date research approaches for video forensic analysis. It contributes with multimedia forensics by active mechanisms, which include watermarking and digital signatures, as well as modern rapidly emerging passive techniques and presents a detailed comparison, with previous works (Wolfgang and Delp, 1997; Luo et al. 2007; Pandey et al. 2016).

Acknowledgment

This publication is based upon work from COST Action 16101 “MULTI-modal Imaging of FOREnsic SciEnce Evidence” (MULTI-FORESEE), supported by COST (European Cooperation in Science and Technology).

References

- Arva, G. and Fryza, T. (2017). Embedded video processing on Raspberry Pi. *2017 27th International Conference Radioelektronika (RADIOELEKTRONIKA)*.
- Böhme, R. and Kirchner, M. (2016). *Media Forensics*. [online] Artech House, pp.231–259.
- Bruno, A., Ardizzone, E. and Mazzola, G. (2015). *Copy-move forgery detection by matching triangles of keypoints*
- Guera, D. and Delp, E.J. (2018). Deepfake Video Detection Using Recurrent Neural Networks. *2018 15th IEEE International Conference on Advanced Video and Signal Based Surveillance (AVSS)*.
- Guttmann, M., Wolf, L. and Cohen-Or, D. (2011). Content aware video manipulation. *Computer Vision and Image Understanding*, [online] 115(12), pp.1662–1678.
- Kot, A.C. and Cao, H. (2012). Image and Video Source Class Identification. *Digital Image Forensics*, [online] pp.157–178.
- Lillis, D., Becker, B., O’Sullivan, T. and Scanlon, M. (2016). *Current Challenges and Future Research Areas for Digital Forensic Investigation*.
- Luo, W., Qu, Z., Pan, F. and Huang, J. (2007). A survey of passive technology for digital image forensics. *Frontiers of Computer Science in China*, [online] 1(2), pp.1662–1678.
- Mande, V. and Lakhe, M. (2018). Automatic Video Processing Based on IoT Using Raspberry Pi. *2018 3rd International Conference for Convergence in Technology (I2CT)*.
- Milani, S., Fontani, M., Bestagini, P., Barni, M., Piva, A., Tagliasacchi, M. and Tubaro, S. (2012). An overview on video forensics. *APSIPA Transactions on Signal and Information Processing*.
- Nagothu, D., Schwell, J., Chen, Y., Blasch, E. and Zhu, S. (2019). *A Study on Smart Online Frame Forging Attacks against Video Surveillance System*.
- Pandey, R.C., Singh, S.K. and Shukla, K.K. (2016). Passive forensics in image and video using noise features: A review. *Digital Investigation*, [online] 19, pp.1–28.
- Roy, S.D., Li, X., Shoshan, Y., Fish, A. and Yadid-Pecht, O. (2013). Hardware Implementation of a Digital Watermarking System for Video Authentication. *IEEE Transactions on Circuits and Systems for Video Technology*, 23(2), pp.289–301.
- Wolfgang, R.B. and Delp, E.J. (1997). A Watermarking Technique For Digital Imagery: Further Studies. *Proc. Int. Conf. Imaging Science, Systems, and Technology*, pp.279–287.

Multi Criteria, for Decision Making Systems, in Face Recognition Process

Ivana Ognjanović¹, Nicolas Sklavos², Ramo Šendelj¹

¹ University of Donja Gorica, Montenegro

e-mail: ivana.ognjanovic.edu@gmail.com, ramo.sendelj@gmail.com

² SCYTALE Group,

Computer Engineering & Informatics Department University of Patras, Hellas

e-mail: nsklavos@upatras.gr

Keywords: Multi-criteria decision making, face recognition, features, preferences, CS-AHP, TCP

Face recognition is one of the most important and influential disciplines of modern biometrics. Even they have been attracting attention for both researchers and end-users, still facing several issues and challenges. The modern techniques that are focused on formalizing and exploiting important pieces of knowledge describing human's face (Karczmarek et.al, 2018) (Karczmarek et.al, 2017) still need to integrate machine-oriented approaches with knowledge and attitudes of experts participating in the process, in order to deliver final decision about face recognition process.

On the other side, there is a variety of multicriteria decision-making formalisms and methods for addressing different preference structures with scales of input and output information with different semantics. Most of the current approaches collect independent preferences (Karczmarek et.al, 2018) (Karczmarek et.al, 2017), under the mutual preference independence (MPI) hypothesis (Keeny & Raiffa, 1993), which means that a user's preference for an option is independent of the other options (Ognjanović, Gašević & Bagheri, 2013). When applied in face recognition domain, the features and respective preferences could be related to different application domains (e.g. criminology, cognitive psychology, psychology of emotion, etc.) as well as different experts' knowledge and backgrounds (e.g. professionals in the field of forensics and psychology, etc.)

This work contributes to the different structure of features and preferences can be integrated in face recognition process by using different decision-making techniques (Ognjanović, Gašević & Bagheri, 2013) (Boutillier et.al, 2004). In this direction, it provides sound mechanisms for making joint decisions by experts and computers, adaptable to different domains of applications and practical use.

Acknowledgment

This publication is based upon work from COST Action 16101 "MULTI-modal Imaging of FOREnsic SciEnce Evidence" (MULTI-FORESEE), supported by COST (European Cooperation in Science and Technology).

References

- P.Karczmarek, A.Kiersztyn, W.Pedrycz, M.Dolecki, Linguistic Descriptors in Face Recognition, *Int. J. Fuzzy Syst.* (2018) 20 (8): 2668-2676
- P.Karczmarek, W.Pedrycz, A.Kiersztyn, P.Rutka, A study in facial features saliency in face recognition: an analytic hierarchy process approach, *Soft Computing* (2017) 21: 7503-7517
- I.Ognjanović, D.Gašević, E.Bagheri, A Stratified Framework for Handling Conditional Preferences: an Extension of the AHP, *Expert Sys.with Applications* (2013) 40 (4):1094-1115
- Keeny, R. L., Raiffa, H. *Decisions with Multiple Objectives: Preferences and Value Tradeoffs*. Cambridge: University Press, 1993
- Boutilier, C., Brafman, R. I., Domshlak, C., Hoos, H. H., Poole, D., CP-nets: a tool for representing and reasoning with conditional ceteris paribus preference statements, *Journal of AI Research*, (2004) 21(1), 135-191.

PURSUING IMAGES ON SOCIAL NETWORKS

Roberto Caldelli^{♦♦}, Irene Amerini[♦] and Giulia Boato[♣]

[♦]MICC, University of Florence, Florence, Italy,

[♦]CNIT, Parma, Italy

[♣]DISI, University of Trento, Trento, Italy

{roberto.caldelli, irene.amerini}@unifi.it, {giulia.boato}@unitn.it

Keywords: social networks, image up-download, origin tracking, image forensics.

Enormous amounts of multimedia contents, mainly photos and videos, are uploaded and successively shared on social networks (SNs) so fast that is not possible to determine anymore the origin of a certain content and moreover the path it has followed. According to this, users can act as being granted by a sense of anonymity that makes easier to commit crimes such as reputation attack and, among youngsters, cyberbullying. Especially in this last case, pictures are often published and rapidly shared without considering possible consequences and repercussions. Instruments able to understand this flow, or at least part of that, could be strategic, to reveal all the intermediate steps a certain content has followed.

Some techniques in the last years to determine the social network of origin of a given image have been proposed but, in very few cases, the challenging problem of tracking multiple shares has been considered in depth.

This work proposes and tests a methodology to track multiple image shares on social networks, by resorting at specific traces left by each SN within the image file, during the process of up-download; indeed this procedures seems to characterize each specific social network and can be used for classification purpose. Deep learning-based strategies are presented and satisfactory results have been obtained succeeding in recovering till triple up-downloads bounces.

References

- Farid, H., 2009, "A survey of image forgery detection", IEEE Signal Processing Magazine, vol. 2, no. 26, pp. 16–25.
- Caldelli, R., Becarelli, R. and Amerini, I., 2017, "Image origin classification based on social network provenance", IEEE Trans. on Information Forensics and Security, vol. 12, no. 6, pp. 1299–1308.
- Phan Q-T, Pasquini, C., Boato, G., De Natale, F. G. B., 2018, "Identifying image provenance: an analysis of mobile instant messaging apps," in Proc. of IEEE 20th Int. Workshop on Multimedia Signal Processing.
- Phan, Q-T, Boato, G., Caldelli, R., Amerini, I., 2019 "Tracking multiple image sharing on social networks", ICASSP 2019, Brighton, UK, pp. 8266-8270.
- Giudice, O., Paratore, A., Moltisanti, M., Battiato, S., 2017 "A classification engine for image ballistics of social data", ICIAP2017, pp. 625-636.

Multimodal matching using a Hybrid Convolutional Neural Network

Elad Ben Baruch and Yos Keller

Faculty of Engineering, Bar Ilan University

yosi.keller@biu.ac.il

Keywords: multi sensor, deep learning, image registration.

In this work we propose a novel Convolutional Neural Network (CNN) architecture for the matching of pairs of image patches acquired by different sensors. Our approach utilizes two CNN sub-networks, where the first is a Siamese CNN and the second is a subnetwork consisting of dual non-weight-sharing CNNs. This allows simultaneous joint and disjoint processing of the input pair of multimodal images.

patches. The convergence of the training and the test accuracy is improved by introducing auxiliary losses, and a corresponding hard negative mining scheme. The proposed approach is experimentally shown to compare favourably with contemporary state-of-the-art schemes when applied to multiple datasets of multimodal images, by reducing the matchings errors by 50%-70% compared to previous works.

This allows the matchings to be further refined by geometrical matching schemes such as RANSAC and Spectral Graph Matching that can only be applied to matchings with low outliers rates.

References

E. Ben Baruch, Y. Keller, Multimodal matching using a Hybrid Convolutional Neural Network, <https://arxiv.org/abs/1810.12941>.

Digital evidence and intelligent video surveillance image

Avv. Mario Ianulardo

Cyber crime lawyer – Board IISFA

marioianulardo@codicieleggi.it

Keywords: digital evidence, video surveillance.

The presentation addresses the path of imaging digital evidences (i.e., images and videos), with a specific focus on the ones acquired by an intelligent video surveillance system. The even growing technological development allowed the exploitation of new investigation methods, used toward the interest of the defence and security of the nation, to contrast criminal phenomena, such as terrorism. This caused an exponential augment of digital data (and images) acquired by investigators and proposed as proofs during criminal proceedings.

However, to consider such images valid proofs, they need to have specific features that guarantee their immutability during both the acquisition and analysis. They also need to be considered original and, hence, not forged. Although already exist tools that guarantee the immutability of an image and/or assess if an image has been forged, it is not enough to guarantee that the image is admitted, used and evaluated as a proof during a proceeding. In the presentation are hence highlighted the aspects related to the regulatory framework and to the privacy field, which regulate the image acquisition activities in public areas with smart video surveillance systems, and also the following phases which an “admitted evidence” is involved to, since the moment it is admitted in a courtroom. A particular attention will be dedicated to the phase of digital evidence evaluation: in this step, the judge has the role of gatekeeper, which is of major importance and responsibility as he has to admit the guilty or not-guilty verdict.

The speech will also rise doubts on the fact that the judge can conclude to a right decision “beyond reasonable doubt”. Indeed, the judicial experience as cyber crime lawyer, demonstrated that is rare that the judge can accomplish such function without be affected by the technical consultants, who are not always have the appropriate skills. Furthermore, to make a decision, the judge, will issue the verdict only after he has chosen which methodology used by the technical consultants for the activities of computer forensics and digital analysis is the right procedure. The speech also offers insights and suggest possible solutions.