ACADEMIC GRADUATION MONITORING REPORT

2019

European Association for Biometrics (EAB)
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RESEARCH MONITOR
CONTENT

PREFACE

During the 2019 EAB general assembly in September it was proposed to compose an annual academic graduation monitoring report, which should provide information about academic theses that are completed in EAB member institutions.

Such report should contain lists of entries of Bachelor-, Master- or PhD-theses and a short summary of each thesis.

This report should provide an overview of the research going on in Europe. If you are member of EAB and you can not find any of your 2019 Graduates listed in this document, then simply send information on the missing thesis to: christoph.busch@ntnu.no.

The document will be a living document until the next general assembly in September 2020. Afterwards we will start the monitoring report for the year 2020.

This report was composed by the European Association for Biometrics (EAB) for its members. If you are not EAB member yet – please join and share the non-profit spirit of EAB. We are grateful for your continuous support of the EAB initiatives through your membership.

MONITOR
PHD-THESES

RAWABI ALSEDAIS – SHAPE-BASED PERSON RE-IDENTIFICATION

Full Title: Shape-Based Person Re-Identification
Institution: University of Kent
Supervisor: Richard Guest
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Abstract: The increasing demand for public security, including forensic security, has resulted in a substantial growth in the presence of surveillance camera networks (i.e., closed-circuit televisions, or CCTVs) in public areas. Significant improvements in the computer vision and machine learning fields have advanced the traditional surveillance camera network system (i.e., monitored by people) towards an intelligent surveillance system involving automated person detection, person tracking, activity recognition, and person re-identification. The field of person re-identification has recently received much attention from computer vision researchers. Appearance model-based features, which are detection features that are built based on elements of the subject's appearance, such as texture, colour, and clothes, are used in person re-identification. However, using the body shape (as one of the appearance model-based features) as a signature for person re-identification is an area of research still open for examination.

This thesis presents the methodology, implementation, and experimental framework of a shape-based person re-identification system. The proposed system segments the human silhouette into eight different parts: *Body*, *Head & Neck*, *Shoulders*, *Middle*, *Lower*, *Upper Quarter*, *Upper Half*, *Torso,* and *Lower Half*. These segmentations are built based on anthropometry studies. This system exploits the shape descriptor information of these segments to build a subject-unique signature for person re-identification using a Generic Fourier Descriptor (GFD). The discrimination level of shape-based signatures are assessed by classifying them using image-based and video-based approaches. The image-based system classifies the signatures on a frame-by-frame basis using Linear Discriminant Analysis (LDA), which evaluates the feasibility of re-identifying subjects based on their shape static feature. The video-based approach exploits the signatures of the entire sequence (i.e., multiple frames) to re-identify subjects based on their dynamic features that occur within a collection of frames using Dynamic Time Warping (DTW). Comprehensive system outcomes for image-based and video-based systems are analysed by comparing the performance of both systems for each segment individually. Finally, a rank list fusion method, which combines the image-based generated rank lists so that the lists generated by all frames in each sequence are replaced by one rank list for the entire sequence, is proposed for performance enhancement. Extensive experiments were conducted using publicly available dataset to evaluate the proposed shape-based person re-identification. In scenarios where a subject who maintains the same appearance is identified and re-identified from the same angle, the image-based and video-based approaches were found to outperform a number of state-of-art systems. In situations where the subject is identified and re-identified from different viewing angles (inter-view) and with a change in appearance (cross-scenario), the results reflected a comparable

performance. The results of the rank list fusion implementation indicate superior performance enhancement in all situations, including the inter-view and cross-scenario.

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LEATITIA JEANCOLAS – VOICE ANALYSIS

Full Title: Detection of the Parkinson disease in early stages through voice analysis
Institution: Institut Mines Telecom-Telecom SudParis-IPP
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Abstract: Vocal impairments, known as hypokinetic dysarthria, are one of the first symptoms to appear in Parkinson's Disease (PD). A large number of articles exist on PD detection through voice analysis, but few have focused on the early stages of the disease. Furthermore, to our knowledge, study had been published on remote PD detection via speech transmitted through the telephone channel. The aim of this PhD work was to study vocal changes in PD at early and preclinical stages, and develop automatic detection and monitoring models. The long-term purpose is to build a cheap early diagnosis and monitoring tool, that doctors could use at their office, and even more interestingly, that could be used remotely with any telephone.

The first step was to build a large voice database with more than 200 French speakers, including early PD patients, healthy controls and idiopathic Rapid eye movement sleep Behavior Disorder (iRBD) subjects, who can be considered at PD preclinical stage. All these subjects performed different vocal tasks and were recorded with a professional microphone, with the internal microphone of a computer. Moreover, they called one a month an interactive voice server, with their own phone. We studied the effect of microphone quality, speech tasks, gender, and classification analysis methodologies.

We analyzed the vocal recordings with three different analysis methods, covering different time scale analyses. We started with cepstral coefficients and Gaussian Mixture Models (GMM), then we adapted x-vectors methodology (which never had been used in PD detection) and finally we extracted global features classified with Support Vector Machine (SVM). We detected vocal impairments at PD early and preclinical stages in articulation, prosody, speech flow and rhythmic abilities.

With the professional microphone recordings, we obtained an accuracy (Acc) of 89% for male early PD detection, just using 6min of reading, free speech, fast and slow syllable repetitions. As for women, we reached Acc = 70% with 1min of free speech. With the telephone recordings, we achieved Acc = 75% for men, with 5min of rapid syllable repetitions, and 67% for women, with 5min of free speech. These results are an important first step towards early PD telediagnosis.

We also studied correlations with neuroimaging, and we were able to linearly predict DatScan and Magnetic Resonance Imaging (MRI) neuromelanin sensitive data, from a set of vocal features, in a significant way. This latter result is promising regarding the possible future use of voice for early PD monitoring.

KLEMEN GRM – FACE HALLUCINATION

Full Title: Face hallucination using cascaded super-resolution and identity priors
Institution: University of Ljubljana
Supervisor: Vitomir Struc
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Abstract: In this thesis we address the problem of hallucinating high-resolution facial images from low-resolution inputs at high magnification factors. We approach this task with convolutional neural networks (CNNs) and propose a novel face hallucination model that incorporates identity priors into the learning procedure. The model consists of two main parts: i) a cascaded super-resolution network that upscales the low-resolution facial images, and ii) an ensemble of face recognition models that act as identity priors for the super-resolution network during training. Different from most competing super-resolution techniques that rely on a single model for upscaling (even with large magnification factors), our network uses a cascade of multiple SR models that progressively upscale the low-resolution images using steps of $2\times$. This characteristic allows us to apply supervision signals (target appearances) at different resolutions and incorporate identity constraints at multiple-scales. The proposed C-SRIP model (Cascaded Super Resolution with Identity Priors) is able to upscale low-resolution images and produce convincing results for diverse inputs. We evaluate our model on several datasets and report superior performance compared to the state-of-the-art.

GABRIEL EMILE HINE – ANONYMOUS BIOMETRICS

Full Title: Aymous Biometrics
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Abstract: In this thesis, I developed techniques that enable to use of biometric traits for authentication in an anonymous manner.

At first glance, the concept of anonymous biometrics seems quite odd since biometric traits are closely linked to our identity. Moreover, the widespread adoption of biometrics in forensics, border control, surveillance applications has biased the general vision that users have if asked to show their biometrics.

The basic idea behind anonymous biometrics is to do not use biometrics themselves as identifiers, but rather bind the biometric trait with a secret key that acts as the authenticator. The biometric trait becomes a factor of the authentication protocol that lets the user reproduce the identifier that has been previously assigned to him. In this way, the authentication service provider does not need to know the biometric sample itself, or any representation of it. Because of the intrinsic noisiness of biometrics, classical cryptographic techniques are not suitable, and specific techniques, known as biometric cryptosystems, have been developed.

In this context, I present a novel biometric cryptosystem obtaining perfect security, that is not leaking any information about the employed secret key from the knowledge of the data stored in the database. While similar methods have already been sought in the literature, the approaches proposed so far have been evaluated in terms of recognition performance under the unrealistic assumption of ideal statistical distributions for the considered biometric data. Conversely, in this thesis, I investigate the applicability of the proposed framework to practical scenarios while managing a trade-off between privacy and recognition performance. This goal has been achieved by introducing a class of transformation functions enforcing zero-leakage secrecy, by designing an adaptive strategy for embedding the secret key bits into the selected features, and by developing a system parameters optimization strategy with respect to security, recognition performance, and privacy. Experimental tests conducted on real fingerprint data prove the effectiveness of the proposed scheme.

Another important aspect is to ensure untraceability along with different services. That means that we should be able to produce different identifiers starting from the same biometric trait, but these should be indistinguishable from identifiers originated by independent users.

The vulnerability of our system to the linkability attack has been analysed and an enhanced system is proposed in order to counteract it.

A frequently neglected aspect in cryptosystem design proposals and analysis is the impossibility to synchronise signals once they are encrypted. Any kind of biometric should be aligned before doing any comparison. That means that further auxiliary data must be stored as a reference. This could leak too much information making the cryptosystem design useless. In this context, I propose a novel translation-invariant representation for fingerprint minutiae.

ONDŘEJ KANICH - FINGERPRINT DAMAGE SIMULATIONS

Full Title: Research in Fingerprint Damage Simulations
Institution: Brno University of Technology
Supervisor: Martin Drahanský
URL: https://www.fit.vut.cz/study/phd-thesis/832/.en
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Abstract: The goal of this research is to develop methods for fingerprint damage simulations. In the first part of this thesis the emphasis is placed on a summary of the current knowledge of synthetic fingerprint generation and the damage to these fingerprints. Moreover, general information about fingerprints, fingerprint recognition, and phenomena that damage fingerprints including skin diseases are stated herein. This thesis contains the design and implementation of the SyFDaS application for generation and modular damaging of fingerprints. The next part is a description of methods for damage by swipe mode, narrow sensor, damaged sensor, pressure and moisture, skin distortion, warts, atopic eczema, and psoriasis. Several other types of damage, including fingerprint spoofs, are analyzed. Overall, there are 43 basic damages which were visually verified. Due to damage combinations, there are 1,171 types of damage and 348,300 fingerprint images generated, which were evaluated by four different quality measurement methods.

CHIARA LUNERTI – FACIAL BIOMETRICS ON MOBILE DEVICES

Full Title: Facial Biometrics on Mobile Devices: Interaction and Quality Assessment
Institution: University of Kent
Supervisor: Richard Guest
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Abstract: Biometric face recognition is a quick and convenient security method that allows unlocking a smartphone device without the need to remember a PIN code or a password. However, the unconstrained mobile environment brings considerable challenges in facial verification performance. Not only the verification but also the enrolment on the mobile device takes place in unpredictable surroundings. In particular, facial verification involves the enrolment of unsupervised users across a range of environmental conditions, light exposure, and additional variations in terms of user's poses and image background. Is there a way to estimate the variations that a mobile scenario introduces over the facial verification performance? A quality assessment can help in enhancing the biometric performance, but in the context of mobile devices, most of the standardised requirements and methodology presented are based on passport scenarios. A comprehensive analysis should be performed to assess the biometric performance in terms of image quality and user interaction in the particular context of mobile devices. This work aimed to contribute to improving the performance and the adaptability of facial verification systems implemented on smartphones. Fifty-three participants were asked to provide facial images suitable for face verification across several locations and scenarios. A minimum of 150 images per user was collected with a smartphone camera within three different sessions. Sensing data was recorded to assess user interaction during the biometric presentation. Images were also recorded using a Single Lens Reflex camera to enable a comparison with conditions similar to a passport scenario. Results showed the relationship within five selected quality metrics commonly used for quality assessment and the variables introduced by the environment, the user and the camera. Innovative methodologies were also proposed to assess the user interaction using sensors implemented in the smartphone. The analysis underlined important issues and formulated useful observations to enhance facial verification performance on smartphone devices.

DOMINIK MALČÍK – ATTACKS ON BIOMETRIC REFERENCE STORAGE

Full Title: Analysis of attacks on (micro)chips and development of enhancement of their robustness/security
Institution: Brno University of Technology
Supervisor: Martin Drahanský
URL: https://www.fit.vut.cz/study/phd-thesis/544/.en
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Abstract: Nowadays, microchips are used virtually everywhere, from simple home devices to confidential military equipment. In many scenarios, sensitive data is being processed by these devices. For example, in the case of electronic personal documents, fingerprints, facial images, and personal data are processed by the chip; and in some cases also iris images. Auditing proclaimed functions and a level of security of such microchips is becoming a valued service. In this doctoral thesis, we present an experimentally proven process for the microscopic analysis of chips, feasible in a low-cost setup. The described process was demonstrated on a chip acquired from the Czech biometric passport - from extracting the chip out of the plastic card up to analysis of the acquired microscopic images. We investigated and evaluated various potentially viable methods for logic element recognition; without the employment of machine-learning. Additionally, hardware-oriented attacks are discussed and followed by proposals for countermeasures leading to the hindering of microscopic analysis.

ANDREAS NAUTSCH – SPEAKER RECOGNITION

Full Title: Speaker Recognition in Unconstrained Environments
Institution: Hochschule Darmstadt
Supervisor: Christoph Busch
URL: https://tuprints.ulb.tu-darmstadt.de/9199/19/Dissertation-anautsch-Fassung-20191028.pdf
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Abstract: Speaker recognition is applied in smart home devices, interactive voice response systems, call centers, online banking and payment solutions as well as in forensic scenarios. This dissertation is concerned with speaker recognition systems in unconstrained environments. Before this dissertation, research on making better decisions in unconstrained environments was insufficient. Aside from decision making, unconstrained environments imply two other subjects: security and privacy. Within the scope of this dissertation, these research subjects are regarded as both security against short-term replay attacks and privacy preservation within state-of-the-art biometric voice comparators in the light of a potential leak of biometric data. The afore-mentioned research subjects are united in this dissertation to sustain good decision making processes facing uncertainty from varying signal quality and to strengthen security as well as preserve privacy.

Conventionally, biometric comparators are trained to classify between mated and non-mated reference – probe pairs under idealistic conditions but are expected to operate well in the real world. However, the more the voice signal quality degrades, the more erroneous decisions are made. The severity of their impact depends on the requirements of a biometric application. In this dissertation, quality estimates are proposed and employed for the purpose of making better decisions on average in a formalized way (quantitative method), while the specifications of decision requirements of a biometric application remain unknown. By using the Bayesian decision framework, the specification of application-depending decision requirements is formalized, outlining operating points: the decision thresholds. The assessed quality conditions combine ambient and biometric noise, both of which occurring in commercial as well as in forensic application scenarios. Dual-use (civil and governmental) technology is investigated. As it seems unfeasible to train systems for every possible signal degradation, a low amount of quality conditions is used. After examining the impact of degrading signal quality on biometric feature extraction, the extraction is assumed ideal in order to conduct a fair benchmark. This dissertation proposes and investigates methods for propagating information about quality to decision making. By employing quality estimates, a biometric system's output (comparison scores) is normalized in order to ensure that each score encodes the least-favorable decision trade-off in its value. Application development is segregated from requirement specification. Furthermore, class discrimination and score calibration performance is improved over all decision requirements for real world applications.

In contrast to the ISO/IEC 19795-1:2006 standard on biometric performance (error rates), this dissertation is based on biometric inference for probabilistic decision making (subject to prior probabilities and cost terms). This dissertation elaborates on the paradigm shift from requirements by error rates

to requirements by beliefs in priors and costs. Binary decision error trade-off plots are proposed, interrelating error rates with prior and cost beliefs, i.e., formalized decision requirements. Verbal tags are introduced to summarize categories of least-favorable decisions: the plot's canvas follows from Bayesian decision theory. Empirical error rates are plotted, encoding categories of decision trade-offs by line styles. Performance is visualized in the latent decision subspace for evaluating empirical performance regard- ing changes in prior and cost based decision requirements.

Security against short-term audio replay attacks (a collage of sound units such as phonemes and syllables) is strengthened. The unit-selection attack is posed by the ASVspoof 2015 challenge (English speech data), representing the most difficult to detect voice presentation at- tack of this challenge. In this dissertation, unit-selection attacks are created for German speech data, where support vector machine and Gaussian mixture model classifiers are trained to detect collage edges in speech representations based on wavelet and Fourier analyses. Competitive results are reached compared to the challenged submissions.

Homomorphic encryption is proposed to preserve the privacy of biometric information in the case of database leakage. In this dissertation, log-likelihood ratio scores, representing biometric evidence objectively, are computed in the latent biometric subspace. Conventional comparators rely on the feature extraction to ideally represent biometric information, latent subspace comparators are trained to find ideal representations of the biometric information in voice reference and probe samples to be compared. Two protocols are proposed for the the two-covariance comparison model, a special case of probabilistic linear discriminant analysis. Log-likelihood ratio scores are computed in the encrypted domain based on encrypted representations of the biometric reference and probe. As a consequence, the biometric information conveyed in voice samples is, in contrast to many existing protection schemes, stored protected and without information loss. The first protocol preserves privacy of end-users, requiring one public/private key pair per biometric application. The latter protocol preserves privacy of end-users and comparator vendors with two key pairs. Comparators estimate the biometric evidence in the latent subspace, such that the subspace model requires data protection as well. In both protocols, log-likelihood ratio based decision making meets the requirements of the ISO/IEC 24745:2011 biometric information protection standard in terms of unlinkability, irreversibility, and renewability properties of the protected voice data.

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SHI PAN – PRESENTATION ATTACK DETECTION

Full Title: Conventional and Neural Architectures for Biometric Presentation Attack Detection
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Abstract: Facial biometrics, which enable an efficient and reliable method of person recognition, have been growing continuously as an active sub-area of computer vision. Automatic face recognition offers a natural and non-intrusive method for recognising users from their facial characteristics. However, facial recognition systems are vulnerable to presentation attacks (or spoofing attacks) when an attacker attempts to hide their true identity and masquerades as a valid user by misleading the biometric system. Thus, Facial Presentation Attack Detection (Facial PAD) (or facial anti-spoofing) techniques that aim to protect face recognition systems from such attacks, have been attracting more research attention in recent years. Various systems and algorithms have been proposed and evaluated. This thesis explores and compares some novel directions for detecting facial presentation attacks, including traditional features as well as approaches based on deep learning. In particular, different features encapsulating temporal information are developed and explored for describing the dynamic characteristics in presentation attacks. Hand-crafted features, deep neural architectures and their possible extensions are explored for their application in PAD.

The proposed novel traditional features address the problem of modelling distinct representations of presentation attacks in the temporal domain and consider two possible branches: behaviour-level and texture-level temporal information. The behaviour-level feature is developed from a symbolic system that was widely used in psychological studies and automated emotion analysis. Other proposed traditional features aim to capture the distinct differences in image quality, shadings and skin reflections by using dynamic texture descriptors.

This thesis then explores deep learning approaches using different pre-trained neural architectures with the aim of improving detection performance. In doing so, this thesis also explores visualisations of the internal representation of the networks to inform the further development of such approaches for improving performance and suggest possible new directions for future research. These directions include interpretable capability of deep learning approaches for PAD and a fully automatic system design capability in which the network architecture and parameters are determined by the available data. The interpretable capability can produce justifications for PAD decisions through both natural language and saliency map formats. Such systems can lead to further performance improvement through the use of an attention sub-network by learning from the justifications.

Designing optimum deep neural architectures for PAD is still a complex problem that requires substantial effort from human experts. For this reason, the necessity of producing a system that can automatically design the neural architecture for a particular task is clear. A gradient-based neural architecture search algorithm is explored and extended through the development of different optimisation functions for designing the neural architectures for PAD

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automatically. These possible extensions of the deep learning approaches for PAD were evaluated using challenging benchmark datasets and the potential of the proposed approaches were demonstrated by comparing with the state-of-the-art techniques and published results.

The proposed methods were evaluated and analysed using publicly available datasets. Results from the experiments demonstrate the usefulness of temporal information and the potential benefits of applying deep learning techniques for presentation attack detection. In particular, the use of explanations for improving usability and performance of deep learning PAD techniques and automatic techniques for the design of PAD neural architectures show considerable promise for future development.

TIAGO DE FREITAS PEREIRA – FACE RECOGNITION

Full Title: Learning How To Recognize Faces In Heterogeneous
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Abstract: The task of Heterogeneous Face Recognition consists in matching face images that are sensed in different domains, such as sketches to photographs (visual spectra images), thermal images to photographs or near-infrared images to photographs. In this work we suggest that high level features of Deep Convolutional Neural Networks trained on visual spectra images are potentially domain independent and can be used to encode faces sensed in different image domains. A generic framework for Heterogeneous Face Recognition is proposed by adapting Deep Convolutional Neural Networks low level features in, so called, "Domain Specific Units". The adaptation using Domain Specific Units allow the learning of shallow feature detectors specific for each new image domain. Furthermore, it handles its transformation to a generic face space shared between all image domains. Experiments carried out with different face databases covering different image domains show substantial improvements, in terms of recognition rate.

PATRICK SCHUCH – DL FINGERPRINT RECOGNITION

Full Title: Deep Learning for Fingerprint Recognition Systems
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Supervisor: Christoph Busch
URL: https://www.christoph-busch.de/files/Schuch-PhD-Thesis-2019.pdf
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Abstract: Biometric recognition is a typical means to identify individuals or to verify claimed identities. Use cases are manifold. For example, users can unlock their smartphones for convenience by presenting their faces or fingerprints. Or one's identity is verified when crossing borders. Today, biometric recognition already has many points of contact with our daily life and there are more to come. Besides iris and face, fingerprint is the most wide spread biometric trait used for recognition. Fingerprints are assumed to be unique for each and every finger. This makes it an ideal trait for recognition. In addition, fingerprint recognition has more than a century of tradition in the field of biometric recognition. A great amount of expertise and engineering skill made it a quite mature technology over time.

Only few false positive and false negative errors are made in recognition in today's deployed systems. However, fingerprint recognition is still far from being perfect. In contrast to popular opinion, fingerprint recognition is not a solved problem. Actually, there is still a lot of work to do. As biometric systems become larger and become more inclusive, even new challenges arise. Systems need to deal with large amounts of data while keeping performance with respect to recognition performance as well as transaction times in a reasonable order. Recognition shall work for everyone and shall not exclude a certain ethnic group or subset of the population. It will work in unconstrained conditions. However, it shall still make no erroneous decisions. Engineering may have come to its limits at this stage. In contrast to classical engineering, machine learning based on artificial neural networks may be a reasonable alternative. The emerging technologies of Deep Learning achieve tremendous successes in many domains of image processing and pattern recognition. This work assesses the application of such innovative machine learning concepts to fingerprint recognition. Three central aspects and challenges in fingerprint recognition are inspected in detail: fingerprint sample enhancement, orientation field estimation, and efficient processing structures.

RUBEN TOLOSANA – HANDWRITING AND SIGNATURE AUTHENTICATION

Full Title: Disruptive approaches to handwriting and signature authentication for security-enhanced schemes
Institution: Universidad Autonoma de Madrid – BiDA Lab
Supervisor: Ruben Vera-Rodriguez / Javier Ortega-Garcia
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Abstract: Handwritten signature is one of the most socially accepted biometric traits as it has been used in financial and legal agreements for over a century. However, is signature biometric technology really adapted to current scenarios? With the massive deployment of mobile general-purpose devices such as smartphones and tablets, new very interesting and user-friendly scenarios have appeared beyond the traditional office-like scenario considering high quality devices specifically designed for signature acquisition. In addition, despite the high technological evolution, and concretely, the success of deep learning techniques in combination with Graphics Processing Units (GPUs), the core of most of the state-of-the-art signature verification systems is still almost the same than 20 years ago. Why deep learning techniques do not outperform traditional systems as it happens in other fields?

The last motivation for this Thesis is related to password-based systems. Traditionally, the two most prevalent user authentication approaches have been Personal Identification Numbers (PIN) and One-Time Passwords (OTP). However, and despite the high popularity and deployment of PIN- and OTP-based authentication systems in real scenarios, many studies have highlighted the weaknesses of these approaches as they are very easy to guess or steal (i.e., through shoulder-surfing and smudge attacks). Is it possible to increase the security of these traditional authentication systems at the same time that we provide a good experience to the users?

As a way of finding the answers to these questions, this Thesis is mainly focused on the analysis of the new opportunities that bring up these novel scenarios and technologies and the challenges that must be tackled in order to achieve state-of-the-art results.

This Dissertation comprises five different parts. Part I first concentrates on the problem statement and main contributions of the Thesis. The experimental chapters are then divided into three parts, Part II, Part III, and Part IV. Lastly, Part V concludes the Thesis.

Part I first introduces the basics of biometrics, focusing on handwritten signature biometrics, which is the main topic of study in this Thesis, and the challenges and opportunities for it along an exhaustive overview of the state-of-the-art. Then, we concentrate on describing the most relevant features of existing on-line signature databases, making special emphasis on all the databases acquired during this Thesis. Finally, Part I concludes explaining first the specific details of the traditional on-line signature verification systems considered in the experimental parts of the Thesis, and then our novel end-to-end writer-independent RNN signature verification systems proposed in this Dissertation.

The first experimental part (Part II of this Dissertation) starts analyzing the system performance of traditional signature verification systems on emerging scenarios such as finger input, device interoperability and mixed writing-input. Due to the high system performance degradation of them, in this Thesis we propose a two-stage approach based on robust preprocessing and feature selection techniques. We then study the novel scenario where the number of stored samples or templates per user can grow very fast, making it possible to train more robust statistical user models, improving the performance of biometric systems, and in particular, reducing the template aging effect. The research carried out in this part aims to answer the following questions: How is the system performance affected on these novel scenarios? What approach should we consider to overcome these challenges?

In the second experimental part (Part III of this Dissertation) we propose new ways to improve traditional signature verification systems. Concretely, we first evaluate the potential of including deep learning technology through a new architecture (Siamese) more adapted to the signature verification task. We then focus on the concept of complexity in signature and enhance the traditional systems through the selection of the most robust features for each signature complexity level.

Finally, Part IV of this Dissertation evaluates the potential of incorporating handwriting biometric information to traditional authentication systems based on passwords, asking the user to draw each digit of the password on the touchscreen instead of typing them as usual.

The research carried out in this Dissertation has led to novel contributions which include: i) analysis and adaptation of on-line signature verification systems to emerging scenarios such as finger input, device interoperability and mixed writing-input through robust preprocessing and feature selection techniques, ii) an exhaustive experimental analysis of template update strategies for three popular on-line signature verification approaches, extracting various practical findings related to the template aging effect in signature biometrics, and configuring time-adaptive improved versions of the considered baseline approaches overcoming to some extent the template aging, iii) exploring the potential of deep learning approaches for on-line signature verification. We have proposed a novel end-to-end writer-independent on-line signature verification system based on Recurrent Neural Networks with a Siamese architecture, which has outperformed other state-of-the-art systems, iv) improvement of traditional signature verification systems through the incorporation of the signature complexity concept, v) enhancement of traditional PIN and OTP authentication systems through the incorporation of handwriting biometric information as a second level of user authentication, vi) acquisition of new unprecedented handwriting and signature databases and release of them to the research community, and vii) part of the research presented in this Thesis has been deployed successfully in a pilot project in which on-line signature verification will be used massively in the Spanish banking sector.

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MATEUSZ TROKIELEWICZ – IRIS RECOGNITION

Full Title: Iris Recognition Methods Resistant to Biological Changes in The Eye
Institution: Warsaw University of Technology / National Research Institute
Supervisor: Adam Czajka
URL: http://zbum.ia.pw.edu.pl/PAPERS/Trokielewicz_PhD_2019.pdf
Contact email: mateusz.trokielewicz@pw.edu.pl

Abstract: Iris recognition has served the society as a secure and fast way of personal authentication for more than 25 years. During this time, multiple new research challenges have been identified, one of them being the possibly degrading impact of biology-related changes in the human eye, such as those caused by ocular diseases, but also post-mortem decay processes. This doctoral dissertation aims at quantifying the negative influence that these changes may inflict on iris biometrics systems, learning what causes errors, and proposing countermeasures to neutralize them.

First, an examination of the reliability that current methodologies offer when confronted with difficult samples, analysis of errors, and their underlying reasons, are conducted. From this we learn that most of the erratic performance originate from an incorrectly executed image segmentation stage. However, even when segmentation is manually adjusted in post-mortem samples, not all of the matching accuracy is regained, indicating that biological processes can cause the iris features to be altered or even lost, especially for post-mortem samples collected over time horizon exceeding a couple of days.

The image segmentation problem is solved by introducing a novel method employing a deep convolutional neural network, which localizes the iris, while effectively masking out iris regions affected by severe disease or post-mortem changes. We show how to use such masks in a traditional iris recognition pipeline, which allows us to achieve matching performance superior to the existing state-of-the-art methodologies, allowing the reduction of equal error rate from 23.69% to 6.40% for post-mortem samples collected up to 60 hours after death, and from 18.73% to as low as 0.68% for samples collected no more than 24 hours after death for the OSIRIS method. A significant reduction of equal error rate from 8.90% to 1.73% was obtained for samples collected from disease-affected eyes.

In an attempt to regain some of the iris features that were altered during post-mortem decomposition, a new set of image filters is devised by combining typical Gabor wavelets with data-driven filters learned from the post-mortem images. This allows to further decrease the recognition error rates by even as much as one third – a reduction of equal error rate from 6.40% to 4.39% for the same capture time horizon.

Finally, the proposed system is complemented with the first known to the Author method for iris liveness detection in a post-mortem setting, offering 99% correct live and post-mortem presentations classification rate.

The Author hopes that the contributions of this doctoral dissertation will constitute a valuable addition to the state-of-the-art in iris recognition, and enable efficient and reliable identification in biologically challenging circumstances, while also possibly extending the applications of iris biometrics to new fields, such as forensic examinations.

PANKAJ WASNIK – BIOMETRICS ON SMARTPHONES

Full Title: Robust Biometrics on Smartphones – Using Quality Assessment, Presentation Attack Detection, and Biometric Fusion
Institution: Norwegian University of Science and Technology
Supervisor: Raghavendra Ramachandra
URL: https://ntnuopen.ntnu.no/ntnu-xmlui/bitstream/handle/11250/2597766/Pankaj%20Shivdayal%20Wasnik_Fulltext.pdf
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Abstract: With the technological advancements in mobile technology, there is a massive adoption of biometrics as a security measure in today1s smartphones. Smartphones are used in all day to day activities such as online banking, accessing official and personal emails, social networking and also to store personal data. Although smartphones provide high user convenience, there is an inherent security threat as losing such a device could lead to a loss of such sensitive data. This could cause disastrous effects on the smartphone user. In order to reduce the privacy and security threats, basic solutions are provided with every smartphone. However such solutions could cause user inconvenience sometimes, for example, it is hard to remember complex lock patterns, longer pin codes; also such patterns and pins could be easily hacked. Thus, an inherent need of added security measure is there and which could be conveniently fulfilled by biometrics on smartphones. As a result of which, recently, most of the smartphones are manufactured with inbuilt fingerprint sensor, or state-of-the-art face or iris recognition system. Today, we can say that for any smartphone, a biometric system is one of an essential component just like the front and rear cameras. However, the inclusion of such a biometric system comes with a cost such as the performance of a biometric system depends on several factors such as the input sample quality, systematic and random errors. Moreover, biometric systems are highly vulnerable to direct and indirect attacks. The direct attacks aka presentation attacks are carried out at the biometric sensor level by presenting a fake biometric sample. If a biometric system does not have an attack detection module also known as presentation attack detection module, it is trivial to spoof any biometric system. Thus, the primary objectives of this thesis are to address the challenges of smartphone biometrics. The unconstrained nature of biometric samples captured in a smartphone environment could cause challenging input samples for the recognition system and results in a lower comparison score. Therefore, it is essential to assess the precise quality if the input samples. In this work, we present and compare several quality assessment algorithms to formulate a unified face recognition system. This thesis proposes two presentation attack detection techniques for smartphone-based face recognition systems and one for fingerphoto recognition systems. The thesis also extends the applications of some concepts from Subjective Logic to fuse the comparison scores from face and fingerprint recognition systems. Additionally, this thesis proposes a multi-biometric and multi-algorithmic fusion scheme to mitigate the effects of body weight variations for face recognition systems. Although the proposed framework does not use smartphone biometric data, the method could be easily adapted for the smartphone-based face recognition. The validity of proposed frameworks for

consistent performance is demonstrated through extensive experimentation on publicly available and newly created databases. We have also presented a new smartphone based multimodal biometric database as well as a presentation attack database in this work. Conclusively, the thesis proposes robust Biometric Quality Assessment (BQA), Presentation Attack Detection (PAD) and Biometric Fusion techniques to address the issue of sample quality assessment, presentation attacks, and multi-modal biometric fusion. A detailed experimental analysis and comprehensive studies have been executed to evaluate the proposed methods under the scope of this thesis work. The presented methods will help the researchers and users of smartphone biometrics to improve the robustness of the systems.

MONITOR
MASTER-THESES

NICOLE BELVISI – DIGITAL FORENSICS THROUGH TEXTUAL ANALYSIS

Full Title: Document Forensics Through Textual Analysis
Institution: Halmstad University
Supervisor: Naveed Muhammad
URL: http://urn.kb.se/resolve?urn=urn:nbn:se:hh:diva-40157
Contact email: naveed.muhammad@ut.ee
Abstract: This project aims at giving a brief overview of the area of research called Authorship Analysis with main focus on Authorship Attribution and the existing methods. The second objective of this project is to test whether one of the main approaches in the field can be still be applied successfully to today's new ways of communicating. The study uses multiple stylometric features to establish the authorship of a text as well as a model based on the TF-IDF model.

MARTA BLAZQUEZ – STATIC SIGNATURE VERIFICATION

Full Title: Verificacion de firma manuscrita estatica mediante redes neuronales convolucionales - Verification of static handwritten signature using convolutional neural networks.
Institution: Universidad Autonoma de Madrid – BiDA Lab
Supervisor: Ruben Vera-Rodriguez
URL: https://repositorio.uam.es/handle/10486/687091
Contact email: marta.blazquezc@estudiante.uam.es

Abstract: The research in deep neural networks has produced a great improvement in the world of biometrics. Facial recognition systems are used more often and require a higher accuracy. A common way of improving these systems is the reinforcement through characteristic attributes from each person which are known as soft biometrics. The gender, age or ethnic group are the most common attributes.

Analyzing the performance of facial recognition systems, differences are observed within each demographic group. Considering the gender, women obtain the worst results. Regarding the ethnicity group, dark skin persons or Asian have more difficulties in the facial recognition. This problem is mainly due to the training sets used for the learning process of the models. These are not usually balanced and that is reflected in the results obtained for each class. Usually datasets include more men and more white race identities.

In this project, specific models are developed for the demographic groups of gender and ethnicity. The experimental results show that using trained models with images from a single class, it is possible to the performance of a generic facial recognition system trained with images from all classes. Two estimators for the gender and ethnic group attributes are also proposed. System performance is compared when race and gender information is obtained automatically or manually, through label. Moreover, a more complete system is proposed combining gender and ethnic group information. Proposing a fusion of this information at the scores or the features level.

TOMÁŠ COUFAL – FACE IDENTIFICATION

Full Title: Descriptor for Identification of a Person by the Face
Institution: Brno University of Technology
Supervisor: Tomáš Goldmann
URL: https://www.fit.vut.cz/study/thesis/21775/.en
Contact email: igoldmann@fit.vutbr.cz
Abstract: Thesis provides an overview and discussion of current findings in the field of biometrics. In particular, it focuses on facial recognition subject. Special attention is payed to convolutional neural networks and capsule networks. Thesis then lists current approaches and state-of-the-art implementations. Based on these findings it provides insight into engineering a very own solution based of CapsNet architecture. Moreover, thesis discussed advantages and capabilities of capsule neural networks for identification of a person by its face.

HATIM DALI – VIDEO-BASED FINGERPRINT RECOGNITION

Full Title: A video-based approach on contactless fingerprints
Institution: Hochschule Darmstadt
Supervisor: Christoph Busch / Jannis Priesnitz
Contact email: jannis.priesnitz@h-da.de

Abstract: Fingerprints are among the most widely used biometric features and are an integral part of today's life. Since the technologies used have been developed steadily over the last few decades, they are now also used as a safety measure in ordinary smartphones. A promising alternative to traditional detection systems, which may have problems with latent fingerprints or uneven contact pressure, is in contactless systems.

The aim of this work is to develop and evaluate an Android app for contactless, video-based capturing of fingerprints. Hereby, up to four fingers are to be recorded and processed simultaneously. Several steps are necessary to extract the fingerprints from the images, which are obtained from the incoming video stream. These include detecting the fingers and calculating a correction angle to obtain a uniform orientation. Moreover, a separation of the individual finger is needed. In order to ensure a high quality of fingerprints, algorithms are also implemented which sort out unusable images at an early stage. Lastly, the fingerprints on the images thus obtained are programmatically enhanced. The first part of the work consists of an overview on current approaches to the individual steps required for the app. Afterwards the developed pipeline is explained in detail, as well as the criteria of the test database is called.

In the absence of a publicly accessible database with the required data records, this has to be created by oneself. In addition to the finger images, metadata about the test subjects are stored here. These include, amongst others, the age, sex, and skin color of the subjects. Furthermore, image-specific information is recorded, such as the resolution of the image and the correction angle.

Several performance measurements were defined for the evaluation of the developed app. The first step is to evaluate how much of the data can be used for further tests, and what relationships exist between the errors that have occurred. Subsequently, the Equal Error Rate (EER) of each color space of the two smartphones in this thesis will be evaluated, as well as the best-performing color space for both smartphones.

For the final evaluation of the developed system 1620 test images were collected. A first manual control showed that about 40% of the data is faulty. Only a quarter of this shortcomings could be discovered through a programmatic approach. In about 80 of the pictures no minutiae could be detected although these were classified as valid during the manual control. The usable data yielded an EER of about 26,6% and 24,4% for enhanced images on both test devices. Grayscale, as well as RGB images performed worse with about 33.4% to 41,7%. As soon as the same tests were repeated with the previously sorted data, the EER increased significantly in all test scenarios.

BENJAMIN DIECKMANN – DL-BASED PRE-ALIGNMENT OF FINGERPRINTS

Full Title: Entwicklung eines Pre-Alignment Algorithmus für Fingerabdrücke mit Deep Learning
Institution: Hochschule Fulda / secunet Security Networks AG
Supervisor: Alexander Gepperth / Johannes Merkle / Christian Rathgeb
Contact email: Benjamin.Dieckmann@secunet.com
Abstract: Moderne Systeme zur Erkennung von Fingerabdrücken besitzen hohe Anforderungen an die Sicherheit der gespeicherten Referenzdaten und an die Verarbeitungsdauer zur Verifikation und Identifizierung von Personen. Die unterschiedlichen Positionen und Richtungen eines Fingerabdrucks, welche durch eine variierende Auflage des Fingers auf eine Sensoroberfläche entstehen, erschweren den Vergleich von Fingerabdrücken. Dadurch können ebenfalls die erhobenen Referenzdaten nicht mit herkömmlichen, kryptographischen Funktionen gesichert werden. Bei einer Registrierung lassen sich Fingerabdrücke einheitlich vorausrichten, sodass ein Vergleich von mehreren Abdrücke effizienter durchführbar ist. Die Verwendung eines solchen Pre-Alignments ist auch für gängige biometrische Kryptosysteme, wie das Fuzzy Vault Verfahren, notwendig. Deep Learning erzielt besonders seit den letzten Jahren Erfolge bei der Bildverarbeitung, welche die Genauigkeit von herkömmlichen Verfahren übertreffen. Deshalb wird mit dieser Arbeit ein auf Deep Learning basierendes Pre-Alignment Verfahren vorgestellt, welches sich auf Fingerabdrücke aus verschiedenen Datenbanken anwenden lässt. Ein Convolutional Neural Network erlernt die globalen Strukturen und Muster der Orientierungsfelder von Fingerabdrücken, sodass sich eine absolute Translation und Rotation bestimmen lässt. Die Berechnung erfolgt für Fingerabdrücke von verschiedenen Musterklassen und Sensortypen weitgehend gleichmäßig. Dabei wird die Ausrichtungsgenauigkeit von existierenden Verfahren teilweise übertroffen. Besonders hohe Ausrichtungsabweichungen werden durch die Verwendung des Deep Learning Verfahrens reduziert. Die Bestimmung der absoluten Rotationen erfolgt deutlich robuster, als die Translationen. Diese Eigenschaft wird auch durch die Anwendung des Pre-Alignments in einer Fuzzy Vault Implementierung verdeutlicht. Mit der Nutzung der Translationen eines vergleichbaren Verfahrens und der Rotation des künstlichen neuronalen Netztes, lassen sich die Fehlerraten des biometrischen Kryptosystems verringern.

FLORIAN DOMIN – FACE MORPHING ATTACK DETECTION

Full Title: Detektion von Morphing-Angriffen auf biometrische Gesichtserkennungssysteme mittels Analyse von Merkmalsvektoren durch maschinelles Lernen
Institution: Hochschule für Wirtschaft und Technik Berlin / secunet Security Networks AG
Supervisor: Martin Spott / Johannes Merkle / Christian Rathgeb
Contact email: Florian.Domin@secunet.com

Abstract: Automated facial recognition systems are widely used today. But are these systems also resistant to manipulation? Using morphing techniques, facial images can be modified in a way these artificial images contain biometric information from multiple subjects, making it possible to attack biometric facial recognition systems. In this thesis a Morphing Attack Detection (MAD) System is developed, which is trained with the help of machine learning on feature vectors of biometric facial images. For this purpose, feature vectors are calculated with a commercial facial recognition software and the distance between vectors of two biometric facial images is measured in a differential procedure. A new Classifier will be developed especially for the recognition of morphing-attacks and the recognition performance will be measured. The master thesis is of interest for readers working in the field of biometric systems, as it highlights current problems and provides a possible solution.

VILÉM JELEN – BIOMETRIC GATEWAY TO IDENTIFY PEOPLE

Full Title: Biometric Gateway Using Camera to Identify People
Institution: Brno University of Technology
Supervisor: Tomáš Goldmann
URL: https://www.fit.vut.cz/study/thesis/21775/.en
Contact email: igoldmann@fit.vutbr.cz

Abstract: Biometric gateways are used to quickly and accurately identify people. Of the biometric characteristics, iris, face and fingerprints are commonly used. By combining them, better identification results can be achieved. The aim of this thesis is to create such a biometric gateway together with the control application. A combination of iris of both eyes and face is used, which is captured by cameras from three angles to increase accuracy. Neural networks are used to detect and extract face features. Iris recognition is realized using Daugman's algorithm.

HENRIK KAWA – HOMOMORPHIC ENCRYPTION FOR FINGERPRINT RECOGNITION

Full Title: Homomorphic Encryption for Fingerprint verification
Institution: Hochschule Darmstadt / Technical University of Denmark
Supervisor: Christian Jensen / Christoph Busch / Jascha Kolberg
Contact email: jascha.kolberg@h-da.de

Abstract: Biometric data is unique to each individual and according to EU's General Data Protection Regulation (GDPR), it classifies as sensitive data. When it is classified as sensitive data, there is a requirement to protect the data. This thesis aims to benchmark a FingerCode based fingerprint verification system and a Minutiae based fingerprint verification system against each other when applying homomorphic encryption. There are existing works which apply homomorphic encryption to Minutiae-based fingerprint and FingerCode, and those are discussed in this work and used for inspiration. This work will differ from them, as the focus will be on the performance of the encryption, how they compare and what is the trade-off between them.

The Biometric performance for Minutiae-based system and the FingerCode was evaluated using False Match Rate (FMR) and False Non-Match Rate (FNMR). The FMR and FNMR were 1.46% and 73.00% for the FingerCode system, and 0.95% and 75.75% for the Minutiae based system. During the work it was proved that by applying homomorphic encryption to the systems, the biometric performance remained unaffected. The encryption scheme implemented in this thesis are Paillier and Damgård, Geisler and Krøigaard (DGK). Paillier is a well known homomorphic encryption scheme that is based on Composite Degree Residuosity Classes. DGK is a homomorphic encryption scheme which security is based on k bit RSA modulus.

By applying the encryption schemes on the biometric fingerprint systems the times for FingerCode verification were 0.3598 seconds using DGK and 0.6728 seconds using Paillier. For Minutiae based verification the times were 615.53 seconds using Paillier and 69.42 seconds using DGK. Regarding the file size of the templates, FingerCode increased from 3KB to 662KB using Paillier and 498KB using DGK. For Minutiae based the file size increase from 3.9KB to 60.6KB using Paillier and 45.2KB using DGK. This investigation indicate that DGK is a better homomorphic encryption scheme than Paillier for biometric fingerprint systems. Both systems can be used, but regarding speed FingerCode seem to be the best choice.

MARTIN KUBÍČEK – DEPTH MAP FROM IRIS

Full Title: Creating a Depth Map of Eye Iris in Visible Spectrum
Institution: Brno University of Technology
Supervisor: Martin Drahanský
URL: https://www.fit.vut.cz/study/thesis/22566/.en
Contact email: drahan@fit.vutbr.cz

Abstract: The aim of the master thesis is to propose and introduce in practice the methodology of scanning the iris of an eye in the visible spectrum. It emphasizes the quality of images, credible color rendering in comparison to the real basis and, in particular, the continuous depth of sharpness that could reveal previously unexamined aspects and details of the iris. Last but not least, the thesis will also focus on minimizing exposure to physical stress to the iris. Part of the methodology is a precise procedure for iris imaging while ensuring image consistency. This will allow the creation of an iris database that tracks their evolution in time or other aspects such as the psychological state of the person being scanned. To start with in practice, the anatomy of the human eye and especially that of the iris is presented. Known methods of iris scanning are given. Then, there is a section about proper iris lighting. This is necessary for the desired level of image quality but at the same time it exposes the eye to great physical stress. It is therefore necessary to find a compromise between these factors. Important is the very description of the methodology itself as it describes in detail the scan. Furthermore, the thesis deals with necessary post-production adjustments, such as compiling images with different depths of sharpness into a single continuous image or applying filters to remove defects from the images. The last part of the thesis is divided into evaluation of the results and the conclusion in which is discussed the possible extension or modification of the methodology so that it can be used outside the laboratory conditions.

ALEKSANDAR MITKOVSKI – GAN FOR SIMULATING PRINT-SCAN

Full Title: Simulation of Print-Scan Transformations for Passport-compliant Facial Images using a Generative Adversarial Network
Institution: Hochschule Fulda / secunet Security Networks AG
Supervisor: Alexander Gepperth / Johannes Merkle / Christian Rathgeb
Contact email: Johannes.Merkle@secunet.com

Abstract: Highly sophisticated image manipulation is becoming progressively easier, in particular with the advent of artificial intelligence. At the same time, sovereign security documents, such as identity cards or passports, are increasingly subject to facial image manipulation. In one particular scenario, the passport image may be generated by morphing the image of the applicant with that of another person. In Germany, for example, this manipulated image could then be submitted to the governmental passport issuing office, where it is scanned and used to issue a passport. This document may ultimately be misused for authentication purposes by these two persons. Most current publications regarding image manipulation detection rely on conventional methods based solely on digital images. On the other hand, printing and scanning are part of the passport issuance process, which will result in information loss and render the image artifact detection more difficult. Deep learning-based (DL) image processing has achieved many successes in recent years that have exceeded the capabilities of conventional image processing methods. Therefore, a DL image processing approach may be developed to address the described image manipulation, which typically requires the use of a large amount of print-scan images. However, printing and scanning a large number of passport compliant images is time consuming and costly. The aim of this Master's thesis is to create a proof of concept that simulates a print-scan transformation of passport images using a DL algorithm referred to as Generative Adversarial Network (GAN). An image-to-image transformation was used for the print-scan transformation of the facial images with a conditional GAN (cGAN) variant. When human subjects evaluated the cGAN-generated images, the majority of testers could not differentiate them from the real print-scan images. Additional, quantitative evaluation approaches showed that the cGAN transforms digital passport images in a manner similar to the actual printing and scanning process. The experimental approaches outlined in this Master's thesis suggest that using a cGAN for print-scan transformation is a cost-effective and time-saving image processing workflow.

JAN PAWLUS – IMITATION OF HANDWRITING

Full Title: Device for Imitation of Static and Dynamic Handwriting Characteristics
Institution: Brno University of Technology
Supervisor: Martin Drahanský
URL: https://www.fit.vut.cz/study/thesis/22229/.en
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Abstract: This project deals with designing and assembling a system for imitation of static and dynamic handwriting characteristics. This system's design takes into account special pen targeted for getting the handwriting characteristics, working with these characteristics and their imitation with a 3D printer altered for this purpose. This topic might be interesting because research about this specific field, which would include a real demonstration of how a signature can be forged using dynamic handwriting characteristics not by forger's hand, barely exists. The problem with preventing forgery is that we need to know the attack well, which is a clear motivation for this project.

ALEXANDER RÖTTCHER - DOPPELGÄNGER FOR FACE MORPHING

Full Title: Finding the suitable Doppelgänger for a Face Morphing Attack
Institution: Hochschule Darmstadt / Ruhr University Bochum
Supervisor: Christoph Busch / Markus Dürmuth / Ulrich Scherhag
Contact email: alexander.roettcher@alumni.rub.de

Abstract: Passports, membership cards, or other ID cards often have one thing in common: A facial image is printed on the card and electronically provided on a chip to allow a verification if the card belongs to a person. The face is a universal characteristic which everyone has, can be easily captured by any camera and has a high acceptance to be used for the identification purpose. However, twins destroy or at least weaken the distinctiveness of different faces due to their biological similarity. Also, one might have experienced to falsely identify an unknown person as a friend – colloquially named someone's Doppelgänger. Can this biological effect of similar data subjects be purposefully established between two individuals in order to share an identity?

In this work, the so-called morphing attack, firstly described by Ferrara et al., is further analysed. This image manipulation technique creates an artificial facial image which is similar to two or more different individuals. If introduced into an ID card, this manipulated reference image can be linked to all participating individuals. While the attack itself is rather simple to perform, a recent survey concludes that state-of-the-art research results are difficult to be compared to each other. This work presents a first step-by-step research guideline, provides ways for automation, and discusses the impact of different decisions in order to tackle this challenge. By considering not only the morphing process itself but all preparatory work and subsequent processes, it permits a global view on how odds-and-ends can greatly impact reported performance results. Especially, it is shown that a currently rather neglected part, the pairing of similar data subjects from which facial images are morphed together, negatively influences the vulnerability of automated face recognition systems as well as the morphing attack detection performance. Therefore, a new pairing algorithm is developed which considers complex real-world constraints while being executable in a reasonable amount of time.

CLAUDIA SATNOIANU – EFECTS OF BEAUTIFICATION ON FACE RECOGNITION

Full Title: Face recognition, Effects and Detection of Beautification Applications
Institution: Hochschule Darmstadt / Technical University of Denmark
Supervisor: Christian Jensen / Christoph Busch / Christian Jensen
Contact email: christian.rathgeb@h-da.de

Abstract: The goal of this MSc thesis is to analyze the impact beautification apps can have on face recognition systems and to see if detection systems are capable of noticing when an image has been beautified. The MSc thesis is composed of seven chapters, each of them dealing with a different aspect of the above-mentioned topic.

An introduction is made in Chapter 1, where the reader gets familiarized with topics such as facial image databases, face recognition systems and detection systems.

Chapter 2 is divided into two parts, the first one of them presenting a literature review and the second one proposing the goals which are set for this thesis project. Chapter 3 focuses on presenting the entire process of selecting the beautification apps which are being used during the project based on a set of criteria, to how to use the apps and then what are the final results that can be achieved by using them. Chapter 4 concentrates on both the bona fide databases that are used and on how the beautification process of this bona fide images can be automated, for a faster database generation procedure.

After generating the database that serves the scope of this project, in Chapter 5 a description of the detection systems is made. The chapter is split in two, the first part focusing on the possible scenarios a detection system can be useful, whereas the second part focuses on the detection systems that are being used when doing the experiments. Chapter 6 is divided into three parts. Part one describes how the experiments for both face recognition systems and detection systems were conducted, whereas parts two and three focused on analyzing the experiments' results for each type of system.

Conclusions are drawn in Chapter 7. The main aim of the MSc thesis has been reached. The author suggests that face recognition systems should be improved so that they have a higher performance rate given the beautification scenarios.

TORSTEN SCHLETT – 3D FACE RECOGNITION

Full Title: Enhancement of 3D-Data for Face Recognition
Institution: Hochschule Darmstadt
Supervisor: Christoph Busch / Christian Rathgeb
Contact email: Christian.rathgeb@h-da.de

Abstract: Face recognition can benefit from the utilization of depth data, including for presentation attack detection purposes. This work begins with an overview of inexpensive "consumer" depth cameras. Depth video output from these devices can however contain defects such as holes, as well as general depth inaccuracies.

Therefore the primary part of this work researches a variety of depth enhancement methods, divided into two categories: General enhancer types stemming from RealSense SDK post-processing filters, which are not specifically designed to enhance facial depth input. And deep learning enhancers, which are artificial neural networks using U-Net-like architectures that were created as part of this work. All enhancer types exclusively use depth data as input, which differs from methods that enhance depth based on e.g. visible light color data.

Due to the noted apparent lack of real-world camera datasets with suitable properties, face depth ground truth images and degraded forms thereof are synthesized, both for the deep learning training and for an experimental quantified evaluation of all enhancer types. Enhancer output samples are nevertheless also presented for real camera data, namely custom RealSense D435 depth images and Kinect v1 data from the KinectFaceDB, with special attention given to the description of both devices.

It is concluded that the deep learning enhancement approach is superior to the tested general enhancers, without overly falsifying depth data when non-face input is provided. Furthermore it is extrapolated that, given a finite amount of additional development time, more optimized deep learning network architectures and training procedures can still be achieved, whereas "hand-crafted" enhancement methods are less likely to attain comparable or better results in the same timeframe. The implemented system, which i.a. incorporates PRNet-usage for the ground truth synthesis, is described in detail for potential future work, for which a number of different topical options are proposed.

KACOER STRANSKI / LUKASZ RYBACKI – SIGNATURE VERIFICATION

Full Title: Implementation and examination of a signature verification method
Institution: Gdansk University of Technology
Supervisor: Michal Lech
URL: www.multimed.org
Contact email: mlech@multimed.org

Abstract: The purpose of the M. Sc. thesis was to implement and to examine an intelligent method of verifying the authenticity of the handwritten signature. A dynamic signature authentication method based on neural networks was employed. The chosen method is justified by the growing popularity of machine learning algorithms. The issues of biometrics and machine learning algorithms used for the process of user identity verification were analyzed in detail. The theory contained in the review chapters was preceded by a thorough study of scientific literature in the field of biometrics, as well as in learning algorithms. Then, a detailed description of the proposed algorithm scheme was provided. Particular emphasis was put on examining the influence of the neural network architecture and the applied neuron activation function on the handwritten signature authentication accuracy. Moreover, the effectiveness of signature recognition depending on the selection of input data set was examined. The obtained results were presented in the diploma thesis and on that basis, the applied solutions were evaluated. The last part of the diploma thesis includes conclusions derived from the entire analytical and experimental material gathered. The results of the performed work were summarized in the last chapter, together with possible further direction suggestions for research and development in this subject.

ALEXANDRU VASILE – DL FINGERPRINT PAD

Full Title: Evaluation of Deep Learning Methods for Fingerprint Presentation Attack Detection
Institution: Hochschule Darmstadt / Technical University of Denmark
Supervisor: Christian Jensen / Christoph Busch / Jascha Kolberg
Contact email: jascha.kolberg@h-da.de

Abstract: The usage of biometric systems for automating identification and verification of individuals represents an increasing trend. It is critical that the security of those systems is optimal in order to prevent misuse. Presentation Attack Detection (PAD) methods need to be employed for an increased security on various types of biometric data such as fingerprints. This thesis explores the feasibility of using deep learning techniques as PAD methods, working on fingerprint Laser Speckle Contrast Imaging (LSCI) data. The focus is on utilising Long Short-Term Memory (LSTM) networks in order to effectively process the temporal information that is present in the data. Fourteen deep neural network models are implemented and evaluated on a private data set comprising LSCI fingerprint data. The data set comprises 2302 samples, with 1146 Presentation Attack (PA) samples and 1156 bona fide samples. Five of the trained and evaluated models achieve a classification accuracy above 97%. The best performing model achieves a classification accuracy of 97.86%, with an Attack presentation classification error rate (APCER) of 1.92% and Bona fide presentation classification error rate (BPCER) of 2.35%. The study concludes that it is imper- ative to use a convolutional base together with a LSTM block in order to achieve high classification accuracy. Out of the 36 Presentation Attack Instrument (PAI) species present in the data set, the overlay type represents the biggest challenge in classification for all evaluated models.

MONITOR
BACHELOR-THESES

MARTIN BENEŠ – COUNTING PEOPLE WITH PASSIVE INFRARED

Full Title: Counting People Using a PIR Sensor
Institution: Brno University of Technology
Supervisor: Martin Drahanský
URL: https://www.fit.vut.cz/study/thesis/21967/.en
Contact email: drahan@fit.vutbr.cz

Abstract: PIR (passive infrared) sensors are mainly used to detect a presence of a person and notifying a system to react appropriately. The aim of this thesis is to use the PIR sensors to localize the person and present approach to estimate a count of people. To do so, the thesis suggests a heat signal processing pipeline including wavelet transformation feature extraction, fuzzy logic system with classifiers based on linear regression. The performed experiment and its results are presented an evaluated.

ANGELIKA BOTALJOV – FACE RECOGNITION UNDER BEAUTIFICATION

Full Title: Auswirkung von Verschönerungs-Apps auf Gesichtserkennungssysteme
Institution: Hochschule Darmstadt
Supervisor: Christoph Busch / Christian Rathgeb
Contact email: christian.rathgeb@h-da.de

Abstract: Nowadays, the use of facial recognition systems to verify the identity of individuals is indispensable. They are also used, for example, at border control terminals at airports to compare facial images of people with those stored on electronic travel documents, thus enabling them to pass through without any problems. The application process, in which the applicant has to submit a biometric passport photo, offers the possibility of modifying passport photos through image processing. This could, for example, happen without the applicant's bad intentions by using beautification apps. So, the question arises whether such a change in a facial image is affecting a facial recognition system. This bachelor thesis deals exactly with this topic. The goal is to investigate possible effects of applied beautification apps on facial recognition systems.

For this purpose, an existing facial database was used, which was filtered according to the required characteristics for biometric passport photographs. Original reference images of persons were processed with a selection of suitable beautification apps. The beautified facial images were then processed in a biometric performance analysis using two facial recognition systems, one commercial and one open source, and the corresponding effects evaluated using different metrics.

The analysis has shown that the commercial system is more robust than the open source system in terms of the use of beautification apps. However, it has been shown that especially strong changes in the facial anatomy, such as extreme nose narrowing, have negative effects on both facial recognition systems used. Nevertheless, positive effects were also observed. For example, a skin smoothing or a removal of skin impurities had often led to better biometric comparison scores.

CLEMENTS BROCKSCHMIDT – ML BASED FINGER DETECTION

Full Title: Hand and Finger Detection based on Machine Learning
Institution: Hochschule Darmstadt
Supervisor: Christoph Busch / Jannis Priesnitz
Contact email: jannis.priesnitz@h-da.de

Abstract: Touchless fingerprint recognition is a topic widely approached by researchers because of the ability to scan multiple fingers at the same time, ease of use, as well as hygienic factors. To initialize a fingerprint scan, the fingers to be scanned need to be segmented. Because traditional image processing approaches are overchallenged when considering the variety of skin colors, backgrounds, lighting, and other environment variables, deep learning approaches are investigated in this work.

Two top-performing convolutional neural networks architectures are trained with datasets containing general-purpose segmentation data and specialized hand segmentation datasets. These networks are evaluated using two test datasets. The first test dataset is part of the training dataset used, while the second dataset includes composed images of hands artificially placed in front of various backgrounds.

While the deep learning approach achieves an accuracy of 77% to 97% depending on the test dataset, the traditional approach achieves 3% to 61%. The evaluation results show that the deep learning approach outperforms the traditional approach, especially in challenging environments where it is not possible to adjust the traditional approach to all environment variables.

MIGUEL CARUANA – DYNAMIC SIGNATURE VERIFICATION

Full Title: Verificacion de firma manuscrita dinamica mediante redes neuronales recurrentes - Dynamic handwritten signature verification through recurrent neural networks
Institution: Universidad Autonoma de Madrid – BiDA Lab
Supervisor: Ruben Vera-Rodriguez
Contact email: miguel.caruana@estudiante.uam.es

Abstract: In this Final of Degree Work the development of two systems is carried out, a dynamic sig-nature complexity detector and a dynamic signature verification system. The work has therefore been carried out in two separate phases. Before starting with the development of the systems a study of the different techniques present in the state of the art of the dynamic signature verification systems was made, with particular attention in Recurrent Neural Networks.

Then began the development of a system for detecting the complexity of signature that classified signatures into three categories: high, medium and low complexity. Initially, the signatures and complexity labels of the BioSecurID database were used to find the architecture, based on RNNs, that showed the best performance. Once found, the signatures of a larger base, Deep-SignDB, were classified and the system was trained with these new labels, so that performance improvements are obtained.

After the completion of the first phase of the project, the complexity detector, the second phase began, the development of a dynamic signature verification system. An architecture based on RNNs has been used as it has already achieved good results. The difference with other works lies in the alignment of the characteristics that is done before passing the information to the network. These features are aligned using DTW. With this system three experiments have been carried out, training the system with skilled forgeries, training it with random forgeries and training it with both types of forgeries.

Subsequently, an analysis of the results achieved in each of the two phases is made, comparing them with previous work that used the same data and/or similar methodology. Finally, the conclusions drawn from the various experiments carried out are presented, as well as a future work approach: the development of a system that combines the two systems proposed here.

DAVID DIAZ – HEART RATE ESTIMATION

Full Title: Heart Rate from Video based on Deep Learning
Institution: Universidad Autonoma de Madrid – BiDA Lab
Supervisor: Julian Fierrez
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Abstract: The present final research project makes a revision of the different techniques created to date for the estimation of the heart rate through rPPG from recordings obtained by means of a video camera. In the first place we study the methods called hand crafted that make use, in general, of linear techniques to maximize the signal to noise ratio of the signal from which to make the estimation. Then we review the methods, so called learning-based, that rely on machine learning to produce a model, from input data and its corresponding groundtruth, able to make estimations of the heart rate on a new recording. In particular, the theoretical and mathematical development that results in the model called DeepPhys by Chen and McDuff (2018) is analyzed in detail. This model falls within the set known as end-to-end models and is capable of producing the estimation of the heart rate from a video introduced as input data.

DeepPhys uses a convolutional network to produce an attention mask, based on the appearance of the video frames, which serves as a guide to a second network that extracts the estimated physiological signal from the movement present in the recording. The learning-based method achieves a better result than the hand-crafted methods on videos in the COHFACE database. The performance achieved in rPPG of models learning-based augur a promising future for this type of techniques, since it is easy to imagine many practical applications for them within the medical and sports field.

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DAVID DEJMAL – FINGERPRINT QUALITY ASSESSMENT

Abstract: The aim of this work is to improve the process of determining fingerprint quality by Fingerprint Quality Visualizer (FQV). Mutual comparison of existing programs NIST Fingerprint Image Quality 2.0 and Neurotechnology VeriFinger has proved that FQV is worse in processing of extremely small fingerprints. Therefore, the procedure which estimates the number of minutiae in fingerprint based on its real size has been designed and implemented as an improvement. The final testing has proved that the implemented method works for the selected fingerprint collection. This approach can be an alternative to complex searching and accurate minutiae counting.

DIDEM DOGAN – FACE RECOGNITION AND PLASTIC SURGERY

Full Title: Auswirkungen der plastischen Chirurgie auf Gesichtserkennungssysteme
Institution: Hochschule Darmstadt
Supervisor: Christoph Busch / Christian Rathgeb
Contact email: christian.rathgeb@h-da.de
Abstract: Nowadays, face recognition systems (FRSs) are an increasingly important instrument to ensure security, e.g. for automated border control. Nevertheless, various factors such as pose, ageing or lighting conditions represent difficulties in identifying persons. Another disruptive factor represents plastic surgery. It serves not only to beautify but also to rejuvenate the face. Exactly these changes can be fatal to a FRS.

In this thesis, the effects of plastic surgery on modern FRSs are examined. The used FRSs are on the one hand a commercial system and on the other hand the open source system FaceNet. The recognition performance of both systems is analysed using a non-plastic facial database and an acquired plastic facial database. The plastic facial database is divided into five categories depending on the aesthetic plastic surgery performed on the face. These are the eyelid, eyebrow, nose and facial bone correction as well as the facelift.

The investigations show a very good recognition performance of 99 % for the commercial system with a false match rate (FMR) of 0,1 % and a good value of over 90 % for FaceNet with an FMR of 1 %. Both results show that modern FRSs are relatively robust to changes caused by plastic surgery.

VLADIMÍR DUŠEK - MONITORING PEDESTRIAN BY DRONE

Full Title: Monitoring Pedestrian by Drone
Institution: Brno University of Technology
Supervisor: Martin Drahanský
URL: https://www.fit.vut.cz/study/thesis/21389/.en
Contact email: drahan@fit.vutbr.cz

Abstract: This thesis is focused on monitoring people in a video footage captured by drone. People are detected by trained model of detector RetinaNet. A feature vector is extracted for each detected person using color histograms. Identification of people is realized by comparing their feature vectors with respect to their distance in the frame. In the end the trajectories of all people are visualized in a panorama image. Accuracy of the trained RetinaNet detector on difficult validation data is 58.6 %. Error rate is partially reduced by the way of algorithm design for trajectory visualization. It's not necessary to successfully detect person on every frame for correct visualization of its trajectories. At the same time, static objects which are detected as person but are not moving are not consider as people and are not visualized at all. There is a lot of algorithms dealing with people detection however only a few approaches are focused on detection people from an aerial footage.

MARTIN DVOŘÁK – VASCULAR CIRCULATION OF SYNTHETIC RETINA

Full Title: Algorithm for Realistic Vascular Circulation of Synthetic Retina
Institution: Brno University of Technology
Supervisor: Lukáš Semerád
URL: https://www.fit.vut.cz/study/thesis/21963/.en
Contact email: lsemerad@fit.vutbr.cz
Abstract: The aim of this bachelor thesis is to improve an existing tool for creating synthetic retina of the eye. The improvement of an existing software is carried out by changing the algorithm for creation vascular bed. The problem was solved by designing an algorithm which is based on real behavior of vascular system in the retina of the eye. Real pictures were statistically recorded. Mathematical programs created approximation curves of the blood vessels. Directions of the blood vessels, locations of branching and a number of branching of blood vessels were observed. A model for generation of synthetic pictures was designed based on discovered information and probability of branching. The main results are synthetic retinas which contain patterns of behavior of a real retina of the eye. These pictures have similar number of blood vessels, aiming towards the same location and branching in the same points as real pictures.

MARTA FERNANDEZ – FACE RECOGNITION

Full Title: Nuevos esquemas de aprendizaje para el entrenamiento de representaciones agnósticas: aplicación al reconocimiento facial - New learning schemes for the training of agnostic representations: application to facial recognition
Institution: Universidad Autonoma de Madrid – BiDA Lab
Supervisor: Aythami Morales / Julian Fierrez
URL: https://repositorio.uam.es/handle/10486/688899
Contact email: marta.fernandezde@estudiante.uam.es

Abstract: This work proposes the objective of eliminating sensitive information in the decision-making processes of deep learning algorithms. For this, a new agnostic representation of the characteristic vectors of neural networks is proposed, making difficult for networks to classify protected groups. A growing emergence of studies demonstrates the existence of a high risk of discriminatory effects produced by current algorithms. This situation has led to the emergence of laws that oblige us to eliminate the possibility of any kind of algorithmic discrimination. Therefore, this work is motivated to create a new model capable of meeting the algorithmic needs necessary today.

A method based on the generalization of triplet loss is proposed, which not only optimizes the verification performance, but also has a process for removing bias. More specifically, the project focuses on the elimination of ethnicity and gender information. The model is evaluated using the most cutting-edge algorithms and the use of databases publicly available. In addition, a new database of balanced data with 2 and 3 classes of gender and ethnicity respectively has been generated, which has significantly facilitated the tasks of eliminating bias. The dataset has more than 20K identities that result in more than 100K images. All of them show varieties of pose, quality, lighting, among others. The results of the experimentation have demonstrated the possibility of reducing a large amount of sensitive information while maintaining high verification performance.

JAVIER GISMERO – DYNAMIC HANDWRITING RECOGNITION

Full Title: Adquisicion y analisis de informacion manuscrita en entornos moviles - Acquisition and analysis of handwritten information in mobile environments.
Institution: Universidad Autonoma de Madrid – BiDA Lab
Supervisor: Ruben Tolosana / Julian Fierrez
URL: https://repositorio.uam.es/handle/10486/688898
Contact email: javier.gismero@estudiante.uam.es

Abstract: The Final Degree Project is part of the biometric recognition of dynamic handwriting through the use of mobile devices. Today, the secure methods used in mobile devices have many weaknesses. In order to make these systems more robust, it is proposed to draw the passwords instead of typing them. In this way you can analyze the biometric information of the user's handwriting and have two stages of authentication.

This work arises from the good results obtained with the database e-BioDigit made by the group BiDA Lab, where it was demonstrated the potential of this new method. However, their work is very limited because only numbers, a single capture device, 2 capture sessions and a supervised environment were used in the study.

A new database called MobileTouchDB, composed of more than 200 users in 94 different mobile devices, has been designed and captured in this Final Degree Project. This database has biometric writing information in mobile environments. Users had to draw more than 70 characters and different symbols over 6 temporarily spaced sessions. Once the database has been acquired, it has been preprocessed in order to eliminate errors. In addition, the data have been analyzed with the DTW algorithm to understand how efficient and robust is the work proposed in comparison with the state of the art.

Finally, the conclusions reached throughout this work are presented, as well as the possibilities offered for new approaches to future work.

CARLOS GONZALEZ – MOBILE SIGNATURE VERIFICATION

Full Title: Adaptacion de sistemas de verificacion de firma manuscrita a dispositivos moviles - Adaptation of handwritten signature verification systems to mobile devices

Institution: Universidad Autonoma de Madrid – BiDA Lab

Supervisor: Ruben Vera-Rodriguez

URL: https://repositorio.uam.es/handle/10486/688953

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Abstract: In this Final Degree Project, a study is carried out to adapt handwriting verification systems to mobile devices. To do this, first of all, a study of the existing technologies is made. These technologies have given good results on signatures captured using a pen stylus as a writing tool. After this, similar experiments to the existing ones have been developed, but specifically adapted to the special characteristics of signatures introduced with the finger.

With the results obtained, a second study has been carried out whose objective is to identify the differences between signatures captured using a pen stylus or the finger as writing input tools, so that it is possible to develop a robust system that can work in both cases. Due to differences between both cases are remarkable, the proposed solution is a hybrid system which takes in account both scenarios.

Secondly, in this project has also been carried out a refinement of the existing experimental protocols, avoiding situations of overfitting at training. Previous studies have been made without this consideration. This means that the performance of the system is reduced and generalization to bigger date becomes more difficult.

For the experiments carried out, the main existing databases of signatures introduced with the finger have been used, reaching the conclusion that the most limiting factor for the development of this technology is the small amount of data available, which avoids the maximum exploitation of the performance provided by algorithms such as SFFS that require a large amount of data.

Finally, once the conclusions have been drawn, a series of topics have been proposed for future work.

VLADISLAV HALVA – RECONSTRUCTING FINGERPRINT IMAGES

Full Title: Reconstruction of Damaged Parts of Fingerprint Image
Institution: Brno University of Technology
Supervisor: Ondřej Kanich
URL: https://www.fit.vut.cz/study/thesis/21983/.en
Contact email: kanich@fit.vutbr.cz

Abstract: This bachelor thesis deals with the reconstruction of damaged fingerprint areas. The main goal is the design and implementation of an algorithm for the reconstruction of these regions. The designed algorithm consists of three main parts. The first part is fingerprint feature extraction and their derivation in damaged areas. The second part is a localization of damaged areas, which is based mainly on the structure of papillary lines. The last part is the damaged areas reconstruction itself. Gabor filter is used in this part of the process. The algorithm is implemented in C++ using the OpenCV library. An analysis of the reconstruction success rate is done afterwards. It is at first evaluated using the difference of quality between the input and processed fingerprint image, estimated by NIST NFIQ 2.0 and one other alternative tool for fingerprint image quality evaluation. The next step is a manual evaluation of the reconstruction success rate in various types of damaged areas.

TEREZA HYTYCHOVÁ – GENERATING SKIN DISEASE FINGERPRINT IMAGES

Full Title: Generation of Skin Disease Effects into Synthetic Fingerprints from Anguli Generator
Institution: Brno University of Technology
Supervisor: Ondřej Kanich
URL: https://www.fit.vut.cz/study/thesis/21981/.en
Contact email: kanich@fit.vutbr.cz
Abstract: The aim of this bachelor thesis is to design and implement a tool for generation of skin disease effects into synthetic fingerprints from Anguli generator. The proposed algorithms are capable of creating images with effects of warts and hyperkeratotic eczema. The OpenCV library was used for image processing. The resulting images are tested by VeriFinger and can be used for testing fingerprint recognition systems. Test results proved that both of the diseases have negative impact on fingerprint recognition. By adding effects of warts to a fingerprint image, the image quality has decreased by up to 34 % and by adding effects of hypekeratotic eczema, the quality has decreased by up to 77 %.

DOMINIK KOSÍK – GATEWAY TO IDENTIFY PEOPLE

Full Title: Multicameras Biometric Gateway to Identify People
Institution: Brno University of Technology
Supervisor: Tomáš Goldmann
URL: https://www.fit.vut.cz/study/thesis/21545/.en
Contact email: igoldmann@fit.vutbr.cz
Abstract: This thesis is about creating biometric gate to identify people. The Identification is achieved with 5 RGB cameras and one thermal camera. Thermal camera is used for detection of person. Then, from images acquired from RGB cameras, is created 3D model of photographed person. This model is then used for the identification. However due to inaccuracies in created model, identification isn't precise enough. Because of that, it's necessary to modify used algorithms processing 3D model, so better precision is achieved.

VOJTĚCH KOZEL – BLOODSTREAM IN RETINA IMAGES

Full Title: Reconstruction of Extracted Bloodstream in Images of Retinas
Institution: Brno University of Technology
Supervisor: Lukáš Semerád
URL: https://www.fit.vut.cz/study/thesis/21546/.en
Contact email: lsemerad@fit.vutbr.cz
Abstract: Retinal bloodstream plays a significant role in many specializations. In medicine, retinal images are used for automatic disease diagnosis. The blood vessel tree is unique for each individual, and as such this feature is often used in biometric systems for person-recognition. Healthy individuals possess consistent retinas throughout their life, however, there are many reasons why retinal changes may occur. The most common reason for physical changes is disease. In such cases problems arise in automated processing of retina images. These problems may also lie with retinal scans errors or blood vessel extraction algorithm error. This thesis describes reasons why segmented blood vessels are interrupted. Main goal of this thesis is to create a program which can automatically locate interrupted vessel segments and reconstruct them. The program is implemented in Java with OpenCV library.

DOMINIK KRIŽKA - EXTRACTION OF FACE COVERED BY A MASK

Full Title: Extraction of Face Covered by a Mask
Institution: Brno University of Technology
Supervisor: Martin Drahanský
URL: https://www.fit.vut.cz/study/thesis/22085/.en
Contact email: drahan@fit.vutbr.cz

Abstract: The bachelor thesis focuses on numerous techniques of extraction of a face covered by a mask, with assistance of the terahertz and infrared radiation. In order to resolve the issue, a database with photos of twelve people was created with various levels of face cover. The face extraction is then attempted with three techniques. First method uses ORB and SIFT descriptors on the face recognition. Descriptors were unable to successfully extract the masked face. The second technique is utilizes a facial landmark predictor. During the recognition of an unmasked face, the predictor is able to correctly represent regions of the face. With increased levels of coverage on face, it gets progressively more difficult to find facial landmarks correctly and inaccuracies occur. The last approach encodes the faces to numeric format and compares them between each other. The success rate of the extraction depends primarily on the quality of the model, which was trained on the neural network principle. The main contribution of the bachelor thesis, lies in the carried out experiments. In some cases of experiments, the identity of faces covered by scarf or balaclava were successfully revealed with usage of the infrared radiation and face encoding technique.

GUSTAVO MANZANO – STATIC SIGNATURE VERIFICATION

Full Title: Verificacion de firma manuscrita estatica mediante redes neuronales convolucionales - Verification of static handwritten signature using convolutional neural networks
Institution: Universidad Autonoma de Madrid – BiDA Lab
Supervisor: Ruben Vera-Rodriguez
URL: https://repositorio.uam.es/handle/10486/689034
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Abstract: In this work, a biometric recognition system of synthetic online signatures is studied, developed and evaluated thanks to Convolutional Neural Networks. At first, there is a study of the state of the art in biometric recognition, with special emphasis on systems based on CNNs.

Once understood the most theoretical part of the system, it is explained in detail how is implemented. It extracts useful characteristics of the images through a Neuronal Convolutional Network. The CNN is trained with a large database of oˑ-line synthetic signatures. Then, using a writer-dependent classifier SVM (Support Vector Machines) a hyperplane is created, capable of separating the characteristics extracted before for each user. Thereby, able to verify and identify the user. The Convolutional Neural Network creates a unique model that allows the system to generalize to different databases, improving the results of the state of the art analyzed for original online signatures.

The extraction of the oˑ-line signature from the on-line has been investigated in depth since it has a vital importance for the good behavior of the system, performing changes in the signature's parameters such as pixel size, pressure, pen-ups, etc. At the same time, it has been explored how can affect to vary the number of positive and negative samples in the training phase of the classifiers. Therefore, showing how crucial certain parameters are for the proper operation of the system.

The experimental part is carried out in two parts. First, comparing with the state of art of online signature to be able to extract the synthetic signature the best way possible. And second, using a database of great extension to train a model capable of generalizing to different databases.

Finally, it is shown the conclusions extracted, as well as the possible implementations and the lines of work that can be carried out in order to improve and perfect the system in the future.

BERTA FERNANDEZ DE LA MORENA – BIAS AND ALGORITHMIC FAIRNESS

Full Title: Discriminacion Algoritmica: Estudio del sesgo en arquitecturas de aprendizaje profundo - Algorithmic Discrimination: Study of bias in deep learning architectures
Institution: Universidad Autonoma de Madrid – BiDA Lab
Supervisor: Aythami Morales / Julian Fierrez
URL: https://repositorio.uam.es/handle/10486/689056
Contact email: berta.fernandezdela@estudiante.uam.es

Abstract: Today, technology is more present in our daily life. It is not surprising, that technologies such as biometrics are growing at a high speed. Biometrics cover a large number of areas such as voice recognition, fingerprint recognition and facial recognition.

In this work, we made a depth study about facial recognition technologies, in particular, we studied the bias or human prejudices that these algorithms may present in their results. Facial recognition systems are being used more and more frequently in automated decision making. The fact of not being able to have characteristics and varied information and to generalize the data to train the models can result in a biased model, and as a consequence, in the unfair decision making that would directly impact the users.

The main aim of this study is focused on the performance achieved over different demographic groups. We also propose a general formulation of algorithmic discrimination with application to face biometrics. The experiments are conducted over the new database generated, DiveFace, composed of 24K identities of six different demographic groups.

Two popular face recognition models are considered in the experimental framework: ResNet-50 and VGG Face. We experimentally show strong algorithmic discrimination over the under-represented groups in the most popular facial image databases. This discrimination can be observed quantitatively in large performance differences when applying these models over different demographic groups.

MIGUEL LOPEZ – MOBILE HANDWRITING AUTHENTICATION

Full Title: Incorporacion de información manuscrita en sistemas de autenticación basados en contraseñas: análisis y diseño en escenarios móviles - Incorporation of handwritten information in password-based authentication systems: analysis and design in mobile scenarios.
Institution: Universidad Autonoma de Madrid – BiDA Lab
Supervisor: Ruben Tolosana
Contact email: miguel.lopezr@estudiante.uam.es

Abstract: The use of mobile devices has greatly increased in the past few years. Despite that, a vast majority of applications still use password-based authentication systems, with the problems they suppose. The alternative to these systems are two-factor authentication systems.

In this project the two necessary modules for this kind of systems are implemented along with a demo app to test them. These modules are an Optical Character Recognition (OCR) (responsible of recognizing the input password), and a system able to distinguish between users through biometric information (in particular, the one extracted from the stroke used to draw the password). In addition, the results previously obtained for biometric systems based on the databases used for this project are expected to be improved. Neural networks are used for both the development of the OCR and the biometric system. In the case of the biometric system, the algorithms Dynamic Time Warping (DTW) and Sliding Window DTW (SW-DTW) are also used. In this project a new approach is proposed: to combine the mentioned algorithms with neural networks. An analysis at a character level has been done in order to compare the different designed systems. After that, two more analysis are conducted for the best-performing system achieved in the individual analysis (which is the combination of neural networks with SW-DTW). They consist in an analysis at a password level and an analysis of how time affect the performance of the system. From this last one, it is concluded that the user trains itself as time passes. For the password-level analysis, a relative improvement of a 55.66% with respect to the systems analyzed on the state of the art is achieved.

These results open the doors for future works based on the new approach, which is named Time-Aligned Bidirectional Long Short-Term Memory (TA-BLSTM). Finally, an app for Android devices, which uses both modules, is developed. In it, multiple functionalities are implemented, standing out among them the two-factor authentication system.

BIANCA PALACKOVÁ - RETINAL IMAGES WITH PATHOLOGICAL FINDINGS

Full Title: Comparison of Retinal Images with Pathological Findings
Institution: Brno University of Technology
Supervisor: Martin Drahanský
URL: https://www.fit.vut.cz/study/thesis/22084/.en
Contact email: drahan@fit.vutbr.cz

Abstract: The goal of this thesis is to design and implement software for comparison of retinal images with pathological findings. The most common diseases affecting the retina are diabetic retinopathy and age related macular degeneration. Detection of main components such as optic disc and fovea, need to be detected for proper comparison and detection of diseases. 570 images was used for evaluation of detection of these main components. In both cases, algorithm achieved success over 90%. 120 images were analyzed by 3 ophthalmologists for evaluation of ability to locate pathological findings. Automatic comparison of retinal images can be useful for determination of disease progression.

LUKÁŠ RYBNIKÁR – DETERMINE HEAD ROTATION

Full Title: Determine the head rotation in the image by a neural network
Institution: Brno University of Technology
Supervisor: Filip Orság
URL: https://www.fit.vut.cz/study/thesis/22146/.en
Contact email: orsag@fit.vutbr.cz
Abstract: Artificial neural networks are not a novelty, but their recent rise in popularity is noticeable as well as their gain of attention from the masses. This bachelor thesis focuses on the head pose estimation in an image using the convolution neural networks. The fields of use of neural networks are vast and during last years strong enough hardware has been developed to allow us to train these networks under commonly accessible conditions. In theoretical part there are neural networks introduced with an explanation of what they are, how they work, how they are divided followed by a detailed description of convolutional neural networks. In the practical part the necessary tools used for development needed to perform experiments, such as determining appropriate configuration for neural network and optimization to get the best results possible, are described.

IVANA STANČÍKOVÁ - DISEASE IMPACTS TO EYE RETINA

Full Title: Detection and Recognition of ARMD Disease Impacts to the Human Eye Retina
Institution: Brno University of Technology
Supervisor: Martin Drahanský
URL: https://www.fit.vut.cz/study/thesis/21284/.en
Contact email: drahan@fit.vutbr.cz

Abstract: This thesis aims to create a software able to detect symptoms of age-related macular degeneration in images of human eye retina. This condition is considered one of the leading causes of vision loss in older adults. Lesions of the macular area called druses are the first and also the most distinctive sign of developing ARMD. The approach presented in this thesis utilizes methods of image processing and computer vision to recognize retinal structures, in particular the optical disk and blood vessels, and distinguish between these structures and actual symptoms of the disease. The evaluation of the program's success rate was performed on 692 images originating from four databases. The resulting solution has the potential to assist medical professionals with earlier diagnosis of the disease and thus contribute to prevention of severe vision loss.

VERONIKA SVORADOVÁ – SYNTHETIC FINGERPRINT IMAGES WITH DISEASES

Full Title: Generation of Skin Diseases into the Synthetic Fingerprints Using SFinGe
Institution: Brno University of Technology
Supervisor: Martin Drahansky
URL: https://www.fit.vut.cz/study/thesis/21893/.en
Contact email: drahan@fit.vutbr.cz

Abstract: The bachelor thesis deals with the design and implementation of an algorithm that generates skin diseases into a synthetic fingerprint. Generated objects help to create the main features of skin diseases into fingerprints which are designed by the SFinGe generator. Selected skin diseases are atopic eczema and dishydrosis.

TEREZA SÝKOROVÁ – DETECTING DIABETES FROM RETINA

Full Title: Detection of Diseases of Diabetes on the Human Eye Retina
Institution: Brno University of Technology
Supervisor: Martin Drahansky
URL: https://www.fit.vut.cz/study/thesis/22083/.en
Contact email: drahan@fit.vutbr.cz

Abstract: This bachelor's thesis deals with the detection of the symptoms of diabetic retinopathy at retinal images taken by a digital fundus camera. Optic disc, fovea, and blood vessels are found before searching for exudates and hemorrhages. This step improves final detection. The detector uses morphological reconstruction of a candidate region for determination of specific lesions. An algorithm based on thresholding precises its edges. Found regions are classified according to shape and color. Evaluation of detection was done using 120 images selected from three databases. Adding automatic detection of signs of diabetic retinopathy into equipment for retinal screening can help medical doctors in diagnosis and prevent possible vision loss which the disease can cause.

THAO TRAN / NATHALIE TKAUC – FR AND SR FOR ACCESS CONTROL

Full Title: Face recognition and speech recognition for access control
Institution: Halmstad University
Supervisor: Kevin Hernandez Diaz
URL: http://urn.kb.se/resolve?urn=urn:nbn:se:hh:diva-39776
Contact email: kevin.hernandez-diaz@hh.se

Abstract: This project is a collaboration with the company JayWay in Halmstad. In order to enter the office today, a tag-key is needed for the employees and a doorbell for the guests. If someone rings the doorbell, someone on the inside has to open the door manually which is considered as a disturbance during work time. The purpose with the project is to minimize the disturbances in the office. The goal with the project is to develop a system that uses face recognition and speech-to-text to control the lock system for the entrance door.

The components used for the project are two Raspberry Pi's, a 7 inch LCD-touch display, a Raspberry Pi Camera Module V2, a external sound card, a microphone and speaker. The whole project was written in Python and the platform used was Amazon Web Services (AWS)for storage and the face recognition while speech-to-text was provided by Google. The system is divided in three functions for employees, guests and deliveries. The employee function has two authentication steps, the face recognition and a random generated code that needs to be confirmed to avoid biometric spoofing. The guest function includes the speech-to-text service to state an employee's name that the guest wants to meet and the employee is then notified. The delivery function informs the specific persons in the office that are responsible for the deliveries by sending a notification. The test proves that the system will always match with the right person when using the face recognition. It also shows what the threshold for the face recognition can be set to, to make sure that only authorized people enters the office. Using the two steps authentication, the face recognition and the code makes the system secure and protects the system against spoofing. One downside is that it is an extra step that takes time. The speech-to-text is set to Swedish and works quite well for Swedish-speaking persons. However, for a multicultural company it can be hard to use the speech-to-text service. It can also be hard for the service to listen and translate if there is a lot of background noise or if several people speak at the same time.

NEMANJA VASILJEVIĆ – PARTIAL FINGERPRINT DETECTION

Full Title: Partial Fingerprint Detection Using Blob Detection Algorithm
Institution: Brno University of Technology
Supervisor: Mona Heidari
URL: https://www.fit.vut.cz/study/thesis/22498/.en
Contact email: ihediari@fit.vutbr.cz
Abstract: This bachelor thesis discusses detection and localization of skin diseases in damaged fingerprint images and describes the solution implemented using image processing techniques.

ŽOFIA VRÁBĽOVÁ – GENERATING SPOOF EFFECTS FINGERPRINT IMAGES

Full Title: Generation of Spoof Effects into Synthetic Fingerprints from SFinGe Generator
Institution: Brno University of Technology
Supervisor: Ondřej Kanich
URL: https://www.fit.vut.cz/study/thesis/21981/.en
Contact email: kanich@fit.vutbr.cz

Abstract: The goal of this thesis is to create application to generate spoof effects into synthetic fingerprints from the SFinGe generator. Spoof effects chosen for this thesis are air bubbles, unnatural overall shape and clear external contours of fingerprint. Those effects were analyzed, methods to generate these effects were designed and then implemented. According to testing, generation of implemented methods led to reduction in quality of fingerprint images. Score gained in a commercial tool decreased by 49.37 % in average and image quality evaluated by the method designed in Ing. Oravec's thesis decreased by 6.18 % in average, when the combination of all implemented spoof effects was generated.

RADEK WILDMANN – GENERATING SKIN DISEASE FINGERPRINT IMAGES

Full Title: Generation of Skin Disease Effects into Synthetic Fingerprints from SFinGe Generator
Institution: Brno University of Technology
Supervisor: Ondřej Kanich
URL: https://www.fit.vut.cz/study/thesis/21981/.en
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Abstract: This thesis discuss the topic of generation of skin disease effects, psoriasis and colagenosis into synthetic fingerprints from SFinGe generator. Thesis includes theoretical as well as practical approach of the topic including implementation design, program implementation and experiment results. SFinGe approach is used to generate fingerprints. Python (2.7.6) is used to implement algorithm for image processing and generating disease symptoms withOpenCV, Matplotlib, NumPy and SciPy libraries. For results evaluation, NFIQ standard and Oravec approach are used. The application is able to generate fingerprint image with symptoms of psoriasis or colagenosis, therefore it can be used for further research with biometric systems.

PETR ZUBALÍK – RECONSTRUCTING FACIAL IMAGES

Full Title: Reconstruction of Facial Images Using Neural Networks
Institution: Brno University of Technology
Supervisor: Tomáš Goldmann
URL: https://www.fit.vut.cz/study/thesis/21391/.en
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Abstract: The main purpose of this bachelor's thesis is to propose and implement a model, using neural networks, that will be able to reconstruct low-resolution facial images with blurry parts of the face. The task of super-resolution of facial images is solved by two models based on convolutional neural networks. The first model is built upon the architecture of ResNet whereas the other model makes use of the principles of generative adversarial networks. The proposed models are implemented in the Python programming language with the use of application programming interface of the TensorFlow framework. Moreover, as a part of this work, an application with a simple graphical user interface was created. This application makes it easy to use the implemented models. Several experiments are analyzed in the last chapter of this thesis to evaluate the performance of the models.