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IEEE Biometrics Council Newsletter

CONTENTS

IEEE

IEEE Biometrics Council

EIC's Corner

Dear readers,

We hope you had a restful vacation. Welcome back!

In the section devoted to news and Council activities you will find an important call for applications: we are searching for the new EiC for this publication. In the same section we welcome the new representatives of two Societies participating in the Biometrics Council and announce a new Chapter of the Council. Finally, you can find information about the new edition of the "Handbook of Fingerprint Recognition" by Maltoni, Maio, Jain, and Feng.

The spotlight focuses once more on ethical and sustainable use of biometrics, which is an active field for lawmakers worldwide.

For this issue, the interview is with Imad Malhas. He co-founded Irisguard in 2001, one of the most known stakeholders for the end-to-end iris recognition biometric technology.

A recent issue of IEEE Transactions on Biometrics, Behavior, and Identity Science is the venue of the paper whose summary is presented. The paper title is "GAN-based Inter-Class Sample Generation for Contrastive Learning of Vein Image Representations" and the tackled problem is vein recognition.

The emerging researcher that accepted to give us an interview is Joshua J. Engelsma. Notwithstanding his young age, he already achieved remarkable results in biometric research.

The dataset that we present in this issue is NUPT-FPV, which is built by collecting two modalities, the fingerprint and finger vein images. It has been introduced in the paper "A Dataset and Benchmark for Multimodal Biometric Recognition Based on Fingerprint and Finger Vein" published in IEEE Transactions on Information Forensics and Security. It is freely accessible for research.

In the section devoted to open source software, we describe and provide reference for the publicly available repositories of CosFace, ArcFace, and SCF.

COTS section deals with everyday use of biometrics, that is becoming ubiquitous and offers many useful services available from one's personal devices too.

More and more sensors are embedded into our personal devices. The section about germinal methods deals with the possible biometric authentication using smartphone fingertip photoplethysmography signals.

The final section is devoted, as usual, to active call for papers and for participation. It is worth reminding that these calls are also posted on a regular basis on our social channels.

We hope you will enjoy reading. Please remember that we are always glad to receive comments and suggestions.

All the best

Maria

News and Council Activities

This section starts with an important call for applications.

Call for Applications and Nominations for the 'Editor-in-Chief' of IEEE Biometrics Council Newsletter

The IEEE Biometrics Council Newsletter is published as a quarterly archival and was started in 2011. We are currently seeking nominations and applications for the position of the Editor-in-Chief (EiC) of the IEEE Biometrics Council Newsletter for the publication years, 2023 and 2024.

The applicants must be an IEEE member and have strong, relevant experience in roles such as author, reviewer, and area/associate editor for biometrics related publications/journals, and/or a technical program chair or similar roles in high quality conferences. The key qualities of the Editor-in-Chief are an outstanding understanding of the needs of the community in academics as well as industrial and government organizations, awareness of changing emphases in research areas and development of emerging fields, plus the administrative skills to manage the editorial cycle in a timely fashion. The EiC must also be able to attract respected experts to his/her editorial board. The EiC must have good interpersonal skills to maintain good rapport with authors, editors, contributors and be able to seek financial support for publication activities.

Applications or nominations must include an application/nomination letter, a full complete curriculum vita (CV), a personal statement summarizing their vision and plans for the IEEE Biometrics Council Newsletter.

The last date to receive nominations is October 30th, 2022. The start date for the new IEEE Biometrics Council Newsletter Chief Editor is January 1, 2023.

We continue by welcoming the new representatives of Societies participating in the Biometrics Council and announcing a new Chapter of the Council.

Upload the submission by scanning the QR code or click the link below:

https://tinyurl.com/4b9pymza

IEEE Biometrics Council Webinars

The IEEE Biometrics Council through its Webinar Committee, chaired by **Ioannis A. Kakadiaris**, organizes bi-monthly webinars to promote important topics related to biometrics and share updates on the activities of the Council, the state of the IEEE Transactions on Biometrics, Identity and Behavior (TBIOM), upcoming calls and awards as well as other topics of interest to the community.Attendance at the webinars is free, but prior registration is required.

The title of the next seminar is "Combatting Deep Fakes" (you can find the flyer here, held online (ZOOM platform) on 12 October 2022, at 10 am PT (1 pm EST, 7pm CEST). The speaker is **Hany Farid** from University of California, Berkeley, USA. The attendance is free but registration is required you can do it here.

New Representatives of RAS and of SMC in the IEEE Biometrics Council

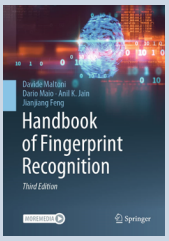
The President of IEEE Robotics and Automation Society Frank Park has nominated Tapomayukh Bhattacharjee_as a new representative for the IEEE Biometrics Council. Tapomayukh Bhattacharjee is currently with Cornell University (USA) and will serve as the Advisory Committee member for the IEEE Biometrics Council for the next 2 years (2022-2024).

The President of IEEE Systems, Man and Cybernetics Society Sam Kwong has nominated Wing W. Y. Ng as a new representative for the IEEE Biometrics Council. Wing Ng is currently with South China University of Technology (Guangzhou, China) and will serve on the Advisory Committee of IEEE Biometrics Council for the next 2 years (2022-2024).

New Chapter of the IEEE Biometrics Council

The Council announces the formation of 1st IEEE Biometrics Council Chapter in Region 10, India. It is the Madhya Pradesh Section Chapter chaired by Dr. Vivek Kanhangad, Assistant Professor at IIT Indore.

New Edition of Handbook of Fingerprint Recognition



Finally, for those who were waiting for the new edition of this basic book, here are the information about the new “Handbook of Fingerprint Recognition” by Maltoni, Maio, Jain, and Feng.

A new edition of the Handbook of Fingerprint Recognition has just been published by Springer Nature (**July 2022**).

Authors: D. Maltoni, D. Maio, A.K. Jain. J. Feng

https://link.springer.com/book/10.1007/978-3-030-83624-

With their distinctiveness and stability over time, fingerprints continue to be the most widely used anatomical characteristic in systems that automatically recognize a person's identity. This fully updated third edition provides in-depth coverage of the state-of-the-art in fingerprint recognition readers, feature extraction, and matching algorithms and applications. Deep learning (resurgence beginning around 2012) has been a game changer for artificial intelligence and, in particular, computer vision and biometrics. Performance improvements (both recognition accuracy and speed) for most biometric modalities can be attributed to the use of deep neural networks along with availability of large training sets and powerful hardware. Fingerprint recognition has also been approached by deep learning, resulting in effective and efficient methods for automated recognition and for learning robust fixed-length representations. However, the tiny ridge details in fingerprints known as minutiae are still competitive with the powerful representations learned by huge neural networks trained on big data.

Features & Benefits:

- Reflects the progress made in automated techniques for fingerprint recognition over the past five decades
- Reviews the evolution of sensing technology: from bulky optical devices to in-display readers in smartphones
- Dedicates an entire new chapter to latent fingerprint recognition, which is nowadays feasible in “lights-out” mode
- Introduces classical and learning-based techniques for local orientation extraction, enhancement, and minutiae detection
- Provides an updated review of presentation-attack-detection techniques and their performance evaluation
- Discusses the evolution of minutiae matching from rich local descriptors to Minutiae Cylinder Code
- Presents the development of feature-based matching: from FingerCode to handcrafted textural features to deep features
- Reviews fingerprint synthesis, including recent Generative Adversarial Networks

Spotlight

Regulating Commercial Use of Biometric Data

Due to an increase in the ability of companies to collect and use biometric data, lawmakers worldwide are scrutinizing legal risks and enacting targeted laws to protect biometric data privacy [1]. The Massachusetts Attorney General reached a settlement with Copley Advertising Inc. about no longer using geofencing (a mobile user's location information) for advertising reproductive care locations [2]. The Federal Trade Commission recently entered a settlement agreement with Flo Health, which was allegedly sharing sensitive health information of women with other organizations such as Google and Facebook [3]. While such offenses have occurred in the past, the overturning of Roe v. Wade has brought these issues under a new lens and has made the FTC even more alert. There are other class action lawsuits concerning the privacy of sensitive and personal information that can be linked to the identity of a user [4]. OpenX will pay 2 million USD to the FTC in settlement for collecting location data of children without parental consent [5]. The commission is also investigating the presence of face images from OkCupid, a dating site, in the training data used by Clarifai [6]. Earlier this year, the Texas Attorney General filed a lawsuit against Facebook (now Meta) for allegedly capturing, storing, and releasing biometric information without obtaining informed consent [7].

As more markets employ biometric technology [8], strengthening privacy laws is becoming a priority. On top of enforcing the GDPR, Europe is witnessing the proposal of new bills, guidelines, and updates [9]. A recent report by the Ada Lovelace Institute in the UK suggests the need for a new Biometric-specific law to create a level playing field for industry players [10]. Lawmakers are looking at different aspects and sources of data abuse and violation, not just specific economic sectors. In light of the approval of the Federal Data Privacy Bill in late July by the House Energy and Commerce Committee, the House Judiciary Committee aims to reinforce the prohibition of conducting surveillance without court-approved warrants. This prohibition may have been bypassed earlier by some government agencies, who could obtain the required data from commercial brokers [11]. In China, officials are going beyond data. They are also looking into specific algorithms that are being used by tech giants such as Alibaba Group, ByteDance, and others in an effort to curb data abuse [12].

While all of the above are seemingly steps in the right direction to ensure user privacy, there are other litigation outcomes where the sentiments differ The Indian Government is restarting on this topic by abandoning the personal data protection bill, reducing optimism and igniting concerns [13]. The US and UK plan to sign a data access agreement in October, which allows them to exchange data that will help them solve serious crimes. While the statement clarified maintaining democratic and civil liberties, the exact form of usage of personal data needs to be fleshed out [9]. However, suppose that one does intend to collect, store or use biometric and other personal data. In that case, there are steps they can take to remain compliant, including understanding the need for biometric in their business and knowing these regulations [14]. Avoiding violations can help the ethical and sustainable development of technology that meets consumer expectations.

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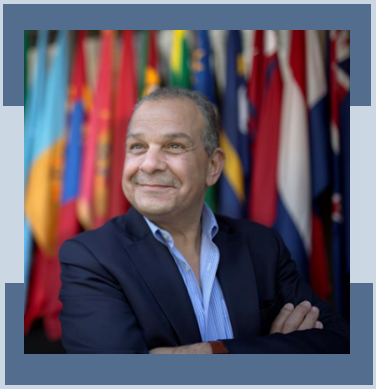
Expert Interview

Imad Malhas co-founded Irisguard in 2001, an electronic payment solutions company and the leading supplier of end-to-end iris recognition biometric technology. Imad pioneered the concept of using iris recognition technology to secure mass-transit national borders and a large-scale cross-country registration of millions of currently over 2.8m UNHCR refugees in the Middle East. In 2009, Imad led Irisguard's deployment of the world's first iris-enabled ATM machines, providing a dignified way for beneficiaries to collect their cash assistance. In 2013, Imad spearheaded the development of the irisguard EyePay® platform, the world's first and only iris-enabled retail POS that is currently used by the UN's World Food Programme in several supermarkets in refugee camps across MEA. Later, Imad has successfully led the effort to develop Irisguard'sEyePay® Phone, the world's iris enabled mobile phone able to transact with millions of beneficiaries using mobile wallets. Imad's leadership and direction has taken the business from a biometrics technology company to a full-service payment solution. This system has faultlessly processed over 25.2m transactions, $2.3bn aid value and soon to be serving 12m beneficiaries across 5 countries. The positive impact of the company technology was recognised on the world stage by the GSMA in 2021 by winning theGLOMO Award. He is the co-inventor on many international patents, an Endeavour Entrepreneur since 2009 and was awarded CEO Today Europe Award in 2018.



Imad Malhas
CEO and Founder
Irisguard UK Ltd

What motivation was behind the creation of IrisGuard and which challenges did you face considering the maturity level of iris recognition technology back in 2001?

The initial motivation for the creation of IrisGuard was the situation in Saudi Arabia related to Haji, where every year, millions of people travel to Saudi Arabic to perform the Muslim Hajj (pilgrimage) from countries around the world. Some of those try and stay in Saudi without the appropriate legal paperwork as they try to seek a better life within the Saudi Arabia's communities, destroying their passports in the process.

Registering those arriving pilgrims using a biometric measure would have been the best solution to ensure that their identities can be verified without the need for any other documentation. However, this project never materialized and instead, we tackled a similar requirement in the UAE, where there was a need to identify deported convicted foreign nationals who were using fake passports.

At that time, iris recognition was at its infancy and we were pioneers attempting something that had not been accomplished before. There simply wasn't enough real-world data to support the accuracy claims the maths was suggesting and there wasn't any already built platforms available that we could use, so we had to build everything from the ground up.

We deployed systems across the UAE without having proof that the algorithms and the underlying assumptions would hold true, in a country that had 195 nationalities (90% of the UAE population consists of foreigner nationals) and our concern was that iris records from different ethnic backgrounds would not adhere to the theoretical principles we were depending upon. In addition to that, there were only a few iris camera systems, which were analogue - based. It was the driving force behind the design and manufacture of our own iris scanners to deliver the best quality images in the world and to produce a platform that was fit-for-purpose. We knew then that a biometric device designed for door-access for example would never be suitable to be installed on an ATM. Fast forward almost 20 years and we designed a mobile Android device with dual iris cameras (front and back) to allow for effective mobile-based iris solutions. This invention was recognized by the GSMA in 2021 and awarded GLOMO Award for Best Mobile Innovation Supporting Emergency or Humanitarian Situations for "Covid-safe mobile iris payment solution, enabling uninterrupted access to aid for millions".

Back then, challenges like countermeasures and pupil dilation attempts using dilation eye drops were yet to be discovered and addressed by IrisGuard. Issues such as focus assessment, motion blur, off-axis gaze, corneal reflections, iris illumination for different pigmentation, effects of cataract, laser and trachoma surgeries on the iris, iris stability over age and dozens of other challenges when it comes to iris recognition, were entirely unknown with no established standards. IrisGuard played a crucial role in the development of the technology to address these issues resulting in 9 unique patents. We also worked with number of academic / industry bodies establishing industry standards for both the hardware and algorithms, which are still adhered to today.

Very early on, we understood that the requirements for ID management of mass populations in extremely challenging circumstances would require a complete end-to-end offering. It was our engineering approach to iris recognition, the creation of a complex yet robust data architecture in the back end, combined with state-of-the art devices would ensure our success and maintain our leadership in this space, two decades on.

In 2005, five years after launching the UAE project (Summer of 2000), we saw the issue of the United Arab Emirates iris study: 'Results from 200 billion iris cross-comparisons' with Cambridge University proving that iris recognition was the most accurate form of biometrics vs other biometrics and crucially, the data set used in the study came from UAE Government database containing 625,000 iris templates. The study put iris recognition on the map. Further information was produced in a paper by John Daugman in November 2006 'Probing the Uniqueness and Randomness of IrisCodes: Results From 200 Billion Iris Pair Comparisons'.

Considering the number of users enrolled in IrisGuard how is the privacy of the data ensured and is this valuable information stored in a decentralized manner?

Since its inception, IrisGuard made a decision not to own, store, or have access to or process iris records.

The ownership is always fully entrusted with the party that is responsible for the registration of the individuals' iris records. Be it a national Government, United Nations agency, health corporation or central financial institution and we have maintained this policy until today. This was achieved by providing our customers with their own centralized back-end software, front-end hardware and APIs. We also introduced, early on, the concept of permutation where the iris of the same person is not compatible between different deployments, which provided a level of protection for individual templates. Finally in 2022, we have introduced EyeQR® technology that allows the identity of a person to be decentralized in the form of a special QR code encrypted using the person's own iris, which does not require a central database or an internet connection for verification.

Recently, EyePay Phone has been certified as Level 1 of ISO 30107-3 Presentation Attack Detection (one of only two devices in the world to complete and pass such independent level testing). Is this result a consequence of the work of the R&D department? How many persons work in this department and what are the major topics of research that IrisGuard is focused on?

PAD level 1 was achieved as a direct result of our own R&D. A team of five people worked for 9 months to achieve a robust PAD detection for the EyePay® Phone. Keep in mind that we had previously achieved similar results using hardware illumination (patented to IrisGuard) on all our Windows-based iris camera systems.

Our R&D is a continuous process, and we take on challenges like the ones mentioned above, which require innovative hardware and/or software solutions.

What's the relation of IrisGuard with academic research community of iris recognition? Does the company usually build bridges with academic institutions for research projects or instead the company keeps track of thelatestadvances and incorporates them into novel products?

We have built up a long-standing and strong relationships with number of academic bodies including the Universities of Cambridge, Bath and Reading in the UK, CASIA, EPFL – Switzerland, Clarkson University, University of Notre Dame, USA as well as the US standards body NIST. We work closely with any academic institution with research projects on iris recognition and as a matter of policy, we provide them with required hardware at subsidized or free pricing to help them achieve their objectives.

We also consider ourselves a global crusader of iris recognition and we push the envelope on use-cases and invent hardware and software solutions that address the challenges at hand. Our deep understanding of iris recognition and the intricacies of detail, continued research & development, combined with our vast field experience has ensured our success and leadership in this field. However, most importantly, it is the mix of technology as well as implementation and direct field deployment in the real world that sets us apart from many other biometric providers.

Did you ever consider extending the operability of IrisGuard products to unconstrained scenarios? Do you believe it will be useful? If so, do you think that research community has to come up with better strategies to allow reliable iris recognition in the wild?

Our systems have been working on 24x7x365 in mission critical projects in both attended and unattended (self-service) deployments for over 14 years now, however the situations we work in are strictly controlled when it comes to the purpose of collecting/using biometrics to ensure compliance with all relevant GDPR regulations and informed consent, all managed by our clients. Our technology has not been designed and is not suitable for biometric verification at a distance or any other covert use-cases.

Our solutions are utilized to authenticate financial transactions in less than three seconds thus removing the complexity of distributing cash assistance from donors to beneficiaries, streamlining the process on the ground and stretching funding further by eliminating identity related fraud. In one deployment alone, over one million iris recognition matches are taking place across five different countries in real-time (verification process of under 3 seconds) and providing refugees / IDPs (Internally Displaced People) with tens of millions of dollars of relief aid via ATM machines, pension and social protection payments via Post Offices, cash via mobile wallets and money exchangers. Our EyeCloud® system is also utilised to authorize humanitarian food payments directly in refugee camps supermarkets and during the initial stages of Covid-19 lockdown, our clients were able to provide both food and cash aid through door-to-door deliveries thanks to our portable EyePay® Phone device.

IrisGuard is a practical company with practical field-deployments. We tackle engineering and deployment challenges, come up with innovative solutions to ensure ease of use, robustness, as for millions of beneficiaries the reliability of our system is their lifeline.

What do you think that are the advantages of using iris for human identification when compared with the fingerprint or the face? Do you notice some mistrust about the use of iris rather than fingerprint?

This question was answered by IrisGuard decades ago. A single iris has more data than is found in ten fingerprints combined and you have two unrelated irises. This puts iris recognition on top of biometrics in terms of accuracy. Facial recognition is not appropriate for 1-to-millions matching but is suitable for unlocking a phone on a 1:1 basis for example. There simply isn't enough information in a human face to provide the level of distinction and accuracy required when desiring to match a single person against millions of people with 100% certainty and crucially, without any other ID token (card/pin, username/password, phone or paperwork) that one would need to de-duplicate a national aid program or to provide a proof-of-life for an entire population. Finally, iris recognition is contact-free and not effected by face coverings or veils / headwear making it the perfect technology to use.

Our experience on trust is the reverse of your question. During first-hand experience of support during Covid-19 we found that people trust iris recognition more than fingerprints. This is due to the latter's historic legacy in criminal records and of course now that iris is completely contact-free. Fingerprints have been associated with criminal activity for over a century now and unlike fingerprints, the iris cannot be left at a crime scene. People using iris recognition for the best uses understand that this technology is about identifying a living person in the here and now (In front of the camera at a trusted location or organisation). Furthermore, fingerprints can be picked up from a glass of water you drank at a public restaurant, adding to the fear in people's mind that using fingerprints as a biometric for daily use can be compromised rather easily.

What are the plans and goals for IrisGuard in the following years? Which novel products do you foresee in the next five years?

As stated earlier, our focus has always been and always will be on R&D, based on needs of the markets we work with. Recently, we converted an iris record with a pointer to the Blockchain and deployed a large-scale iris payment system that uses the largest and private humanitarian Ethereum Blockchain (Building Blocks) to support the purchase of and payment for groceries for hundreds of thousands of refugees in supermarkets. We have just recently been able to encrypt messages using the human iris in a totally offline and decentralized manner. We feel that a hardware crypto wallet based on iris recognition can be a very useful tool for people to have in their pockets to sign their crypt and NFT transactions using their own eyes. We will also focus on extraction of a stable key from the person's iris. Exciting times ahead as always for IrisGuard.

Paper Summary

GAN-based Inter-Class Sample Generation for Contrastive Learning of Vein Image Representations

Wei-Feng Ou, Lai-Man Po, Chang Zhou, Peng-Fei Xian, Jing-Jing Xiong

IEEE Transactions on Biometrics, Behavior, and Identity Science, vol. 4, no. 2, pp. 249-262, 2022.

Introduction

Vein recognition [1],[2] is an emerging biometric technology with attractive advantages in terms of security, reliability, efficiency, and user-friendliness.Biometric vein recognition using deep learning has recently shown promising performance. However, the performance is greatly limited due to the lack of vein image training data. Although using traditional data augmentation can alleviate this problem to a certain extent, it can only enlarge the intra-class samples, which is fundamentally limited by the intra-class space, resulting in limited performance improvement.

In this paper, we address this deep learning data shortage problem by proposing a GAN-based framework that can generate arbitrary-patterns of vein images as well as augment the training data with new vein classes. The proposed generative framework consists of three progressive synthetic steps, namely generation of random vein patterns in the binary space, refinement of the binary vein patterns, and rendering them into grayscale vein images. Furthermore, we use the synthetic dataset to learn a pre-trained feature embedding network through unsupervised contrastive learning, which allows for learning data augmentation invariant and instance separating representations. After that, we further fine-tune the embedding network on the real training data in a supervised manner. Our results demonstrate that high-fidelity and diverse vein image samples can be generated to alleviate the data shortage problem and improve the learning of features representations for biometric vein verification.

Proposed Method

Basically, most of the identity information in the vein image is located within the vein pattern. If we can synthesize arbitrary vein patterns in the vein images, we can create “virtual” vein classes that provide new semantic information to improve deep feature learning. The proposed framework is shown in Figure 1. We first segment binary vein pattern maps from training vein images using traditional methods. We then use these segmented binary pattern maps to synthesize random binary pattern maps through a new Random Block Composition (RBC) technique. These random binary pattern maps will be fed into a refinement network that is trained by CycleGAN [3] to reduce blockiness and noise artifacts. After that, another rendering network trained by Pix2Pix [4] renders the refined binary pattern map as a grayscale vein image. After these progressive generation steps, we can obtain a new synthetic dataset where each image has a random and distinct vein pattern. To obtain high-quality features, we pre-train the embedding network on the synthetic dataset through unsupervised contrastive learning using the SimCLR [5] framework, and then fine-tune the network on the original training set using the supervised framework FusionAug [6] for further improvement. In this way, the embedding network can capture rich prior information from different training data, thereby improving the quality of representation.

Experiments

We evaluate the effectiveness and performance of our proposed method on the FV-USM finger vein database and the Tongji palm vein database. The visual quality assessments on synthetic data, evaluations of the proposed feature learning scheme, and performance comparison with the state-of-the-art methods are summarized in Figures 2-4 and TABLE 1.

Conclusions

In this paper, we propose a GAN-based inter-class sample generation method that can synthesize realistic and diverse vein images with arbitrary vein patterns to alleviate the data shortage problem for deep learning-based biometric vein verification. We also design a progressive feature learning scheme that learns improved feature representations based on unsupervised contrastive learning on synthetic vein images and supervised fine-tuning on real vein images. Extensive experiments on two well-known public finger vein and palm vein databases show that the proposed method effectively improves the performance of biometric vein verification and outperforms existing methods. We hope our research will bring new insights into addressing data shortages for small-data deep learning applications – by generating new classes of samples, rather than generating intra-class samples.

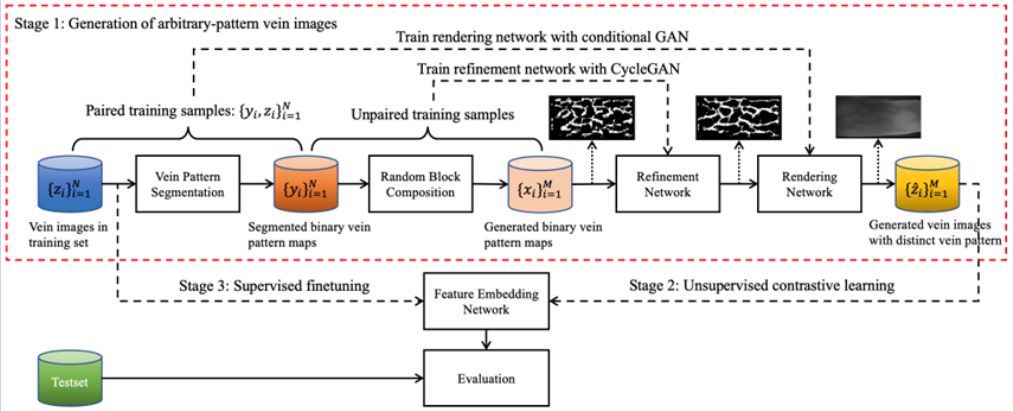
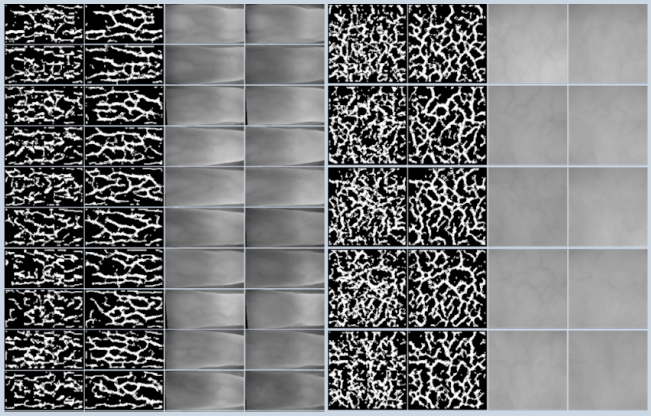
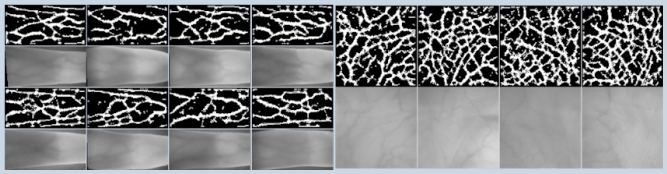


Figure 1. Diagram of the proposed framework.



(a) Synthetic finger vein examples (b) Synthetic palm vein examples



(c) Real finger vein examples and auto-labeled vein patterns (d) Real palm vein examples and auto-labeled vein patterns

Figure 2. Synthetic and real finger vein and palm vein examples.

TABLE 1. Average quality scores of vein images using different image quality metrics.

Metrics	Finger vein		Palm vein	
	Real	Synthetic	Real	Synthetic (6000)
GCF	0.8214	0.7928	0.8955	0.7885
HSNR	79.7975	79.3218	76.0459	74.1031
Wang17	0.2663	0.2660	0.3266	0.3800

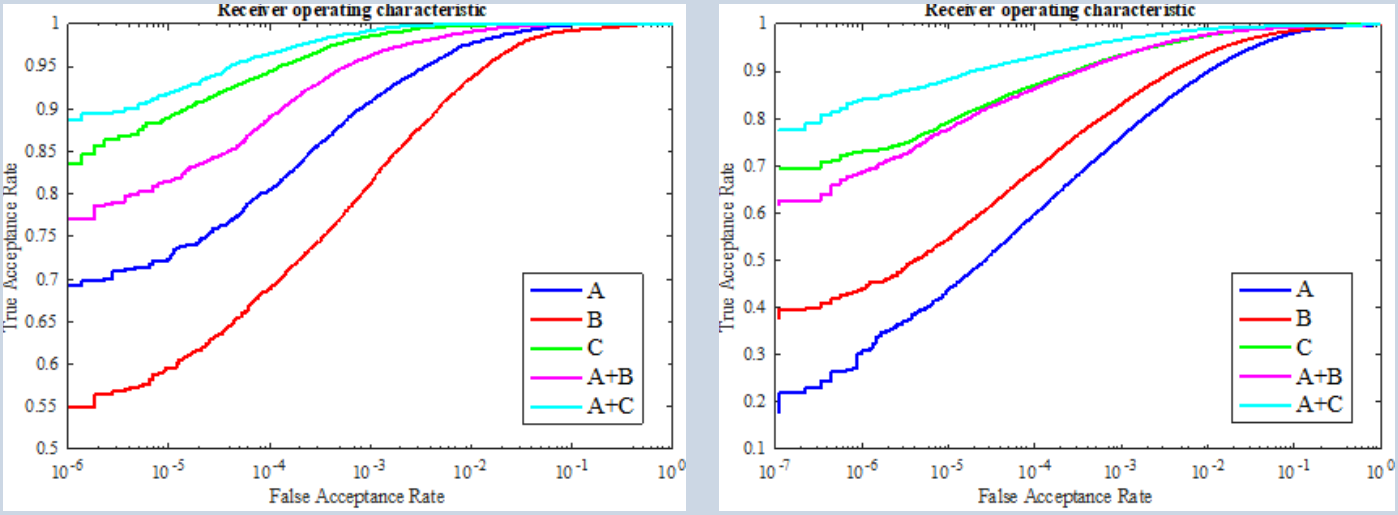


Figure 3. ROC curves of different training schemes. Left: Finger vein; Right: Palm vein. (A: train only on synthetic dataset using unsupervised contrastive learning; B: train only on original training set using naïve supervised baseline; C: train only on original training set using advance supervised baseline; A+B: pretrain by A and then finetune by B; A+C: pretrain by A and then finetune by C)

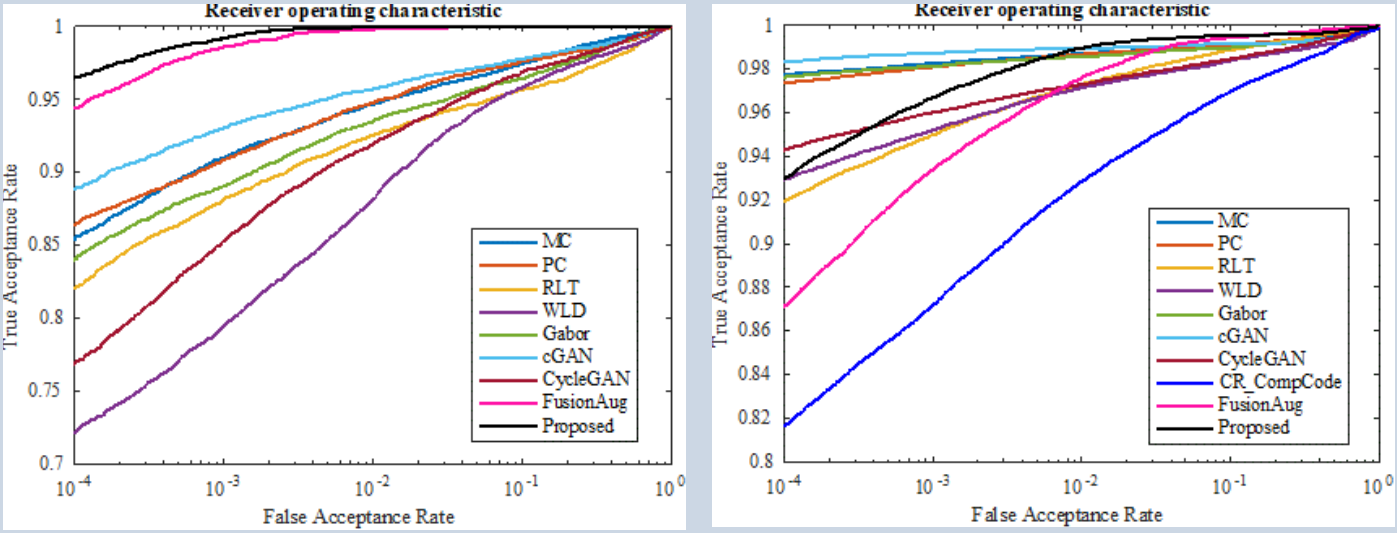


Figure 4. ROC curves of different approaches for biometric vein verification. Left: Finger vein; Right: Palm vein.

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Emerging Researcher Interview

Joshua J. Engelsma
Applied Scientist II
Amazon One product
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Joshua J. Engelsma graduated magna cum laude with a B.S. degree in computer science from Grand Valley State University, Allendale, Michigan, in 2016. He completed his PhD degree in Computer Science at Michigan State University in 2021. His research interests include pattern recognition, computer vision, and image processing with applications in biometrics. He won the best paper award at the 2019 IEEE International Conference on Biometrics (ICB), and the 2020 Michigan State University College of Engineering Fitch Beach Award. He is currently with Amazon, working as an Applied Scientist II on the Amazon One product.

You have published quite a bit in top conferences and journals during your Ph.D. What are the strategies and key factors that have encouraged this level of productivity?

There were several important factors to publishing a number of papers during my Ph.D. First, I would say that having a topic to study that really interested me was of utmost importance. I was passionate about the different topics within fingerprint recognition I was studying because they enabled me to explore the latest advances in Computer Vision while also addressing practical problems. For example, I was able to work on developing an infant fingerprint recognition system which could be useful down the road for helping developing countries more effectively deliver vaccines and nutritional supplements.

Another important element to publishing papers in the Ph.D. is to be surrounded by highly motivated and passionate researchers. My Ph.D. advisor and mentor Dr. Jain really encouraged me to do my best and publish high quality research papers, and my lab mates were always ready to discuss research together. The actions of the people surrounding you are contagious, and this was true in my Ph.D. research.

Your advisor was Prof. Anil Jain, an outstanding personality in the world of biometrics. Can you summarize the most important take-home messages that you received during the Ph.D. period?

Dr. Jain had a plethora of take-home messages that have stuck with me. I am grateful for the time I was able to spend in his lab learning from him. Several take-aways are: 1) Dr. Jain always emphasized the importance of properly conveying our research findings in both papers and formal presentations. While research is incredibly important, it is also of great importance to be able to effectively communicate that research to the community so that they can benefit from it. Furthermore, we need to make sure that when we make a claim, we back that claim up quantitatively with experimental results. 2) Dr. Jain emphasized the need to really understand the problem we were trying to solve. Sometimes researchers can become lost in developing a solution without a problem. Dr. Jain was very practical about keeping the problem in mind as we worked to develop a solution. 3) Dr. Jain encouraged me to set a high bar for myself. When I doubted my abilities, he encouraged me to take a leap. This has been immensely beneficial to me in my research career.

You conducted a virtual Research Intern at Goodix during your Ph.D. in the topic of improving state-of-the-art video super resolution models. Was that experience fruitful to advance in other biometric research lines during your Ph.D.? Which are the positive aspects of an industrial context with respect to an academic one? And vice versa?

I was able to utilize some of the techniques I learned on my project at Goodix for biometrics research. For example, I used some deep learning based super-resolution and image enhancement techniques to enhance infant fingerprints enabling me to better detect fingerprint minutiae. In academia and industry there is a different emphasis on product and research. I think the product focus, more heavily present in industry, is important in that it keeps us focused on all aspects of the problem we are trying to solve.

During your Ph.D. you developed a fingerprint matching system for infants. What do you think are important/useful lessons from this work for other modalities?

One of the biggest challenges with infant fingerprint recognition is that you are dealing with an uncooperative user. If an infant awakens while you are trying to capture their fingerprint, they may start crying and fighting to free their hand. This prompted us to make very careful considerations in the ergonomics of our capturing device. It had to be a small form factor that fit miniscule infant fingers, and it had to capture extremely quickly. When developing methods for recognizing infants with other modalities, e.g., footprint or iris, I think this aspect of the problem is an incredibly important one to remember.

What is the most valuable expertise you have gained during your Ph.D.? What would you change if you could go back?

The most value expertise I gained during my Ph.D. was learning how to do rigorous research. When I joined the Ph.D. program, I had not published any papers, and I was extremely new to the entire research pipeline (identifying a good problem to solve, data to collect, potential solutions, experimental results, and paper writing). Although my specific area of study was in the fingerprint recognition, the research skills I learned can be applied to many different domains of research and even other areas of life. For example, research requires us to really dig deep into a problem and consider all possible points of failure in our analysis. This pattern of deep, critical thinking is valuable in many different areas of life.

If I could go back and change anything, it would be to take more internship opportunities throughout. I ended up doing two during my 5 years of Ph.D., but I think that even more is beneficial as different skills can be picked up in industry that may not be as emphasized while doing Ph.D. research.

This particular question might help give a perspective to fresh Ph.D. students or new researchers just starting out. Given a research problem, how do you approach it? What are the steps from identifying a problem to coming up with a research paper out of it?

When I am given a research problem, the first thing I do is as thorough a literature review as I can. I begin by looking at the most recent papers, and I work backwards. At the same time, I begin brainstorming how I will solve the research problem. Typically, I try to break the research problem up into sub-problems and then attack each one separately. Many times, I have more ideas than I have time to try, so I try to prioritize experiments based on a probability of success vs. time taken to implement. As I work on my experiments, I ask other researchers about their research. In asking about and understanding others work, I add more tools to my tool-bag which I can then use for my own problem. Finally, after completing the experiments, it is important to give the paper writing enough time. As I write, I iteratively go over my writing, critically asking if I would understand the text as an external reviewer. How would an external reviewer read this, and what potential questions might they have?

You are currently working in Amazon as Applied Scientist. Are you still working in biometrics? Please, tell us about your experience regarding this transition and the motivation.

I am part of the Amazon One team, working on palm-print recognition for payments in our physical stores. Since my Ph.D. research was in the area of fingerprint recognition, the Amazon One team was a great fit for me, and I am able to apply many of the things I learned in the Ph.D. to our product. What motivates me most working at Amazon One is the opportunity to be part of a growing product which drastically improves our customers' experience. I am excited that the algorithms I am working on now have the possibility to impact millions of people's lives on a day-to-day basis.

In your opinion, which are the key differences between academia and industry when developing research projects? Any aspect that can be beneficial for academia?

I would say the key difference is that in industry there is a simultaneous emphasis on both the product and the research. Sometimes in academia we get too focused on obtaining the best results and beating SOTA on a dataset collected in a controlled laboratory environment. In industry, we really must think about all the edge cases of the system and how these edge cases may impact our customer. This deep dive analysis on the practical implications of edge cases is something we can be more cognizant of in academia as we seek to publish our papers.

If you had extra time and funds, which topic would be of your interest?

These days I am getting really interested in fintech, blockchain, and cryptocurrencies in my free time. If I had more spare time and funds, I would like to investigate applications at the intersection of biometrics and blockchain. Since both technologies are heavily motivated by security, I think that many interesting problems may lie at the intersection of these two topics.

A New Biometric Database

NUPT-FPV

Multimodal biometric systems are now gaining a lot of attention for improving organizational security and performing human identification and authentication. Systems that rely on a single biometric for identity verification frequently experience issues, such as spoofing attacks, subpar recognition performance, and sensitivity to environmental factors, and are therefore unable to keep up with the rapidly evolving security requirements. ,Thus, to improve the security of the multimodal biometric systems,reduce the cost and space requirements for multimodal systems, the NUPT-FPV dataset is built by collecting two modalities, the fingerprint and finger vein images at the same time from each subject.

The authors designed a device that could simultaneously capture fingerprint and finger vein data and merged the two collection modules in a compact spaceto carry out the data collection. A fingerprint collection module and a finger vein collecting module together make up this device. To capture and save the fingerprint, the fingerprint module used an optical sensor with light sources dispersed on both sides of the camera. On the other hand, the finger vein module used transmission mode and a near-infrared light-emitting diode with a wavelength of 850 mm. When the finger touched the fingerprint acquisition window, a trigger was employed to simultaneously launch the fingerprint and finger vein modules to acquire the data from the subjects.

This database was gathered from a total of 140 people (108 males and 32 females) whose ages ranged from 16 to 29 and had an average of 19.3 years. This data was collected over the course of two sessions. The first session took place in a lab. In contrast, the second session was held outside to more precisely assess the session change and the performance of the multimodal identification algorithm across each session. The index, middle, and ring fingers from the left and right hands of each individual were provided, and each finger was captured ten times in both sessions, resulting in a total of 16800 fingerprint images and 16800 finger vein images from two sessions.

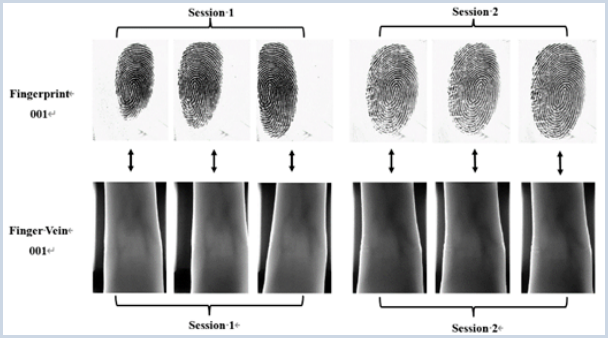

Figure 1. The fingerprint and finger vein pictures from each subject that were taken over the course of two sessions are displayed in the above figure.

Reference

H. Ren, L. Sun, J. Guo and C. Han, "A Dataset and Benchmark for Multimodal Biometric Recognition Based on Fingerprint and Finger Vein," in IEEE Transactions on Information Forensics and Security, vol. 17, pp. 2030-2043, 2022, doi: 10.1109/TIFS.2022.3175599. Available at: https://github.com/REN382333467/NUPT-FPV

Source Code

Spherical Spaces for Face Recognition

Facial recognition is everywhere, making complex tasks more straightforward. For instance: automated phone login, more convenient access to biometric data, faster identification at security points, and purchasing. In the last few years, a novel line of research has revealed that spherical spaces can better fit the underlying geometry of facial images than classical Euclidean approaches, as evidenced by cutting-edge facial recognition methods which use spherical representations empirically. This new direction certainly aligns latest works demonstrating that the latent spherical space is better suited for representing facial features than Euclidean space. In this regard, several works have shown remarkable performance for face recognition. In this issue, we describe and provide reference for the publicly available repositories of CosFace, ArcFace, and SCF.

The Large Margin Cosine Loss (LMCL), also known as CosFace, replaces the traditional softmax loss as a cosine loss by L2 normalizing features and weight vectors. Then, a cosine margin term is introduced to maximize the decision margin in the angular space achieving a minimum intra-class margin and maximum inter-class margin for accurate face verification. CosFace has a nonlinear angular margin. Feature vectors from the same classes are clustered together, and those from different classes are pulled apart on the hypersphere's surface. A classical repository provided by Wujiyang[1] implements this technique, among others, such as ArcFace.

Precisely, ArcFace employs a similarity learning mechanism that solves distance metric learning in the classification task by replacing Softmax Loss with Angular Margin Loss. The inner product of two normalized vectors is used to calculate the distance between faces, a method used by search engines. If the two vectors are identical, θ will be 0 and cos(θ)=1. Otherwise, they are orthogonal; the result will be π/2 and cos(θ)=0. As a result, it can be used as a similarity metric. Contrary to CosFace, ArcFace has a constant linear angular margin throughout the whole interval that separates classes. From a coding perspective, InsightFace[2] is an integrated Python library for 2D&3D face analysis that integrates ArcFace. This library provides several state-of-the-art facial recognition, face detection, and face alignment algorithms. This library provides new techniques arising from ArcFace, such as the Sub-center ArcFace.

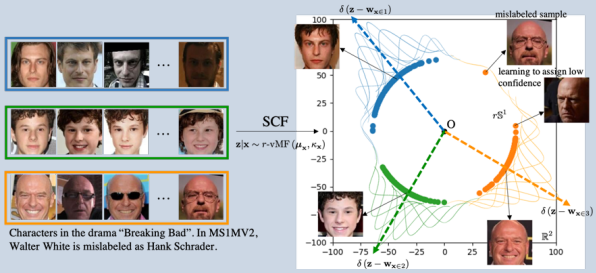

Figure 1. Image extracted from the paper entitled Spherical Confidence Learning for Face Recognition, showing a subset of MS1MV2 containing three identities. Authors found that mislabeled samples for the third identity hamper training otherwise, SCF learns to assign low confidence to such samples in an adaptive manner.

More recently, a paper entitled Spherical Confidence Learning for Face Recognition[3] was presented at CVPR 2021. In this work, the authors claimed that spherical-spaces approaches rely on deterministic embeddings and hence suffer from the feature ambiguity dilemma, whereby ambiguous or noisy images are mapped into poorly learned regions of representation space, leading to inaccuracies. ArcFace and CosFace are defined in spherical spaces, essentially Dirac delta in a deterministic mapping. This new proposal seeks to minimize the KL divergence between the spherical Dirac delta and the model distribution. By doing this, the SCF learns to assign low confidence to such samples in an adaptive manner (see Figure 1). An SCF repository can be found on Github[4].

[1] https://github.com/wujiyang/Face_Pytorch

[2] https://github.com/CMU-Perceptual-Computing-Lab/openpose

[3] Shen Li, Jianqing Xu, Xiaqing Xu, Pengcheng Shen, Shaoxin Li, and Bryan Hooi. Spherical Confidence Learning for Face Recognition, IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR) 2021.

[4] https://github.com/MathsShen/SCF

Commercial Off-The-Shelf-System

The Emergence of “Everyday Use” Biometrics

The use of biometric technologies in everyday activities is increasingly commonplace. While several years ago biometric recognition was largely reserved for forensic applications, biometric applications today range from unlocking smartphones[1] to tracking hospital visitations[2] to health data management for children[3], among many others. Some of these new applications reflect a greater mix of security and convenience, straying away from the focus on person identification alone, to now consider contactless interactions, cashless and cardless purchases, paperless data management systems, personalized experiences, customized retail recommendations, and more.

For example, some of Amazon’s Whole Foods supermarkets now offer Amazon’s One palm scanner for contactless payments[4]. Innovative Technology Ltd’s MyCheckr is being used in Bestway Retail stores for age detection to prevent the sale of alcohol to underage buyers[5].Further, Mercedes-Benz uses the Cerence Look system to enable multi-modal understanding of voice, sight, touch, and gestures which allows drivers to interact with their vehicle[6].

With these examples, one could argue that we are moving (or have moved) well into an era of everyday use biometrics. This could have significant implications for the biometrics community, for example, the need for new biometric identifiers, a need to revisit the properties of suitable biometric identifiers, or the need to develop new metrics which quantify measurability depending on the targeted device that is acting as the biometric sensor. While there isn’t an argument for or against such investigations, there is a clear call to consider the possibilities.Everyday usebiometrics could easily be regarded as a new biometric type (alongside physical and behavioral biometrics) that has its own set of classifications and properties, potentially leading to a new, interdisciplinary direction for identity science.

[1] Use Face ID on your iPhone or iPad Pro: https://support.apple.com/en-us/HT208109

[2] The University of Chicago Medicine Biometric Data Policy:
https://www.uchicagomedicine.org/about-us/privacy-practices/biometric-data-policy

[3] Using thumbprints, vaccination records to save children’s lives:
https://msutoday.msu.edu/news/2021/using-thumbprints-vaccination-records-to-save-lives

[4] Amazon expands palm-scanning payment tech to 65 more Whole Foods locations:
https://techcrunch.com/2022/08/10/amazon-expands-palm-scanning-payment-tech-to-65-more-whole-foods-locations/

[5] ITL age estimation technology to be extended into additional Bargain Booze stores:
https://www.intelligent-identification.com/itl-age-estimation-technology-to-be-extended-into-additional-bargain-booze-stores

[6] How Mercedes is Creating Innovative Multi-Modal Experiences with Cerence Look:
https://www.cerence.com/news-releases/news-release-details/how-mercedes-creating-innovative-multi-modal-experiences-cerence

Germinal Proposals

A Biometric Authentication Technique Using Smartphone Fingertip Photoplethysmography Signals

Ortiz, B. L., Chong, J. W., Gupta, V., Shoushan, M., Jung, K., & Dallas, T. (2022).
IEEE Sensors Journal.

Usually, Photoplethysmography (hereafter PPG) signals are used for monitoring the volumetric changes of blood in the blood vessels; recently, they have been used very often, especially for estimating the oxygen saturation in blood (very sensitive parameter for the coronavirus COVID-19 diagnosis). Its acquisition is unobtrusive, since flashlights in smartphones can be used for gathering PPG information from fingertips or face like shown in [1,2,3].

In a paper entitled “A Biometric Authentication Technique Using Smartphone Fingertip Photoplethysmography Signals”, published online in July 2022 on IEEE Sensors Journal, the authors have proposed a smartphone PPG-based biometric authentication, whose system embodies the four canonical steps for biometric enrollment and authentication:

- PPG collection by using a smartphone;
- A PPG signal pre-processing phase;
- Time and Frequency domain feature extraction step;
- Classification by exploiting an ensemble of Bagging Trees.

For collecting PPG signals, smartphone cameras have been used; more in details, the green channels of a sequence of fingertips’ images have been averaged according to their color intensity. The choice of the green channels has been reasonably used given its best signal-to-noise ratio [4] in extracting PPG signals from smartphones [5]. Then, after the signal is collected, the Nexus-10 MKII Biofeedback device has been used for measuring the signal. This measurement is used as a gold-standard in evaluating the performance of the average heart rate estimation of the proposed system. The dataset is composed by 30 subjects over the age of 18, recruited from the Texas Tech University community. Data have been recorded for 120 seconds.

Signals from the smartphone were then passed over an MNA (motion and noise artifacts) reduction preprocessing approach, which consist of three steps:

1. Removal of direct current (DC) from the raw signal;
2. Normalization by subtracting the mean signal from the resulting PPG signal;
3. Segmentation of the resulting signal into 30-seconds fragments.

The feature extraction step acts on the peaks and the troughs (systolic and diastolic points, respectively), of the MNA reduced PPG signal. The features extracted are both in the time and in the frequency domain:

Time domain

- Peak-to-Peak Amplitude difference interval (PPD);
- Peak-to-Trough Time interval (PTI);
- Slope Ratio (SR);
- Trough Values (TV);
- Peak-to-Peak time interval domain (PPI);
- Heart Rate Frequency (FHR);
- Root Mean Squares of successive difference (RMSSD);
- Standard Deviation (STD);
- Percentage of PPI values varying more than 50ms (pNN50).

Frequency domain

- Maximum value of amplitude spectrum (using FFT);
- Minimum value of amplitude spectrum (using FFT);
- Minimum/Maximum amplitude spectrum (using FFT);
- Heart Rate Frequency difference (dFHFR);
- Maximum value of Power Spectral Density (using Lomb-Scargle Periodogram);

- Minimum value of Power Spectral Density (using Lomb-Scargle Periodogram);
- Minimum/Maximum Power Spectral Density Ratio ((using Lomb-Scargle Periodogram).

User Recognition is done by an Ensemble of Bagged Trees (EBT), with a Majority voting policy which follows the equation:

$$C^{\wedge}_{bag}(x) = \text{MajorityVote}\{C(T^{*m}, x)_{m=1}^{M}\}$$

where M is the number of trees, T is the training data, x, is the input data which is divided into m samples across the M trees. Number of trees is set to 100; the value has been chosen according to the reaching of a good compromise between accuracy and computational complexity.

Also, the choice of the EBT classifier has been chosen according to the training accuracy, against other well-known classifiers. Indeed, whereas KNN and SVM has reached about the 84% in training, the EBT managed to obtain the 98%. In testing, the accuracy is stable on the 95%, with a precision of 97% and a recall of 92%. In verification, the Equal Error Rate has been calculated. In training, the EER value of the EBT is 2.15%, whereas in testing this reached 5.90%.

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Call for Papers and Participation

CALL FOR WORKSHOP PAPERS - IEEE/CVF WACV 2023

The IEEE/CVF Winter Conference on Applications of Computer Vision (WACV) 2023, to be held in Hawaii, USA in January 2023, will host multiple workshops on different topics with paper submission deadlines in October and November 2022. Several of the workshops are realted to biometrics. Accepted papers will be published as part of the WACV 2023 workshop proceedings and will appear in IEEE Xplore.

Many of the workshops also include challenges.

This year's workshops with tentative deadlines (may get extended) include :

2nd Workshop on Video/Audio Quality in Computer Vision

Organizers: Yarong Feng; Zongyi Liu; Kevin Bowyer; Larry Davis

Current submission deadline: October 11, 2022

Web: https://sites.google.com/view/wacv2023-workshop-quality-va/home

Real-World Surveillance: Applications and Challenges

Organizers: Kamal Nasrollahi; Sergio Escalera; Radu Tudor Ionescu; Fahad Shahbaz Khan; Thomas B. Moeslund; Anthony Hoogs; Shmuel Peleg; Mubarak Shah

Current submission deadline: October 20, 2022

Web: https://vap.aau.dk/rws-wacv2023/

Workshop on Fine-grained Activity Recognition

Organizers: Jeffrey Byrne; Jonathan Fiscus; Yooyoung Li; Hilde Kuehne; Yogesh Rawat; Mubarak Shah; Alexander Hauptmann; Rama Chellappa

Current submission deadline: October 10, 2022

Web: https://openfad.nist.gov/workshop/fgad23

2nd Workshop on Computer Vision for Winter Sports (CV4WS)

Organizers: Matteo Dunnhofer; Nicola Conci; Christian Micheloni

Current submission deadline: October 12, 2022

Web: https://machinelearning.uniud.it/events/CV4WS-2023/Home.html

1st Workshop on Maritime Computer Vision

Organizers: Benjamin Kiefer; Fabio Poiesi; Matej Kristan; Janez Perš; Fabio Andrade; Alexandre Bernardino; Matthew D Dawkins; Jenni Raitoharju

Current submission deadline: October 25, 2022

Web: https://seadronessee.cs.uni-tuebingen.de/wacv23

4th Annual Workshop on Demographic Variations in Performance of Biometric Algorithms

Organizers: Nisha Srinivas; Michael King; Arun Ross; Kevin Bowyer; Karl Ricanek

Current submission deadline: October 22, 2022

Web: https://sites.google.com/trueface.ai/bias-workshop-wacv2023/home

3rd Workshop on Explainable & Interpretable Artificial Intelligence for Biometrics - xAI4Biometrics

Organizers: Ana F. Sequeira; Jaime S. Cardoso; Adam Czajka; Hugo Proenca; João Pinto; Kiran Raja; Naser Damer; Pedro C. Neto; Tiago FS Gonçalves; Sara P. Oliveira; Isabel Rio-Torto; Peter Eisert; Cynthia Rudin

Current submission deadline: October 11, 2022

Web: https://vcmi.inesctec.pt/xai4biom_wacv2023/index.html

Long-Range Recognition

Organizers: Scott McCloskey; Terrance E Boult; Patrick Flynn; Rama Chellappa; Vishal Patel; Benjamin Riggan

Current submission deadline: November 3, 2022

Web: https://sites.google.com/kitware.com/lrr-workshop-2023/home

Workshop On Manipulation, Adversarial and Presentation Attacks In Biometrics

Organizers: Kiran Raja; Naser Damer; Raghavendra Ramachandra; Julian Fierrez

Current submission deadline: October 15, 2022

Web: https://sites.google.com/view/wacv2023-map-a/home

For details on the submission procedure, deadlines and other information please visit:

https://wacv2023.thecvf.com/node/138

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