# Cutting-Edge Biometrics Research: Selected Best Papers From IJCB 2023

WELCOME to the special issue of best-reviewed papers from the 2023 International Joint Conference on Biometrics (IJCB 2023), the premier forum for cutting-edge research and innovation in the field of biometrics. IJCB combines the previous two major biometrics conferences, the IEEE International Conference on Biometrics Theory, Applications, and Systems, and the IAPR International Conference on Biometrics. IJCB was made possible through a special agreement between the IEEE Biometrics Council and the IAPR Technical Committee on Biometrics (TC-4).

As in the previous editions, the IJCB 2023 conference attracted high-quality submissions on a broad range of topics related to biometrics and supporting technologies. The conference received 199 papers, which underwent a rigorous peer-review procedure by the Program Chairs and 26 Area Chairs. More than 230 reviewers helped with the reviewing process. Ultimately, 72 (36.2%) of the highest-quality papers were accepted for presentation, out of which 30 (15.1%) were scheduled as orals and the remaining 42 (21.1%) as posters. Among the papers presented at the conference, selected authors of 13 papers with the best review ratings were invited to submit an extended version of their work to this special issue of the IEEE TRANSACTIONS ON BIOMETRICS, BEHAVIOR, AND IDENTITY SCIENCE (TBIOM). The submissions in this special issue went through the normal peer review cycle at TBIOM, with revisions by the authors based on the reviews and a second round of reviews. One of the Guest Associate Editors recommended them for acceptance. We want to thank the authors and the reviewers for keeping to an ambitious timeline that enabled us to assemble this special issue promptly. We hope that you enjoy the papers in this special issue and that they will increase your interest in both IJCB and TBIOM.

**Papers related to face recognition:** The paper [A1] by Banerjee et al. deals with the problem of aging that impacts the performance of biometric recognition systems and presents a novel facial aging and de-aging technique using regularization-based conditional image generation via latent diffusion models. This is achieved by curating a small regularization set of image and caption pairs to teach the model the concept of facial aging and enforcing identity preservation using a novel combination of biometric, cosine, and contrastive losses. This helps to preserve the biometric integrity of the original individual and at the same time to customize their appearance to fit the target age in the prompt. Experiments show that face recognition classifiers may benefit by fine-tuning generated images with significant age variations.

The paper [A2] applies the recent denoising of diffusion probabilistic models (DDPMs) into the area of face image quality assessment (FIQA). The main idea of this approach is to utilize the forward and backward processes of DDPMs to perturb facial images and quantify the impact of these perturbations on the corresponding image embeddings for quality prediction. This new approach achieves competitive performance against ten existing FIQA methods.

In the paper [A3], George and Marcel conceptualize the domain gap in Heterogeneous Face Recognition (HFR) as a manifestation of distinct styles from different imaging modalities. The core of the method is the introduction of a new module, called Conditional Adaptive Instance Modulation (CAIM). This module can be trained from scratch, transforming a standard face recognition system into an HFR network. The robustness and effectiveness of the method are shown through an extensive evaluation of various challenging HFR benchmarks.

The paper [A4] introduces a method called ExplaNET, which relies upon interpretable and explainable prototypes to detect deepfakes. The idea is to employ prototype-based learning to generate representative images that encapsulate the essential characteristics of real and deepfake images. Ultimately, the authors leverage the Grad-CAM technique to generate heat maps, highlighting the image regions that contribute most significantly to the decision-making process. The idea is that the interpretability and explainability intrinsic to the method's core enhance its trustworthiness among forensic experts, owing to the transparency of the model.

In [A5], the authors propose a methodology that generates unbiased data from a biased generative model using an evolutionary formulation. They leverage a StyleGAN2 model trained on the Flicker Faces High-Quality dataset to generate data for singular and combinations of demographic attributes such as Black and Woman. In addition, the authors generate a large racially balanced dataset of 13.5 million images and show that it boosts the performance of facial recognition and analysis systems while reducing their biases.

**Papers related to recognition by gait:** Thejaswin et al.'s paper [A6] provides three main contributions: 1) they propose a framework for the dynamic fusion of multiple biometrics modalities leveraging attention techniques; 2) they perform an extensive evaluation of the proposed method in comparison to various other fusion techniques such as Bilinear Pooling, Parallel Co-attention, Keyless Attention, Multimodal Factorized High-order Pooling, and Multimodal Tucker Fusion; and 3) they use an Explainable Artificial

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Intelligence-based interpretation tool to analyze how the attention mechanism of Adapt-FuseNet is capturing context implicitly and making the best weighting of the different modalities for the task at hand.

In [A7], Zheng et al. explore using a two-stream representation of skeletons for gait recognition alongside silhouettes. By fusing the combined data of silhouettes and skeletons, they refine the two-stream skeletons, joints, and bones through self-correction in graph convolution and cross-modal correction with temporal consistency from silhouettes. The authors claim that such kinds of refined skeletons achieve further improvements in performance concerning the state-of-the-art.

They are considering the temporal and spatial characteristics of gait data, in [A8], Zou et al. propose a multi-stage feature fusion strategy (MSFFS), which performs multimodal fusions at different stages in the feature extraction process. They describe an adaptive feature fusion module (AFFM) that considers the semantic association between silhouettes and skeletons. The fusion process fuses different silhouette areas with their more related skeleton joints. Since visual appearance changes and time passage co-occur in gait periods, they propose a multiscale spatial-temporal feature extractor. (MSSTFE) to learn the spatial-temporal linkage features thoroughly. Finally, a multi-stage adaptive feature fusion neural network performs classification.

**Papers related to fingerprint:** Miao et al.'s paper [A9] seeks to improve the utility of sweat pores as a third-level fingerprint feature. They propose a Generative Adversarial Networks (GAN) approach to enhancing sweat gland images from Optical Coherence Tomography (OCT), seeking to improve the accuracy of sweat gland segmentation and extraction. Their paired dataset generation strategy and pix2pix network improved by incorporating a perceptual loss and were analyzed through extensive experiments documenting their proposed method's effectiveness.

Priesnitz et al.'s paper [A10] seeks to advance the emerging field of **contactless** fingerprint recognition, which promises distinctly improved user-friendliness for fingerprint recognition. They focus on the generalizability and explainability of CNN-based contactless fingerprint presentation attack detection (PAD) methods. They evaluate several PAD algorithms using four databases in a leave-one-out protocol and find that generalization across datasets is still challenging.

**Papers on other topics in biometrics:** Wang et al.'s paper [A11] reports on a new vision transformer and CNN-based approach to sclera segmentation and recognition, named Sclera-TransFuse. On the segmentation side, they extract coarse and fine-grain features, fused and upsampled to produce a sclera mask. On the recognition side, a lightweight EfficientNet B0 and a multiscale vision transformer are used to analyze features of sclera vasculature. Experimental results are reported for several publicly available datasets, and the algorithms' codes are made available.

Nguyen et al.'s paper [A12] reports on an extension of the BehaveFormer framework for combining time series data from multiple sensors to provide higher security in behavioral biometrics. Their experiments were analyzed using two related behavioral biometrics: keystroke and swipe dynamics. They compare their approach's results to existing techniques for keystroke dynamics on three publicly available datasets and to existing techniques for swipe dynamics on two publicly available datasets.

In [A13] proposes a feature distribution conditioning approach called CoNAN for template aggregation. Unlike the traditional feature aggregation methods, it aims to learn a context vector conditioned over the distribution information of the incoming feature set, which is utilized to weigh the features based on their estimated informativeness. It produces state-of-the-art results on long-range unconstrained face recognition scenarios in which high-quality metadata or style information is only sometimes feasible. It validates the effectiveness of CoNAN in feature aggregation.

## Appendix: Related Articles


[A1] S. Banerjee, G. Mittal, A. Joshi, S. P. Mullangi, C. Hegde, and N. Memon, "Identity-aware facial age editing using latent diffusion," *IEEE Trans. Biom., Behav., Ident. Sci.*, vol. 6, no. 4, pp. 443–457, Oct. 2024, doi: 10.1109/TBIOM.2024.3390570.

[A2] Ž. Babnik, P. Peer, and V. Štruc, "eDifFIQA: Towards efficient face image quality assessment based on denoising diffusion probabilistic models," *IEEE Trans. Biom., Behav., Ident. Sci.*, vol. 6, no. 4, pp. 458–474, Oct. 2024, doi: 10.1109/TBIOM.2024.3376236.

[A3] A. George and S. Marcel, "From modalities to styles: Rethinking the domain gap in heterogeneous face recognition," *IEEE Trans. Biom., Behav., Ident. Sci.*, vol. 6, no. 4, pp. 475–485, Oct. 2024, doi: 10.1109/TBIOM.2024.3365350.

[A4] F. Khalid, A. Javed, K. M. Malik, and A. Irtaza, "ExplaNET: A descriptive framework for detecting deepfakes with interpretable prototypes," *IEEE Trans. Biom., Behav., Ident. Sci.*, vol. 6, no. 4, pp. 486–497, Oct. 2024, doi: 10.1109/TBIOM.2024.3407650.

[A5] A. Jain, R. Dholakia, N. Memon, and J. Togelius, "Zero-shot demographically unbiased image generation from an existing biased StyleGAN," *IEEE Trans. Biom., Behav., Ident. Sci.*, vol. 6, no. 4, pp. 498–514, Oct. 2024, doi: 10.1109/TBIOM.2024.3416403.

[A6] S. Thejaswin, A. Prakash, A. Nambiar, and A. Bernadino, "Exploring fusion techniques and explainable AI on adapt-FuseNet: Context-adaptive fusion of face and gait for person identification," *IEEE Trans. Biom., Behav., Ident. Sci.*, vol. 6, no. 4, pp. 515–527, Oct. 2024, doi: 10.1109/TBIOM.2024.3405081.

[A7] W. Zheng, H. Zhu, Z. Zheng, and R. Nevatia, "GaitSTR: Gait recognition with sequential two-stream refinement," *IEEE Trans. Biom., Behav., Ident. Sci.*, vol. 6, no. 4, pp. 528–538, Oct. 2024, doi: 10.1109/TBIOM.2024.3390626.

[A8] S. Zou, J. Xiong, C. Fan, C. Shen, S. Yu, and J. Tang, "A multi-stage adaptive feature fusion neural network for multimodal gait recognition," *IEEE Trans. Biom., Behav., Ident. Sci.*, vol. 6, no. 4, pp. 539–549, Oct. 2024, doi: 10.1109/TBIOM.2024.3384704.

[A9] Q. Miao, H. Wang, Y. Zhang, R. Yan, and Y. Liu, "Sweat gland enhancement method for fingertip OCT images based on generative adversarial network," *IEEE Trans. Biom., Behav., Ident. Sci.*, vol. 6, no. 4, pp. 550–560, Oct. 2024, doi: 10.1109/TBIOM.2024.3459812.

[A10] J. Priesnitz et al., "Mobile contactless fingerprint presentation attack detection: Generalizability and explainability," *IEEE Trans. Biom., Behav., Ident. Sci.*, vol. 6, no. 4, pp. 561–574, Oct. 2024, doi: 10.1109/TBIOM.2024.3403770.

[A11] C. Wang, H. Li, Y. Zhang, G. Zhao, Y. Wang, and Z. Sun "Sclera-TransFuse: Fusing vision transformer and CNN for accurate sclera segmentation and recognition," *IEEE Trans. Biom., Behav., Ident. Sci.*, vol. 6, no. 4, pp. 575–590, Oct. 2024, doi: 10.1109/TBIOM.2024.3415484.

[A12] K.-N. Nguyen, S. Rasnayaka, S. Wickramanayake, D. Meedeniya, S. Saha, and T. Sim, "Spatio-temporal dual-attention transformer for time-series behavioral biometrics," *IEEE Trans. Biom., Behav., Ident. Sci.*, vol. 6, no. 4, pp. 591–601, Oct. 2024, doi: 10.1109/TBIOM.2024.3394875.

[A13] B. Jawade, D. D. Mohan, P. Shetty, D. Fedorishin, S. Setlur, and V. Govindaraju, "CoNAN: Conditional neural aggregation network for unconstrained long range biometric feature fusion," *IEEE Trans. Biom., Behav., Ident. Sci.*, vol. 6, no. 4, pp. 602–612, Oct. 2024, doi: 10.1109/TBIOM.2024.3410311.

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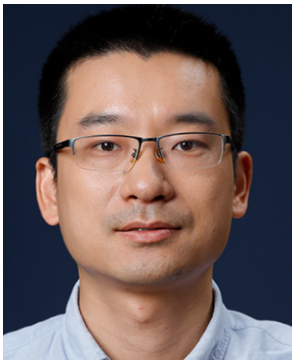

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