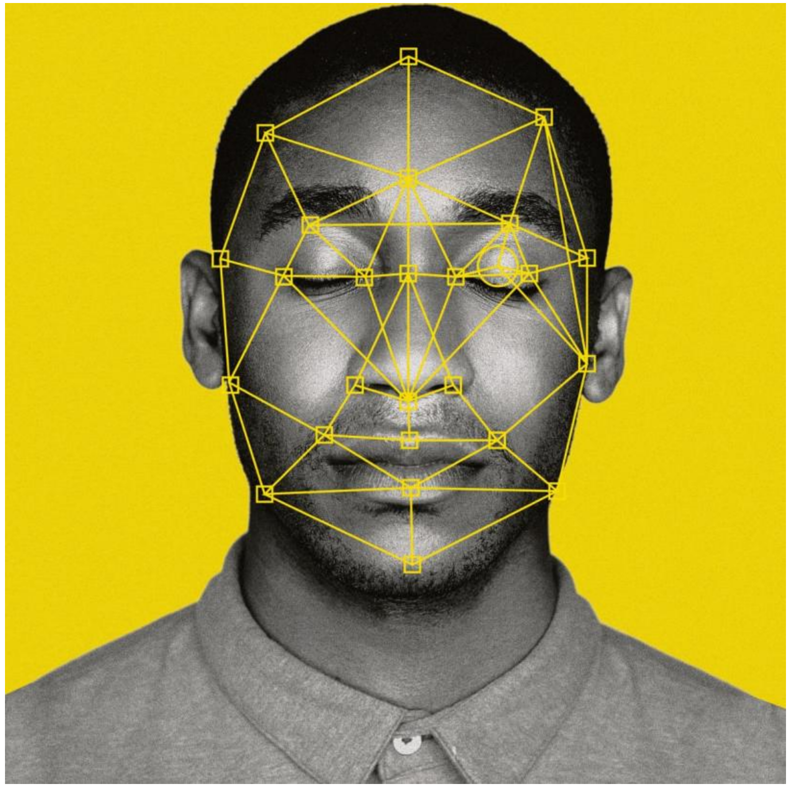


Enhancing Authentication Through Fusion of Face and Palm Print

Allen Chen and Grace Boban | COP-4931

Why Multimodal Biometrics Matter

- Multimodal biometric systems combine multiple traits to improve security and resilience, especially when one modality is compromised [3].
- Face-only systems often fail under real-world conditions like poor lighting or occlusions (e.g., masks), particularly during the COVID-19 pandemic [4].
- This project investigates combining face and palmprint recognition to overcome the limitations of unimodal systems and improve authentication robustness.

Unimodal systems fail under real-world stress.
Multimodal fusion can fix this.

Literature Review

Face-only systems suffer under occlusion.

Gomez-Barrero et al. [4] observed a significant rise in false rejection rates in face-based biometric systems during the COVID-19 pandemic due to mask occlusions.

Palmprint biometrics offer high distinctiveness and low spoofing risk.

Prior studies [8], [9] show palmprints contain rich textural and structural features (e.g., principal lines, ridges) and achieve recognition rates exceeding 98% in controlled environments.

Score-level fusion balances performance and efficiency.

Research by Jena et al. [7] and Thasiyabi et al. [3] supports the use of score-level fusion for combining heterogeneous modalities. It enables complementary strengths while minimizing computational complexity.

Specs on Faces (SoF) and BMPD are proven datasets.

SoF [5] captures real-world facial occlusions (masks, glasses, hats), while BMPD [6] simulates mobile-based palmprint acquisition—both ideal for evaluating robustness and cross-modal performance.

Key Research Findings

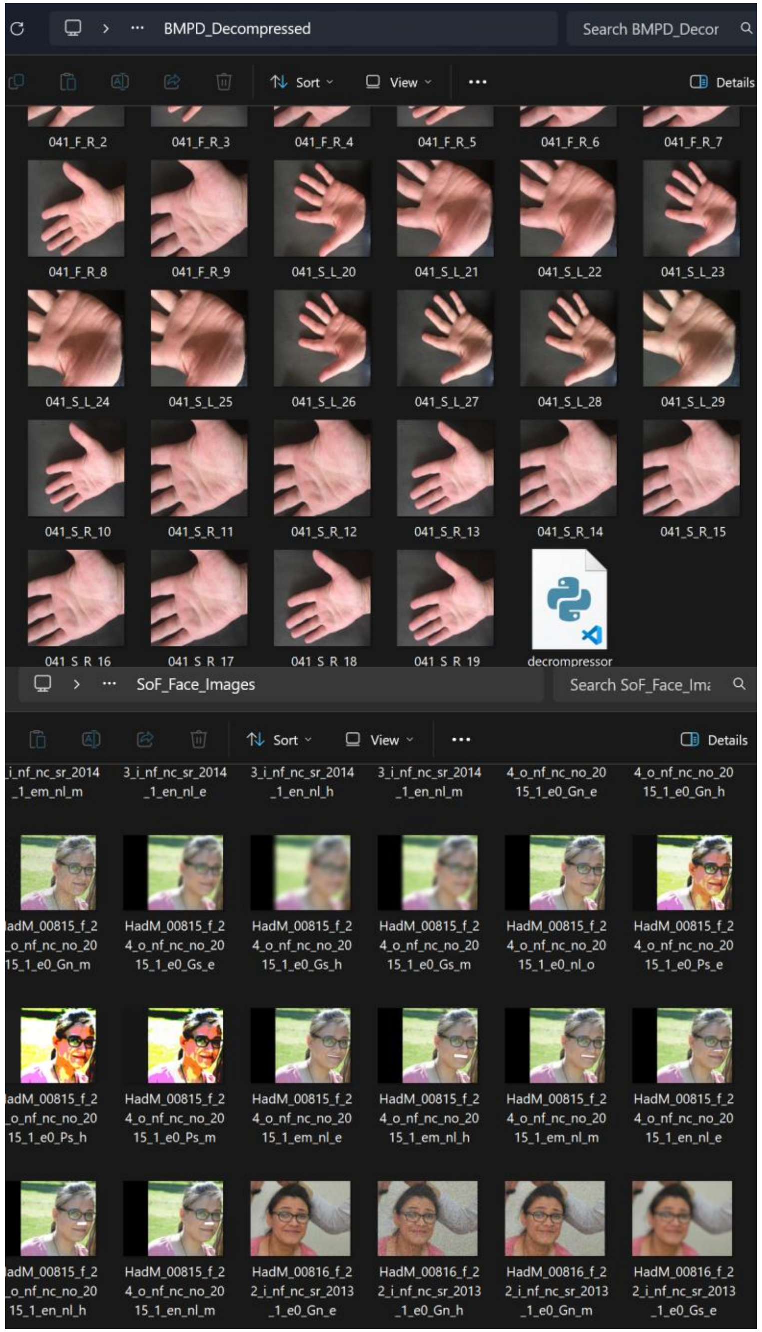
- Studies show that multimodal systems significantly outperform unimodal systems in resisting spoofing, sensor noise, and performance degradation [2], [3].
- Facial recognition systems are especially vulnerable to occlusions, leading to high false rejection rates in mask scenarios [4].
- Palmprints offer high biometric entropy and are resilient to occlusion, making them a valuable secondary modality [8], [9].

Questions That Drives Research

- RQ1: How does combining face and palmprint modalities affect authentication accuracy compared to using only one?
- H1: We expect multimodal systems to outperform unimodal ones by lowering the Equal Error Rate (EER) [3].
- RQ2: How do occlusions like masks or glasses affect the accuracy of multimodal systems?
- H2: We hypothesize that multimodal systems will remain robust under occlusion, outperforming face-only systems [4].

Datasets That Power The System

- The Specs on Faces (SoF) dataset contains 640×480 facial images with real-world occlusions like masks, hats, and glasses, captured under varying lighting conditions and image filters [5].
- The Birjand University Mobile Palmprint Database (BMPD) includes high-resolution palm images (3264×2448), acquired using mobile devices, then resized to 256×256 by python script for efficient processing [6].
- Both datasets are public, anonymized, and ethically sourced with informed consent from participants, making them suitable for academic research and privacy-respecting experimentation.



How The System Works

1. Extract the landmarks from raw face images using Dlib and Shape Predictor 68 Landmarks file and apply Local Binary Patterns (LBP) to analyze decompressed palmprints [8].
2. Use the five classifiers—Logistic Regression, SVM, KNN, LDA, and Decision Trees—to train independently for each modality. Combine all classifiers separately for face and palmprints.
3. Use predict_proba() to generate probability scores representing classifier confidence for each biometric sample.
4. Perform score-level fusion by averaging face and palmprint classifier outputs. Final scores are used for authentication decision-making [3], [7].
5. Evaluate performance using Equal Error Rate (EER), Receiver Operating Characteristic (ROC), and other standard biometric metrics.

This pipeline combines geometric (face) and textural (palm) features across multiple classifiers, enabling a robust multimodal authentication framework resilient to occlusion and spoofing.

What the Results Reveal

- Multimodal fusion of face and palmprint modalities improves overall verification performance, particularly under occlusion scenarios such as facial masks or glasses, supporting H1 and RQ1.
- Figure 1 shows a sharp separation between genuine and impostor face scores, suggesting strong facial discriminability under ideal conditions.
- Figure 2 reveals more overlap in palmprint score distributions, indicating higher false accept/reject rates compared to face. However, palmprints remain valuable due to their robustness against occlusions.
- Fusion results (Fig. 3) demonstrate that the multimodal system balances EER, FAR, and FRR, yielding performance that outperforms palm-only and remains resilient to occlusion, aligning with H2 and RQ2.

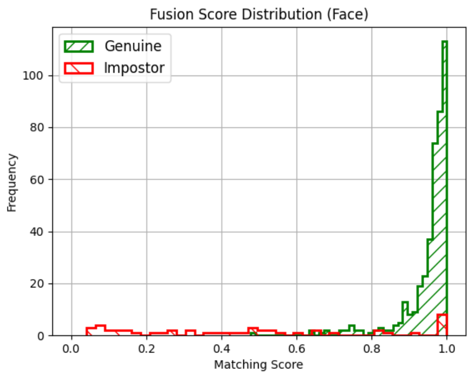


Figure 1: Distribution of matching scores for genuine vs impostor pairs — clear separation for face modality.

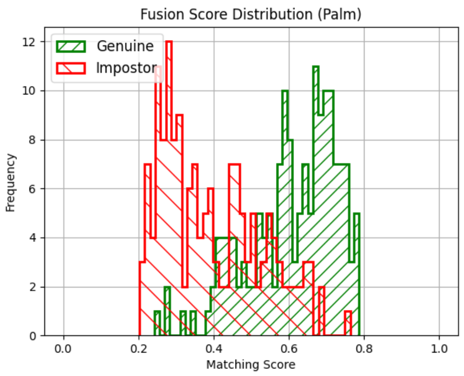


Figure 2: Palm scores show more overlap between impostor and genuine classes, indicating lower discriminative power.

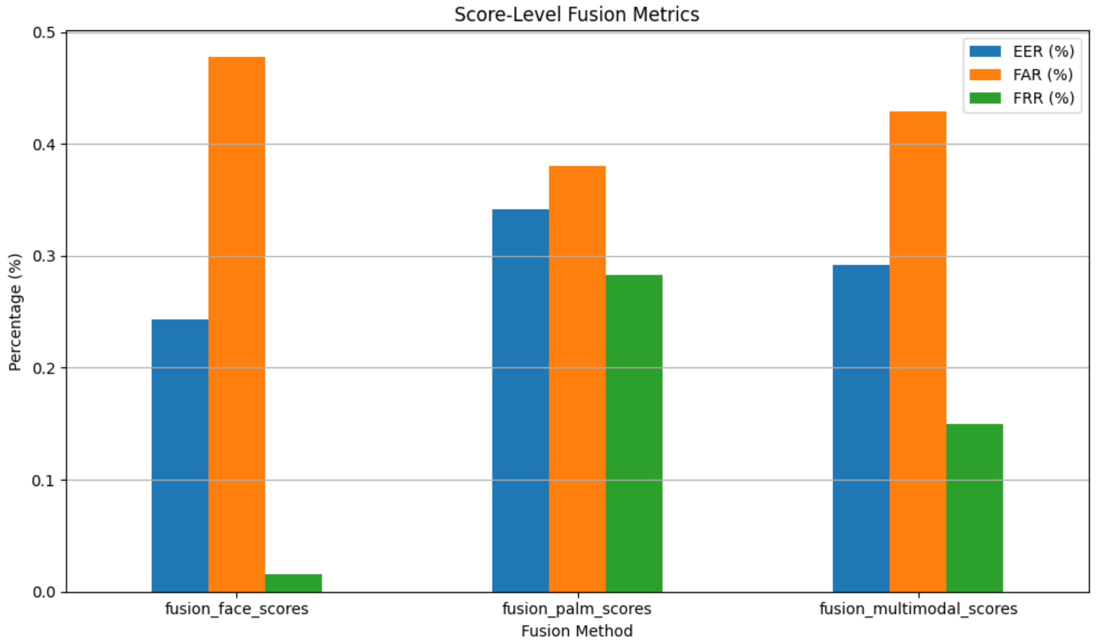
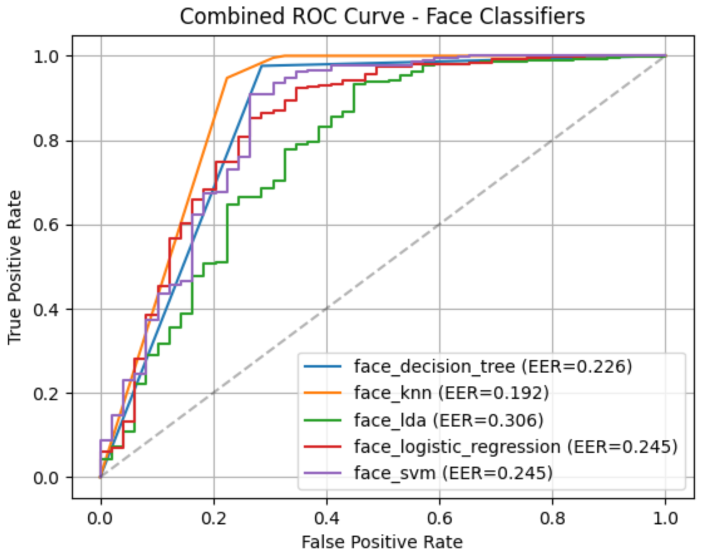
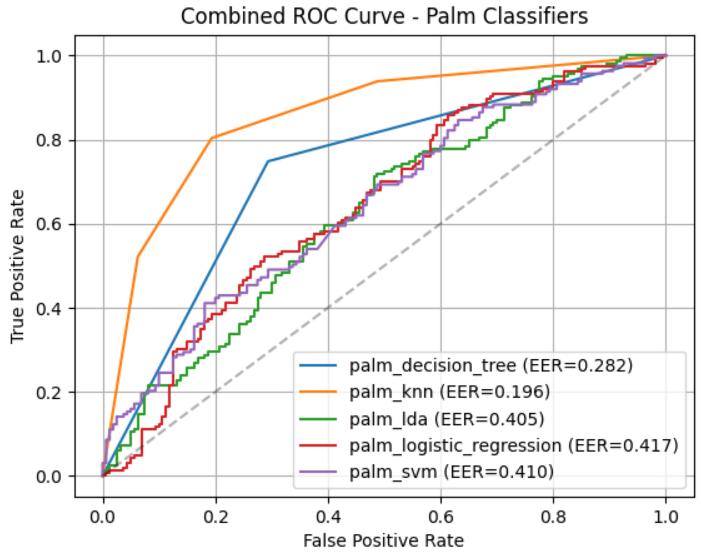


Figure 3: Score-level fusion metrics — multimodal system balances EER, FAR, and FRR across conditions.

Performance Evaluation Insights

- Face classifiers generally outperform palmprint classifiers in terms of lower EER.KNN for face achieved the best EER at 0.192, suggesting strong discriminability.
- Palm classifiers, especially SVM and LDA, showed higher EER, reflecting lower separability between classes.
- This variation confirms that face modality is more discriminative, while palmprint provides complementary robustness.
- Multimodal fusion (covered in next slide) leverages the strength of face and the resilience of palm, providing a balanced solution.

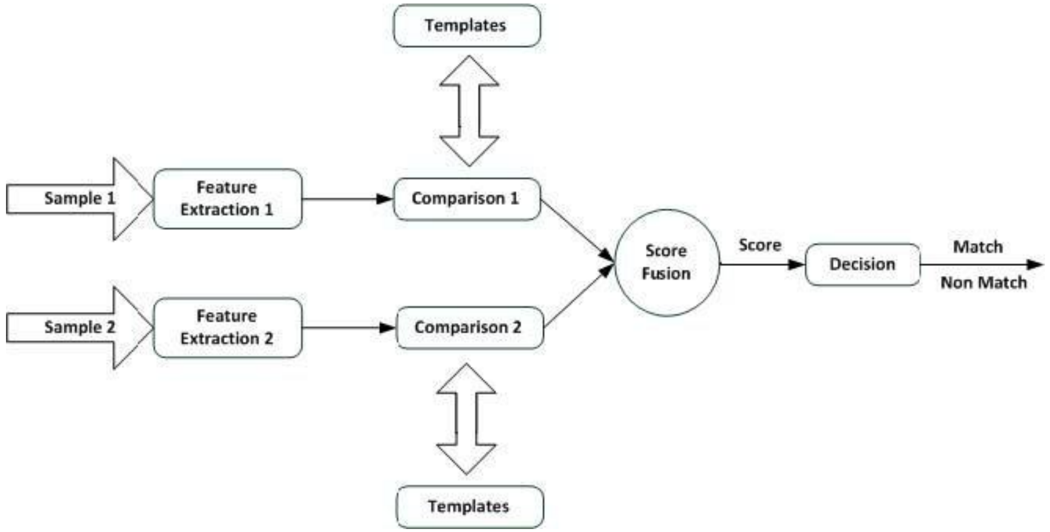


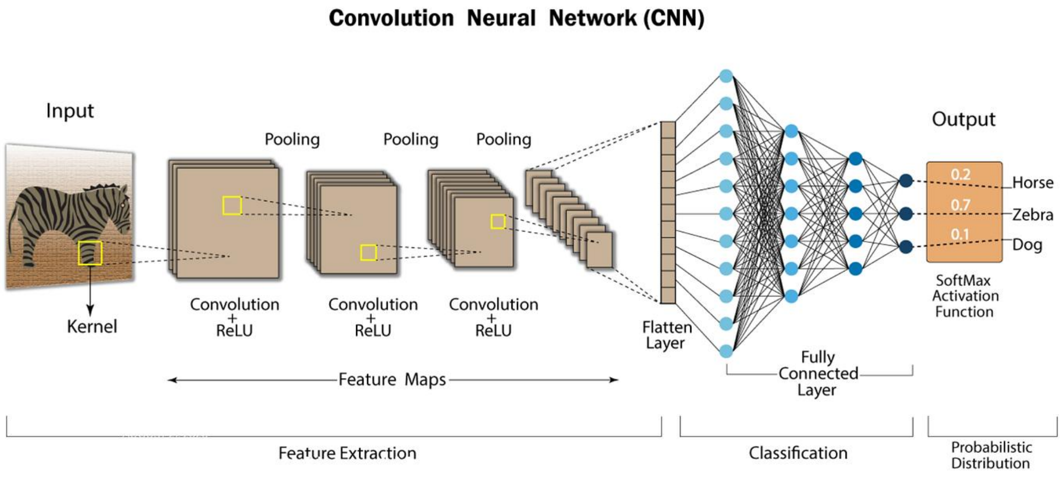


Face classifiers demonstrate higher discriminability (lower EER), while palm classifiers offer robustness under occlusion — supporting the case for multimodal fusion.

Interpretation and Impact

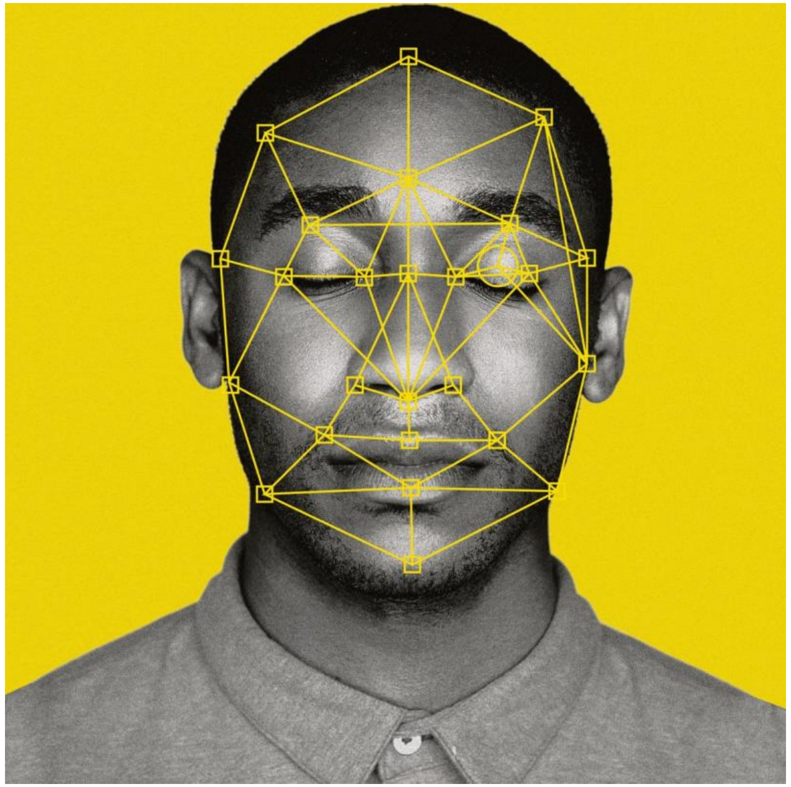
- The integration of face and palmprint recognition mitigates the weaknesses of each modality, enhancing authentication accuracy in real-world scenarios [4], [8].
- Score-level fusion, which combines outputs from each classifier, offers a balance between performance and computational efficiency, as supported by prior studies [3].
- Classifiers such as SVM and LDA are particularly well-suited for this task due to their robustness in high-dimensional feature spaces [2].
- Future enhancements could explore deep learning model such as Convolution Neural Network to dynamically weigh classifier outputs and improve generalization across diverse datasets.





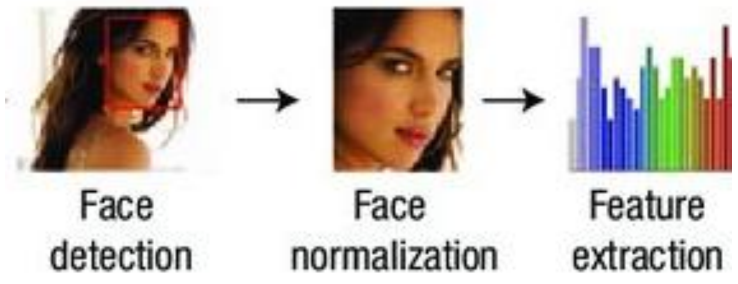
Ethical Considerations in System Design

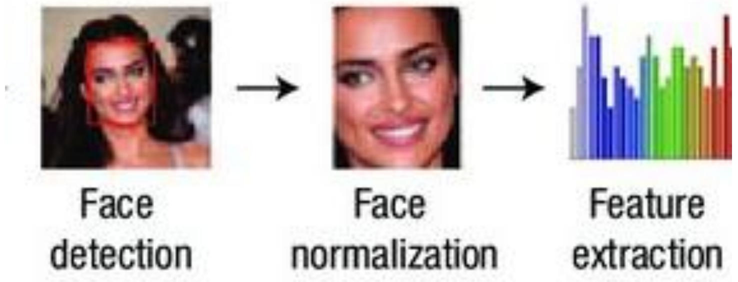
- The datasets employed in this project are anonymized, publicly accessible, and released with informed consent from participants, ensuring ethical compliance [5], [6].
- The system avoids the collection of personally identifiable information and incorporates audit logging to support transparency and accountability in authentication attempts.
- Palmprint recognition, being less affected by facial occlusions, contributes to fairness across diverse user demographics and helps reduce performance disparities [4].
- The system design adheres to biometric ethics frameworks, including secure template protection, consent-aware usage, and equitable access [7].

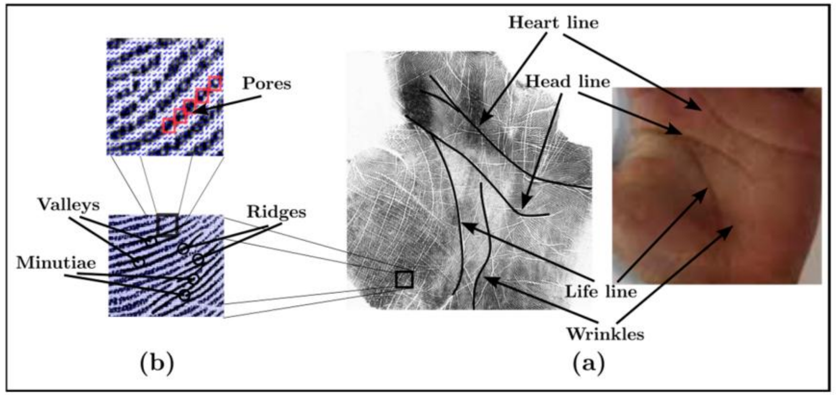


Summary and Future Directions

- The fusion of facial and palmprint modalities significantly enhances the resilience and accuracy of biometric authentication systems under occlusion-prone conditions [4], [8].
- Multimodal systems reduce false rejection rates and offer greater robustness compared to unimodal systems, particularly those relying solely on facial recognition [2], [3].
- These findings support the development of privacy-conscious, bias-aware, and ethically grounded biometric technologies.
- Future work will explore real-time deployment, deep neural network architectures, and the expansion of datasets to improve demographic diversity and scalability.







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