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Privacy-preserving Workload Reduction of Biometric Systems

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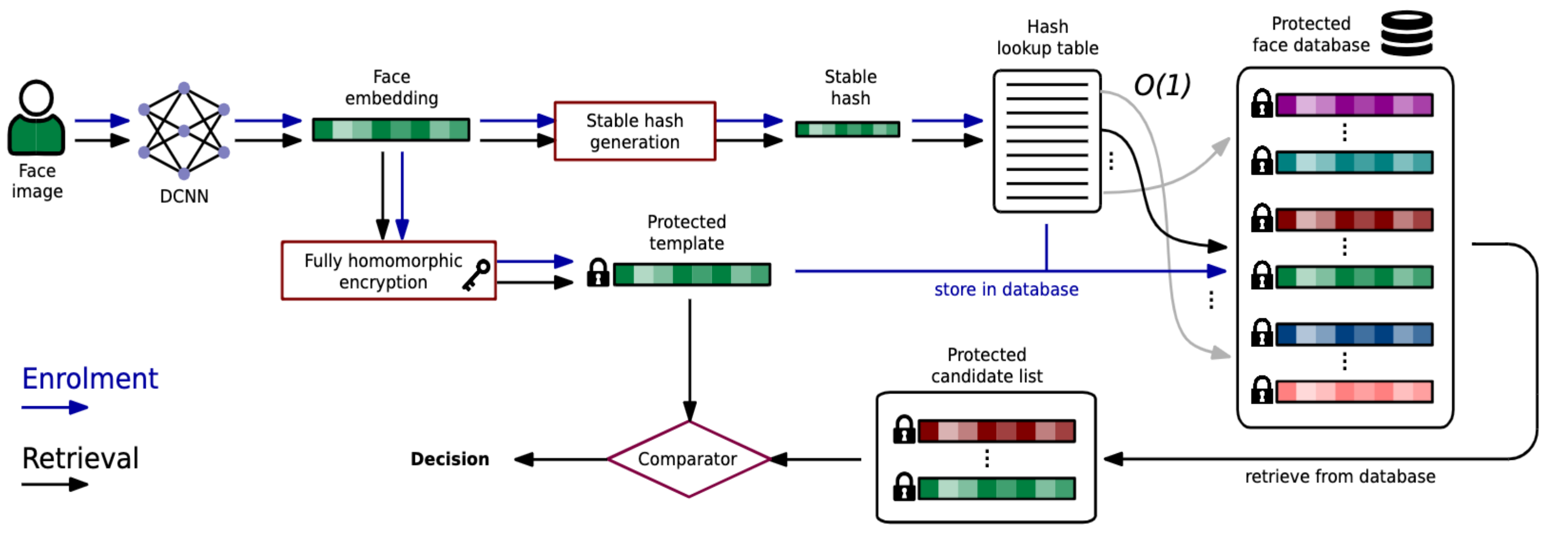
Introduction

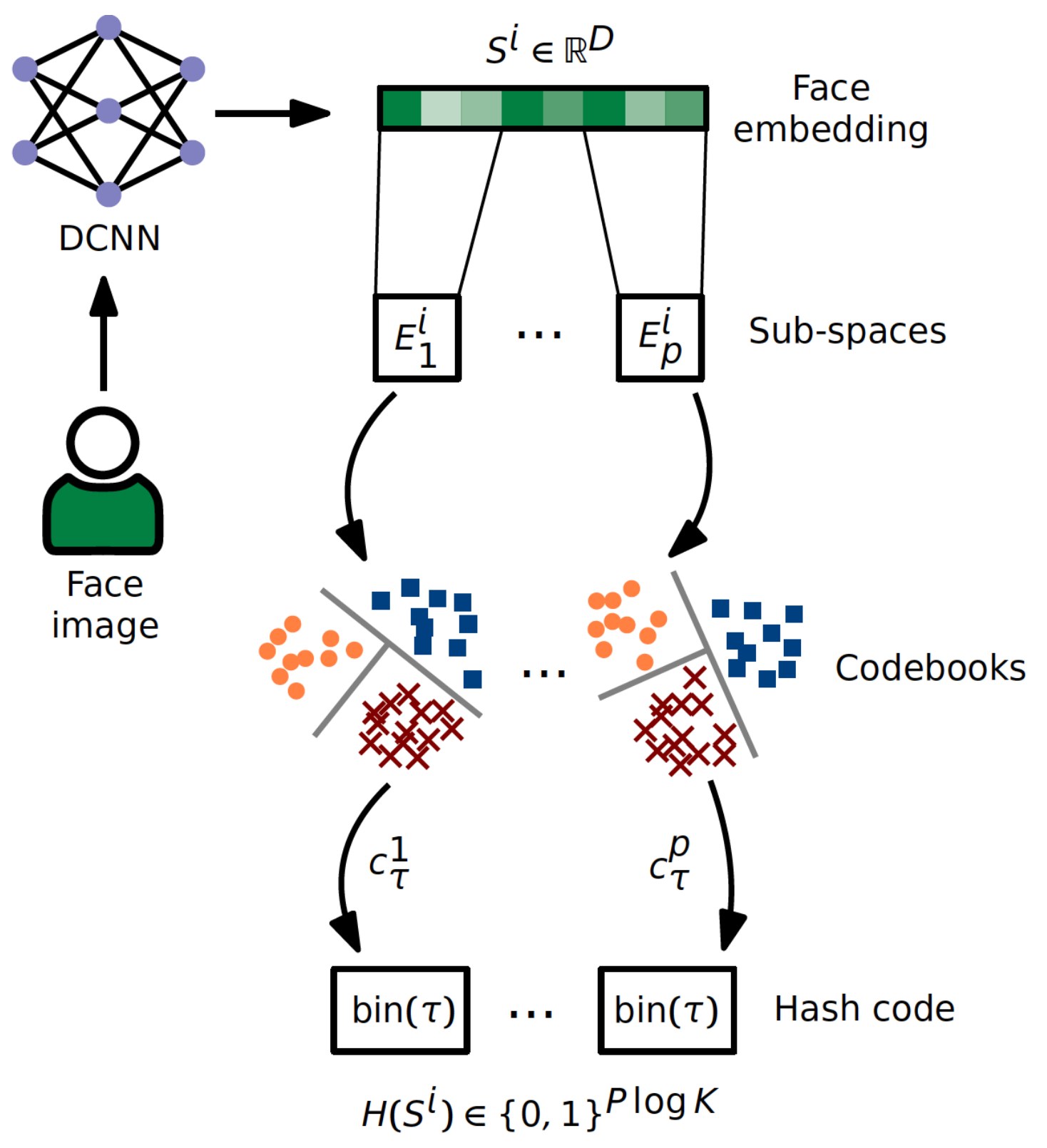
- **Identification scenario**: The "process of searching against a biometric enrolment database to find and return the biometric reference identifier(s) attributable to a single individual" (1:many).
- Time-consuming tasks dominated by the number of comparisons.
- Biometric technologies demand interoperability and deployment assuring maximum usability by including multi-modal biometric solutions.
- Biometric template protection schemes (BTPs) appear to be unsuitable for indexing in biometric identification systems.
- Need of BTP- and modality-agnostic indexing schemes.

- **Security and data privacy**
- Findings on new vulnerabilities in facial soft-biometric privacy enhancement.
- Privacy-preserving indexing schemes are designed to offer an end-to-end protection (i.e. from the template to the indexing scheme).

Selected Results



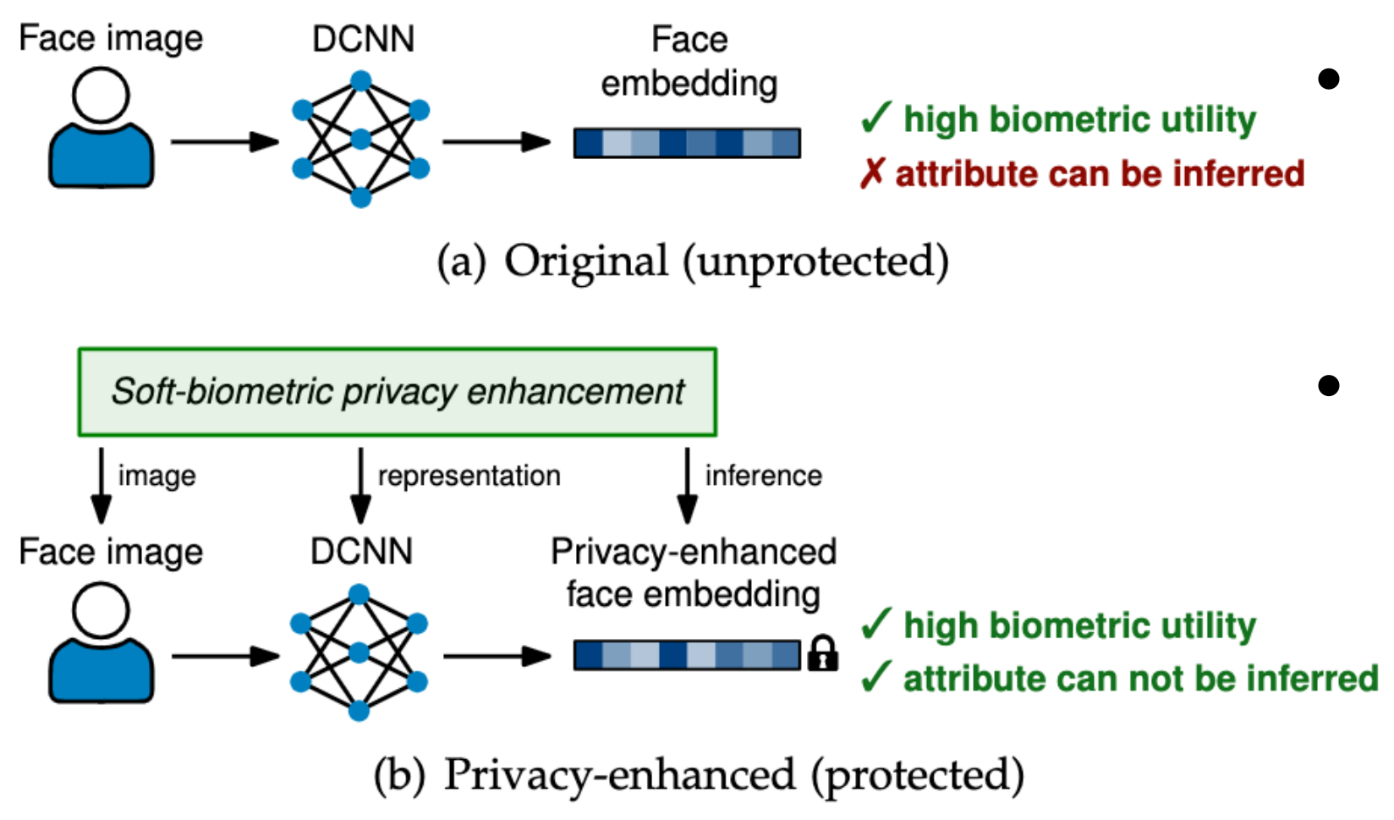
Identification system with Stable Hashes and Fully Homomorphic Encryption



Hash Generation Scheme

- Privacy-preserving face identification system for indexing and retrieval of protected face templates [1].
- Application of *Fully Homomorphic Encryption* in identification scenarios.
- *Not* to the exhaustive searches: search in O(1), *Not* to the dimensionality reduction.
- *Stable face hashes* through the Product Quantisation-based and clustering-based look-up table are analysed.
- Application of *conventional cryptographic methods* is feasible since the system enables an *exact match* (*non-fuzzy* comparison) of hash codes.
- *Workload reduction* down to 0.1% of a baseline approach (i.e. exhaustive search).

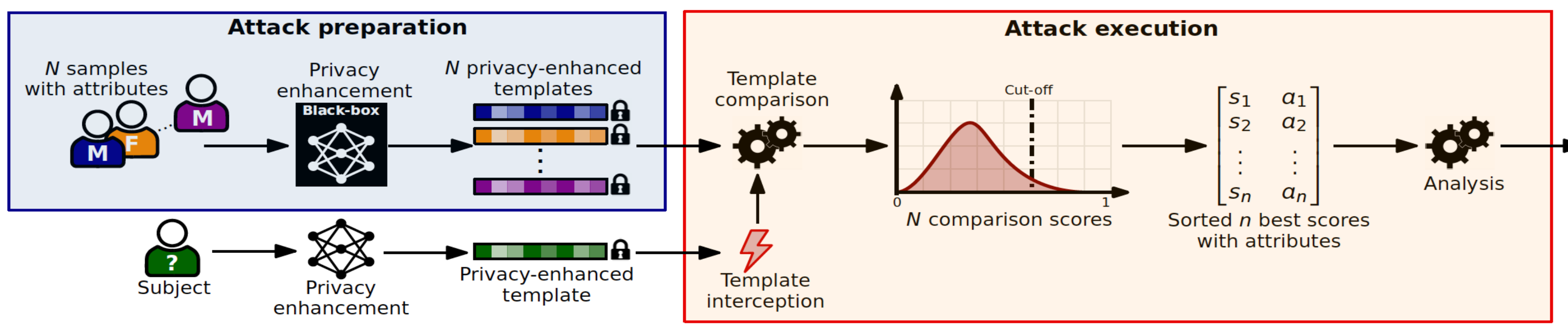
- An attack on Facial Soft-biometric Privacy Enhancement is shown in [2].


Face image
DCNN
Face embedding
✓ high biometric utility
✗ attribute can be inferred
Soft-biometric privacy enhancement
image
representation
inference
Face image
DCNN
Privacy-enhanced face embedding
✓ high biometric utility
✓ attribute can not be inferred

(a) Original (unprotected)

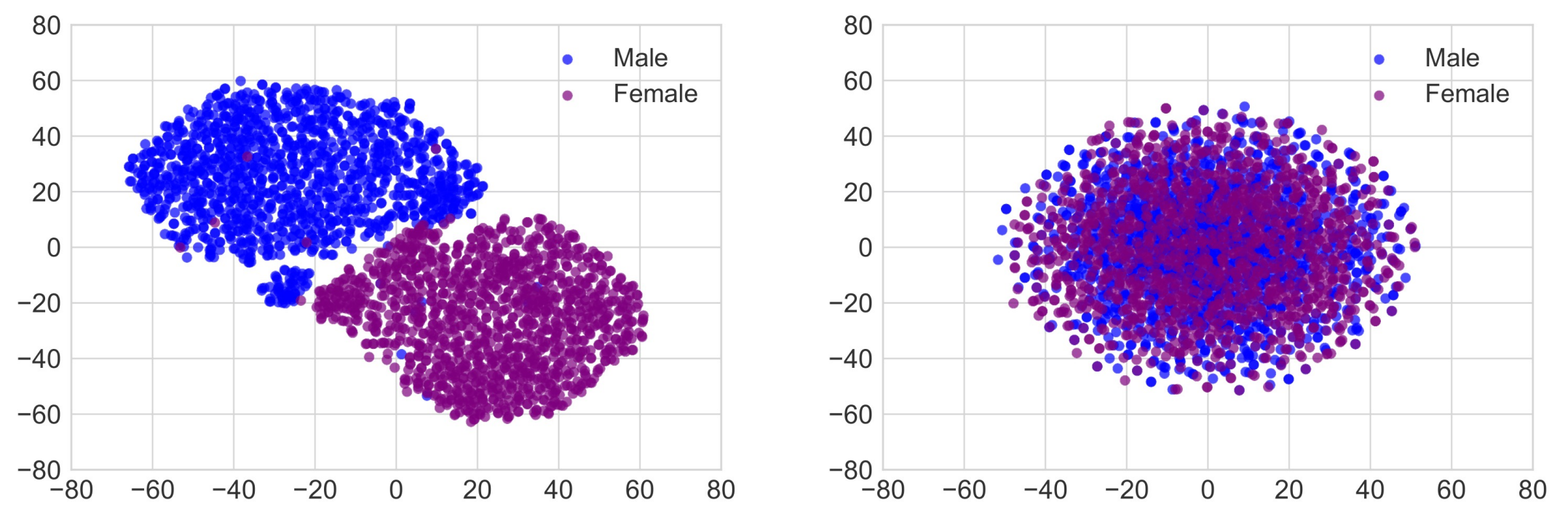
(b) Privacy-enhanced (protected)

- Exploiting the effect of broad homogeinity and demographic differential in face recognition.
- Analysis of the false match chances leading to the execution/design of these attacks.



Overview of the attack

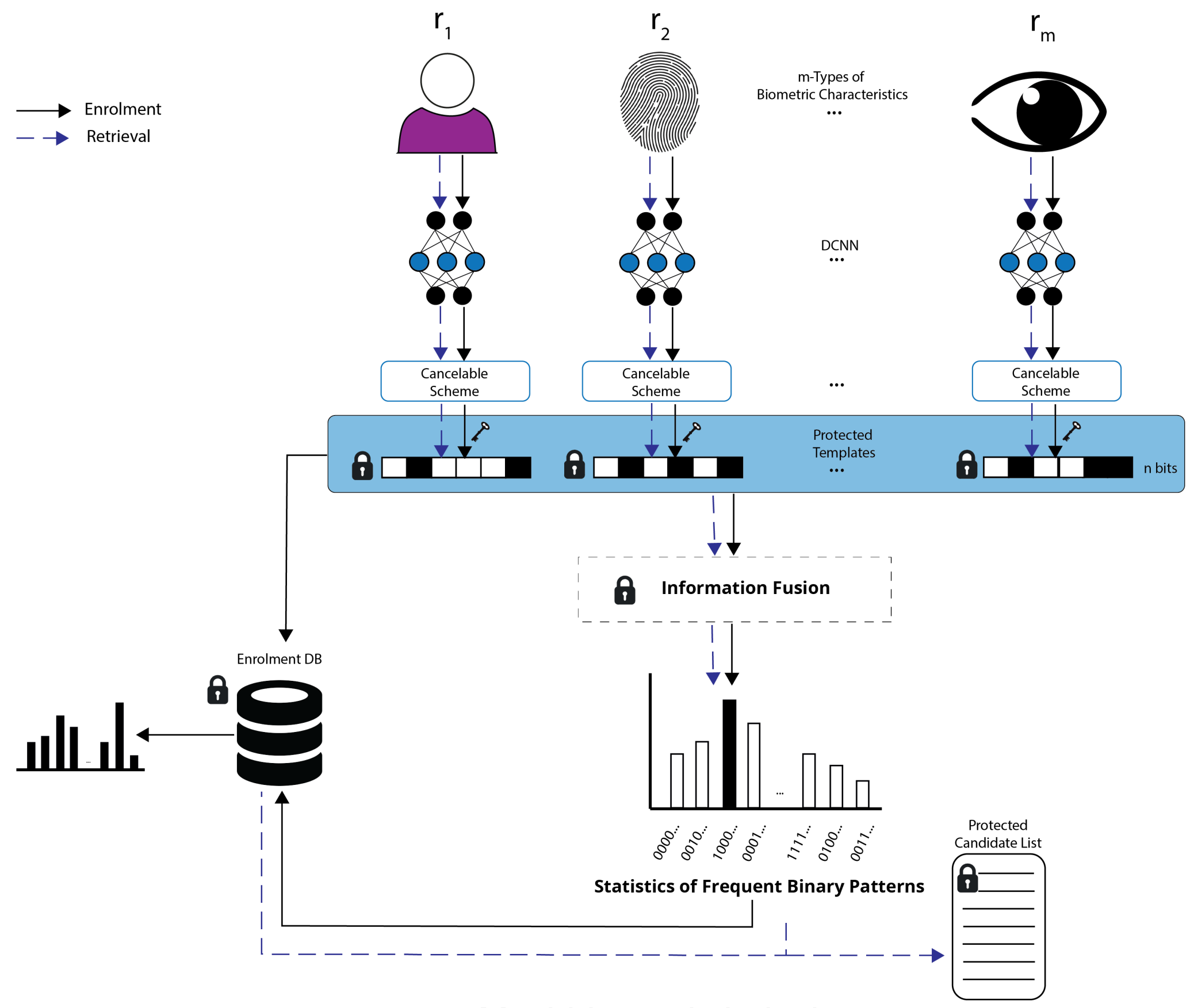
- Unknown attribute is inferred from the attributes associated with the highest obtained similarity scores.
- Classification on gender with an accuracy of up to approximately 90%.
- Rigorous analysis is necessary to measure the actual privacy enhancement provided by such techniques.



Unprotected space

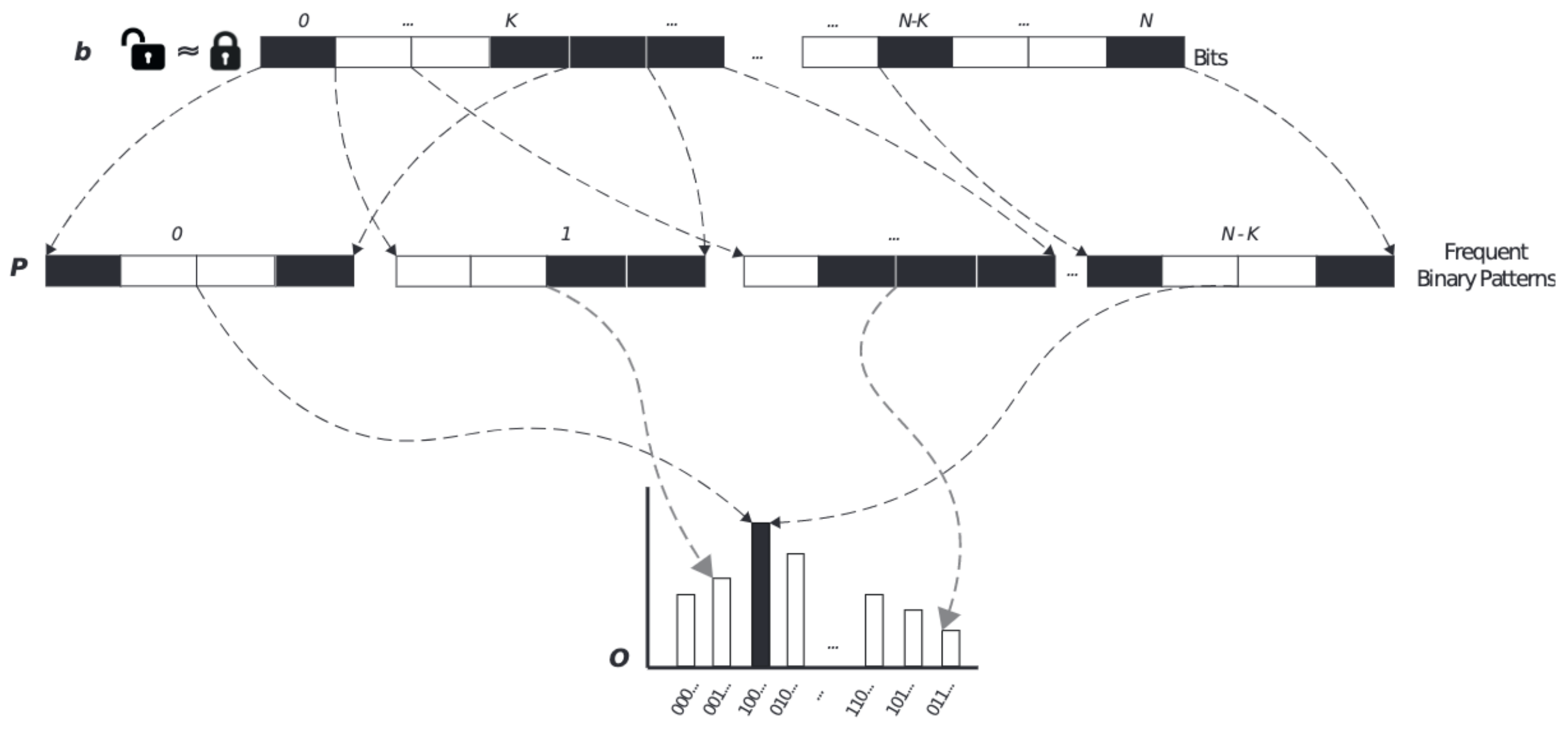
Protected space

- Protection capabilities are tested using machine learning-based classifiers and dimensionality reduction tools.
- They are not enough!



Multi-biometric indexing

- Cancelable schemes with base of binary representation: BioHashing and IoM-GRP.
- State-of-the-art DNN-based embedding extractors with 512-floating values.
- Evaluation on the three most commonly used biometric modalities (Face, Iris, and Fingerprint).



Frequent binary pattern extraction

- Cancelable biometric template protection scheme- and modality-agnostic indexing scheme.
- Successful application of the proof-of-concept of frequent binary patterns on individual biometric characteristics.
- Fusion strategies on the concept of frequent binary patterns at two steps: the representation- and feature-based step.
- Computational workload reduction is reduced to approximately 57% (indexing up to 3 modalities) and 51% (indexing up to 2 modalities).
- Improvement of the biometric performance at the high-security thresholds of a baseline biometric system.

Own Publications

[1] Dailé Osorio-Roig, Christian Rathgeb, Pawel Drozdowski, Christoph Busch, “Stable Hash Generation for Efficient Prvacy-Preserving Face Identification”, in Transactions on Biometrics, Behavior, and identity Science (TBIOM), July 2021.

[2] Osorio-Roig D, Rathgeb C, Drozdowski P, Terhörst P, Štruc V, Busch C. An Attack on Facial Soft-biometric Privacy Enhancement. IEEE Transactions on Biometrics, Behavior, and Identity Science. 2022 May 9.

[3] D.Osorio-Roig, T.Schlett, C.Rathgeb, J.Tapia, C.Busch “Exploring Quality Scores for Workload Reduction in Biometric Identification”, International Workshop on Biometrics and Forensics (IWBF), Salzburg, Austria,2022.

[4] D. Osorio-Roig, C. Rathgeb, H. Otroshi-Shahreza, C. Busch, S. Marcel, Indexing Protected Deep Face Templates by Frequent Binary Patterns, in International Joint Conference on Biometrics (IJCB), 2022.

[5] D. Osorio-Roig, T. Rohwedder, C. Rathgeb, C. Busch, Analysis of Minutiae Quality for Improved Workload Reduction in Fingerprint Identification, in Proc Intl. Conf. of the Biometrics Special Interest Group (BIOSIG), 2022.

[6]Tim Rohwedder and Daile Osorio-Roig and Christian Rathgeb and Christoph Busch, “Benchmarking fixed-length Fingerprint Representations across different Embedding Sizes and Sensor Types”, in Proc Intl. Conf. of the Biometrics Special Interest Group (BIOSIG), 2023.

[7] Reversing Deep Face Embeddings with Probable Privacy Protection (under revision).

[8] Optimizing Key-Selection for Face-based One-Time Biometrics via Morphing (under revision).

[9] Privacy-preserving Multi-biometric Indexing based on Frequent Binary Patterns (under revision).

EAB - Protecting Your Data in Biometric Systems

Participate in the survey “*Protecting your data in biometric systems*”

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