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Indexing Protected Deep Face Templates by Frequent Binary Patterns

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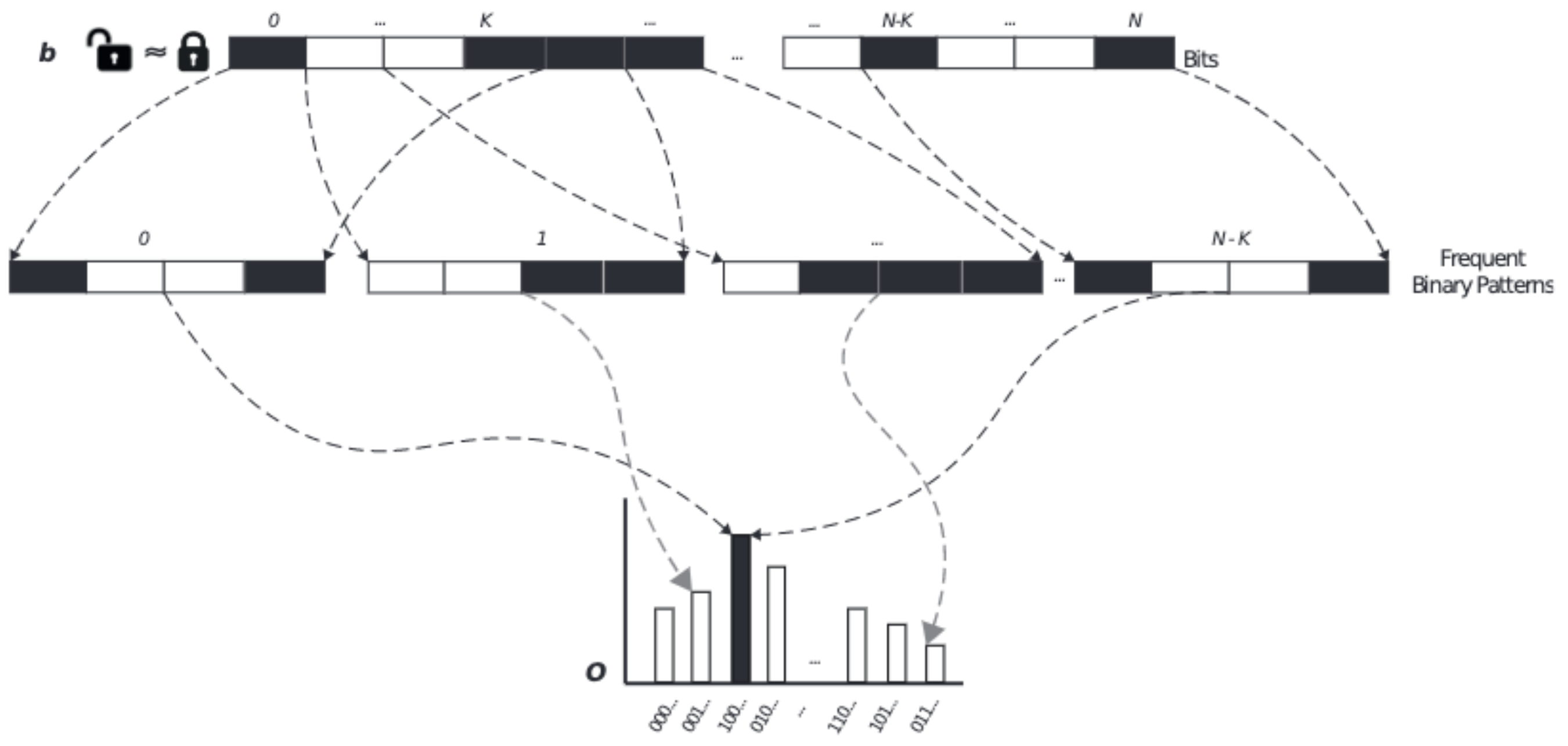
Introduction

In the context of face biometrics, researches have mainly focused on cancelable biometrics for identification systems. Some observations can be analysed:

- computational costs in these schemes, which apply a typical exhaustive search-based identification, tend to grow linearly with the number of enrolled subjects.
- most of the cancelable schemes introduce the randomness to fulfill BTP requirements defined by the ISO/IEC 24745 standard (i.e. renewability, unlinkability, irreversibility) yielding binary representations-based features.

i. Explore whether the most frequent binary patterns over cancelable templates could be most stable and sufficient for indexing.
ii. First proposal of search space-reducing ***Workload Reduction*** scheme for deep face templates protected by well-known cancelable biometric schemes.
iii. Experimental results showcase that the proposed scheme is agnostic w.r.t the applied cancelable schemes.

Proposed Scheme



- Frequent binary pattern extraction: a set **P** of binary patterns are extracted from N bits; subsequently, frequent patterns are defined to their corresponding number of occurrences in N.

Computational Workload Reduction

$$\mathcal{W} = \sum_{i=1}^{z} |l_i|$$

Experimental Setup

Cancelable schemes

- BioHashing
- IoM with Uniformly Random Permutation (IoM-URP)
- IoM with Gaussian Random Projection (IoM-GRP)
- Original face embeddings are used as baseline (unprotected system)

Identification experiments

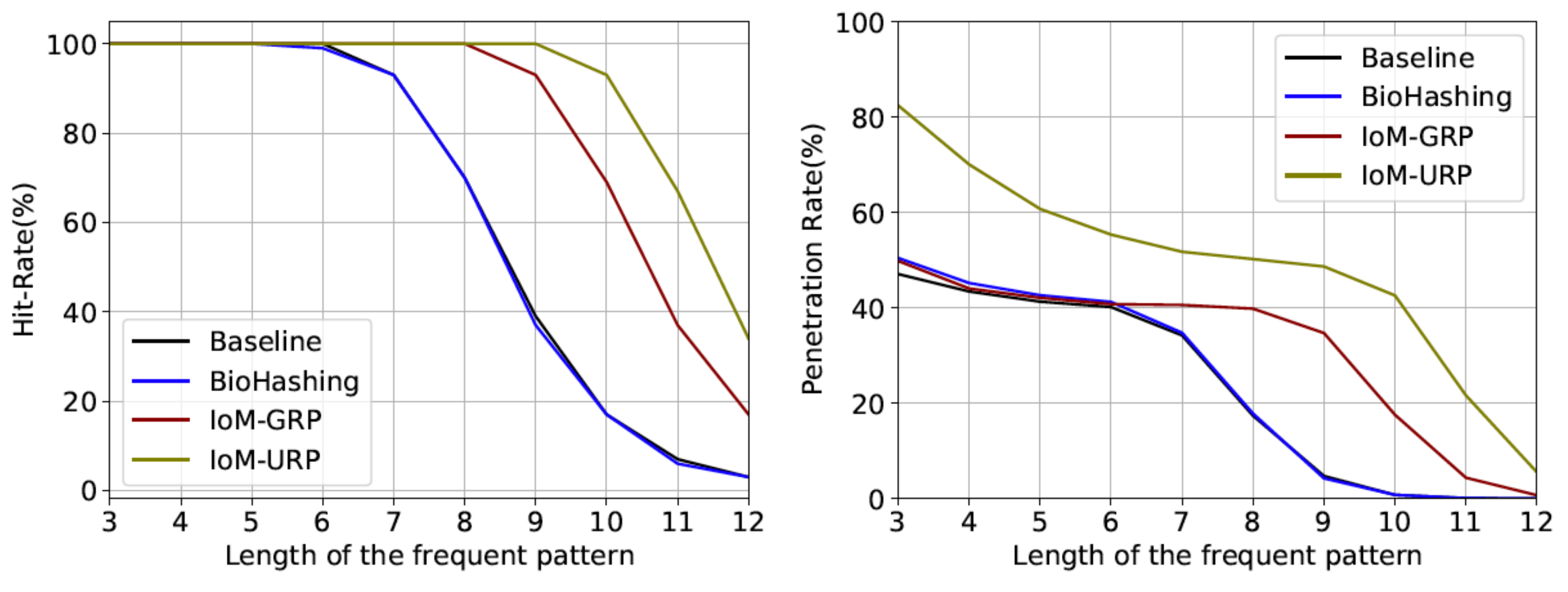
- Closed-set scenario (sub-sampling of 10 rounds)
- Open-set scenario (10-folds cross-validation)
- Normal and stolen-token scenarios
- Baseline workload of an identification system is considered to be an exhaustive search, i.e. a biometric probe is compared against all references enrolled in the database.
- Experiments are conducted on LFW database containing 1,680 in enrolment

Metrics

- **Biometric performance**: for closed-set scenario, the hit-rate(H-R); for open-set scenario, the detection error trade-off (DET) curves.
- **Computational workload**: penetration rate (P-R) and the necessary number of comparisons per identification transaction.

Experimental Results

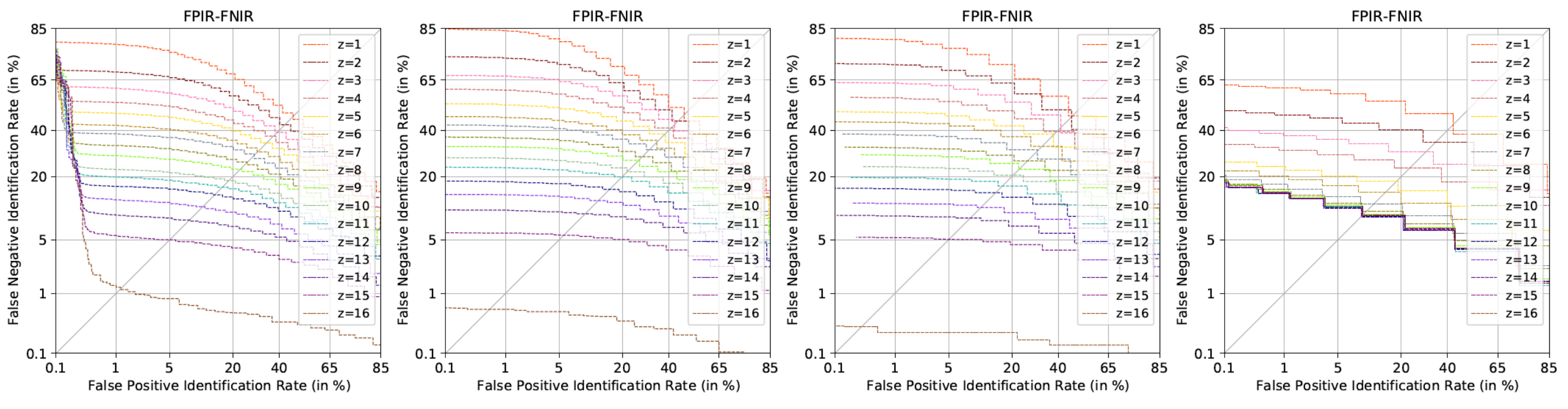
Closed-set scenario evaluation



(a) H-R – Normal scenario (b) P-R – Normal scenario

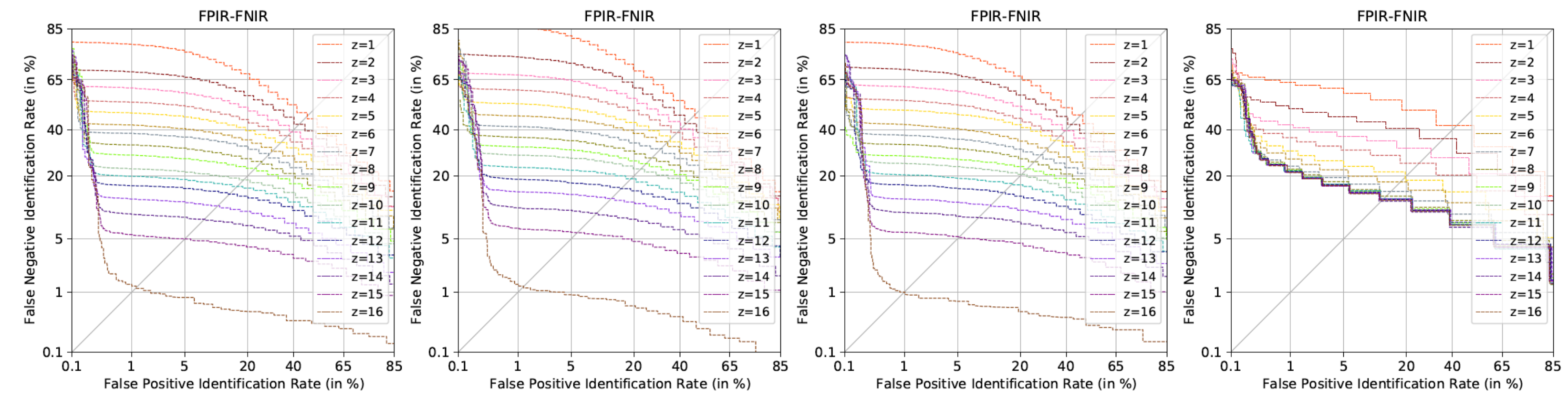
- It can be perceived that the curves can be maintained at almost 100% H-R up to a certain length of the frequent pattern depending on the cancellable scheme.
- P-R can be reduced to approximately half (i.e. P-R < 52%) of the baseline workload, while maintaining a high H-R.

Open-set scenario evaluation



(a) Unprotected baseline (b) BioHashing (c) IoM-GRP (d) IoM-URP

Normal Scenario



(a) Unprotected baseline (b) BioHashing (c) IoM-GRP (d) IoM-URP

Stolen-token Scenario

- Evaluating the effect of the parameter z over challenging scenarios.
- A fixed length of frequent pattern, i.e. $K = 4$, and z ranging in [1,16].
- Biometric performance improves as the maximum number of visited bins corresponding to the most frequent binary patterns from the probe (z) increase.

BTP approach	Normal-scenario			Stolen-token-scenario		
	FNIR@FPIR=1.0%	z	P-R(%)	FNIR@FPIR=1.0%	z	P-R(%)
Unprotected baseline	19.76	11	66.08	19.76	11	66.08
BioHashing	23.30	11	66.27	23.14	11	66.44
IoM-GRP	19.57	11	66.28	20.37	11	66.61
IoM-URP	22.33	5	87.90	29.99	5	88.59

- Summary of the best results over open-set evaluation for normal and stolen-token scenarios, respectively.
- For a FNIR@FPIR = 1.0%, the system achieves a rejection rate for genuine identification transactions of less than 24%, while reducing to approximately 66% of the workload over open-set scenarios.

Future work

- Extend the proposed system to multi-biometrics where frequent binary patterns will be extracted from multiple biometric characteristics.

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