Turning a Vulnerability into an Asset: Accelerating Facial Identification with Morphing

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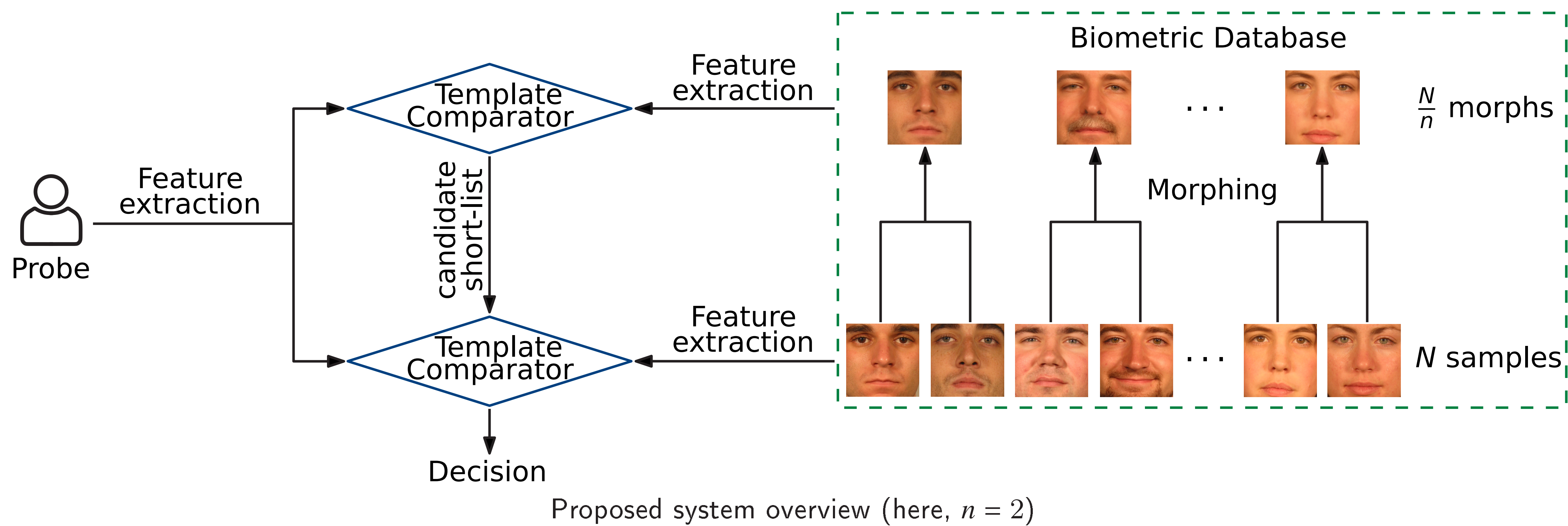
System Overview

Proposed system overview (here, $n = 2$)

Introduction & Motivation

Background

For large-scale biometric systems, the high computational workload and chance of false positives caused by a naïve, brute-force *identification* (i.e. 1 to N search) algorithm quickly becomes unacceptable as the size of the enrolment database increases.

Contribution

In this work, two hitherto unrelated areas of biometric research are combined in a proof-of-concept manner to facilitate a more efficient search:

1. Computational workload reduction in biometric identification.

2. Facial image morphing.

Experimental Setup

- FERET image database, ICAO compliant images only.

- Face recognition with FaceNet and ArcFace using pre-trained models.

- Cross-validation over 10 folds.

- $n \in \{2, 4, 8\}$ samples morphed together for the pre-selection using open-source tools.

- $N = 400$ enrolled subjects, and varying number $k \in \{1 \ldots \frac{N}{n}\}$ of the pre-selected candidate short-list.

- Evaluation in terms of hit rate (HR), penetration rate (PR), and rank-1 identification rate (RR-1).

Subject 1   Morph   Subject 2

Acknowledgements
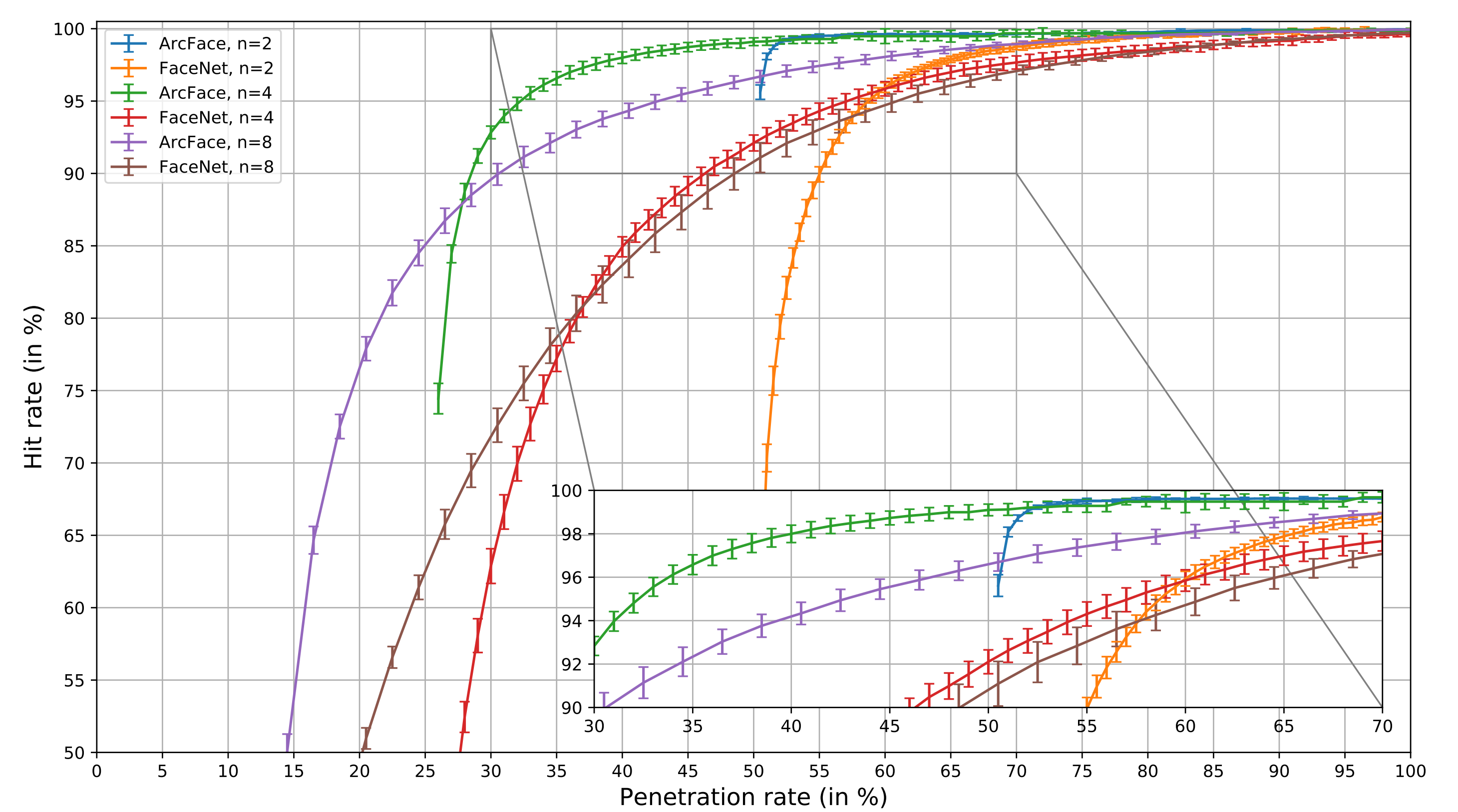
Results

Trade-off between hit rate and penetration rate (with 95% confidence interval)

Pre-selection results

Feature Extractor	n	PR at		
		95% HR	99% HR	99.5% HR
ArcFace	2	50.5%	52.0%	55.0%
	4	32.0%	48.0%	57.0%
	8	42.5%	70.5%	80.5%
FaceNet	2	57.0%	86.0%	95.0%
	4	42.5%	70.5%	80.5%
	8	60.5%	86.5%	94.5%

Two-stage system results

Feature Extractor	n	k	RR-1	PR
ArcFace	2	5	98.82% ± 0.12%	52.5%
	4	20	97.57% ± 0.26%	45.0%
	8	25	96.09% ± 0.19%	50.0%
FaceNet	2	30	96.97% ± 0.31%	65.0%
	4	30	93.61% ± 0.56%	55.0%
	8	30	96.51% ± 0.26%	72.5%

Baseline results

Feature Extractor	RR-1	PR
ArcFace	99.18% ± 0.11%	1.0
FaceNet	98.84% ± 0.16%	

- Penetration rate can be effectively reduced to **50%** without significantly impairing the biometric performance of ArcFace w.r.t. the baseline.

- The penetration rate reduction causes a noticeable biometric performance degradation of FaceNet w.r.t. the baseline.

- Even when morphing more than 2 samples, enough biometric information is retained to facilitate recognition.

Future Work

This proof-of-concept work could be extended, e.g. by considering:

- Other feature extractors and recognition frameworks, particularly commercial off-the-shelf systems.

- Additional morphing techniques and tools.

- Larger datasets.

- Intelligent morphing process (instead of random sample selection).

- Utilising morphing for the purposes of privacy protection.