



MICHIGAN STATE
UNIVERSITY

Altered Fingerprints: Detection and Localization



Elham Tabassi
tabassie@cse.msu.edu

Tarang Chugh
chugtar@cse.msu.edu

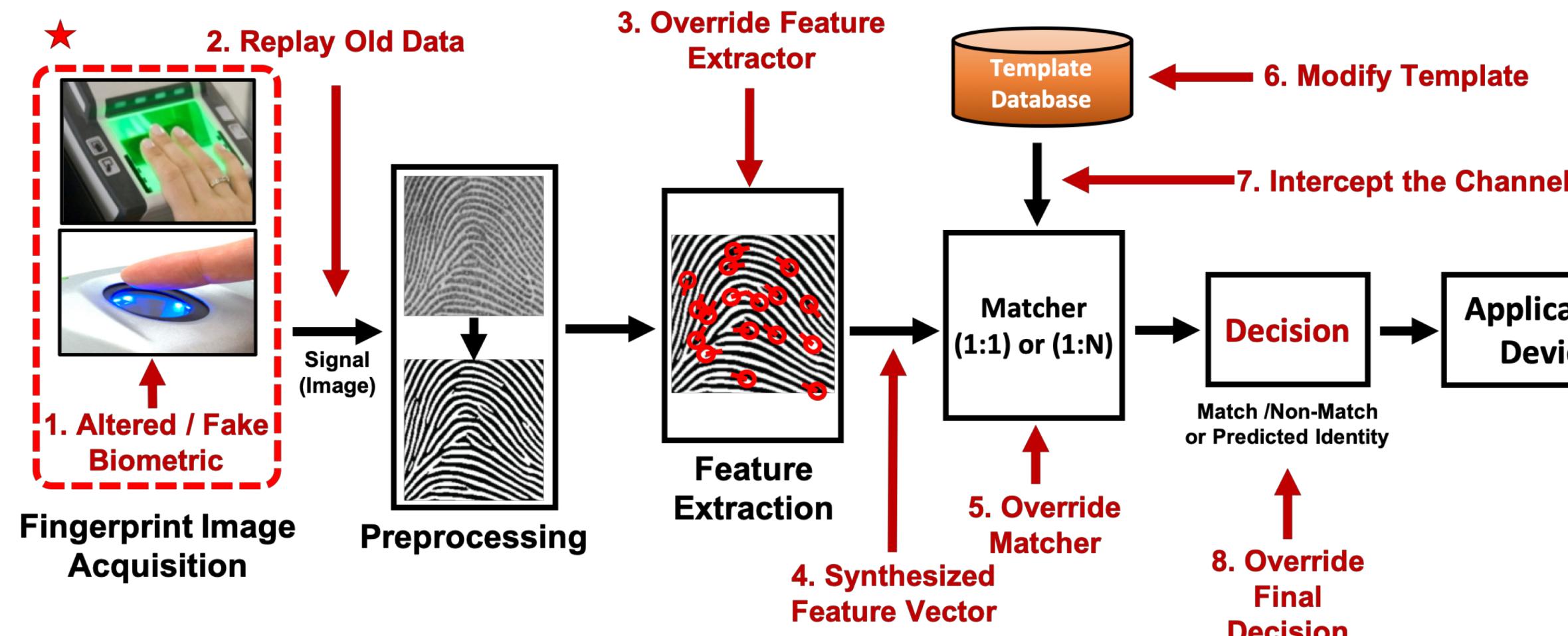
Debayan Deb
debdebay@cse.msu.edu

Anil K. Jain
jain@cse.msu.edu

Department of Computer Science and Engineering, Michigan State University

Introduction

Modules of a fingerprint recognition system and associated vulnerabilities



Altered Fingerprints: “Intentional destruction of friction ridge structures to obfuscate the true identity”

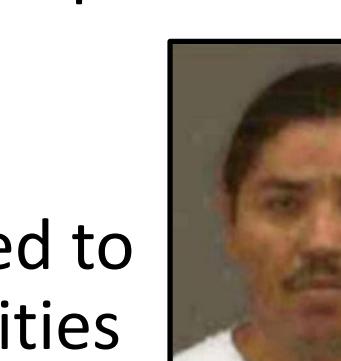


Motivation

In 2009, a Chinese woman underwent a surgery to alter her fingerprints to deceive the immigrant fingerprint system in Japan



Some asylum seekers to EU, torch skin off their fingertips so they can not be identified by AFIS (EURODAC)



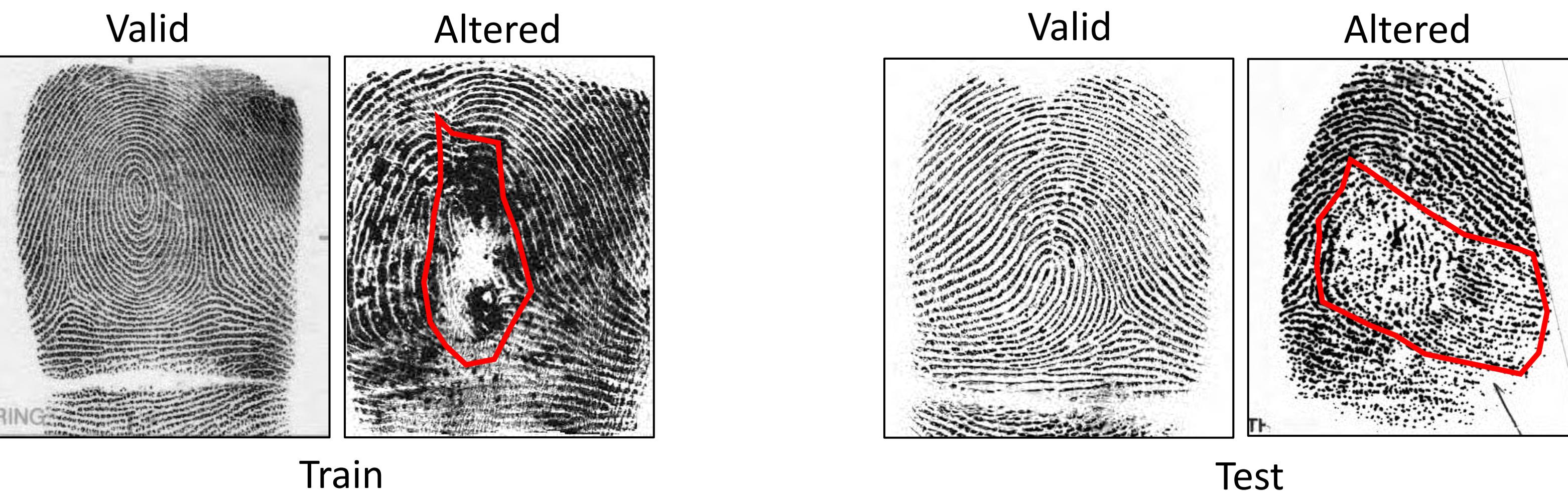
Eduardo Ravelo, part of FBI’s top-10 most wanted list (2017), is believed to have had a plastic surgery and altered his fingerprints to evade authorities

Previous Approaches

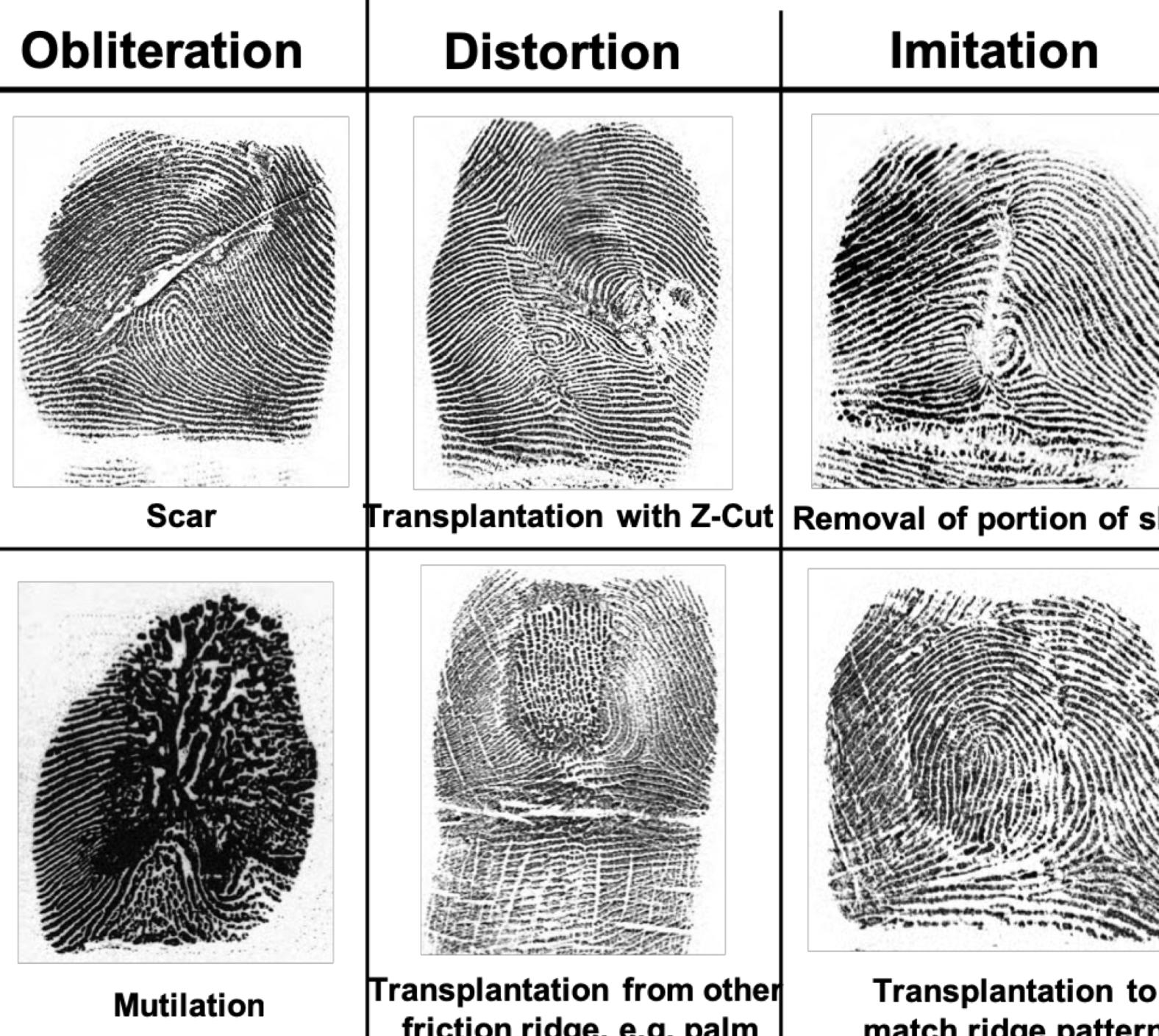
Study	Method	Altered Fingerprint Dataset	Performance
Feng, Jain, and Ross, 2010	Orientation Field	1,976 simulated altered fingerprints	TDR = 92% @ FDR = 7%
Tiribuzi et al., 2012	Minutiae density maps, orientation entropies	1,000 valid and synthetic altered fingerprints	Avg. Acc. = 90.4%
Yoon et al. [2012, 2013]	Orientation field, minutiae distribution	4,433 operational altered fingerprints	TDR = 70.2% @ FDR = 2.1%
Ellingsgaard and Busch, [2014, 2017]	Orientation field, minutiae orientation	116 altered fingerprints	TDR = 92% @ FDR = 2.3%

Proposed Approach

Altered Fingerprint Dataset

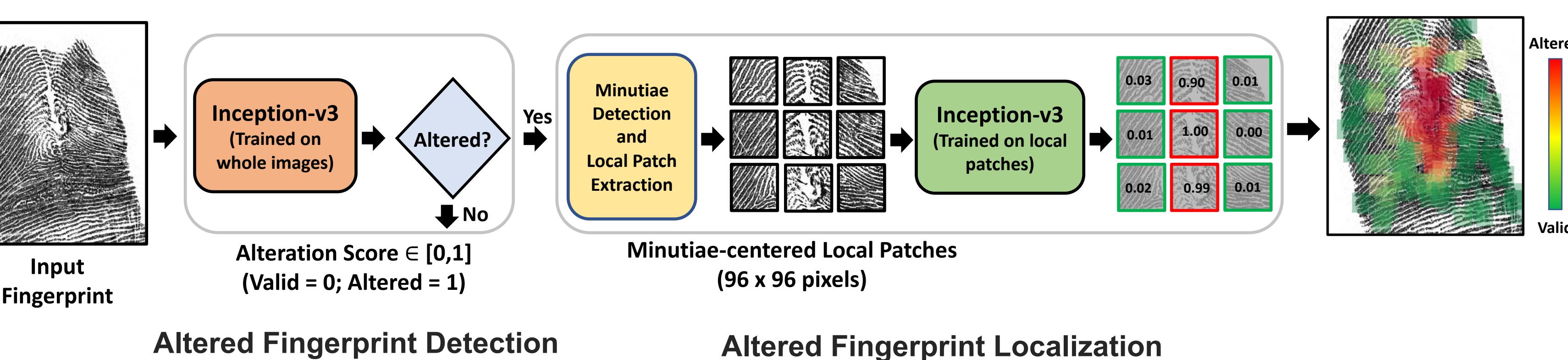


Altered Fingerprint Detection



Single CNN model for all three alteration types due to:

- Insufficient data for each alteration type,
- Manual labeling is subjective; multiple alterations may exist in single fingerprint image.



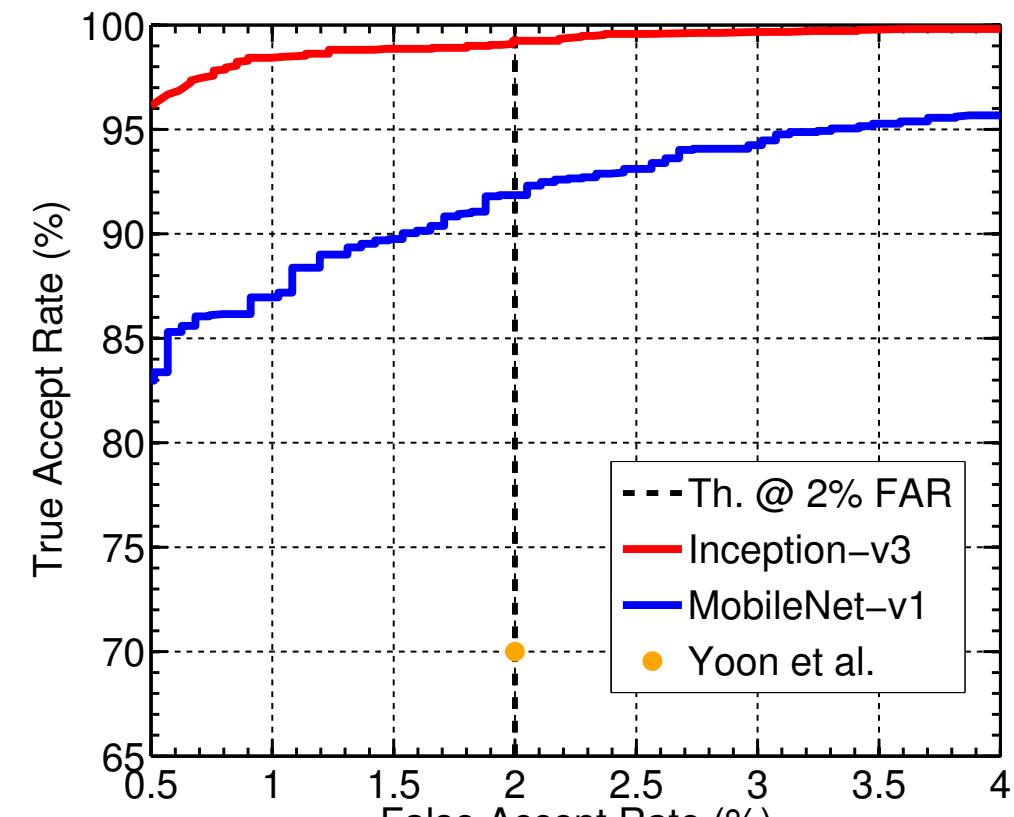
Experimental Results

- Achieved avg. TDR = 99.24% @ FDR = 2% across five folds (std. = 0.58%)

Evaluation time/image on NVIDIA 1080Ti GPU: 50ms (Inception-v3) and 6ms (MobileNet-v1)

Outperformed state-of-the-art approach (Yoon et al.) TDR = 70.2% @ FDR = 2.1% with similar sized operational database

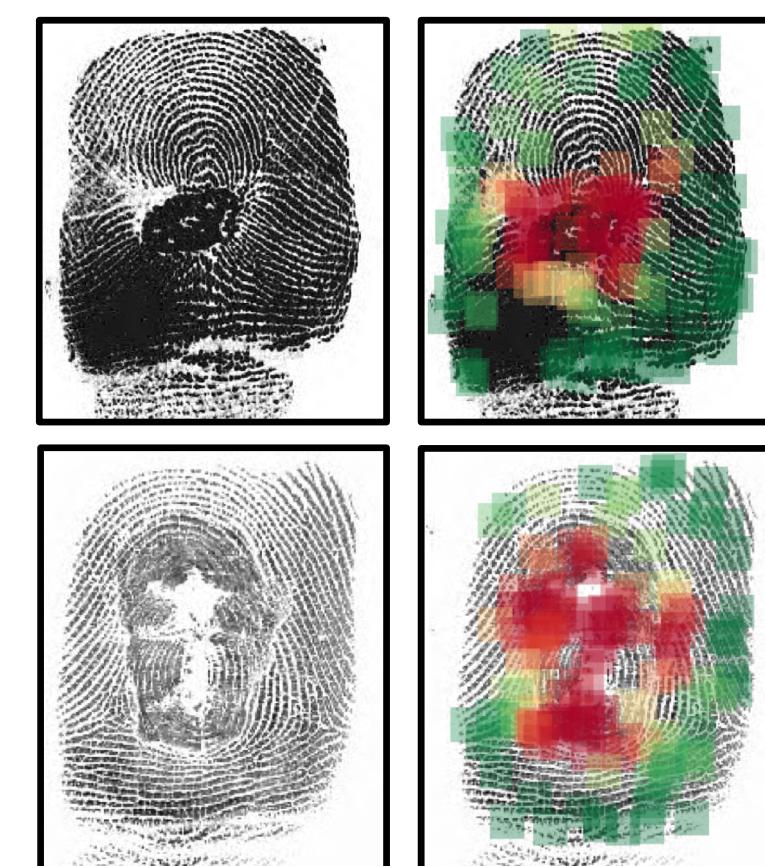
- Performance on *altered fingerprint localization*:
 - 2-fold cross validation on Altered/Valid patches (81,969 valid, and 89,979 altered); EER = 8.5%



Altered Fingerprint Detection

Ground Truth	Output	
	Valid	Altered
Valid	Alteration Score: 0.0	Alteration Score: 0.78
Altered	Alteration Score: 0.31	Alteration Score: 0.98

Altered Fingerprint Localization



Synthetic Altered Fingerprint Generation

To remedy the lack of publicly available altered fingerprint datasets, a Generative Adversarial Network (DC-GAN) is trained to generate synthetic altered fingerprints.

Synthetic Altered Fingerprints



Operational Altered Fingerprints



A total of 4,060 synthetic altered fingerprints are generated and open-sourced

Summary

- Proposed a robust and accurate method of altered fingerprint detection and localization
- Achieved a TDR = 99.24% @ FDR = 0.2% on an operational dataset of 4,815 altered, and 4,815 valid fingerprint images
- Trained a GAN model to alleviate the lack of publicly available altered fingerprint datasets by generating synthetic altered fingerprints