



Generalizing Fingerprint Spoof Detector: Learning a One-Class Classifier

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Spoofing TouchID

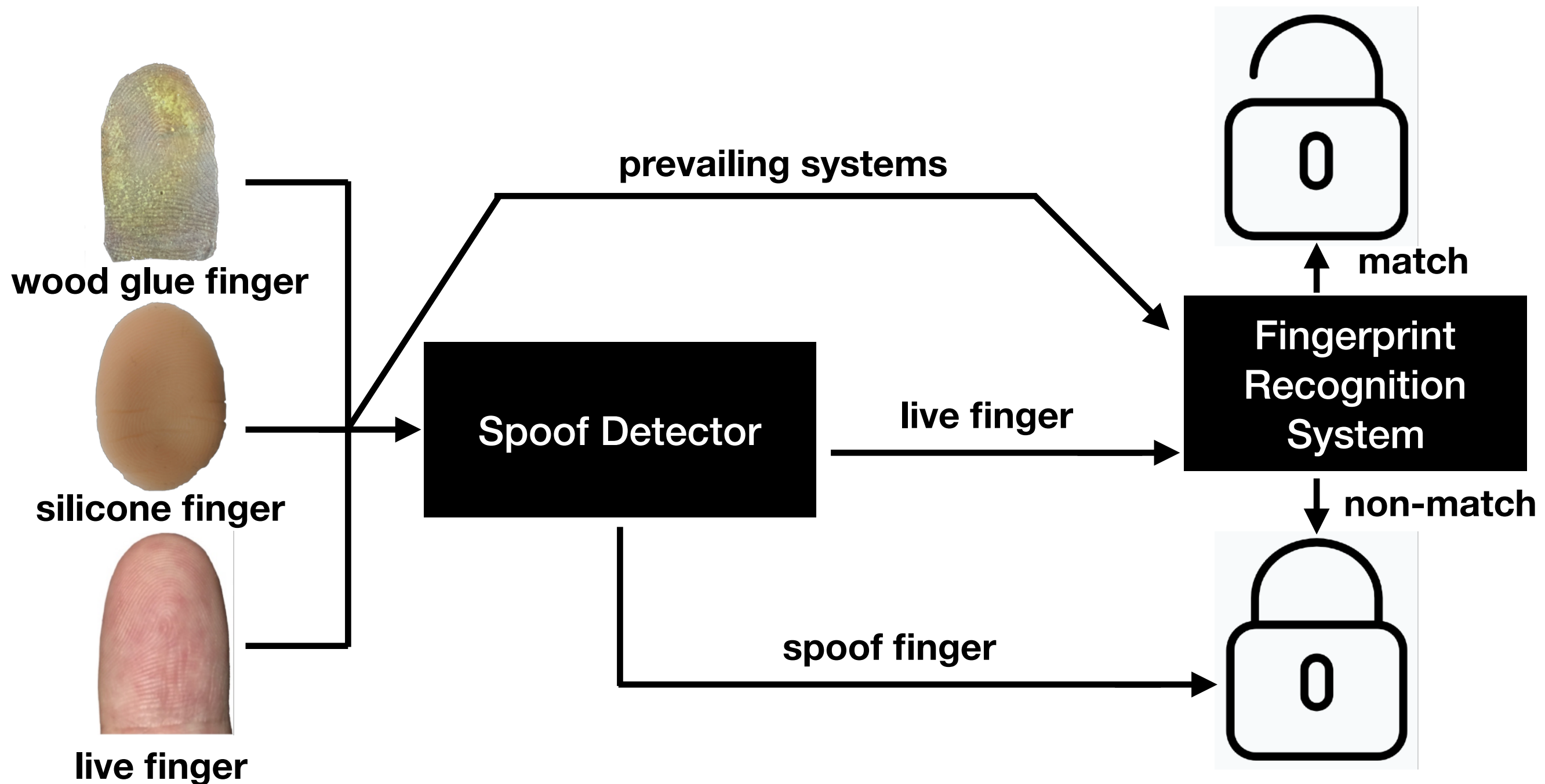


Successful spoof attack on iPhone 5S by German Hacking Club

Spoofs are a specific type of presentation attack

Figure retrieved from, <https://www.ccc.de/de/updates/2013/ccc-breaks-apple-touchid>

Spoof Detection Systems



Goal: automatically detect and flag spoofs prior to authentication or search

Challenge: Large Variety of Spoofs



ecoflex



wood glue



monster latex



playdoh



pigmented ecoflex



crayola



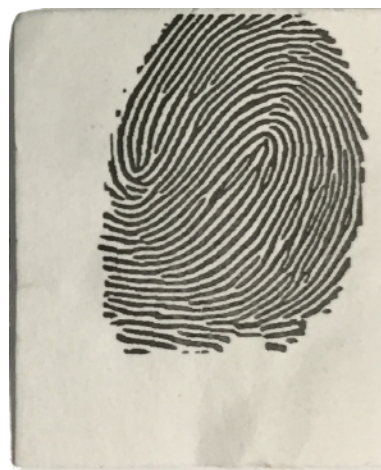
body latex



transparency



gelatin



paper

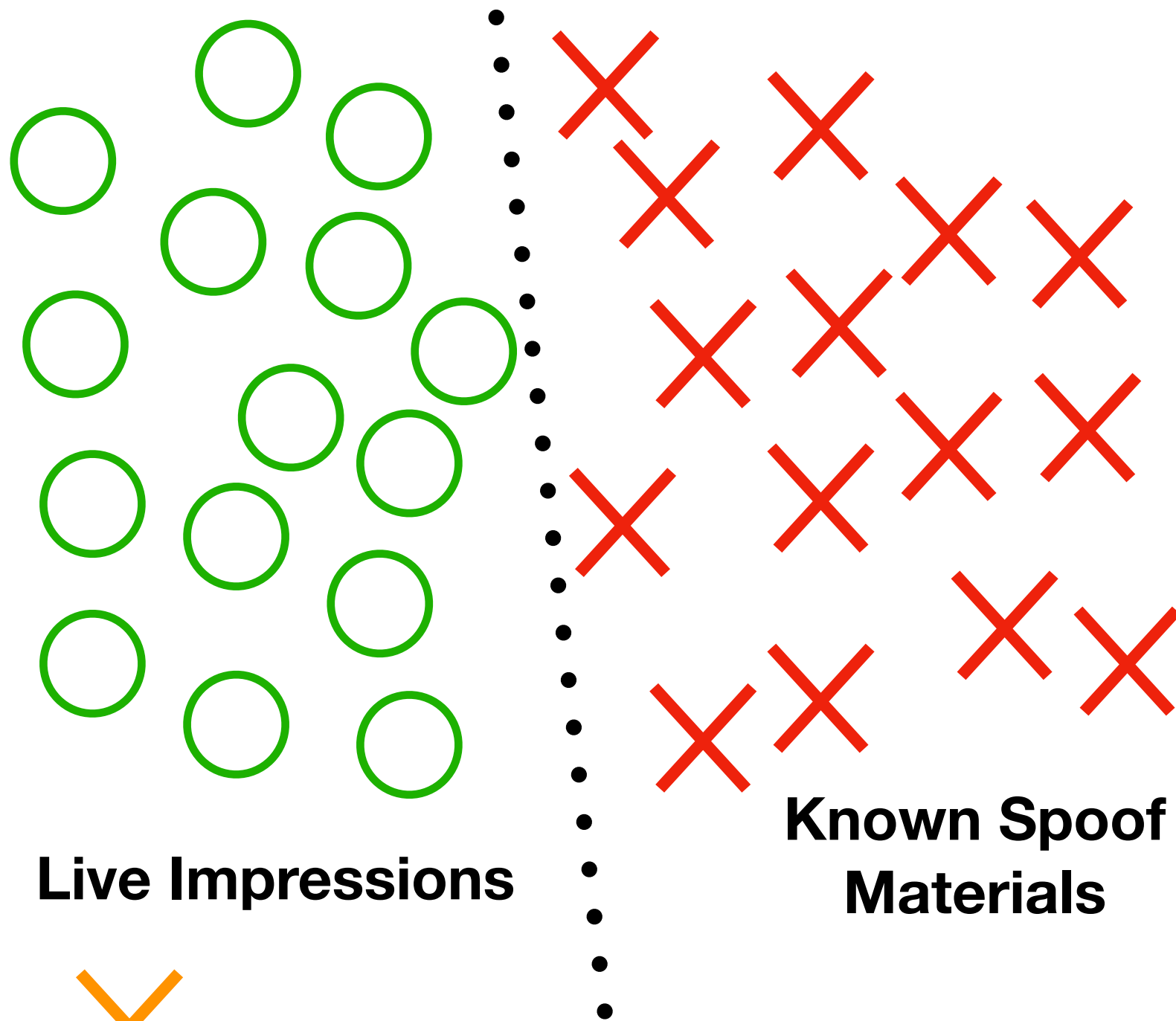


universal target



gold finger

Two-class (Spoof vs. Live) Classifier

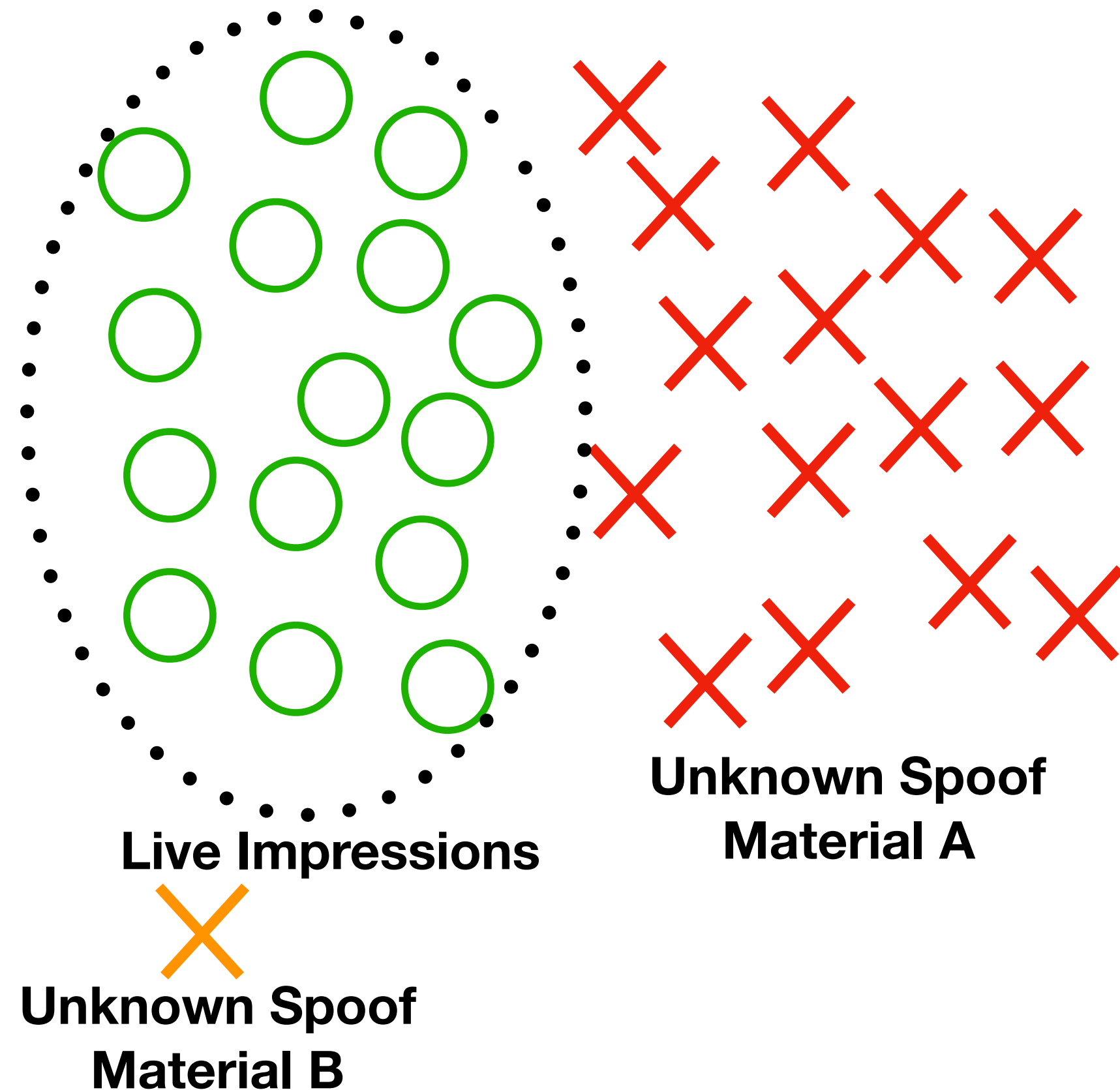


Problems:

- Two-class classifiers prone to overfit to specific materials
- Fail to detect spoofs of “unseen” materials; studies report 3-fold increase in error


**Unknown Spoof
Material**

Solution: One-Class Classifier



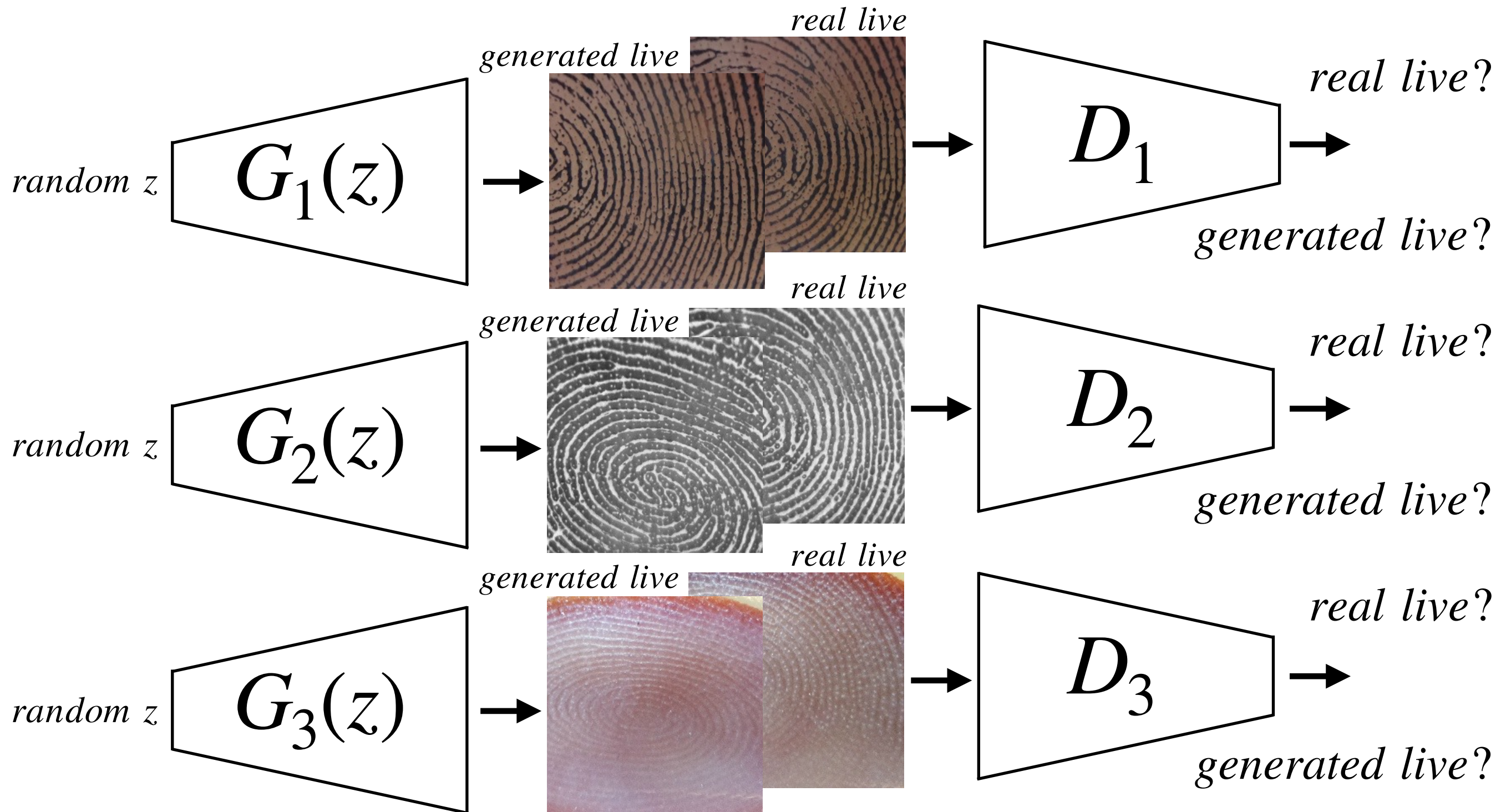
Goal:

- *Only* train with live fingerprint samples
- Generalize to **ALL** spoofs

Challenges:

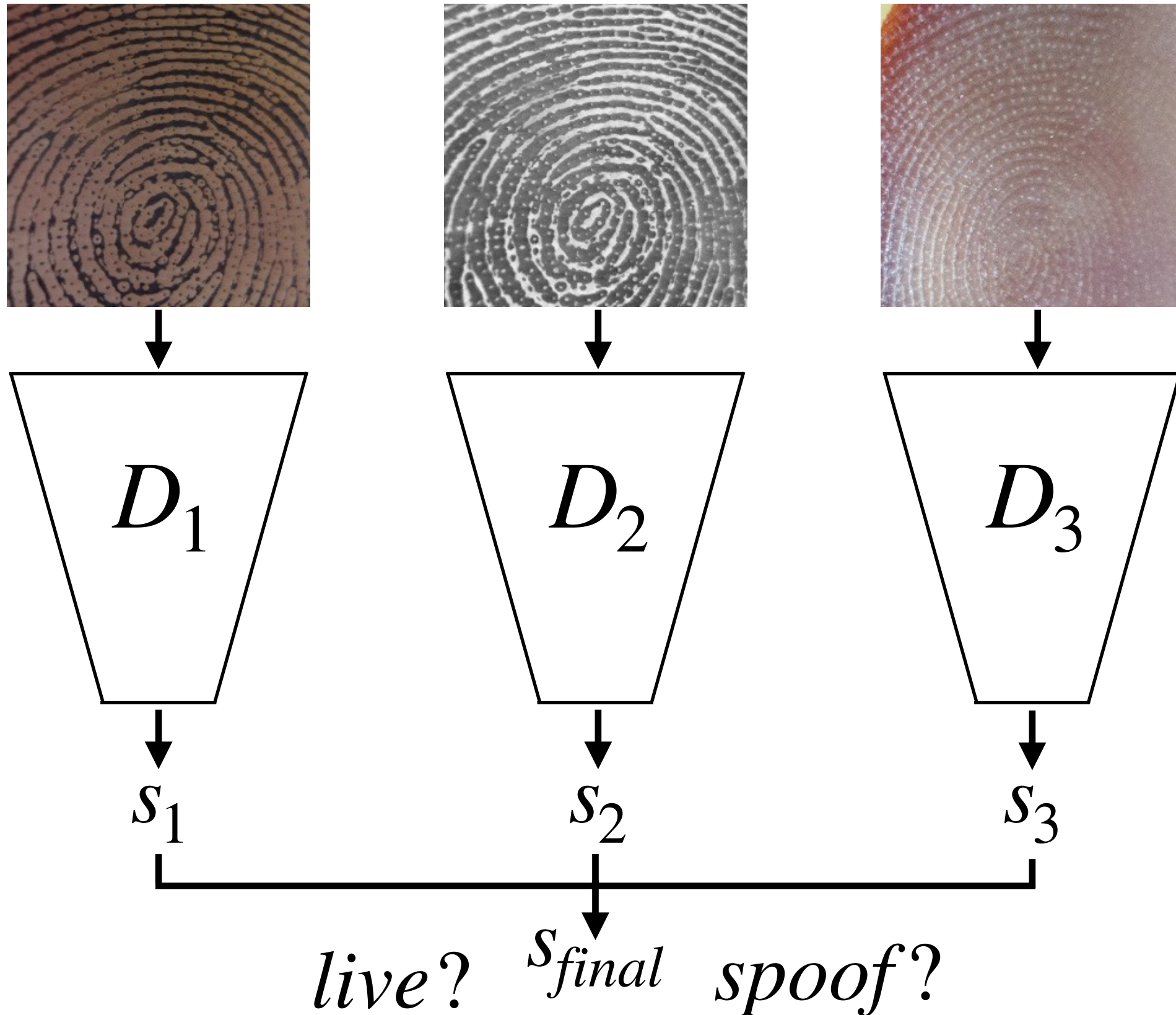
- Need large *number* of *diverse* live training samples
- Grayscale live and spoof images are **very** similar

Training: 3 DCGANs only on Live Impressions



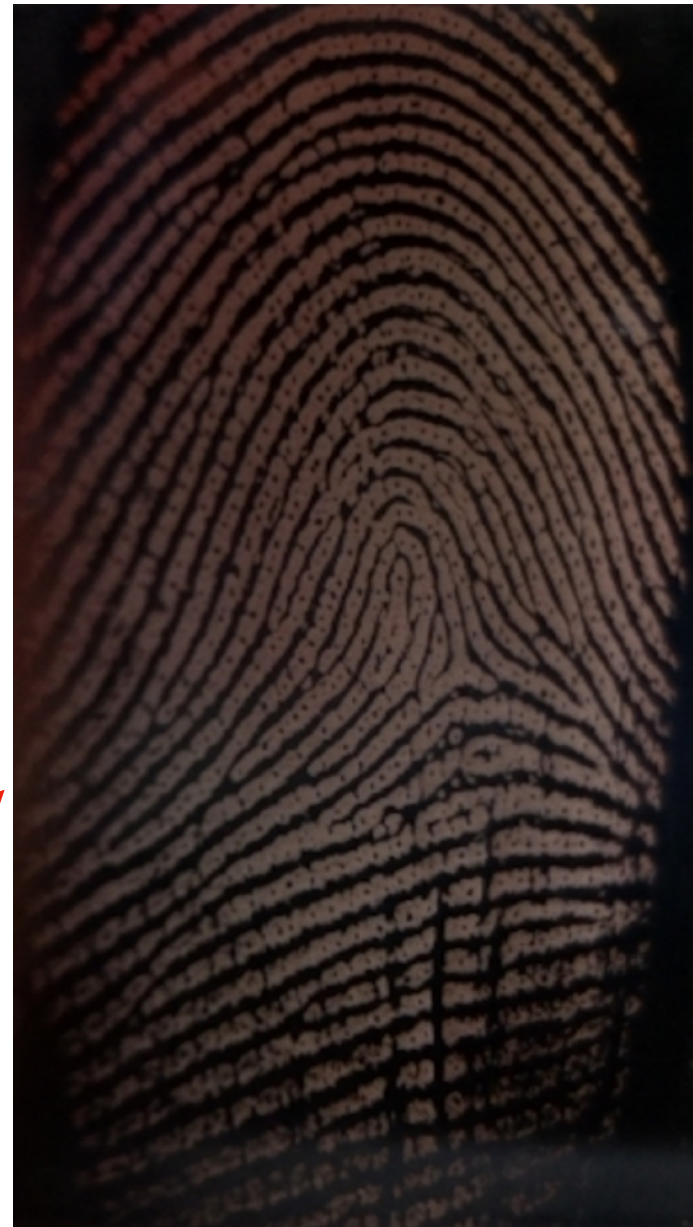
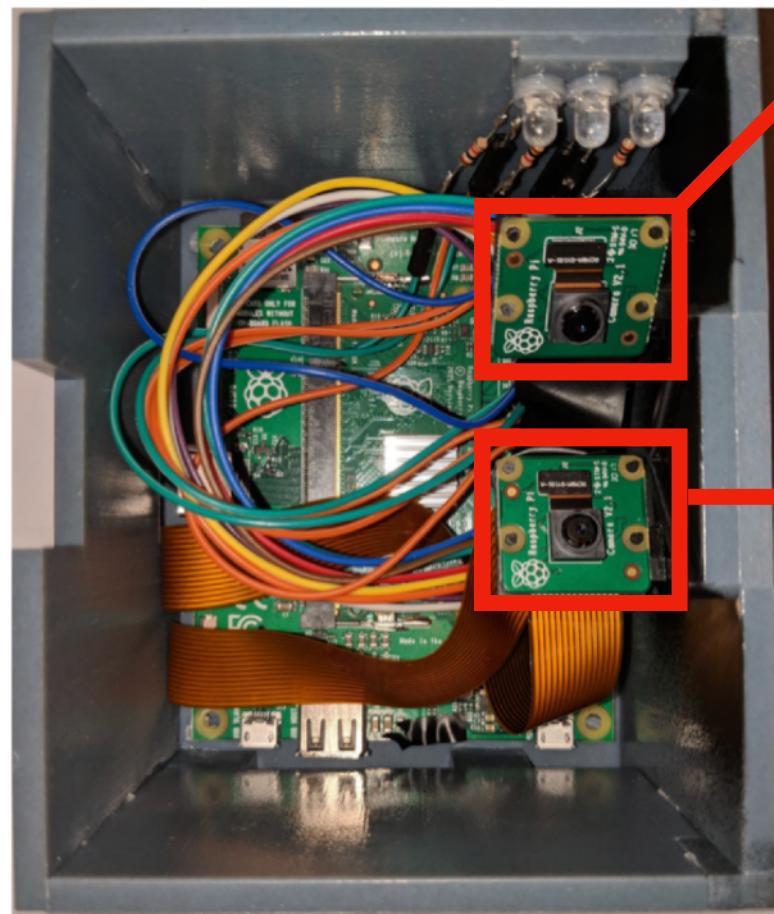
Idea: Discriminators separate real live from synthesized live; can be used to distinguish live and spoof fingerprints

Testing: Discriminate between Live and Spoof



Fused discriminators distinguish live and spoof fingerprints

RaspiReader



FTIR image (1900 ppi)



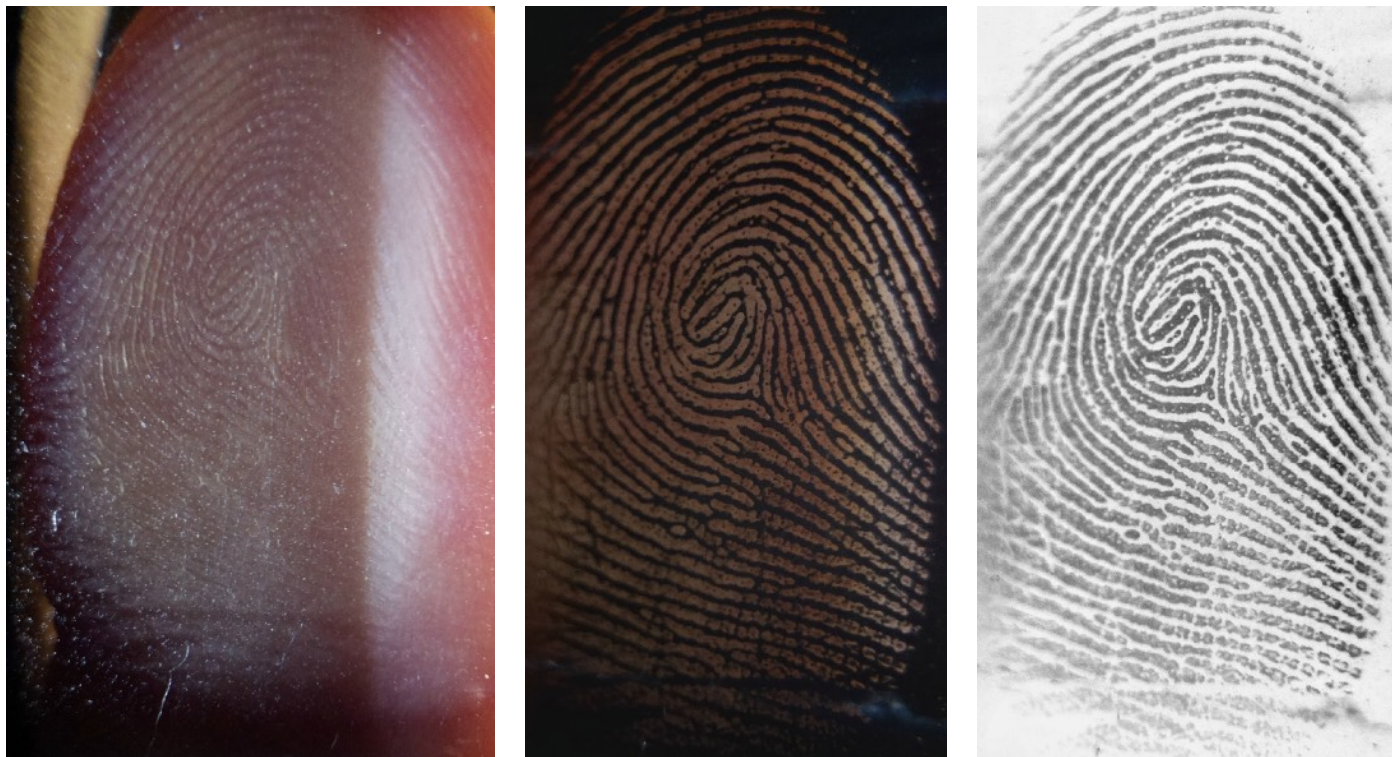
direct image (1900 ppi)

Open-source, multi-image, high-resolution fingerprint reader

Source: github.com/engelsjo/RaspiReader

DIY video: bit.do/RaspiReader

RaspiReader Dataset



Example: RaspiReader Live Impression



Example: RaspiReader Spoof Impression

RaspiReader Live Data

- 6,000 unique fingers
- 11,880 impressions
- 3 collection locations (MSU, Clarkson, JHUAPL)

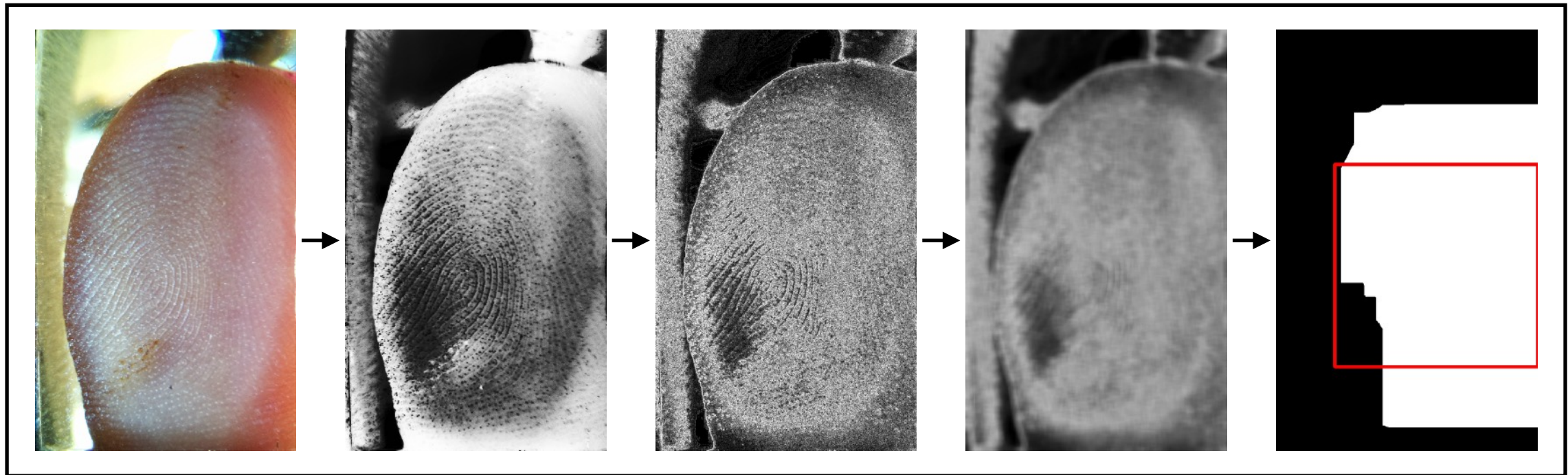
RaspiReader Spoof Data

- 12 materials
- 5,531 impressions

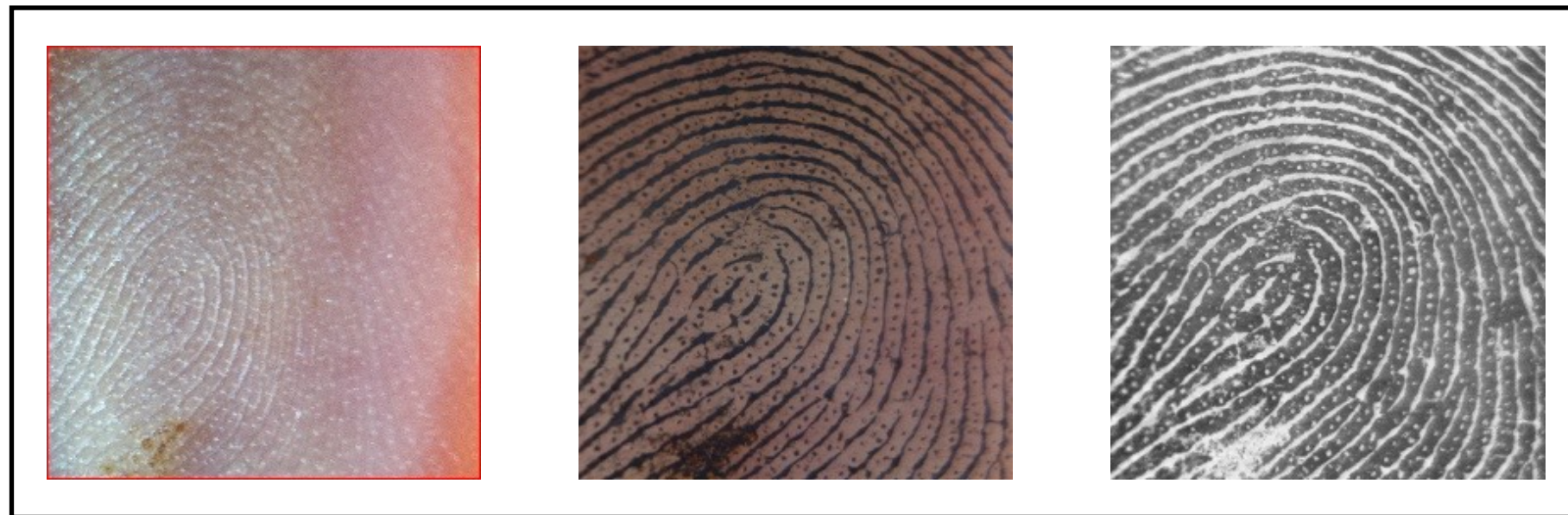
Larger and more diverse dataset than LiveDet

Preprocessing: ROI Extraction

(1) Obtain ROI Mask



(2) Crop ROI from RaspiReader images



Remove background noise which both live and spoof images share

Training and Testing Protocol

Live Dataset	Training Location*	Testing Location	# Training Impressions	# Validation Impressions	# Testing Impressions
	CU & JHUAPL	MSU	8,330	500	3,050

* Location refers to the site where data was collected

Spoof Partition <i>Set</i> ₁	Training Materials	Testing Materials	# Training Impressions	# Validation Impressions	# Testing Impressions
	Dragonskin, Ecoflex, Crayola, Paper, Body Latex, Monster Latex	Gelatin, Woodglue, Pigmented, Gold, Transparency	2,851	134	2,312
Spoof Partition <i>Set</i> ₂	Training Materials	Testing Materials	# Training Impressions	# Validation Impressions	# Testing Impressions
	Gelatin, Woodglue, Pigmented, Gold, Transparency	Dragonskin, Ecoflex, Crayola, Paper, Body Latex, Monster Latex	2,195	117	2,985

Experimental Results

Testing
Partition
Set₁

Algorithm	Gelatin	Pigmented	Playdoh	Woodglue	Transparency	Gold
OCSVM [1]	0.0%	2.0%	0.3%	0.0%	0.0%	0.9%
CNN [2]	67.7%	29.4%	6.0%	55.7%	34.0%	11.8%
Proposed	74.5%	22.3%	96.3%	85.2%	94%	34.2%

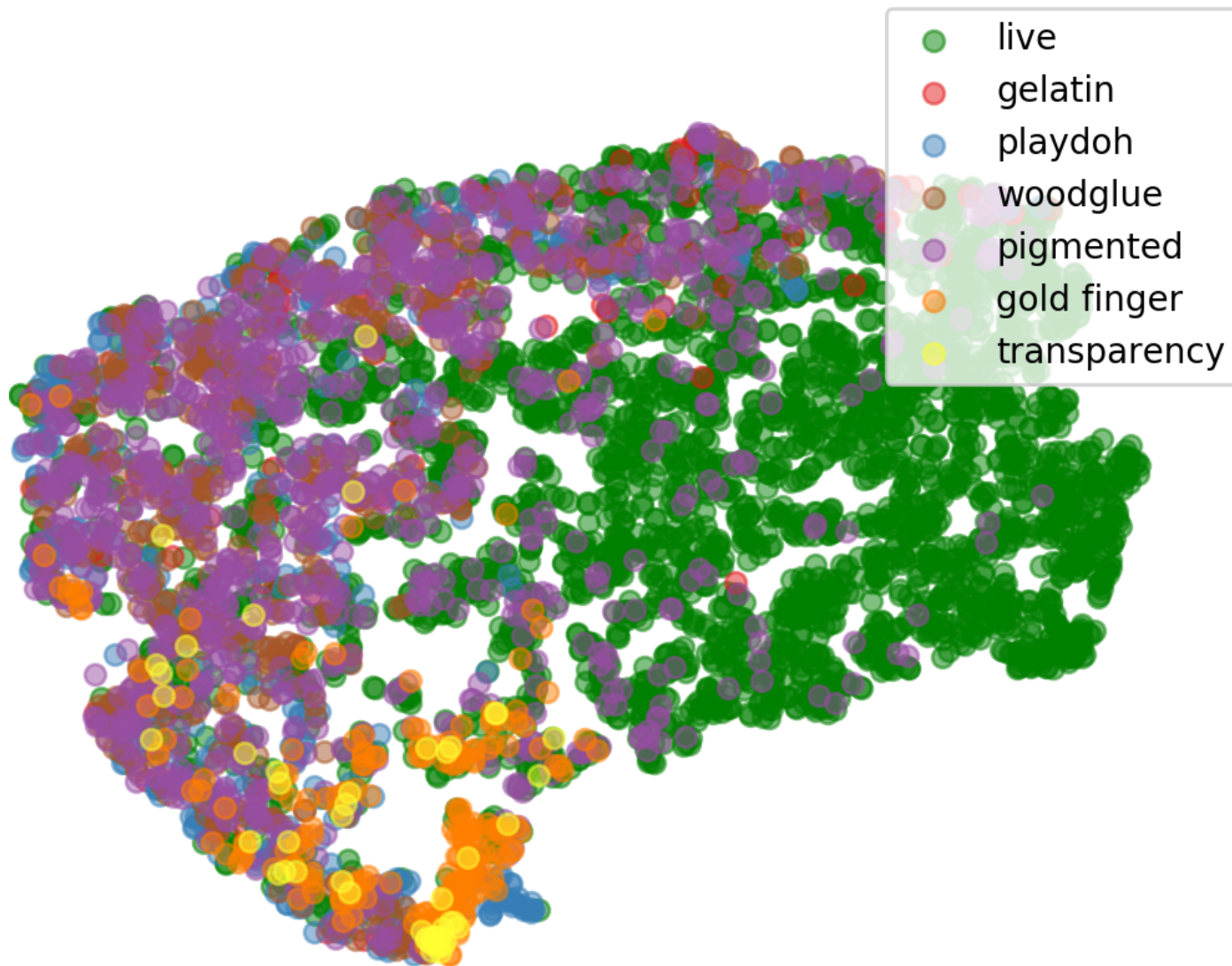
Testing
Partition
Set₂

Algorithm	Dragonskin	Ecoflex	Monster Latex	Crayola	Body Latex	Paper
OCSVM [1]	0.0%	0.2%	0.3%	15.0%	20.6%	33.8%
CNN [2]	49%	39.3%	54.3%	78.1%	12.1%	46.1%
Proposed	2.1%	4.8%	38.5%	83.6%	0.3%	56.8%

- [1] Yaohui Ding, and Arun Ross. "An ensemble of one-class svms for fingerprint spoof detection across different fabrication materials." *IEEE WIFS* (2016)
- [2] Joshua J. Engelsma, Kai Cao, and Anil K. Jain. "Raspireader: Open source fingerprint reader." *IEEE TPAMI* (2018).

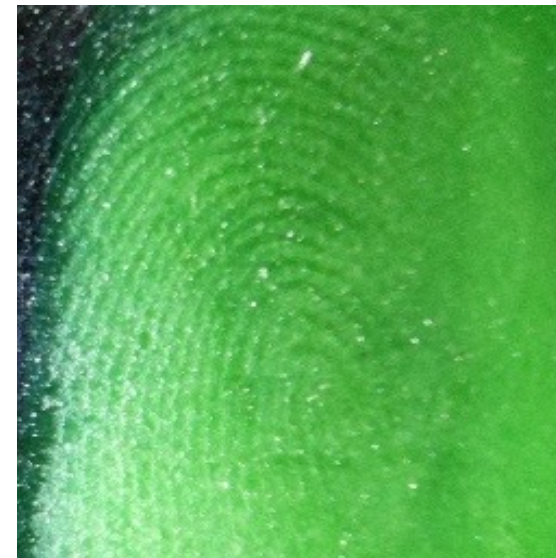
- **True Detection Rate (TDR) @ False Detection Rate (FDR) = 0.2%**

Experimental Analysis



2D tSNE plot of live and spoof features

**Outperforms two-class CNN
in 7 / 12 testing materials**

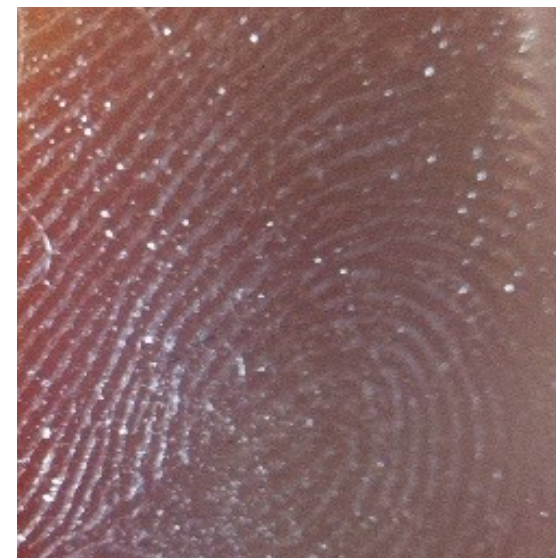


(playdoh)

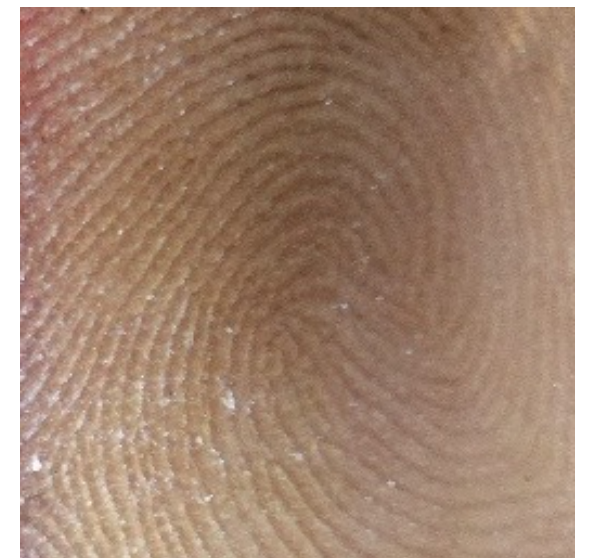


(gold finger)

GAN successes; CNN failures



(ecoflex)



(live finger)

GAN failures (thin clear spoofs)

On-going Research

- Fuse two-class CNN and proposed one-class classifier
- Benchmark one-class classifier on public datasets (LiveDet)
- Additional evaluation of one-class classifier on “unseen” materials

Acknowledgement

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Questions?

