



MICHIGAN STATE
UNIVERSITY

Fingerprint Spoof Detection using Minutiae-based Local Patches



Tarang Chugh

chughtar@cse.msu.edu

Kai Cao

kaicao@cse.msu.edu

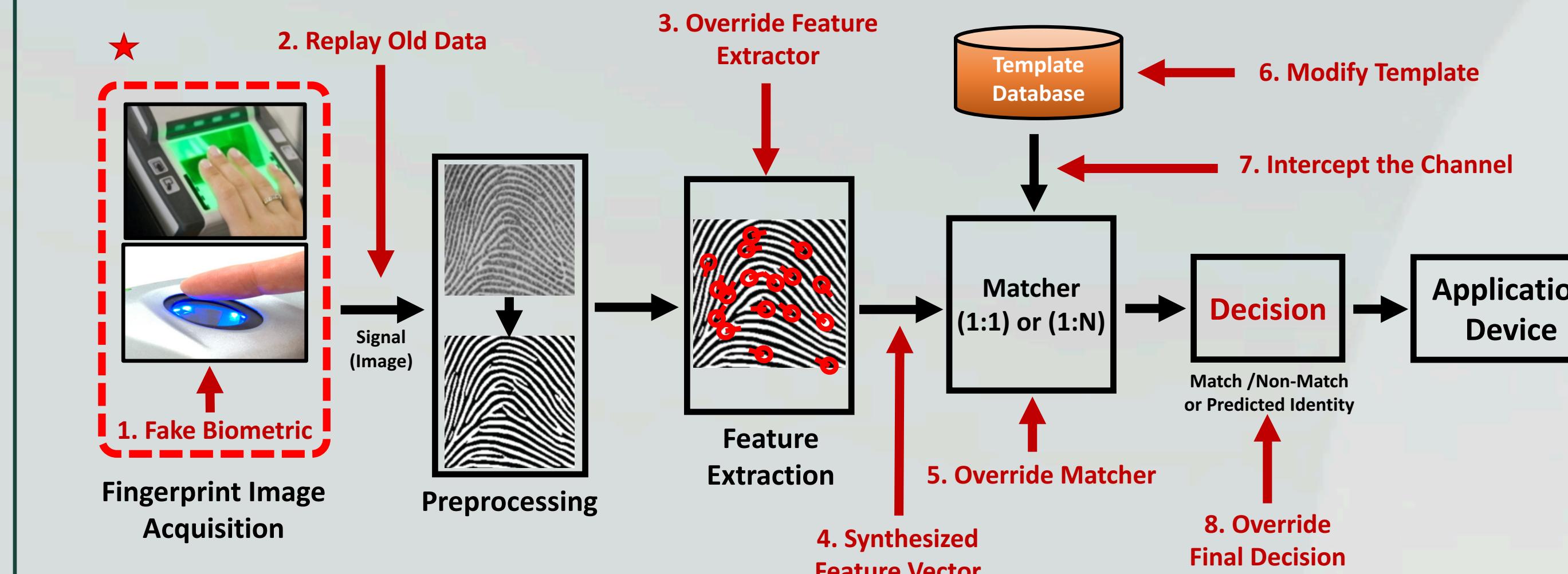
Anil K. Jain

jain@cse.msu.edu

Department of Computer Science and Engineering, Michigan State University

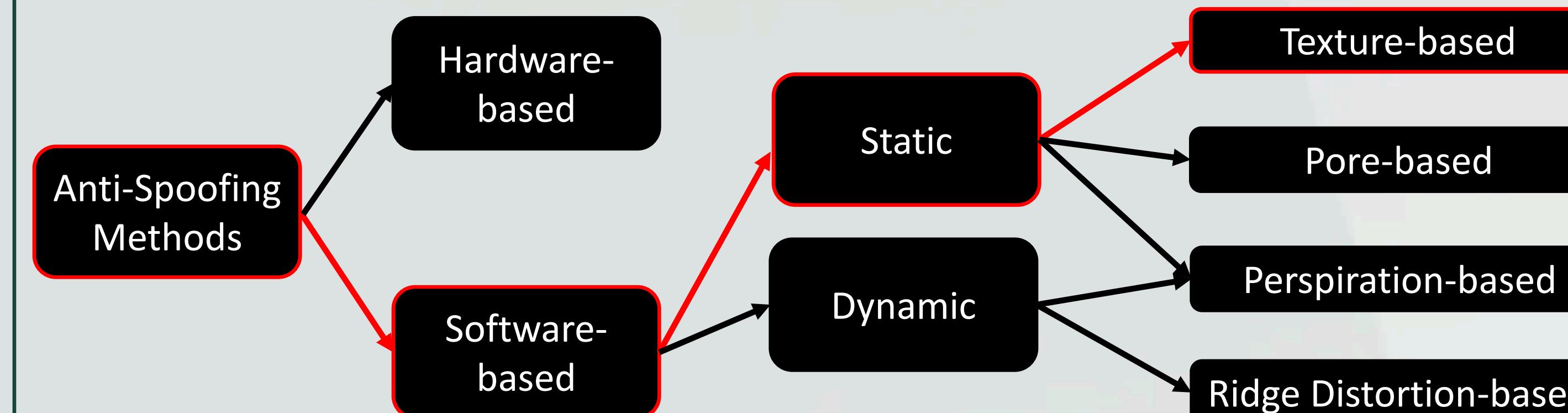
Introduction

Modules of a fingerprint recognition system and associated vulnerabilities



Presentation Attacks: "presentation to the biometric subsystem with the goal of interfering with the operation of the biometric system"

– ISO standard IEC30107-1:2006 (E)

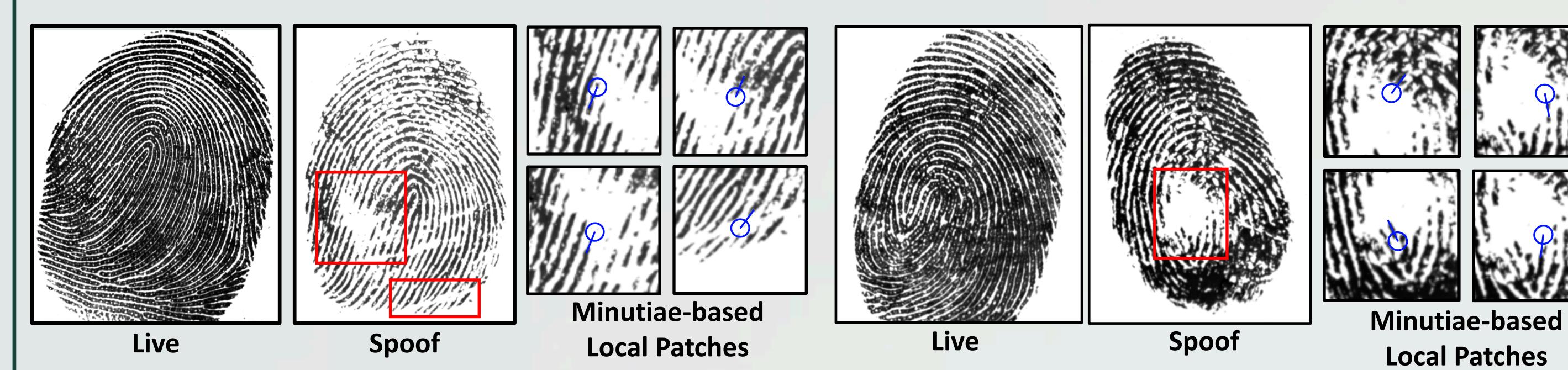


Challenges and Motivation

Which of the fingerprints are live?



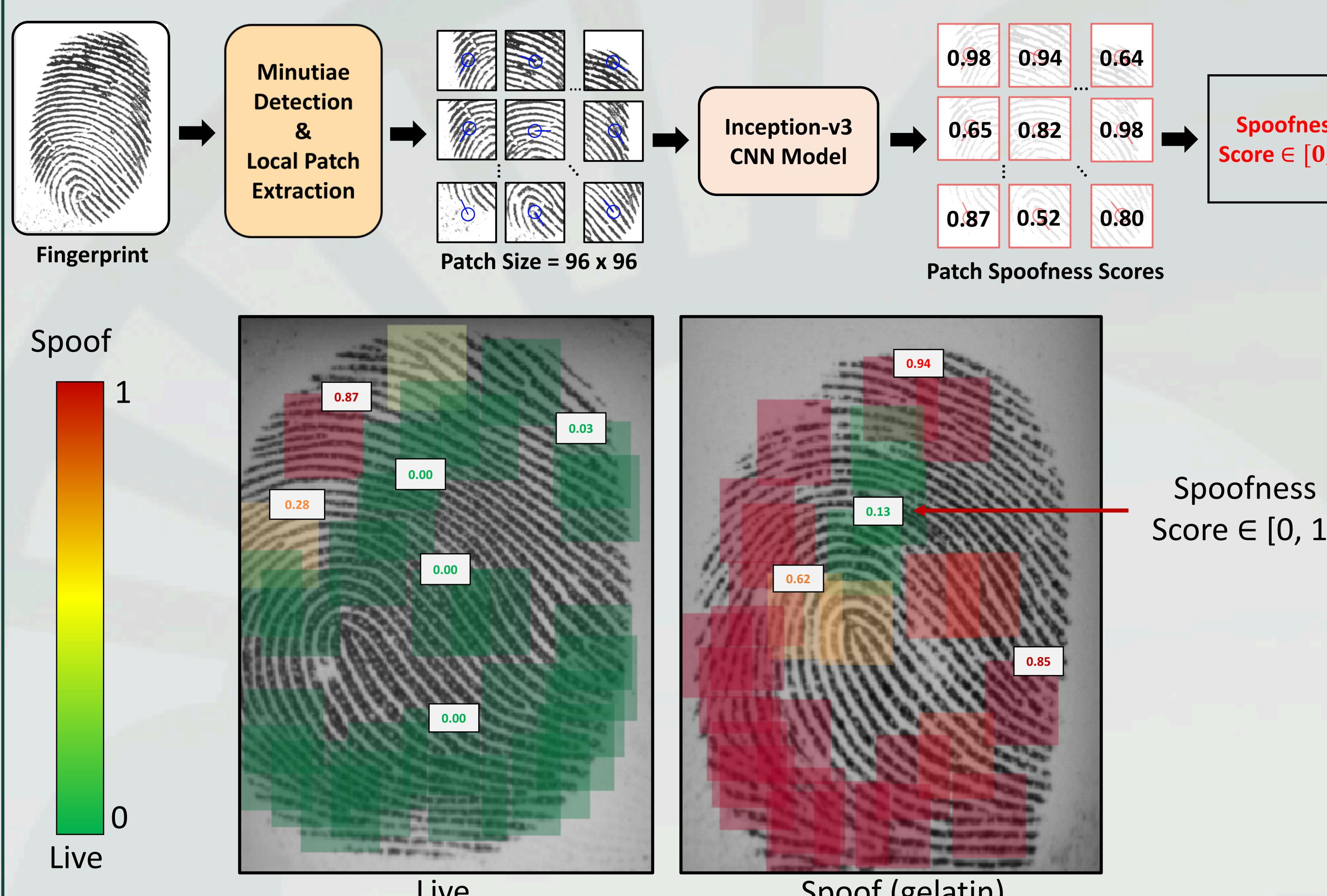
- ❖ Existing approaches do not utilize fingerprint domain-knowledge
- ❖ We extract minutiae and learn patch “texture” around minutiae



- ❖ Robust to different fingerprint image sizes
- ❖ Large amount of training data to train deep CNNs
- ❖ Generalizable to unknown spoof types

Proposed Approach

Overview of the proposed approach for fingerprint spoof detection using CNNs trained on minutiae-based local patches.



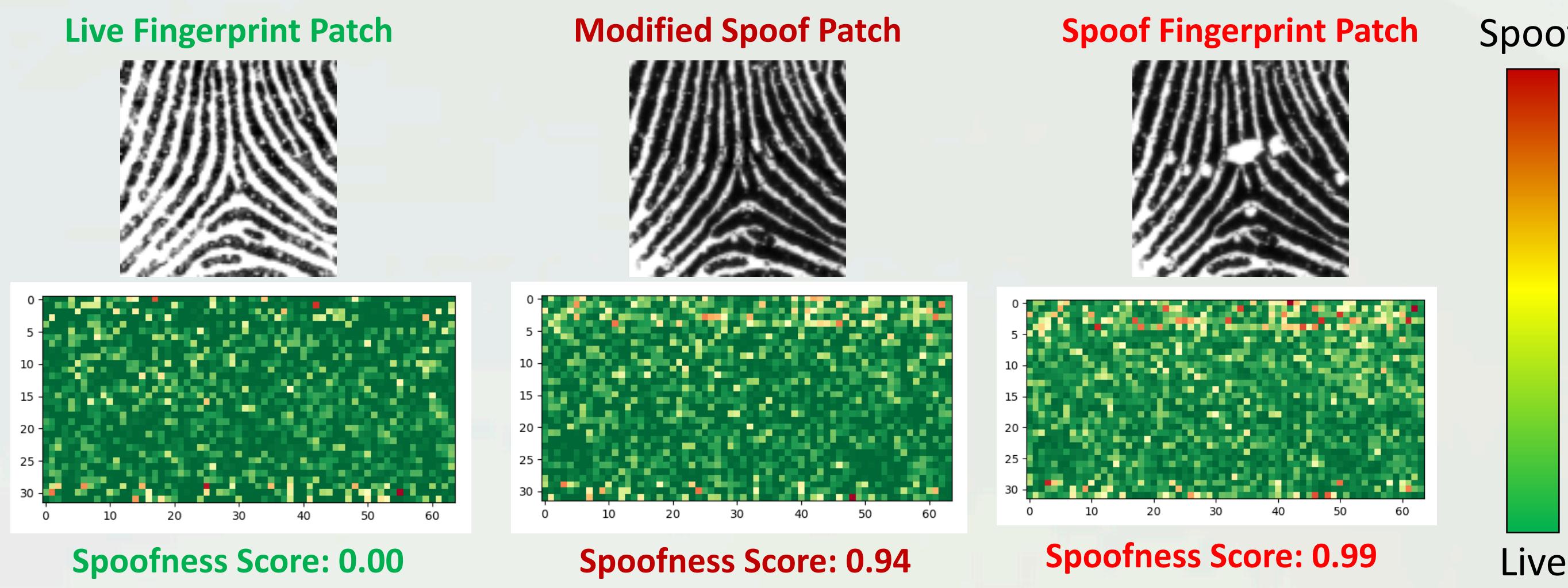
Finding The Best Patch Size

Dataset: LivDet2011 (Biometrika Sensor)

Method	TDR @ FDR=0.2%
Whole Image (372 X 312)	63.1%
Random Patches [96 x 96]	78.4%
Minutiae-based Patches	
[64 x 64]	86.9%
[96 x 96]	93.1%
[128 x 128]	88.6%

Understanding CNN Representation

CNN's 2048 dim. feature vector is graphically represented as 32 x 64 image for analysis



Experimental Results

LivDet Databases

Database	Fingerprint Sensors	#Training Images / #Testing Images	Spoof Materials	Average TDR @ FDR=0.2%
LivDet 2011	• Biometrika • Digital Persona • ItalData • Sagem	8,000 / 8,000	Ecoflex, Gelatine, Latex, PlayDoh, Silgum, Silicone, Wood Glue	88.2%
LivDet 2013	• Biometrika • ItalData	4,000 / 4,000	Ecoflex, Gelatine, Latex, Modasil, Wood Glue	99.6%
LivDet 2015*	• Biometrika • Digital Persona • CrossMatch • GreenBit	8,983 / 10,448	Body Double, Ecoflex, Gelatine , Latex, Liquid Ecoflex , OOMOO, PlayDoh, RTV, Wood Glue	96.8%

*LivDet 2015 contains both known-material and cross-material experiments; Images of spoof materials marked in red are unavailable for training

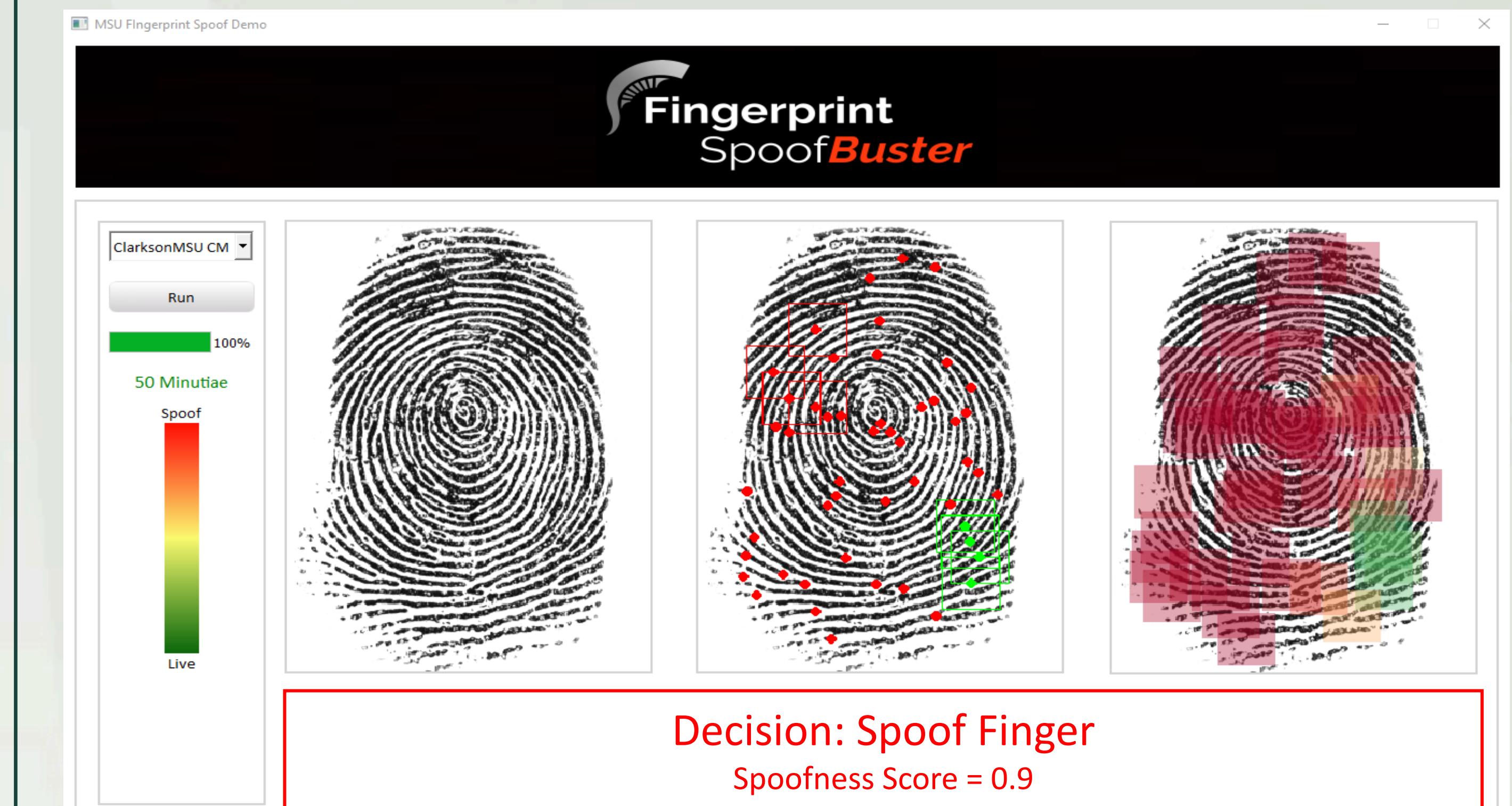
➤ Images are resized to 500 ppi

➤ Avg. number of patches: 48 patches/live image; 50 patches/spoof image

Best Average Classification Accuracy (%) in LivDet Competitions

Study	Approach	LivDet 2011	LivDet 2013	LivDet 2015
Ghiani et al., 2012	Local Phase Quantization (LPQ)	88.9	97.0	N/A
Gragniello et al., 2013	Weber Local Descriptor (WLD)	92.1	N/A	N/A
Ghiani et al., 2013	Binarized Statistical Image Features (BSIF)	92.8	97.9	N/A
Gragniello et al., 2015	Local Contrast-Phase Descriptor (LCPD)	94.3	98.7	N/A
Nogueira et al., 2016	Transfer Learning + CNN-VGG + Whole Images	95.5	98.9	95.5
Proposed Approach	CNN-Inception v3 + Minutiae-based local patches	97.4	99.5	98.6

Interface of the Live Demo



Decision: Spoof Finger

Spoofness Score = 0.9

Conclusions

- ✓ Proposed a patch-based approach for fingerprint spoof detection
- ✓ Achieves state-of-the-art detection performance on LivDet Databases
- ✓ Avg. spoof detection time: 0.57s (Nvidia GTX 1080 GPU)
- ✓ Strengths: (i) utilizes minutiae information,
(ii) robust to image size,
(iii) patch-based approach results in large training set
- ✓ Limitations: generalizability