Group 1

FINGERPRINT ATTACK

Josh Agron, Adam Bisignani, Maggie Brown, Julia Buckley, Stuart Hayden, Jake Hracho, Simon Rodriguez, Nora Tucker

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FALSE FINGER GENERATION

Julia, Maggie, Jake, & Josh

Gelatin with a Liquid Latex Mold

Materials

Liquid Latex
Makeup sponge/applicator
Hair dryer
Baby powder

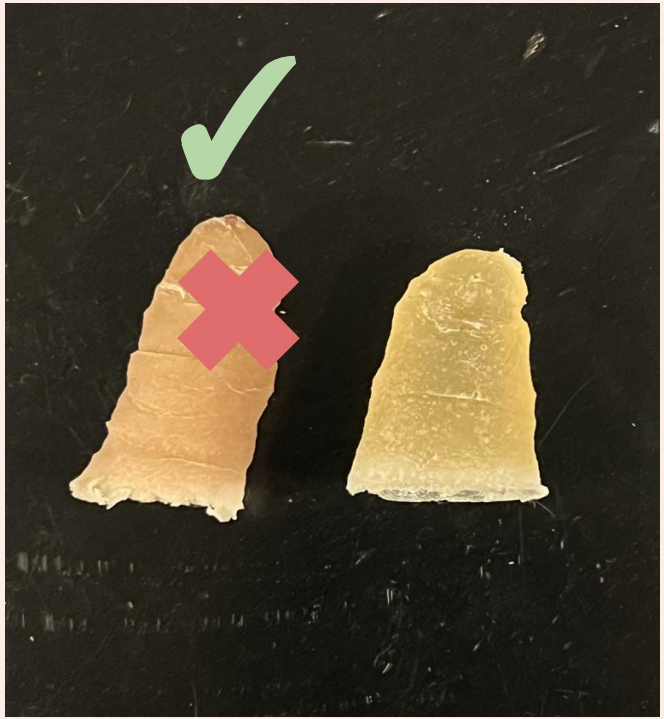
Gelatin
Vegetable glycerin
Water
Pressed powder makeup (used for 1/2)

Gelatin with a Liquid Latex Mold

Process

1. Coat finger in 8-10 thin layers of liquid latex, drying between
2. Use baby powder to carefully remove mold
3. Create false fingerprint mixture (1 part gelatin, 1 part glycerin, 1.5 part water)
4. *Add pressed powder
5. Add to mold and cool

Gelatin with a Liquid Latex Mold



The Difference

The clear finger did not pass, but the pressed powder one did

Gelatin with a Paraffin Wax Mold

Materials

Gelatin
Pressed Powder Makeup
Water
Paraffin Wax

Gelatin with a Paraffin Wax Mold

Process

1. Melt paraffin wax until it is malleable
2. Form a ball and press print for five minutes
3. Make extra-thick gelatin mixed with press-powder makeup
4. Pour into mold and refrigerate overnight

2D Print Out

Materials

Paper
Pencil
Tape

2D Print Out

Process

1. Scribble on a piece of paper until a thick layer of graphite is formed
2. Rub print in the graphite
3. Press a piece of tape onto the print
4. Place tape onto a white piece of paper

Hot Glue Fingerprint

Materials

Mounting Putty
Hot Glue and Gun
Freezer

Hot Glue Fingerprint

Process

1. Create a mold with the mounting putty
2. Put mold in freezer to solidify (24 hr)
3. Pour hot glue on a piece of paper
4. Press mold onto hot glue from above
5. Remove mold from hot glue

2

ATTACKING THE SYSTEM

Nora & Adam

Data Generation

44 Pairs: 22 Genuine, 22 Impostor

22 genuine pairs (from our group and the files from our class)

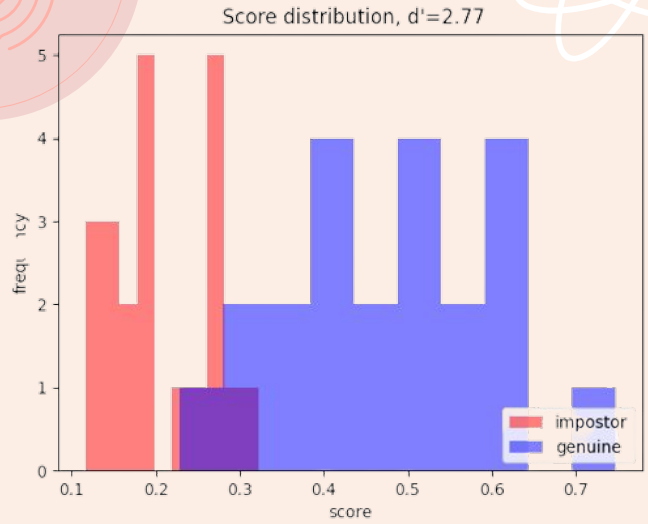
22 impostor pairs (comparing each of 11 false fingers to 2 genuine scans of the finger they are attacking)

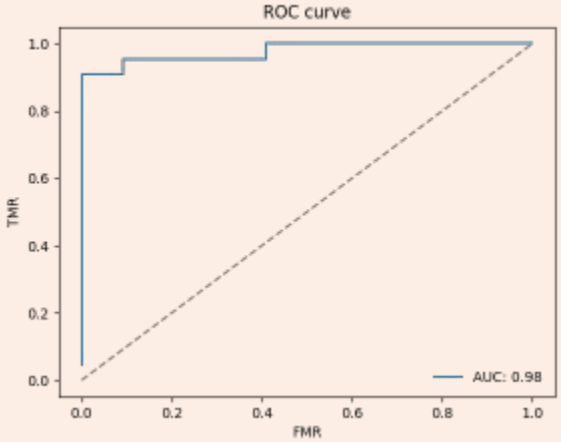
Sensor

Futronic FS88H Optical Sensor

Determining a Threshold

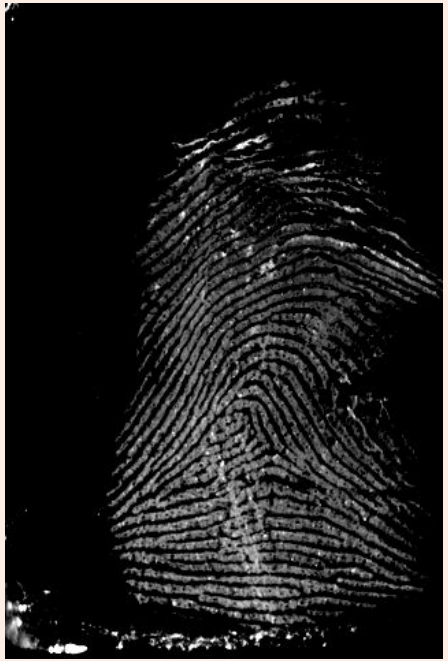
- Calculated the similarity scores for each of the 44 pairs
- Calculated the EER (.09) and determined the threshold (.30058)
- Calculated the D-prime value to be 2.77
- Calculated AUC value to be .98





Compare Similarity Scores to Threshold

- Compared the similarity scores of each of 22 impostor pairs to the calculated threshold
- Only one fake finger had a similarity score higher than the threshold
- Sim score: 0.32258



Fake Finger

Authentic Scan

Averaging Similarity Scores

- Had two genuine scans per person
- Averaged the similarity scores of each attack finger with the two genuine scans
- Once averaged, none of the 11 fake fingers were above the threshold
- Highest was .29625, which was less than threshold of .30058

0 Successful Attacks after averaging similarity scores

Ranking the Fake Fingerprint Methods

Fingerprint Type	Similarity Score (highest)
Gelatin with Liquid Latex Mold	.32258
Gelatin with Paraffin Wax Mold	.26248
Hot Glue	.18706
2D Print Out	Unable to compute - system did not recognize the print as valid

3

PROPOSING A FIX

Simon

Finding a solution

Asking for Multiple Scans

Only one print met the threshold to fool the system.

- If we ask for multiple scans from the user, there is a higher likelihood that imposters would be detected
- Have multiple scans to compare against. There can often be a high variance between scans of the same finger (intra-class variability).

https://www.semanticscholar.org/paper/On-the-Individuality-of-Fingerprints%3A-Models-and-Dass-Pankanti/70a1e069c2fdceff8644c8104dbaec1815da9f9b/figure/1

Finding a solution

Scan Multiple Fingers at Once

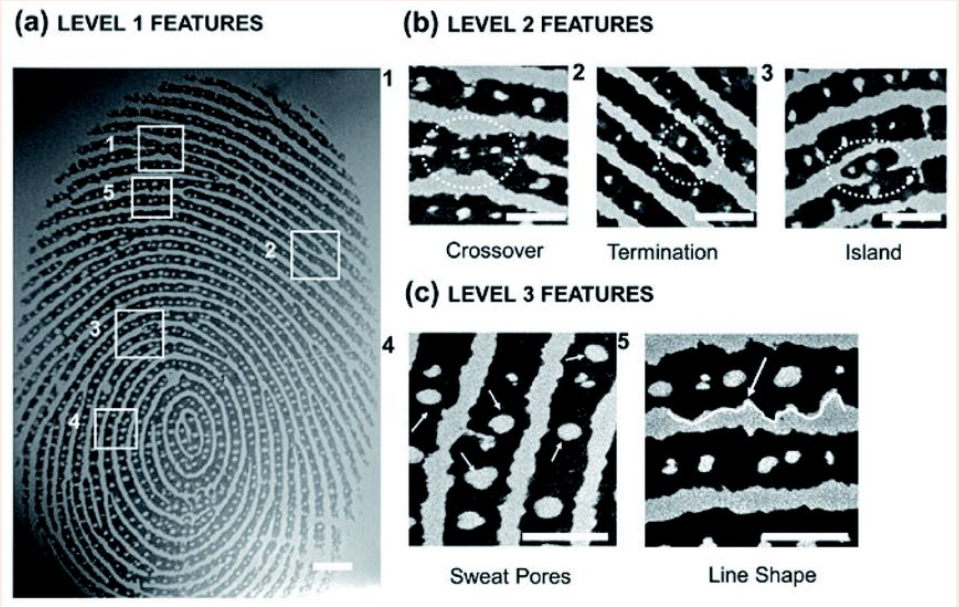
- For the reasons on the previous slide, some sensors exist that scan multiple fingers at once.
- This would greatly increase the amount of work that an attacker must commit, as they would need to make multiple working fingers from the same hand.

https://www.auodplus.com/template/images/gd/fingerprint/feature-1/auodplus-gd-fingerprint-feature-1.jpg

Finding a solution

Use a Higher Resolution Sensor and Detect Level 3 Features

- According to the manufacturer's website, the sensor's resolution is only 500 dpi. A higher resolution sensor could detect smaller details that would be missing in a gelatin print, such as sweat pores.
- The software would also need to be extended to detect such features as well.



https://pubs.rsc.org/image/article/2021/AY/d1ay01508g/d1ay01508g-f2_hi-res.gif

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KEY TAKEAWAYS

Stuart

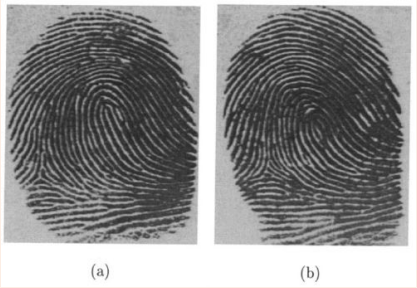
Key Takeaways

Takeaway 1

Fake Fingerprints are
Easy to Produce

Takeaway 2

Optical Sensors
Susceptible to Gelatin



Takeaway 3

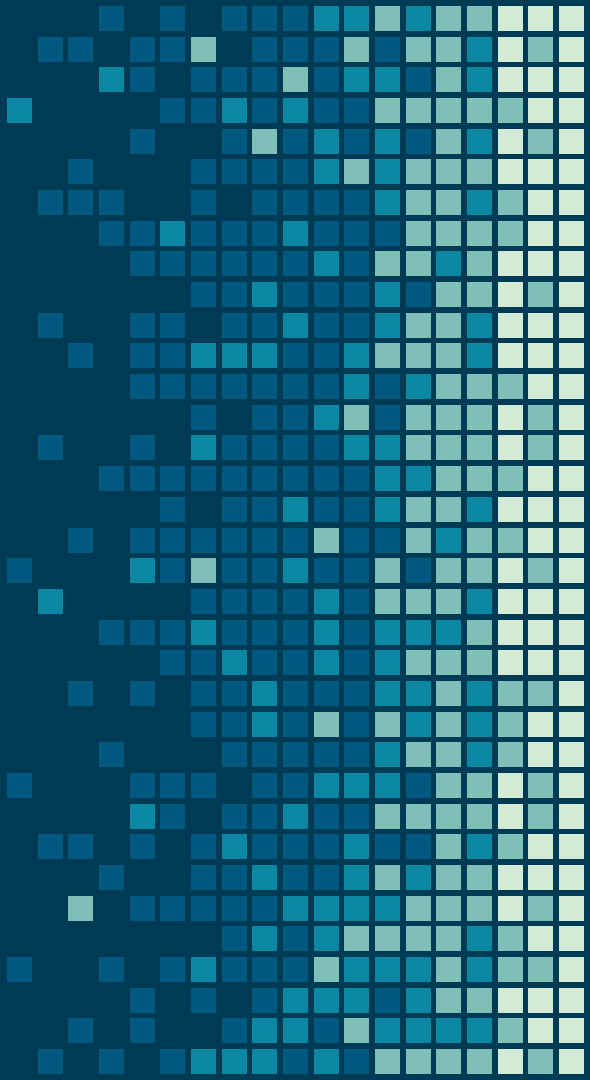
Multiple Genuine Scans
Improve Security

Questions?

Group 2

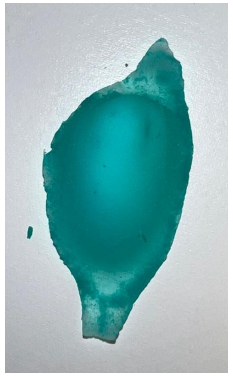
Fingerprint Attack Presentation

Livia Johan, Estefania Romero Valdez, Grace Qi, Tyler Krasny, Luke McKay, Sean Hawkshaw



Fake or Real?

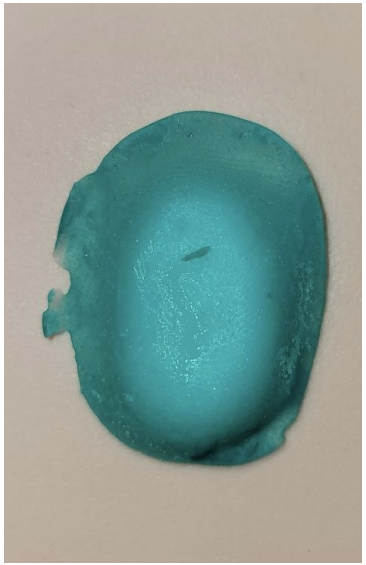
Generated Middle Finger





Generated Index Finger

Generated Thumb

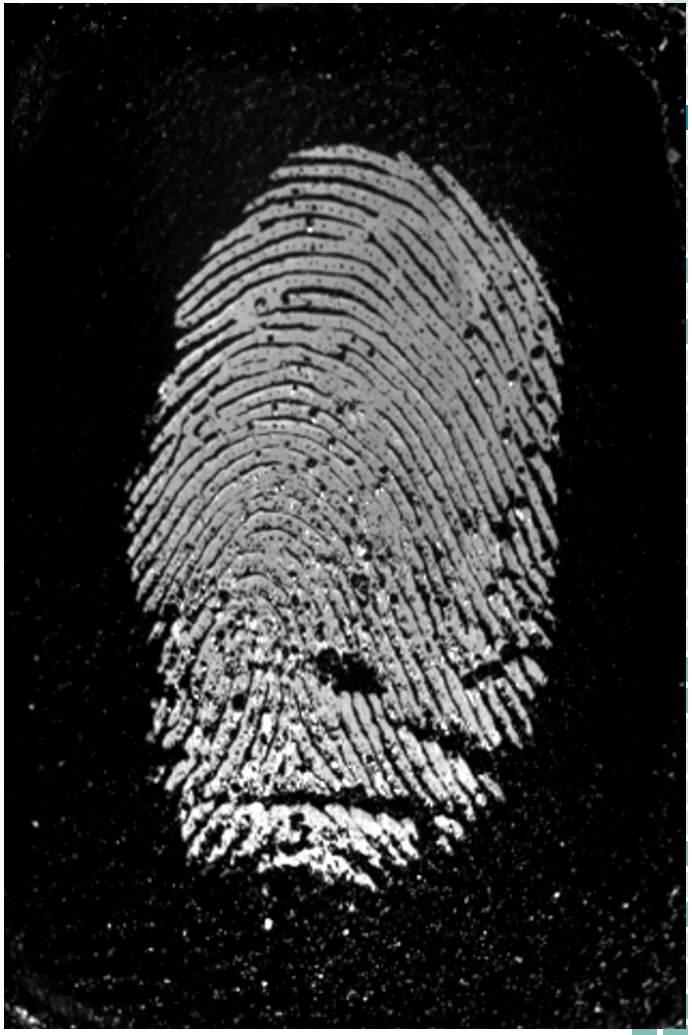




How to Generate: Latex Mold

- For the mold: layer on latex to the finger (like we saw in the video in class) using makeup sponge → then use to hold the gelatin
- Mold as fingerprint attack: flip the mold inside out & scan. During image processing, set dark ridges = True and mirror the image

How to Generate: Gelatin

- Gelatin + glycerin + water
- Pour into latex mold and allow to cool
- Some sweat pores still visible, but there are also some other bubbles from the gelatin itself
- Scars visible
- Darker than when you scan real fingerprint, ridges are thicker



How to Generate: Hot Glue/Glue/Latex

- For all: create finger imprint into Play Doh & fill with desired medium
- Challenge: must imprint evenly, otherwise you get dents in fingerprint

Hot glue:

- More difficult to attack with because it is more rigid
- Harder to get around the challenge of having dents in the print

White Glue:

- Took a lot longer to dry
- When it came out of the mold, still seemed smooth but showed up in scans
- Easier to work around the challenge because it is more flexible

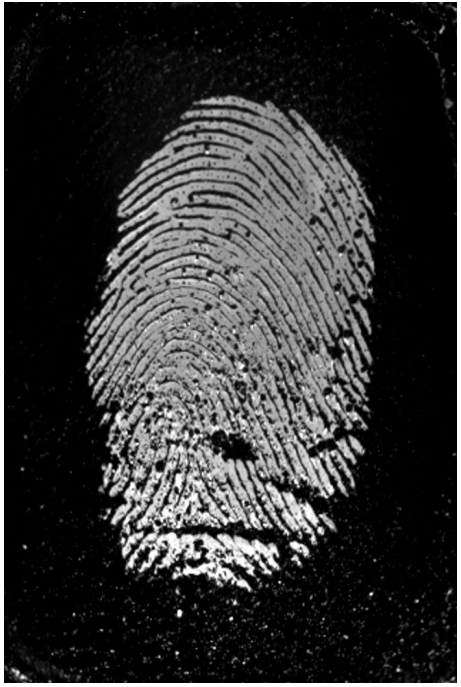
Latex:

- Like white glue, not super rigid
- Easy to bend so that it would scan correctly
- A few sweat pores showed up

Threshold generated in class (HW 2):
0.2598870056497175

Middle Finger

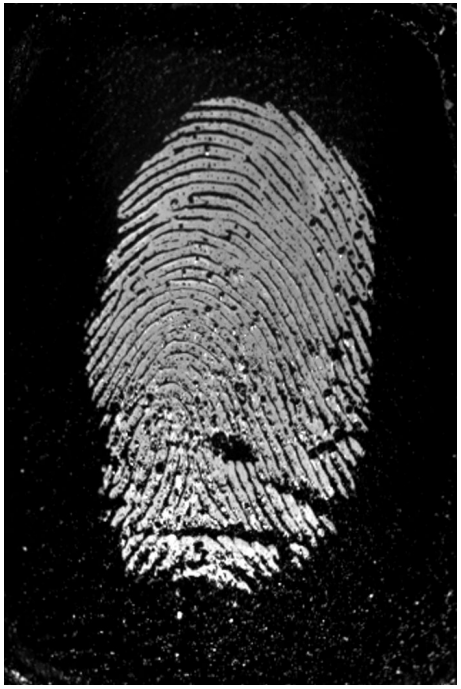
Gelatin: 0.32

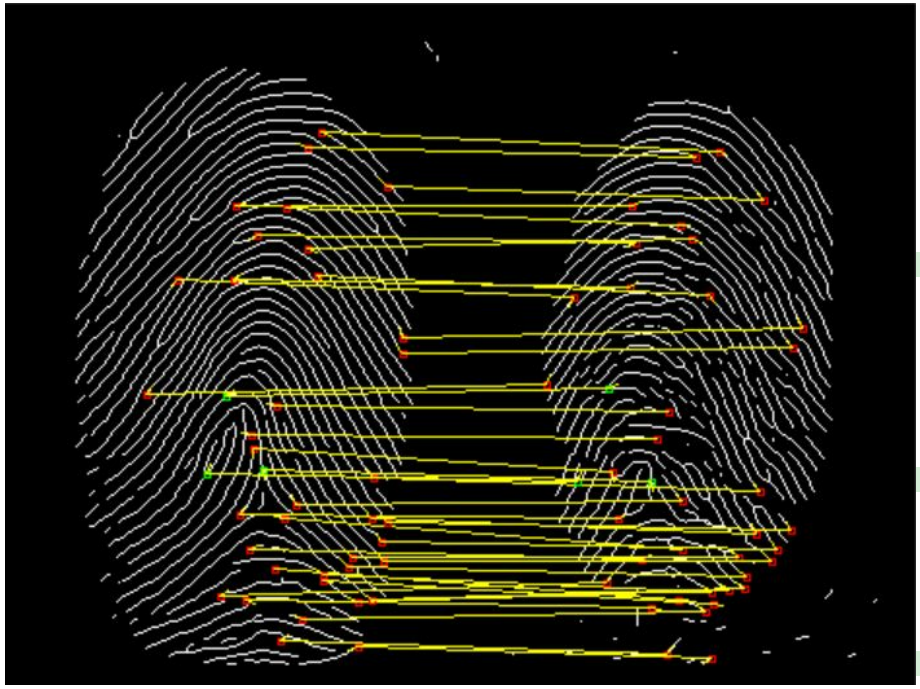


Latex: 0.33

Middle Finger

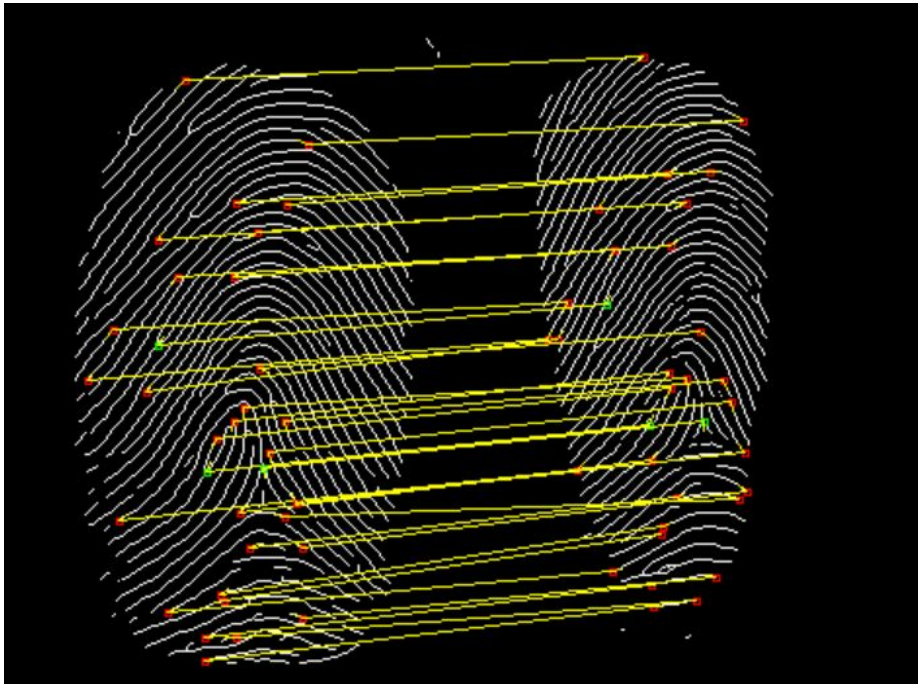
Gelatin: 0.32





Middle Finger

Latex: 0.33

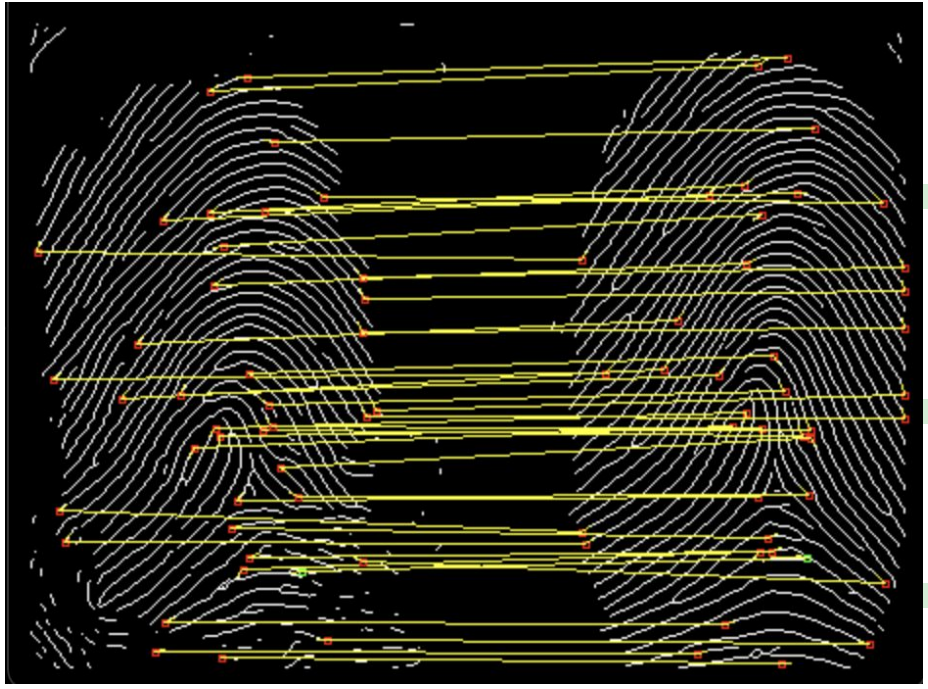


Middle Finger

Mold: 0.2749

Middle Finger

Mold: 0.2749

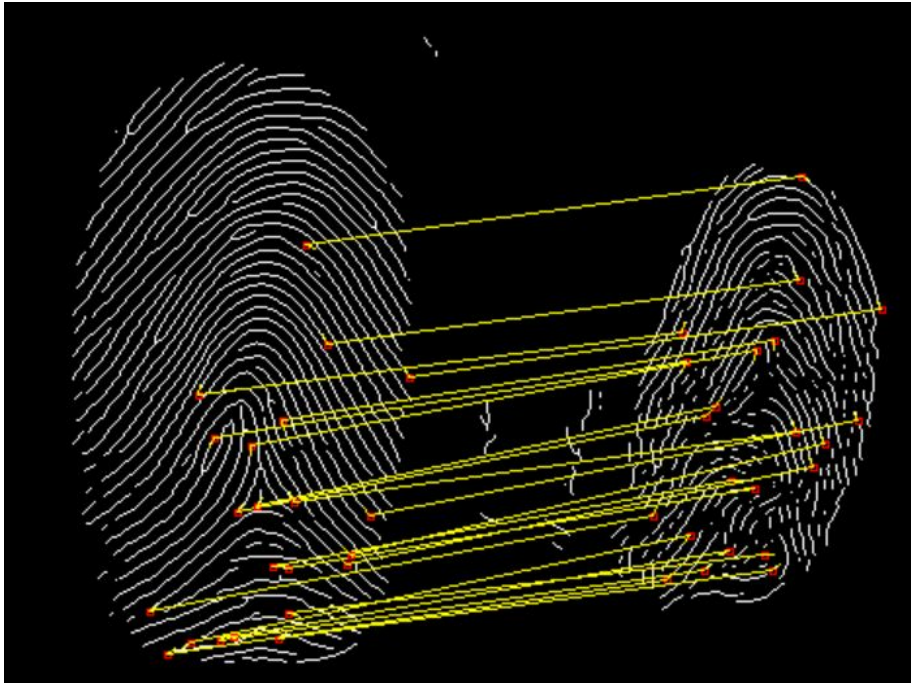


Middle Finger

White Glue: 0.2095

Middle Finger

White Glue: 0.2095

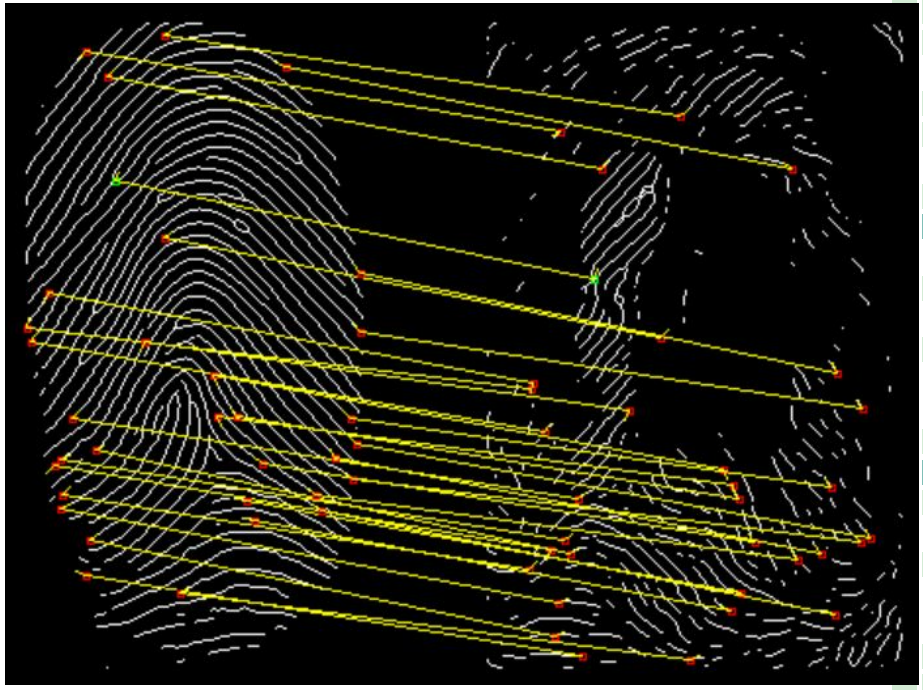


Middle Finger

Hotglue: 0.2282

Middle Finger

Hotglue: 0.2282

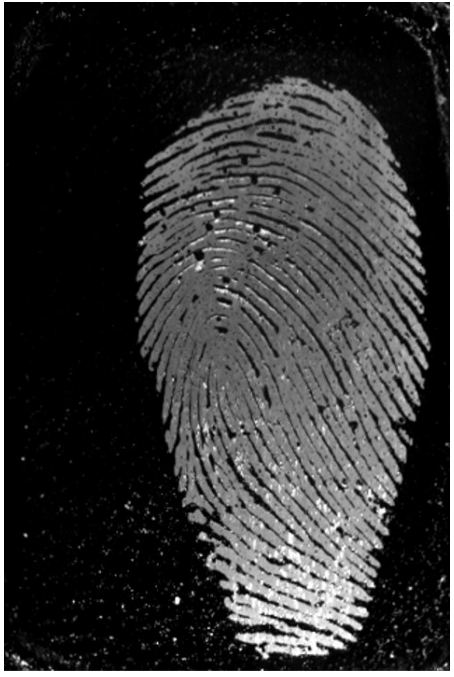


Middle Finger

Paper – will not scan

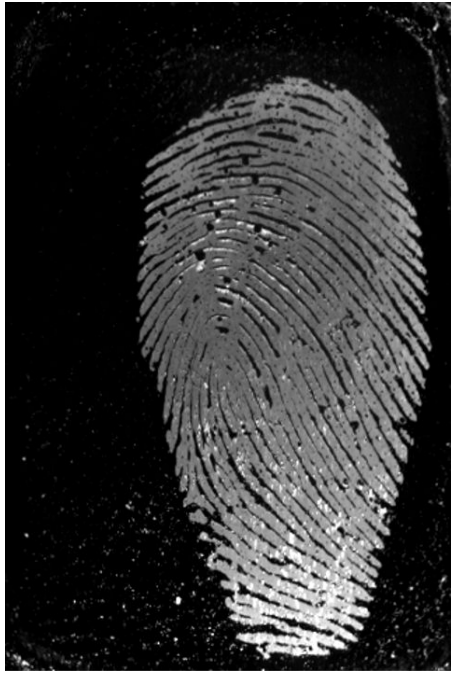
Index Finger

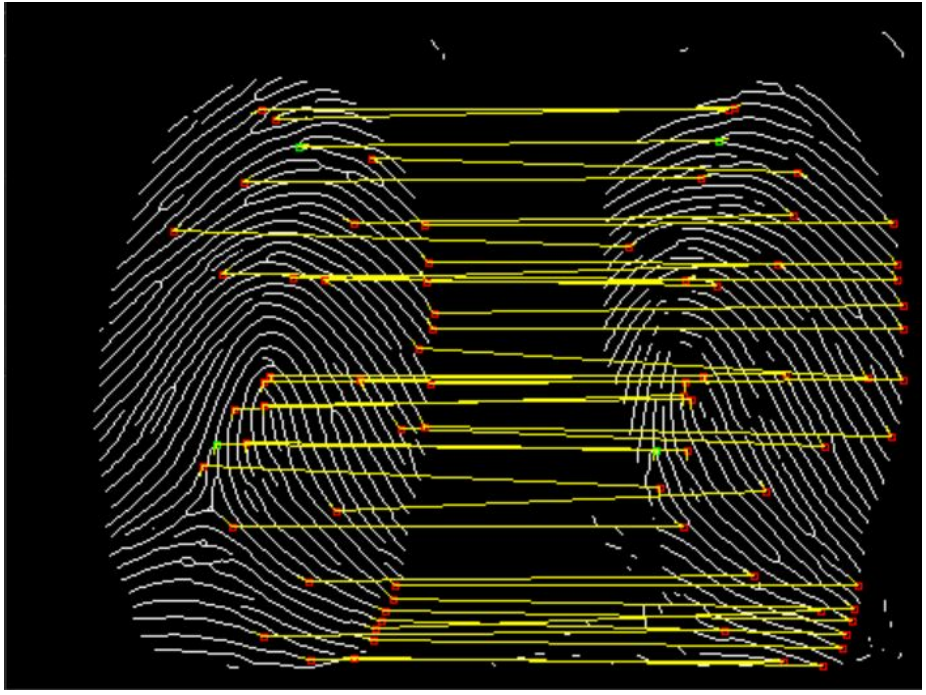
Gelatin: 0.3628



Index Finger

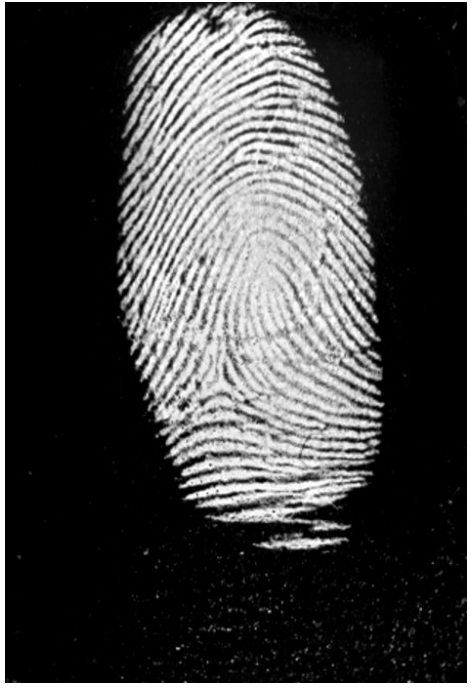
Gelatin: 0.3628



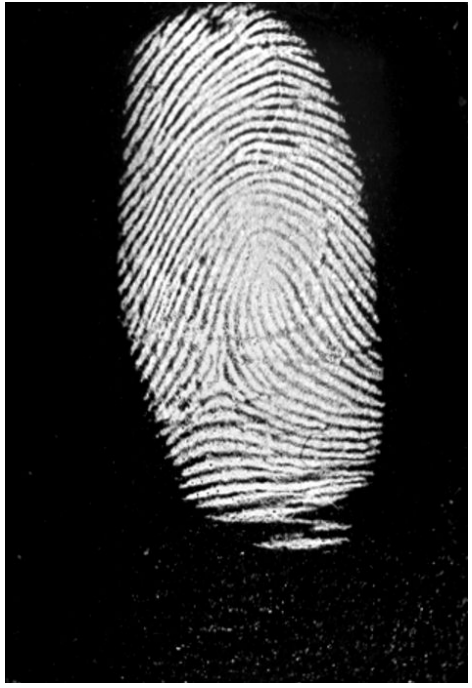


Index Finger

Latex: 0.3484



Index Finger



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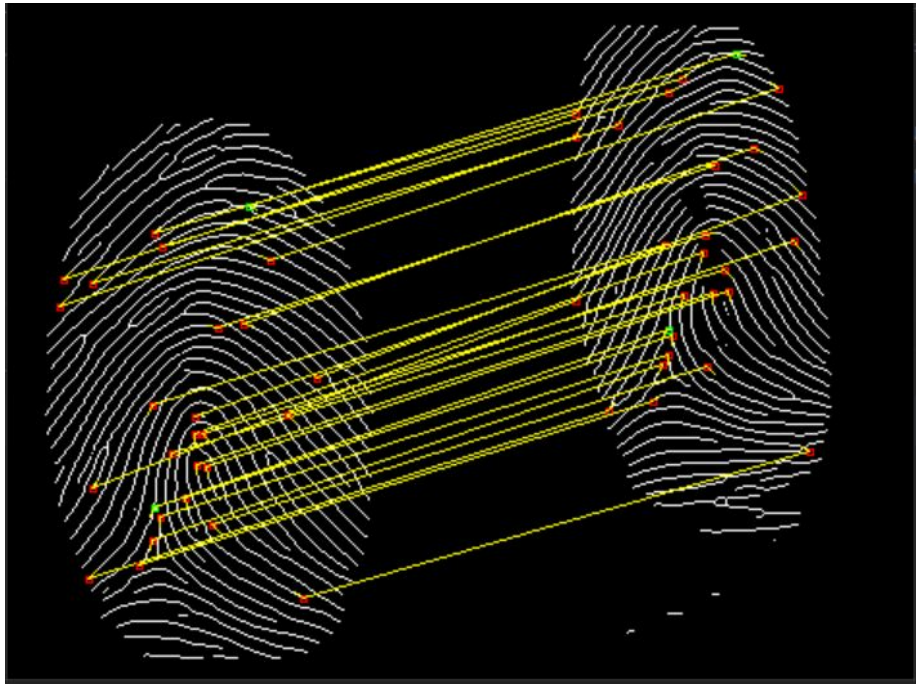
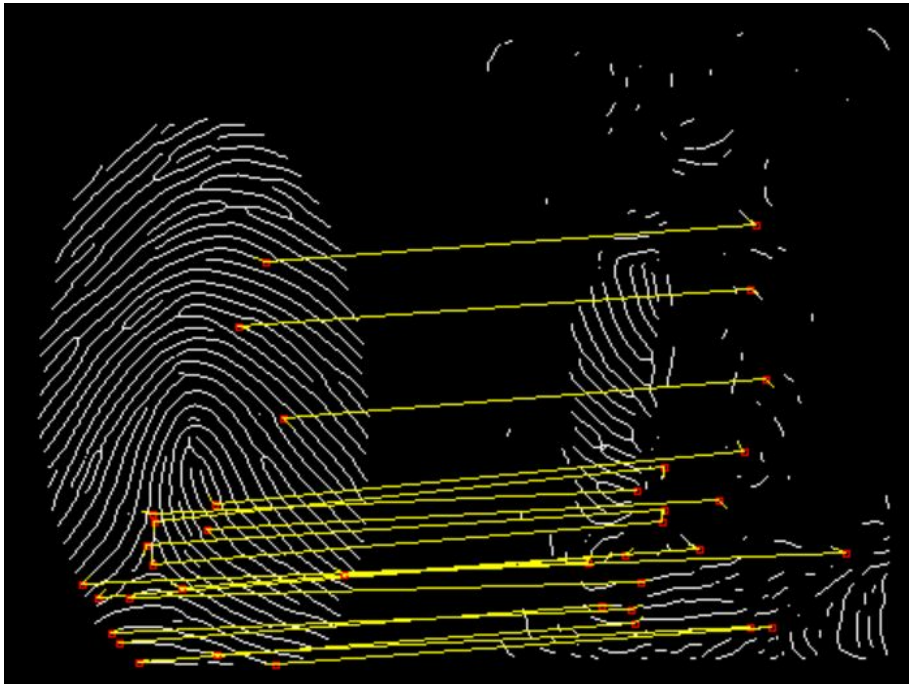


Index Finger

Hotglue: 0.1767

Index Finger

Hotglue: 0.1767

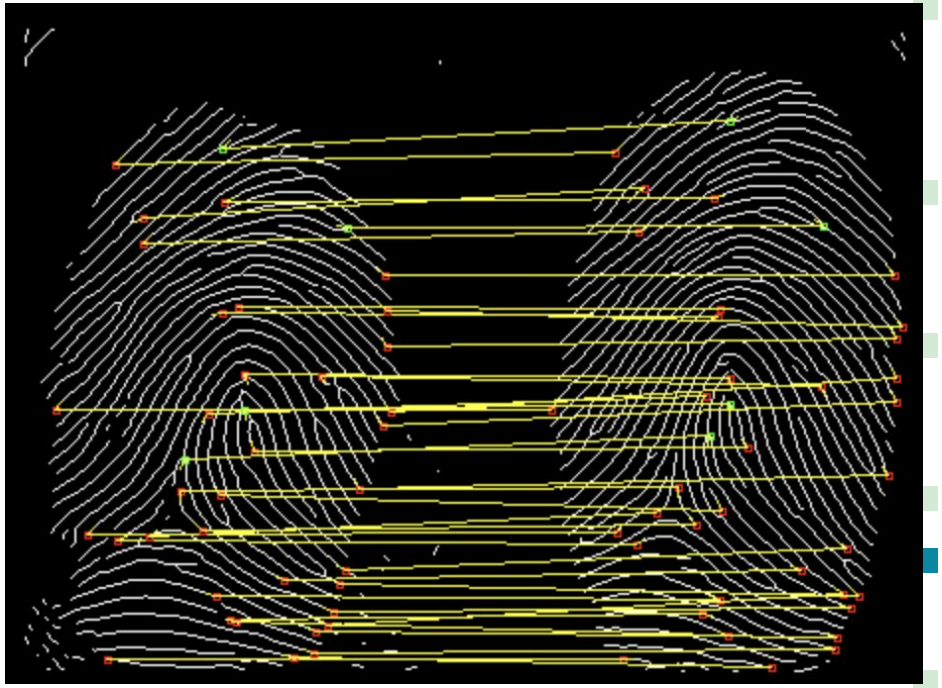


Index Finger

Mold: 0.3442

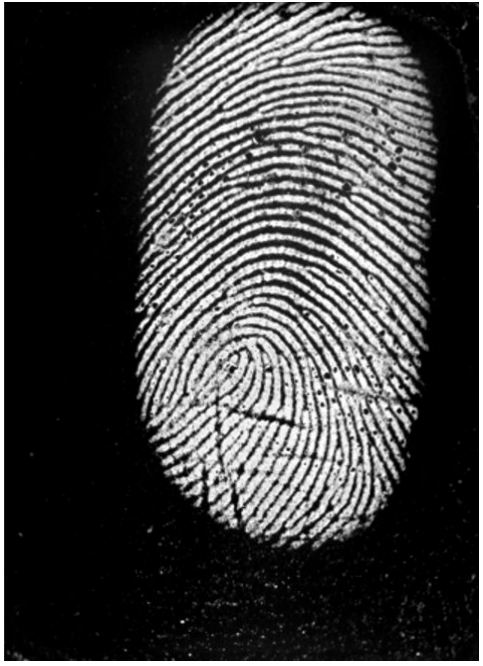
Index Finger

Mold: 0.3442



Thumb

Latex: 0.4088



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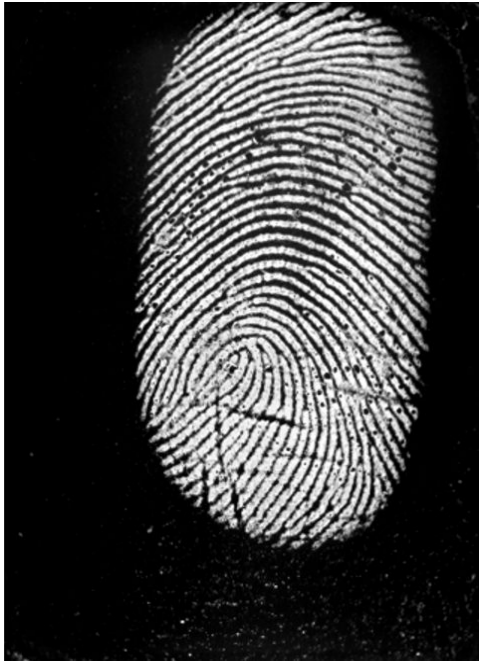
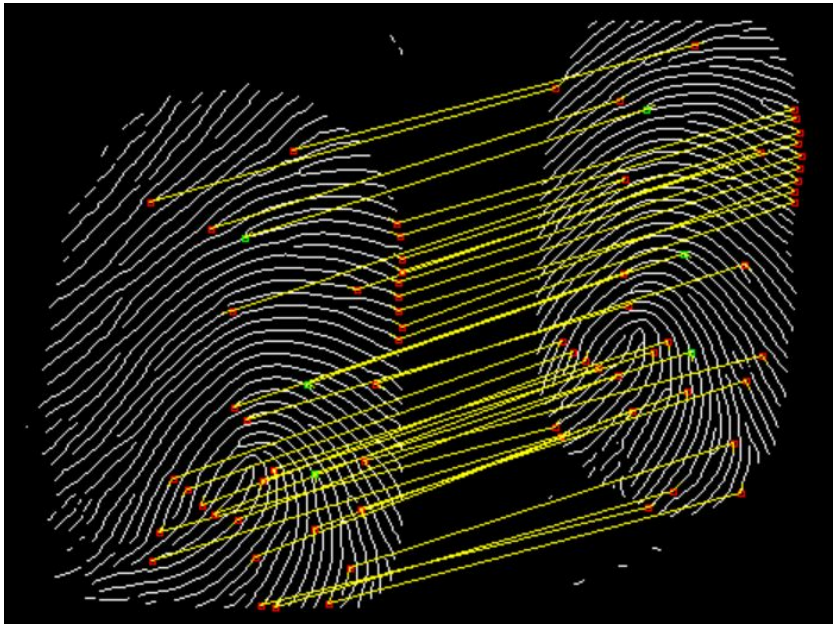


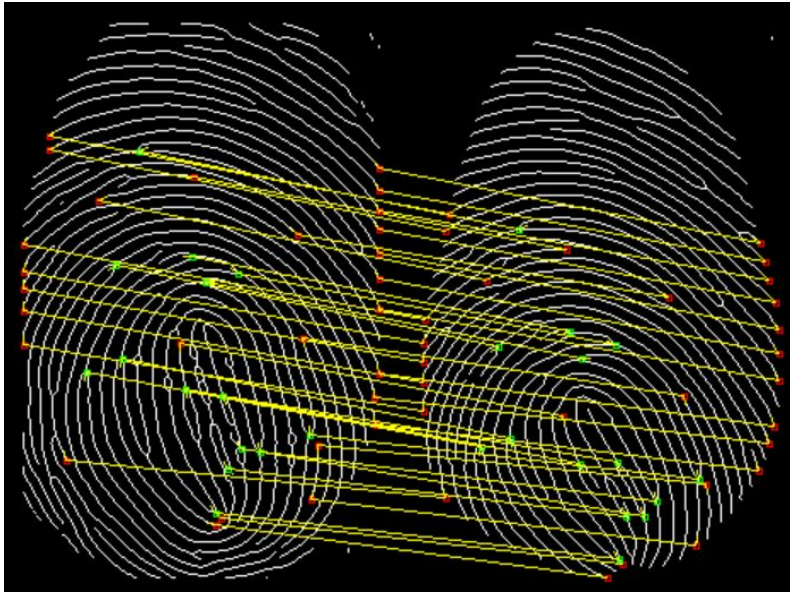


Thumb

Latex: 0.4362

Thumb

Latex: 0.4362

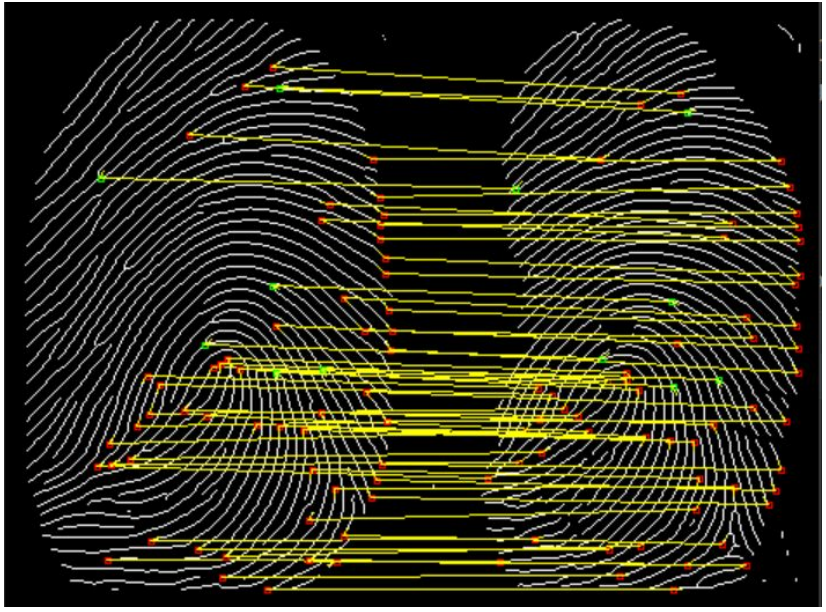


Thumb

Gelatin: 0.4797

Thumb

Gelatin: 0.4797

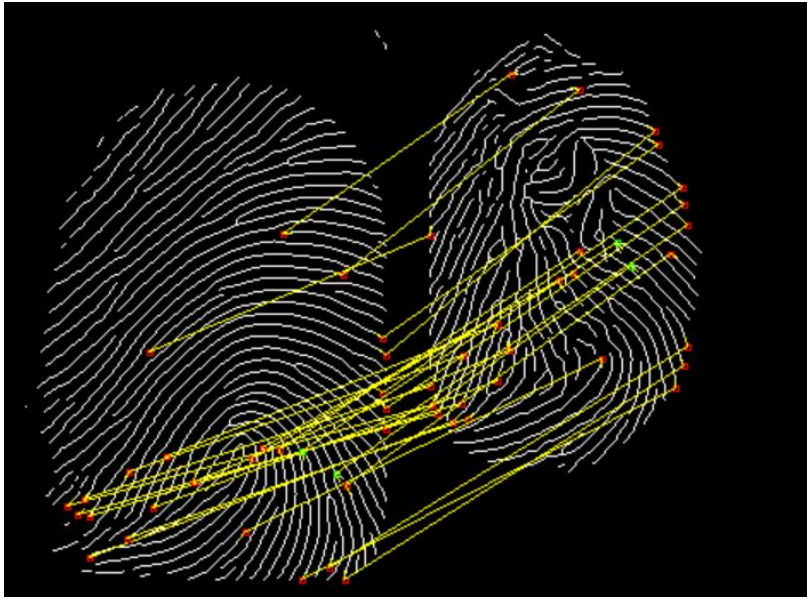


Thumb

White Glue: 0.2286

Thumb

Whiteglue: 0.2286

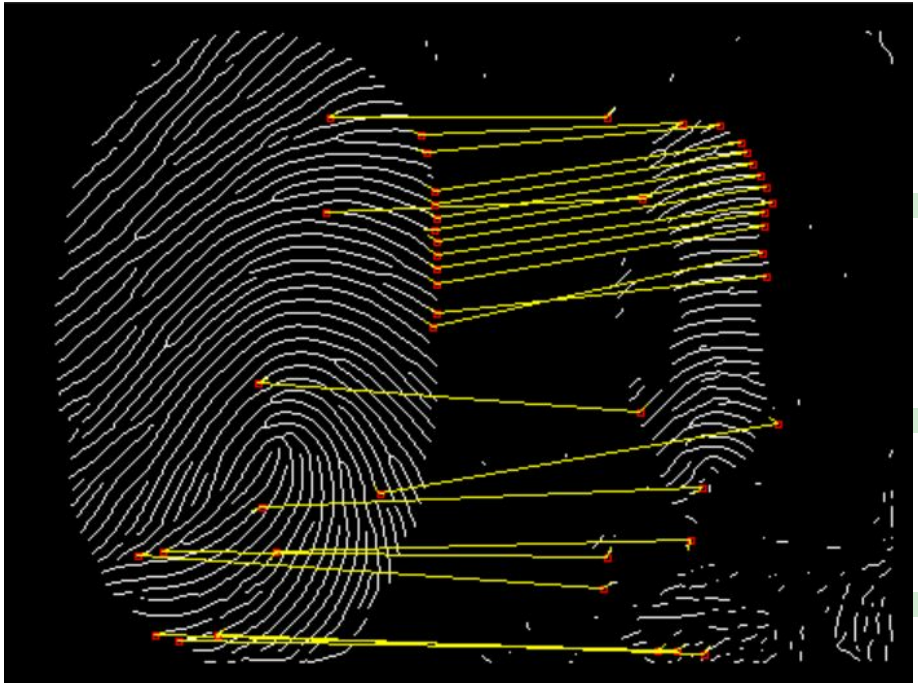


Thumb

Hotglue: 0.2180

Thumb

Hotglue: 0.218

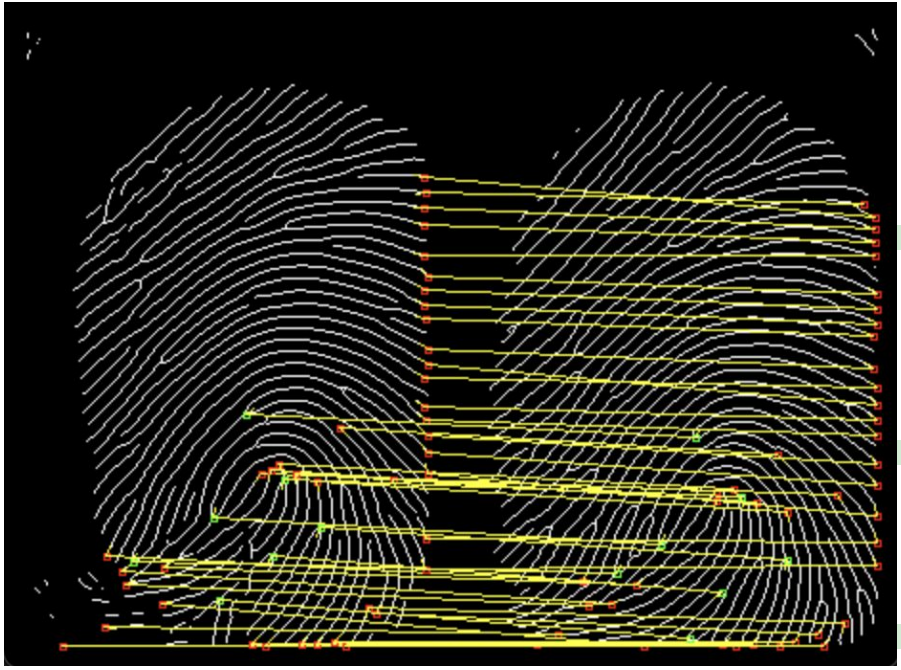


Thumb

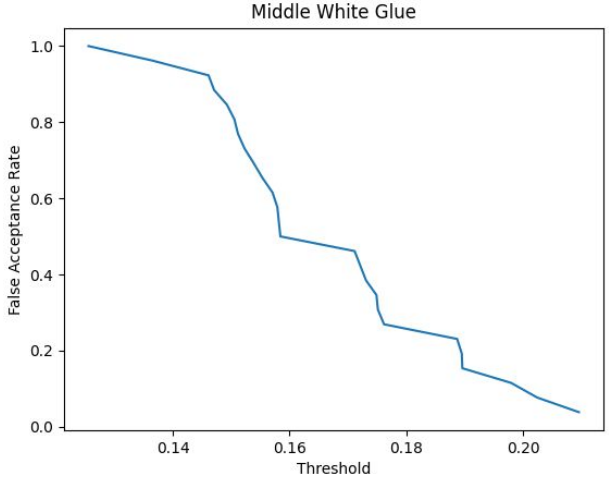
Mold: 0.3951

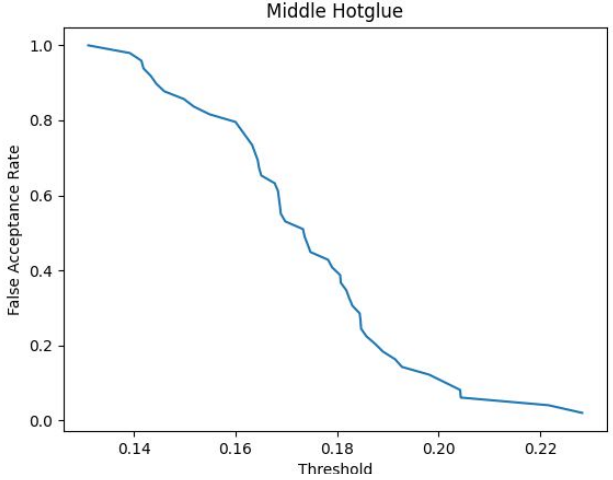
Thumb

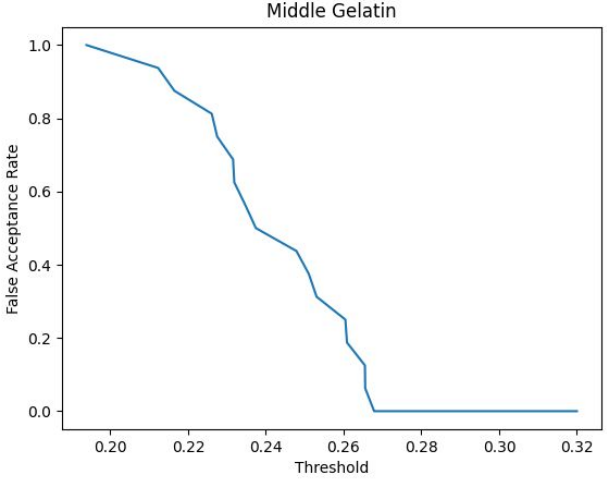
Mold: 0.3951

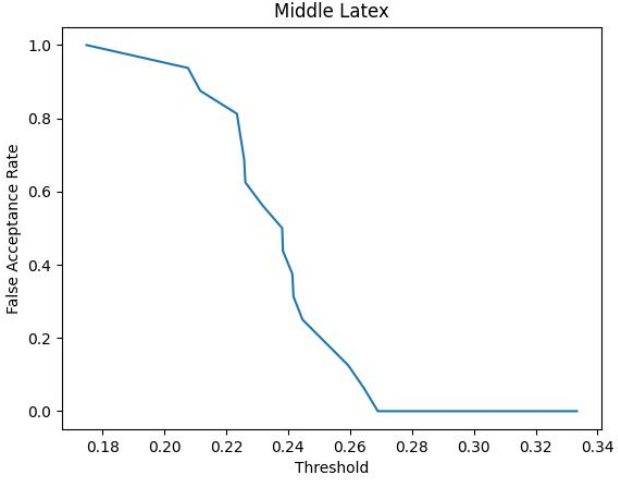


Middle Finger

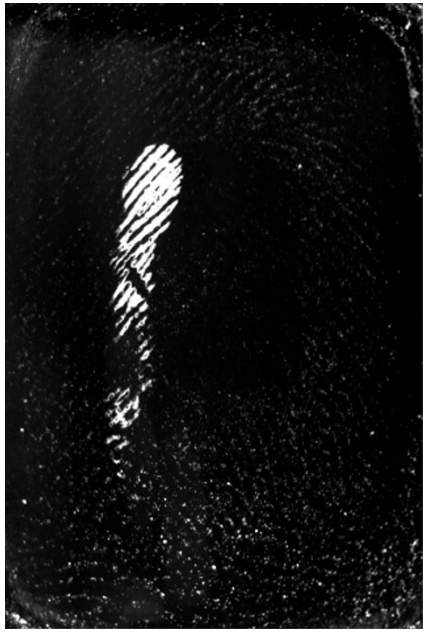




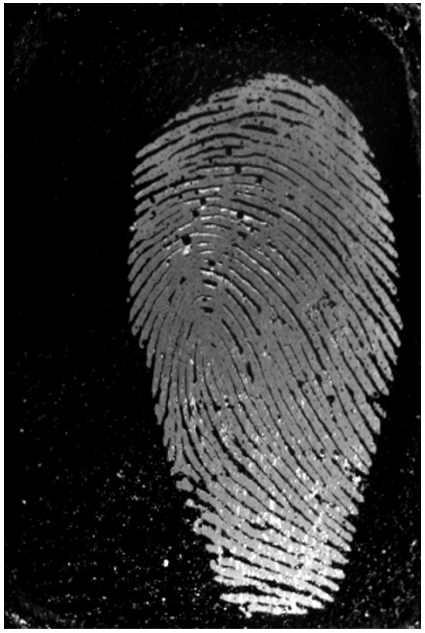




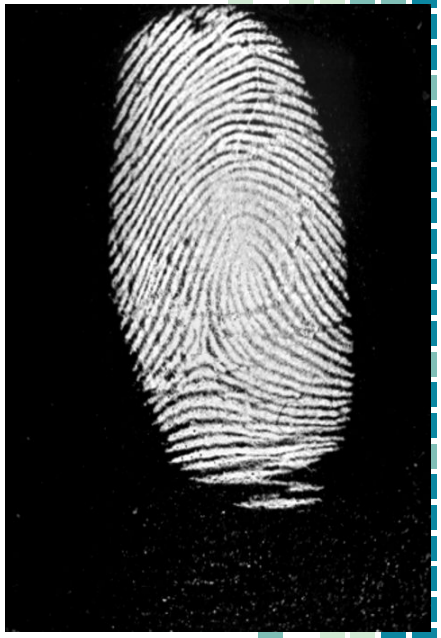
Middle White Glue



Middle Hot Glue

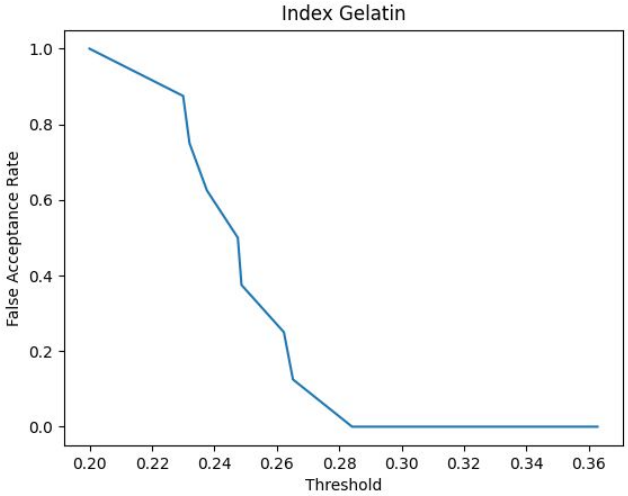


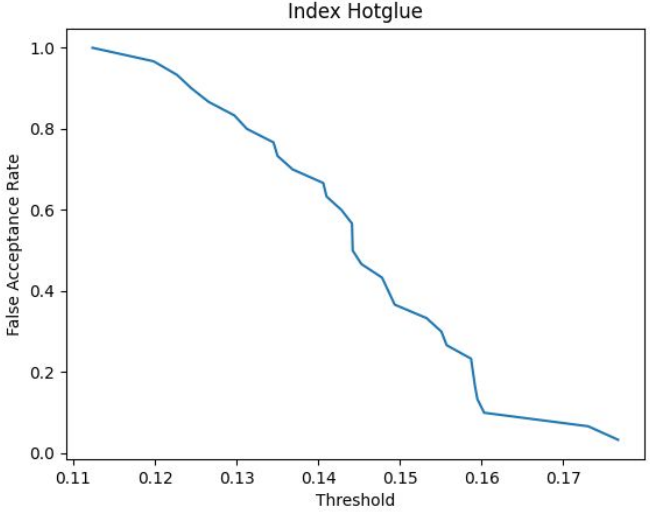
Middle Gelatin

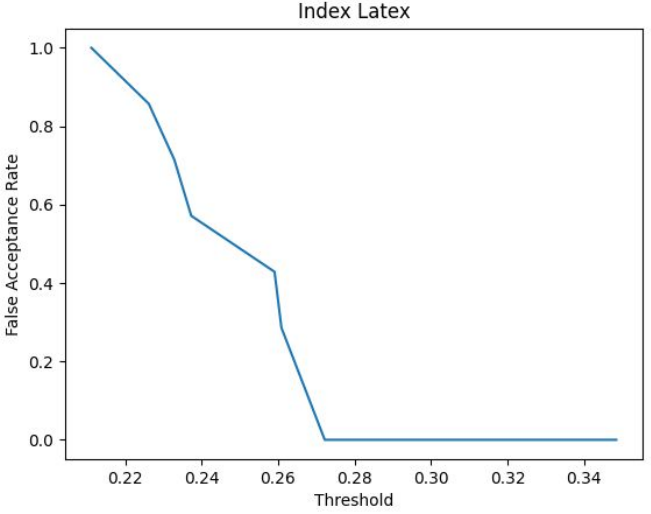


Middle Latex

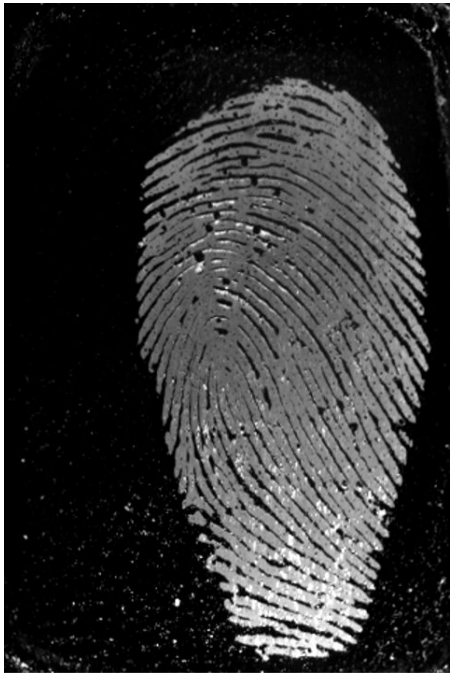
Index Finger



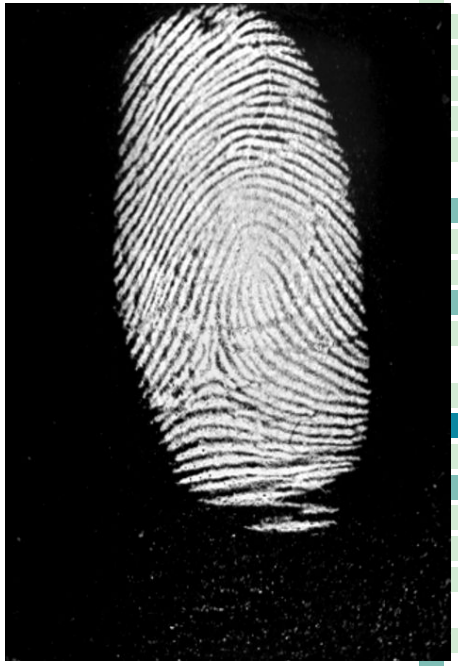




Index Gelatin

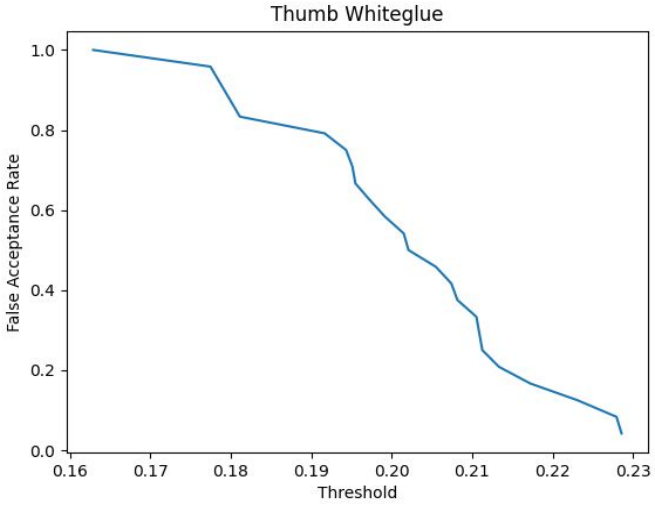


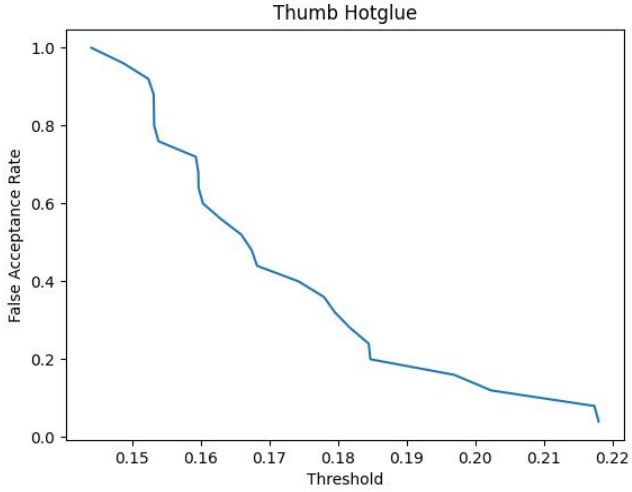
Index Hot glue

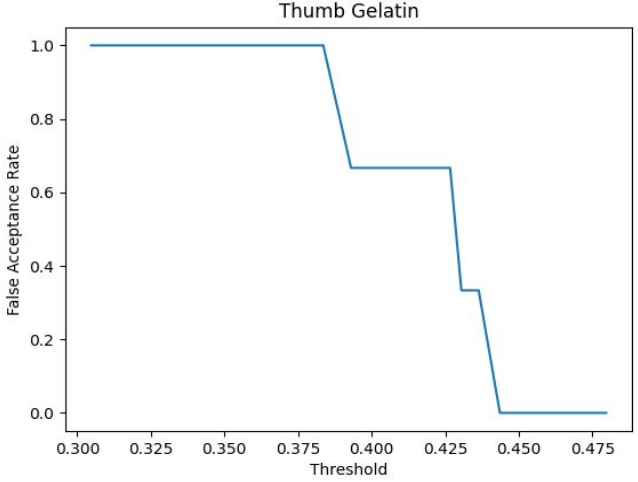


Index Latex

Thumb


Thumb Whiteglue
False Acceptance Rate
Threshold
1.0
0.8
0.6
0.4
0.2
0.0
0.16
0.17
0.18
0.19
0.20
0.21
0.22
0.23


Thumb Hotglue
False Acceptance Rate
Threshold
1.0
0.8
0.6
0.4
0.2
0.0
0.15
0.16
0.17
0.18
0.19
0.20
0.21
0.22


Thumb Gelatin
False Acceptance Rate
Threshold
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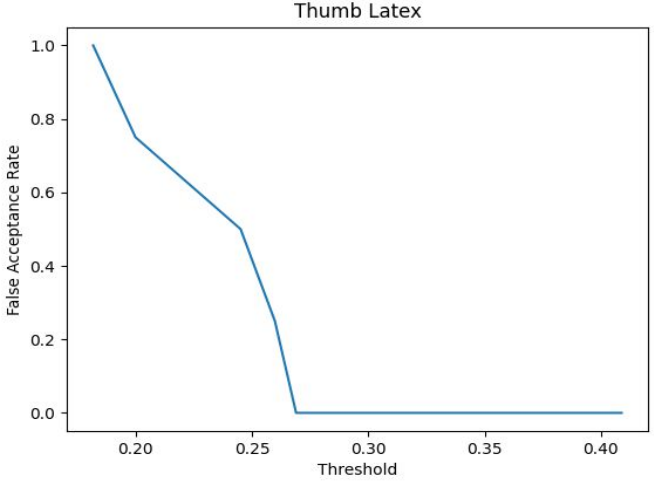
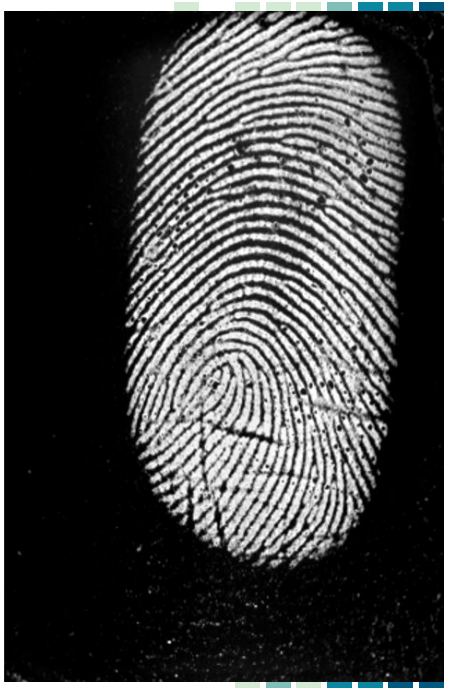
0.300
0.325
0.350
0.375
0.400
0.425
0.450
0.475


Thumb Latex
False Acceptance Rate
Threshold
1.0
0.8
0.6
0.4
0.2
0.0
0.20
0.25
0.30
0.35
0.40

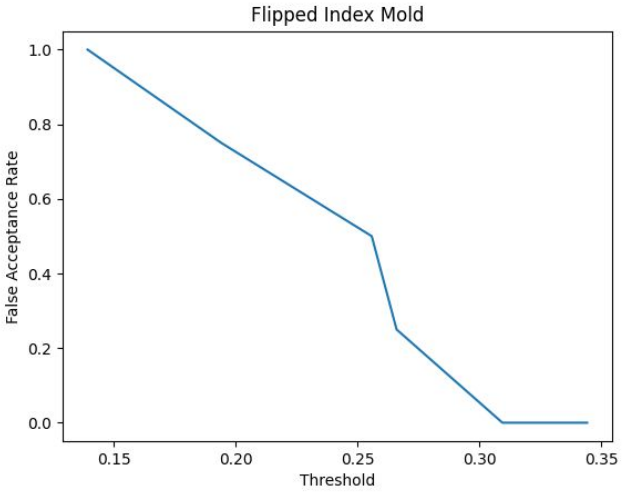
Thumb White Glue

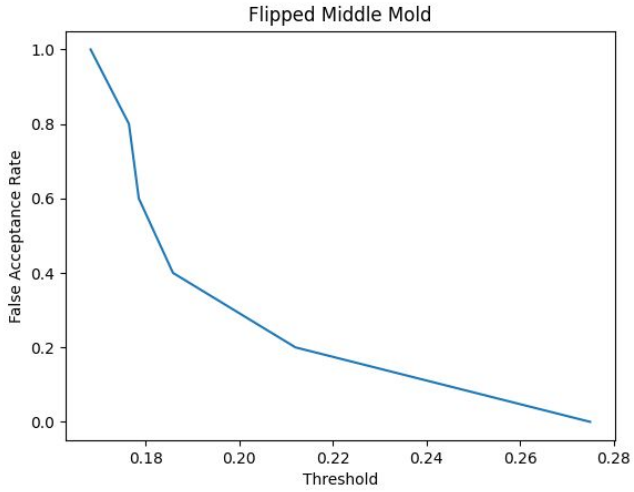
Thumb Hot Glue

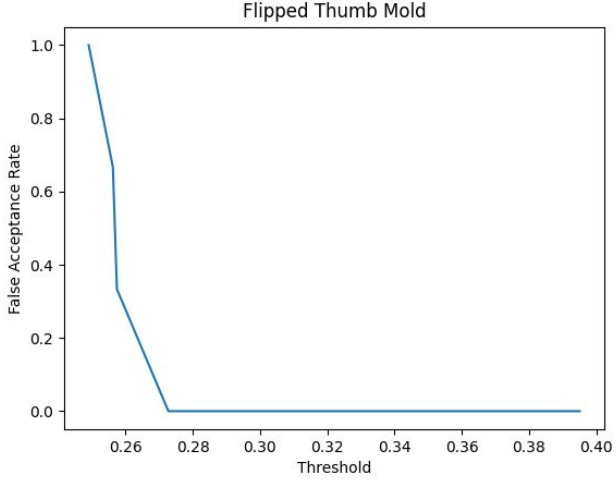
Thumb Gelatin



Thumb Latex







Flipped Fingers

Preventative ideas

- Two main areas where additional steps can be taken to detect fake fingerprints:
  - Hardware - Applied at the time of the fingerprint capture
  - Software - Applied during the processing steps ‘behind the scenes’

Preventative Strategies - Hardware

- In short: Better capture equipment -> More secure system
- With better equipment, higher level features can be detected
  - Sweat Pores
  - Blood pressure (somewhat uncommon)
- Especially important given most systems operate off partial scans of the finger (ie the entire fingerprint isn't needed for a scan to be valid)

“Liveness” Detection

- Skin distortion analysis - skin turns whiter under pressure
- Blood flow detection - detect blood movement beneath the fingerprint to determine liveness
- Active sweat pores containing ionic fluid on a live finger

Preventative Strategies – Software

- Two main strategies:
  - Feature-based
    - The in-class code falls here
    - Limited ceiling - studies have found an EER of 2-3 %
  - Deep-learning (Up to only 1.35% error rate)
    - Processing time a major downside
    - Input size often needs standardized - image could become distorted
      - Offset by taking ‘patches’ of fingerprint scans

Preventative Strategies - Other considerations

- Lock-out multiple failed attempts
  - Prevents brute force methods of intrusion
  - Could pose hassle to user experience
- Friendly vs Unfriendly fingerprint spoofing
  - Unlikely that a user will voluntarily submit their finger for a duplication method
  - Far more likely a partial print will be used by lifting off of a high-contact surface

Preventative Strategies – Final Thoughts

- No “perfect” solution yet
  - Best chances lie in combining the ideas discussed
- Reality: if top-security is the main focus of the biometric system, probably shouldn’t be using fingerprints
- Of course, fingerprints are still very relevant in biometric systems for their ease of use and high degree of social acceptability