NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

# Red Bleed: A Pragmatic Near-Infrared Presentation Attack on Facial Biometric Authentication Systems

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*15 Aug 2025*


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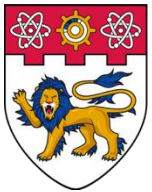
Aug 15, 2025

CICS



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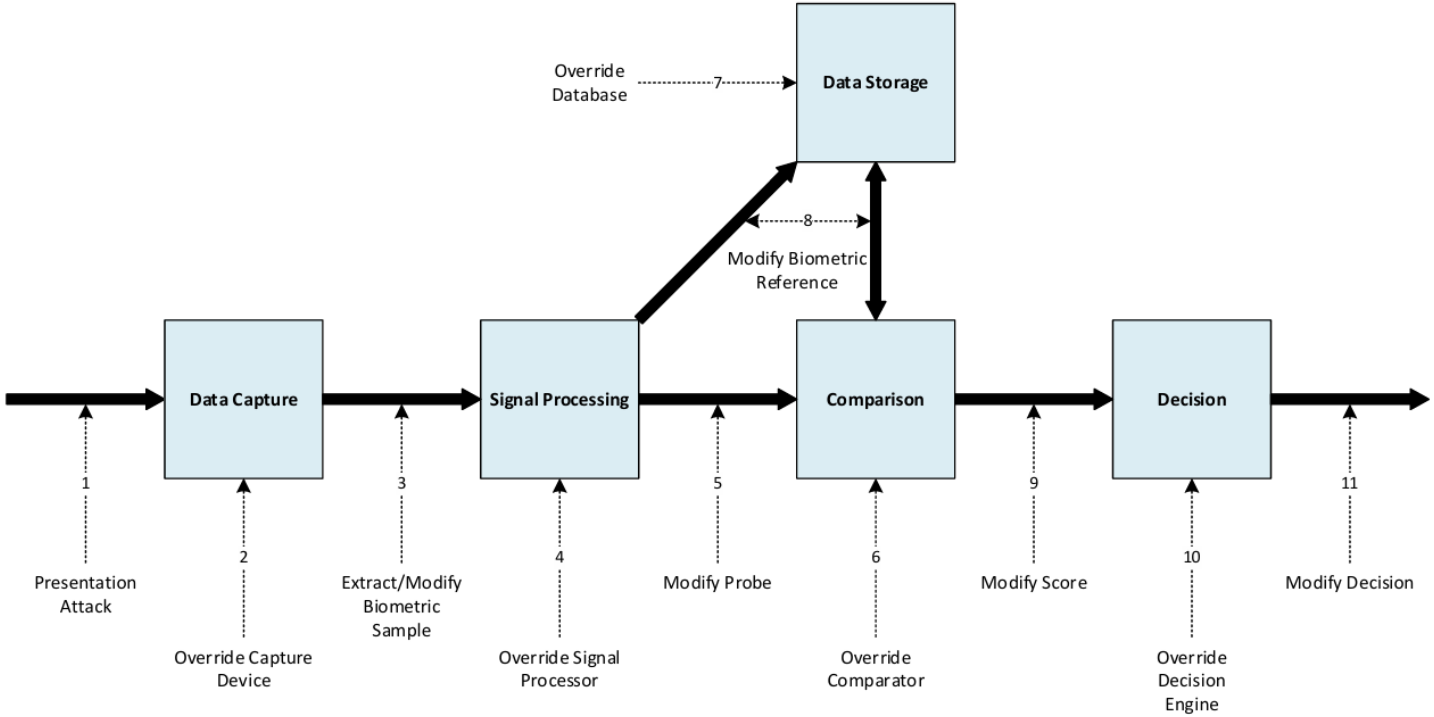
# Face Recognition - The Most Popular Biometric Today

- Unique and Universal
- Contactless, passive and non-intrusive
- Easy to use and fast
- Low cost
- High acceptance
- Widely used for
  - Verification (Personal ID)
  - Identification (Surveillance, Forensic)
  - Monitoring (Robots, personalized care)
- Facial recognition drivers:
  - Sensor technology
  - Artificial intelligent
  - Hardware acceleration
  - ...

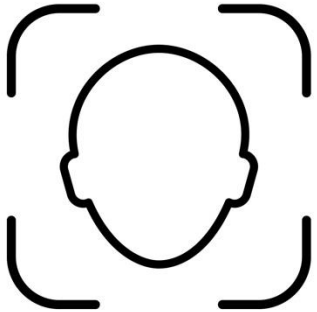
# Scheme of a Generic Face Recognition System




https://www.nist.gov/system/files/nstic-strength-authentication-discussion-draft.pdf

# Vulnerability of Face Recognition Systems

- Specialty of the Vulnerability of Face Recognition Systems:



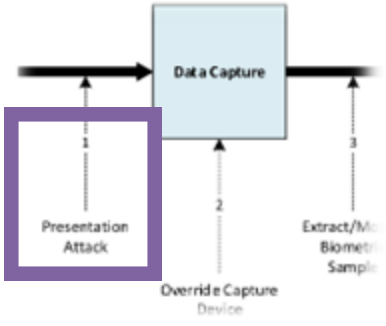
⚠ Face data is easy to obtain

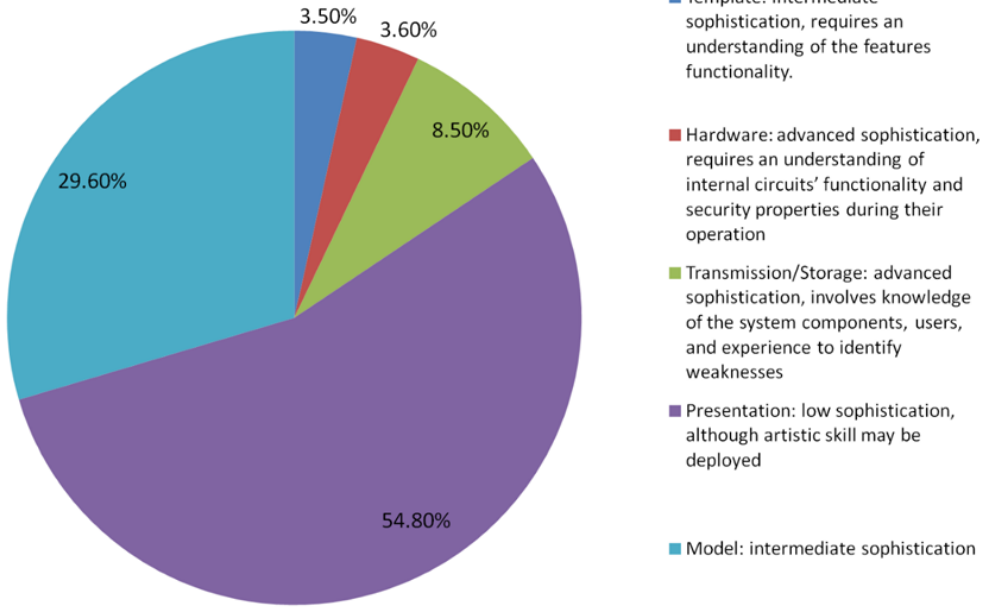
⚠ Face artifacts are easy to generate

⚠ Face is the “PASSWORD” that cannot be changed

# Vulnerability of Face Recognition Systems: Presentation Attack

- Attacks by proportion groups.
- From 2018–2021, studies focus on the presentation attack more frequently than any other sort of attack.



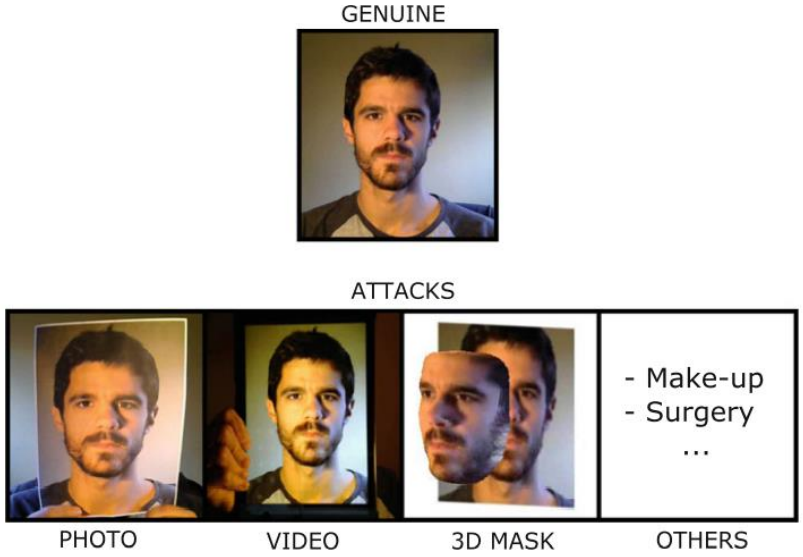






https://www.turing.ac.uk/sites/default/files/2023-05/attacks_against_facial_recognition_systems_technical_briefing_final_copyedit.pdf

# Presentation Attacks

- Printed photo presentation
- Display photo presentation
- Video presentation
- 3D mask presentation
- …

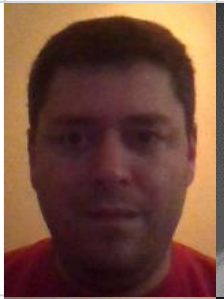





https://link.springer.com/chapter/10.1007/978-3-319-92627-8_9

# Face Recognition with Near-Infrared

- Traditional color recognition systems rely on turning up the brightness, exposure, or other settings to create a useable image – all of which expose artifacts that impact the robustness of the system.
- In contrast, near infrared images are consistent across ambient lighting scenarios

| Scenario | Color Image from integrated Camera | IR Image from Microsoft Reference Sensor |
|---|---|---|
| Low light representative of watching TV or giving a PowerPoint presentation |  |  |
| Side lighting when sitting near a window or desk lamp |  |  |



https://learn.microsoft.com/en-us/windows-hardware/design/device-experiences/windows-hello-face-authentication

# Face Recognition with Near-Infrared

- NIR for anti-spoofing
- NIR doesn't display in photos and displays






https://learn.microsoft.com/en-us/windows-hardware/design/device-experiences/windows-hello-face-authentication

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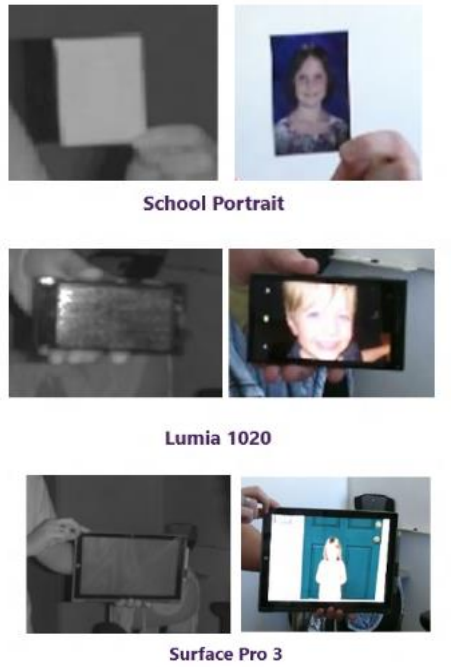
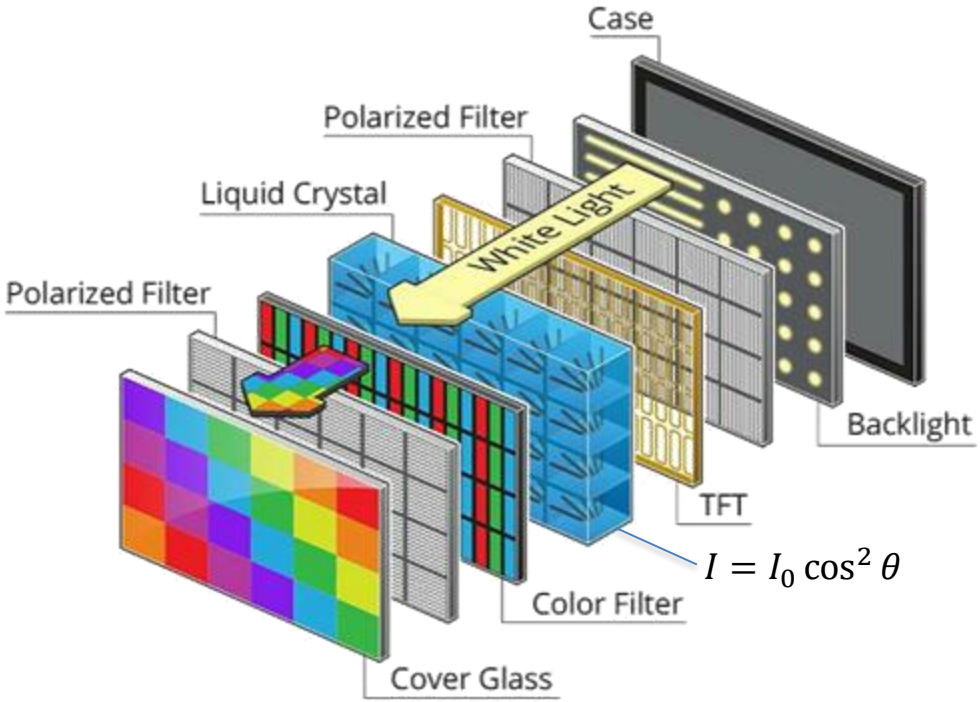
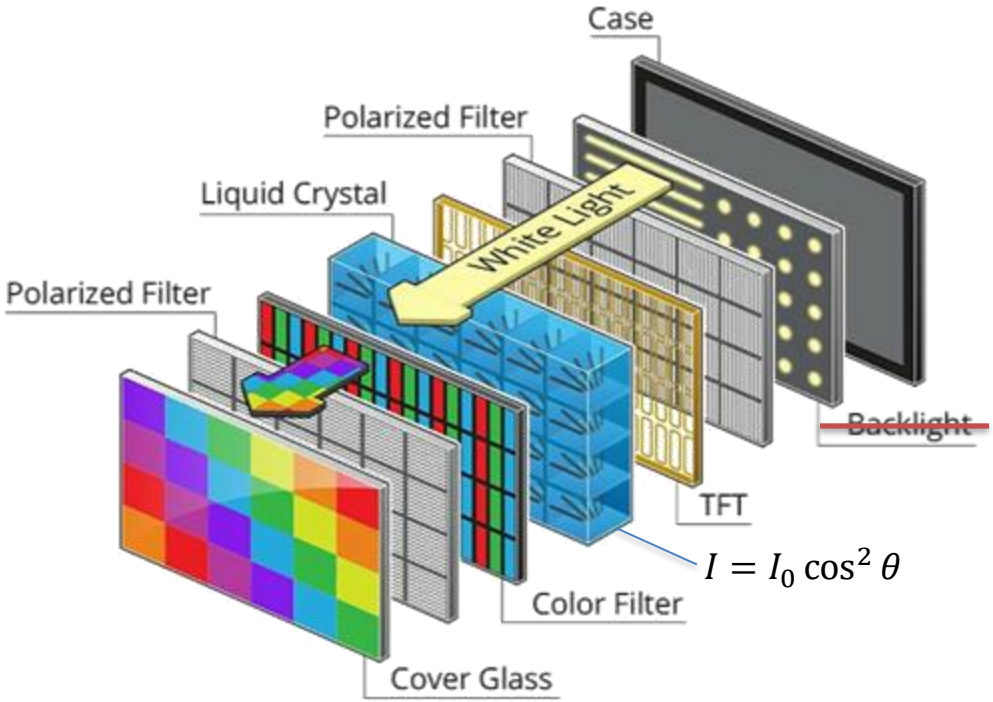



https://learn.microsoft.com/en-us/windows-hardware/design/device-experiences/windows-hello-face-authentication

# Liquid Crystal Display (LCD)

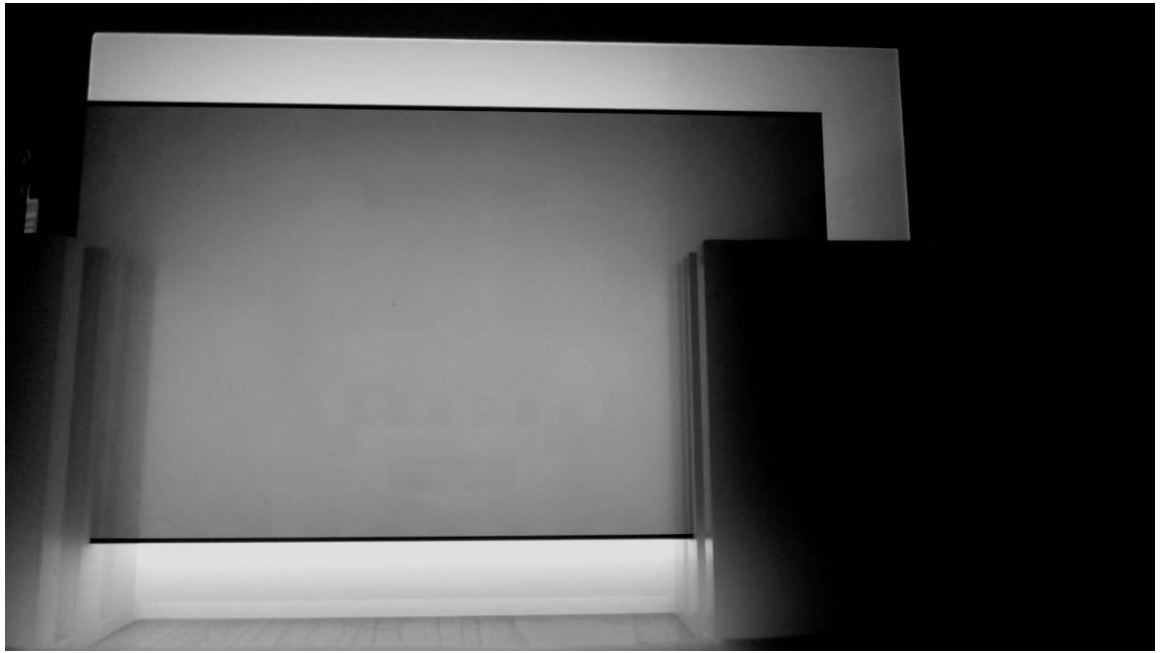



# Liquid Crystal Display (LCD)



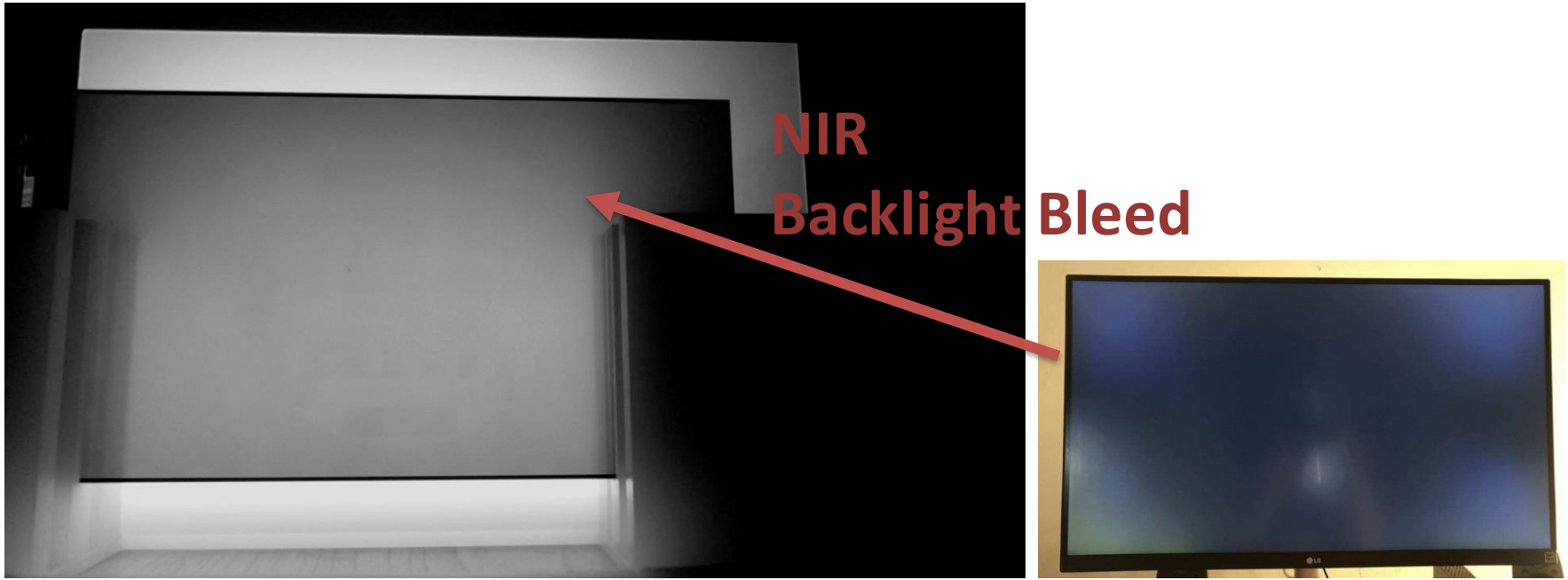

What if we swap it for the NIR backlight?

# Liquid Crystal Display with NIR Backlight



With only the backlight changed to NIR, some very shallow patterns can be seen on the screen.

# Liquid Crystal Display with NIR Backlight

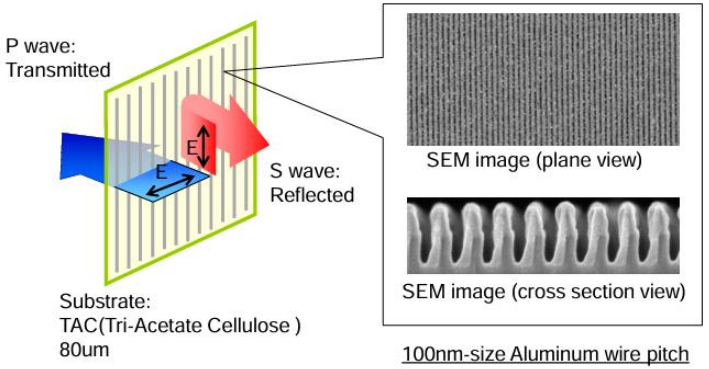


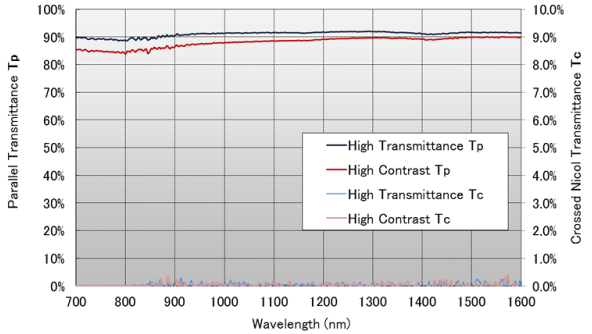



Recall the title of this paper: Red Bleed

# Polarizer of LCDs

- Polarizers on LCDs are designed for 400-700 nm visible light wavelength.
- Wire grid polarizer can polarize effectively in a wide range from Visible to NIR



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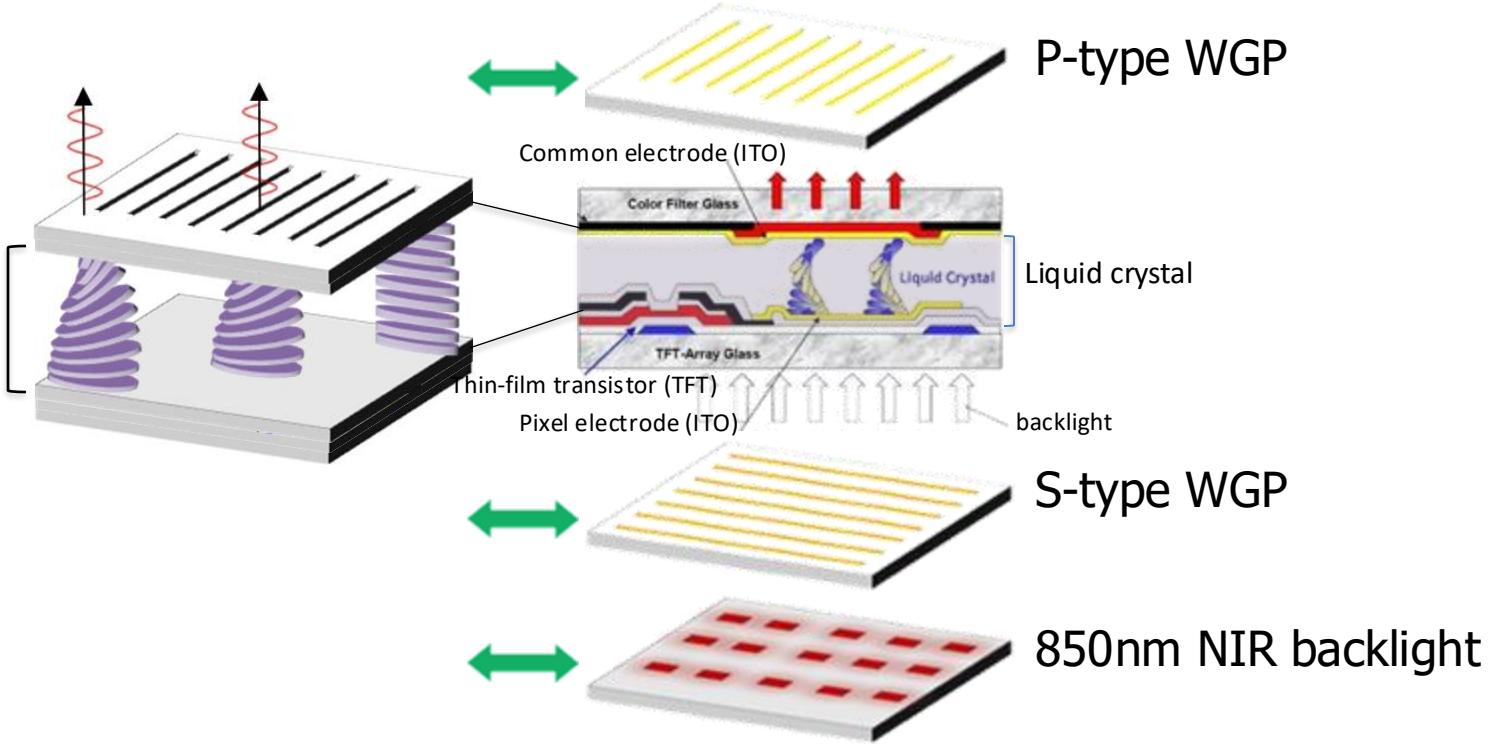
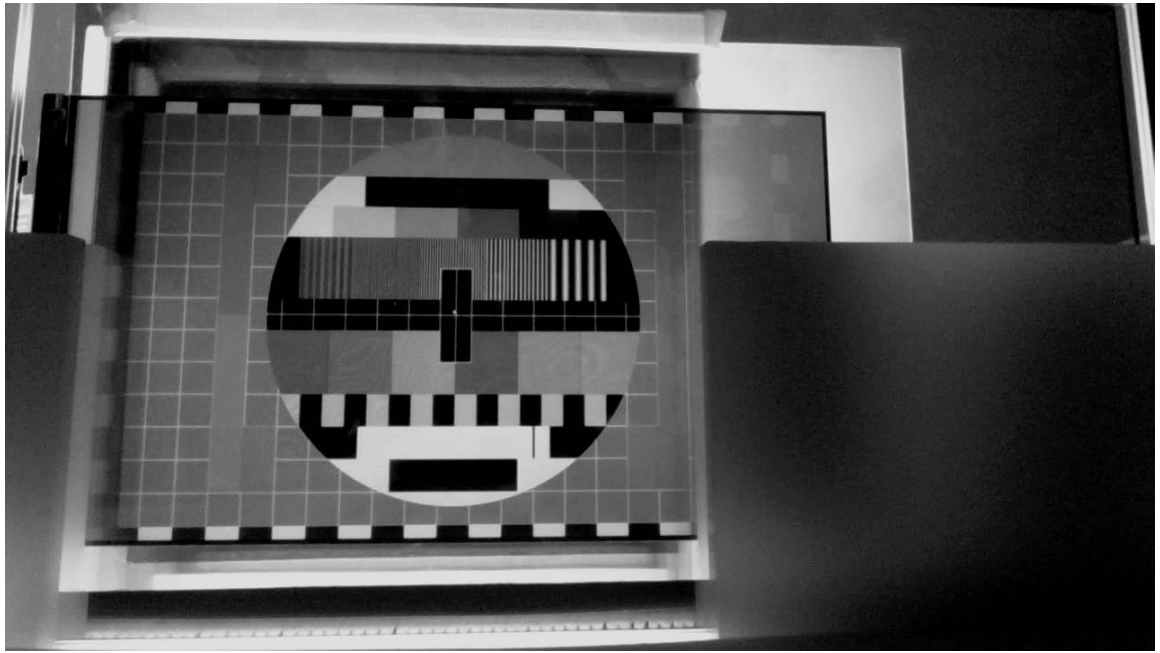


# LCD with NIR Backlight and WG polarizers



Good polarizers makes wonders

With WG polarizers added, very clear pattern is displayed on the screen under NIR spectrum.

# Material Costs

**850nm LED Board**

150mm×100mm

**$15.50**

**PP Diffuser**

150mm×100mm

**$0.07**


**Asaki KASEI HC12N Wired Grid Polarizer**

240mm×80mm

**$309.90**

**Sharp 5.5-inch 2K LCD**

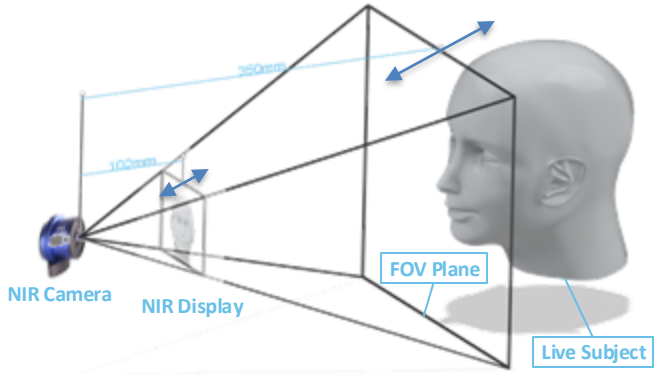
1140(RGB)×2560

LS055R1SX04A

**$30.90**

**356.37**

# Ready for attack




**Geometric Alignment Between Camera, LCD and Real Face**

# Victims: Windows hello modules

**HP:** 340×340 pixels, 30 fps

**Dell:** 340×340 pixels, 30 fps

**Lenovo:** 640×360 pixels, 15 fps

- 6.6s (200 frames), 1280 ×720 NIR video each of 22 subjects.
- OmniVision OV9281 monochrome camera with Gamma adjustment.
- Looped to create a 13.2 s continuous video for replay attack.
- The video uses FFV1 lossless encoding.

**100%** attack successful rate on all three modules

# Live Captured Frame Vs Captured Replay Frame

LIVE NIR

REPLAY NIR

# Limitations of the NIR presentation attack

- Require Acquisition of a 2~3 seconds of NIR **video** of the target
  - The subject should be illuminated with NIR light
  - The image should be captured with a NIR camera
  - Not stealthy enough

- Whereas, VIS facial images are omnipresent and easily accessible.
  - Secret videography from distance
  - Wedding and other group activities
  - Social medias
  - Video conferencing
  - …

# Addressing the Challenge of Dataset Limitation

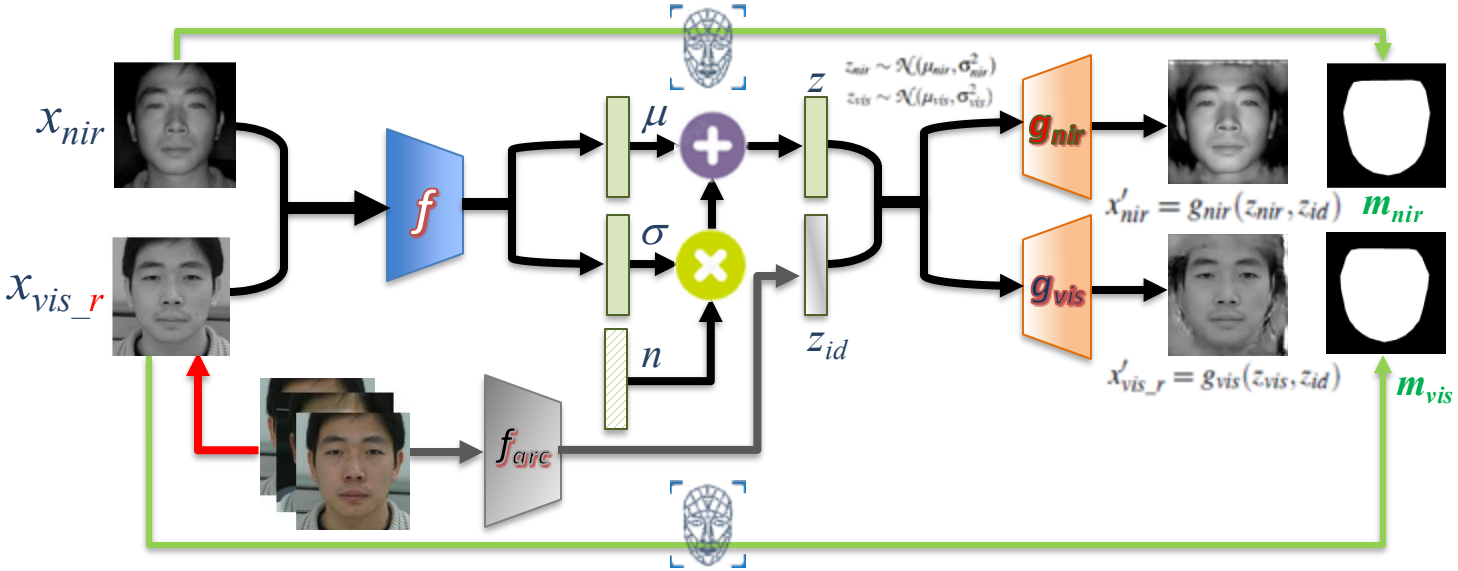
- Dataset: CASIA NIR-VIS Face 2.0 database
  - Released in 2013 CVPR Workshop
  - 725 subjects (from children to old people) with 1~22 VIS sample and 5~50 NIR samples
  - No pixel-level correspondence

- Our Data: Target subject samples
  - Few-shot learning: **nine** pairs of VIS-NIR samples are used for training
  - One-shot learning: **one** pair of VIS-NIR samples are used for training
  - No pixel-level correspondence required

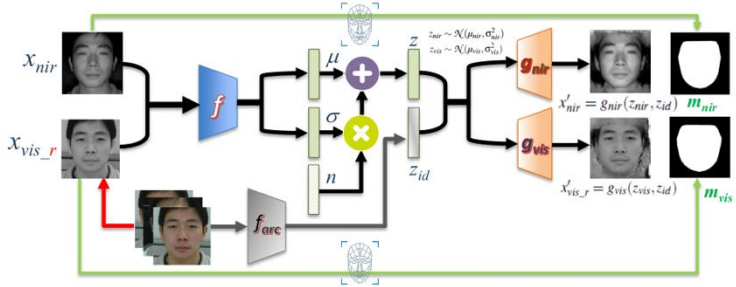
Uneven class distribution

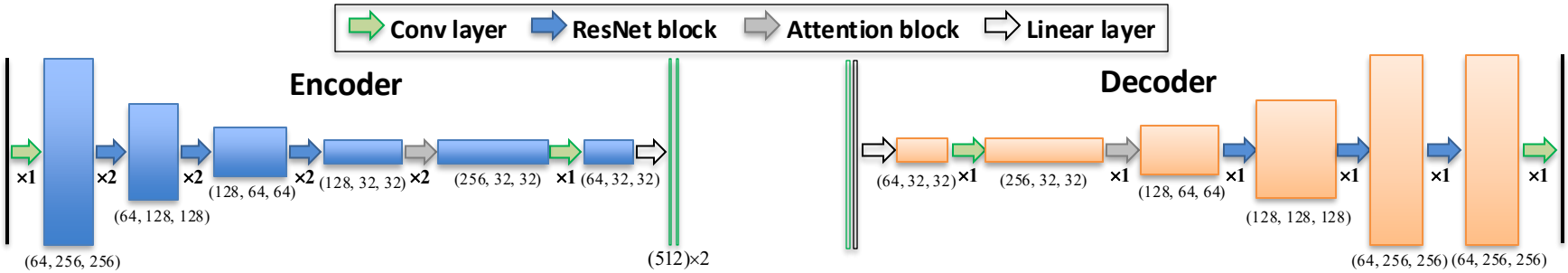
NIR-VIS Face 2.0 database: VIS and NIR face images, with variations in resolution, lighting conditions, pose and age, of one subject.

# Variational Autoencoder (VAE) based NIR Identity Preserving Face Generation



# Variational Autoencoder (VAE) based NIR Identity Preserving Face Generation



# Synthesis Results and Attack Performance

Generated NIR face

RGB video, Red channel

DeepFaceLab Face Swap

We generate a 5 seconds video
by swapping 100 frames.
22 subjects tested.

Nine-shot learning
Success rate 97.73%

One-shot learning
Success rate 61.25%

# Limitations of the Red Bleed Attack

- Cannot break "Enhanced Face Anti-spoofing" of Windows Hello Upon Windows April Updates (KB5055547, ver 24H2).

- Cannot break Apple Face ID and other 3D FRS.

# Limitations of the VIS to NIR Generative Model

- At least one shot from the target sample is required.
- A larger dataset with cross-spectral pixel correspondence is required for an unseen subject synthesis.
- Some artifacts appear in the generative result.

# Responsible Research

- Upon confirming the effectiveness of the attack on September 25, 2024, we immediately notified the security departments of Microsoft (MSRC), HP (HP PSRT), Dell (DELL PSIRT), and Lenovo (LENOVO PSIRT).

- We provided complete technical details in a report to each vendor and actively addressed their questions. We have agreed to withhold public release of this research until Microsoft has fully mitigated the issue.

- Microsoft managed to address this vulnerability with the **CVE-2025-26644** published and the patch released in the KB5055523 security update for all in-service Windows versions on April 8, 2025.

# Acknowledgments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- The presenter: Dr. Dirmanto Jap

# Thanks

For inquiries and research collaboration, please contact
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