



ACM UIST 2025

PricoEye: The Eye of Primary Colors for Fast and Convenient 3D Reconstruction of Fine-grained Palmprint on Smartphones

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香港中文大學

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Background

Teaser video



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Background

Palm Payment



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MasterCard



WeChat



Hong Kong Science Park



Amazon



Motivation

Fingerprint vs Palmprint



Contact-Based



Non-Contact-Based



Hygiene Concerns



Public Health





Motivation

Current solutions are high-cost



Handkey II (4677 USD)



Amazon One (-)



SoundScan 517 (28500 CNY)



SoundScan MC527 (39000 CNY)



ZHIANG AYF800 (-)



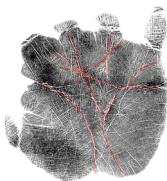
Motivation

A solution based on ubiquitous smartphones

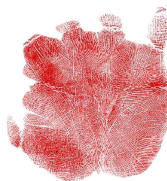


Amazon One (-)

Affected by ambient light
Limited resolution
Non-portable
High-cost



Crease-level
Features



Ridge-level
Features



Ubiquitous
smartphones

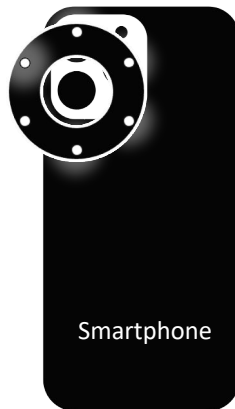
Can we develop a low-cost solution utilizing ubiquitous smartphones?



Key Idea

Embedded Add-on + Photometric Stereo

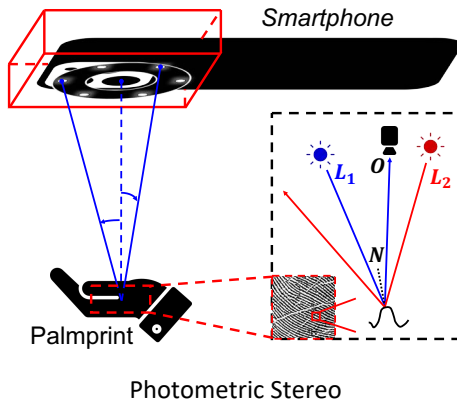
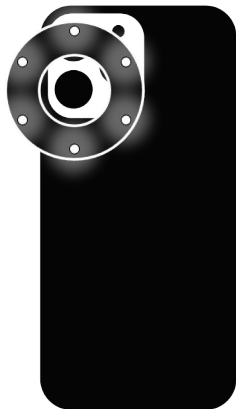
Embedded Add-on





Key Idea

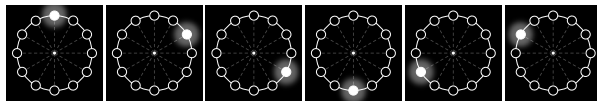
Embedded Add-on + Photometric Stereo



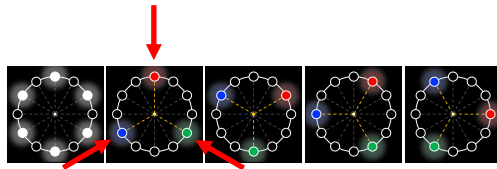


Flash Mode

TDM Mode vs FDM Mode



Time Division Multiplexing (TDM)



Frequency Division Multiplexing (FDM)



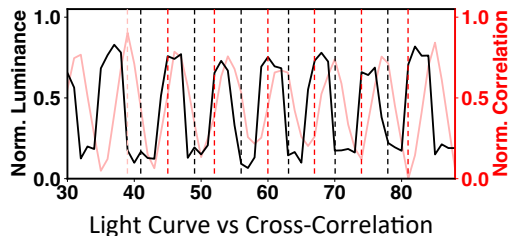
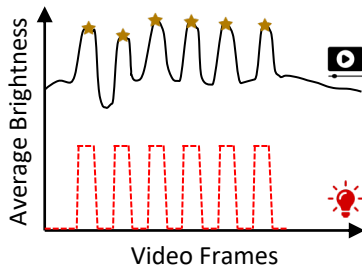
Cycle Time



Challenges & Solutions

#1: Key frame extraction for PS

How to efficiently extract precise key frames for Photometric Stereo?

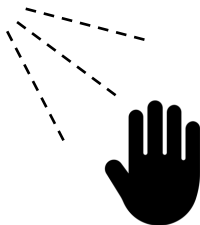


Challenges & Solutions

#2: Robustness to skin tone and ambient light

How to eliminate the effects of skin tone and ambient light?

Ambient Light



Skin tone affects the reflectance ρ

$$L = \begin{bmatrix} l_1 \\ l_2 \\ l_3 \end{bmatrix} = \begin{bmatrix} l_{1R} & l_{1G} & l_{1B} \\ l_{2R} & l_{2G} & l_{2B} \\ l_{3R} & l_{3G} & l_{3B} \end{bmatrix}$$

$$\tilde{L} = (L' \odot s) \cdot X + E$$

$$= (M(n, c, \alpha \odot L) \odot s) \cdot X + E$$

Skin Tone

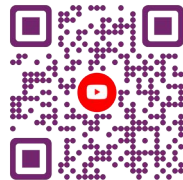
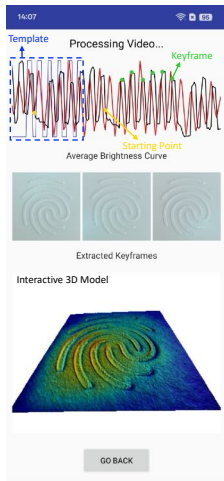
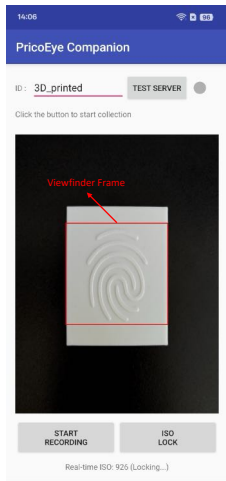
Transformation Matrix

Ambient Light

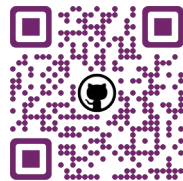


Implementation

Companion App, Hardware Design, and Demo



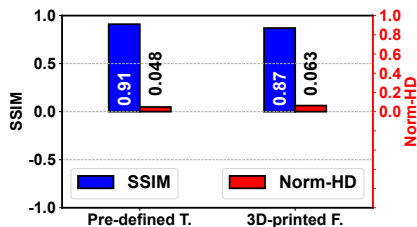
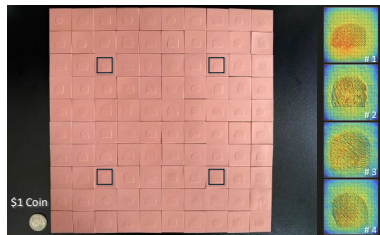
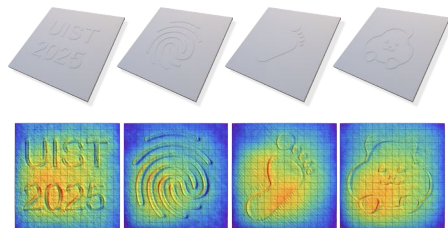
Demo Video



Hardware Design

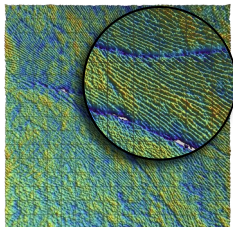
Evaluation

Study #1: High-precision 3D-printed films (with ground truth)

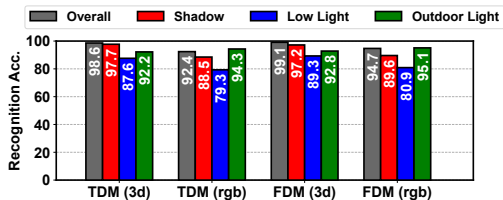


Evaluation

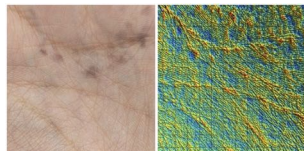
Study #2: Real-world palmprint recognition



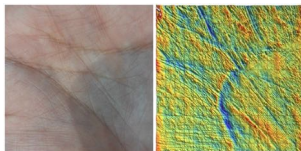
Visualization



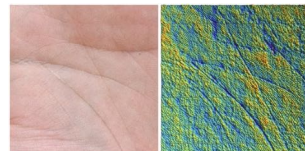
Downstream Task Performance



Corner Case: Birthmark



Corner Case: Shadow



Corner Case: Low Light



Conclusion

- ◆ PricoEye is a hardware-software co-design solution to achieve low-cost 3D palmprint reconstruction on ubiquitous smartphones.
- ◆ The design facilitates the democratization of Photometric Stereo technology on mobile devices.
- ◆ By specializing the reflection model (Lambertian reflectance in PricoEye), the fine-grained reconstruction has great potential to be applied in many fields, such as surface defect detection and skin health monitoring.



Thank you!

Q & A



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The Chinese University of Hong Kong (CUHK)

Scan Me!

