

Mobile Biometrics:

Trends and Issues

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Outlines



- 1 Biometrics Intro
- 2 Mobile Biometrics: for you
- 3 Mobile Biometrics: for me
- 4 Issues in Mobile Biometrics
- 5 Concluding Remarks

1. Why Biometrics?



Secure

Identification by
Physical Presence



Convenient

No need to
Carry or Memorize



New Solutions

Solutions which were
not possible before

Access Control at Disney



at Shanghai Disneyland*



*June 8, 2016, <http://fortune.com/2016/09/07/disney-fingerprints/>.



Security Protection: Smart Gun



Pretoria inventor Nic van Zyl Photo: *Popular Mechanics*

Intelligent Fire Arm,
South Africa

Smart Washing Machine



Vented in Spain the First Ever Washing Machine for Men

Friday, March 11, 2005

by: [IPFrontline](#)

The invention was shown yesterday in the acts of the International Women's Day and consists of a original System (named Lazy Man System) that forces a man to necessarily USE the washing machine 50% with his wife.

Healthcare at Arrixaca Hospital's Day Hospital*



*<http://www.iritech.com/iris-healthcare-umanick>

Use of fingerprint, iris and face biometrics to reduce the misidentification for,

- ❖ 67% of the errors in blood transfusions
- ❖ 13% of all adverse effects that harm patients in surgeries
- ❖ ID wristbands only reduce errors by 50%

2. Mobile Biometrics: to Identify You



- ❖ Needing a handheld or movable identifying solution
 - Police patrol, military, border security, public safety and justice, etc.
 - Ex. Police inspection on a car driver sitting in a car.
 - Ex. Inspection on civilians working in military camps.

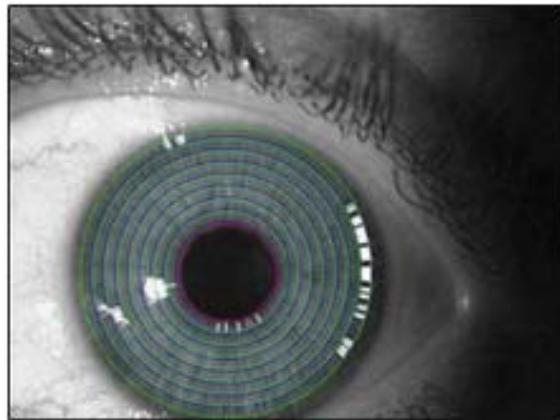


<http://www.datastrip.com/index.html>

Old model: Mobile Iris Recognizer



- ❖ Mobile iris scanner; XVISTA*



*Xvista Biometrics Ltd

Old model: Mobile Iris Recognizer



❖ PIER series



PIER (Portable Iris Enrollment and Recognition) handheld camera from Securimetrics, specializing in military and police deployments.

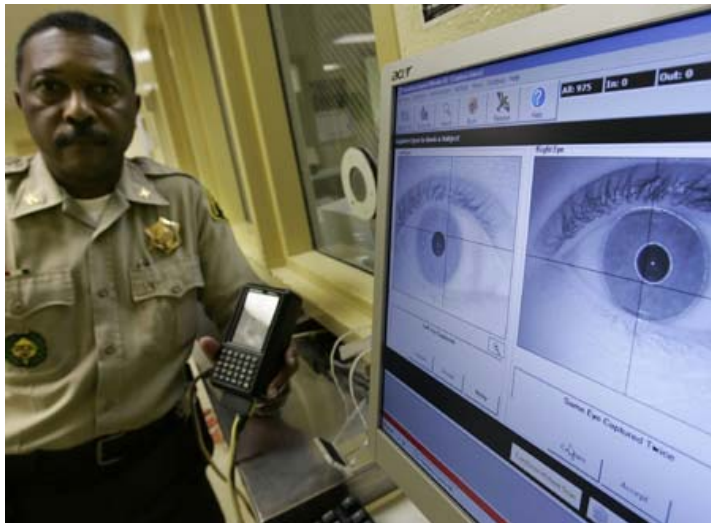
<http://www.securimetrics.com/>

Operating range : 4" ~ 6",
operating time : 15 frame/sec
Dimensions : 8.9(W)×15.3(H)×4.6(D)cm³
weight : 0.468 Kg

Max. # of users : 200,000~400,000 subjects

System speed : 1.33 MHz, X86

Display : 240 by 320 LCD touch screen



Multimodal Mobile: HIIDE*



* Securimetrics, <http://newatlas.com/hiide-portable-biometric-device/15144/>

For identifying others



Iris (640*480 VGA monochrome)

Face (640*480 VGA color)

Fingerprint (500 dpi)



Recent one: MorphoRapID 2*



(* <http://www.morpho.com/en>)

MorphoRapID 2



Fingerprint and face recognition

- FAP 30, FBI certified fingerprint sensor
- 8MP camera with flash for portrait capture

Wireless connectivity

- 4G/3G cellular, Wi-Fi, Bluetooth 4.0

MorphoTablet™ 2*



*<http://www.morpho.com/en/biometric-terminals/mobile-terminals/morphotablet-2>



The 8" touchscreen Android device now offers **4G high speed data transfer**, complete credential acquisition/reading capabilities, plus enhanced usability and robustness to ensure seamless **enrollment, ID verification** and **identification** on the spot.

- 8" touchscreen tablet with incorporated FBI PIV IQS and STQC certified optical fingerprint sensor
- 13 MP camera with dual LED for face capture, 1D/2D barcode and MRZ reading
- Contact smart card reader
- Contactless smart card and e-passport reader
- Signature capture
- Embedded security features
- 4G, Wi-Fi and Bluetooth

Biometric Engineering Research Center - MMS 2.0



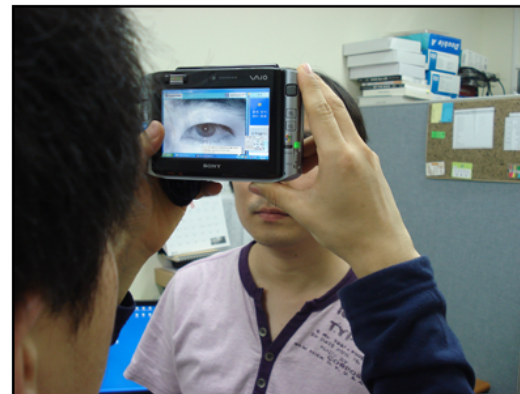
Built-in Camera for
face recognition

Fingerprint sensor for
fingerprint recognition



Cold mirror and
Infrared illuminators
for iris recognition

Operating range : 14 ~ 21cm/iris, 25~95cm/face
Processing time : less than 1 sec
Accuracy : EER of 0.44%/iris, 10.61%/face
Size : 15(W)× 10(H)× 8.3(D)cm³
Weight : 700 g
Maximum Enrollments : 3,200,000 persons
CPU : Intel 1.2 GHz
4.5"LCD Display
Expected Price : \$2,000 (Others: \$4,000~\$6,000)



AOptix Stratus Biometric Scanner*



(*<http://www.aoptix.com/>)

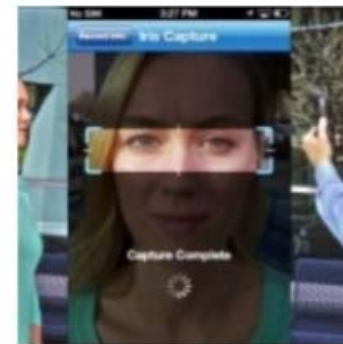


❖ Multimodal Biometric Scanner

- Face
- Iris
- Fingerprint
- Voice

❖ iPhone Add-on: 2014

(<http://www.wptv.com/news/science-tech/aoptix-stratus-biometric-app-for-iphone-tech-company-turns-your-phone-into-biometric-scanner>)



1st Generation Mobile Biometrics



Used by trained persons



To Identify who YOU are

Unit price and accuracy are more important
than user convenience.

3. Mobile Biometrics: to Verify ME



2nd Generation Mobile Biometrics



iPhone 5S: Touch ID
www.apple.com/kr



Galaxy S5
<http://www.samsung.com/sec/>



Pantech Vega: Secrete Note
<http://www.pantech.co.kr/>

Since 2014, Phone Unlocking -> Big application

Others, More Recent

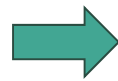


Sensor at side power button:
Sony Xperia Z5 (IFA 2015)

List of All Fingerprint Scanner Enabled Smartphones: 2016. 1



- » Galaxy Note 5 and Galaxy S6 Edge Plus
- » OnePlus 2
- » HTC One M9+
- » Elephone P7000 (exceptional high-end affordable phone)
- » Motorola Atrix
- » Apple iPhone 5S, iPhone 6 and 6 Plus
- » HTC One Max
- » Samsung Galaxy S5
- » Samsung Galaxy Note 4 and Note Edge
- » Galaxy S6
- » Huawei Ascend Mate 7
- » Xolo Q2100
- » Meizu MX4 Pro
- » Oppo N3

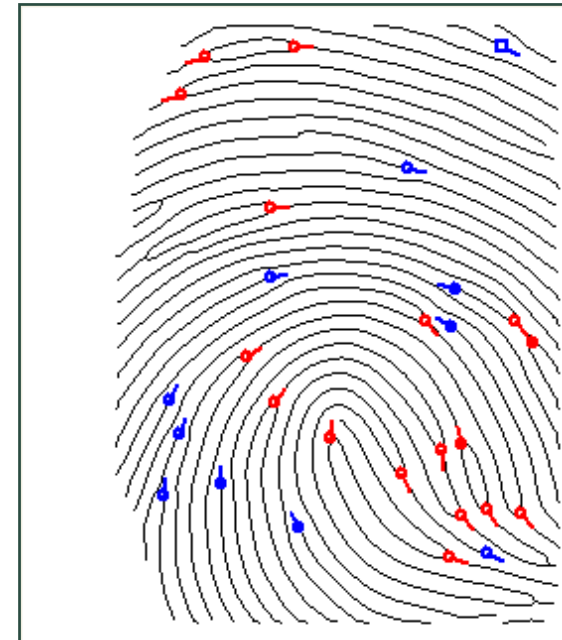
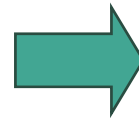


- Phone unlocking to **verify ME**:
- **User convenience** is mostly important.

Fingerprint Image by Optical Sensor



Captured image



Processed image

- ❖ Minutia: 11 **ending points** & 17 **branches**
- ❖ Typically, more than 30 minutiae are extracted from an optical sensor.
- ❖ **Typically, more than 10 matched minutiae assure the same fingerprint.**

Fingerprint Recognition Accuracy: Global Top Level (Non-mobile)



(10/2016,* <https://biolab.csr.unibo.it/FvcOnGoing/UI/Form/Home.aspx>)

Fingerprint Verification Competition*: FV_STD-1.0



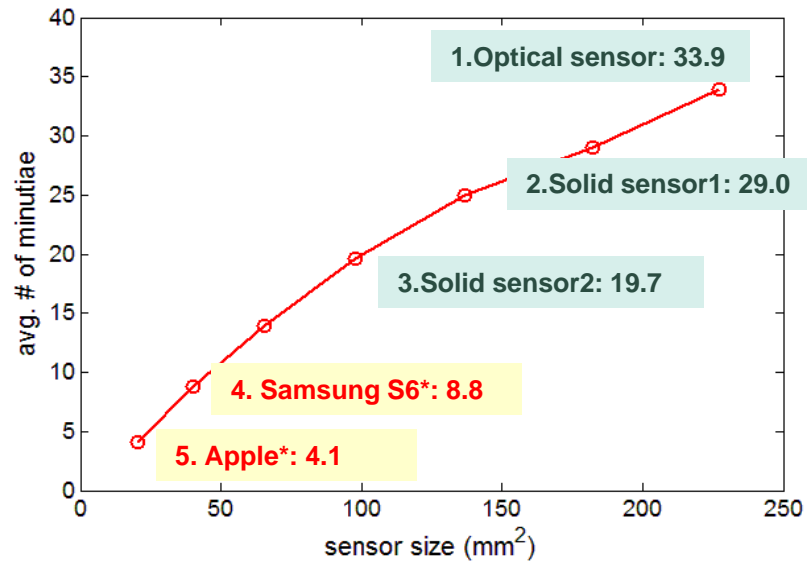
Published on	Benchmark	Participant	Type	Algorithm	Version	EER ▲	FMR ₁₀₀₀	FMR ₁₀₀₀₀
09/02/2016	FV-STD-1.0	Neurotechnology	Company	MM_FV	5.5	0,042%	0,032%	0,083%
29/08/2011	FV-STD-1.0	Tiger IT Bangladesh	Company	TigerAFIS	1.2ec	0,108%	0,115%	0,242%
14/09/2010	FV-STD-1.0	Green Bit S.p.A	Company	GBFRSW	1.3.2.0	0,118%	0,155%	0,519%
31/08/2011	FV-STD-1.0	AA Technology Ltd.	Company	EMB9300	1.1	0,142%	0,159%	0,220%
15/05/2011	FV-STD-1.0	AA Technology Ltd.	Company	EMB9200	2.3	0,176%	0,188%	0,303%
15/01/2015	FV-STD-1.0	GenKey Netherlands BV	Company	BioFinger	1.0	0,249%	0,267%	0,375%
14/05/2011	FV-STD-1.0	Institute of Automation, Chinese Academy of Sciences	Academic Research Group	MntModel	1.0	0,293%	0,512%	1,209%
22/03/2015	FV-STD-1.0	Beijing Hisign Bio-info Institute	Company	HXKJ	2.1	0,356%	0,455%	0,613%
15/05/2011	FV-STD-1.0	UnionCommunity	Company	Triple_M	1.1	0,418%	0,859%	1,977%
20/02/2015	FV-STD-1.0	ru zhou	Independent Developer	AllStar	1.0	0,613%	0,938%	1,396%

EER(Equal Error Rate): Error rate when FAR(False Accept Rate)=FRR(False Reject Rate)

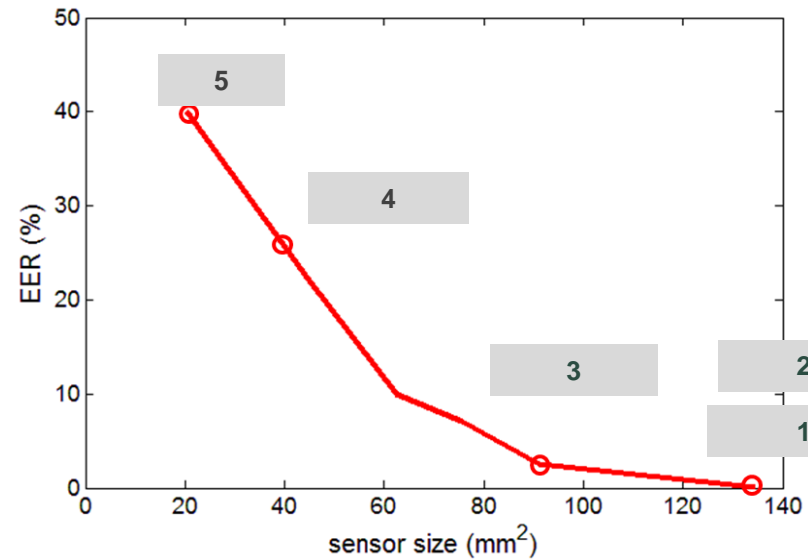
Sensor size vs # of minutiae



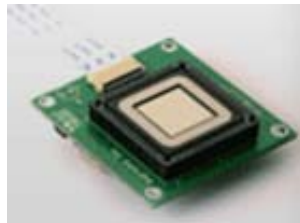
Number of Captured Minutiae



Performance Based on Minutia Only



1. Optical sensor:
14.2mm×16mm



2. Solid sensor1 : (13mm×13mm)
3. Solid sensor2: (9.6mm×9.6mm)



4. Samsung, S6*: 10mm× 4mm*



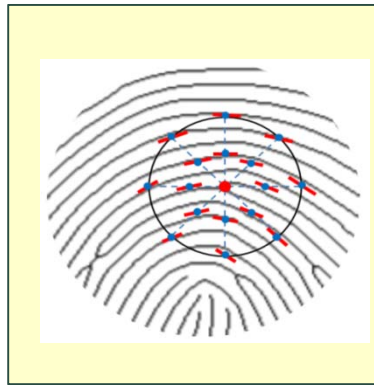
5. Apple : 4.5mm×4.5mm*

*(Estimated)

Researches for Small Sensor



❖ Features in addition to minutiae



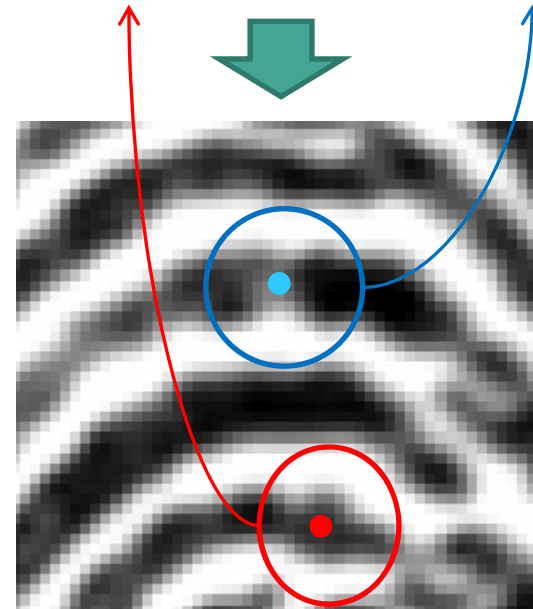
Minutiae + Ridge Flows (2014)



Pores in a high 1000 resolution image

<edge shapes of ridge>

1	2	3	4	5	6	7
—	⌒	∩	Ω	∪	∪	∩
Straight	Convex	Peak	Table	Pocket	Concave	Angle



<types of proposed micro ridge features>

Micro-features:
BERC for 500 dpi

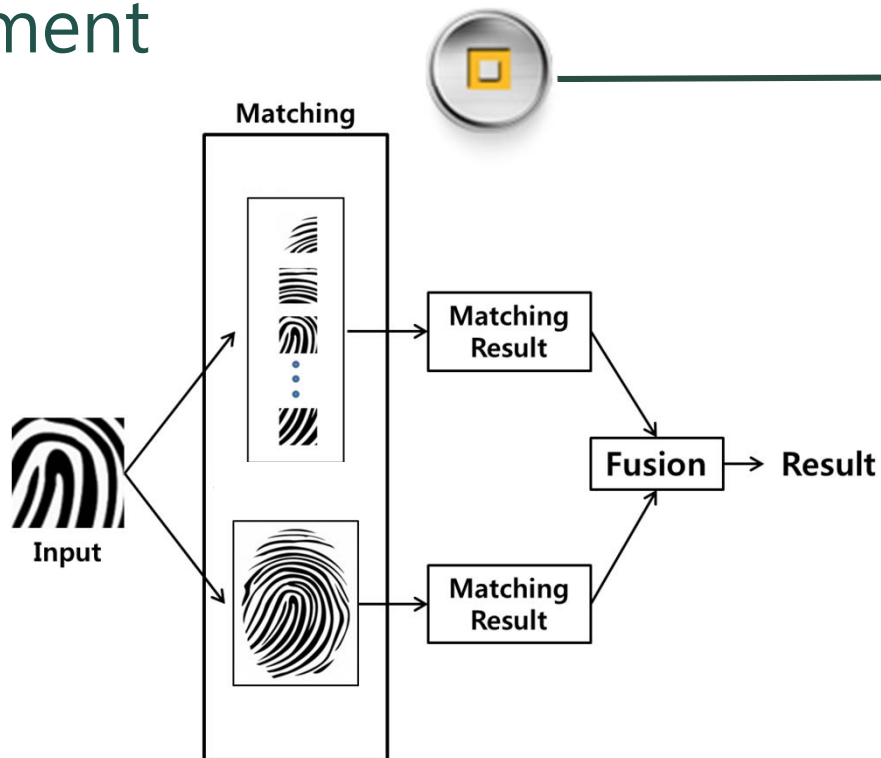
Performance of Micro Ridge Features



FVC2002 DB1						
Sensor size (mm ²)		11.8 x 11.4	9.8 x 9.3	8.9 x 8.5	8.1 x 7.7	6.9 x 6.5
EER (%)	Conventional minutiae matcher	0.05	0.39	1.30	2.41	6.24
	Proposed matcher	0.00	0.10	0.50	0.85	1.35

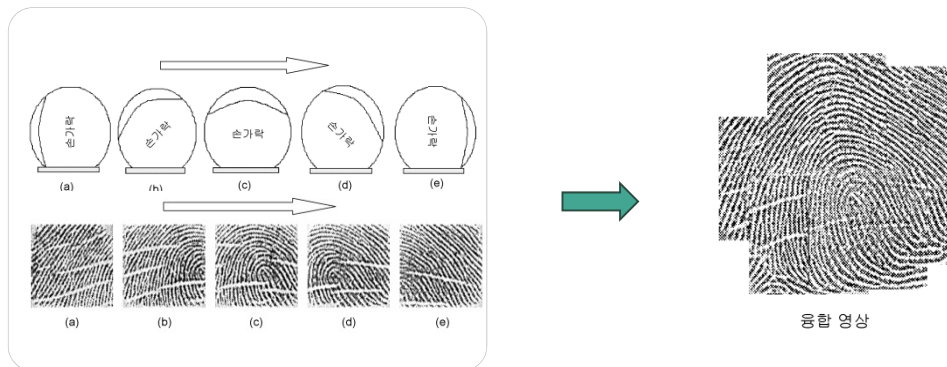
Smart Enrollment

Use of partial and fused fingerprint images*

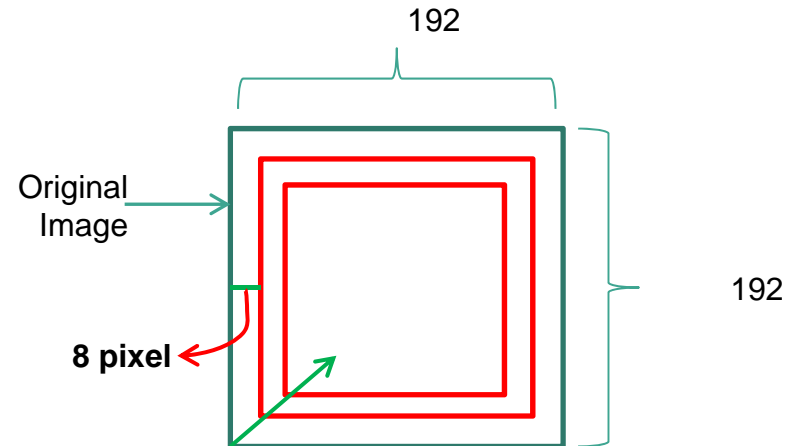


Fusion of fingerprint images
By rubbing

To obtain a large fingerprint image, rubbing the finger on a sensor and fusing the images into a large one.



Accuracy vs Registered Images: Multiple Image Enrollment



*BERC

	EER (%)			
Sensor Size (mm)	7.2 x 7.2 (56.3%)	8.0 x 8.0 (69.4%)	8.8 x 8.8 (84.0%)	9.6 x 9.6 (100.0%)
5 Images	18.59%	12.17%	7.04%	4.48%
10 Images	15.34%	8.69%	3.91%	1.75%

Sensor at front touch glass



Sensor at front touch glass?:

Crucialtec, LG Innotek, Apple

Resolution, 500dpi?

Qualcomm Snapdragon Sense ID 3D Fingerprint Sensor*



*<https://www.qualcomm.com/products/snapdragon/security/sense-id>

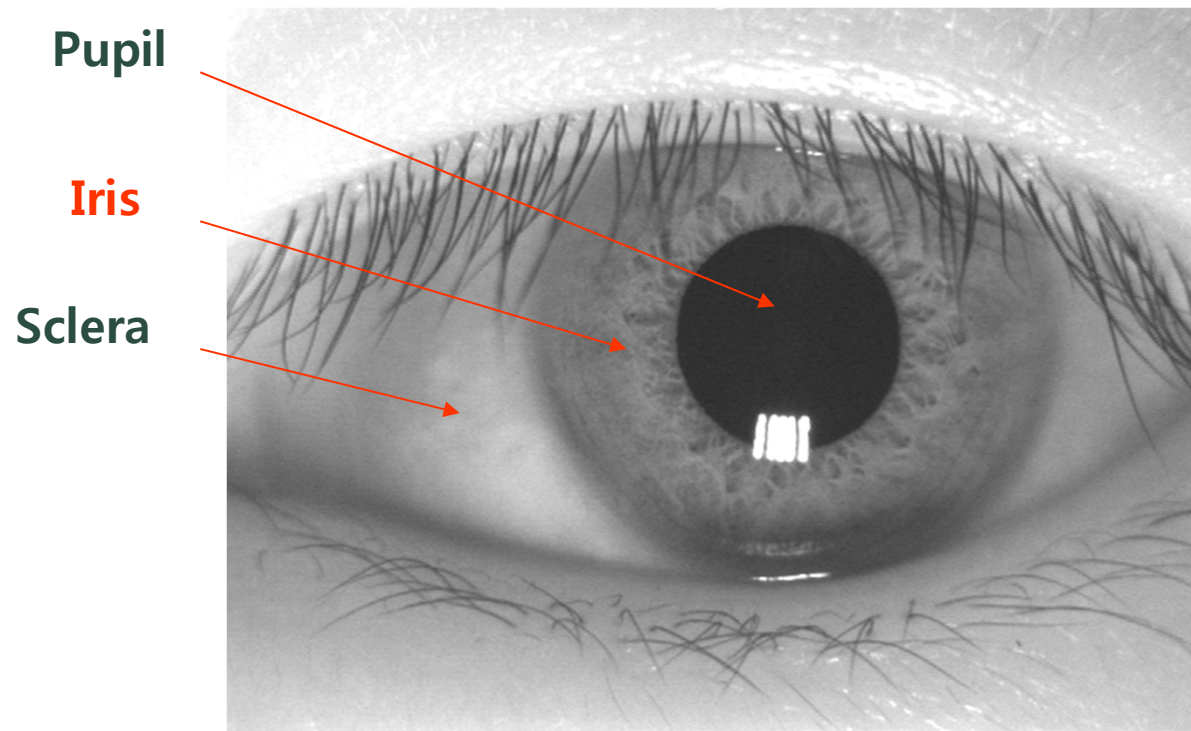
3D fingerprint scanner by ultra-sonic sound wave

- An ultrasonic pulse is transmitted against the finger that is bounced back to the sensor.
- By measuring replied time difference of the pulses, a highly detailed 3D reproduction of the scanned fingerprint is obtained.



- More accurate 3D data
- Robust to dusties
- Robust to fake fingerprint

Mobile Iris Recognition for ME



- Iris pattern is different for different person.

Mobile Iris Recognition



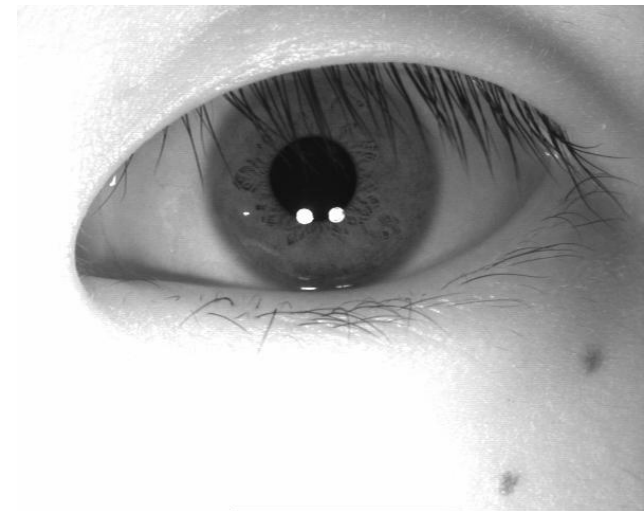
Mobile Iris Images



By Normal Mobile
Phone Camera



Phone Camera with
flash-on

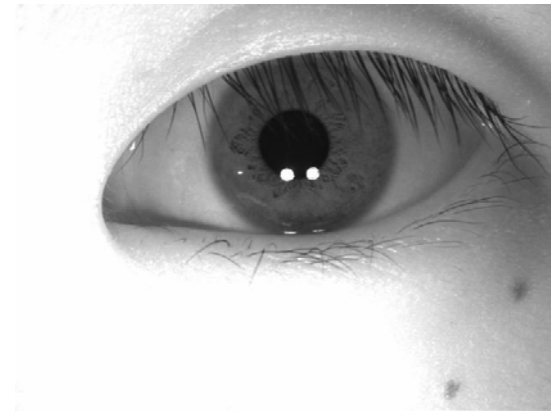
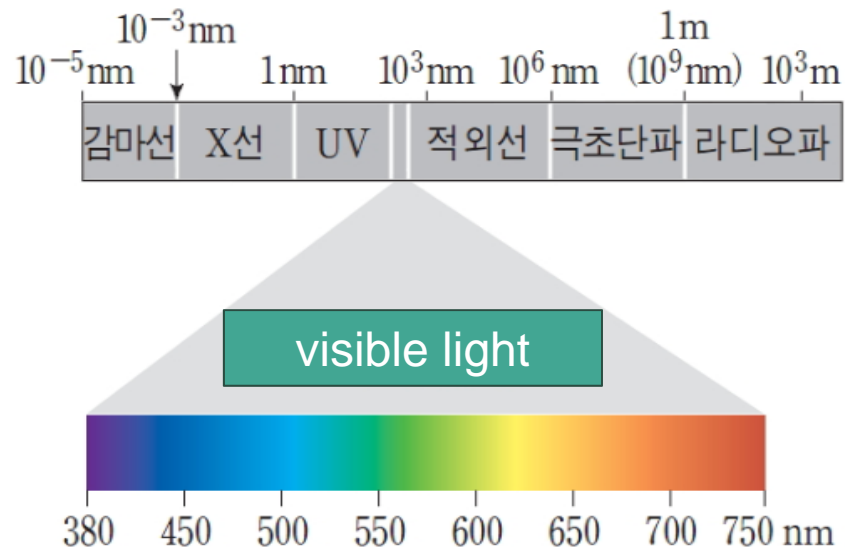


With NIR (750~850 nm)
LEDs.

Optical Conditions



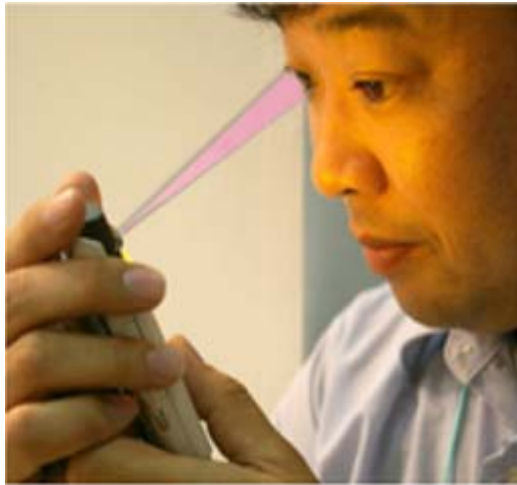
- ❖ NIR light and iris camera: 720-900 nm
- ❖ Power limit of NIR light: $< 18000 t^{0.750} w / m^2$
- ❖ Iris image size > 200 pixels



Mobile Iris Rec. on Phone



- ❖ OKI mobile for one iris scanner: 2007



Basic feature: Generate/Compare iris data, Encrypt iris data
Processing time: Authenticate in less than 0.5 seconds after capture
Authentication accuracy: FAR<1/100,000 (Tested on a 2Mpixel mobile phone camera)

HP Elite x3* with One Iris Scanner



<http://store.hp.com/us/en/ContentView?storeId=10151&catalogId=10051&langId=-1&eSpotName=Elite-x3>

Fingerprint & Iris anti-spoof



BERC for One Iris Recognition



NIR LED

NIR
Camera



BERC Mobile Iris Recognition



<Issues for mobile iris recognition>

- *Location for guide screen showing user's image
- *Locations of NIR LEDs (750~850 nm) and iris camera
- ***Iris camera resolution: iris image size > 200 (pixels)**

Guide Window



- ❖ The window guide shows the input user's eye images in real time.
- ❖ The window guide has an eye shape template where the user fits his eye on it.
- ❖ The system captures a good iris image **automatically** among the input image stream in real time.



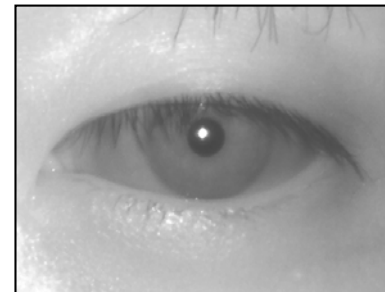
Location of Window Guide



Iris LED & Camera are placed at the top

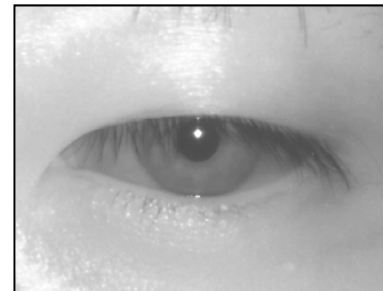


O



Guide should be at upper part.

X

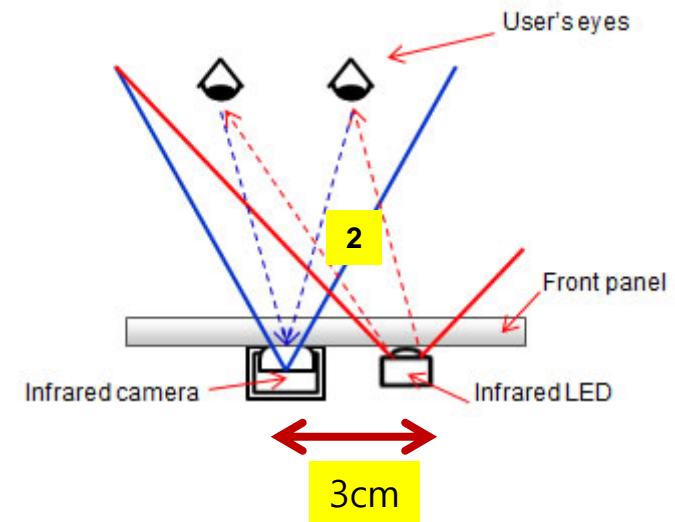


Shade and occlusion by eyelid and eyebrow

Positions for Iris Camera, LEDs



*D.Kim et al, "An Empirical Study on Iris Recognition in a Mobile Phone", Expert Systems with Applications, July 2016.



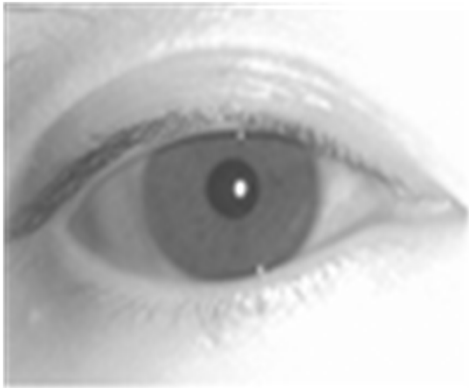
Optical Issues:

1. To avoid Red-eye effect or glass glint, Camera and LEDs should be separated more than 5 degrees.
(3cm for 35cm working distance)
2. Too far from each other makes a shadow at one side of an eye.
3. Iris camera resolution: iris image size > 200 (pixels) -> reason for one eye

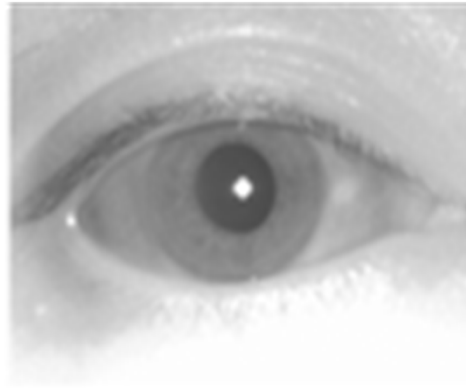
Wavelength and Power of LEDs



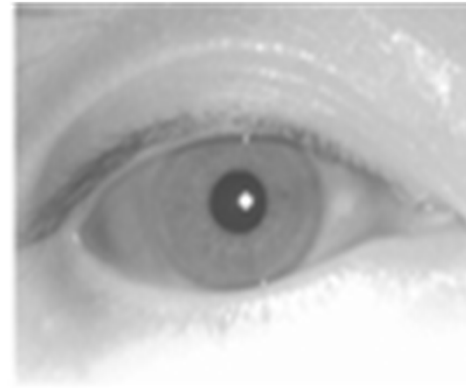
- ❖ Power limit of NIR light: $< 18000 t^{0.750} w / m^2$
 - However, it should be strong enough to get a bright iris image



(a)



(b)



(c)

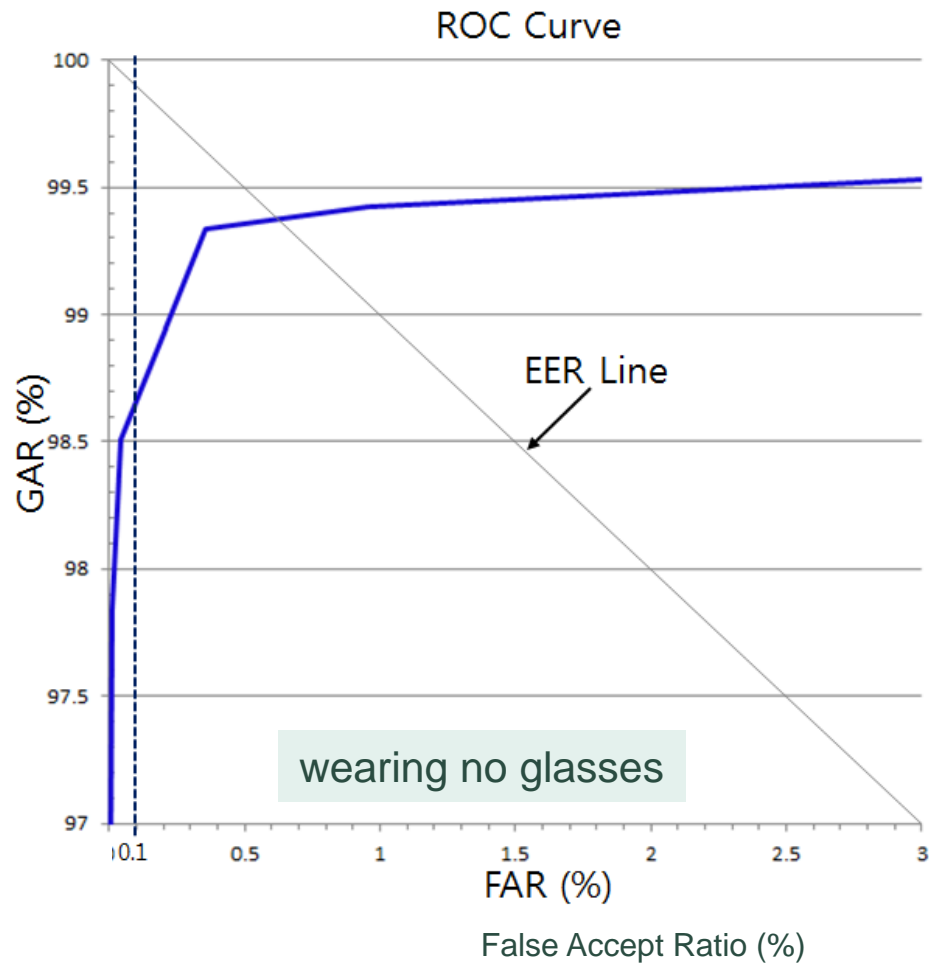
- (a) four 750nm LEDs, good for iris boundary detection but too dark
(b) two 750nm LEDs and one 850nm LED, still dark
(c) **two 850nm LEDs, good for small space and bright iris image but less clear iris boundary**

Performance Example*



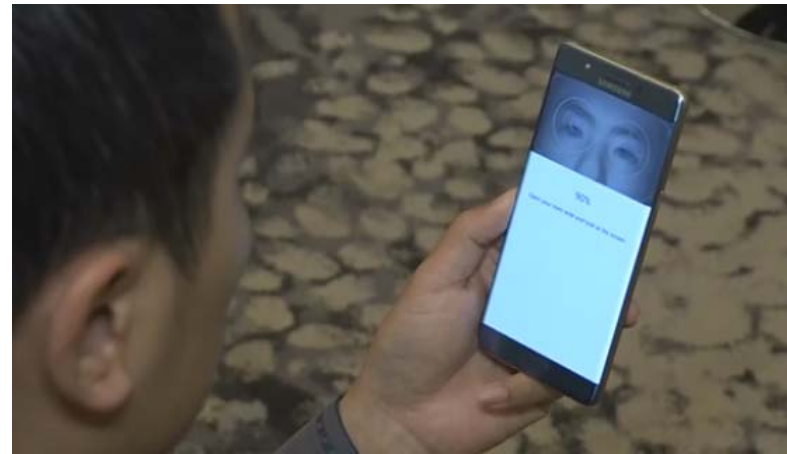
(*2013, BERCC)

GAR = 100 - False Reject Ratio = True Accept Ratio



Enrollment Valid code size	> 1150
Recognition Valid code size	> 850
EER (%)	0.5105
FAR vs GAR (%)	0.0427 : 98.5078 0.1399 : 98.9440 ~0 : < 97.0
FTA Rate (%)	1.4
FTE Rate (%)	2.1

Mobile Iris for two eyes, Samsung Note 7

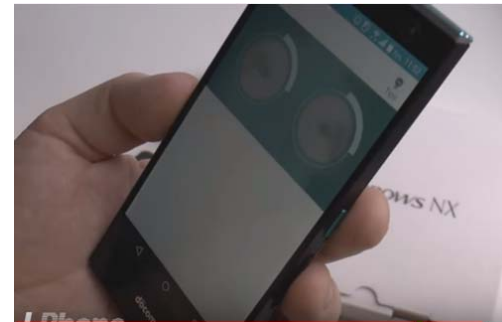


- ❖ Improvement of Collectability and Accuracy by using two eyes
- ❖ Resolution of iris camera: Full HD 2M pixels
- ❖ Usages: phone unlocking + mobile authentication

Others for two eyes



Fujitsu NX F-04G*

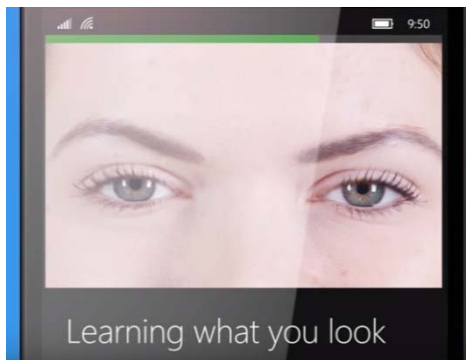


*<https://www.youtube.com/watch?v=-HJmrYEvxV0>

- ❖ First iris recognition on a phone for two eyes: 2015 June
- ❖ 30 seconds for enrollment, 1 second for authentication



Microsoft Lumia 950 XL



*<https://www.youtube.com/watch?v=L8QYh6KXc6Y>

Iris Rec. in a wearable (future appear?*)



* <http://www.iritech.com/>



Solve Three Major Problems

1. Passwords
2. Privacy issues
3. Authentication

LED

Iris Camera

**IRIS RECOGNITION ENABLED SMARTWATCH FOR
PERSONAL SECURITY & DATA CONTROL**



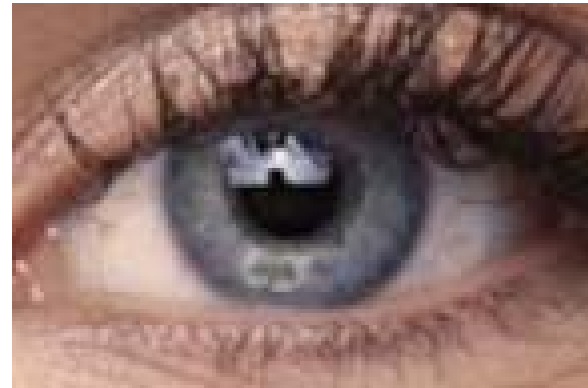
- ❖ **Engineering Sample?**
- ❖ **In Wearable Device, bio-signal like ECG will be more typically used for identification with or without conventional biometrics.**

Sclera Recognition



*<http://www.eyeverify.com/>

Blood Vessels in White Sclera: Eyeprint ID of EyeVerify*



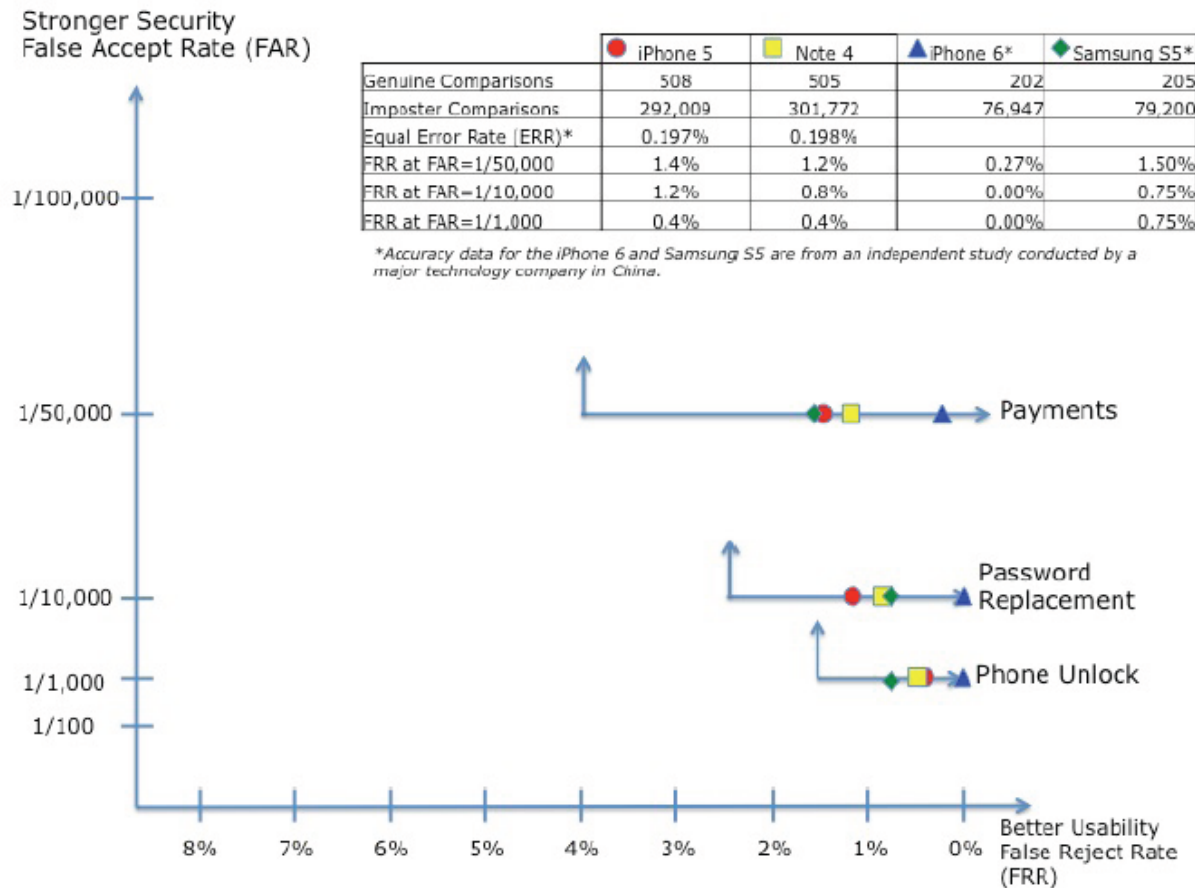
- ❖ No need of NIR illuminator/iris camera
- ❖ Usable in the outdoor sunny environment
- ❖ ZTE Grand S3, VIVO X5 Pro/China, Alcatel Idol 3/France, UMI Iron/Hong Kong
- ❖ **Is it universal, permanent and unique?**

Eyeprint ID v2.4 Perfr*



*<http://www.eyeverify.com/technology>

This is the only mobile biometrics of which performance is announced.



Mobile Facial Recognition



- ❖ (2012) - Android 4.0, also known as Ice Cream Sandwich, offers Android users the "Face Unlock" option.
- ❖ The "Face Unlock" is a screen-lock option that lets users to unlock their Android devices with facial recognition

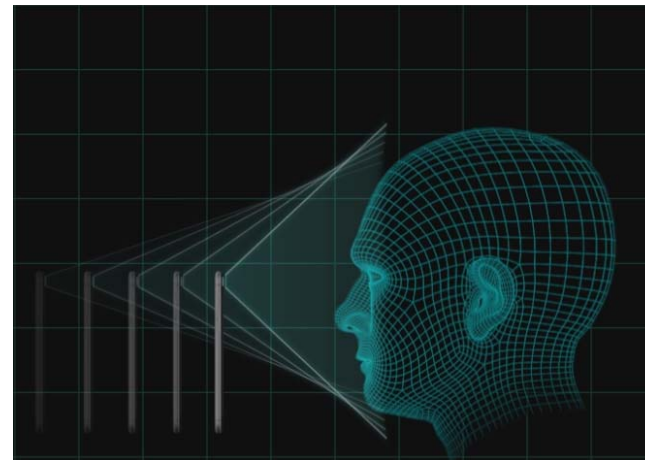


<http://www.gadg.com/2012/07/13/unlock-your-smartphone-through-facial-recognition/>

3D facial recognition for smartphone



- ❖ FacialNetwork's ZoOm, a patent-pending 3D facial authentication smartphone app
- ❖ Wells Fargo, Chase, Bank of America and Citi as well as Amazon, Paypal, Expedia, Salesforce, ADT, ADP, E-trade and Ticketmaster
- ❖ The app works by using the front-facing camera on a smartphone to take a selfie video. As the user slowly moves the phone toward his or her face, the app captures a dynamically changing perspective of the face.



<http://www.biometricupdate.com/201507/facialnetwork-to-release-facial-recognition-smartphone-app>
<https://zoomauth.com/#intro>



**So far, these mobile biometrics are to unlock the phone.
Or, they are to verify me.**

Is there any other killer application?

Mobile Biometrics for Fintech



Password
for
Fintech

Mobile banking
E-Commerce
Mobile Payment

Unsecure
Inconvenience
Repudiation

FIDO Alliance
(Fast Identity Online)

Mobile
Biometrics for
Fintech

IoT
Healthcare

Face Recognition for Payment



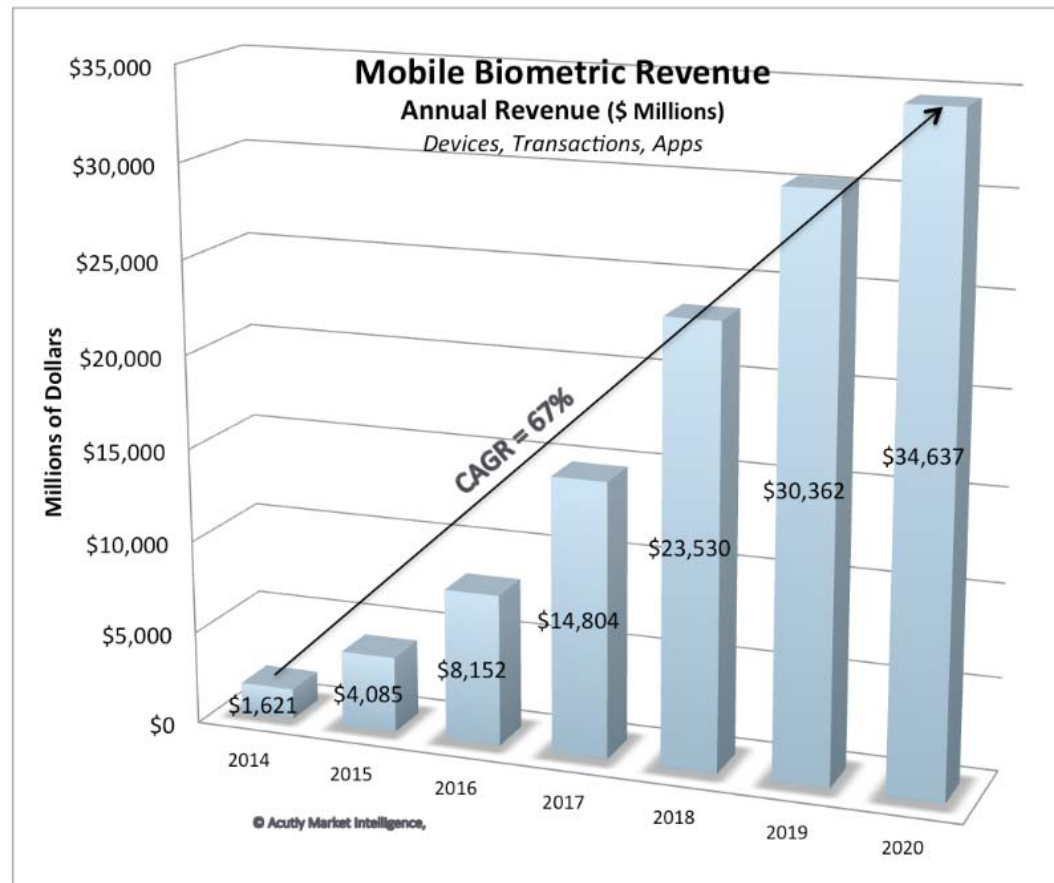
- ❖ Alibaba developed a facial recognition technology which allows consumers to pay by taking a selfie.

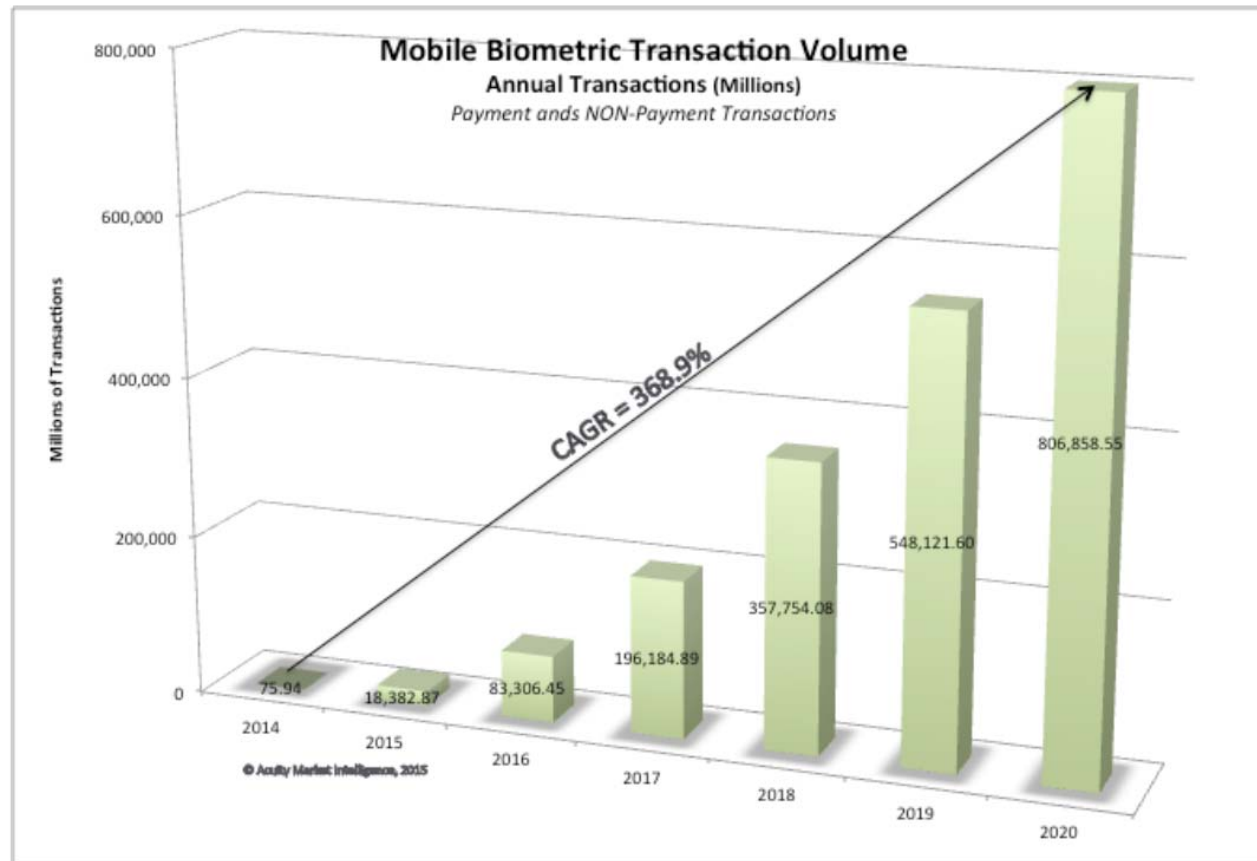


Mobile Biometric Global Market*



(*2015 Acuity Market Intelligence Report, http://www.acuity-mi.com/GBMR_Report.php)





2020: 807 billion biometrically secured payment and non-payment transactions

Mobile Biometrics Issue 1:

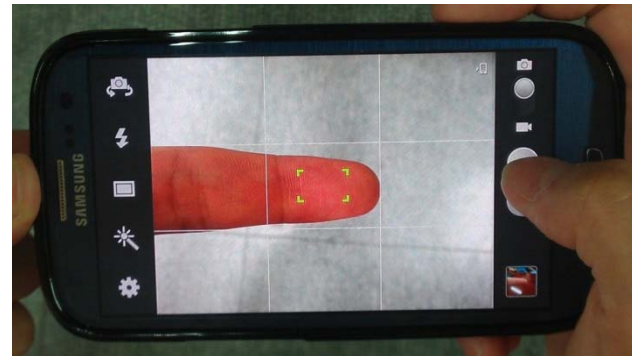
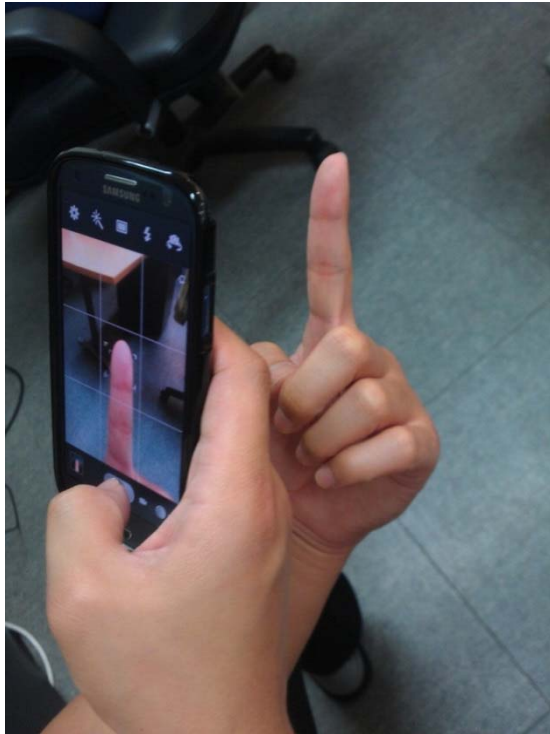


- ❖ How about those having old phones or non-biometric phones?

Mobile biometrics issue 1: Biometrics for old phone



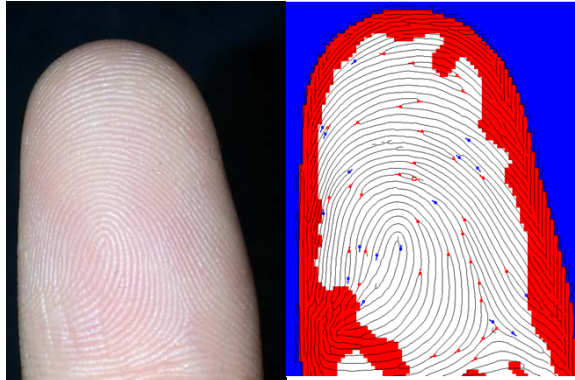
Mobile Touchless Fingerprint Recognition



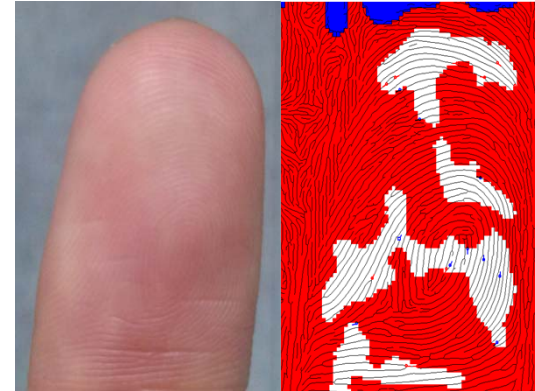


'Depth of Field' in the macro mode
of the mobile camera
is crucial for clear fingerprint image!

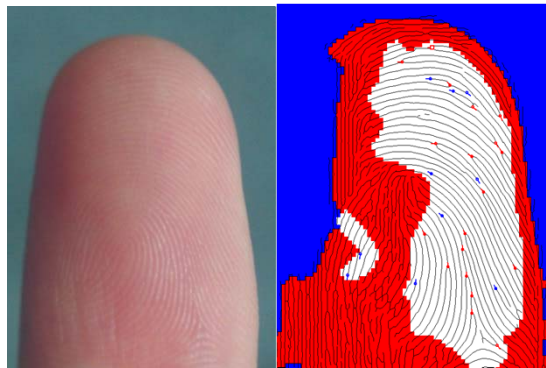
Image Examples, 6/2012



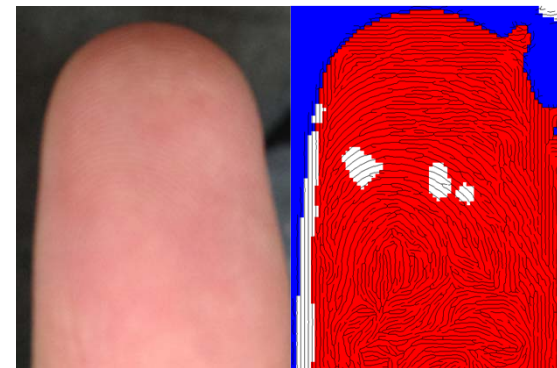
Samsung Galaxy:
Total 53 minutiae



LG Optimus:
Total 21 minutiae

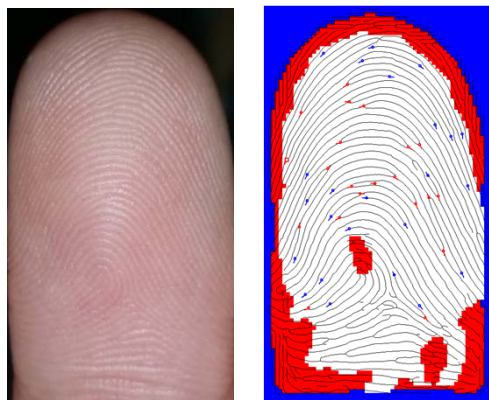


HTC DesireHD:
Total 29 minutiae

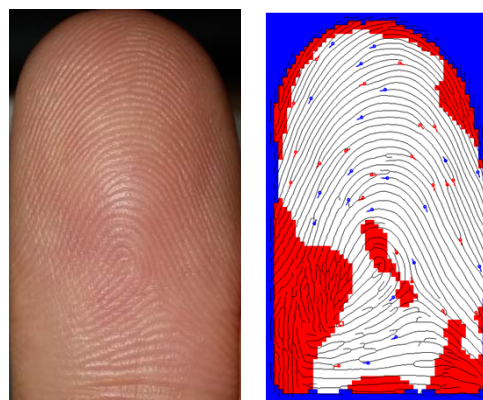


Apple i-phone:
Total 0 minutiae

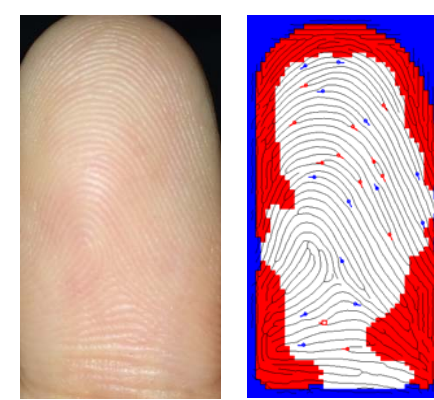
Recent Examples



<Galaxy S5>
of minutiae: 46



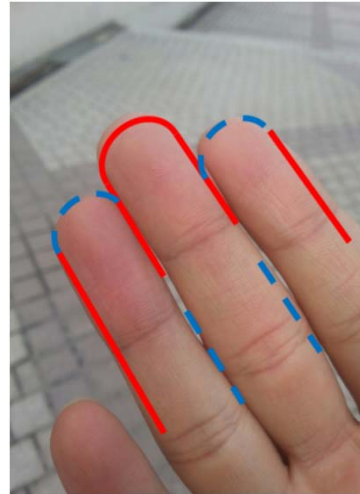
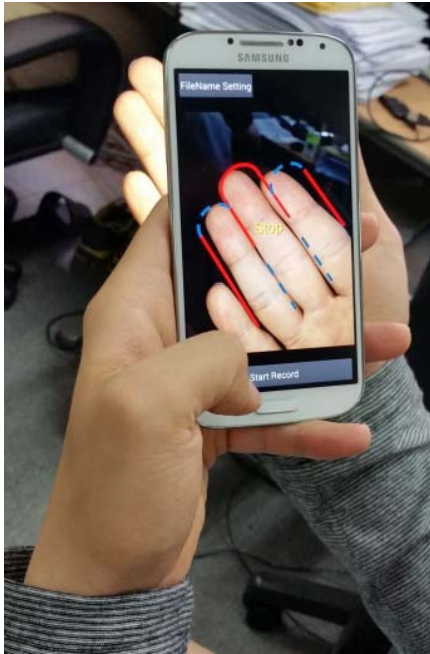
<LG G Pro 2>
of minutiae: 43



<I-phone 5S>
of minutiae: 25

	Samsung Galuxy S5	LG G Pro 2	Apple I-phone 5S
Resolution	16 M (5312 x 2988)	13 M (4160 x 3120)	8 M (2448 x 3264)
Depth of Field In the macro mode (Easiness of image capture)	Very good	Very good	Not so good

BERC: Window Guide

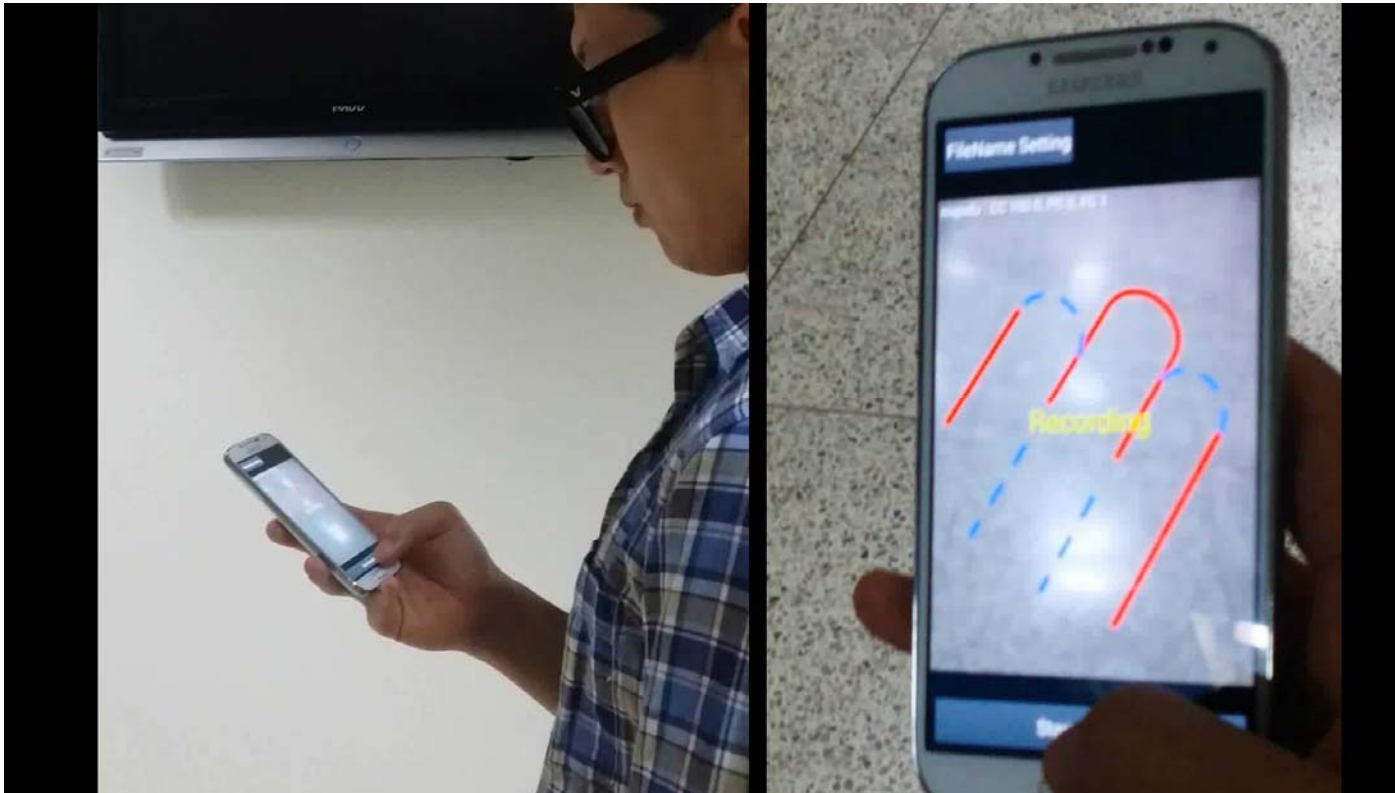


- Guide window for three fingerprints
- Easy/fast detection and segmentation for foreground finger image

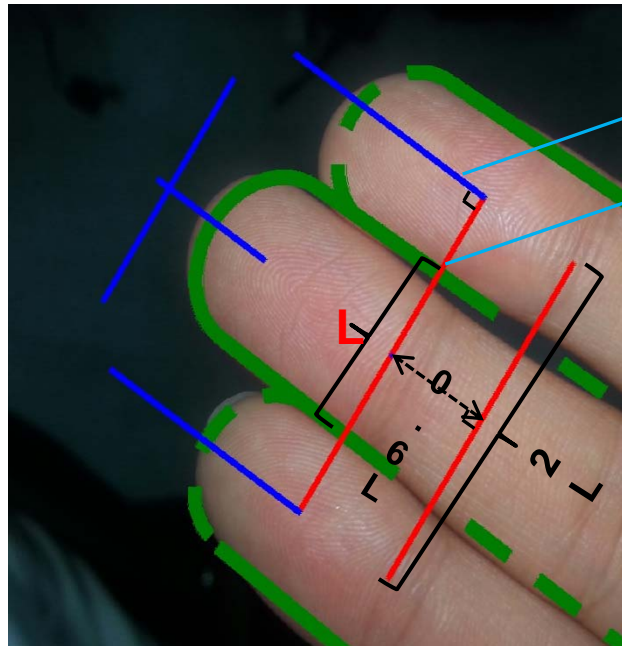
Image Capturing for Touchless Fingerprint Recognition*



(*2013, BERK with Samsung Electronics DMC
-US Patent, METHOD OF RECOGNIZING CONTACTLESS FINGERPRINT
RECOGNITION AND ELECTRONIC DEVICE FOR PERFORMING THE SAME)



Fingerprint Segmentation by Line Profile Checks on Window Guide



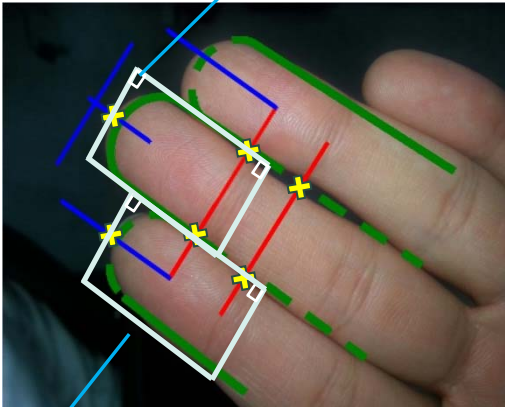
Fitting check for input finger images

- To check a finger image is in the guide
- To check three fingers are in the guide

Fingerprint segmentation



<second-finger>

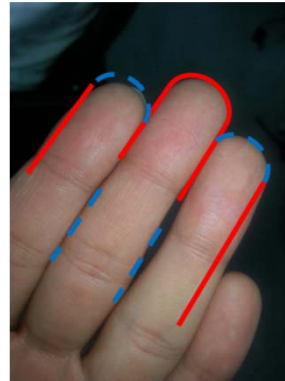
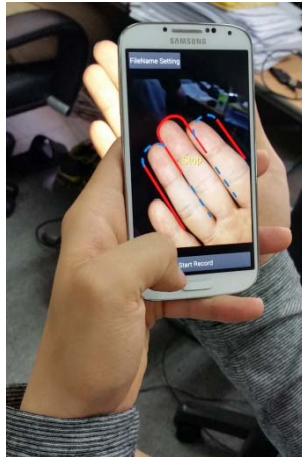


<first-finger>

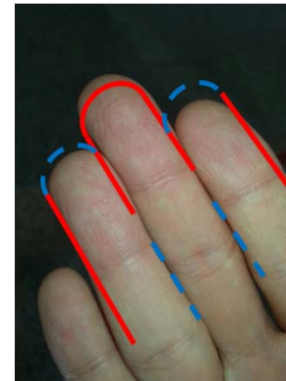
Performance example*



*(2013. 12. 1)



**Guide window
(left fingers)**



**Guide window
(right fingers)**

Indoor condition, 5 image enrollment, S3/4 with 2 M pixel auto-selection

(fusion of first and second fingerprints)

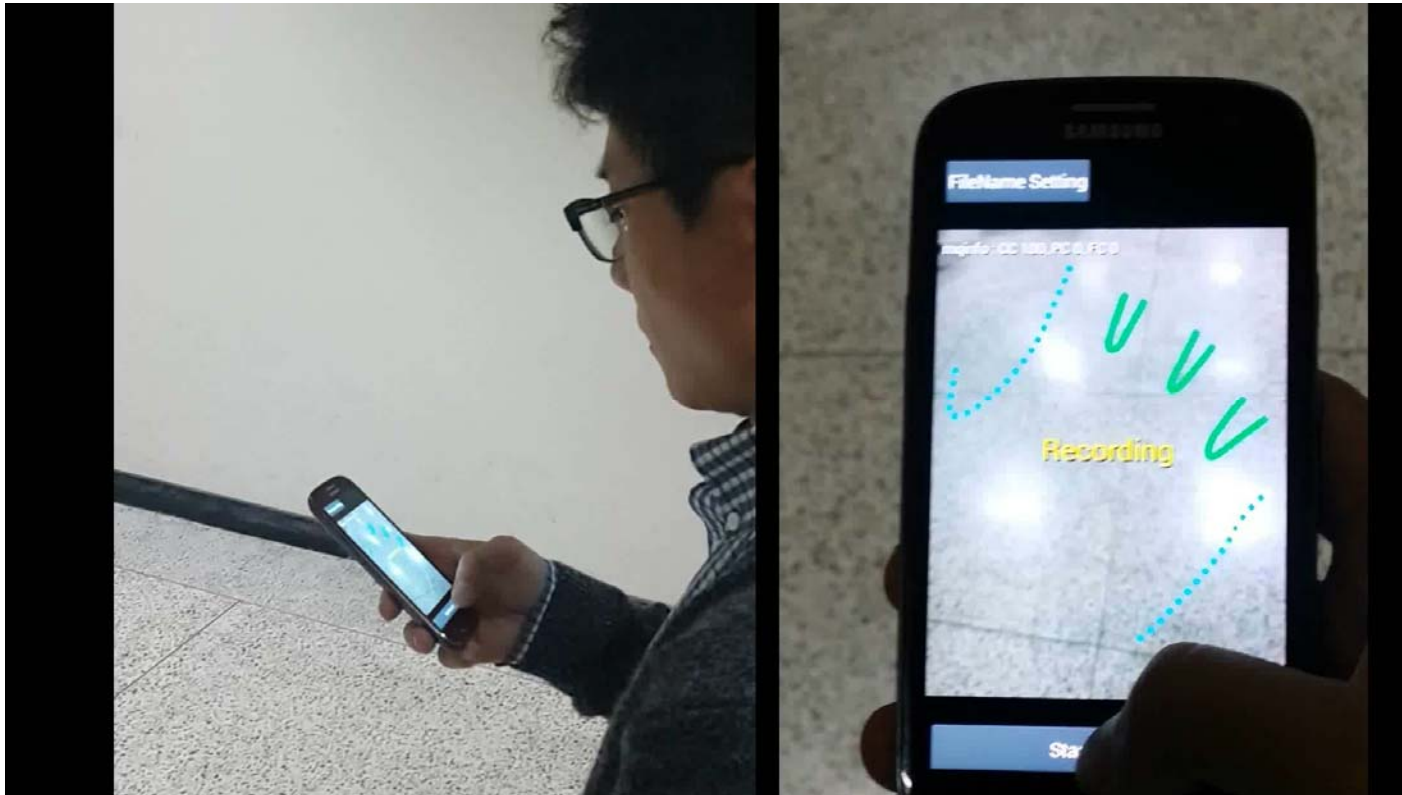
FAR	10%	1%	0.7%(EER)	0.1%	0.01%
GAR (FRR)	99.78% (0.22%)	99.35% (0.65%)	99.3% (0.7%)	98.9% (1.1%)	98.4% (1.6%)

Mobile Touchless Palmprint Recognition*



(*2013, BERK with Samsung Electronics DMC)

*J. Kim et al, "An Empirical Study of Palmprint Recognition for Mobile Phones," IEEE Transactions on CE, vol. 61, Issue 3, Aug, 2015.



Touchless Mobile Palmprint recognition*



(* J.S. Kim et al, "An Empirical Study of Palmprint Recognition for Mobile Phones", IEEE CE, August 2015.)

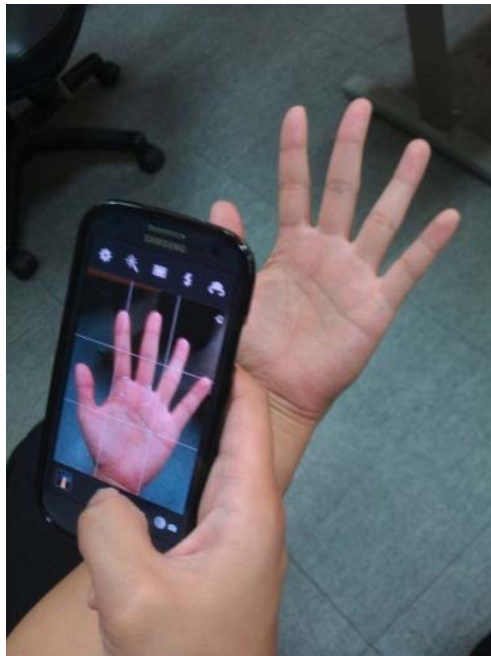


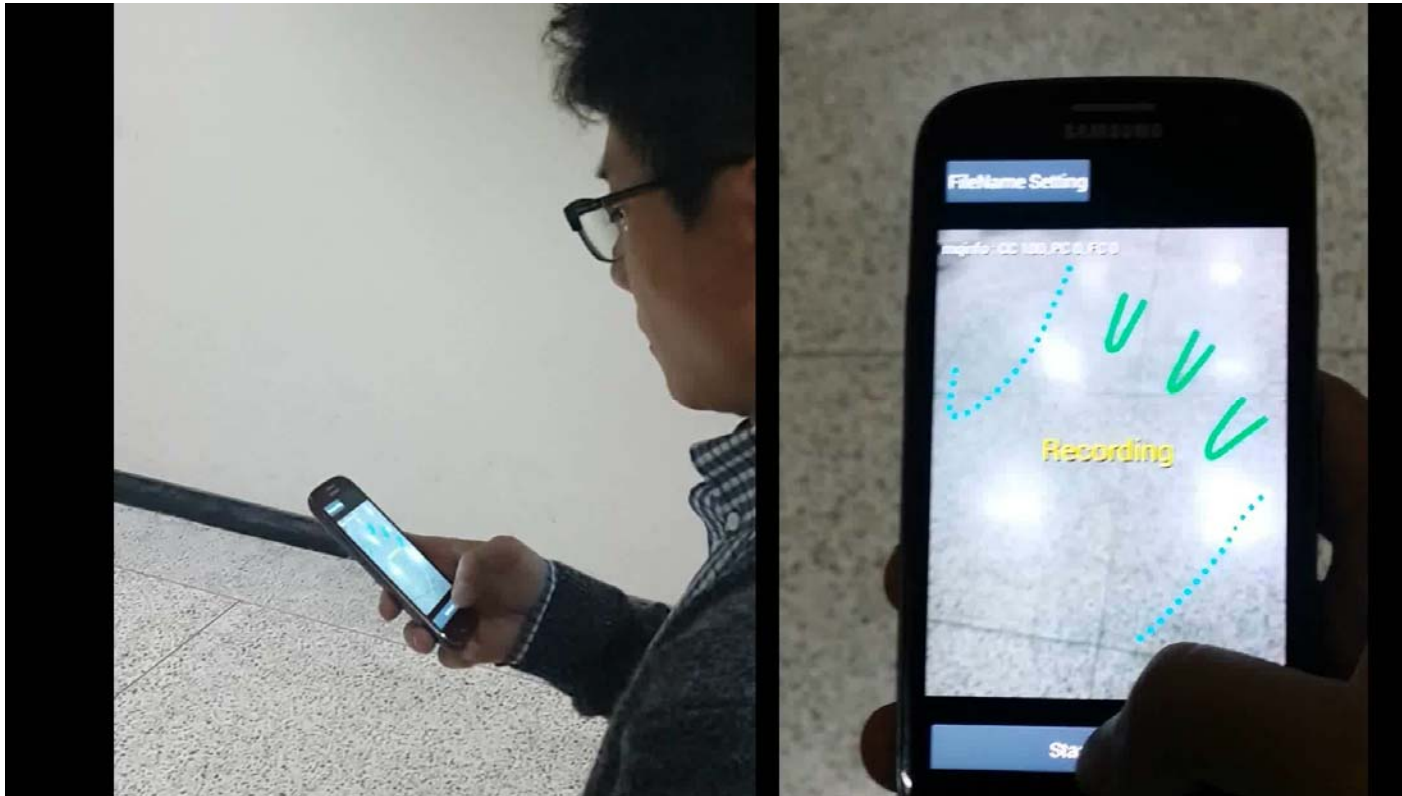
Image Capturing with a Guide

Image Capturing for Touchless Palmprint Recognition*



(*2013, BEREC with Samsung Electronics DMC)

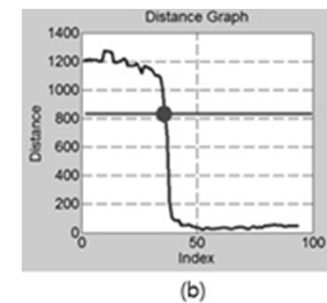
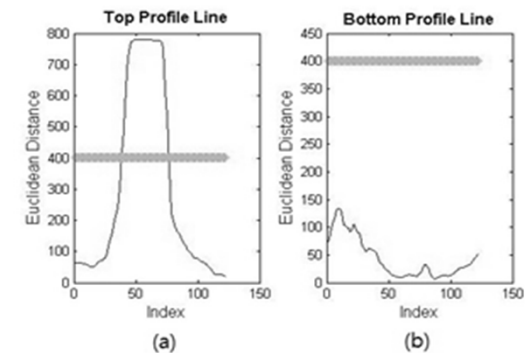
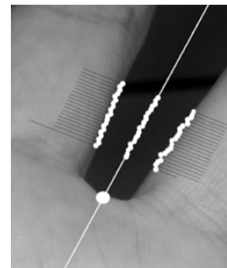
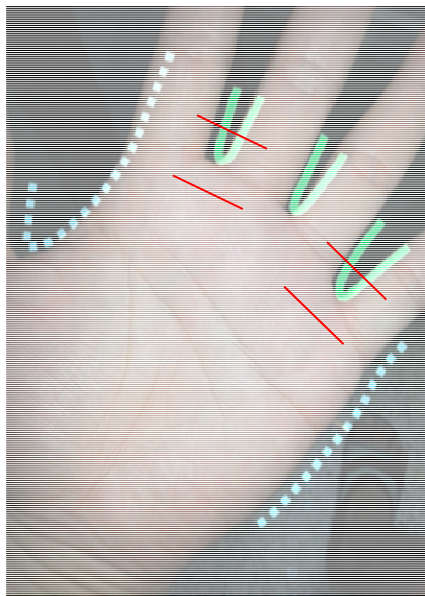
*J. Kim et al, "An Empirical Study of Palmprint Recognition for Mobile Phones," IEEE Transactions on CE, vol. 61, Issue 3, Aug, 2015.



Use of Guide Window



- ❖ Easy to check if the hand is fitting to the guide.
 - Simple line profile check for skin-background-skin
 - No need of foreground hand image segmentation
- ❖ Simple line check for valley point detection



Performance1*



(*J. Kim et al, ' An Empirical Study of Palmprint Recognition for Mobile Phones', IEEE CE, Aug. 2015)

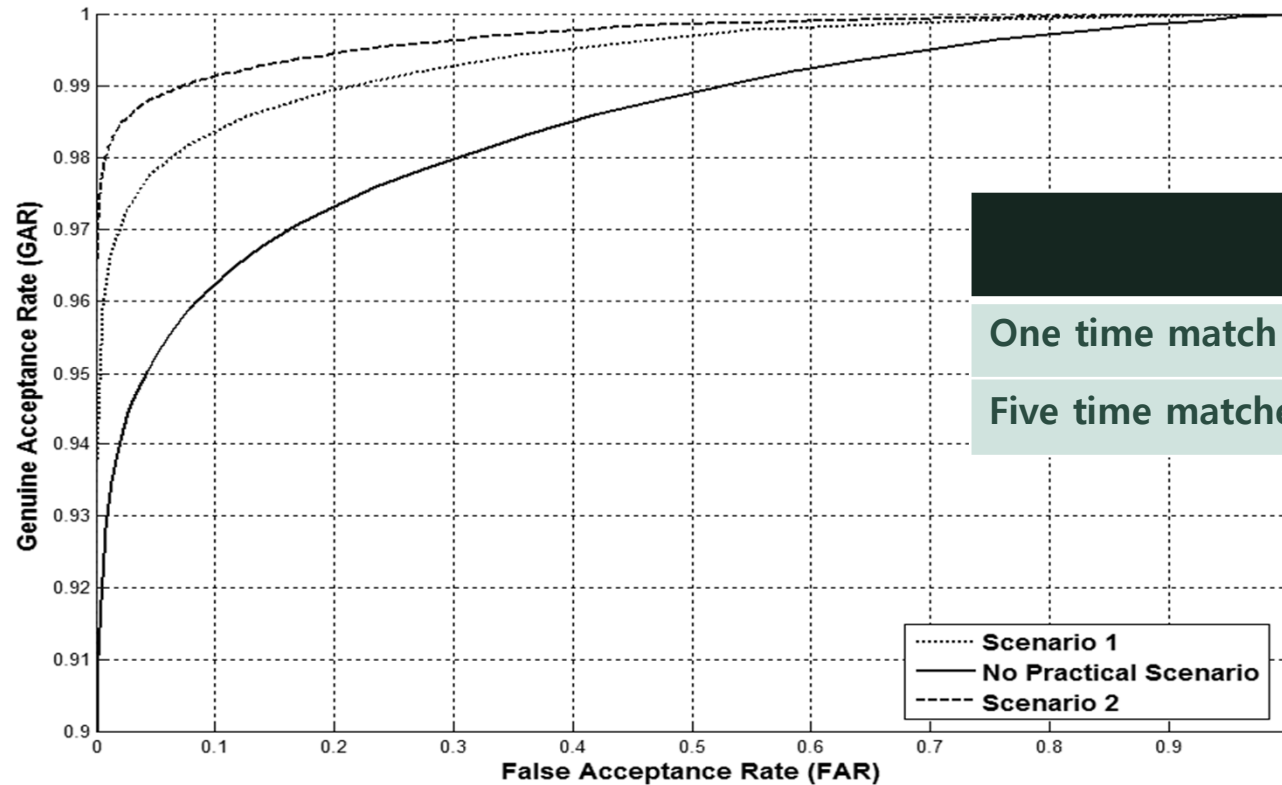
Verification performance (in EER)

DATABASE	COMPCODE	OLOF	BOCV	FCM	PROPOSED METHOD
PolyU DB	0.09%	0.13%	0.15%	0.09%	0.11%
BERC DB1	6.14%	5.14%	6.35%	5.48%	2.88%
BERC DB2	5.87%	5.33%	7.64%	7.10%	3.15%
IITD DB	6.33%	5.26%	5.69%	5.67%	5.19%

Performance by N Matches



(*2013. 11. 15, BERC DB1)



	EER
One time match	2.88%
Five time matches	0.97%

Performance Improvement by Multiple Matches

Mobile biometrics issue 2: Performance Evaluation

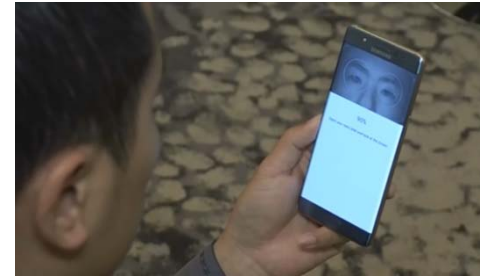


- ❖ Performance of all non-mobile biometric systems are publically announced.
- ❖ Performance of all phone biometrics is NOT publically known:
 - So far, they have been used for their phones only.
 - Now, they need to work with banks and other.
 - The quality of a biometrics system itself should be a competitive factor.

Mobile biometrics issue 3: Open phone biometrics to identify YOU



Mobile biometrics:
'For you'



PHONE biometrics:
'For me'



Phone biometrics 'For you'?
Open phone biometrics for publics

Galaxy Tap Iris in India



Integrated Iris Scanning device*

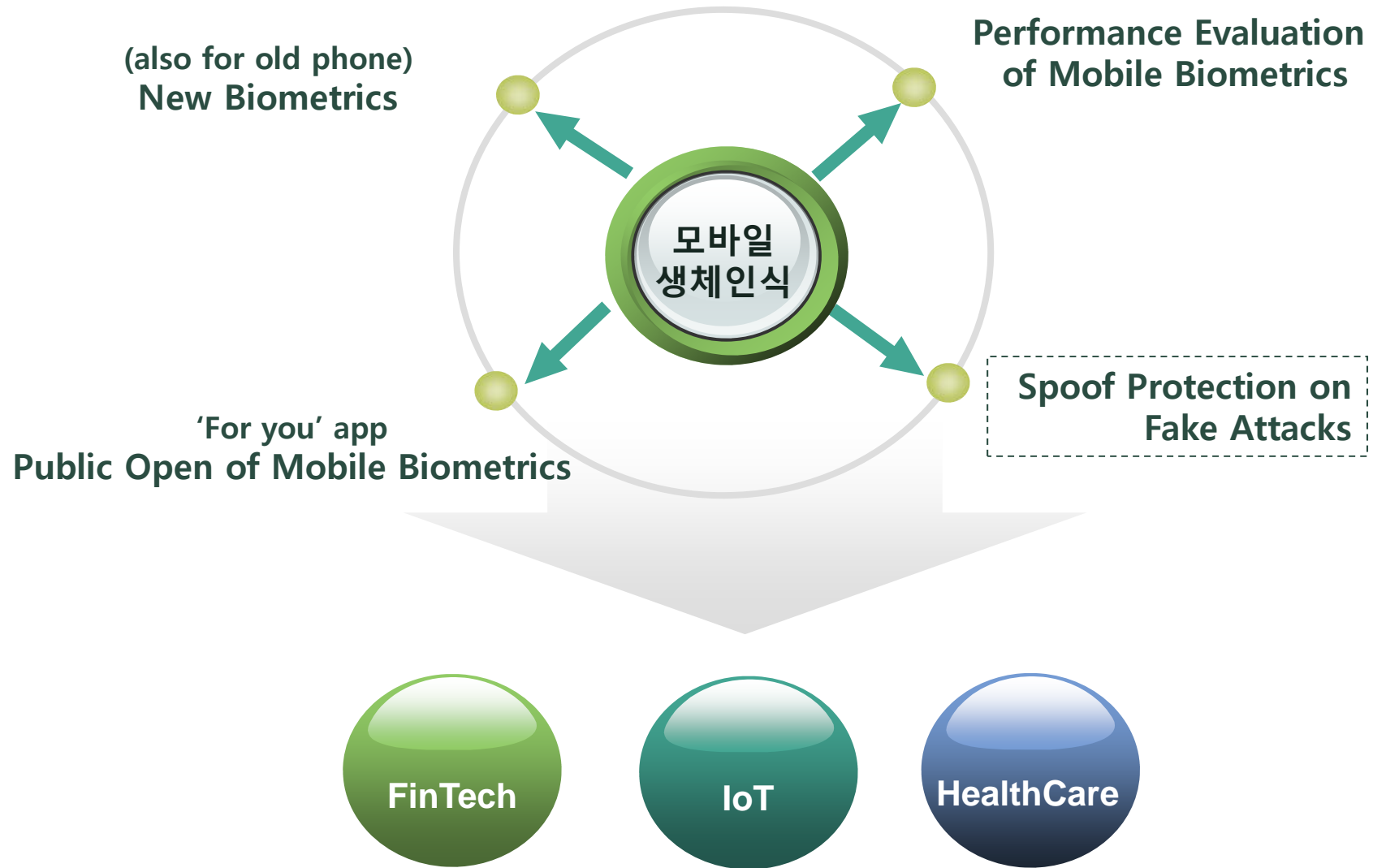


Dual-Eye IRIS Scanner



Aadhaar-compliant in India
Identity SDK for application developers to build financial inclusion,
payments and authentication solutions

Concluding Remarks: Future Expectations of Mobile Biometrics





Thanks