Fingerprints: Giving Child an Identity

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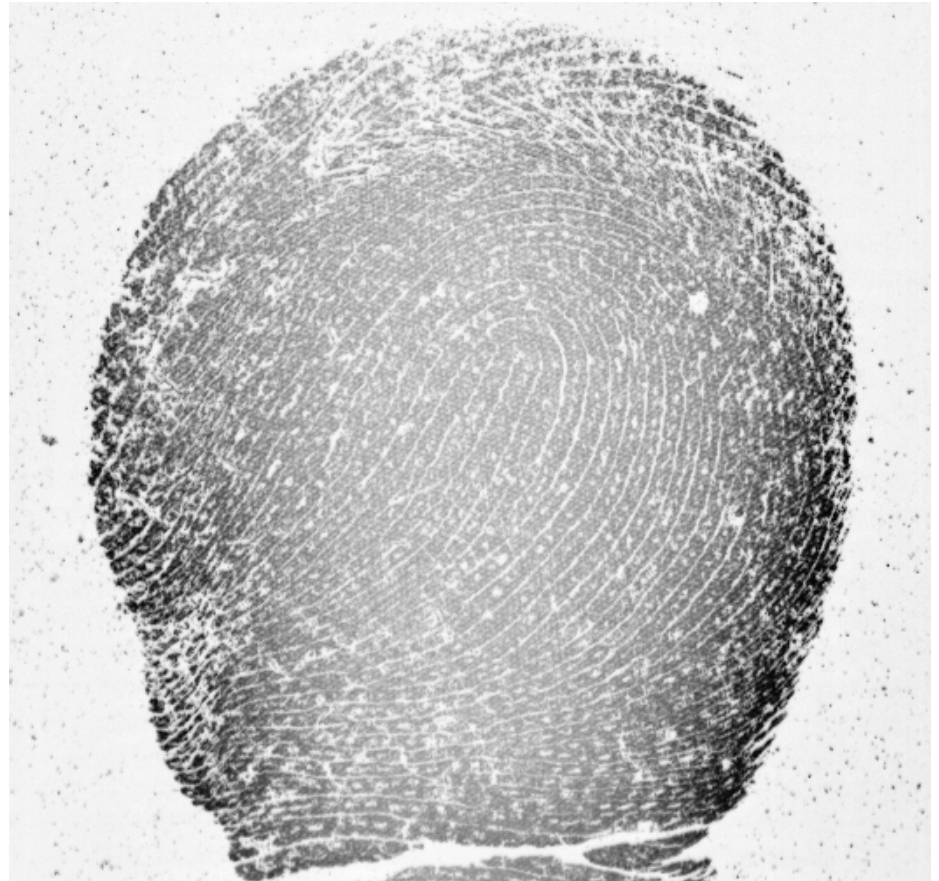
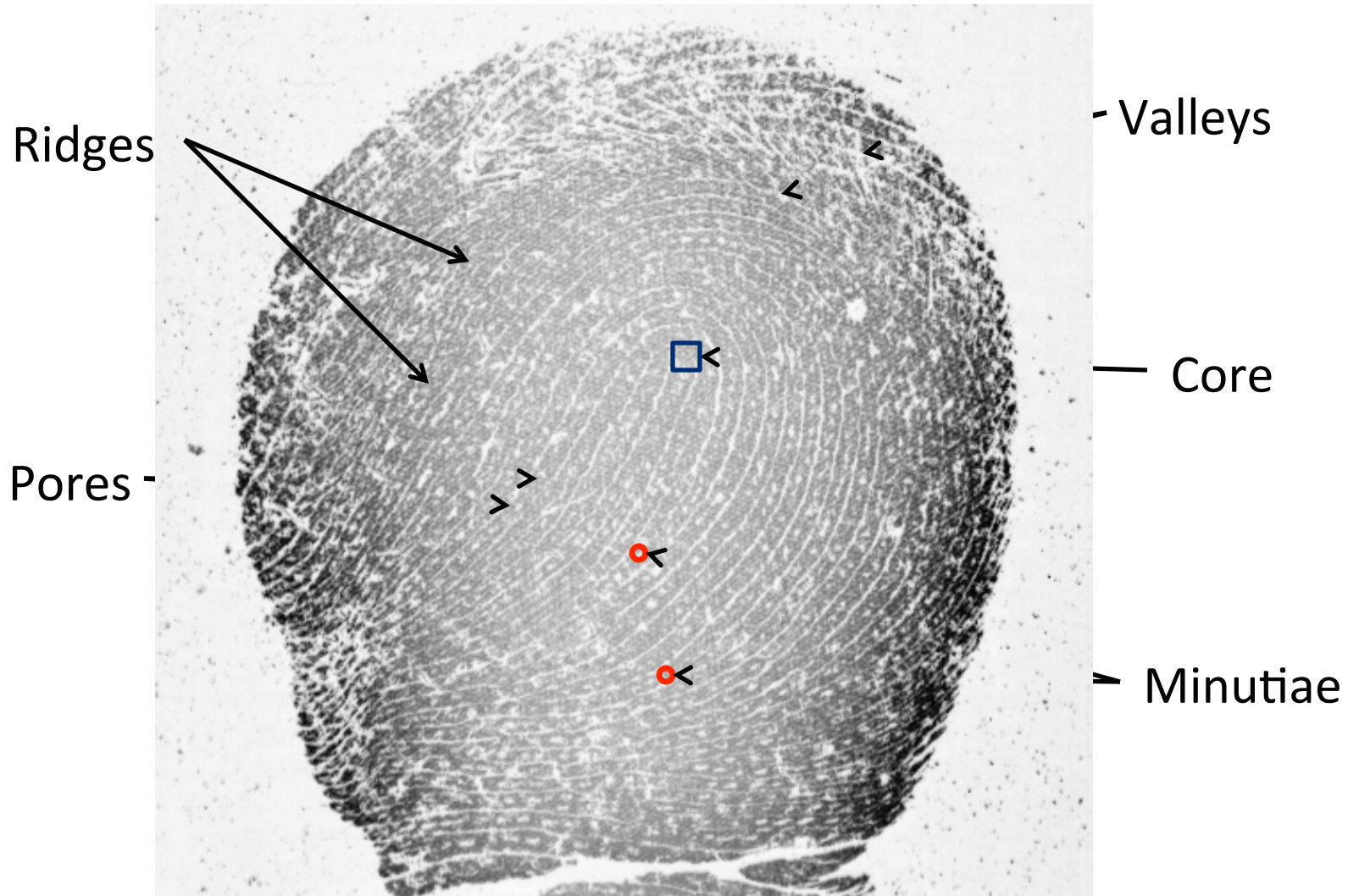May 4, 2016

Who is This Child?

"Baby of Renu"
Female
Born 9/22/15

6 hours after birth

Left Thumbprint of "Baby of Renu"
(Six hours after birth)

Fingerprint Features

Ridges

Valleys

Pores

Core

Minutiae

Research Objectives

- Feasibility of child recognition via fingerprints

- Requirements
  - Compact & high resolution reader
  - Robust matcher
  - Longitudinal study

Age: 16 months

Mar. 2015
16 months

Sept. 2015
22 months

Jan. 2016
25 months

Mar. 2016
28 months

6

Fingerprints of Young Children

- Galton (1892) obtained all ten fingerprints of a newborn from birth until she was 4.5 years old

- Key observations:
  - *"Far more delicate printing is needed on account of the low relief of features and minuteness of the pattern"*
  - *"Babies are the most difficult to deal with, the persistent closing of their fists being not the least of the difficulties"*
  - *"Many undecipherable blurs are made before one moderate success is attained"*

"The print of a child at the age of 2.5 years would serve to identify him ever after"

Recent Studies

Study	Purpose	Conclusion
TNO (2004)	Assess the viability of biometric traits for Dutch Travel Documents	*"Not possible to obtain clear fingerprints from children under 4 years of age" due to minuteness of ridge pattern on their fingers*
BIODEV II (2007)	Capture, store and verify biometric data for Schengen visa applicants	*Challenging to fingerprint children below 12 years of age*
Ultra-Scan (2006-2009)	Model the growth of fingerprint patterns of children through adolescence	*No insights into child fingerprint capture and recognition*
JRC (2013)	Passport processing by the Portuguese government	*Fingerprint recognition of children younger than 6 years of age is difficult*

Aadhaar

- ~1 B residents already enrolled
- Next Challenge: **~25M babies born/year**
- PoC for children 2+ years underway

http://uidai.gov.in/faq.html?catid=18

Tracking Vaccination Schedule
(Benin, May 2014)

Lessons Learned from Benin Study

- Motion blur, image distortion
- Very small finger size, image resolution
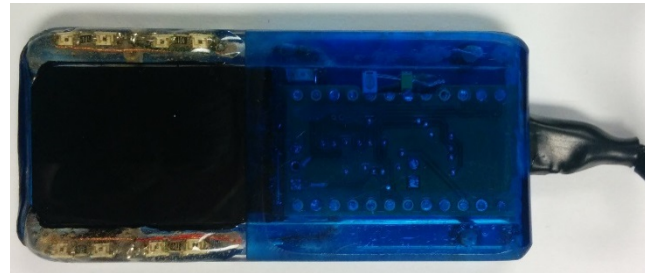- Dry, wet & dirty fingers
- Throughput

3 hour old baby

Fingerprint Readers

U.are.U
4500

NEC Zakuro

Silk ID

Reader	U.are.U 4500	NEC Zakuro	Silk ID
Technology	Optical	CMOS+SLDR	Optical
Image Capture Area (L x W) in mm	14.6 x 18.1	35.4 x 21.8	20.3 x 15.2
Maximum resolution (DPI)	512	1,270	1,000
Size (L x W x H) in mm	65x36x15.6	72x35x7.5	44.2x36.2x15.9
Capture mode	Automatic	Manual	Automatic

SLDR: Structured Light Direct Reading

500 vs. 1270 ppi Fingerprint Image

7-month old Child

Digital Persona U.are.U 4500

NEC Zakuro

Data Collection Protocol

- Longitudinal study (four sessions)
  - March 2015; Sept. 2015; Jan. 2016; March 2016
- 500 ppi DP & 1270 ppi NEC readers (Sept 2015)
- 3 images/thumb (left and right)
- Face images using iPhone 5/5s
- Total no. of subjects = 319
- No. of subjects in all four sessions = 161

Fingerprint Capture

Dr. Bhatnagar's clinic, Saran Ashram Hospital, Agra

Process Flow

| | Mar. 2015 (6 months) | Sept. 2015 (12 months) | Jan. 2016 (15 months) | Mar. 2016 (18 months) |

500 ppi

Face

Left Thumb

Right Thumb

	Mar. 2015 (6 months)	Sept. 2015 (12 months)	Jan. 2016 (15 months)	Mar. 2016 (18 months)
Face				
Left Thumb				
Right Thumb				

1270 ppi

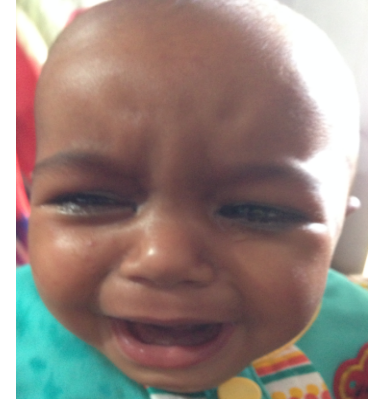|	Mar. 2015	Sept. 2015 (1 day)	Jan. 2016 (3 months)	Mar. 2016 (6 months)

1270 ppi
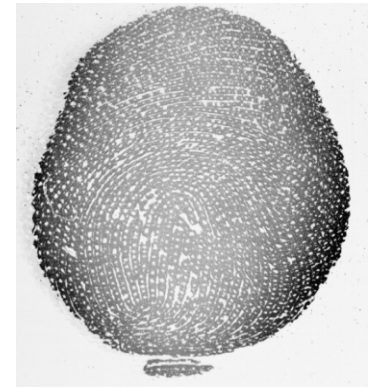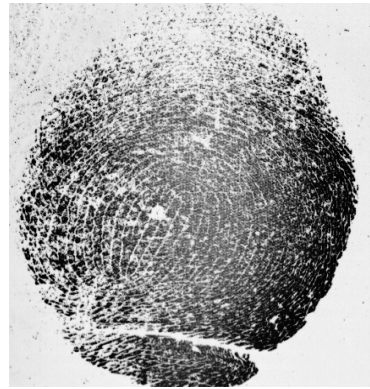
Face

Left Thumb
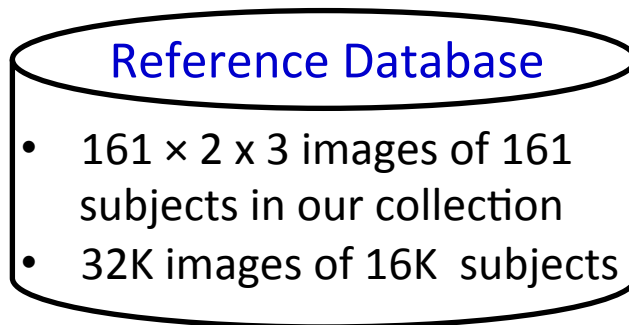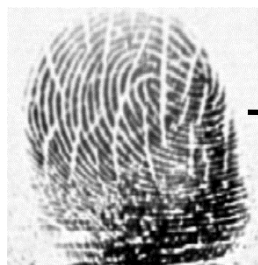
Right Thumb

Recognition Protocol

Face

Left thumb

Right thumb

Down (up) sampling to 900 DPI; ridge spacing is close to adults

Reference Database

- 161 × 2 x 3 images of 161 subjects in our collection
- 32K images of 16K subjects

COTS Latent Matcher
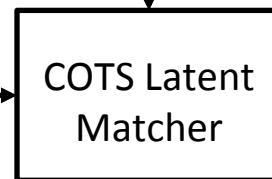
Top-9 hits; face in red box is the true mate

Verification

(1 query image; 3 enrolled templates; fusion of 2 thumbs)

	Session gap (months)	TAR@FAR=0.1% 500 ppi DP sensor (1270 ppi NEC sensor)	
		Age @ enroll >12 mos	Age @enroll ≤ 12 mos
No. of subjects		119	42
Session 4 vs. 1	12	100%	85.7%
Session 4 vs. 2	12	100% (100%)	96.0% (99.5%)

0-6 months: 71.1% and 95.0% (98.9%) for rows 1 & 2

6-12 months: 99.0% and 97.0% (100%) for rows 1 & 2

Search
(1 query image; 3 enrolled templates; fusion of 2 thumbs)

	Session gap (months)	Top-10 retrieval 500 ppi DP sensor (1270 ppi NEC sensor)	
		Age @ enroll >12 mos	Age @enroll ≤ 12 mos
No. of subjects		119	42
Session 4 vs. 1	12	100%	90.5%
Session 4 vs. 2	12	100% (100%)	97.6% (100%)

0-6 months: 80.0% and 95.0% (100%) for rows 1 & 2

6-12 months: 100% and 100% (100%) for rows 1 & 2

Successful Comparison
1270 ppi NEC sensor

Left thumb

Right thumb

Query fingerprints (age: 7 months)

Enrollment age: 1 month

Unsuccessful Comparison
1270 ppi NEC sensor

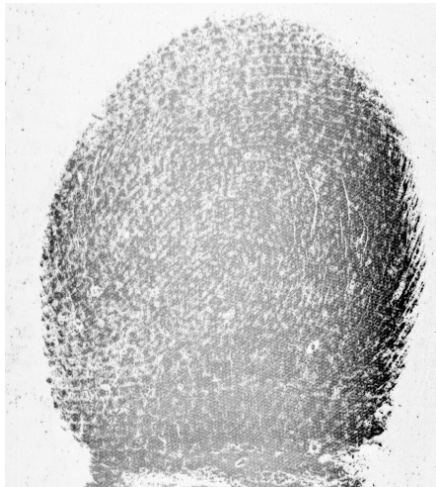
Left thumb

Right thumb

Query fingerprints (age: 13 months)

Enrollment age: 7 months

Tracking Newborns

(Single query; 3 enrolled templates/thumb; fusion of thumbs)

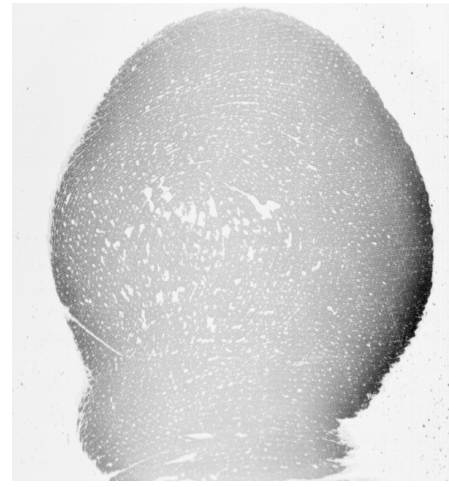| Age at Enrollment	Session gap (months)	TAR @ FAR=0.1% 1270 ppi NEC sensor
0-3 months	3	43.5%
0-3 months	6	31.7%

No. of subjects = 47

2 days   5 days   5 weeks   7 weeks

Summary

- Need solutions for large-scale child biometrics
- Our research shows
  - Newborns have well-formed friction ridges
  - 500 ppi sensors work for 12 months+ children; higher resolution for infants (0-12 months)
- Challenges & requirements
  - Uncooperative subjects; difficult capture conditions
  - Matching noisy & distorted images
  - Compact, low cost, high res., ergonomic readers
  - Operator training for quality images & throughput

Acknowledgement

- A. K. Jain, S. S. Arora, L. Best-Rowden, K. Cao, P. S. Sudhish, A. Bhatnagar and Y. Koda, "Giving Infants an Identity: Fingerprint Sensing and Recognition", *Eighth Intl' Conf. on Information, Communication Technologies & Development (ICTD)*, Ann Arbor, June, 2016

- A. K. Jain, S. S. Arora, L. Best-Rowden, K. Cao, P. S. Sudhish and A. Bhatnagar, "Biometrics for Child Vaccination and Welfare: Persistence of Fingerprint Recognition for Infants and Toddlers", *MSU Tech. Report*, April 15, 2015