

Biometric Recognition of Children: Challenges and Opportunities

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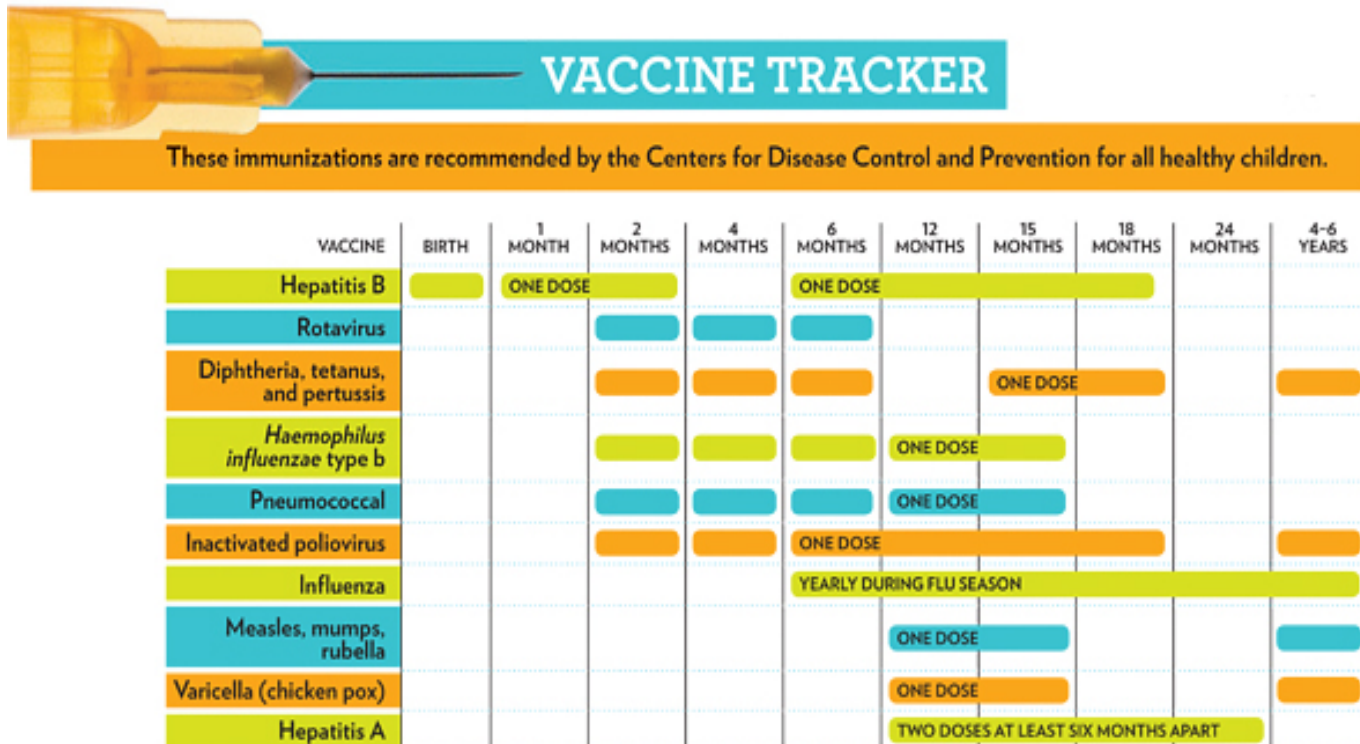
June 7, 2016



Tracking Vaccination Schedules



“Vaccine wastage rates are higher than 50% in some of the most challenging geographies.”-VaxTrac
(<http://vaxtrac.com/mission/challenge>)



Vaccination Camp

(Cotonou, Benin, West Africa, May 2014)



Preventing Newborn Baby Swaps



October 30, 2013: Two newborn babies born 5 minutes apart were swapped due to negligence of the medical staff at the Vijayanagar Institute of Medical Sciences (VIMS) in Bellary; a DNA test later confirmed the swap*

Giving Child an Identity?

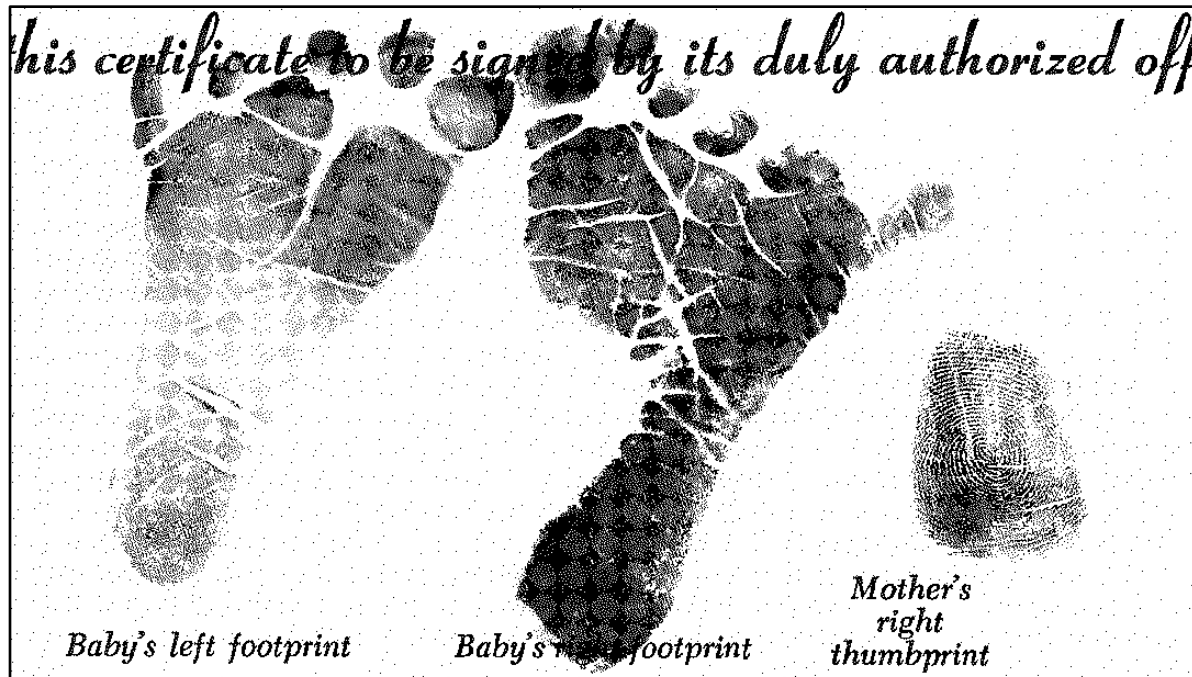
- Who is this child?
- Have we seen her before?



National ID, vaccination tracking, healthcare, social benefits

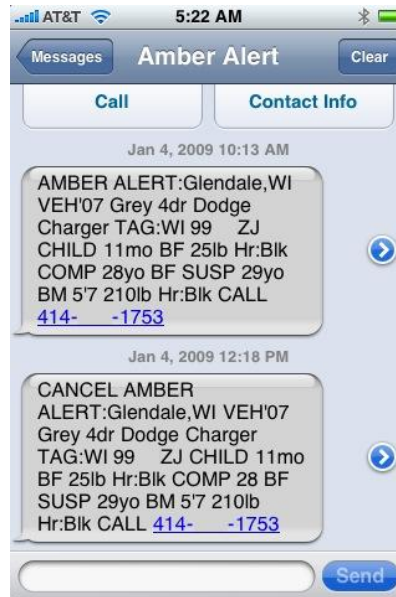
Why Biometrics?

- ID cards either not available or cannot be trusted
- Parents may not always accompany the child to vaccination/health camps



Linking newborn's footprint to mother's thumbprint

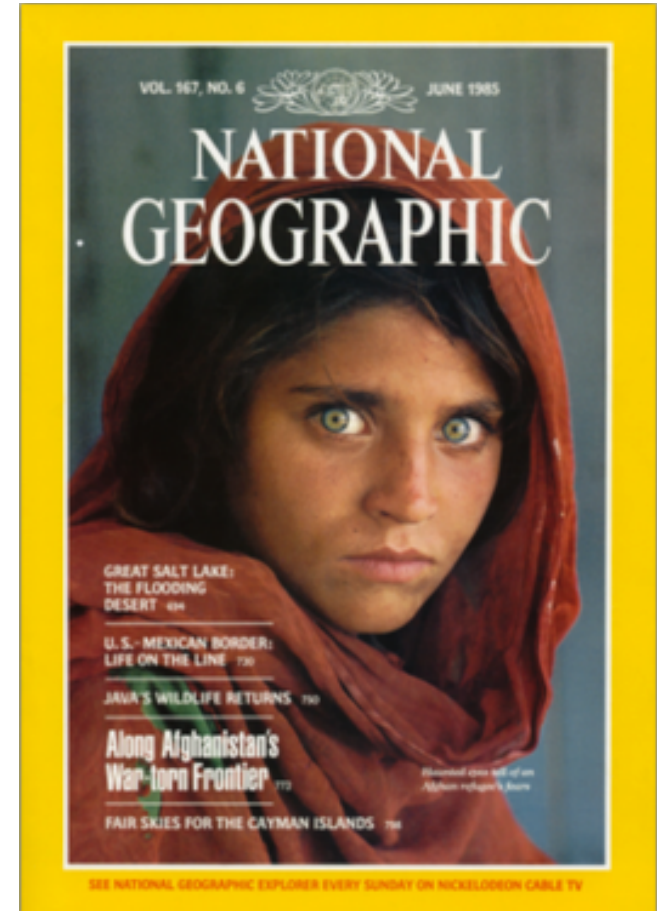
Missing Children



Amber Alert System for Child Abduction in the U.S.

Number of Missing Children

	2014 - 2015
India	73,549
US	466,949
Worldwide	~8 million



Afghan Girl (age 13 years), from the 1985 issue of National Geographic, identified as *Sharbat Gula* in 2002, using her Iris image

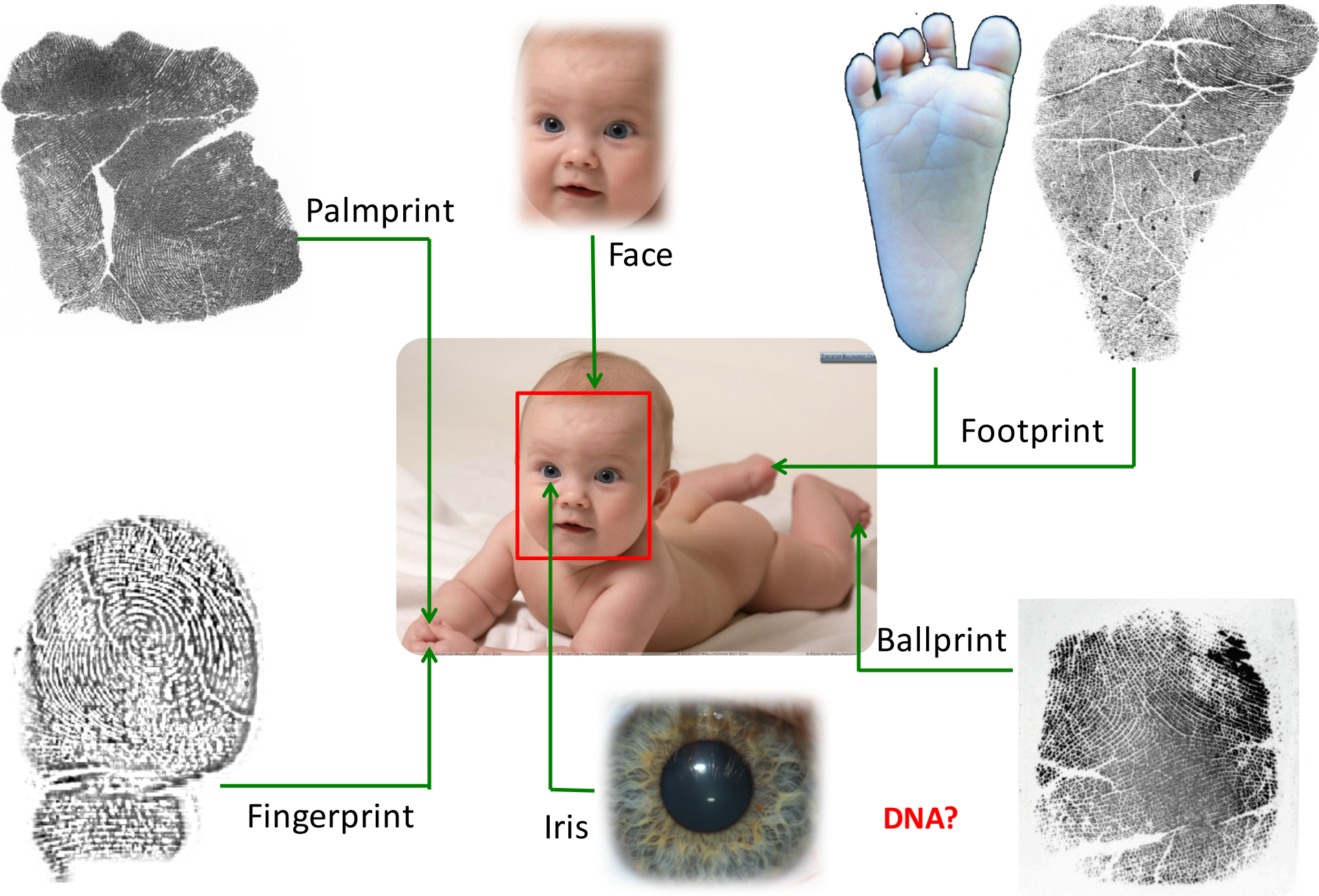
<http://www.amberalert.gov/>

<http://www.nationalgeographic.com/magazine/2002/04/afghan-girl-revealed/>

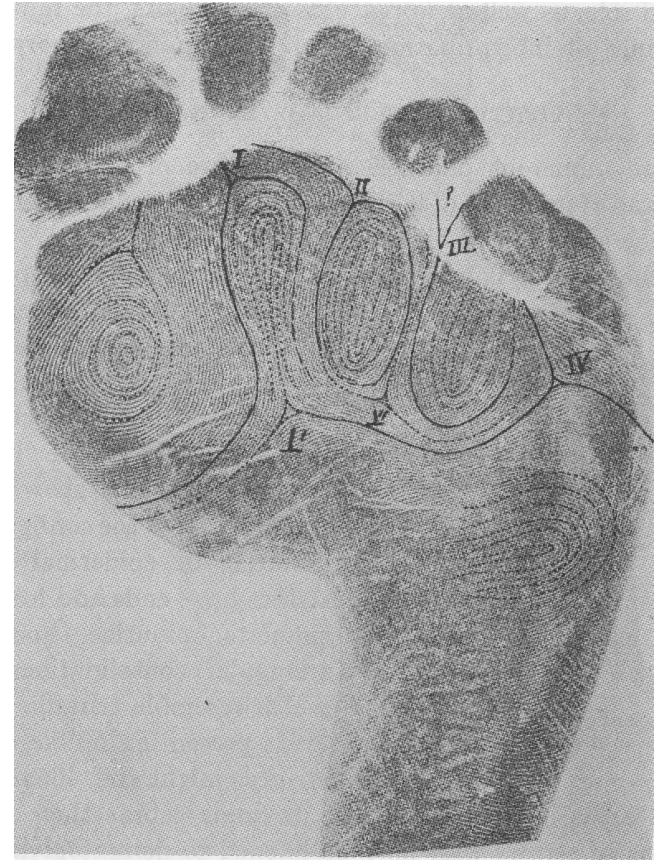
<http://www.missingkids.com/KeyFacts>

<http://pib.nic.in/newsite/PrintRelease.aspx?relid=123600>

Which Biometric Trait?



Friction Ridge Patterns



- **Ridges are different for every finger of every person**
- **They do not change throughout life & survive superficial injury**
- **The precise patterns & minutiae are determined at ~10 weeks**

Penrose and Ohara, The development of the Epidermal Ridges, J. Medical genetics, 1973

Cummins and Midlo, Finger Prints, Palms and Soles, Dover, 1961

Comparing Biometric Traits

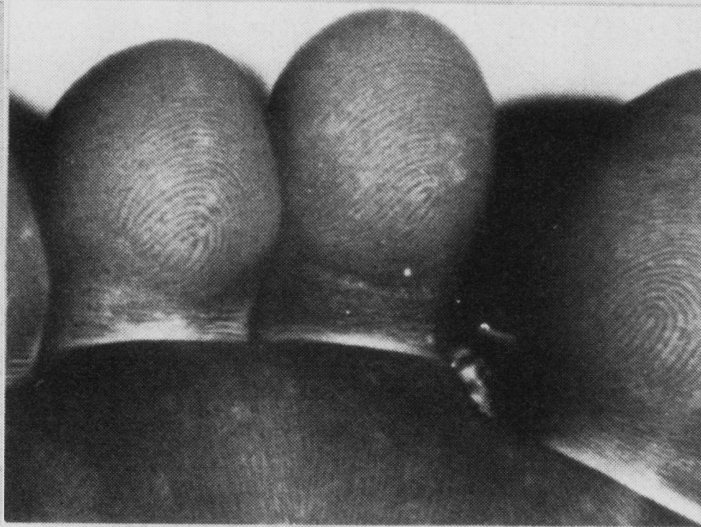
Trait	Pros and Cons
Face	Easy to capture; difficult to control pose, illumination and expression
Iris	Child may be sleeping or crying; parental concerns
Fingerprint	Need compact, high resolution (>1000 ppi) sensor to resolve ridges; wet and dry fingers
Palmprint	Large surface area; surface concavity; infants keep their fists closed
Footprint	Large surface area; surface concavity; removing socks and shoes; dirty feet

- **Acquisition: uncooperative child, capture conditions, throughput**
- **Properties of trait: Capacity (1:N comparison) and persistence**

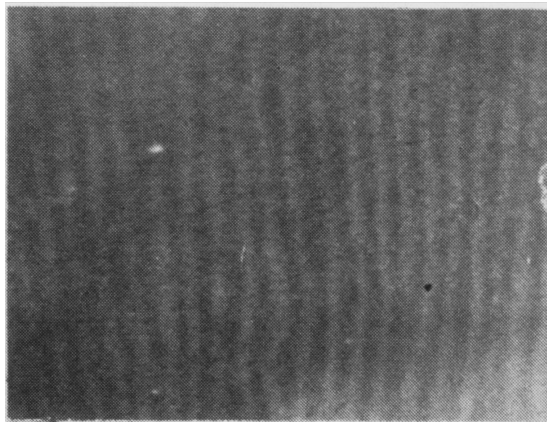
Development of Friction Ridge Patterns of Fetus



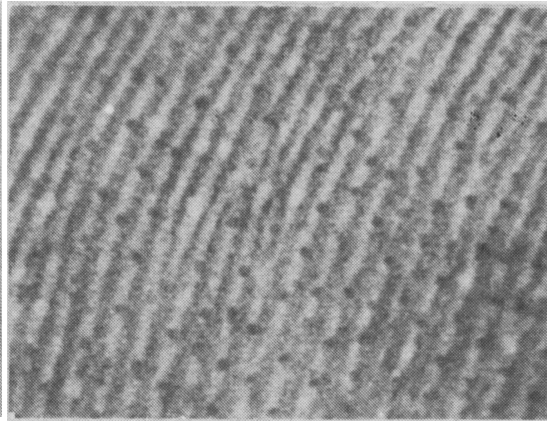
Ring finger, 13 weeks of gestational age



Toes, gestational age unknown, crown-rump length 100mm



Thenar area of palm, 15 weeks and 4 days of gestational age



Hypothenar area of palm, 16 weeks and 5 days of gestational age



Middle finger, gestational age unknown, crown-rump length 140mm



Fingerprints of Young Children

- Galton (1892) collected 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”

Child Fingerprinting

- Challenges
 - Small finger size; high ridge density; low contrast; wet & dirty fingers; image distortion
- Requirements
 - Compact, high resolution, low cost sensor; fast image capture; **longitudinal study**



The Dayalbagh Longitudinal Fingerprint Study

Saran Ashram Hospital, DEI, NEC, Silk ID, Digital Persona, Gates Foundation, VaxTrac, MSU

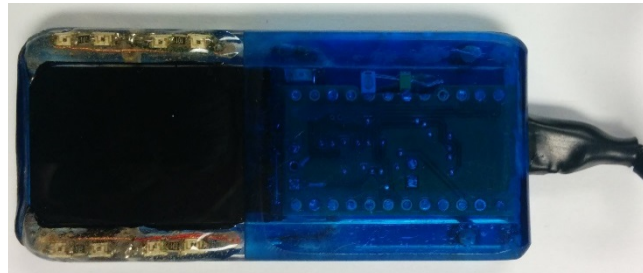


Four sessions: March & Sept. 2015; Jan. & March 2016

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

Fingerprint Capture



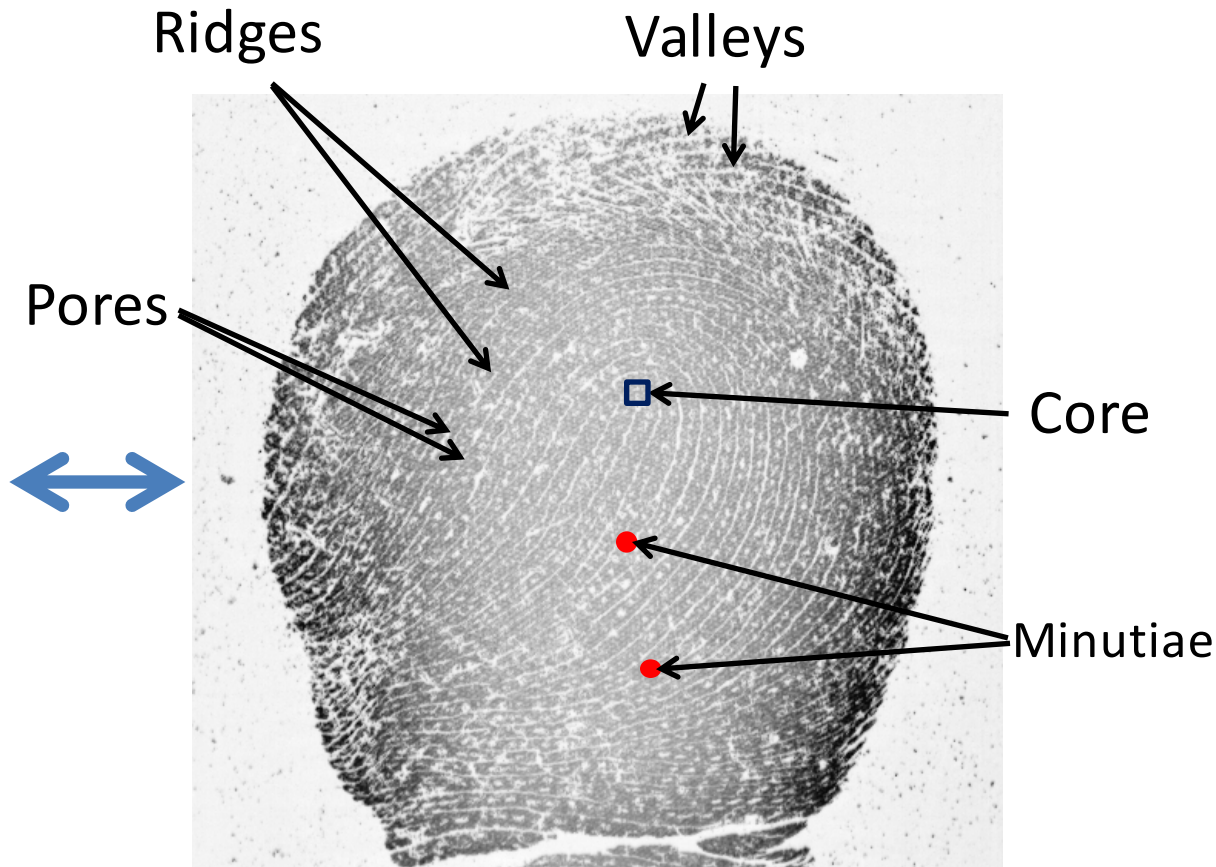
- 500 ppi DP & 1270 ppi NEC readers
- 3 fingerprint images/thumb/session; 3 face images/session
- Total of 319 children; 161 came to all the four sessions

Left Thumbprint of “Baby of Renu”

(NEC Zakuro sensor, 1270 ppi)



6 hour old



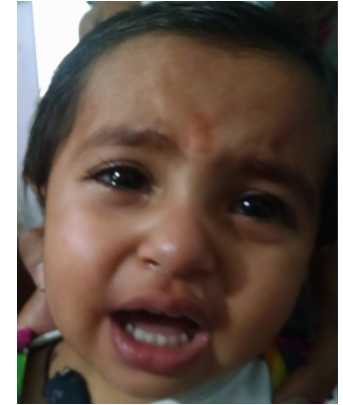
Mar. 2015
(6 months)

Sept. 2015
(12 months)

Jan. 2016
(15 months)

Mar. 2016
(18 months)

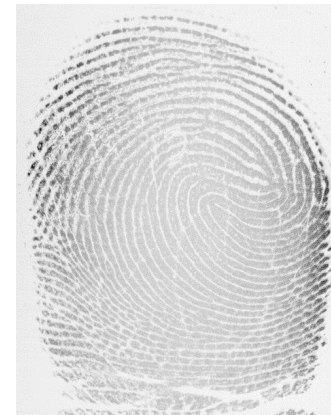
Face



Right
thumb
500 PPI



Right
thumb
1270 PPI



Recognition Protocol



Face



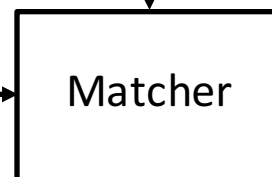
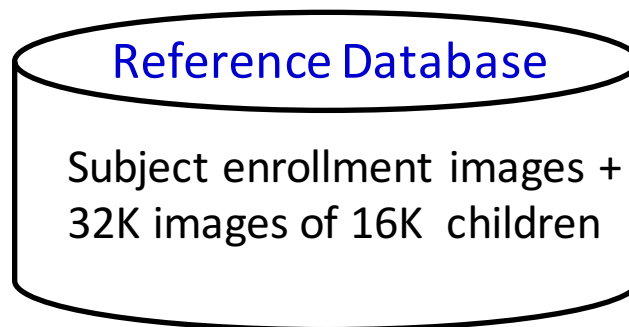
Left thumb



Right thumb








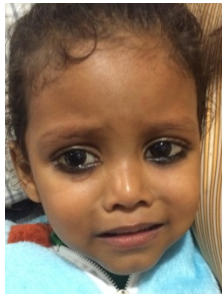







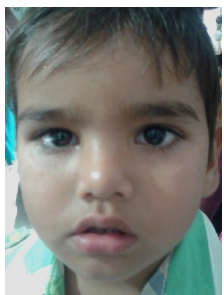










Preprocessing



Top-9 hits

Face Matching

Session 1 Mar. 2015	Session 2 Sep. 2015	Session 3 Jan. 2016	Session 4 Mar. 2016	Session 1 Mar. 2015	Session 2 Sep. 2015	Session 3 Jan. 2016	Session 4 Mar. 2016
							
3 months	0.598	0.543	0.510	1 year	0.632	0.300	0.487
							
4 months	0.545	0.597	0.650	2.5 years	0.415	0.473	0.469
							
5 months	0.539	0.410	0.145	3 years	0.723	0.613	0.828

Threshold @ 0.1% FAR = 0.615

Fingerprint Verification (1:1 Comparison)

	Session gap	TAR@FAR=0.1%	
		500 ppi DP sensor	(1270 ppi NEC sensor)
		Age @ enrollment >12 months	Age @enrollment ≤ 3 months
No. of subjects		119	47
Session 4 vs. 2	6 months	100% (100%)	N/A (32%)

95% accuracy for Infants > 6 months using 1270 ppi images

Summary

- Growing opportunities for large-scale child biometric systems
- The Dayalbagh longitudinal study shows fingerprint recognition is viable for infants
- Challenges:
 - Uncooperative subjects
 - Difficult capture conditions
 - Large scale de-duplication
 - Which biometric trait(s)?