### Infant-ID: Fingerprints for Global Good

#### Anil Jain Michigan State University http://biometrics.cse.msu.edu/

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## Who is This Infant?



- Authentication: Is this the infant her parents claim her to be?
- Search (de-duplication): Have we seen this infant before?

Infants: 0-12 months (CDC)

# Four Births Every Second





Classification based on poverty levels (GNI per capita < USD 1,025 for LDC), human resource weakness (nutrition, health, education and literacy), and economic vulnerability. As of Feb. 2019, there are 47 least developed, 92 developing, and 54 developed countries in the world. https://unctad.org/webflyer/least-developed-countries-report-2018

Infant mortality rates (per 1,000 live births): Low-income countries: 49; High income countries: 5 https://bit.ly/2i2SBjs

# Why Infant Recognition?



Vaccination Clinic



**Food Distribution** 

U.N. Sustainable Development Goal (16.9): "By 2030, provide legal identity for all, including birth registration"

https://bit.ly/1oIVAOf

## Which Trait for Infants?



Requirements: permanence, uniqueness, ergonomic, acceptability, low cost, high throughput

# Why Fingerprints?



### **MSU Infant-Prints Reader**



Reader: 1,900 ppi, cost: \$85; assembly time: < 2 hours Open Source: *https://bit.ly/31s2TQT* (13 days old) Challenges: Blur, distortion, small ridge gaps, wet/dry finger

# **MSU Infant-Prints Pipeline**



- Image capture: Reader to smartphone over bluetooth
- Preprocessing: Enhancement and aging
- Matching: Minutiae, latent and texture matchers

#### Dataset: Saran Ashram Hospital, Dayalbagh, Agra, India



#### **Evaluation**



Time Lapse	3 Months	9 Months	12 Months
Infant-Prints	95%	90%	85%

- Reporting TAR @ FAR = 0.1% (threshold = 0.1)
- Infants enrolled at 2-3 months of age

# Summary

- Fingerprints necessary for infant authentication/search
- Applications: healthcare, vaccination, nutrition delivery
- MSU Infant-ID provides accurate, cost-effective end-toend solution for recognizing adults and infants (>2 mos)





#### In-situ Evaluation: Saran Ashram Hospital, Dayalbagh, Agra, India



Enrollment	0-1 Months	1-3 Months	2-3 Months
Left Thumb	59.0%	62.3%	76.5%
	(65.4%)	(69.6%)	(82.4%)
Right Thumb	55.8%	60.9%	68.4%
	(58.4%)	(63.8%)	(74.5%)
Thumbs Fused	66.7%	75.4%	90.2%
	(78.2%)	(85.1%)	(94.1%)

- Reporting TAR @ FAR = 0.1% (1.0%)
- Infants authenticated 3-months after enrollment
- Three complementary matchers (sum score fusion) used to compute match scores

#### 6 days



1 Month, 12 days



2 Months, 13 days



3 Months, 13 days





1 Month, 14 days



2 Months, 15 days



3 Months, 15 days





4 Months, 5 days

5 Months, 5 days

6 Months, 5 days

6 days



1 Month, 12 days



2 Months, 13 days 2 M





8 days

1 Month, 14 days

3 Months, 15 days



#### 2 Months, 27 days



4 Months, 5 days



5 Months, 5 days



6 Months, 5 days



# **Challenges in Infant Fingerprint Recognition**

Motion blur and image distortion

• Small finger size

- Dry/wet/dirty fingers
- Small inter-ridge spacing (4-5 pixels) vs. (9-10 pixels) for adults



#### Who is This Infant?



What is the youngest enrollment age at which infant can be recognized, say 12 months later?

# Why Infant Identity?



Food distribution

Vaccination Clinic

U.N. Sustainable Development Goal (16.9): "By 2030, provide legal identity for all, including birth registration"

https://bit.ly/10IVAOf

## Which Biometric Trait?



Requirements: permanence, uniqueness, ergonomic, acceptability, low cost, lifelong usability

#### **Data Collection**



Dr Anioo Bhatnagar's clinic Saran Ashram Hosnital

#### Dataset

![](_page_19_Picture_1.jpeg)

#### 6 days

![](_page_20_Picture_1.jpeg)

1 Month, 12 days

![](_page_20_Picture_3.jpeg)

2 Months, 13 days

![](_page_20_Picture_5.jpeg)

3 Months, 13 days

![](_page_20_Picture_7.jpeg)

![](_page_20_Picture_8.jpeg)

1 Month, 14 days

![](_page_20_Picture_10.jpeg)

2 Months, 15 days

![](_page_20_Picture_12.jpeg)

3 Months, 15 days

![](_page_20_Picture_14.jpeg)

![](_page_20_Picture_15.jpeg)

4 Months, 5 days

5 Months, 5 days

6 Months, 5 days

6 days

![](_page_20_Picture_17.jpeg)

1 Month, 12 days

![](_page_20_Picture_19.jpeg)

2 Months, 13 days 2 M

![](_page_20_Picture_21.jpeg)

![](_page_20_Picture_22.jpeg)

8 days

1 Month, 14 days

3 Months, 15 days

![](_page_20_Picture_24.jpeg)

#### 2 Months, 27 days

![](_page_20_Picture_26.jpeg)

4 Months, 5 days

![](_page_20_Picture_28.jpeg)

5 Months, 5 days

![](_page_20_Picture_30.jpeg)

6 Months, 5 days

![](_page_20_Picture_32.jpeg)

### **Proposed System**

![](_page_21_Figure_1.jpeg)

- End-to-end system (low-cost, high-res, compact) fingerprint reader
- Fusion of minutiae-based and texture matchers
- Enrollment at 2 months provides TAR= @FAR =0.1%, 6 months later

### Image Acquistion

• Figs 4 and 5 from the PAMI paper

## Summary and Challenges

- Longitudinal data collection
- Data sharing (privacy issues)
- Low-quality images (non-cooperative subjects)
- Wet and dirty fingers
- Relatively larger acquisition time
- Patience during data collection

![](_page_24_Picture_0.jpeg)

## **Biometric Recognition**

![](_page_25_Picture_1.jpeg)

- ID Bands: damaged or switched; 1 mistake in 1,000 baby transfers
- Biometrics: Automated recognition of infants from their biological traits

#### Aadhaar: World's Largest Biometric System Limited to 5 years and older

![](_page_26_Picture_1.jpeg)

**Biometrics India's Answer to Safe Payments** 

![](_page_26_Picture_3.jpeg)

Adult fingerprint Infant fingerprint **500 ppi**