# Artificial Intelligence (AI) Challenges and Opportunities


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Michigan State University


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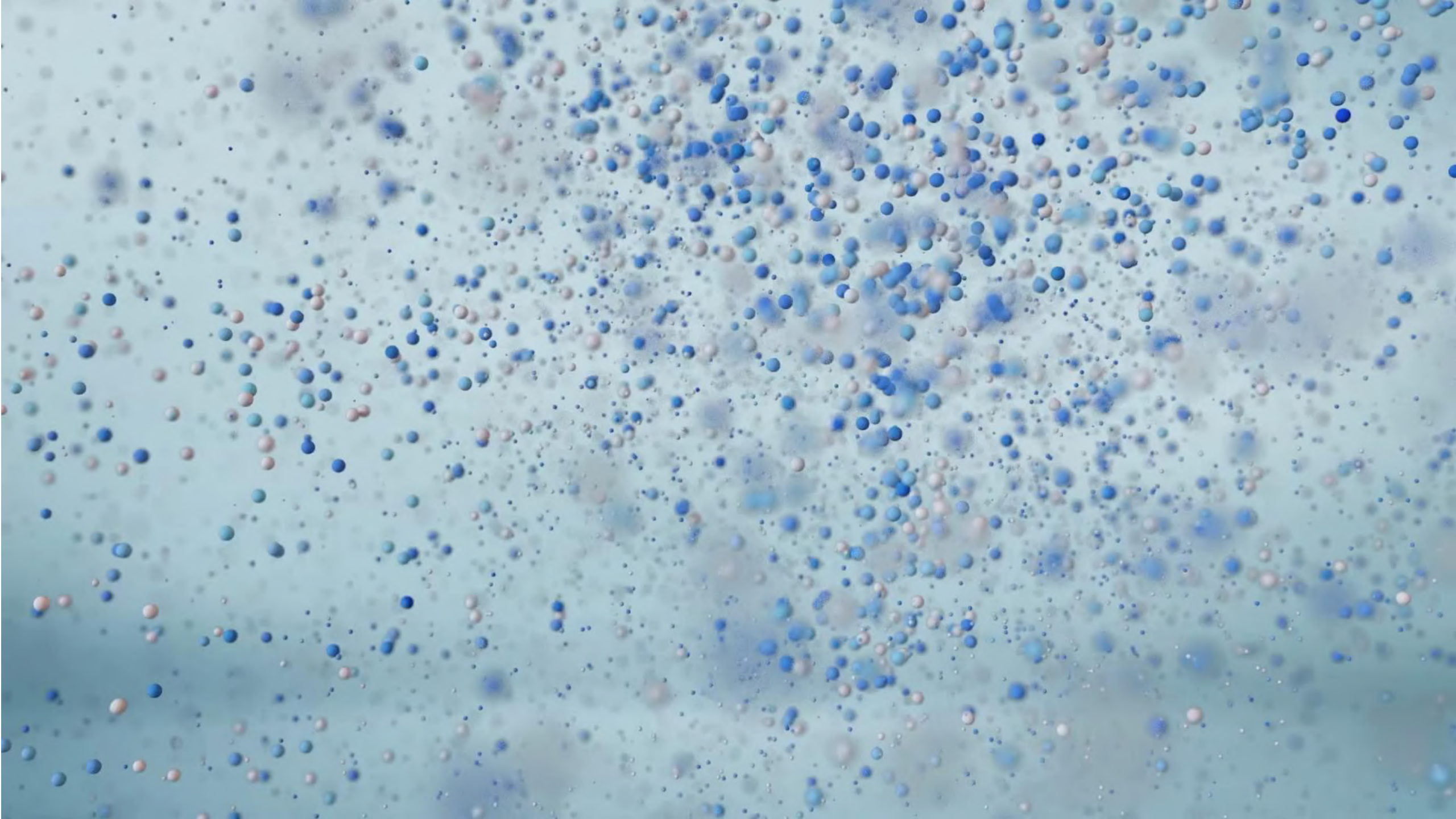


# What is Artificial Intelligence (AI)?

**“The science of making machines do things that would require intelligence if done by men.”**

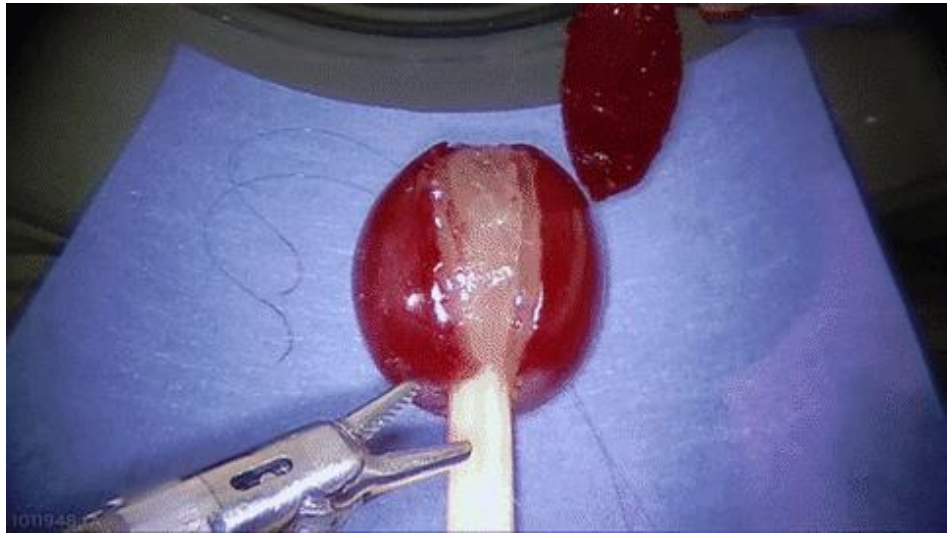
*Marvin Minsky (1927-2016), referred to as the father of AI*

# Examples of AI systems


Robots

Autonomous Vehicles

Robotic Surgery



# AI for Surveillance

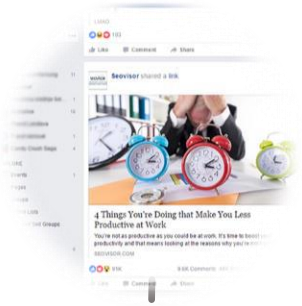
# LG WASHING MACHINES WITH AI

- **LG's AI technology leverages big data on 20,000 pieces of information (e.g. washer usage) and adjusts settings, based on the load, to provide the most optimized washing cycle."**

*http://www.lgnewsroom.com/2019/09/lg-washing-machines-with-artificial-intelligence-and-direct-drive-motor-roll-out-region-wide/*

# 10 Most-influential Technologies of the Decade

Facebook's **News Feed**




2006

Facebook's **Instagram**

2007

Tesla's **Model S**

2010

Ring's **Doorbell**

2011

Amazon **Alexa**

2012

Apple **FaceID**


2013

2012

Netflix **Streaming**

2013

Uber

2014

Apple **iPad**

2015

Apple **TouchID**


2017

Apple **Watch**

https://www.washingtonpost.com/technology/2019/12/26/we-picked-most-influential-technologies-decade-it-isnt-all-bad/

# Ethical Principles for AI Systems

*https://www.microsoft.com/en-us/ai/our-approach-to-ai*

**FAIRNESS:** SHOULD TREAT ALL PEOPLE FAIRLY

**INCLUSIVENESS:** SHOULD EMPOWER EVERYONE AND ENGAGE PEOPLE

**RELIABILITY & SAFETY:** SHOULD PERFORM RELIABLY AND SAFELY

**TRANSPARENCY:** SHOULD BE UNDERSTANDABLE

**PRIVACY & SECURITY:** SHOULD BE SECURE AND RESPECT PRIVACY

**ACCOUNTABILITY:** SHOULD HAVE ALGORITHMIC ACCOUNTABILITY

# Benefits and Perils of AI-based Technology

- How do the companies ***safeguard user data? Do they "sell" it?***
- Apps (mobile applications) **decide what we read and watch.**
- Ola & Uber decide what **jobs a driver gets and where he goes?**
- Fake news, photos and videos on social media can **create hatred and influence outcomes of elections.**
- Widespread use of surveillance **can track your activities.**
- AI systems are not always ***fair*** **(unbiased)?**

# Data Privacy Law in India

Passenger providing face image at Hyderabad airport

- *A new legislation in the Parliament, will restrict how companies can collect and use information from the country's 1.3 billion people.*
- *But, no restrictions on the government use.*

"India Charts Own Path on Data Privacy", NY Times, Dec 11, 2019


Artificial
Intelligence for
Good

Microsoft

*"Applied AI uses technology to empower solutions to humanitarian issues and create a more sustainable and accessible world."*

Google

*"Through research, engineering, and initiatives to build the AI ecosystem, we're working to use AI to address societal challenges."*

facebook

*"Artificial intelligence brings the promise of improved access to health care, accelerated economic development, reduced inequalities, and other gains."*

# Infant-Prints: Fingerprint Recognition of Infants

# Who is this Infant?

**Authentication:** Is this the infant his parents claim him to be?

**Search:** Have we seen this infant before?

# Why Infant Identity?

Birth registry
Baby swapping
Vaccination
Nutrition

Vaccination Clinic

Food distribution

**U.N. Sustainable Development Goal (16.9):**

***"By 2030, provide legal identity for all, including birth registration"***

# Biometric Recognition

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

# Which Biometric Trait?

Palmprint


Face

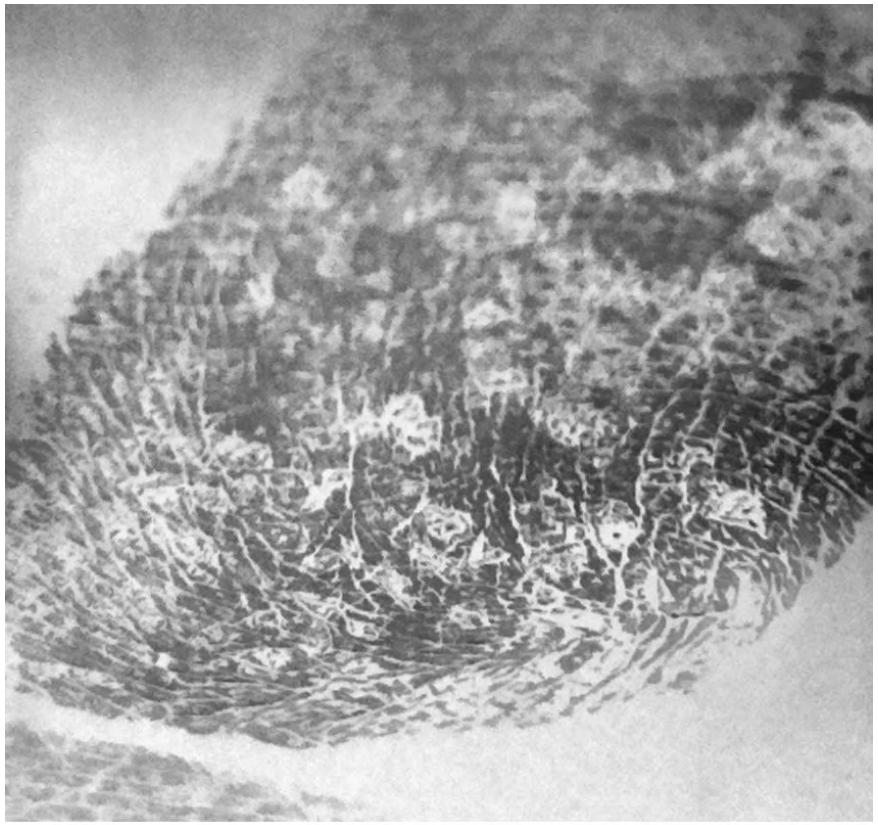
Iris

Fingerprint

Footprint or Ballprint

*Requirements: Permanence, uniqueness, ergonomic, low cost, lifelong usability, throughput*

# Why Fingerprints?



Day 1

**Permanence**
(Stable over time)

**Uniqueness**
(Distinct for each person)

**Portability, acceptability, cost**
(Accessible to all)

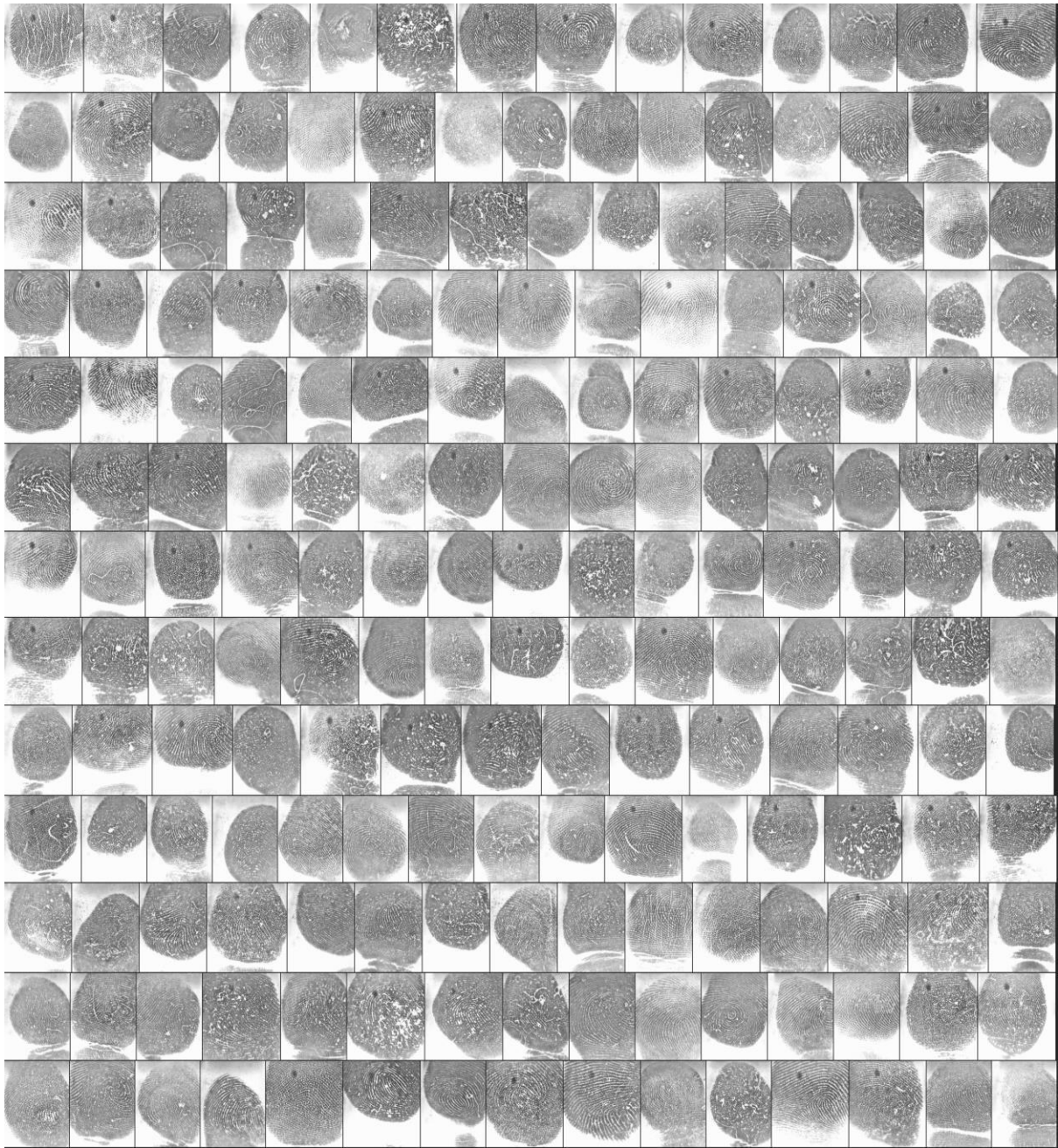
# Adult vs. Infant Fingerprints


Adult fingerprint

Infant fingerprint

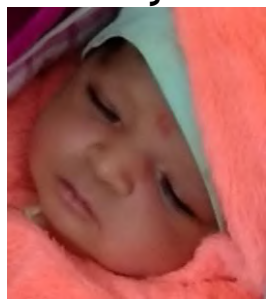
**500 ppi**

# Dataset of 194 infants



6 days

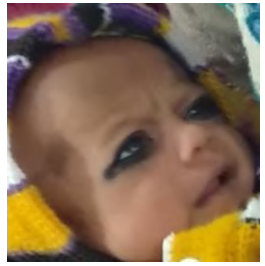
8 days



2 Months, 27 days

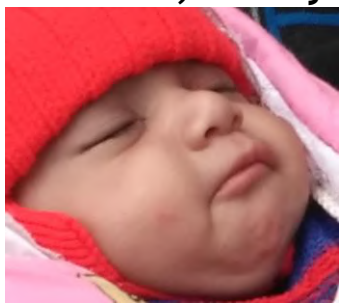
1 Month, 12 days

1 Month, 14 days



4 Months, 5 days

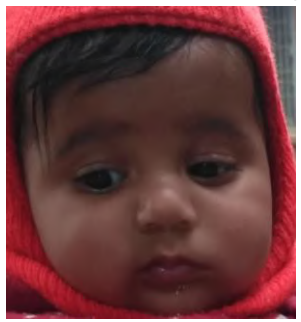
2 Months, 13 days



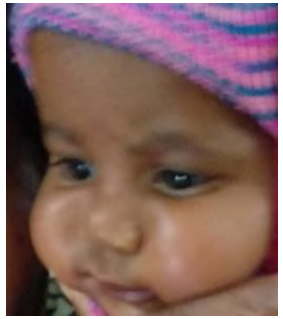
2 Months, 15 days

5 Months, 5 days

3 Months, 13 days



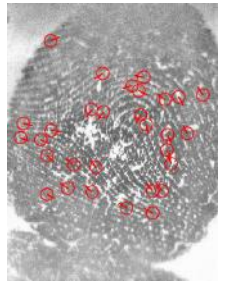
3 Months, 15 days



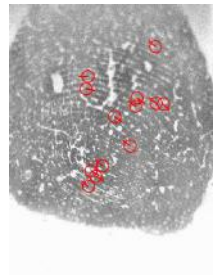
6 Months, 5 days

Longitudinal Data

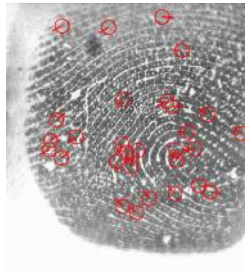
6 days



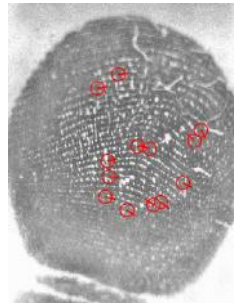
8 days



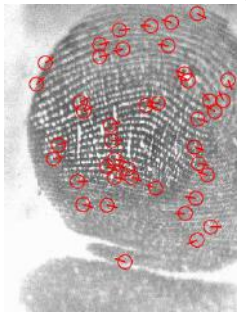
2 Months, 27 days



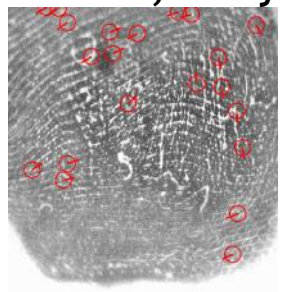
1 Month, 12 days



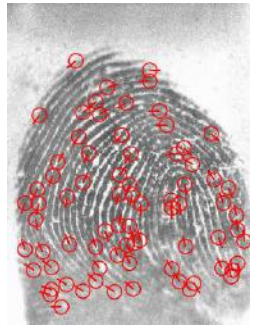
1 Month, 14 days



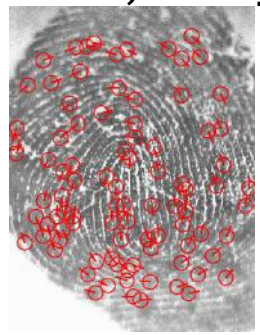
4 Months, 5 days



2 Months, 13 days

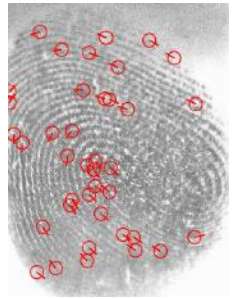


2 Months, 15 days

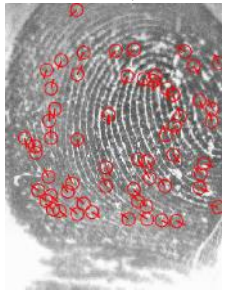


5 Months, 5 days

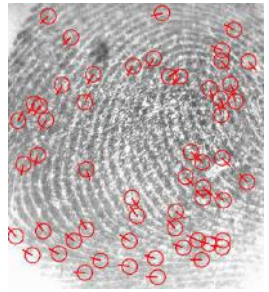
3 Months, 13 days



3 Months, 15 days

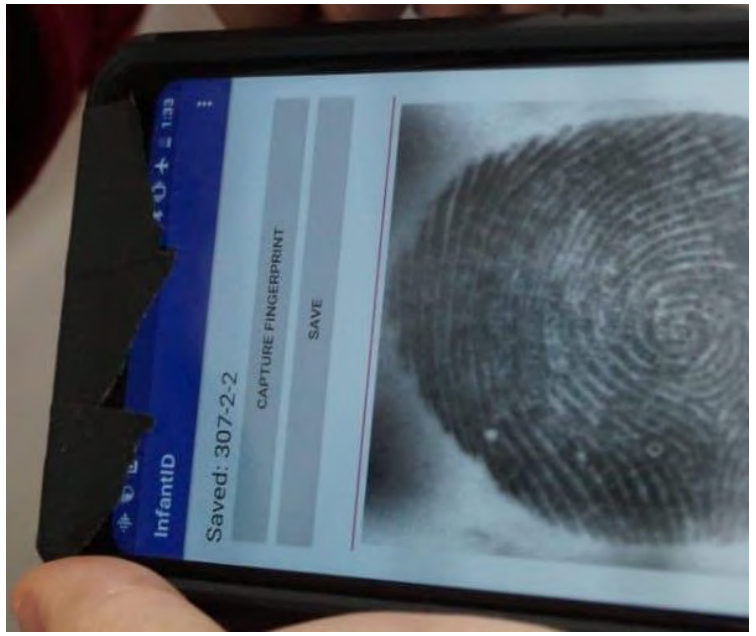


6 Months, 5 days



# In-situ Evaluation:

## *Saran Ashram Hospital, Dayalbagh, Agra, India*




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

- TAR @ FAR = 0.1% (1.0%)
- Authenticate after 3 months
- Fusion of 3 matchers

*Engelsma, et al., "Infant-Prints: Fingerprints for Reducing Infant Mortality", in CVPR Workshop, 2019.*

# Primate Trafficking

**22,818**

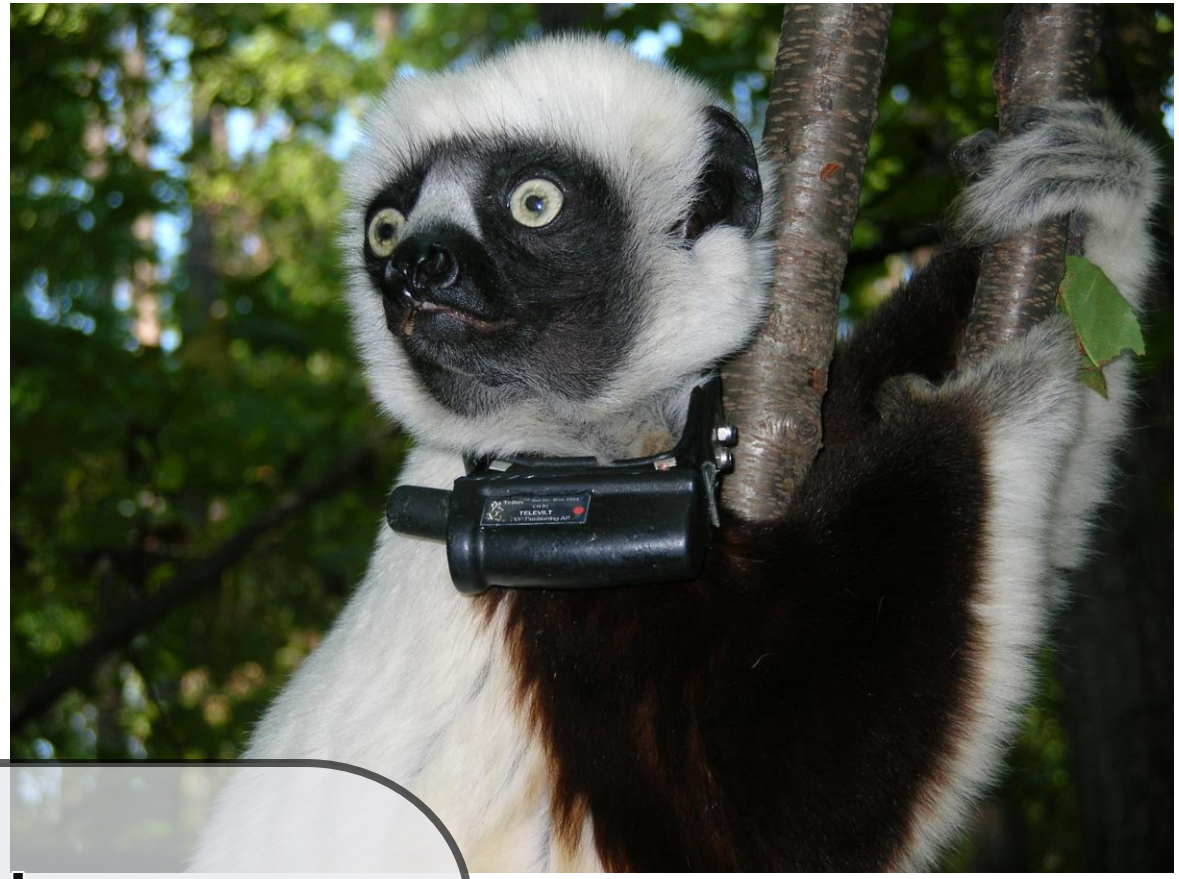
Great Apes Trafficked
2005 - 2011

**27**

Arrests

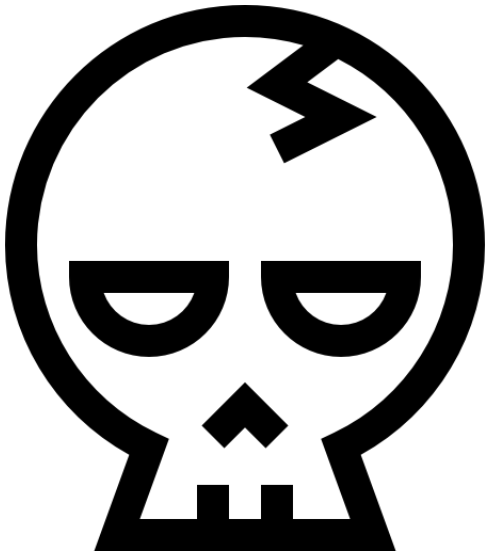
* Statistics from UNESCO

# Tracking Primate Individuals

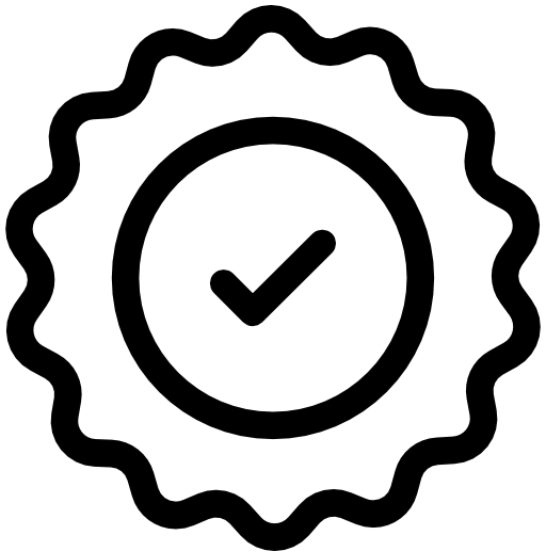


$400 to $4,000

# PrimID



Non-Invasive



Reliable

Automatic

# PrimID: Primate Identification in the Wild

D. Deb, S. Wiper, S. Gong, Y. Shi, C. Tymoszek, A. Fletcher and A. K. Jain, "Face Recognition: Primates in the Wild", in IEEE BTAS, 2018


# Finding Missing Children: Aging Deep Face Features

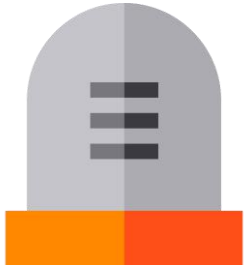
D. Deb, D. Aggarwal and A. K. Jain, "Finding Missing Children: Aging Deep Face Features", arXiv:1911.07538, 2019

# Missing Refugees

# Child Trafficking

28% of human trafficking victims are children.

Each year,  8 million children are reported missing.



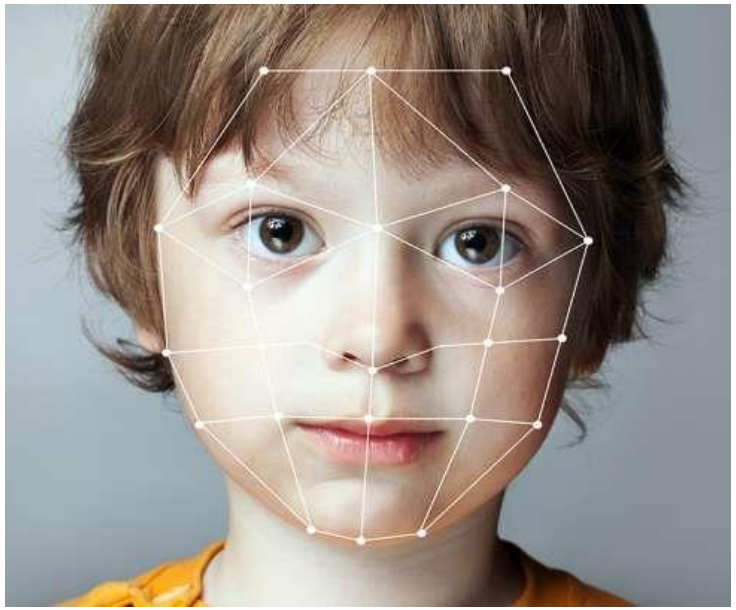
Expected to survive only 7 years.

* Statistics from UNICEF

# Which Biometric trait to use?

Iris

Fingerprints



Face

**Parents or relatives are more likely to have the missing child's face images opposed to iris or fingerprints.**

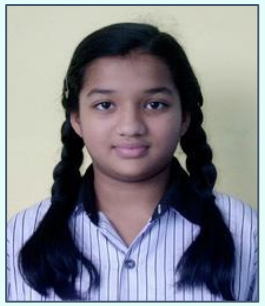
# Problem

## Gallery of Missing Children


7 years


4 years


6 years


10 years


12 years


10 years

. . . . . .

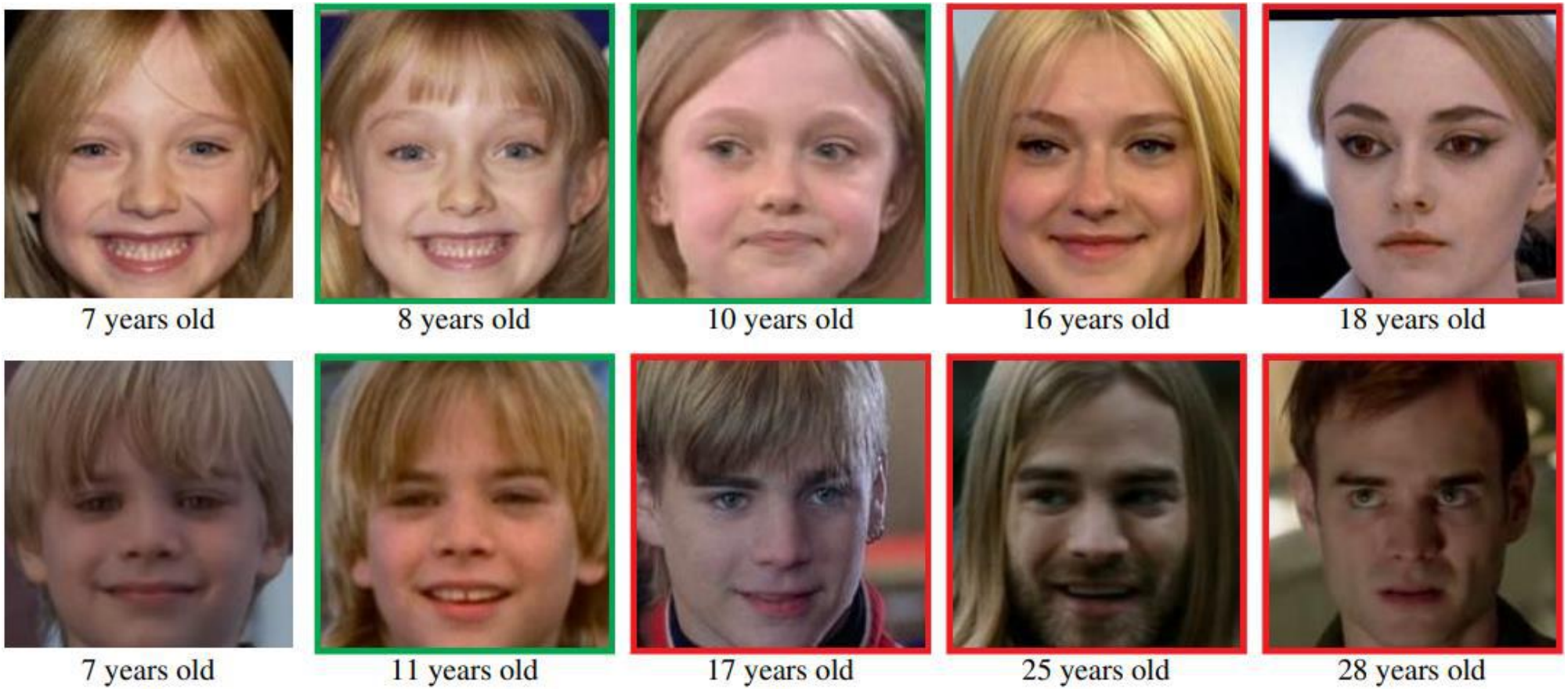

Probe
(17 years)


MATCH

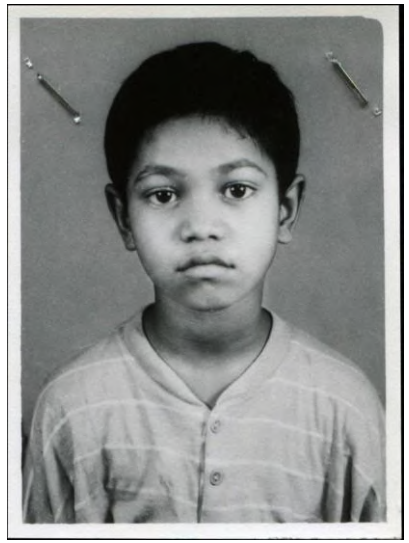

7 years

# Challenges

- **Large time lapse** between times child goes missing and found
- Available **FR systems do not perform well on this use case**



# High Profile Cases



5 years

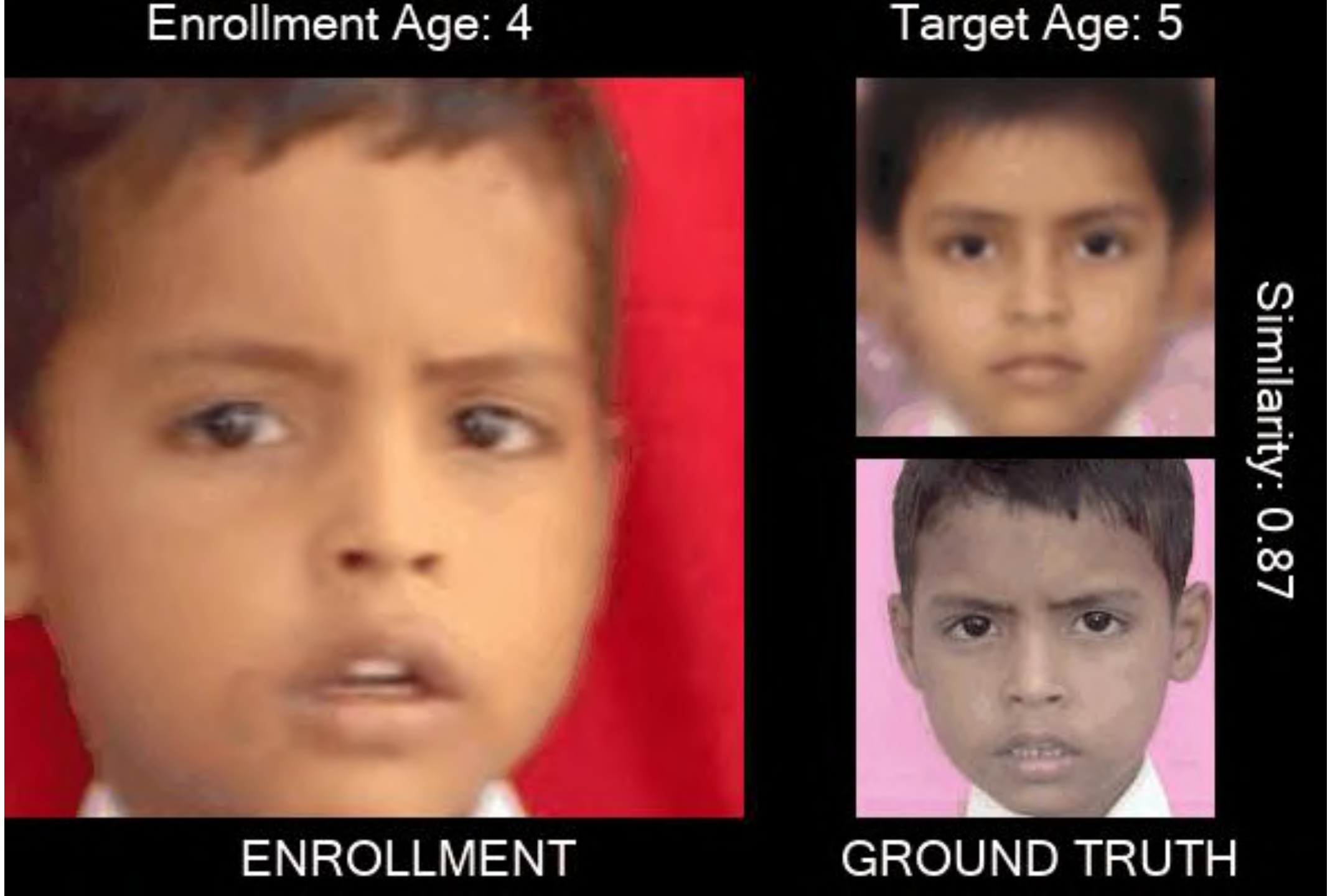
30 years

Saroo Brierley lost at the age of 5 (left) and later reunited with his family at the age of 30 (right).

11 years

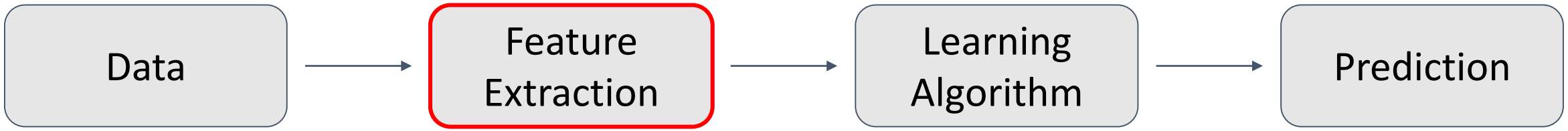
29 years

Jaycee Dugard abducted at the age of 11 (left) and later retrieved at the age of 29 (right).


Enrollment Age: 4
Target Age: 5
Similarity: 0.87
ENROLLMENT
GROUND TRUTH

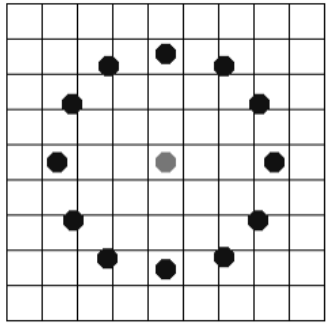
# Deep Learning vs. Traditional Methods

- Traditional Method

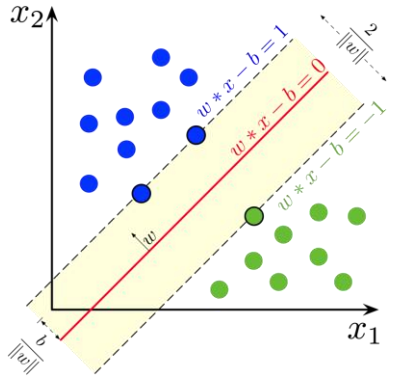



**bottleneck?**

- Example:



LBP features

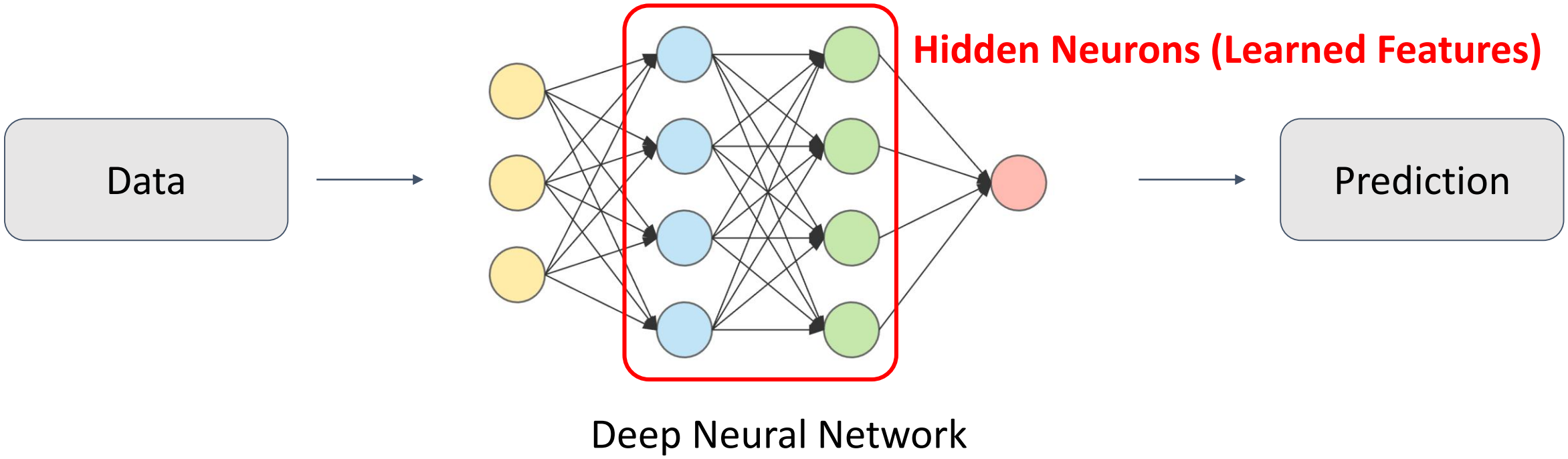



SVM

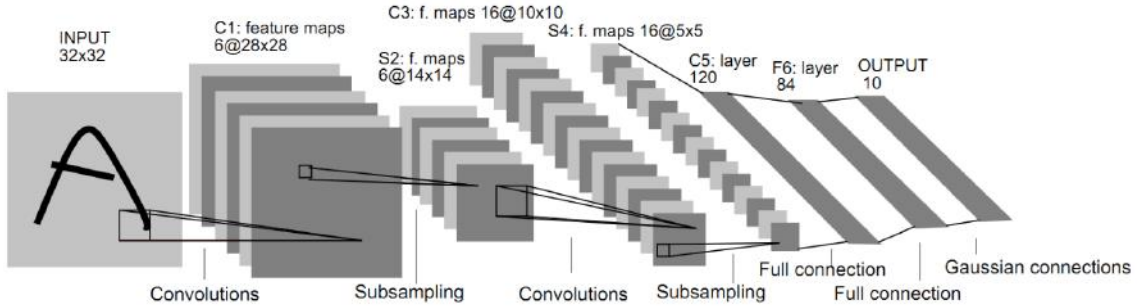
Abraham Lincoln

# Deep Learning vs. Traditional Methods

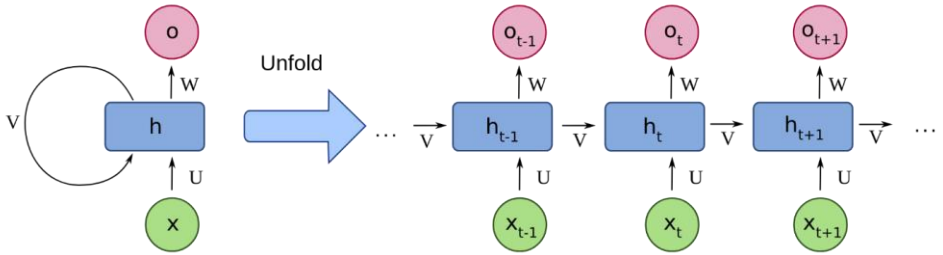
- Deep Learning: Learning the representations as part of the model
- Models are trained and tested end-to-end
- Deep Neural Network: "*mimicking human brains*" by stacking non-linear transformations



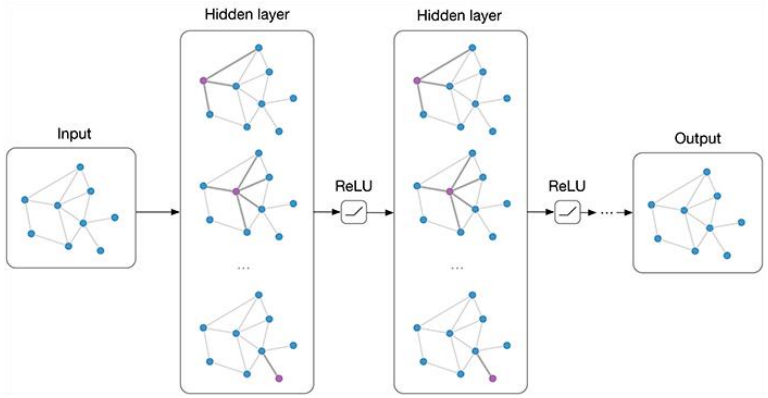
# Different Types of DNNs




**Images: Convolutional Neural Networks**




**Sequences: Recurrent Neural Networks**




**Graphs: Graph Neural Networks**

**Many Others...**

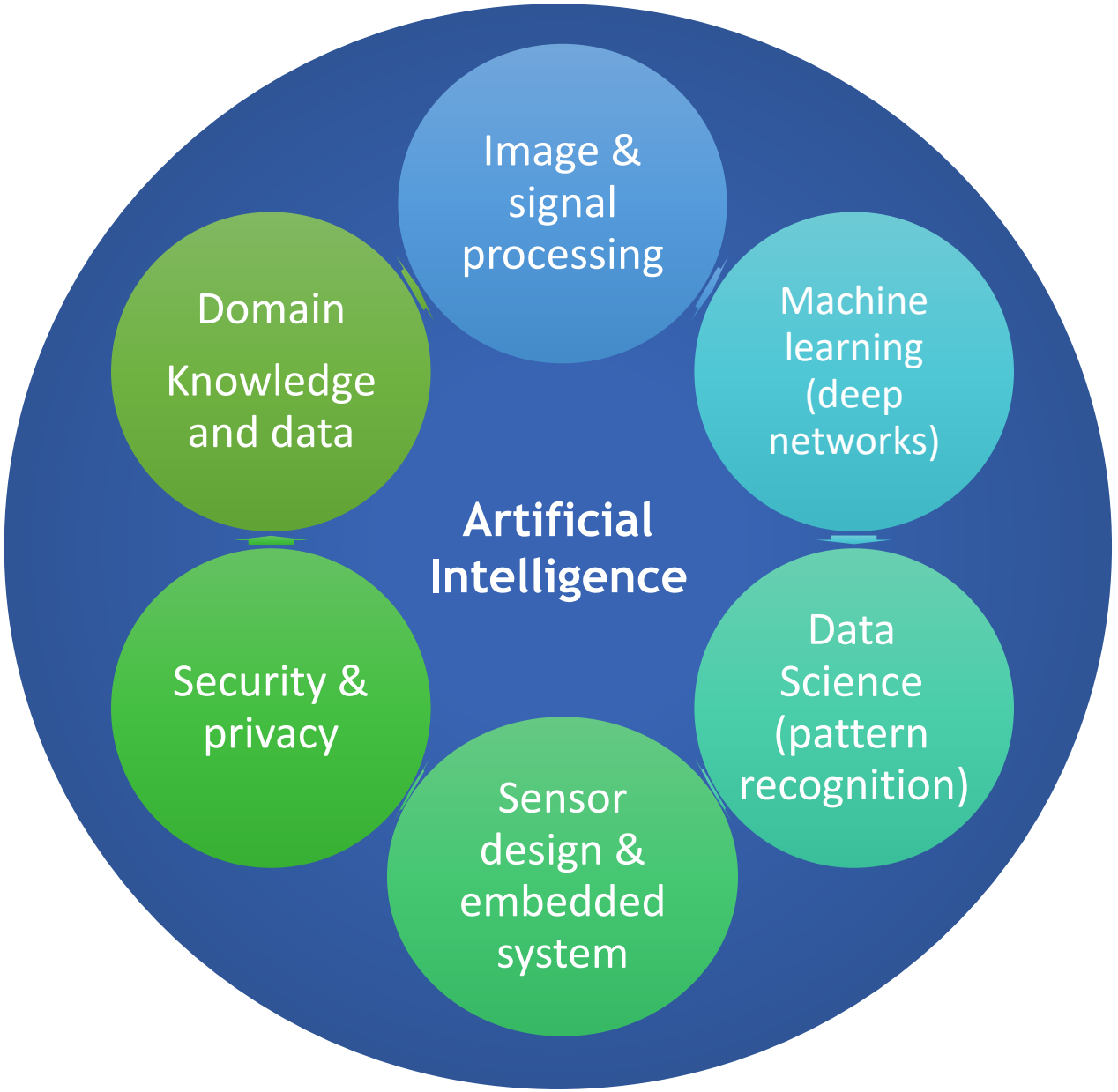
# Why Are Deep Networks Popular?

- Larger databases (e.g. ImageNet with >10M images):
  - DNNs are prone to overfitting but can be powerful with more data
- Better Computing Resources:
  - Development of GPUs allows faster parallel computing.
- Higher Performance
  - On many tasks (e.g. image classification), DNNs can provide near-human performance by utilizing large amounts of data

# Advantages and Limitations

- Advantages:
  - End-to-end model, no need to design features
  - Large Capacity
  - High Performance
- Limitations:
  - Memory/Space demanding
  - Computation intensive
  - Lack of interpretability

# Many Facets of Artificial Intelligence

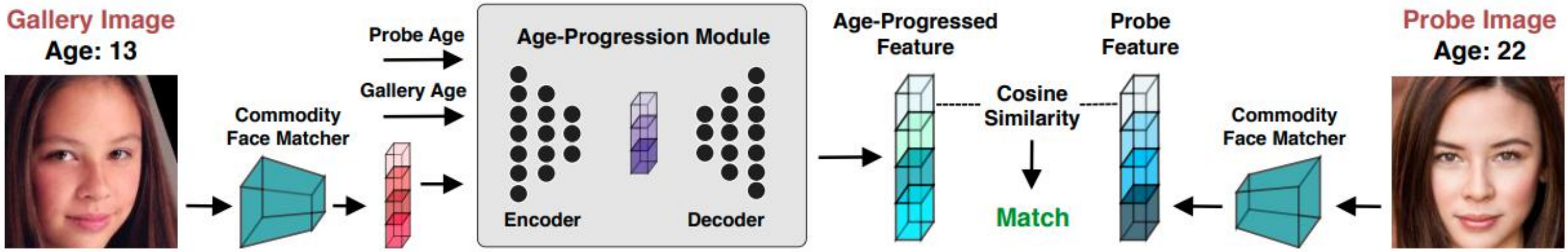


# How Should We Train Students in AI?

## AI Hype

What will be taught and by who?

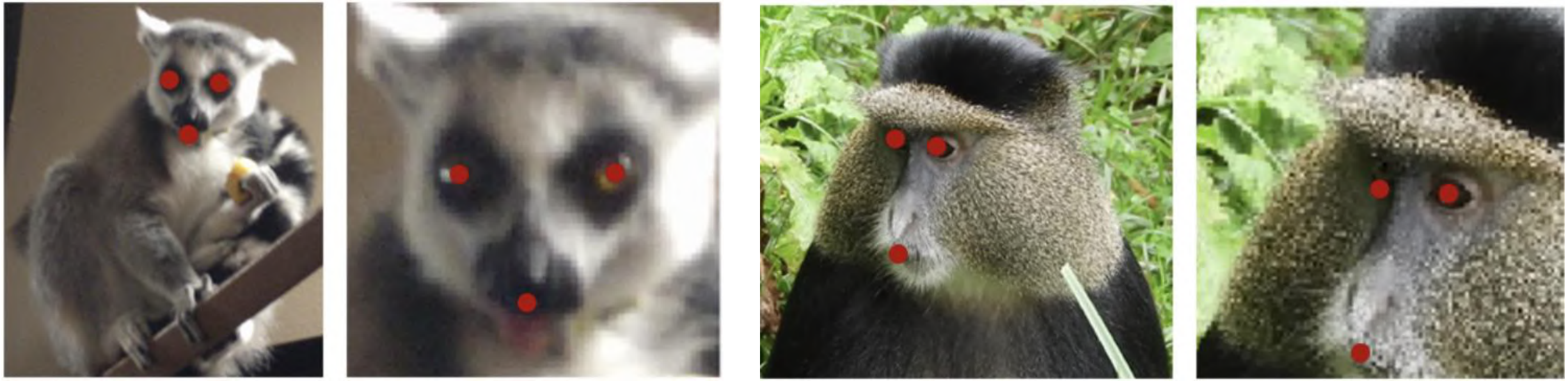
# Questions?




# Feature Age Progression Module

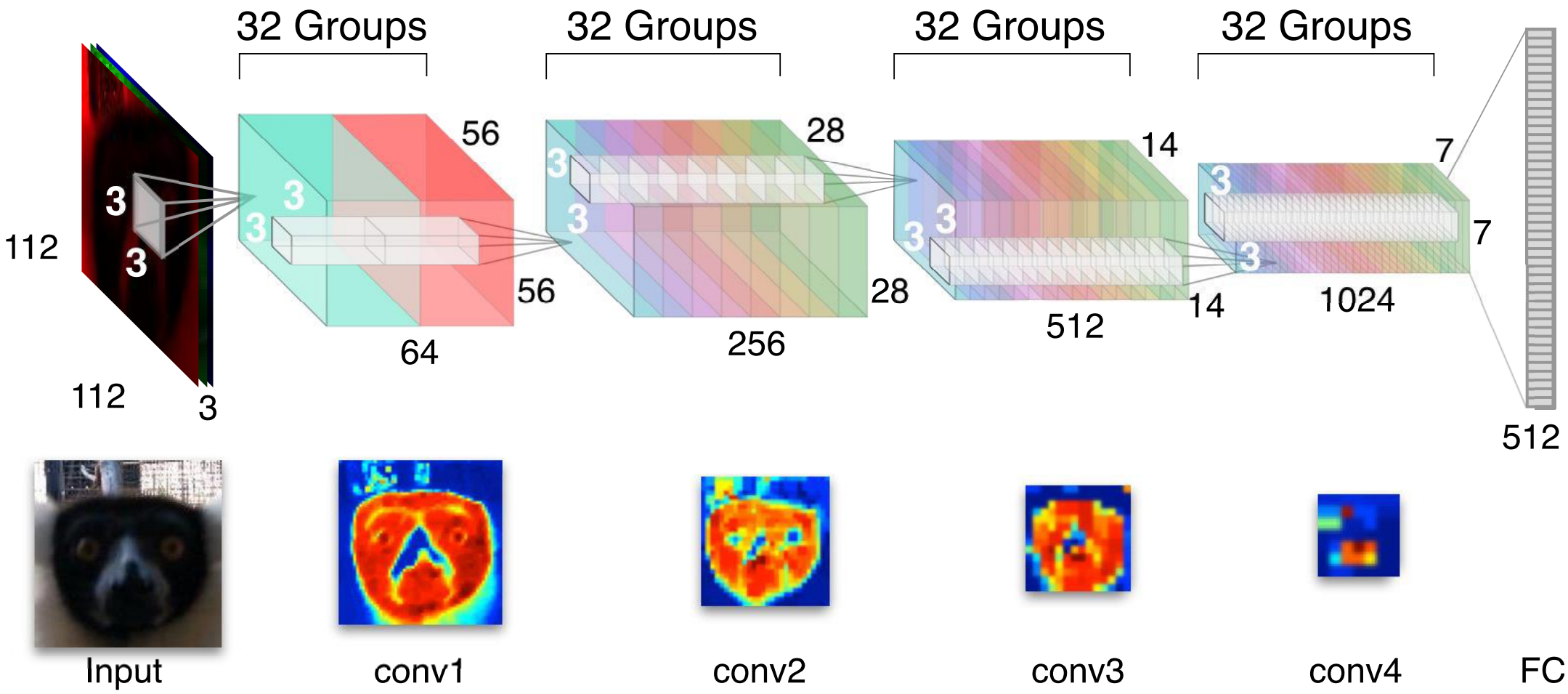
- Age progress the features for higher recognition rates over large time lapses
- The module is a **wrapper** and can be used around **any commodity face matcher**

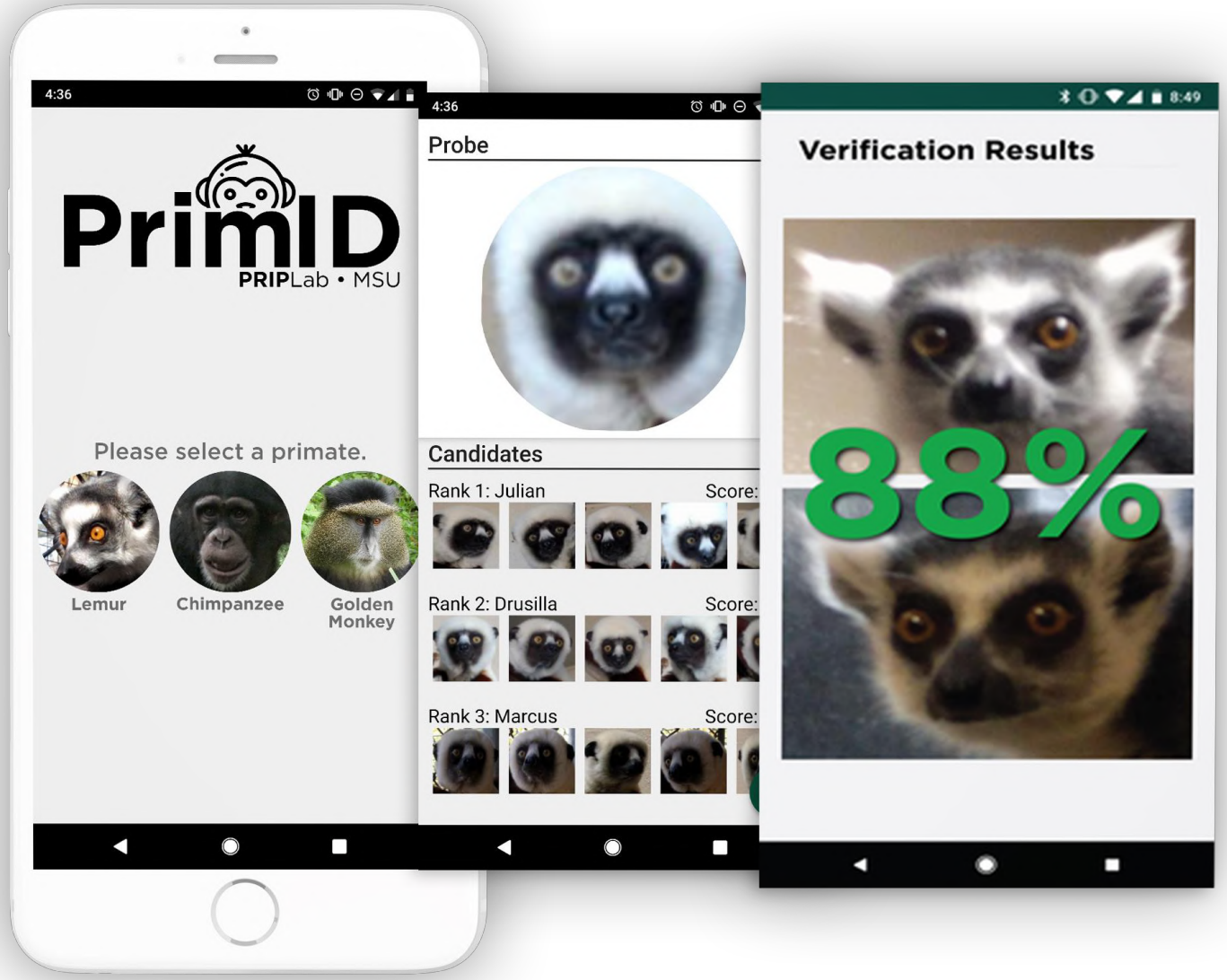
# Alignment



Similarity Transform using 3 manually annotated landmarks (Left Eye, Right Eye, Chin) to align the primate face images

# PrimNet Architecture



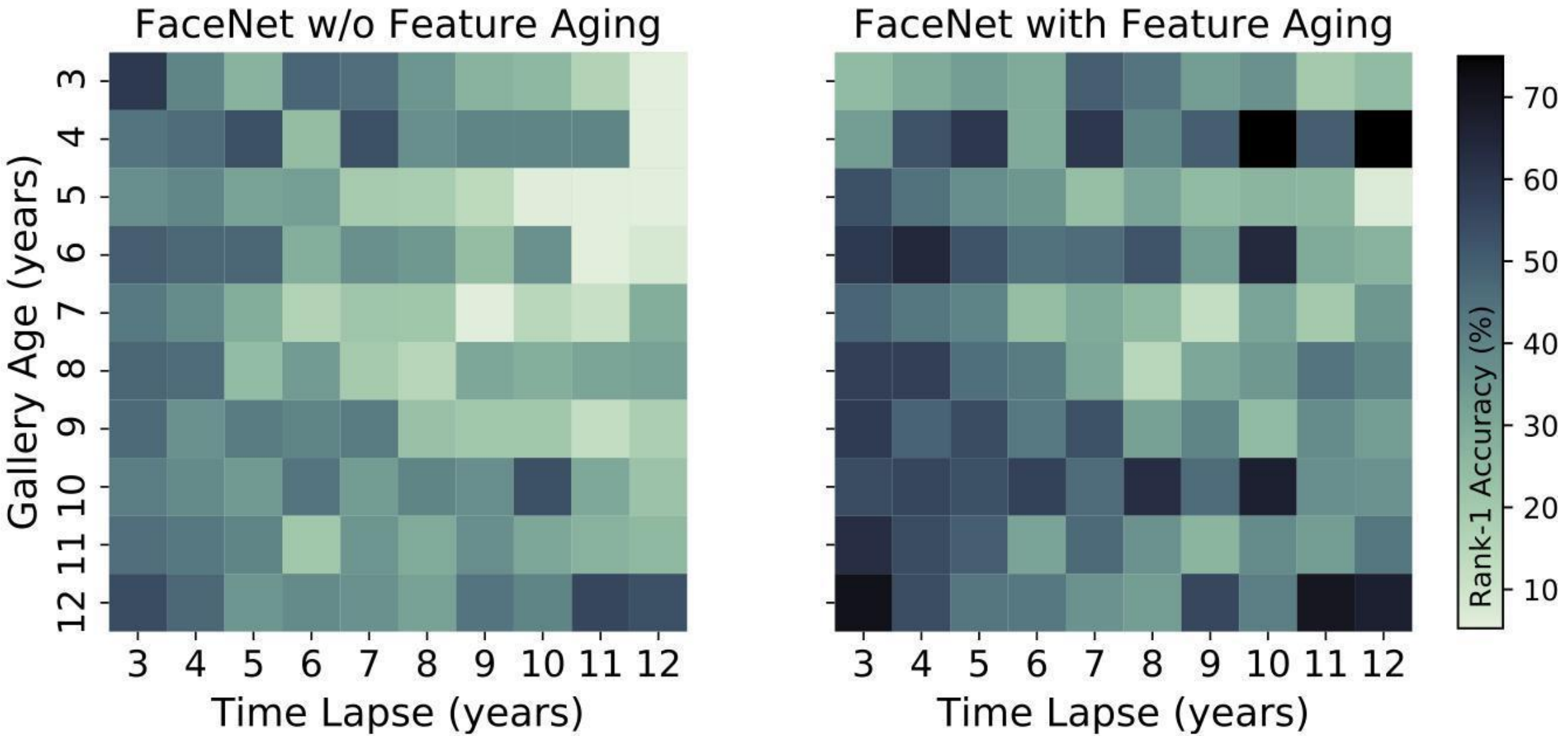



GET IT ON Google Play

# Advantage and Drawbacks

- Advantage:
  - End-to-end model, no need to design features.
  - Large Capacity
  - High Performance
- Disadvantage:
  - Memory/Space costly
  - Computation intensive
  - Less interpretability

# Improved Identification Rates over Time



# Richard Landers : A Case Study

- Richard Landers - abducted at age 5 in July 1994 in Indiana
- Investigators identified him at age 24 through a social security database search
- In a gallery of 12,873 children, proposed method can retrieve Richard at Rank-1

**Richard's image at age 24 (Probe)**

**Incorrect rank-1 retrieval by a state-of-the-art face matcher**

**True mate (Richard at age 5) retrieved at Rank-1 by CosFace with proposed feature aging module**

# Experimental Results

| | Lemurs | | | Golden Monkeys | | | Chimpanzees | | |
|---|---|---|---|---|---|---|---|---|---|
| **Method** | **Verification** | **Closed-set** | **Open-set** | **Verification** | **Closed-set** | **Open-set** | **Verification** | **Closed-set** | **Open-set** |
| | 1% FAR | Rank-1 | Rank-1 | 1% FAR | Rank-1 | Rank-1 | 1% FAR | Rank-1 | Rank-1 |
| Baseline [34] | 81.90 ± 3.69 | 90.82 ± 1.80 | N/A | 74.88 ± 6.75 | 89.33 ± 7.68 | N/A | 44.62 ± 4.38 | 70.16 ± 3.36 | N/A |
| SphereFace-20 [37] | 79.40 ± 5.82 | 92.45 ±1.67 | 80.83 ± 4.48 | 65.18 ± 12.28 | 87.32 ± 4.57 | 61.15 ± 12.80 | 48.62 ± 6.23 | 75.49 ± 3.80 | 30.75 ± 12.41 |
| SphereFace-4 [37] | 73.6 ± 5.81 | 90.18 ± 1.37 | 72.29 ± 9.49 | 72.53 ± 6.57 | 87.49 ± 3.77 | 69.43 ± 9.27 | 53.92 ± 2.57 | 74.19 ± 3.74 | 35.85 ± 8.22 |
| FaceNet [36] | 55.52 ± 7.88 | 87.06 ± 9.63 | 56.12 ± 1.93 | 50.12 ± 15.31 | 73.47 ± 8.81 | 49.69 ± 9.54 | 17.89 ± 7.93 | 59.75 ± 8.64 | 4.86 ± 3.38 |
| PrimNet | **83.11 ± 5.31** | **93.76 ± 0.90** | **81.73 ± 2.36** | **78.72 ± 5.80** | **90.36 ± 0.92** | **66.11 ± 7.99** | **59.87 ± 3.34** | **75.82 ± 1.25** | **37.08 ± 11.22** |

| **Method** | **Inference Speed (ms / img)** | **Model Size (MB)** |
|---|---|---|
| SphereFace-20 [37] | 17.26 | 87 |
| SphereFace-4 [37] | **13.05** | 48 |
| FaceNet [36] | 40.42 | 90 |
| **PrimNet** | 23.58 | **3.9** |

# Datasets

## Lemurs


**3,000** Images
**129** Subjects

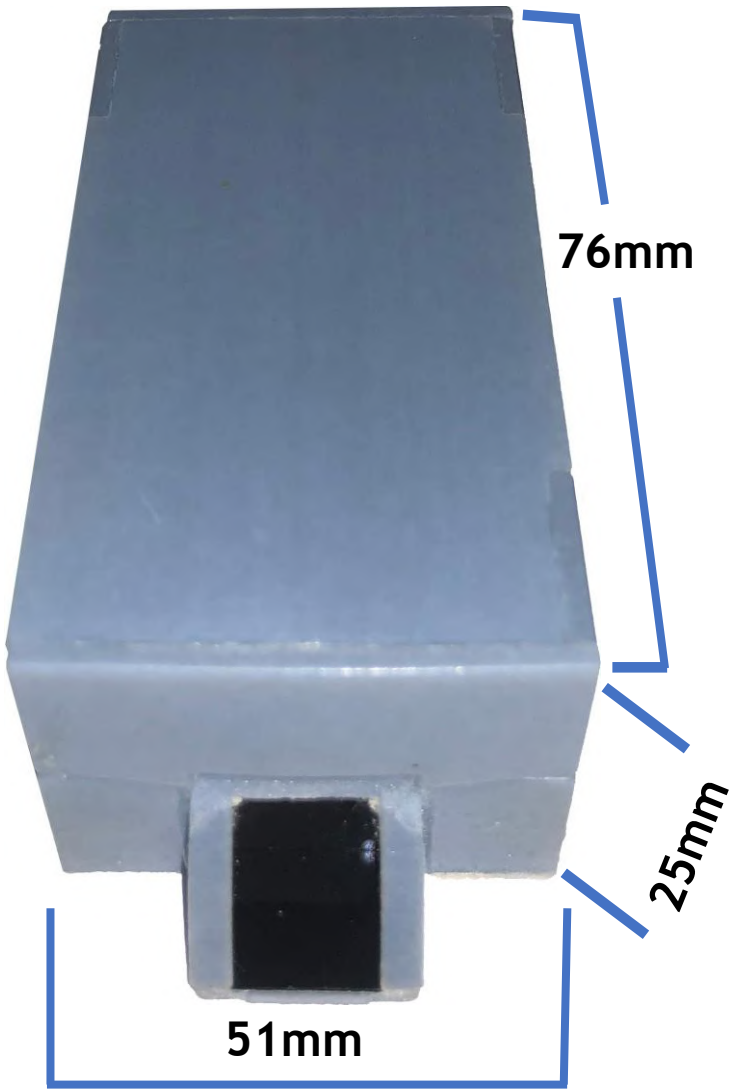
## Golden Monkeys

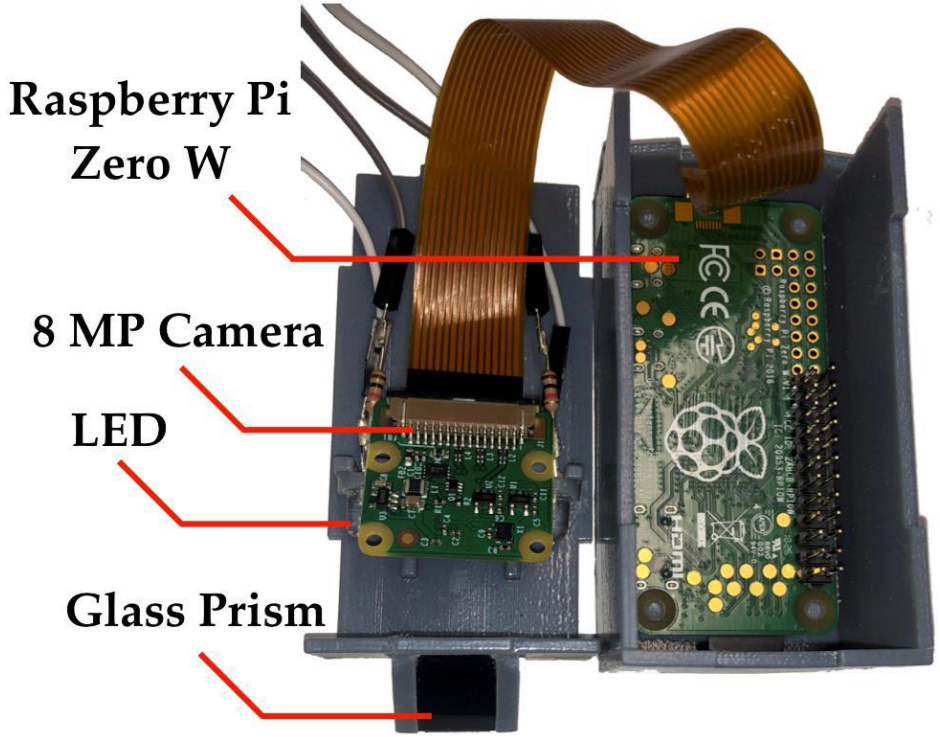
**1,450** Images
**49** Subjects

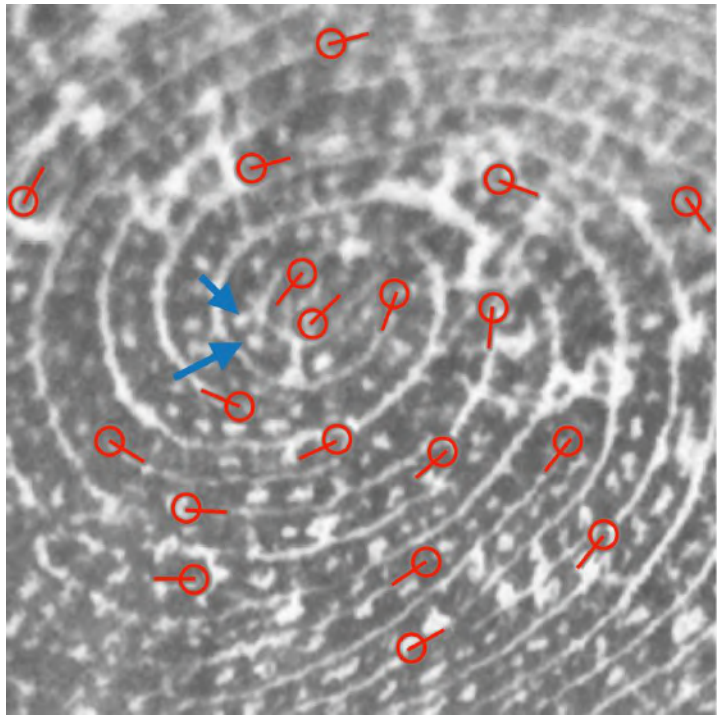
## Chimpanzees

**5,559** Images
**90** Subjects

# MSU Infant-Prints Reader



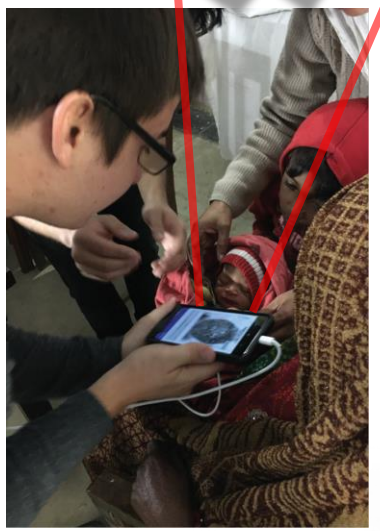



**Reader:** 1,900 ppi; cost: $85; assembly time: <2hours

**Open source:** *https://bit.do/RaspiReader*

*Engelsma, Cao and Jain, "RaspiReader: An Open Source Fingerprint Reader", in IEEE Trans. PAMI, 2018*

# MSU Infant-Prints In Action

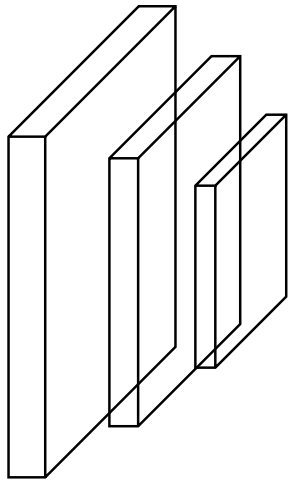


Fingerprint Capture


Infant-Prints App

1,900 ppi Image

Enhanced Image



Fingerprint Matcher

Verify

Search

# Summary

- Fingerprints ensure reliable authentication of infants
- Presented a low-cost, ergonomic, high-resolution solution for life-long identification
  - MSU Infant-Print Reader: 1900 ppi, compact (25 mm x 50 mm x 75 mm), low-cost (US $85), open-source system for recognizing persons of *ALL* ages, including infants
- Technology to empower solutions to humanitarian issues: provide healthcare and nutrition to infants

# 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