

# Child Fingerprint Recognition



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## Motivation and objective for the study on children fingerprints

- **A reasonable minimum age** for automated fingerprint recognition of children was discussed by European legislators around 2008 in the context of biometric passports and the Visa Information System
- JRC has been tasked to conduct a study on the **feasibility** of fingerprint recognition of children **under the age of 12**

## Research Issues

### 1. Growth:

Children grow and so do their fingers

→ *Can older fingerprints still be recognised?*

### 2. Structure size:

Children have smaller fingerprints

→ *Is typical image resolution sufficient?*



## Previous Studies

- **TNO** study on proper enrolment for e-passports, including children: 145 children, fingerprints obtained within short time frame (2004)
- **NJI / Ultra-Scan** study on children fingerprints: 300 children, fingerprints with 2-3 years distance (2006-2009)
- **BKA / Univ. Göttingen** study: 48 reoffending juveniles, fingerprints obtained at various ages, starting at ~12 years (2010)

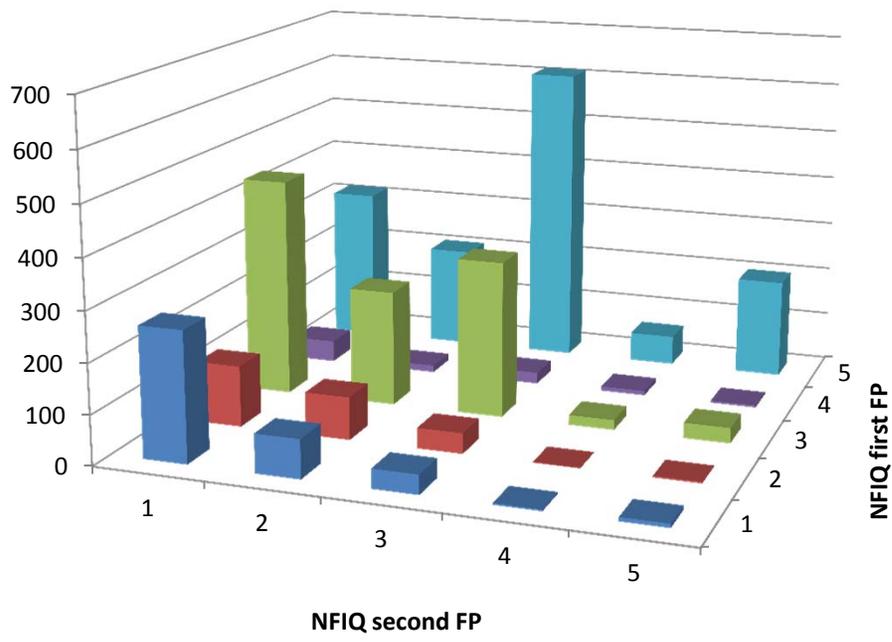
## The JRC Study

- Based on **anonymised children fingerprints**, acquired during issuance and renewal of **passports**
  - provided by **courtesy of the Portuguese government**
  - under application of the highest standards of **security and data protection**
- **Characteristics:**
  - Some **1600 children**, scanned twice within 2 – 4.5 years (using 500-dpi single fingerprint scanners)
  - left and right index finger
  - age coverage: **0-11 years**



# Used Data

	Age Group											
	2	3	4	5	6	7	8	9	10	11		
24	0	6	34	38	0	2	0	0	8	4	92	
25	2	17	36	40	6	0	8	4	8	8	129	
26	2	16	22	38	5	6	2	0	2	2	95	
27	4	15	26	32	9	1	1	2	3	0	93	
28	6	19	29	32	12	4	2	4	4	6	118	
29	11	18	22	30	13	0	0	0	2	4	100	
30	2	19	28	23	12	2	2	6	4	5	103	
31	2	16	20	25	20	6	0	6	4	1	100	
32	3	24	24	23	34	7	7	1	0	4	127	
33	0	24	19	23	28	0	12	0	2	4	112	
34	0	19	21	24	32	0	2	0	6	0	104	
35	0	18	9	25	35	4	0	2	5	8	106	
36	0	9	19	19	46	2	0	3	4	6	108	
37	0	6	22	20	35	12	2	8	4	2	111	
38	0	9	18	27	21	9	1	8	0	2	95	
39	0	6	25	24	26	12	0	2	0	2	97	
40	0	5	31	20	18	11	2	2	0	0	89	
41	0	6	16	26	17	11	1	4	2	0	83	
42	0	3	18	13	20	13	2	2	2	0	73	
43	0	1	22	28	11	22	6	0	4	2	96	
44	0	0	23	16	27	15	2	2	2	4	91	
45	0	0	19	30	9	21	2	5	4	8	98	
46	0	0	12	28	8	21	2	2	4	0	77	
47	0	0	20	24	19	12	5	2	6	2	90	
48	0	0	15	26	20	18	6	8	4	6	103	
49	0	0	5	15	12	8	7	2	6	7	62	
50	0	0	4	5	9	1	4	4	2	6	35	
51	0	0	1	9	5	3	2	0	0	0	20	
52	0	0	0	0	0	1	0	0	0	2	3	
53	0	0	0	0	0	0	0	0	0	0	0	
54	0	0	0	2	0	0	0	0	0	0	2	
	32	256	560	685	509	224	80	79	92	95	2612	



## Summary of technical findings

- Fingerprints of kids **can be recognised** at up to 4.5 years distance.
- **Smaller size** of children fingerprints does not theoretically conflict with typical image resolution (500 dpi)
- Ultimate criteria: **Quality** of fingerprints **is decisive** and increases with age.

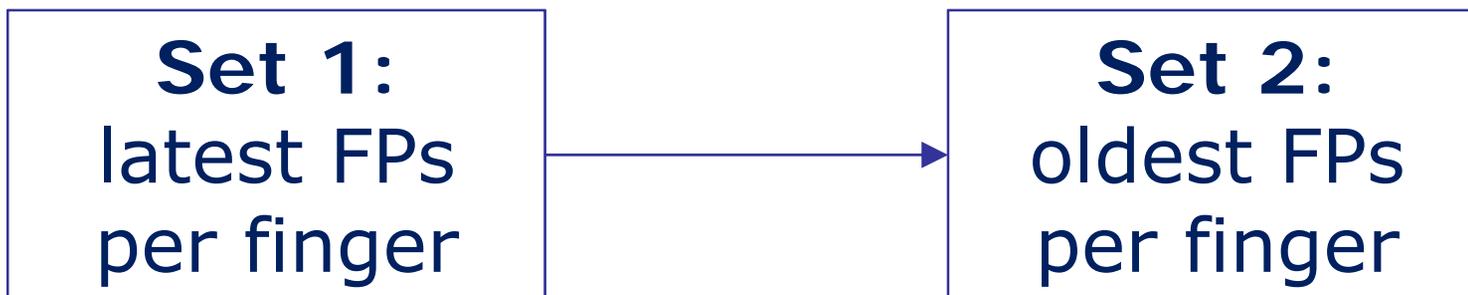
## *First finding:*

# Growth surprisingly not an issue

- All tested algorithms show the **same recognition rate regardless of the time** between the fingerprints (up to 4.5 years)
- Explanation: ability of the algorithms to deal with (limited) distortions.

*Tested algorithms: NIST + 2 commercial systems*

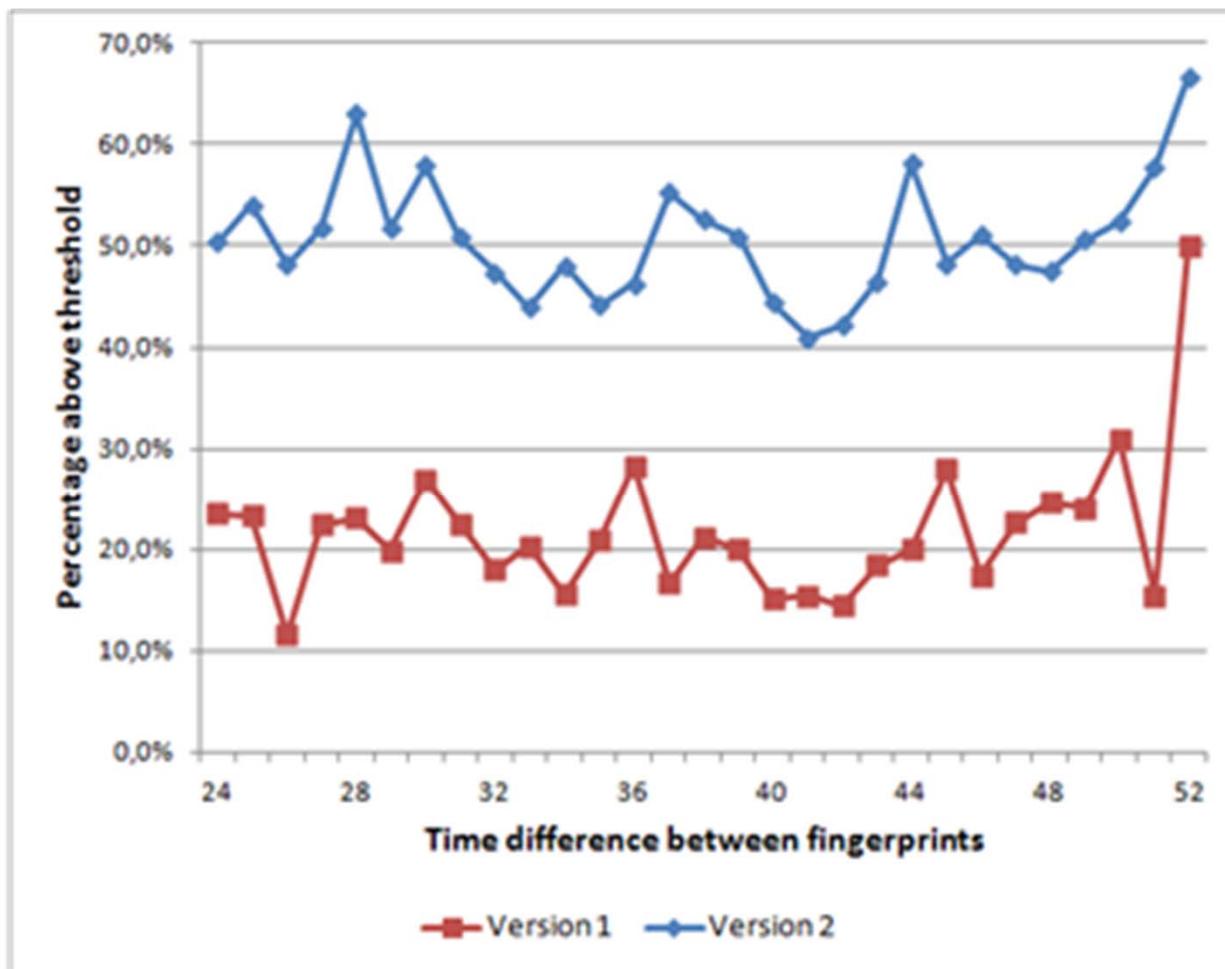
## Matching scenario:

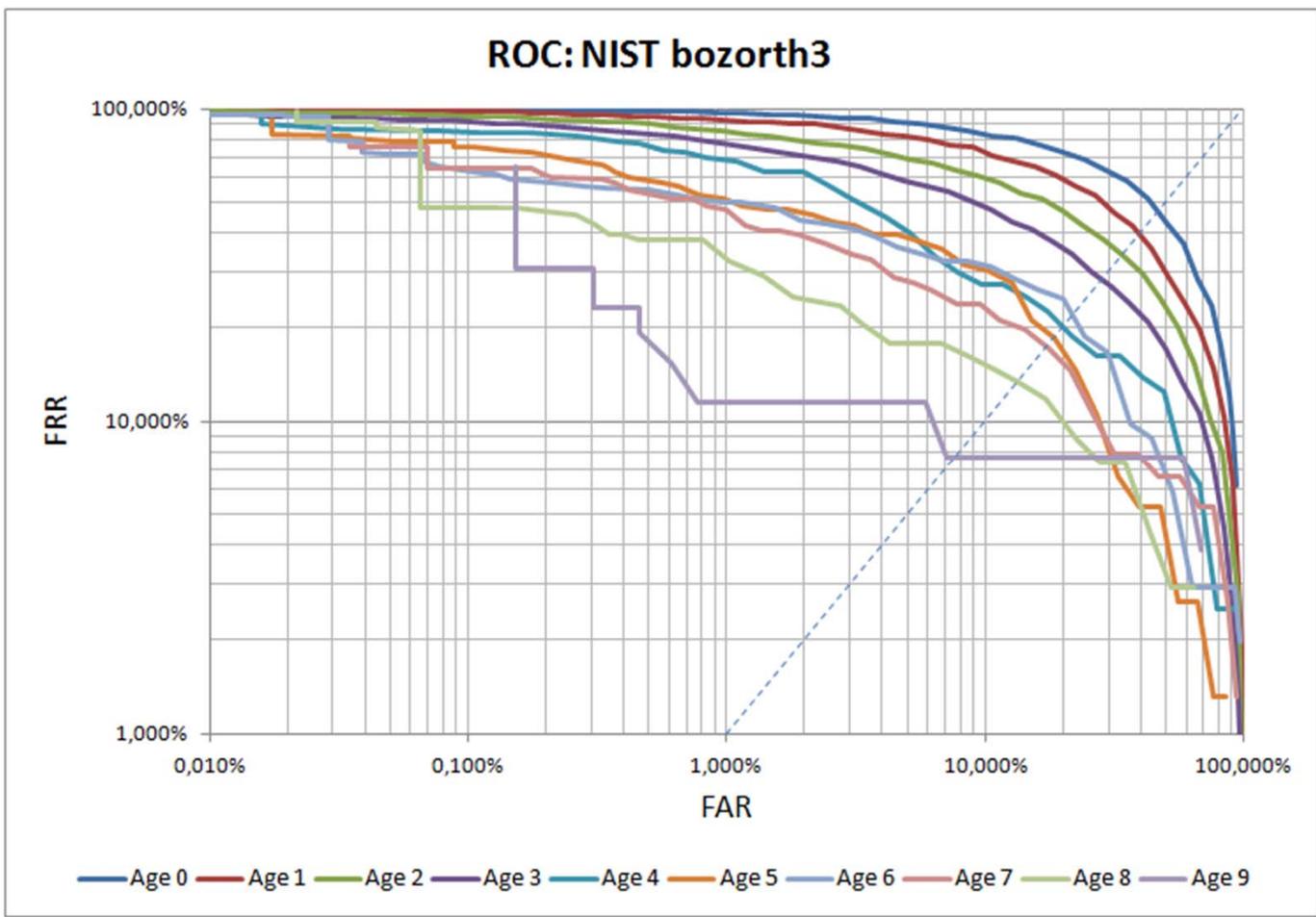


Matching after ground-truthing

(reduction from 3264 to 2611 FP pairs)

## Recognition rate of two matchers (@FAR=0,1%)



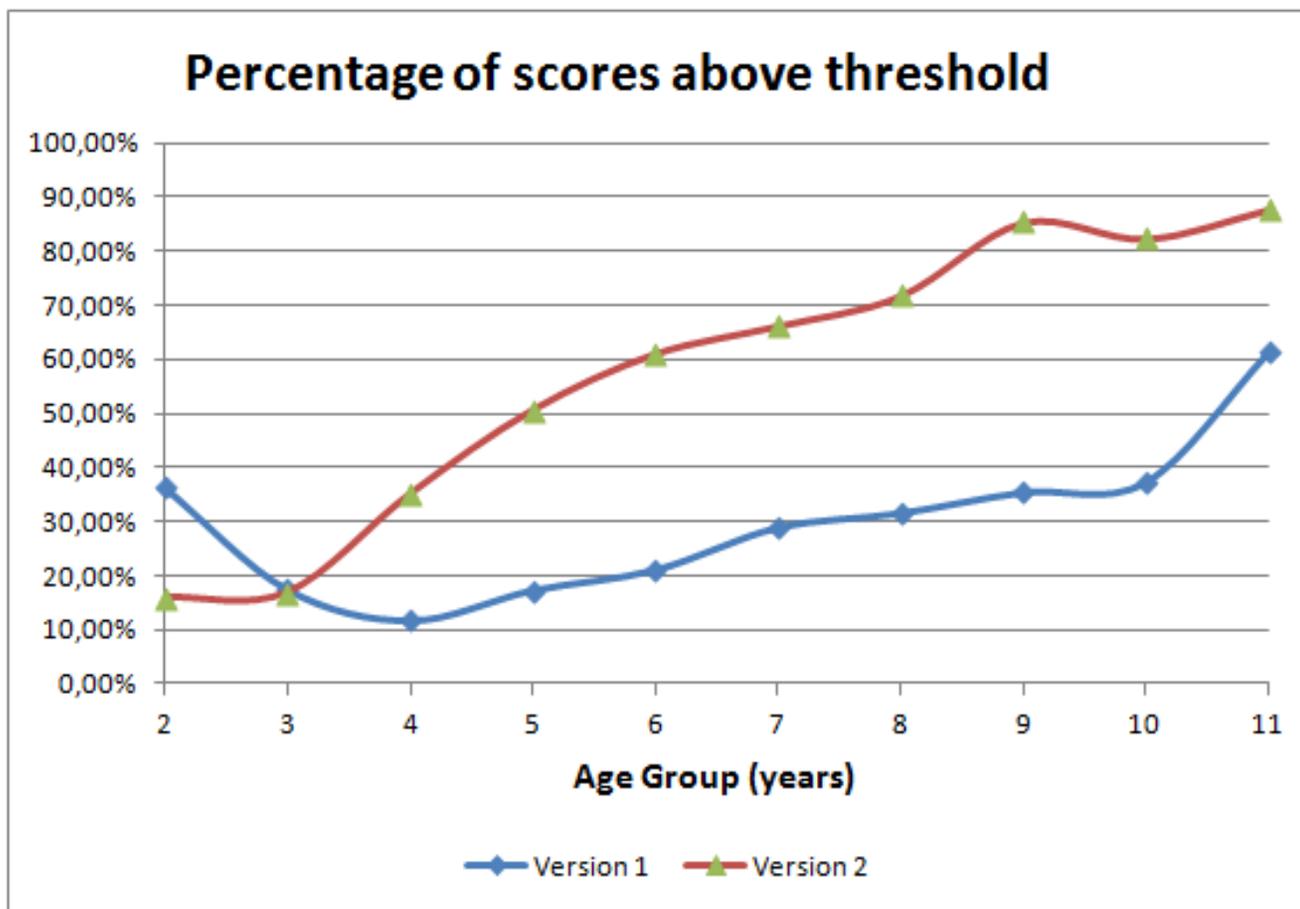


Age group according to oldest (i.e. first) fingerprint of a pair

## *Second finding:*

# Size only matters in relation to quality!

- Even **smaller fingerprints could be recognized** by the given image resolution (500 dpi).
- However, **size conflicts with quality reducing factors!**



Comparison of “genuine” scores above threshold of two versions of commercial matching algorithm (FAR@0.1%)

## *Third finding:*

### Quality comes with age!

- Condition of fingers influence quality (dryness, humidity, dirt and other substances) – for children and adults!



**"good"**



**"bad"**



**"bad"**

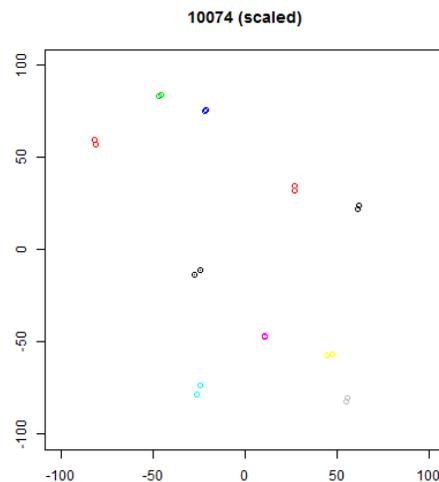
- Children fingerprints: Smaller dimension + bad quality = reduction of recognisability

## Further technical findings:

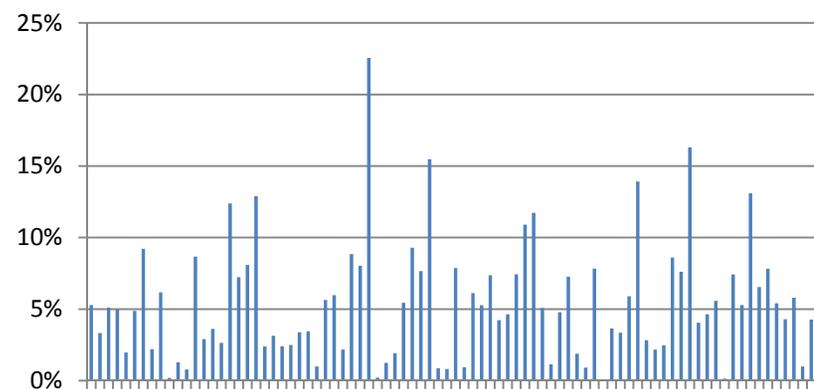
- NFIQ lacks adoption to children case (because most used matchers for training do the same)
- Isotropic growth model seems good enough to serve for cases up to  $\sim 5$  years of time difference
- Alternative scanner types should be considered for children

## Isotropic growth model:

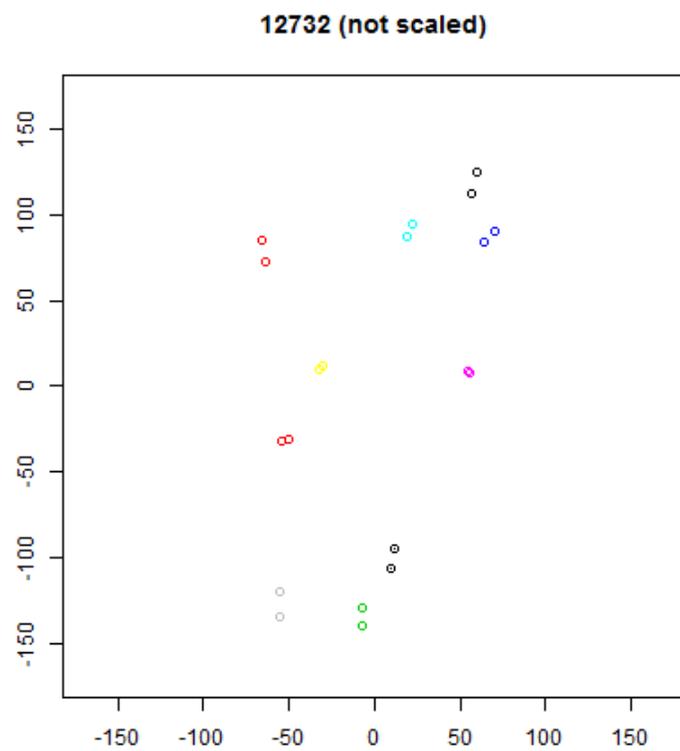
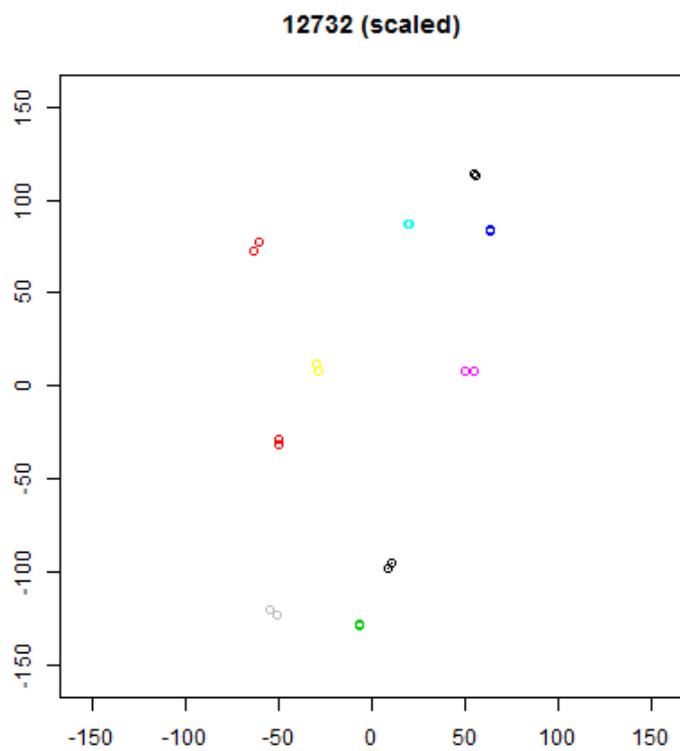
- Predicted by a previous study of BKA /Univ. of Göttingen
- Best alignment of landmarks shows good confirmation of prediction ( $\sim 5\text{-}10\%$  error)



Example

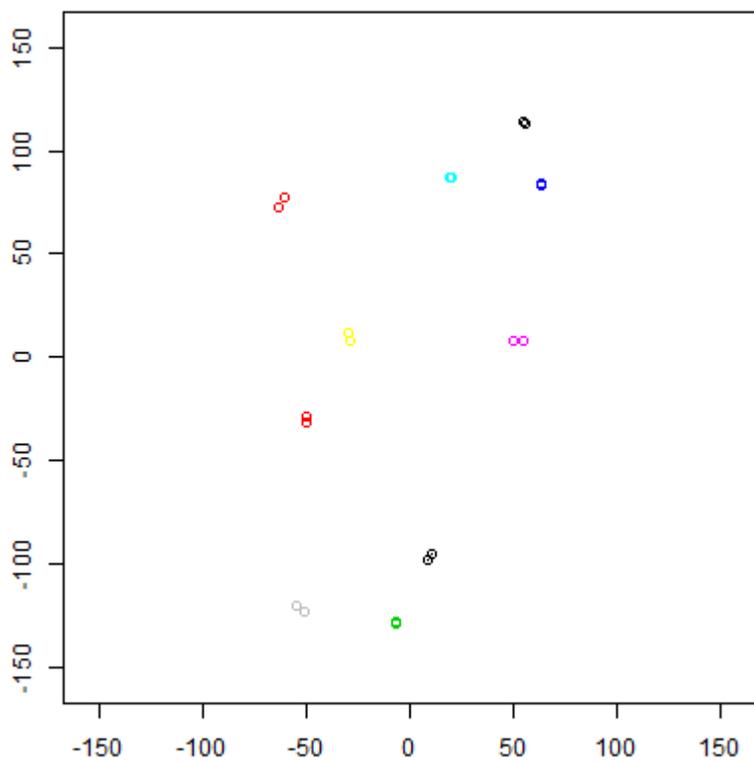


Deviation of 54 hand-coded cases:  
Predicted vs observed best scaling factor

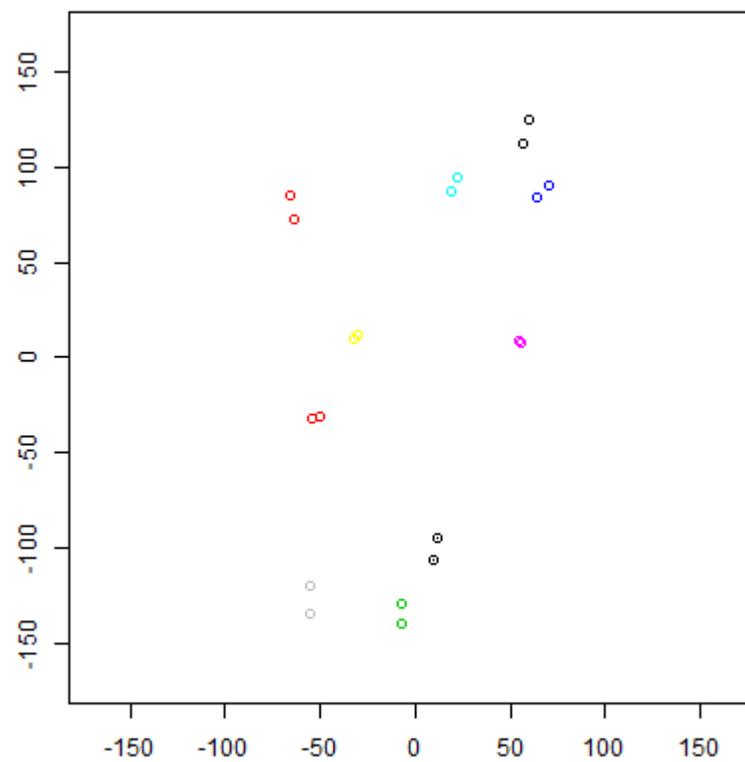


Example: closest shape alignment for 50 months time distance

12732 (scaled)

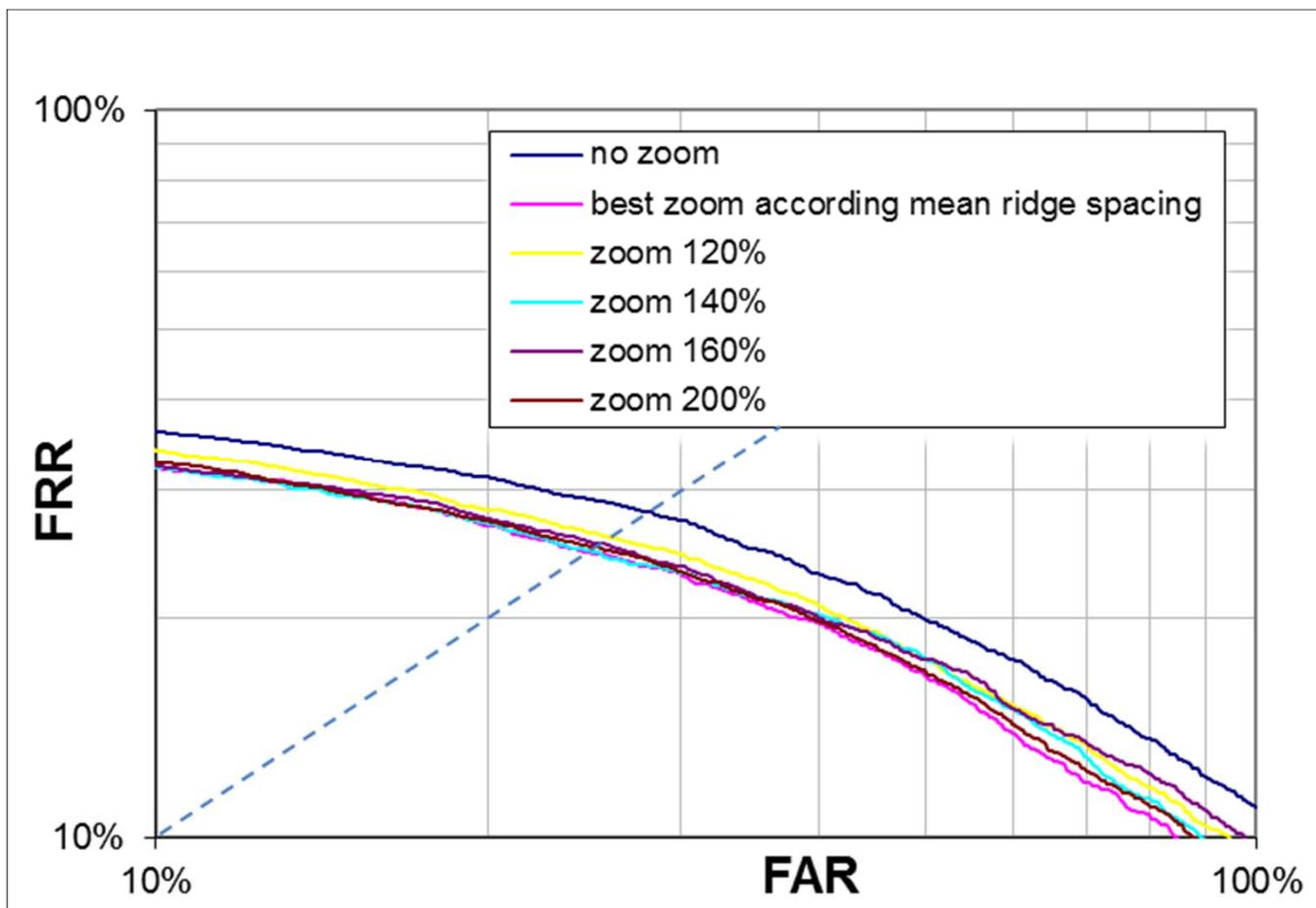


12732 (not scaled)



Example: 50 months time distance

## Performance under various scalings



## Alternative fingerprint acquisition devices ?



Multispectral  
scanner



Touchless  
scanner



CrossMatch's  
new "Guardian"

	<b>Traditional (Dermalog/TBS 2D/ Cross Match)</b>	<b>Multispectral (Lumidigm)*</b>	<b>Touchless (TBS)</b>
<b>Best</b>	Strong recognition at NFIQ 1	Weak recognition though NFIQ was 1-2.	Strong recognition at NFIQ 1-3
<b>Humid</b>	Weak recognition with NFIQ at 4-5.	Weak recognition though NFIQ was 1-2.	Weak to strong recognition rate at NFIQ 3-4.
<b>Sugar</b>	Recognition mostly weak at NFIQ 3-5.	Weak recognition though NFIQ was 1-2.	Strong recognition at NFIQ 1-3
<b>Dirt</b>	Weak to strong recognition at NFIQ 4-5	Weak recognition rate low at NFIQ of mostly 1.	Strong recognition at NFIQ 1-2

Qualitative results (6 test persons only, adults)

Match against best Dermalog FP

\* Lumidigm gets strong recognition against Lumidigm

## Full Report available at:

[http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/29732/1/fingerprint%20recognition%20for%20children%20final%20report%20\(pdf\).pdf](http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/29732/1/fingerprint%20recognition%20for%20children%20final%20report%20(pdf).pdf)

## Further investigations:

- Calibration of results against data from adults
- Complete age group coverage: 0 -25 years
- Further cooperation with vendors of fingerprint recognition systems
- Verification of recommendations in larger field trials



**Thank you !**

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