Child Fingerprint Recognition

Dr. Günter Schumacher

European Commission
Joint Research Centre

Institute for the Protection and Security of the Citizen

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)

Joint Research Centre

The JRC Study

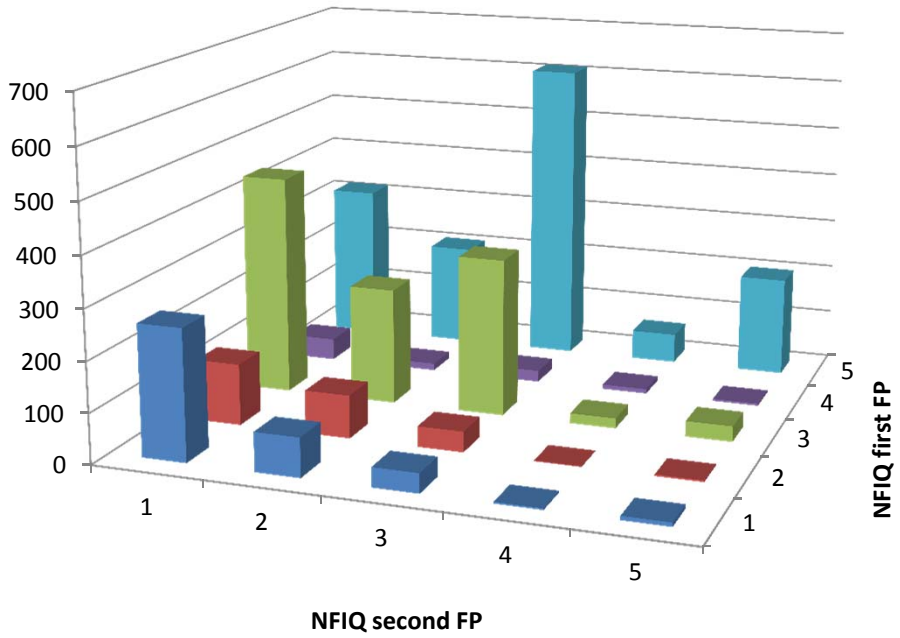
- Based on **anonymised children fingerprints**, acquired during issuance and renewal of **passports**
  - provided by **courtesy of the Portuguese government**
  - under application of the highest standards of **security and data protection**

- **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**

Joint Research Centre

Used Data

Age Difference (months)	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.

Joint Research Centre

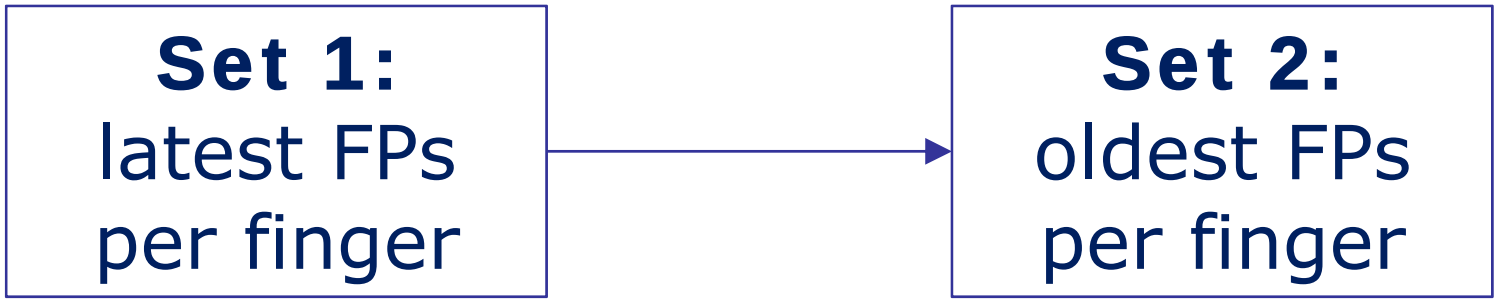
First finding:

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:

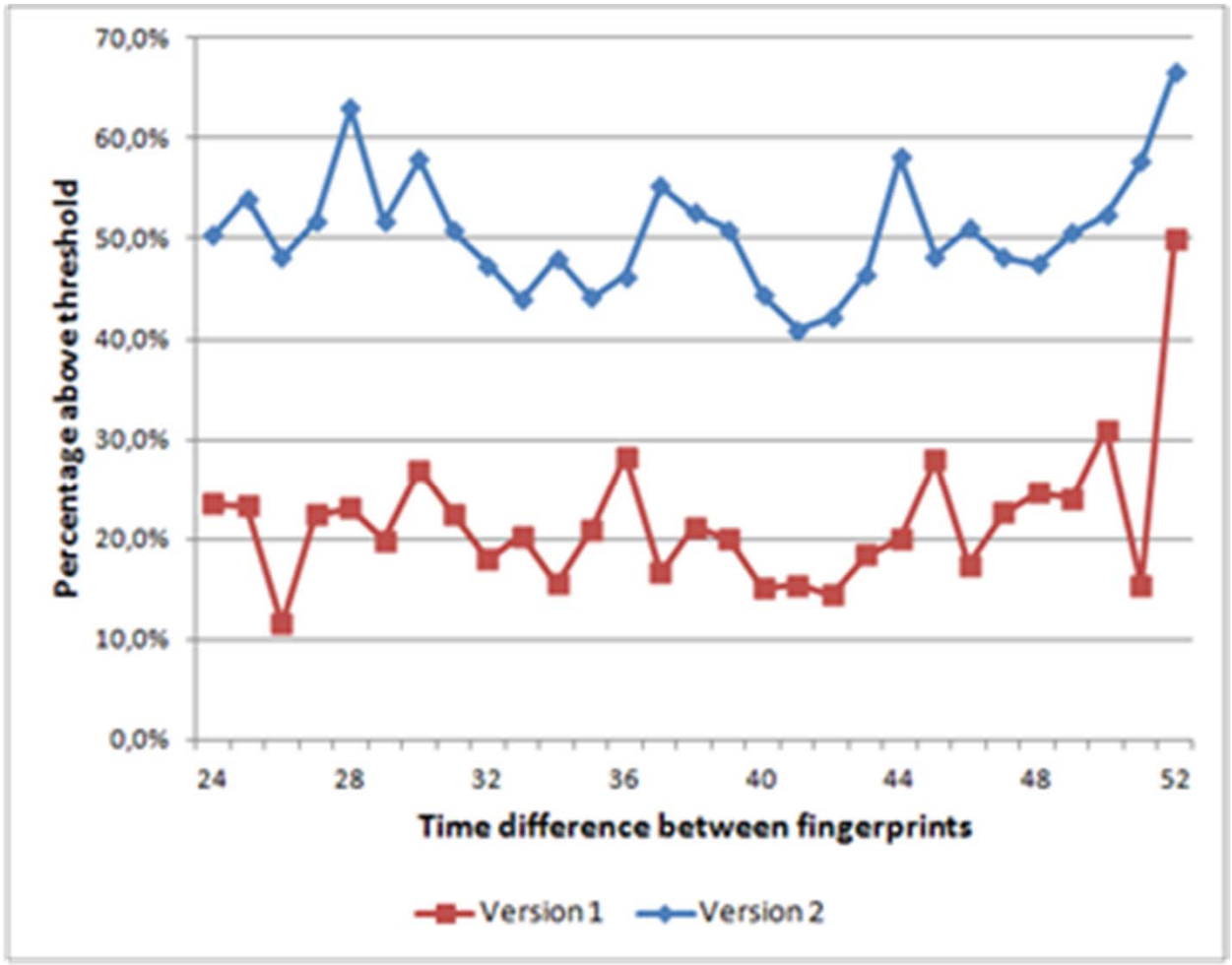


Matching after ground-truthing

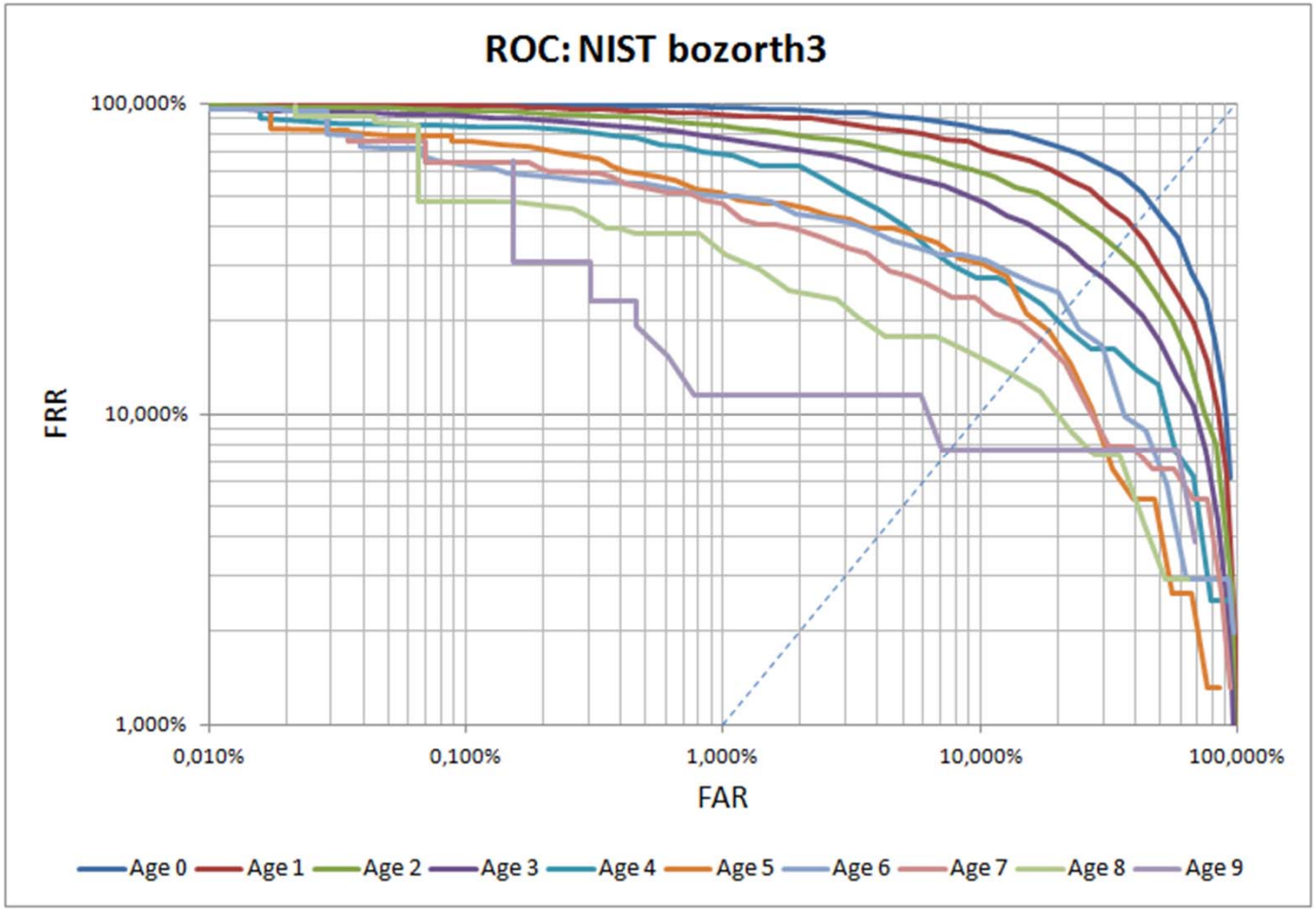
(reduction from 3264 to 2611 FP pairs)

European Commission

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



Joint Research Centre



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

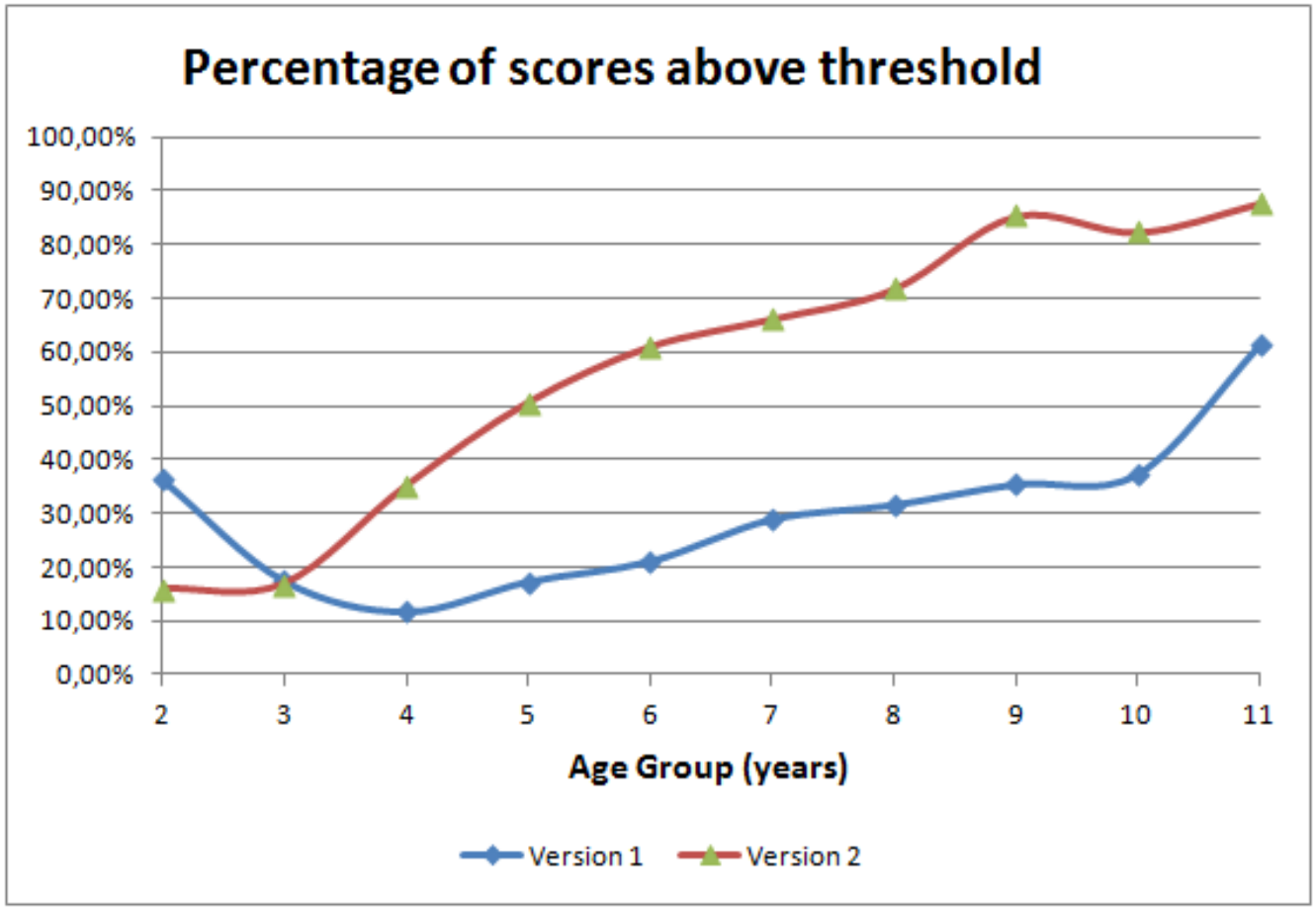
Second finding:

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**!

Joint Research Centre



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

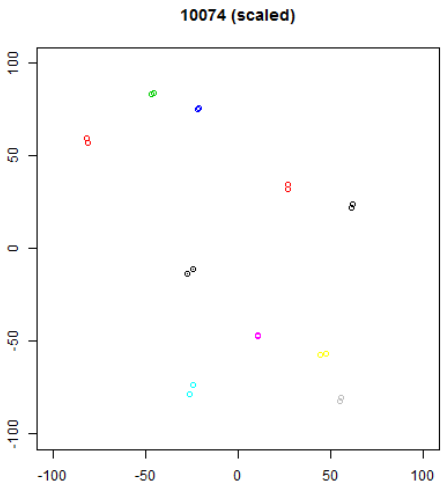
Joint Research Centre

Further technical findings:

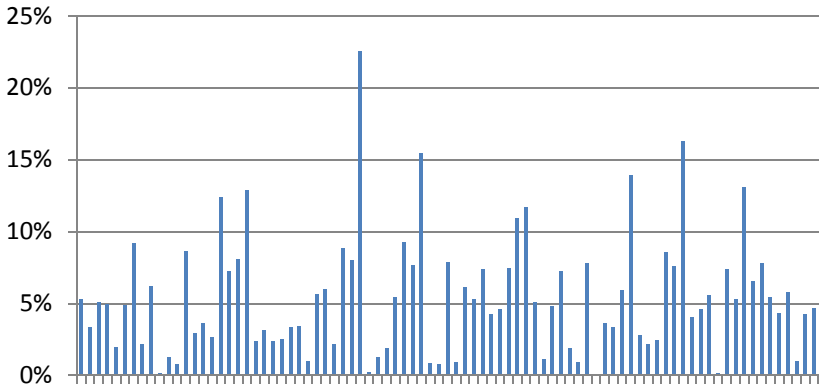
- NFIQ lacks adoption to children case (because most used matchers for training do the same)
- Isotropic growth model seems good enough to serve for cases up to ~5 years of time difference
- Alternative scanner types should be considered for children

Isotropic growth model:

- Predicted by a previous study of BKA /Univ. of Göttingen
- Best alignment of landmarks shows good confirmation of prediction (~5-10% error)

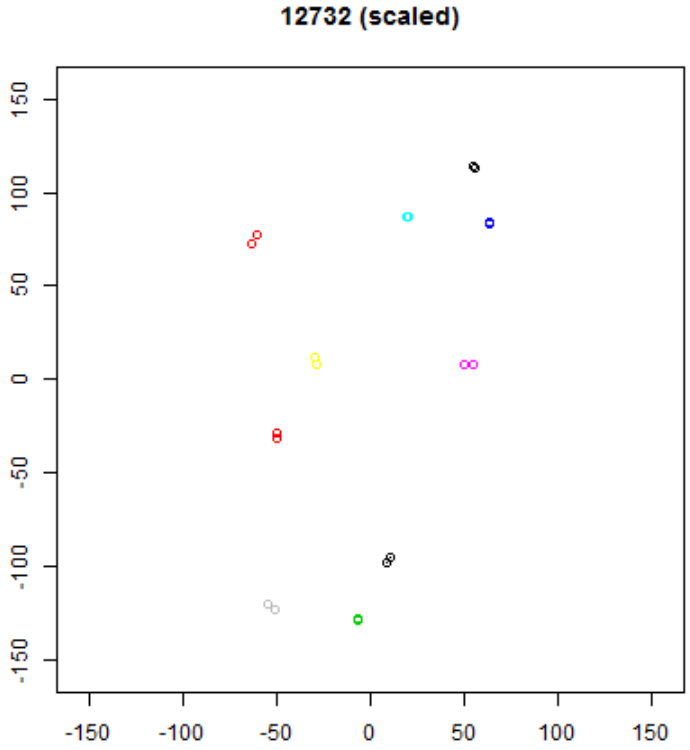


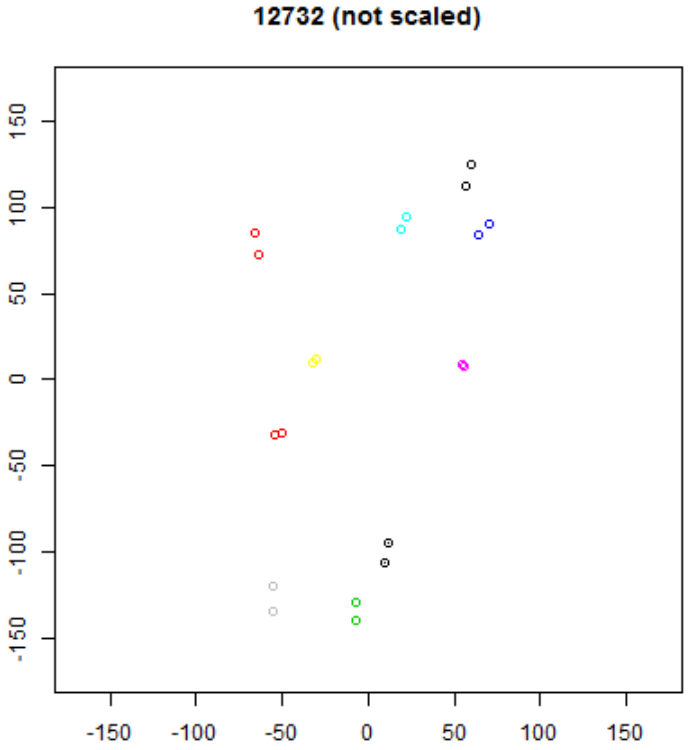
Example



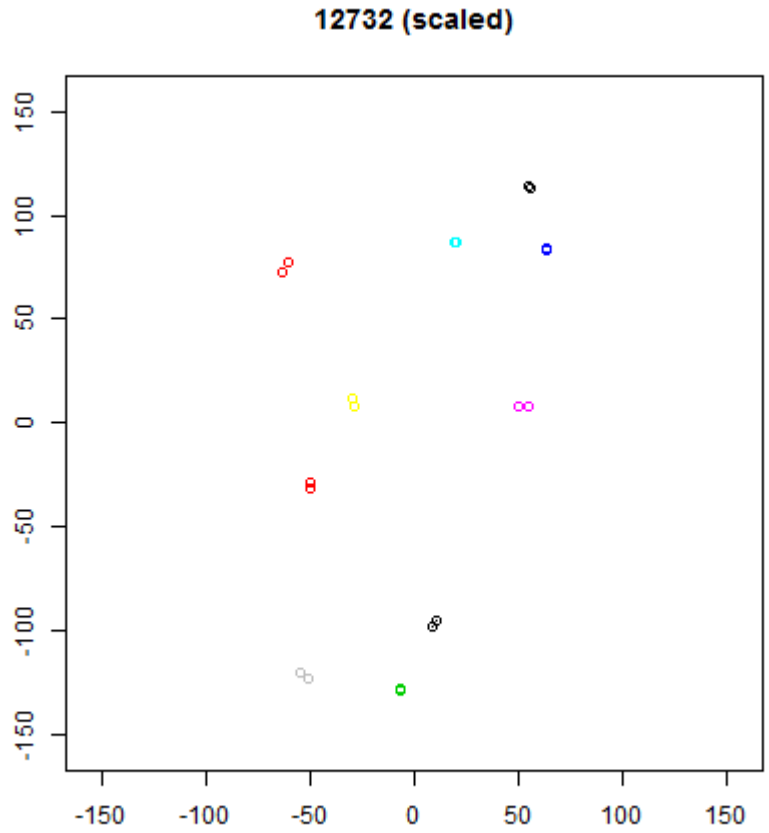
Deviation of 54 hand-coded cases:
Predicted vs observed best scaling factor

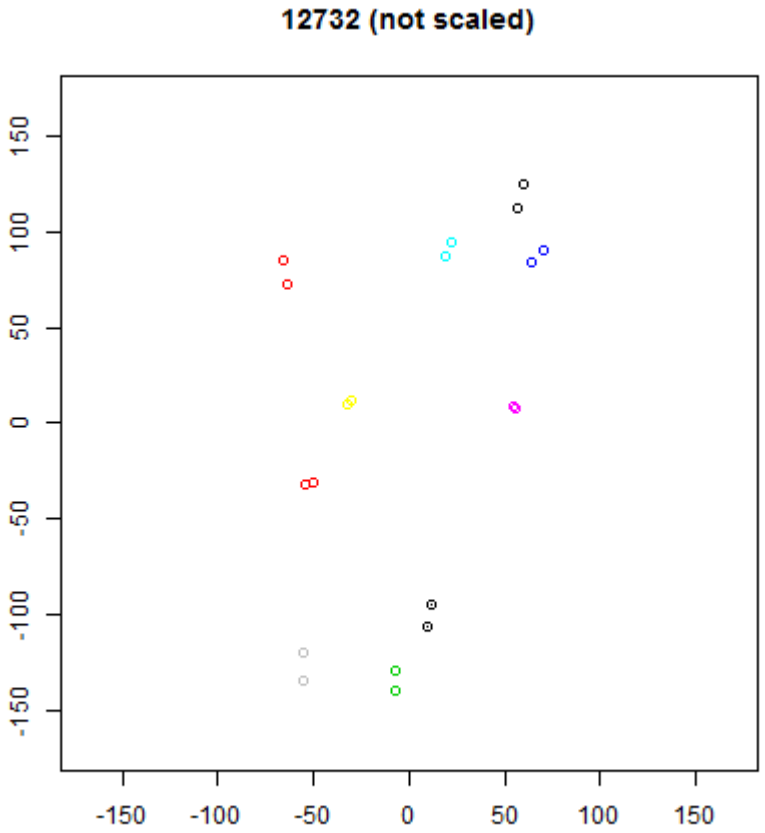
Joint Research Centre





Example: closest shape alignment for 50 months time distance

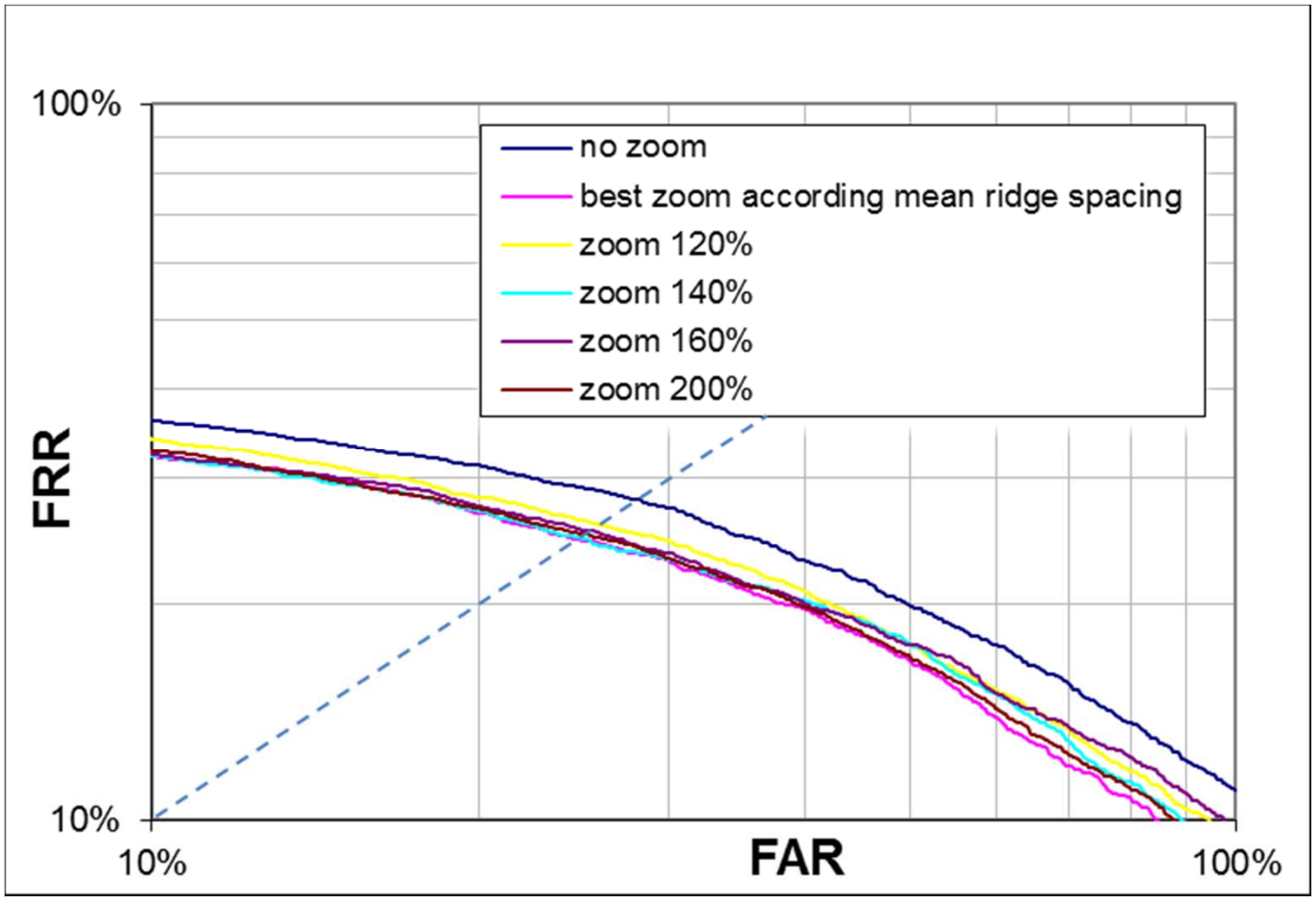




Example: 50 months time distance

European Commission

Performance under various scalings



Joint Research Centre

Alternative fingerprint acquisition devices ?

Multispectral scanner

Touchless scanner

CrossMatch's new "Guardian"

Joint Research Centre

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

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

Joint Research Centre

Thank you !

Guenter-Egon.Schumacher@jrc.ec.europa.eu

Joint
Research
Centre