NIST Biometric Quality Workshop II
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Analysis of Effect of Fingerprint Sample Quality in Template Ageing

Jieun Ryu, Jihyeon Jang, Hale Kim
Inha University
Incheon, Korea

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Background

- Governmental biometrics-based services are multi-year basis:
  - Passport and Driver's license : 10 years
  - NID: no expiration date unless lost
- Long-term duration between enrollment and verification

Enrollment

Years after

Verification

Purpose

- To confirm 'Template Ageing'
- To define 'Measures and Processes for analysis of sample quality' in template ageing
- To find the 'Influencing factors' on Template Ageing

Definition

- Template Ageing
  - Time duration has an effect on matching performance.

- Ageing factor
  - Influencing factors on 'Template Ageing'

Experimental Set-up

- Target Sensors
  - Optical : Digent, Nitgen
  - Semiconductor : UPEK
- Feature Extractor
  - MINDTCT
- Matcher
  - BOZORTH3
- Image Quality Tool
  - NFIQ

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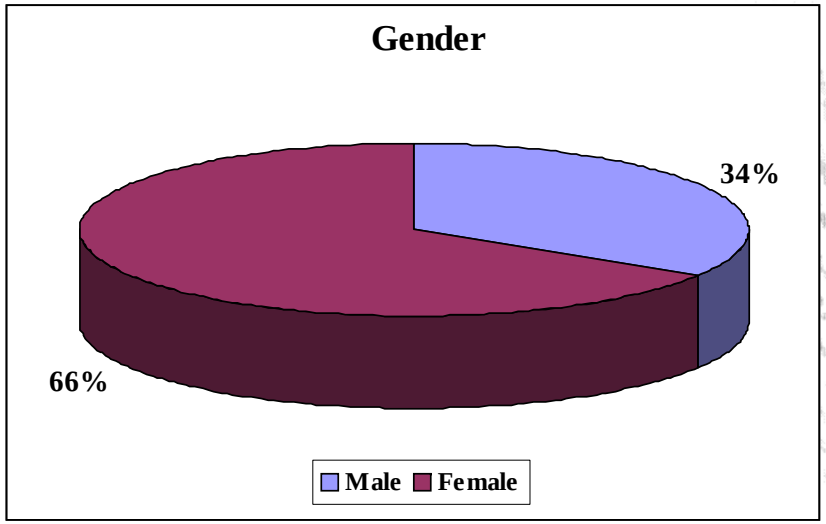
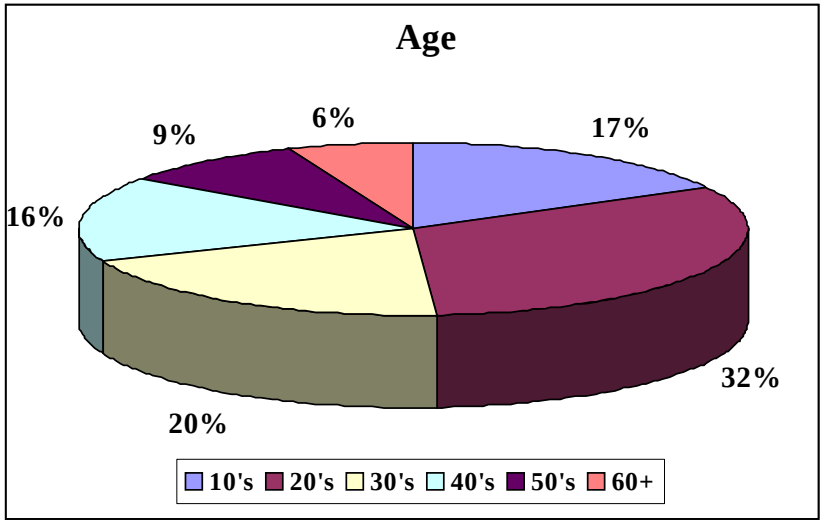
Specification of Database

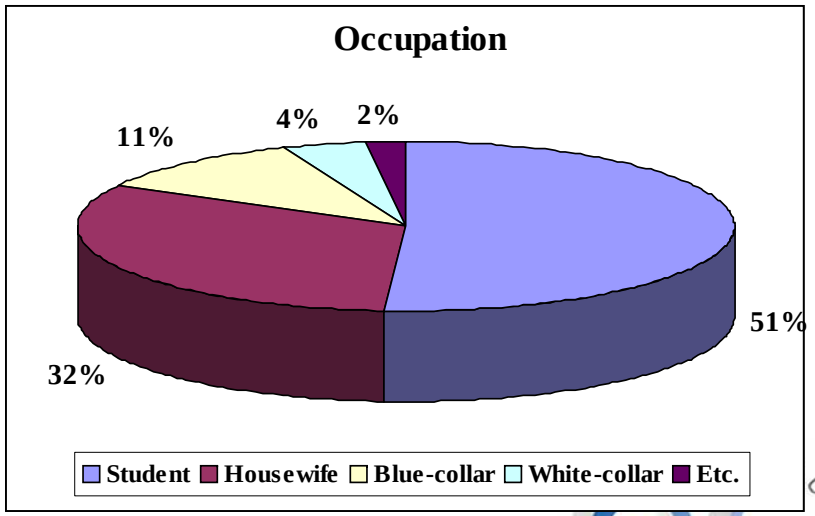
- KFRIA Ageing DB
  - Total 13,200 fingerprint images
    - 2005: 100 persons * 6 fingers * 10 views * 3 sensors * 2 visits
    - 2006: 100 persons * 6 fingers * 10 views * 3 sensors * 2 visits

• KFRIA : Korea Fingerprint Recognition Interoperability Alliance

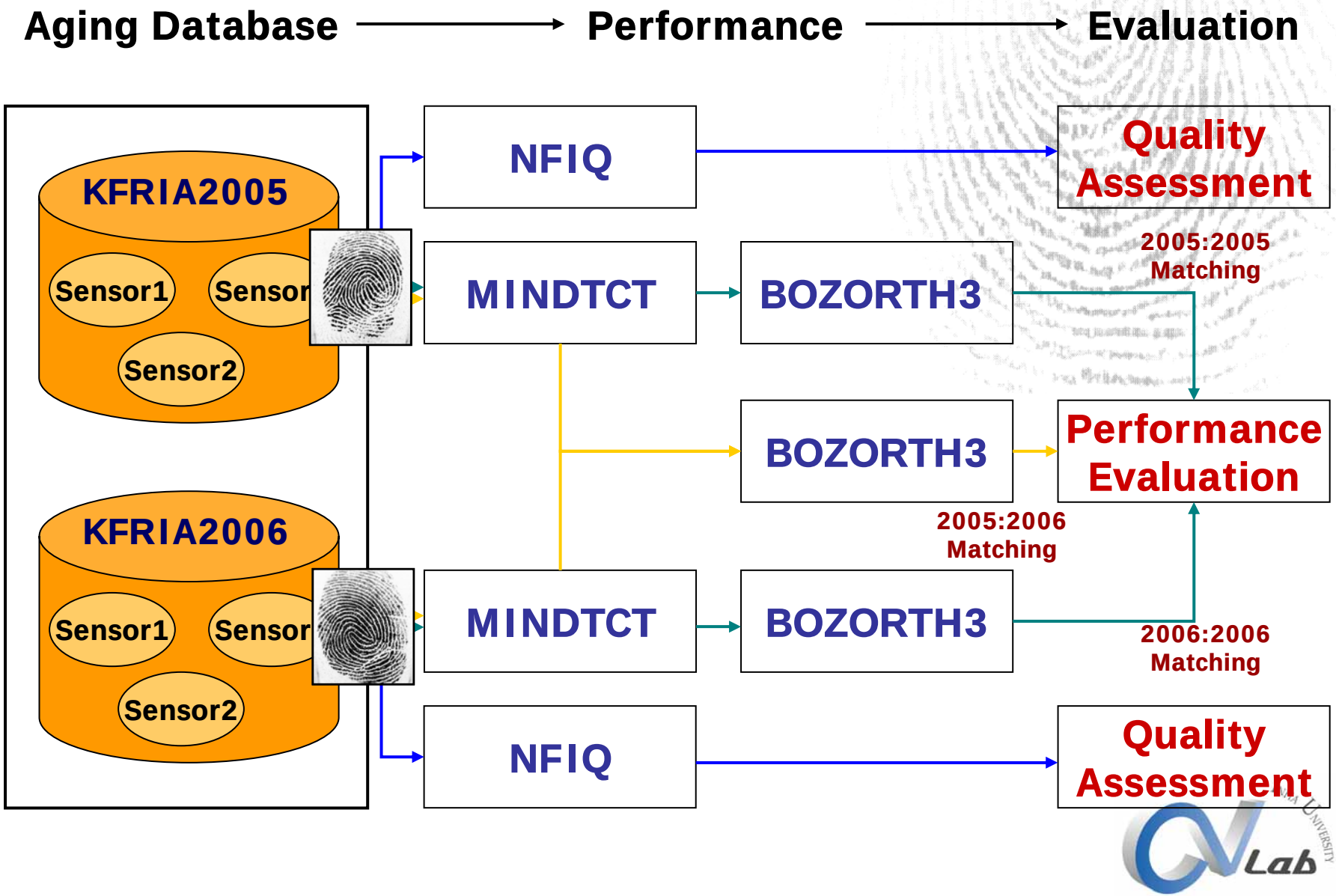
Demographics of Database





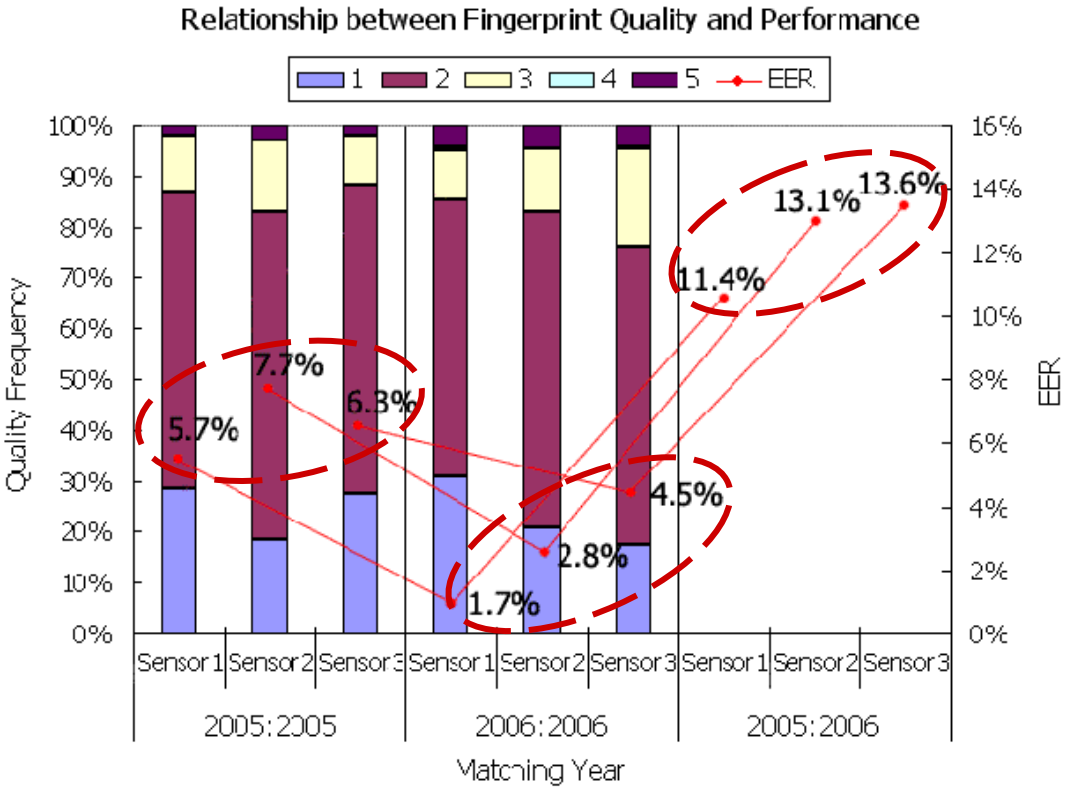


Experimental Procedures



Template Ageing

- Significant variation over time in matching performance
  - → *Template Ageing*
- It seems that there is not a close correlation between sample quality and matching performance



- Representative quality = median (20 views of each subject)

Why are 2006:2006 EER's lower than 2005:2005 EER's?

Why are 2005:2006 EER's high?

even though there is not much variation in overall sample quality

Detailed Quality Analysis

- Using sample quality Co-occurrence table
  1. MMQ (Median:Median Quality) Matrix
     - Row : Column
       = median(20 views/subject) : median(20 views/subject)
  2. MVQ (Median:Views Quality) Matrix
     - Row : Column
       = median(20 views/subject) : 20 views of each subject
  3. MPQ (Matching pairs Quality) Matrix
     - Row : Column = Genuine matching pairs of each subject

Subject1

Median Sample Quality

'1'

Sample Quality Set of Subject1 (20 views)

= {1,1,1,1,1,1,1,1,1,1,1,1,1,1,2,2,2,2,2,3}

MMQ Matrix

- Sample quality
  - Row : Column
    = median(20 views/subject) : median(20 views/subject)
- Total number
  - Total = Person * Finger = 100 * 6 = 600

[Sensor1] 2005:2006 MMQ Co-occurrence Matrix

2006 Median Quality / 2005 Median Quality	1	2	3	4	5	Sum
1	18.33%	6.00%	0.67%	0.17%	1.33%	26.50%
2	11.00%	47.33%	4.17%	0.17%	1.83%	64.50%
3	0.83%	3.17%	2.50%	0.00%	0.83%	7.33%
4	0.00%	0.00%	0.33%	0.00%	0.00%	0.33%
5	0.00%	0.17%	0.83%	0.17%	0.17%	1.33%
Sum	30.17%	56.67%	8.50%	0.50%	4.17%	100.00%

✓ Matrix information

Distribution of Representative sample quality

2006 Sample quality distribution

2005 Sample quality distribution

MVQ Matrix

- Sample quality
  - Row : Column
    = median(20 views/subject) : 20 views of each subject
- Total number
  - Total = Person * Finger * Views = 100 * 6 * 20 = 12,000

[Sensor2] 2005:2005 MVQ Co-occurrence Matrix

2005 Each View Quality / 2005 Median Quality	1	2	3	4	5	Sum
1	9.08%	4.89%	0.67%	0.01%	0.36%	15.00%
2	10.96%	53.35%	7.05%	0.03%	1.94%	73.33%
3	0.80%	3.43%	4.09%	0.07%	1.45%	9.83%
4	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
5	0.07%	0.22%	0.60%	0.00%	0.95%	1.83%
Sum	20.90%	61.88%	12.41%	0.11%	4.70%	100.00%

Median sample quality = 2,

Quality levels of individual samples

- Matrix information

Quality distribution of individual views

MPQ Matrix

- Sample quality
  - Row : Column
    = Genuine matching pairs of each subject = Enrolled : Tested
- Total number
  - Total = Genuine matching # * Person * Finger
    $= {}_{20}C_2 * 100 * 6 = 114{,}000$

[Sensor1] 2006:2006 MPQ Co-occurrence Matrix

2006 Tested Template Quality / 2006 Enrolled Template Quality	1	2	3	4	5	Sum
1	23.33%	7.09%	0.17%	0.01%	0.00%	30.61%
2	7.9%	43.9%	2.3%	0.0%	0.0%	54.02%
3	0.2%	3.3%	6.0%	0.2%	0.9%	10.51%
4	0.0%	0.0%	0.1%	0.2%	0.1%	0.44%
5	0.0%	0.0%	0.8%	0.1%	3.5%	4.42%
Sum	31.44%	54.23%	9.32%	0.43%	4.58%	100.00 %

- Matrix information

Directly related to matching performance

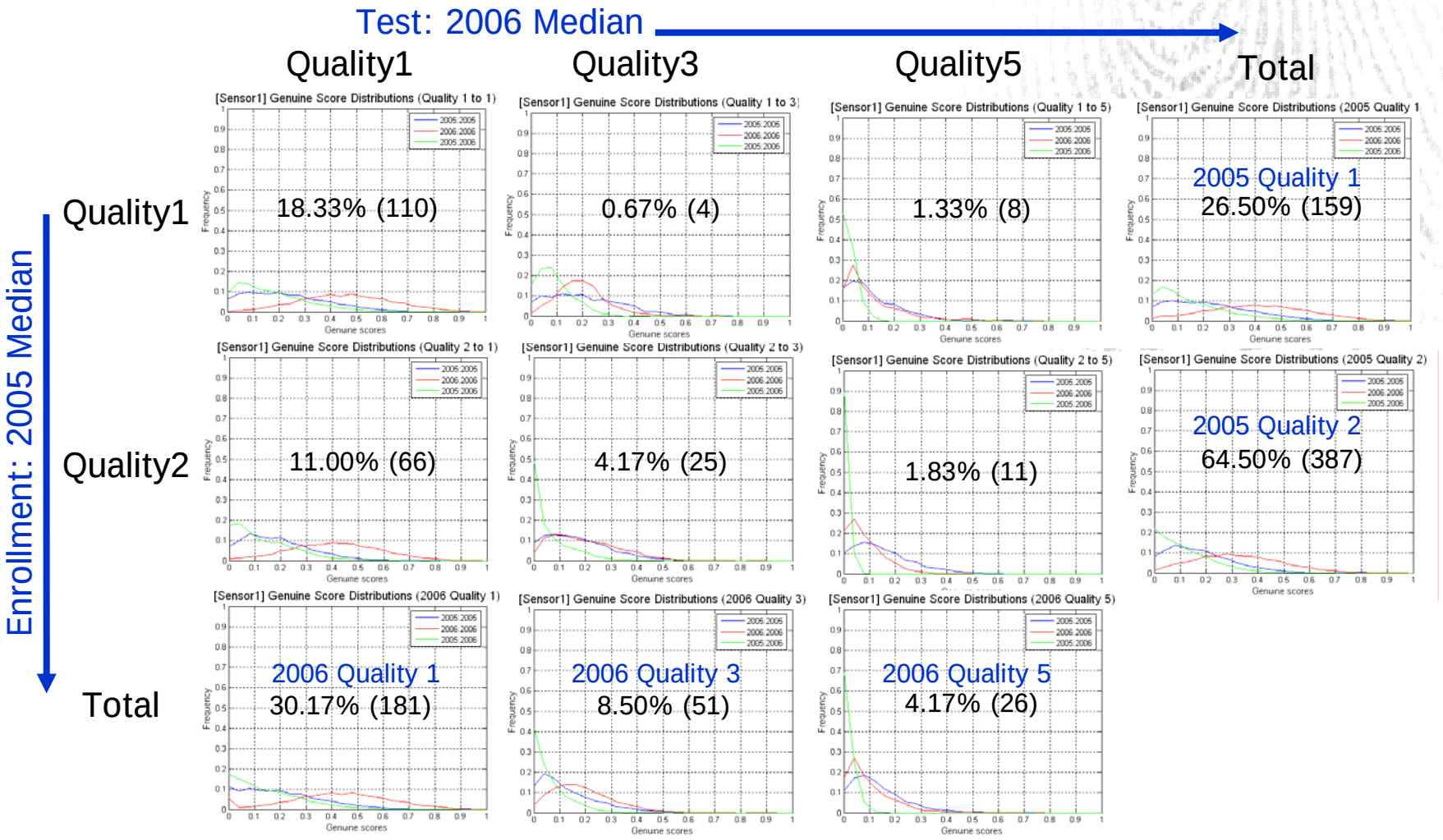
Analysis of Sample Quality and Matching Performance (1)

- To analyze relationship between sample quality and matching performance using MMQ Matrix
- How to analyze
  - Classify the genuine matching scores by 2005:2006 MMQ Co-occurrence Matrix

[Sensor1] 2005:2006 MMQ Matrix

2005 Median Quality \ 2006 Median Quality	1	2	3	4	5	Sum
1	18.33%	6.00%	0.67%	0.17%	1.33%	26.50%
2	11.00%	47.33%	4.17%	0.17%	1.83%	64.50%
3	0.83%	3.17%	2.50%	0.00%	0.83%	7.33%
4	0.00%	0.00%	0.33%	0.00%	0.00%	0.33%
5	0.00%	0.17%	0.83%	0.17%	0.17%	1.33%
Sum	30.17%	56.67%	8.50%	0.50%	4.17%	100.00%

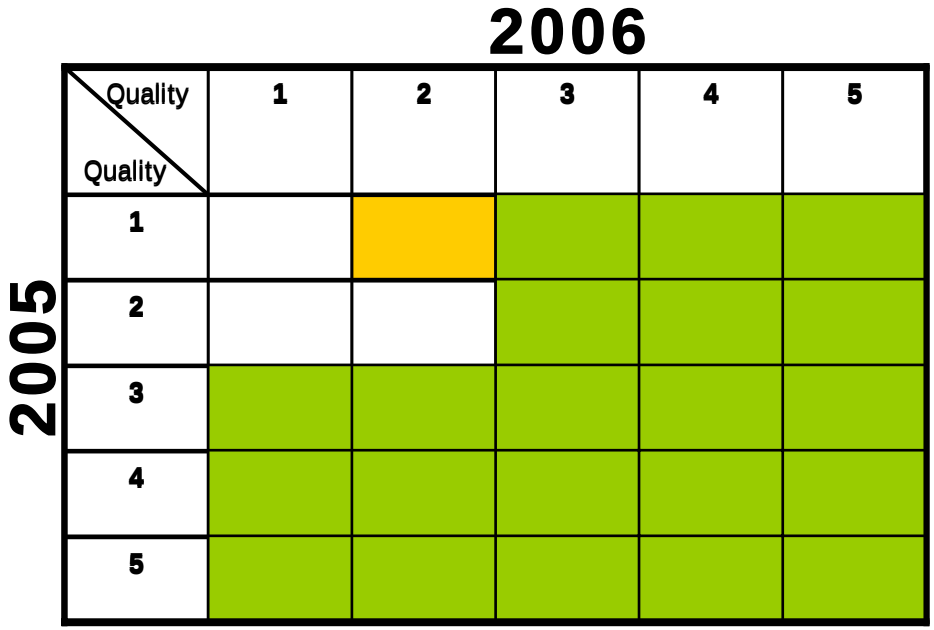
Analysis of Sample Quality and Matching Performance (2)



Lower Quality → Score distribution shift to left

→ Increasing matching errors

Can any part of the Co-occurrence matrices provide the estimation of the matching error in Template ageing?

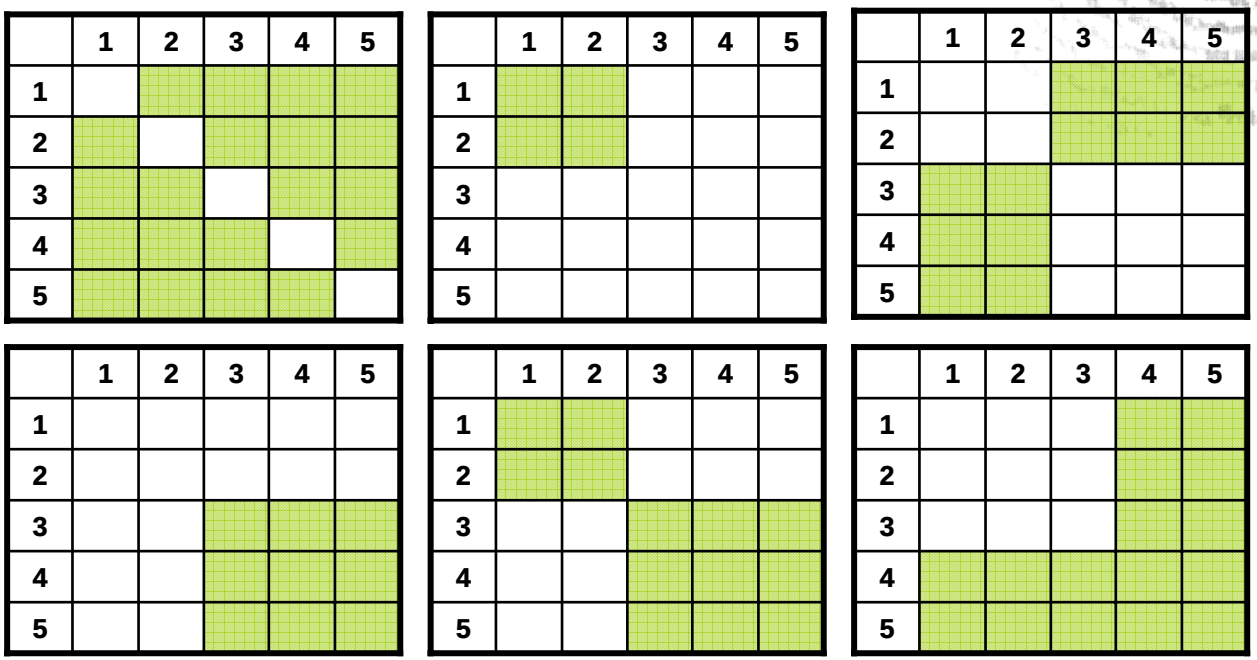


Lower Sample Qualities than before?

Or just bad Qualities?

Correlation between EER and Quality Block

- To find the influencing quality blocks on EER's
  - Define 19 kinds of blocks like below tables
  - Compute the correlation between EER's and sum of proportions of each block



Computing Correlation

- How to compute correlation
  - For example, using MVQ Table on Block1
    - Matching year : A = 2005:2005, B = 2006:2006, C = 2005:2006

Matching year / EER	Sensor1			Sensor2			Sensor3		
	A	B	C	A	B	C	A	B	C
EER	5.7%	1.7%	11.4%	7.7%	2.8%	13.1%	6.3%	4.5%5	13.6%
MEQ_Block1	S1_A	S1_B	S1_C	S2_A	S2_B	S2_C	S3_A	S3_B	S3_C

Sensor3 : MVQ co-occurrence Table

2005:2005

	1	2	3	4	5
1					
2					
3					
4					
5					

Block1

S2_A

2006:2006

	1	2	3	4	5
1					
2					
3					
4					
5					

Block1

S2_B

2005:2006

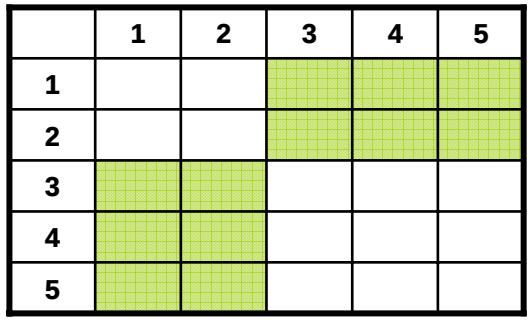
	1	2	3	4	5
1					
2					
3					
4					
5					

Block1

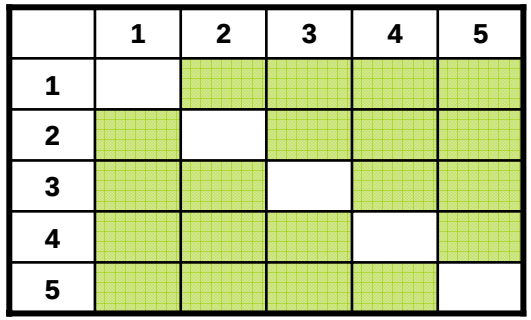
S2_C

Positively High Correlation Blocks

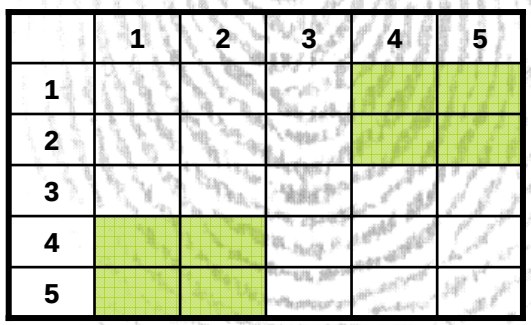
❖ High correlation blocks with EER's



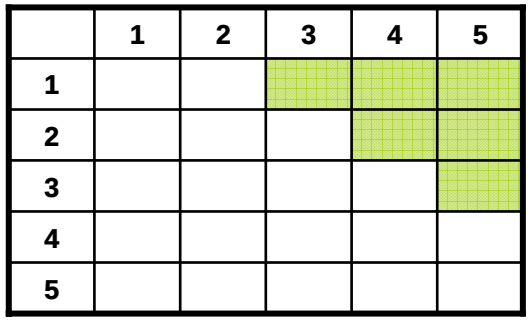
Block16



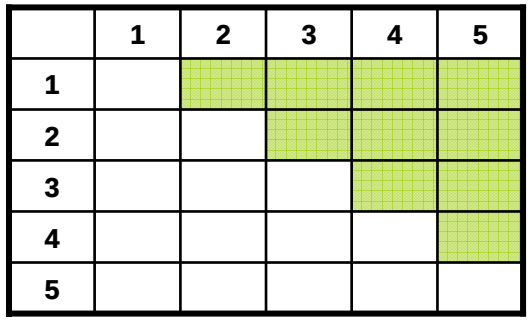
Block7



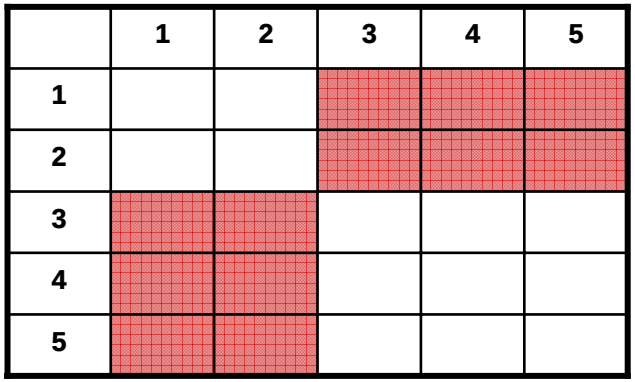
Block17



Block1



Block5

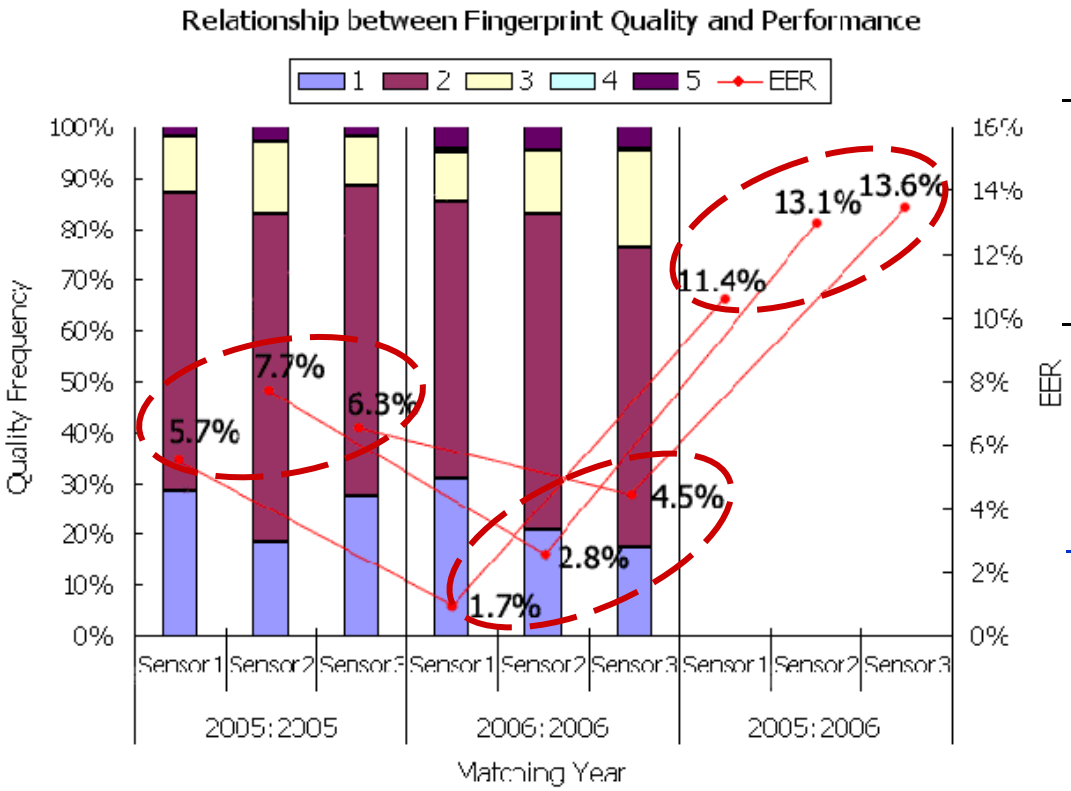


Common Block

→ *Large difference in sample quality over time*

→ *Significant 'Influencing Factors' on Template Ageing*

Back to First Question



Why are 2006:2006 EER's lower than 2005:2005 EER's?

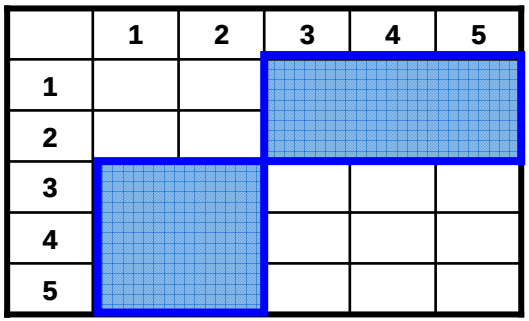
Why are 2005:2006 EER's high?

even though there is not much variation on overall sample quality

→ *Due to variation in sample quality over time*

→ *Basis : MVQ matrix*

Back to First Question



Block16

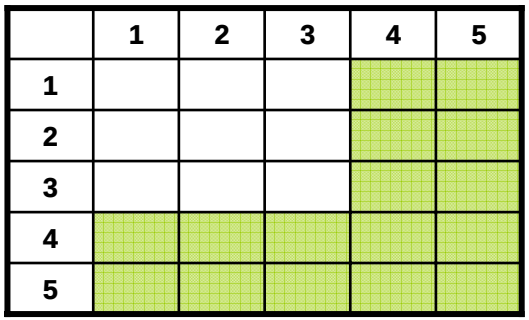
· Block value · EER

Matching / Year / Sensor	2005:2005	2006:2006	2005:2006
Sensor1	**7.98 %** **5.7 %**	**3.85 %** **1.7 %**	**13.93 %** **11.4 %**
Sensor2	10.23 % (7.7 %)	4.95 % (2.8 %)	14.57 % (13.1 %)
Sensor3	6.68 % (6.3 %)	6.55 % (4.5 %)	20.98 % (13.6 %)

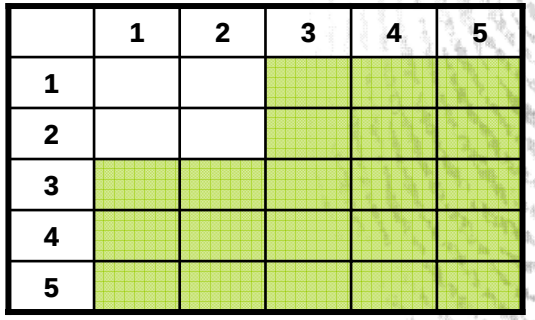
Block value from MVQ
Co-occurrence matrix

Low Correlation Blocks

❖ Blocks of low correlation with EER's

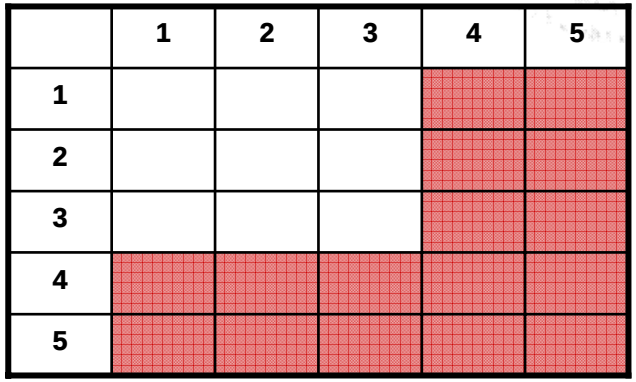


Block15



Block14

Common Block

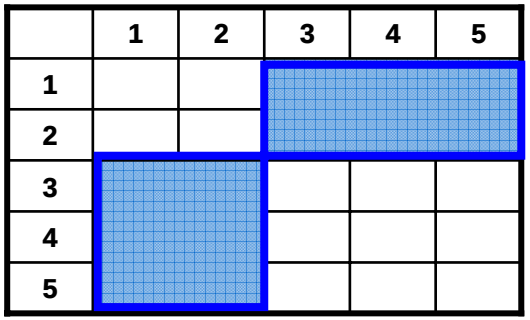


→ *Combined with positively high correlation(PEER) block and negatively high correlation(NEER) block*

→ *Hard to estimate EER*

EER vs. Correlation Block(1)

❖ Block name : PEER(Positive EER) Block

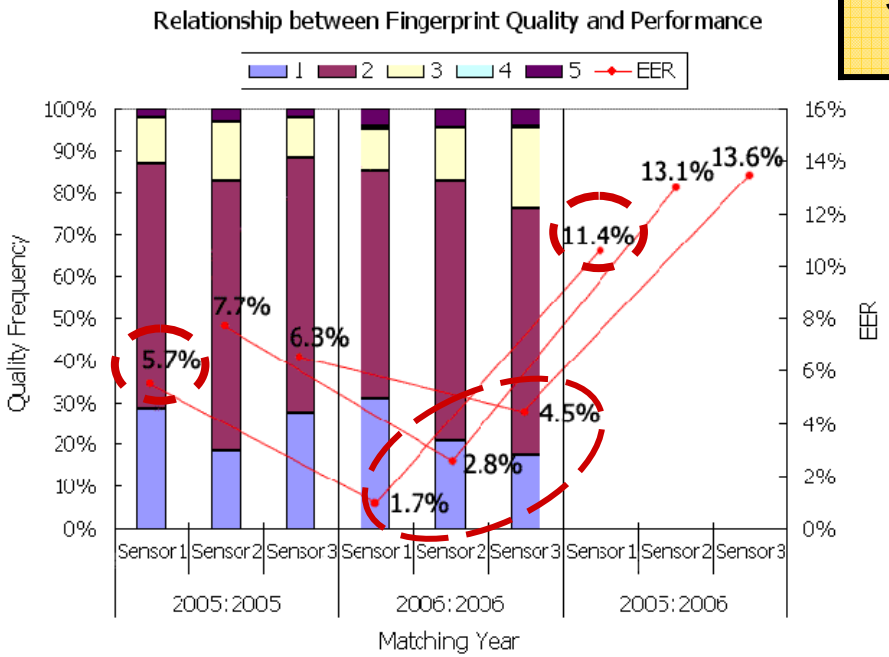


PEER Block

· Block value · EER

Matching Year / Sensor	2005:2005	2006:2006	2005:2006
Sensor1	**7.98 %** **5.7 %**	**3.85 %** **1.7 %**	**13.93 %** **11.4 %**
Sensor2	10.23 % (7.7 %)	**4.95 %** **2.8 %**	14.57 % (13.1 %)
Sensor3	6.68 % (6.3 %)	**6.55 %** **4.5 %**	20.98 % (13.6 %)

Block value from MVQ
Co-occurrence matrix

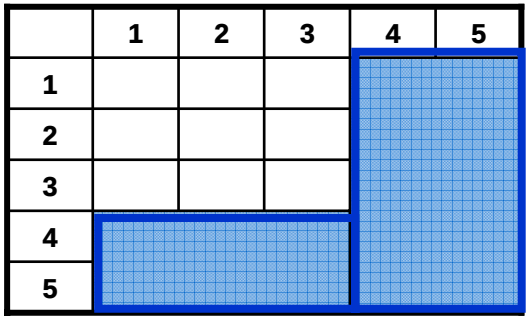


- Block characteristics

Possible to guess lower EER among three sensors

EER vs. Correlation Block(2)

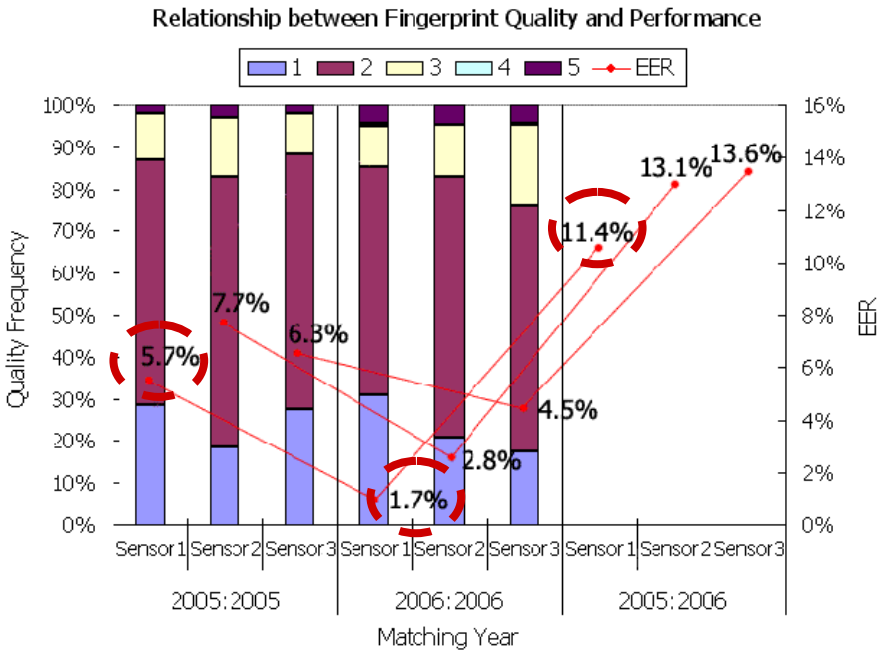
- Block name : LEER (Low Correlation) Block



LEER Block

Matching Year / Sensor	2005:2005	2006:2006	2005:2006
Sensor1	**3.02 %** **5.7 %**	**5.97 %** **1.7 %**	**6.40 %** **11.4 %**
Sensor2	4.46 % 7.7 %	6.02 % 2.8 %	6.72 % 13.1 %
Sensor3	2.81 % 6.3 %	5.73 % 4.5 %	6.10 % 13.6 %

Block value from MPQ Co-occurrence matrix



- Block characteristics

1. No relationship with EER
2. Because of combining with PEER Block and NEER Block

Comparison of Co-occurrence Matrices

- MMQ Matrix
  - No information regarding variation of sample quality
  - Hard to link with EER
- MVQ & MPQ Matrices
  - Useful to figure out relationship between sample quality and matching performance
  - MVQ and MPQ matrices have similar performance

Conclusions

- Template ageing has been confirmed.
- Variation in sample quality is an important factor in template ageing.
- Various matrices and block measures have been defined for the analysis of correlation between sample quality and matching performance.
- Template Updating process is recommended in long-term usage applications of biometrics.

Future works

- Generalization of proposed matrices and measures for various databases such as FVC's
- Prediction of EER from proposed measures
- Evaluation of 'Level of Difficulty' of a database without actual matching
- Search for other factors influencing on 'Template Ageing'

Thank you for your attention!!

E-mail : jeryu@vision.inha.ac.kr

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