Study Report on Facial Biometrics for Japanese ePassports

Biometrics WG,

The IC Passport Committee of Japan
in FY2004

Contents

- Development of Japanese ePassports
  - Development Framework of Japan
  - The IC Passport Committee and Biometrics Working Group
- Studied Key Issues
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Refer to *sc37n2126* for detailed information

Japanese ePassports

- To keep Japanese (e)Passports with well-suited credibility for international consensus (standards) as service to Japanese citizen
  - Lots of countries kindly apply Visa Waiver arrangements to Japan
- Japan has decided only facial information to be embedded in Japanese ePassports
  - Acceptance from the cultural and social points, especially privacy protection issue

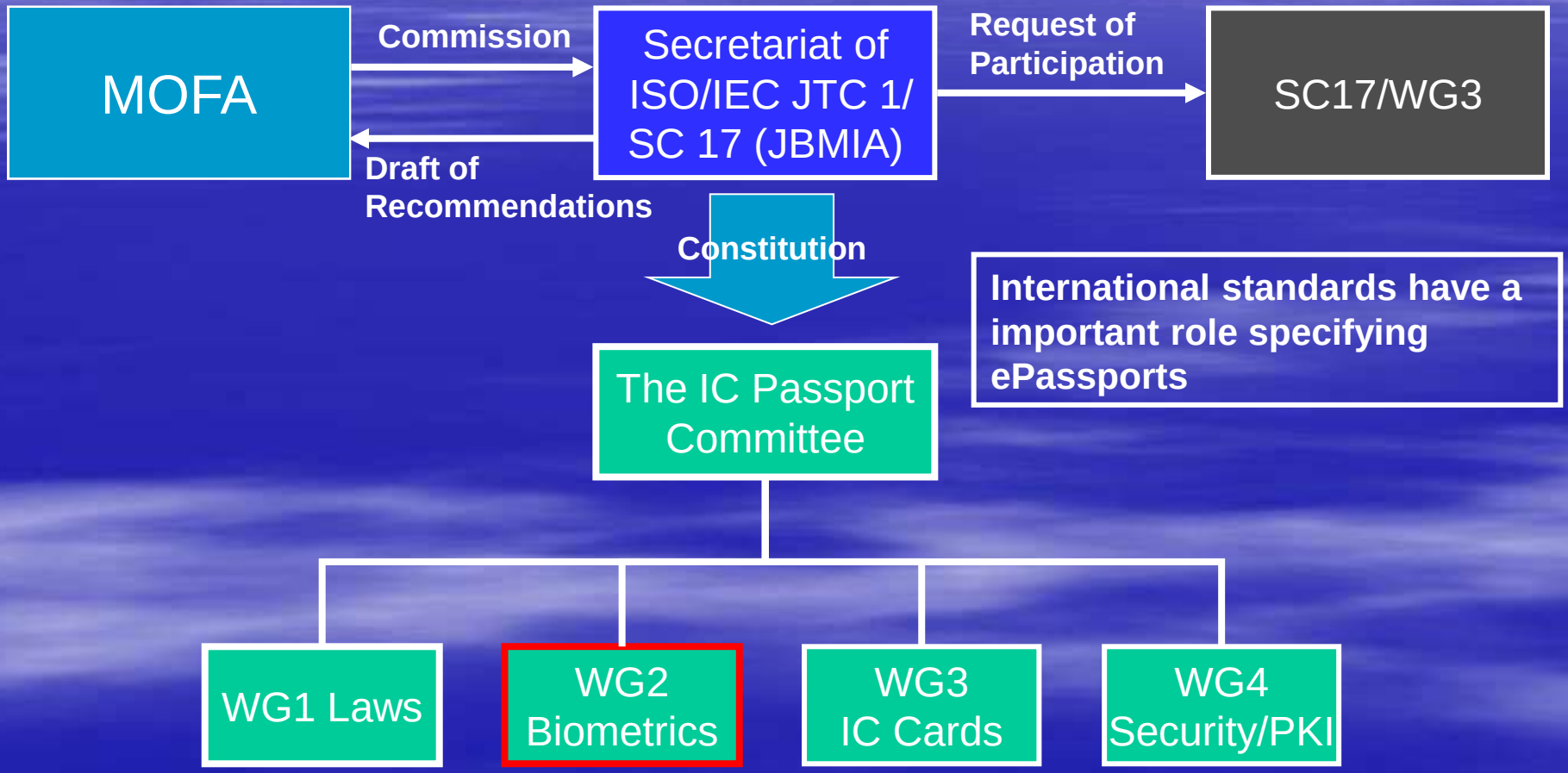
Approach toward ePassport Implementation in Japan (FY 2004 to 2005)

- The IC Passport Committee of Japan, partially reported in this presentation
  - Comprehensive discussion and draft of recommendations, including relevant law amendments, technical specifications regarding biometrics, IC card and PKI -> Japan has issued ePassports since March 2006

- Substantive Evaluations of ePassport held by Japanese Ministries
  - Operational Testing of Japanese ePassports
    - Evaluate immigration procedures in airports by employing experimental diplomatic ePassports and facial authentication using images in them
    - Cooperated by MOJ, MOFA, METI and MLIT
  - Mutual Compatibility Testing amongst ePassports and their readers manufactured by multiple vendors
    - Cooperated by CAS, MOFA, MOJ and METI
  - Secure and Swift Procedure Testing in Airports (not implemented yet)
    - Experimental SPT (Simplifying Passenger Travel) Card
    - Face and other authentications were examined
    - Cooperated by MOJ and MLIT

  Refer to http://www.cas.go.jp/jp/siryou/050114e-Passport.html (in Japanese)

The IC Passport Committee in Japan of FY 2004



Schematic Diagram of Facial Authentication on ePassports

Photo Sample for Previous Passport

Enrollment

Photo printing on Passport

Evaluation of impacts on ID photo application scenes
Development of photo guideline for Japanese citizen
Announcement to vendors related to ID photos
Development of ISO/IEC 19794 5:2005/Amd.1:2007

Photo taking&printing → Photo scanning → Face detection → JPEG encoder

Full Frontal Image (ISO/IEC 19794 5)

writing → Facial information → reading

ePassport

Aging effects against facial authentication accuracies
Recommendation regarding ten year valid period

Specification determination / implementation recommendations for Japanese ePassport regarding LDS/CBEFF/19794 5
Determination of maximum image size for Japanese ePassport

JPEG decoder → Face detection → Feature extraction → Feature comparison → Feature extraction → Face detection → Image capturing

yes **Retry?** → Image capturing

OK? no → Image capturing

OK? yes → ○

→ ×

Presentation of results

Investigation of airport circumstances
Recommendation of how to capture images

Verification

Implementation recommendation in Japan

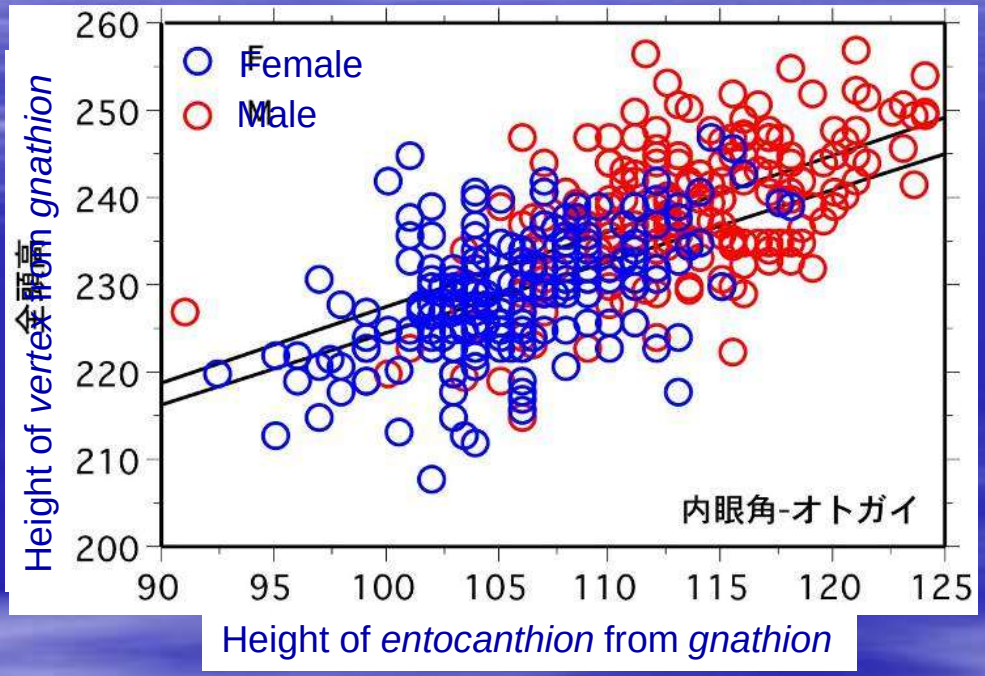
ESTIMATION OF CROWN POSITION

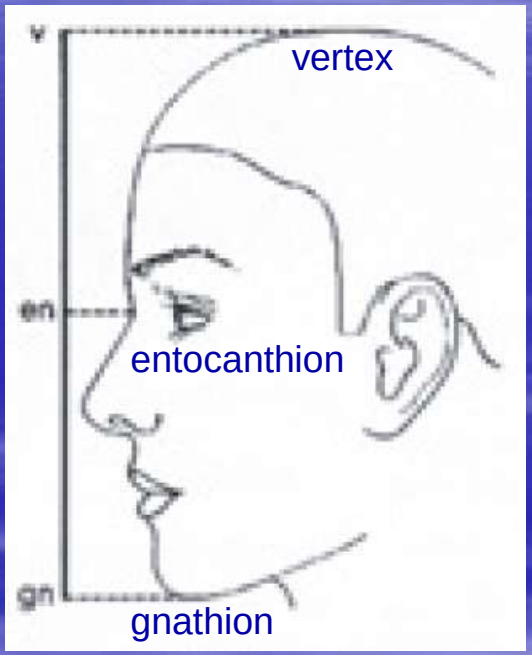
Estimation of the Crown Position

- The definition of the crown position has been changed.
  - The previous standard specified the crown position as “the uppermost point of the head or hair”
  - ISO/IEC 19794-5 referenced by Doc 9303 specifies it as “the top of the skull”, ignoring any hair.
- Usually both positions are almost the same, but in some cases they are different.

-> recommend to estimate the crown position as being twice the height from the inner corner of the eye to the point of the chin if it is hidden by hair

Heights of *entocanthion* from *gnathion* vs. total heights of *vertex* from *gnathion* in millimeters





Vertex: the top of the skull
Entocanthion: the most medial point of the eye fissures
Gnathion: the most inferior point of the mandible in the midline

IMAGE QUALITIES OF EPASSPORT PHOTOGRAPHS

Image Qualities of ePassport Photographs

- Strong relationship between facial authentication accuracies and image capturing conditions
- However, it should be unrealistic that strong restriction would be applied to ID-photo application scenes.
  - Photo studios provide high quality photos to their customers
  - Photo services may have some differences in capturing conditions and may cause lower quality images
  - Recent photo booths have digital process and become to provide high quality photos stably

-> Should ID-photo applications need to be revised, improved, or anything?

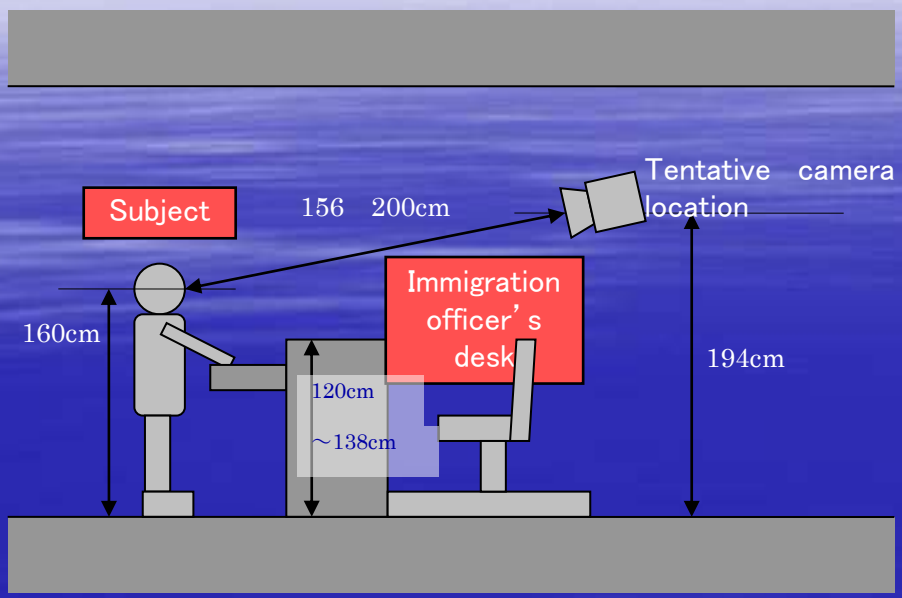
	2000	2001	2002	2003
Photo studio / photo service	40,200	36,000	34,000	32,000
Photo booth	9,000	10,000	11,000	12,000
Scrivener	2,200	2,000	2,000	1,000
Sum.	51,400	48,000	47,000	45,000

	Photo studio			Photo box
Process	Instant photo	Neg. color film	Digital	
ratio	25%	10%	27%	38%

Evaluation of ID-Photo Capturing Conditions (and Airport Conditions, too)

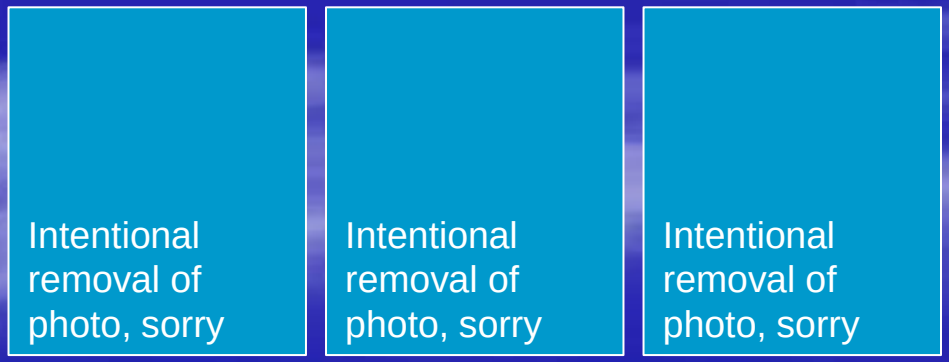
- Investigation of capturing conditions, including expected verification scenes on the basis of biometric comparison process
  - Investigation of ID-photo capturing conditions
  - Investigation of conditions around immigration examination desks
  - Construction of evaluation database under several kinds of simulated conditions
- To obtain results independent of matching algorithms, evaluation experiments nine SDKs submitted by nine venders respectively
  - National Printing Bureau carried out all experiments to maintain objectivity
  - The top three SDKs with the best EER are studied in detail
  - Error bars are plotted based on a binomial distribution with a ninety-percent confidence level

Site Investigation of Airports



Three airports were investigated:

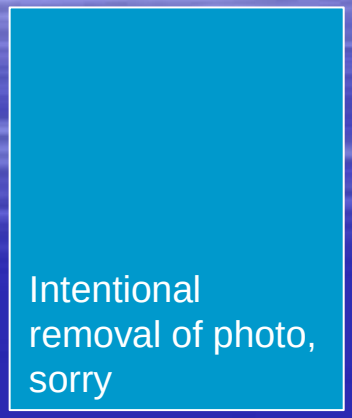
1. Hearing investigation to duty officers
2. Investigation around immigration examination desks
   - Illumination intensities and color temperatures
   - Visual examination of surrounded areas and illumination conditions
     - Indoor lightings
     - Windows and azimuth direction
     - Floor surface reflection
     - Wall surface reflection
     - Structural objects within angle of camera views
     - Flow lines of passengers
3. Photographic subjects
   - Three investigators and a plaster ball



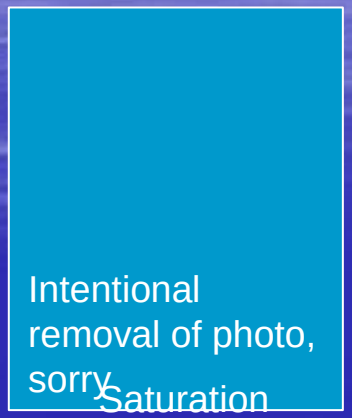
Sample images captured in airports

Construction of Simulated Photographic Conditions

Evaluation Database



Best Practice described in ISO/IEC 19794 5 (1)



Saturation around Forehead

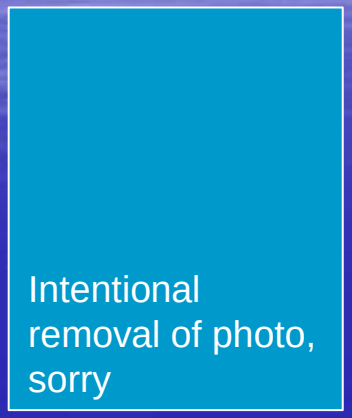
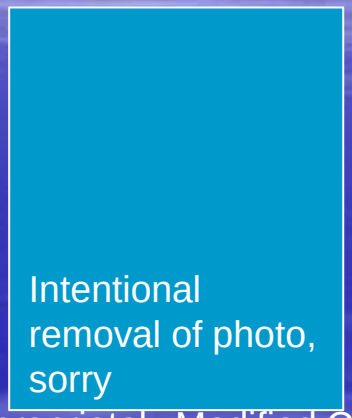
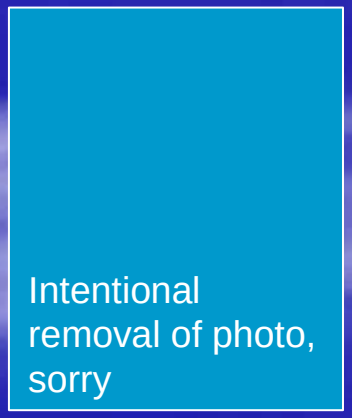


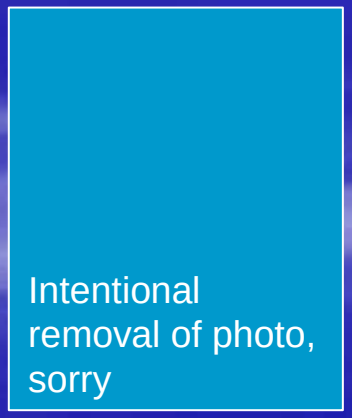
Photo Booth Condition



Appropriately Modified Condition (Airport Simulation)

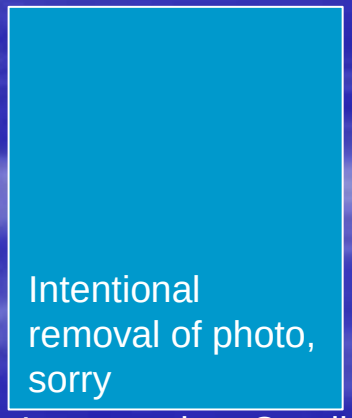


Best Practice described in ISO/IEC 19794 5 (2)



Indistinct Jawline

Frontal Images
420 x 540 pixels



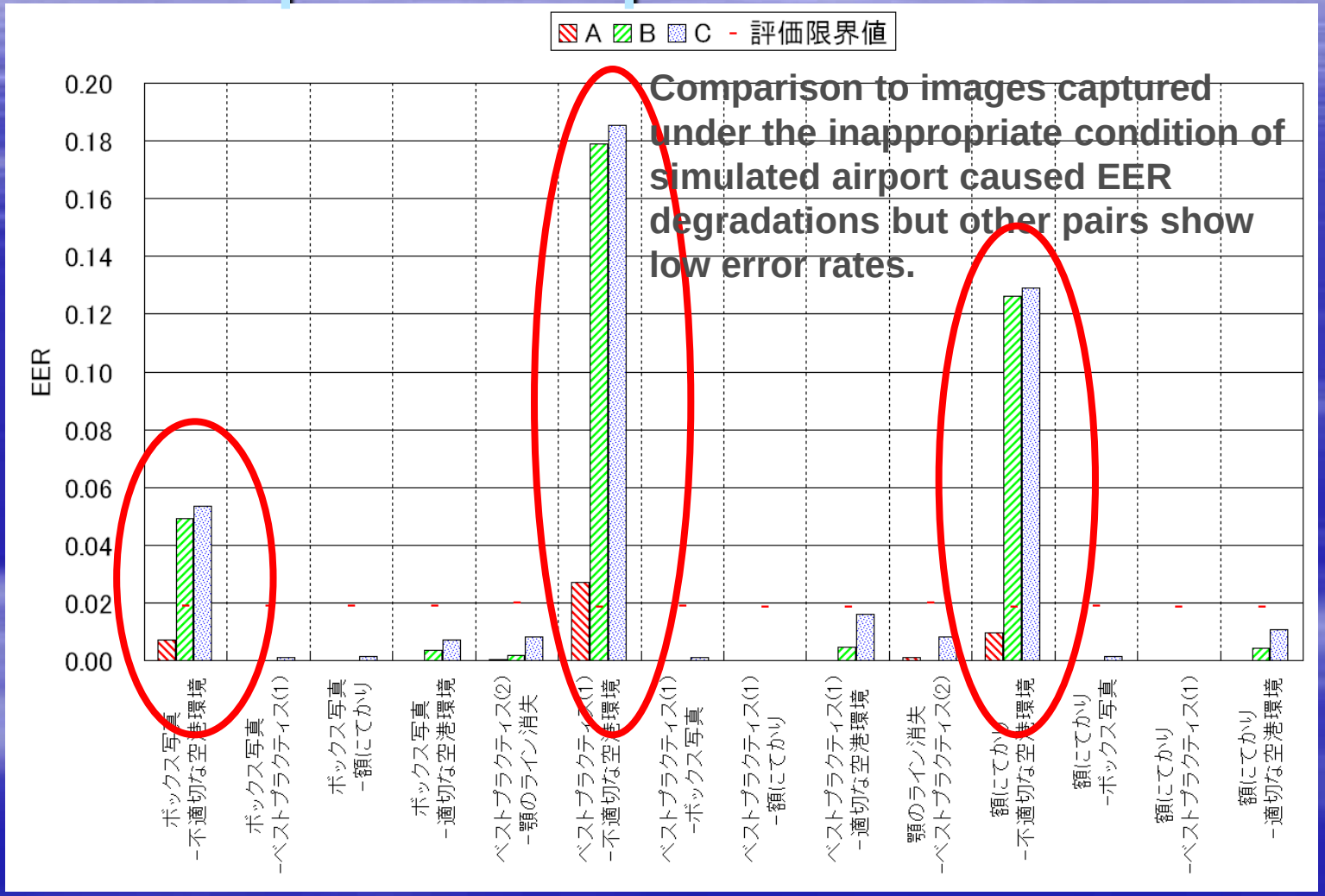
Inappropriate Condition (Airport Simulation)

Verification Experiment Matrix

Enrollment	Query						
	BP (1)	BP (2)	Appropriately Modified Condition (Airport)	Inappropriate Condition (Airport)	Saturation around Forehead	Indistinct Jawline	Photo Booth
Best Practice (1)		×	○	○	○	×	○
Best Practice (2)	×		×	×	×	○	×
Saturation around Forehead	○	×	○	○		×	○
Indistinct Jawline	×	○	×	×	×		×
Photo Booth	○	×	○	○	○	×	

○…161 samples
○…151 samples

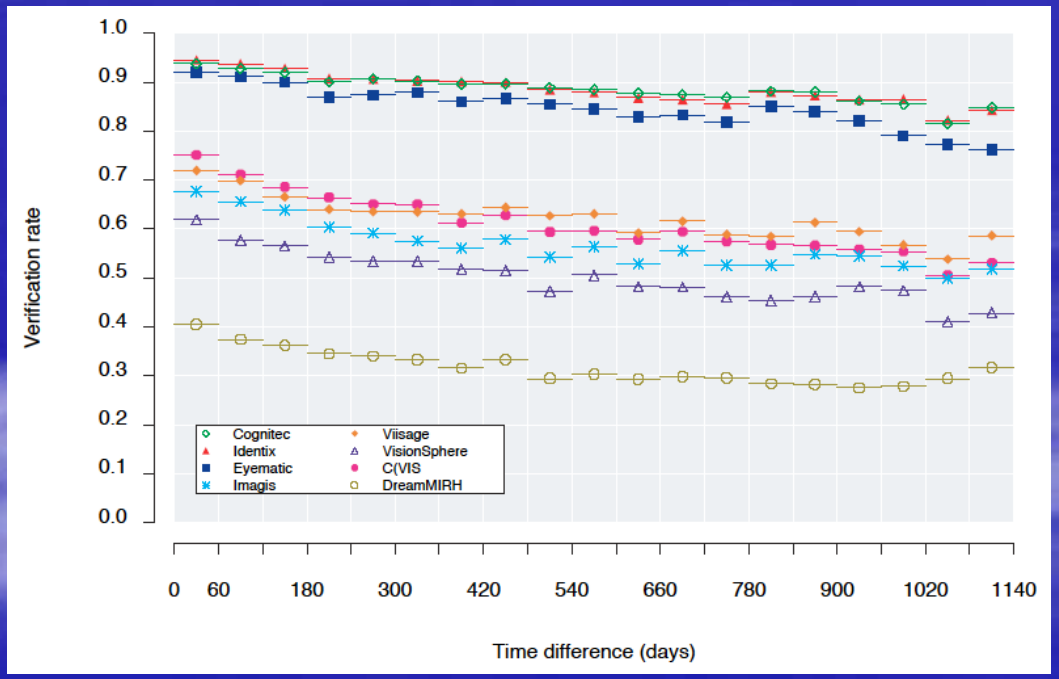
Experimental Result: EER of the top three performers



VALID PERIODS OF EPASSPORTS AND FACIAL AUTHENTICATION ACCURACIES

Facial Authentication Accuracies May Impact on Valid Periods of ePassports

- **Until 2004, Japanese can choose either five-year or ten-year valid period, but should Japan maintain the latter one after ePassport introduction?**



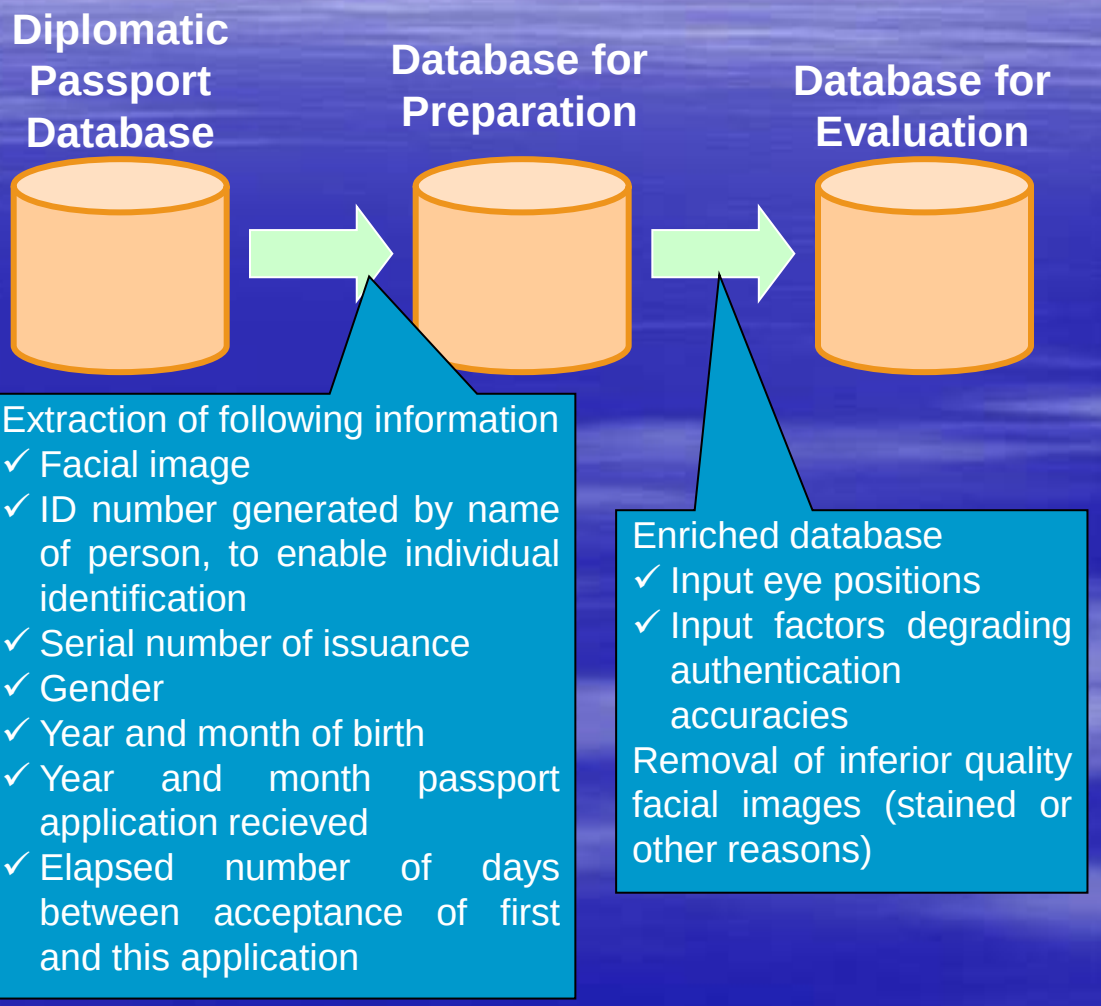
Verification rate at FAR=1% level

•FRVT2002 (Historical !)
http://www.nist.gov/itl/iad/ig/frvt-2002.cfm

Database Construction for Evaluating Valid Period 1/4

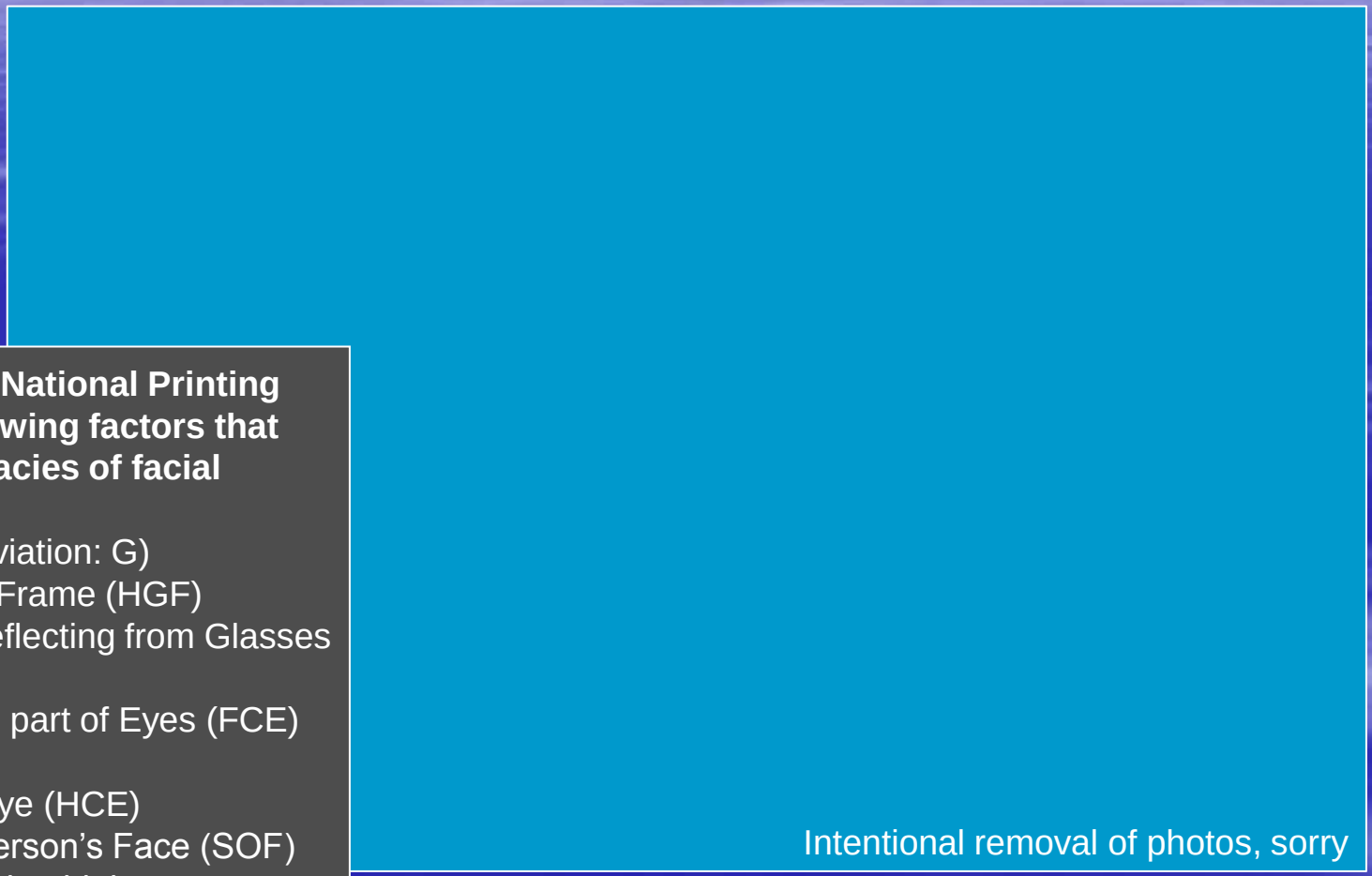
- To evaluate this, facial images that have been continuously stored for a long time are needed

  → Use diplomatic passport (valid per travel) database managed by MOFA
- The Research Institute of National Printing Bureau treated all images and carried out all facial authentication experiments, to assure protection of personal information and to maintain objectivity of results



Database Construction for Evaluating Valid Period 2/4

Frontal Images
420 x 540 pixels

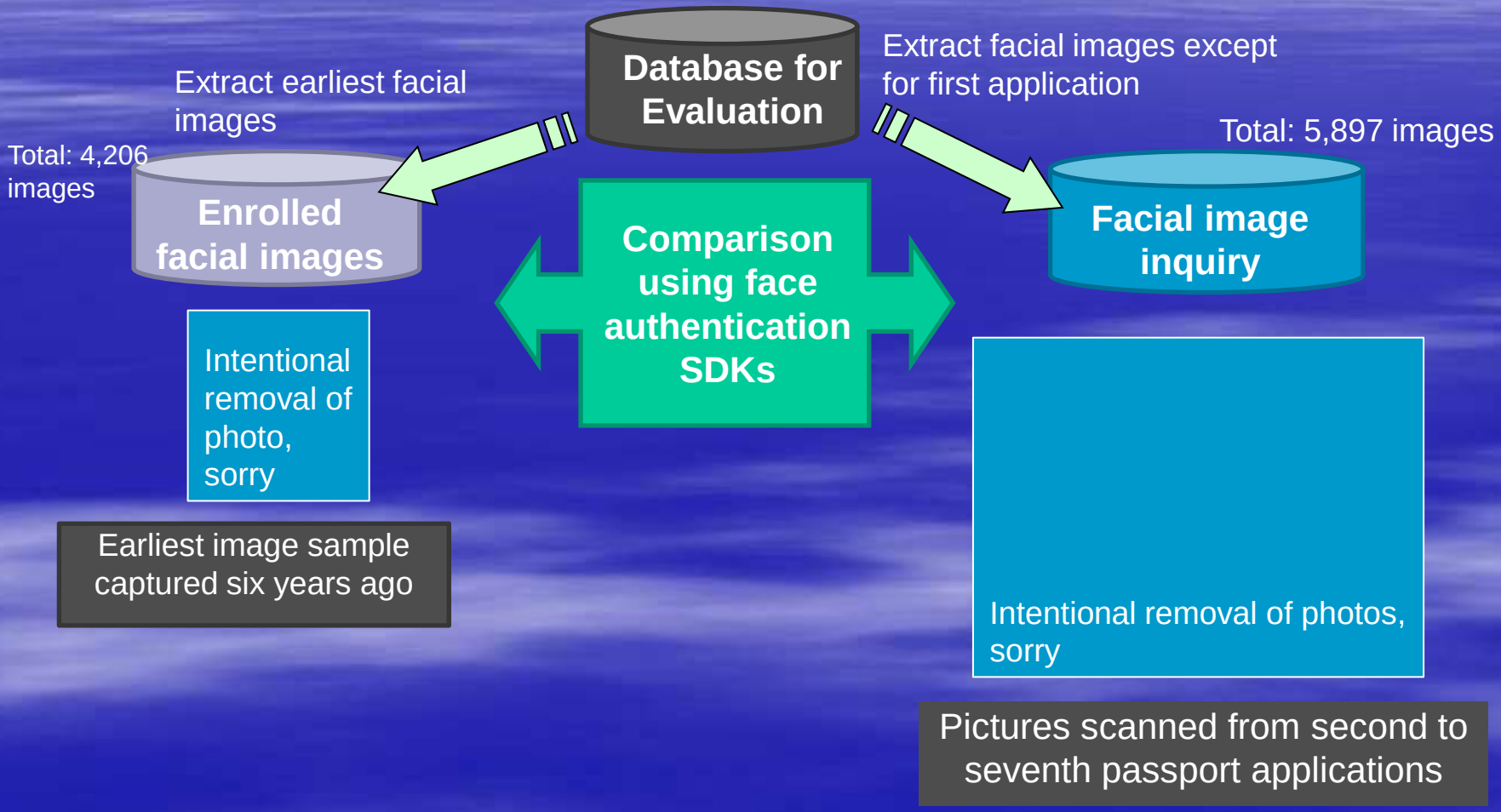


Three operators of National Printing Bureau added following factors that can degrade accuracies of facial authentication:

- Glasses (Abbreviation: G)
- Heavy Glasses Frame (HGF)
- Flash or light Reflecting from Glasses (FRG)
- Frame Covering part of Eyes (FCE)
- Beard (B)
- Hair Covering Eye (HCE)
- Shadow Over person's Face (SOF)
- Bright Area of light shining on person's Face (BAF)

Samples of Database

Database Construction for Evaluating Valid Period 3/4



Database Construction for Evaluating Valid Period 4/4

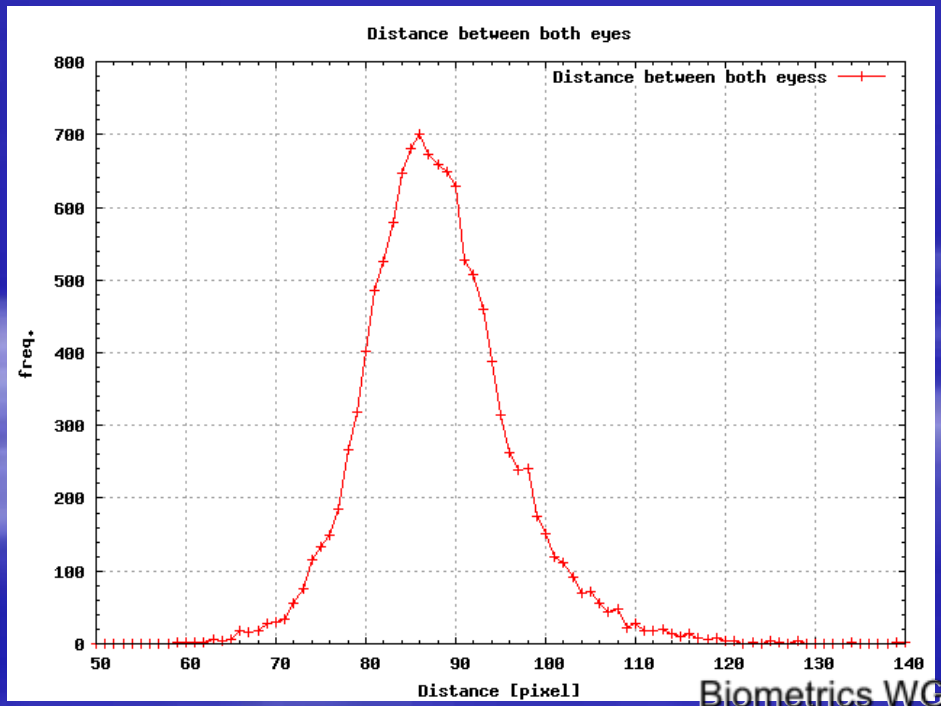
Time Duration Year (Day)	Number of Queries	Number of Enrolled Images
1 year (0～364 days)	772	4,206
2 (365～729)	820	4,206
3 (730～1,094)	1,192	4,206
4 (1,095～1,459)	941	4,206
5 (1,460～1,824)	700	4,206
6 (1,825～2,189)	462	4,206
More than 6 (2,190～)*	1,010	4,206

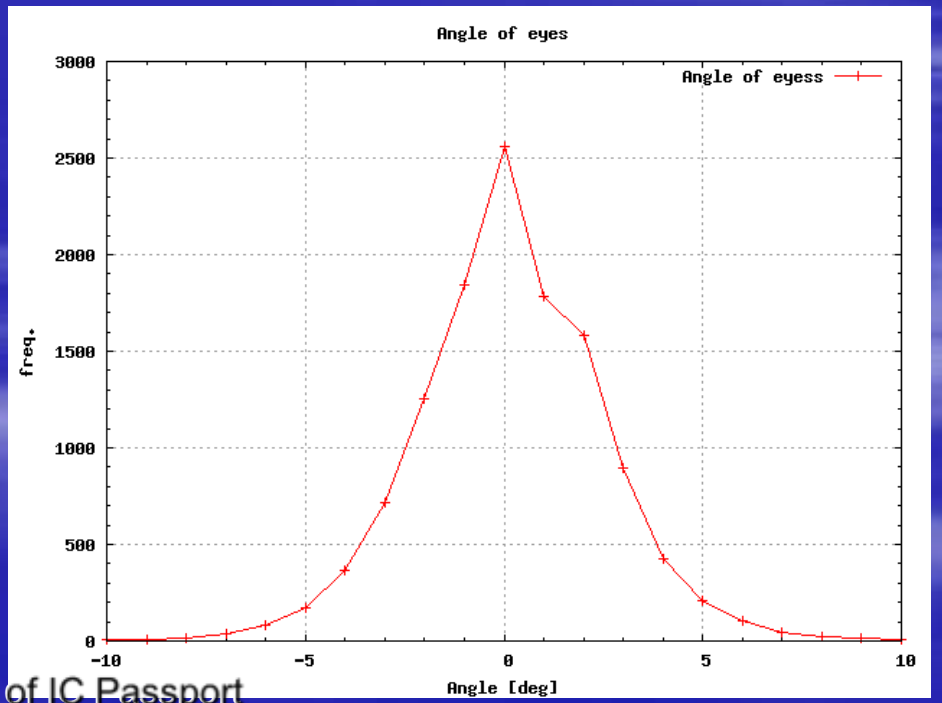
Evaluating Valid Periods of ePassports

- Evaluation Database had facial images with max. six-year time durations, so extrapolating estimation was needed to obtain degradation accuracies after ten-year elapsed
- For more exact estimation, precise analysis based on the degradation factors respectively
- To obtain results independent of matching algorithms, evaluation experiments seven SDKs submitted by nine venders respectively
  - The top three SDKs with the best EER are studied in detail
  - Error bars are plotted based on a binomial distribution with a ninety-percent confidence level
  - In this presentation, accuracies of the top-1 performer but others behave in similar way with it

Statistics of Database:
Distance and Inclination between Eyes

- Distances are distributed between 70 and 110 pixels
- There is not much inclination



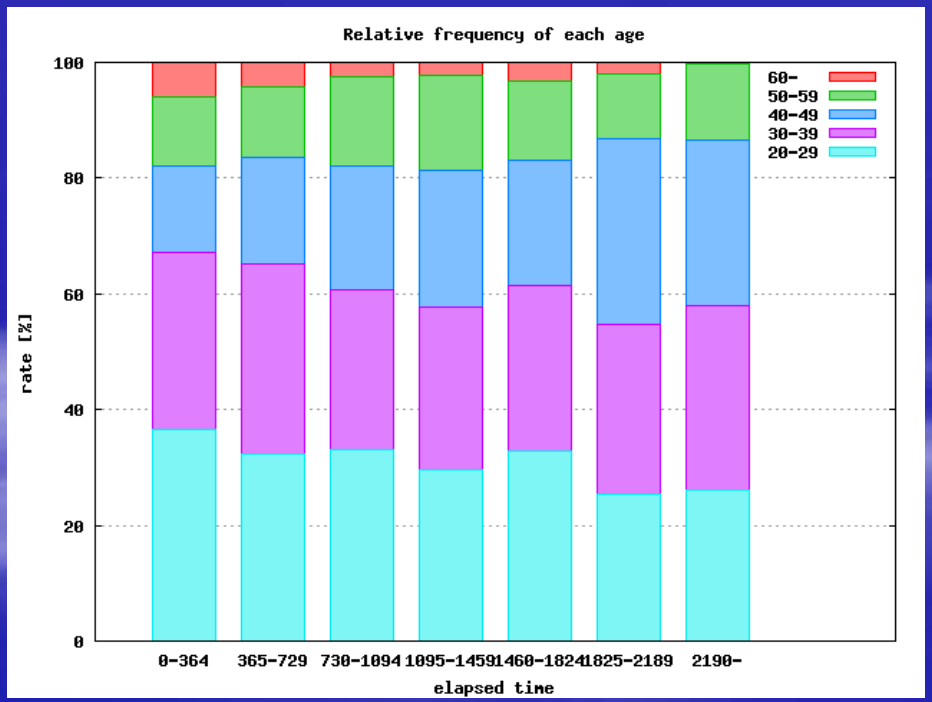


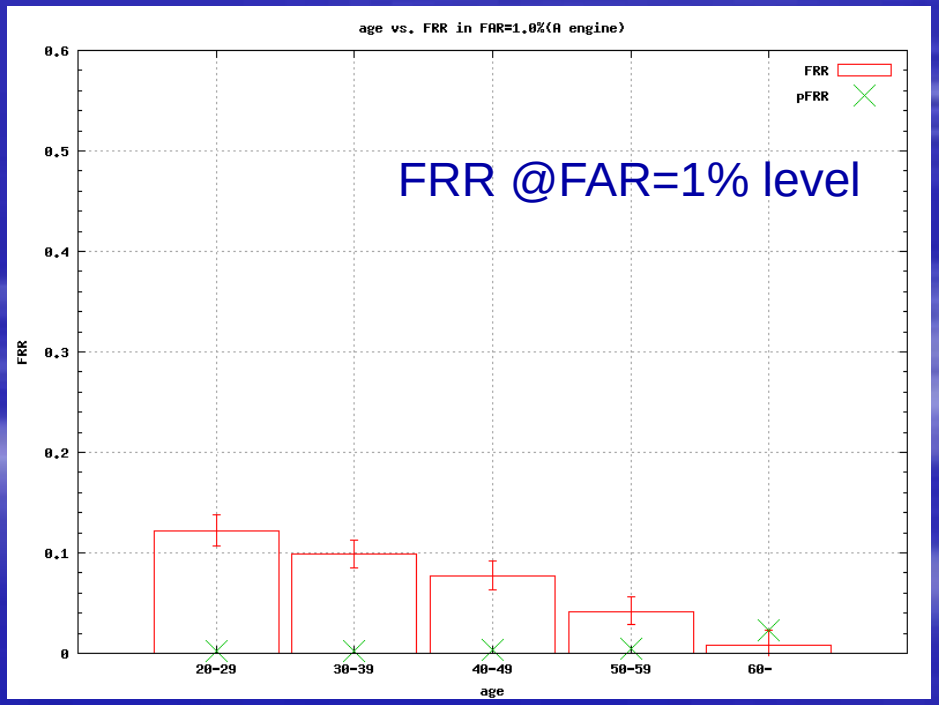
Statistics of Database

Elapsed Year vs. Age Distribution

- Age 20-49 category for more than eighty percent
- 20-29, 30-39 and 40-49 categories show almost equal proportion
- Elder age categories are slightly on the up slope

→ FRR should be expected to be slightly on the down slope



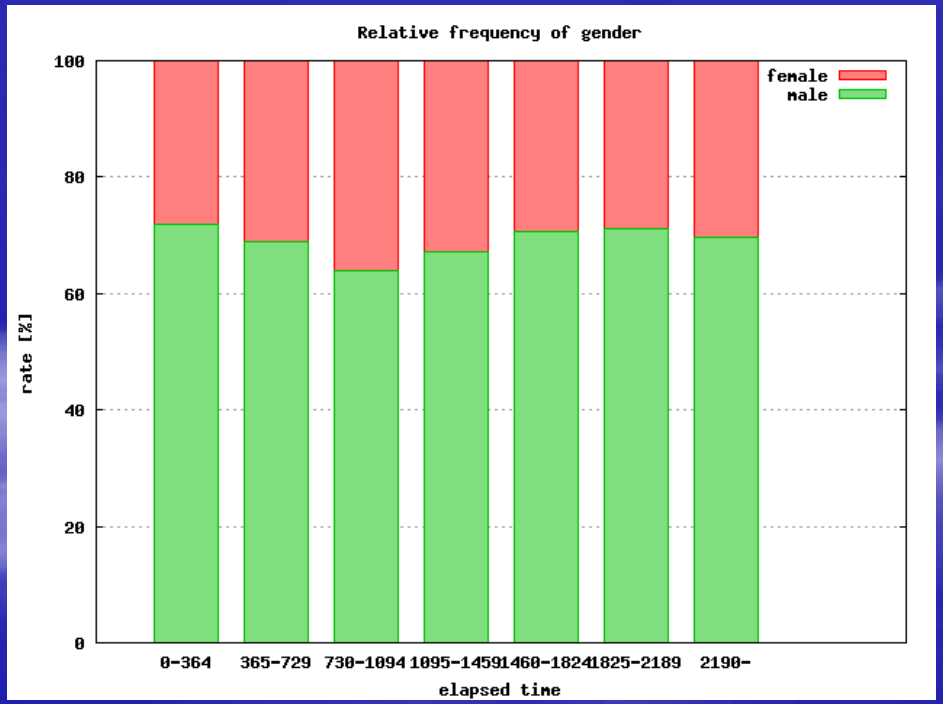


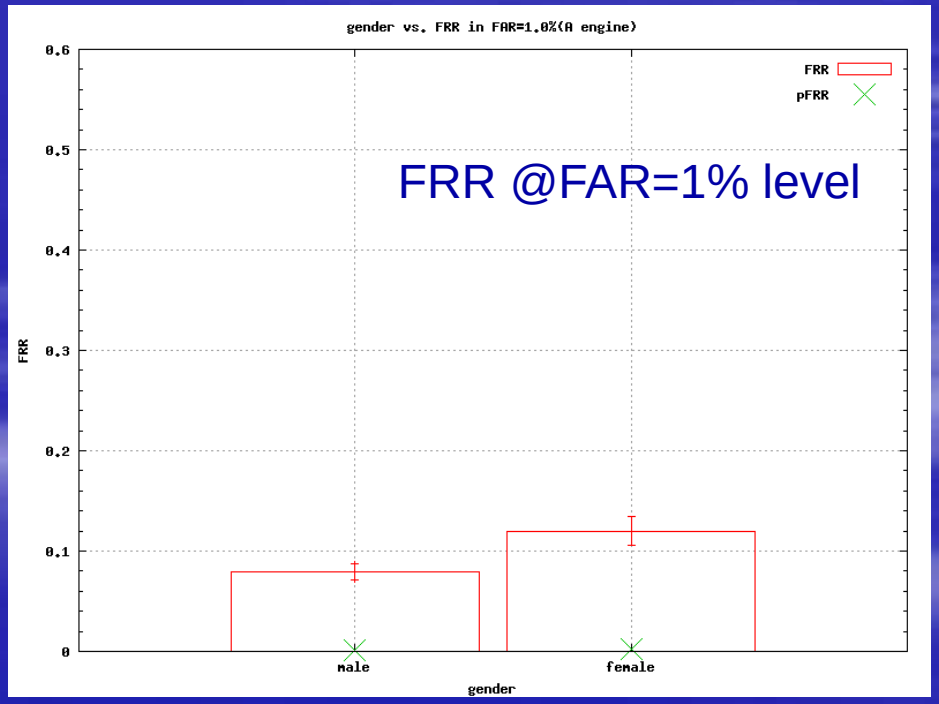
Statistics of Database

Elapsed Year vs. Gender Distribution

- Male proportion is on the down slope from 1 to 3 elapsed years. After this it's on the up slope

→ FRR should be expected to be up from 1 to 3 and then to be down



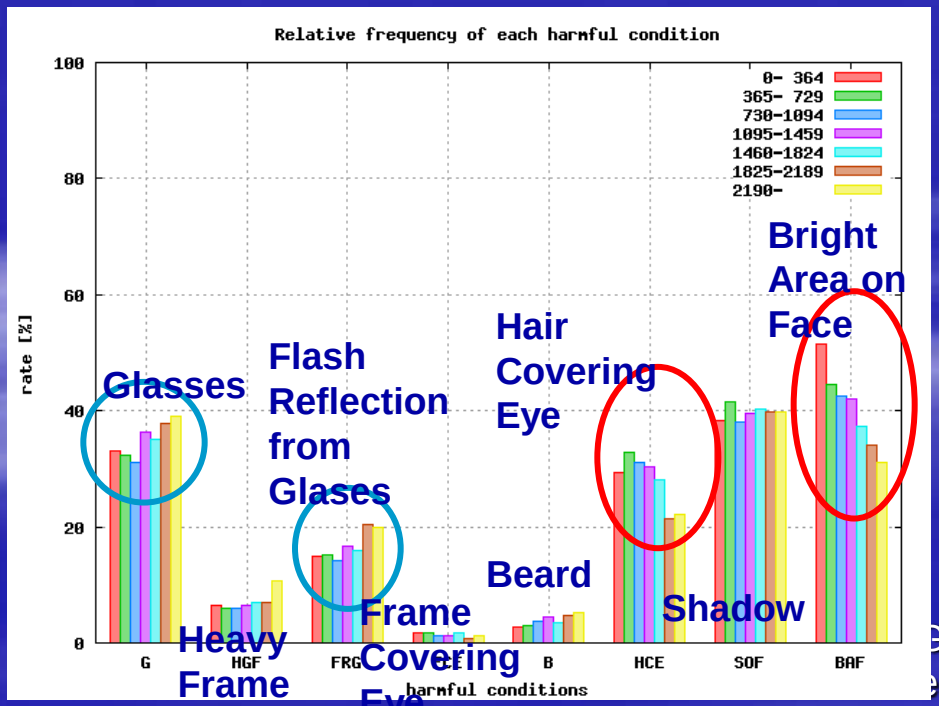


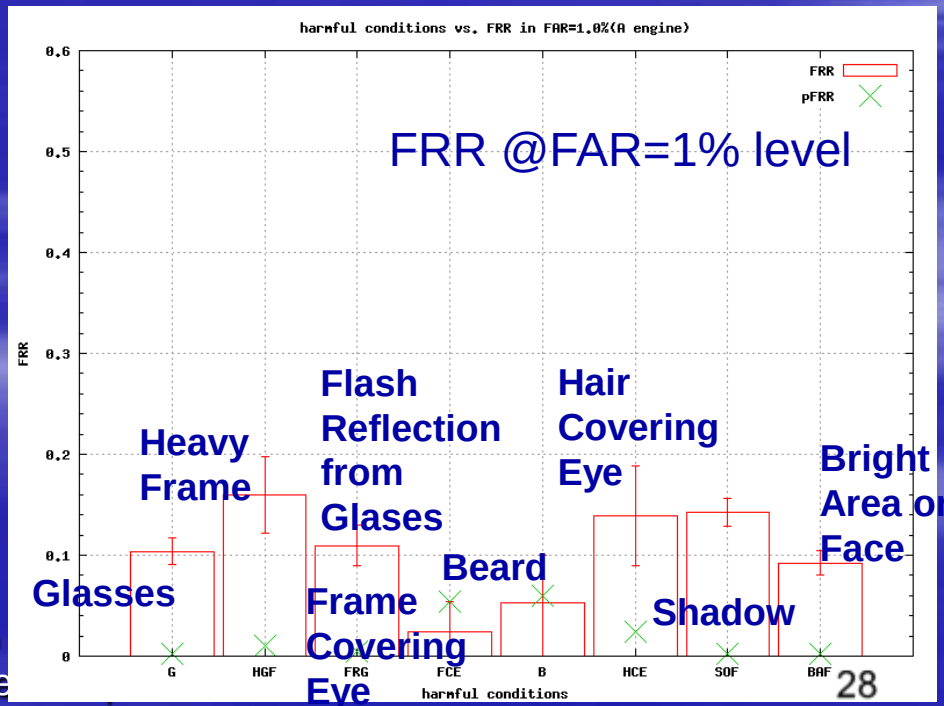
Statistics of Database
Elapsed Year vs. Factors Affecting Accuracies

- Down trend: hair covering eye (- 8%) / bright area of light shining on face (- 17%)
- Up trend: glasses (+5%) / flash or light reflecting from glasses(+5%)

→ FRR should be expected to be on the down slope if these are independent events

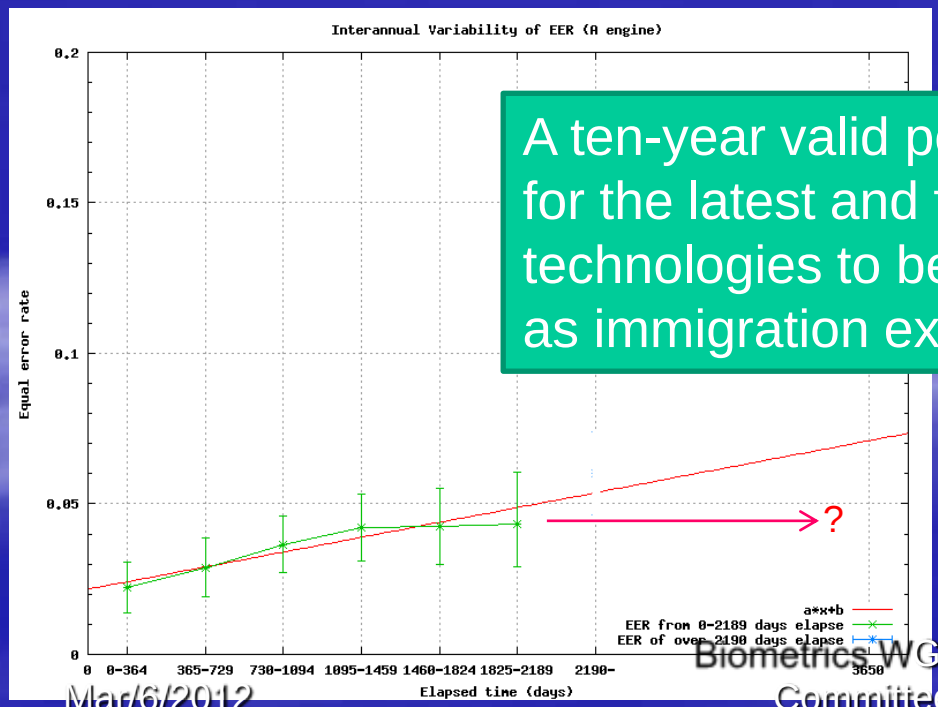
(-0.08)*14%+(-0.17)*9%+0.05*10%+0.05*11%=-1.6%



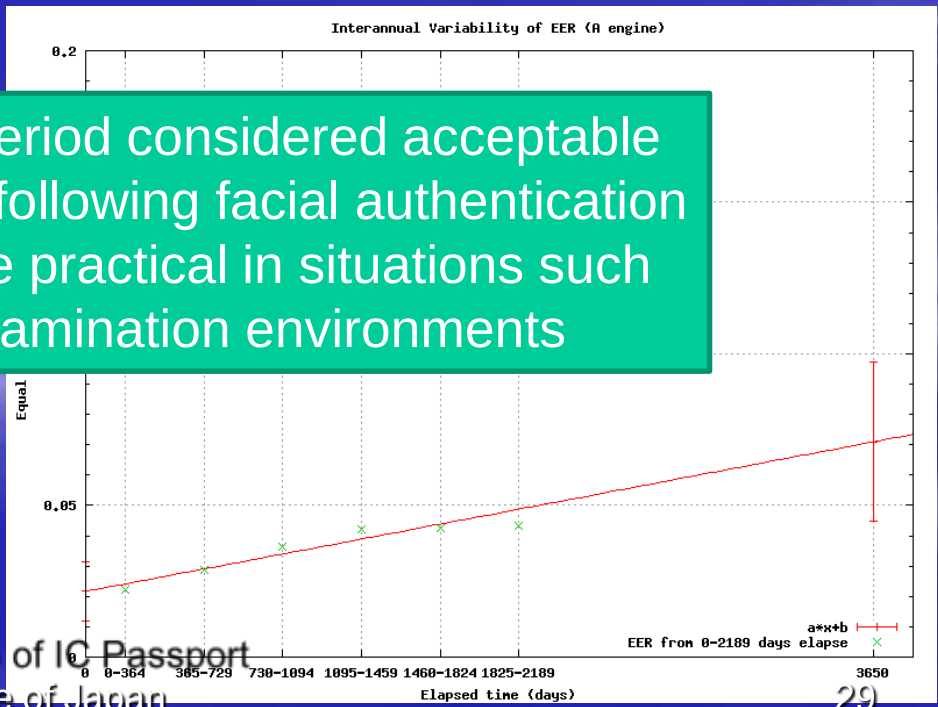


Elapsed Time vs. EER / Estimated EER after Ten Years

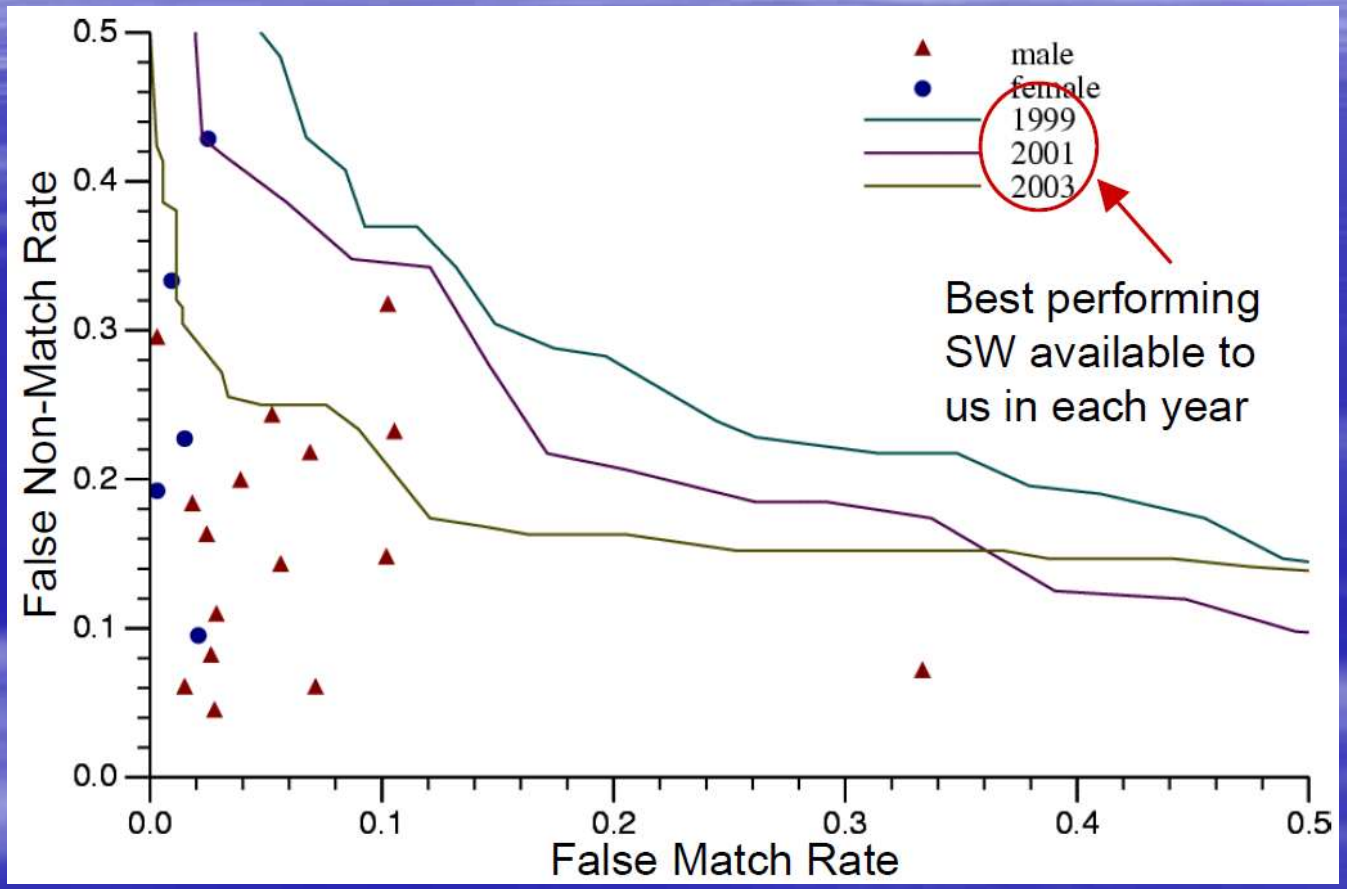
- A linear function and a weighted least-square method were applied to interpret inter-annual variables in the experimental results. (residual error value: 0.92 that is small enough to 9.49 at confidence level 95%)
- The statistical estimation shows EER of 7.1% after ten full years elapsed, and the hypothesis that EER would be more than 10 % should be discarded according to significance test at confidence level 95%)



A ten-year valid period considered acceptable for the latest and following facial authentication technologies to be practical in situations such as immigration examination environments



(informative) Human and Automatic Face Recognition Performance



A. Adler and J. Maclean, 'Human and Automatic Face Recognition Performance,' 2004.

Thanks!