BIOMETRIC PERFORMANCE AND USABILITY STUDY OF COMMERCIAL FINGERPRINT SENSORS

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OUTLINE

- Commercial fingerprint scanners
- Database
- Test tools
- Experiments and Results
  - Basic Performance
  - Interoperability performance
  - Usability analysis
  - Users' opinions analysis
- Conclusions

COMMERCIAL FINGERPRINT DEVICES

- 4 commercial fingerprint readers
  - One device two configurations
  - FBI PIV IQS compliant

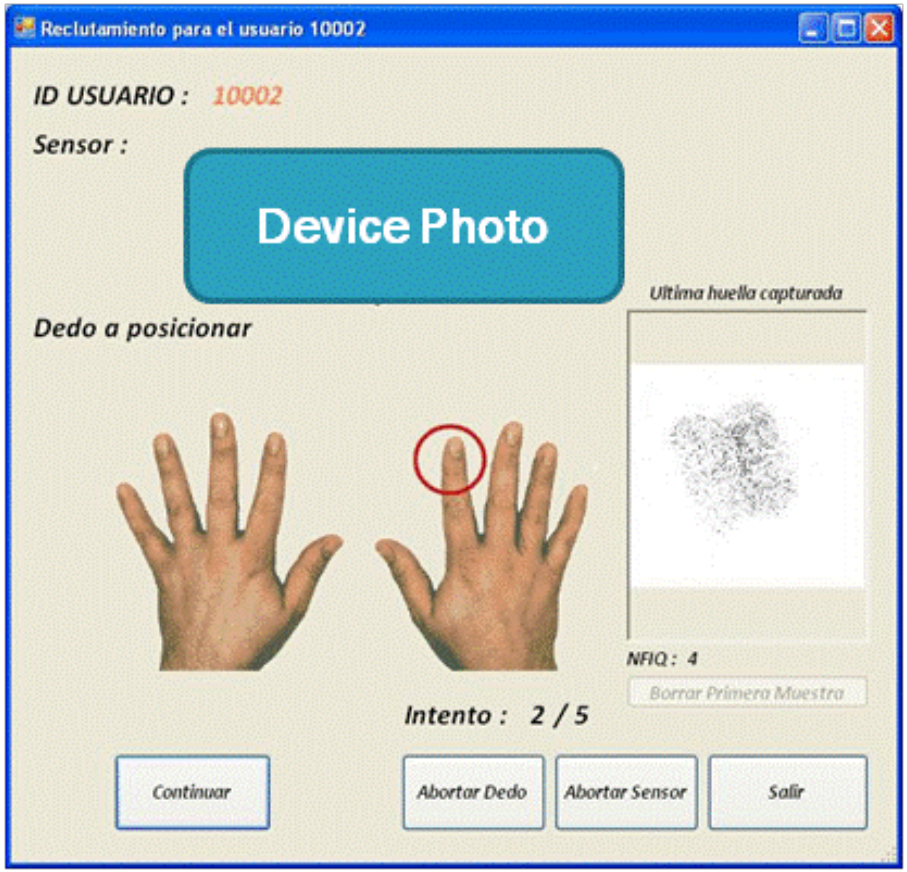
Device	Sensing technique	Type of interaction	Type of fingerprint Images	
O1	Optical	Touch-flat	Single-finger	Flat
O2	Optical	Touch-flat	Single-finger	Flat
CS	Capacitive	Swipe	Single-finger	Flat
OF	Optical	Touch-flat	Dual-finger	Flat
OR	Optical	Touch-roll	Single-finger	Roll

DATABASE ACQUISITION (I)

- 3 Visits
  - Two weeks between visits
    - V1: Training, enrolment and 1st session
    - V2: 2nd session
    - V3: 3rd session and questionnaires
- Samples from both hands
  - Thumb, index and middle fingers (6 fingers per user)
- Random process
  - 1st – Devices
  - 2nd – Hands
  - 3rd – Fingers

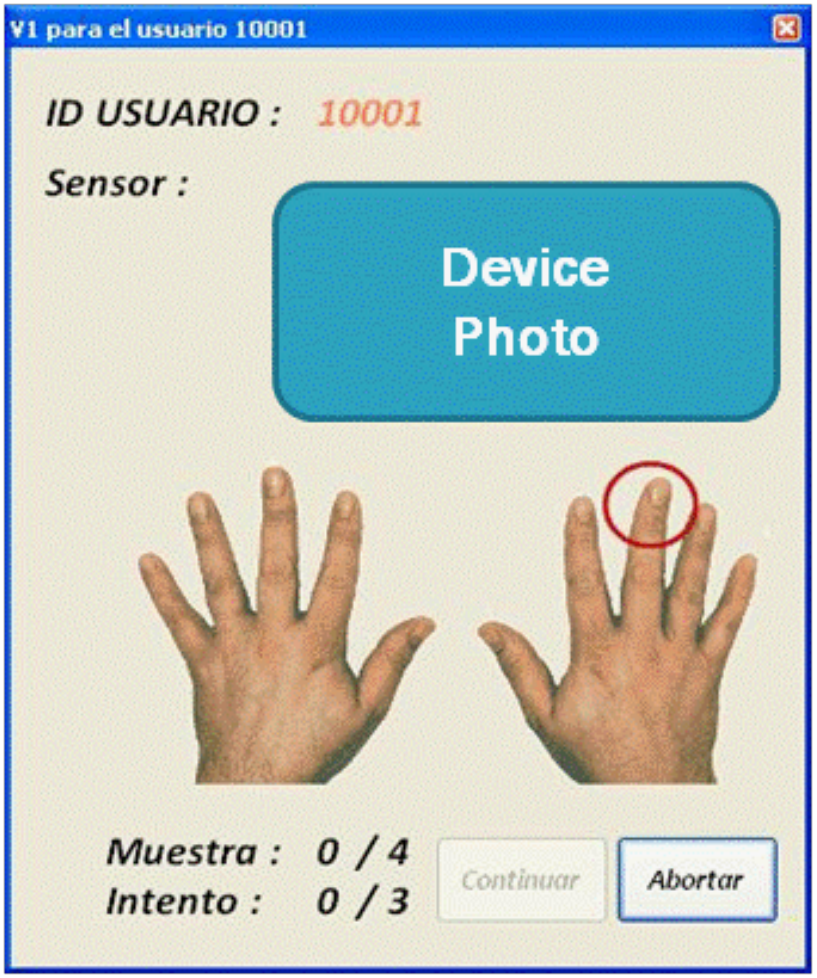
DATABASE ACQUISITION (II)

- Enrolment
  - 2 samples per finger
  - A maximum of 5 attempts per finger
  - NFIQ <= 3
  - Visual Inspection
  - Guided process



DATABASE ACQUISITION (III)

- Sessions
  - 4 samples per finger
  - A maximum of 3 attempts per finger
  - NFIQ <= 4
  - Non-guided process



COLLECTED DATABASE

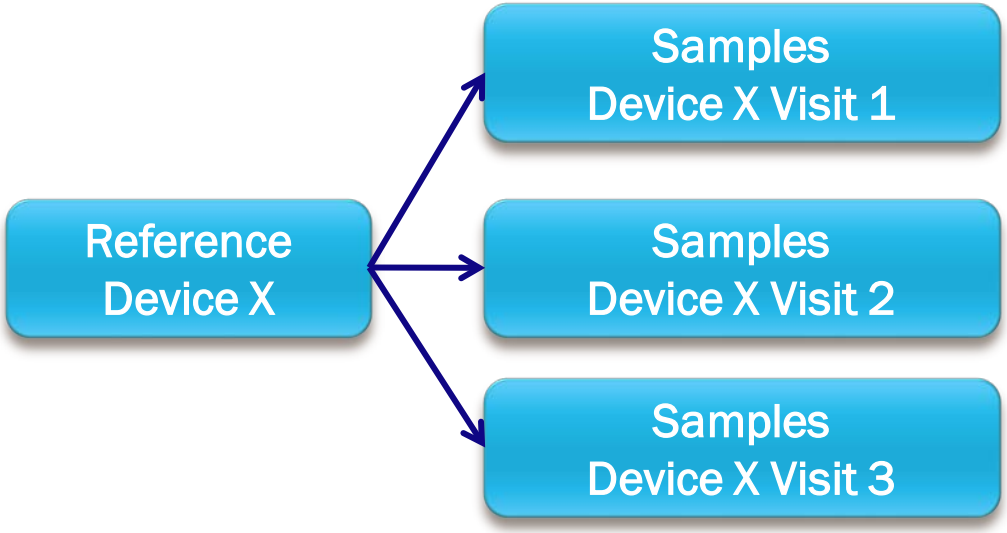
- 70 users
  - 67 users completed the 3 visits
- Age distribution
  - 70% < 30 years old
  - 23% 30 to 50 years old
  - 7% > 50 years old
- Gender distribution
  - 76 % males
  - 24 % females
- Habituation
  - 67% of users have already used a biometric application
  - 33% of users have not used a biometric application

TEST TOOLS

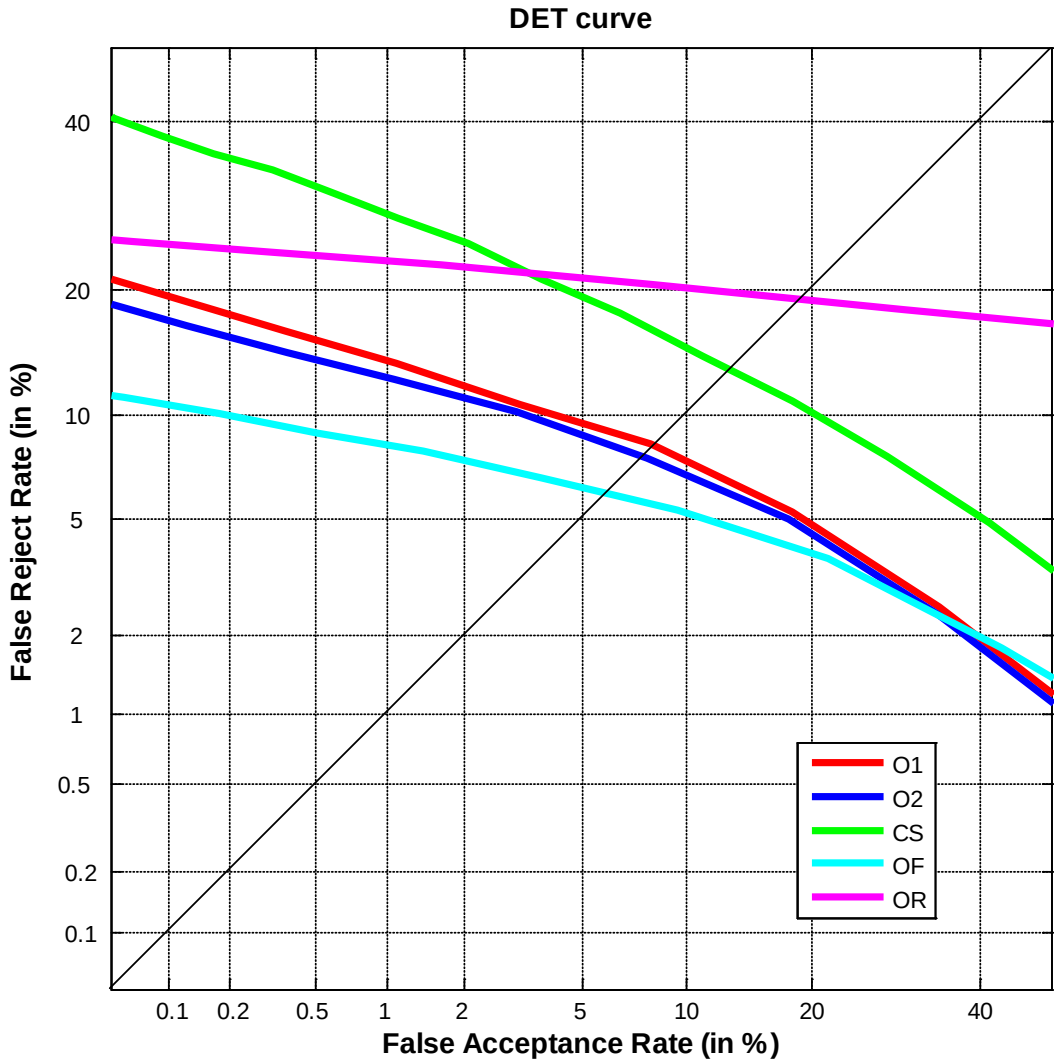
- NFIQ calculation, feature extraction and comparison algorithms
  - Reference implementation
    - NIST Biometric Image Software (NBIS)
- Performance rates calculation
  - Reference implementation for performance evaluation of a biometric verification system
    - BioSecure Tool

EXPERIMENTS

- Basic performance
  - Separate visits
  - Genuine and Impostor comparisons
    - Impostor comparisons: samples that come from different users
  - For all devices (X=1:5)

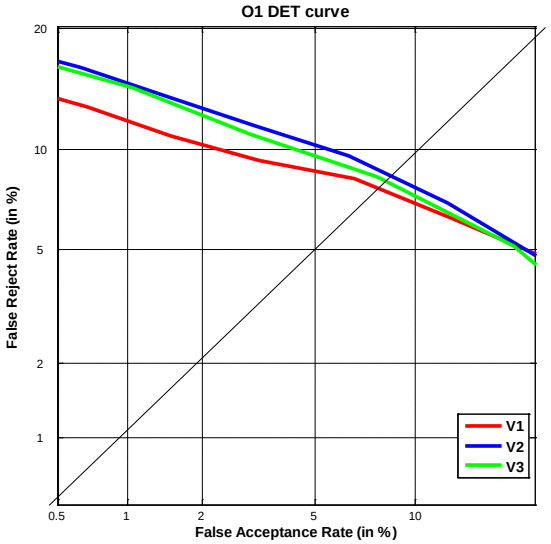


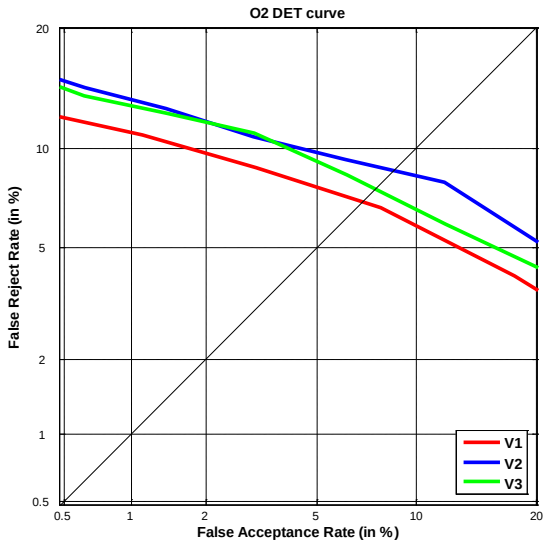
BASIC PERFORMANCE

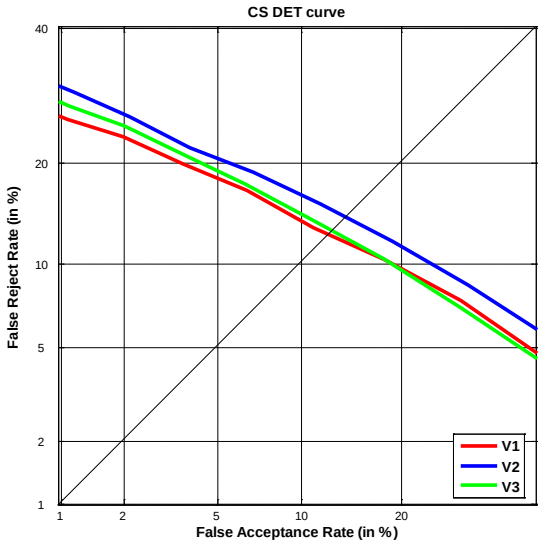


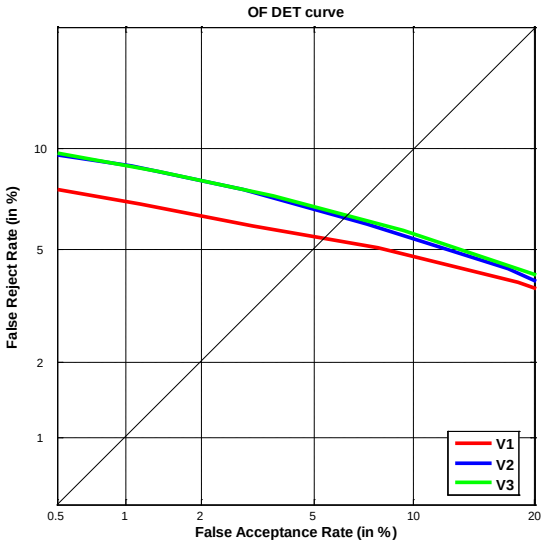
Device	EER (%)
O1	8.17 ± 0.34
O2	7.71 ± 0.33
CS	12.64 ± 0.49
OF	5.20 ± 0.38
OR	24.13 ± 0.53

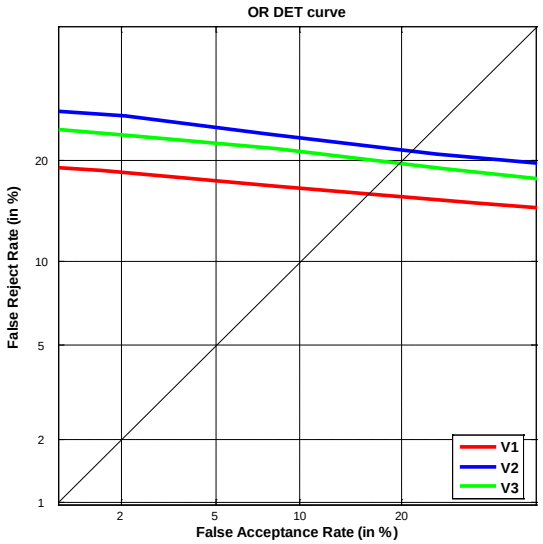
PERFORMANCE ACROSS VISITS





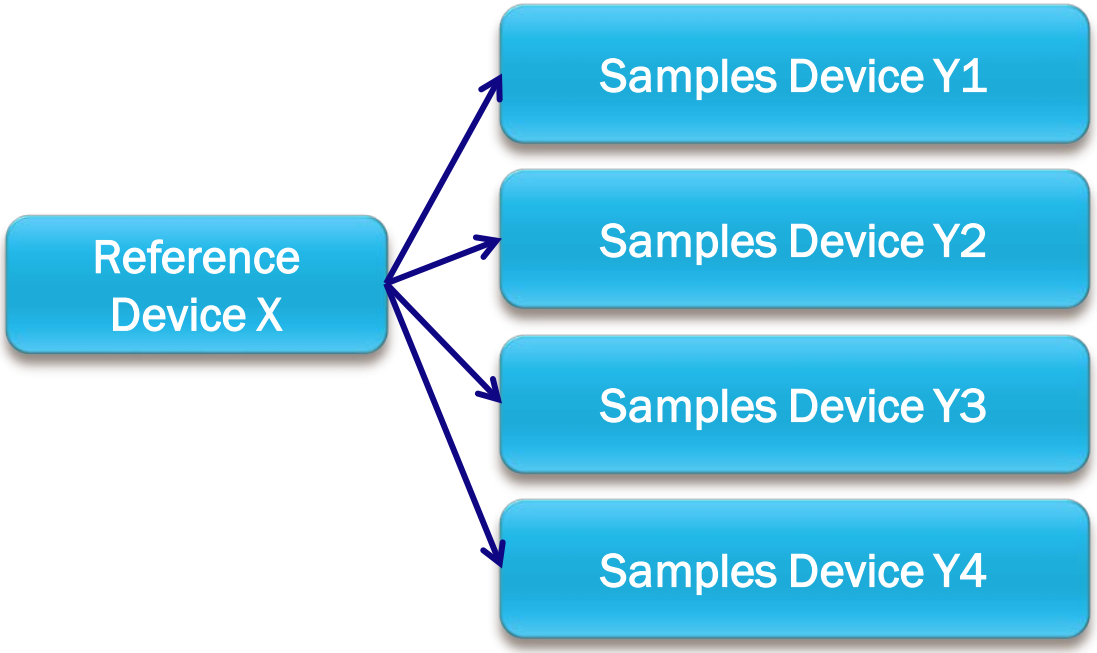




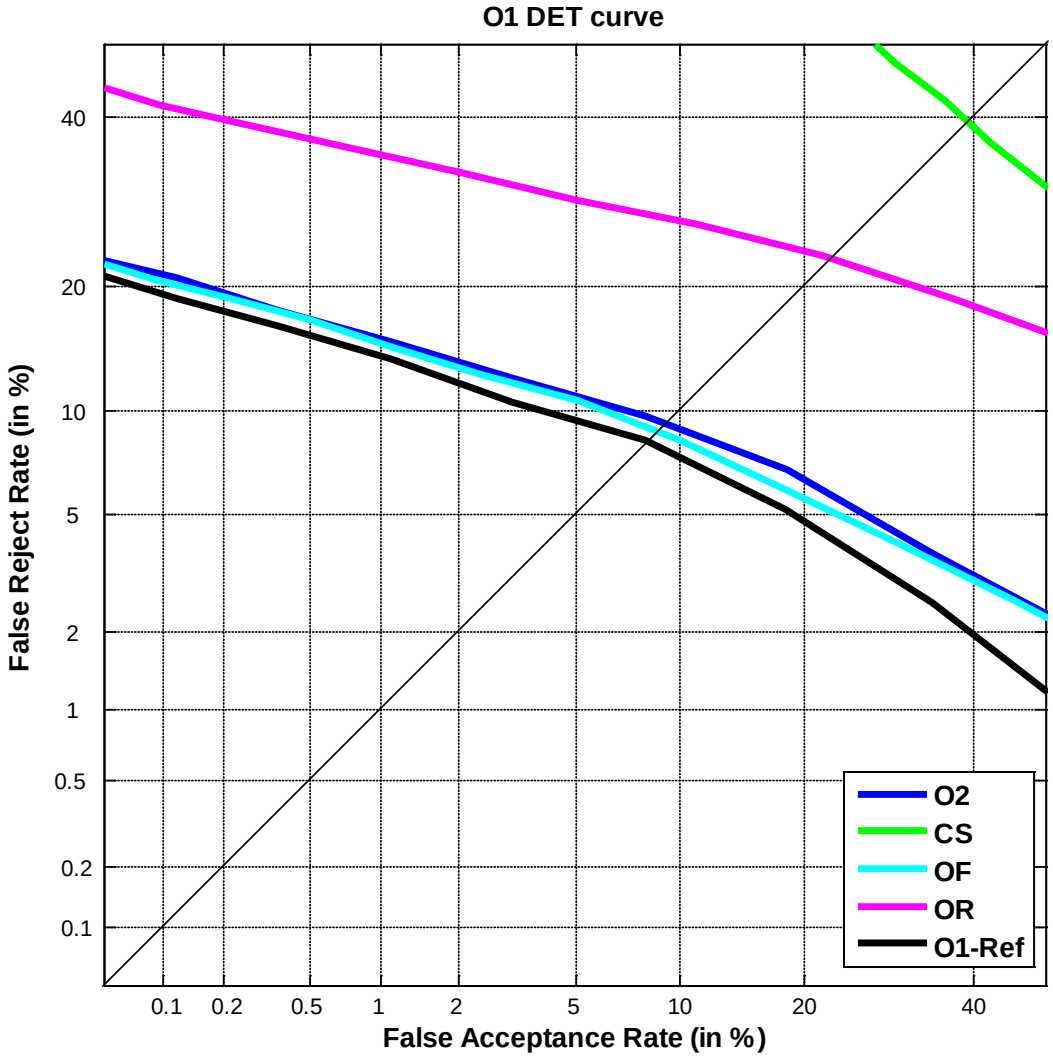


EXPERIMENTS

- Interoperability performance
  - Genuine and Impostor comparisons
    - Impostor comparisons: samples that come from different users
  - For all devices (X=1:5)

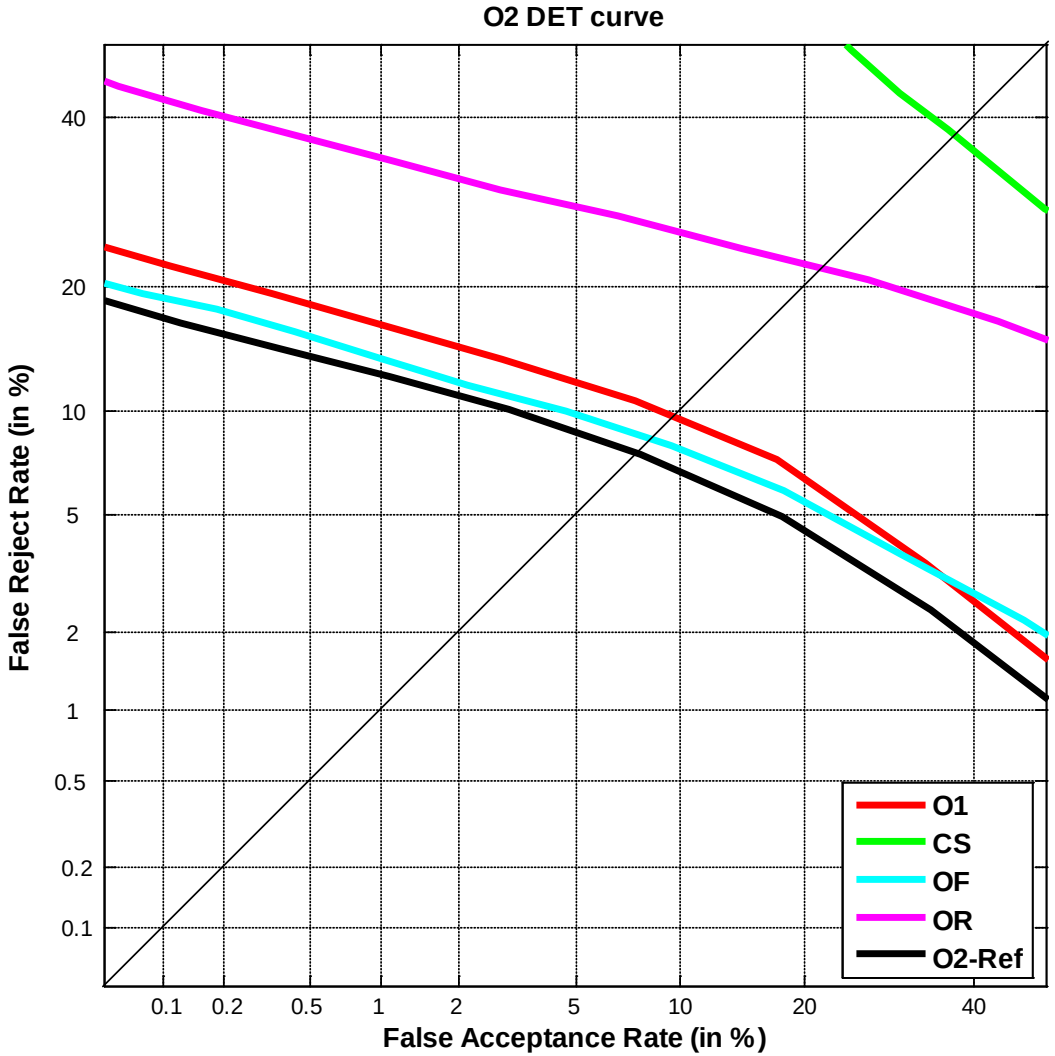


INTEROPERABILITY PERFORMANCE – O1



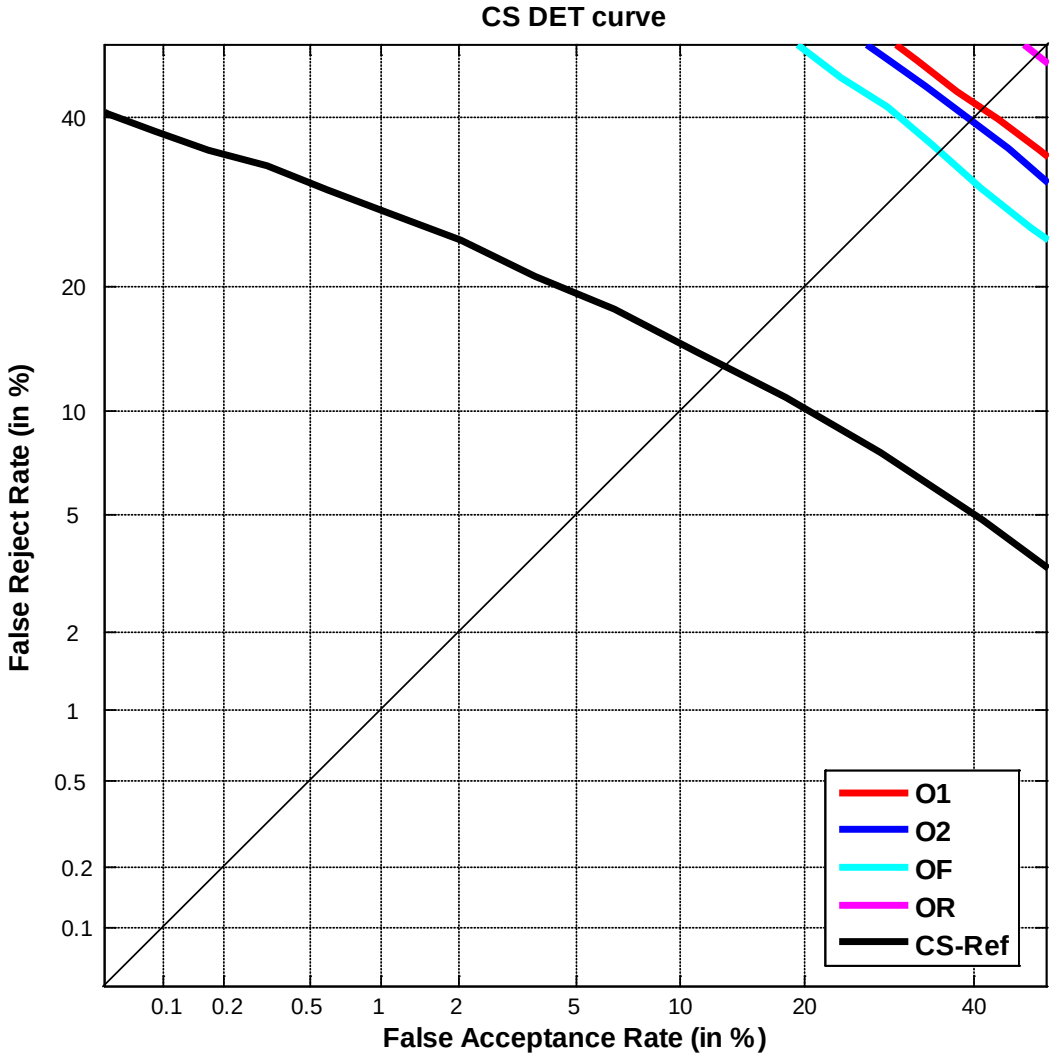
Device	EER (%)
O1-Ref	8.17 ± 0.34
O2	8.86 ± 0.37
CS	39.57 ± 0.68
OF	9.19 ± 0.42
OR	22.41 ± 0.57

INTEROPERABILITY PERFORMANCE – O2



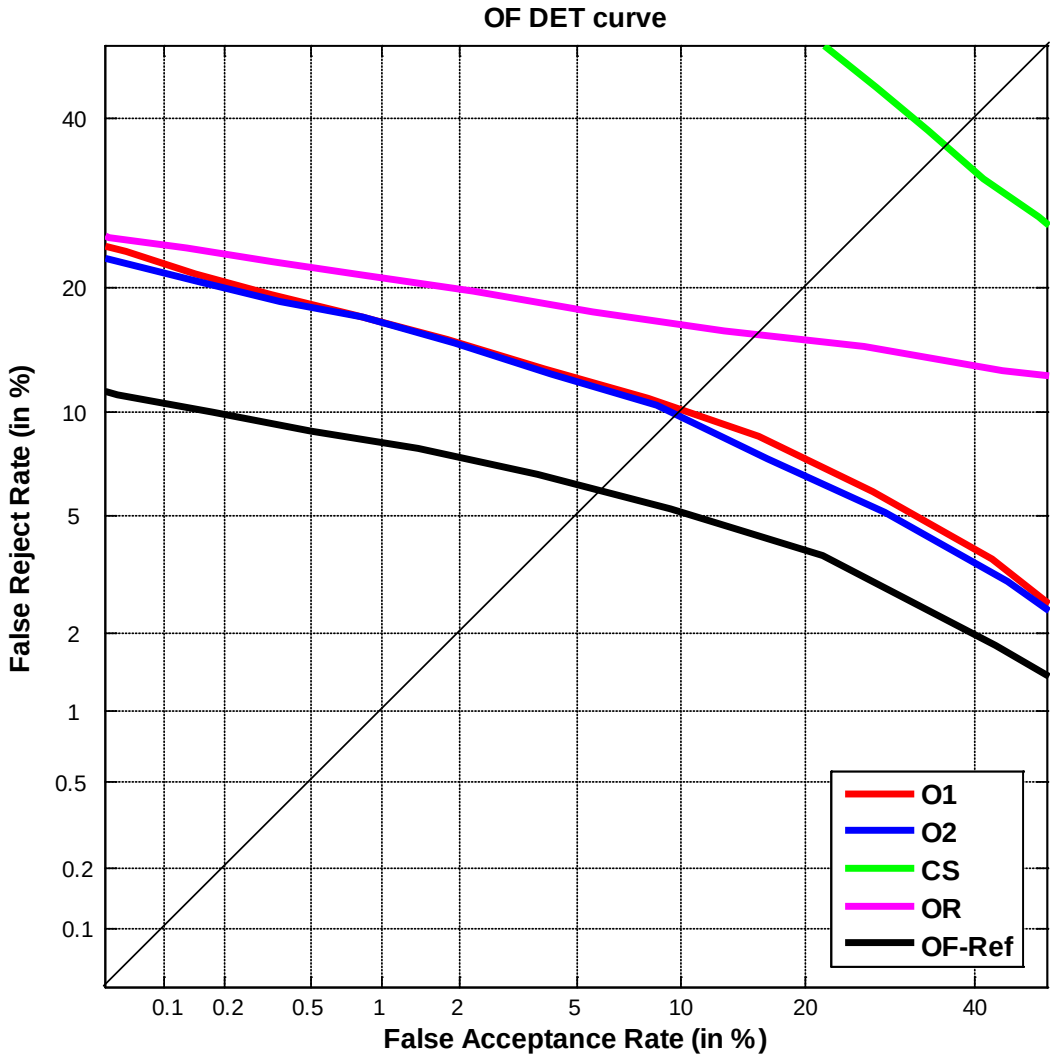
Device	EER (%)
O2-Ref	7.71 ± 0.33
O1	9.12 ± 0.38
CS	37.46 ± 0.68
OF	8.81 ± 0.418
OR	23.70 ± 0.55

INTEROPERABILITY PERFORMANCE – CS



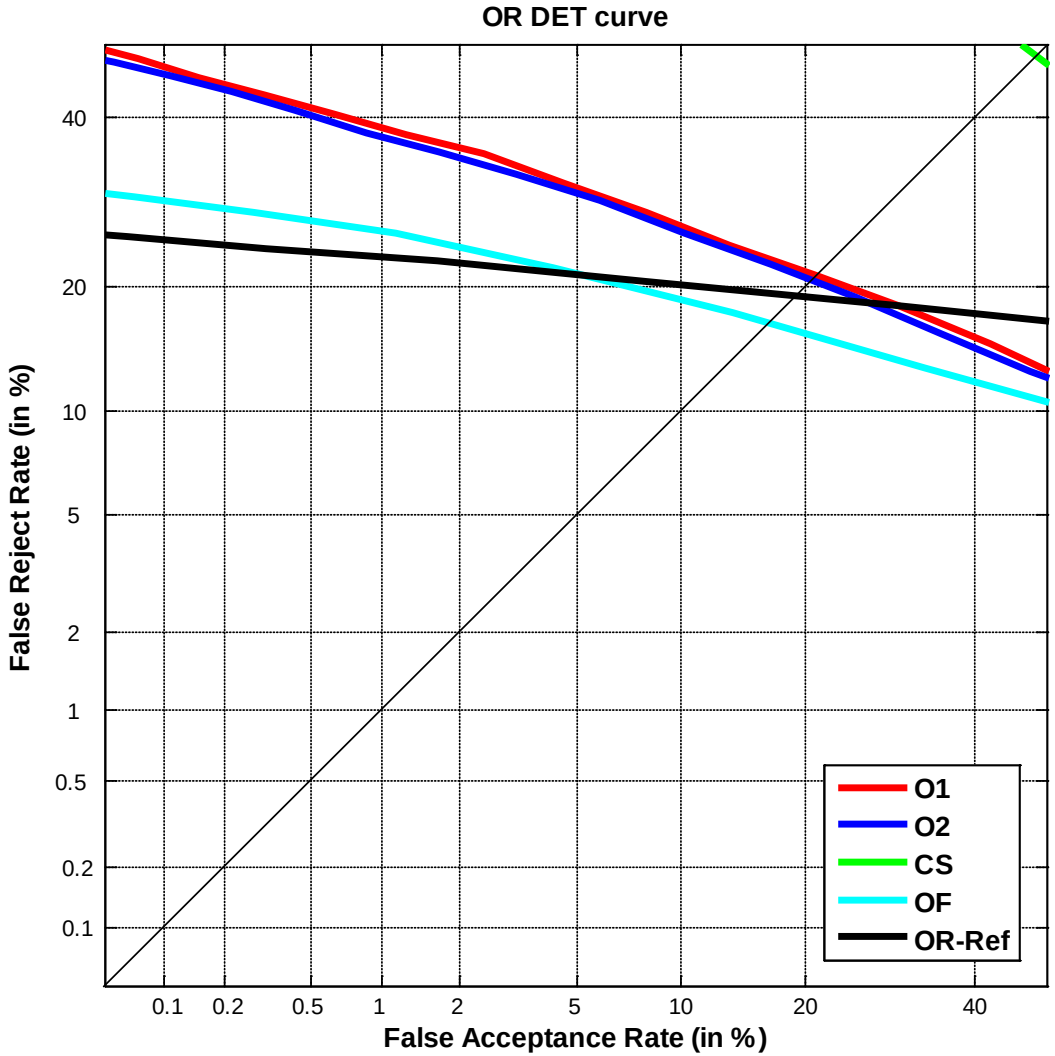
Device	EER (%)
CS-Ref	12.64 ± 0.49
O1	41.67 ± 0.63
O2	39.56 ± 0.63
OF	35.53 ± 0.75
OR	48.94 ± 0.67

INTEROPERABILITY PERFORMANCE – OF



Device	EER (%)
OF-Ref	5.20 ± 0.38
O1	9.52 ± 0.47
O2	9.50 ± 0.47
CS	36.28 ± 0.83
OR	14.44 ± 0.6

INTEROPERABILITY PERFORMANCE – OR



Device	EER (%)
OR-Ref	24.13 ± 0.53
O1	20.95 ± 0.53
O2	19.40 ± 0.63
CS	48.44 ± 0.72
OF	15.53 ± 0.59

USABILITY EXPERIMENTS

- Automatic errors
- Measurements:
  - Enrolment:
    - % users enrolled per each attempt
    - FTE (Failure to enrol)
    - FTC (Failure to capture) for O2, OF and OR
  - Sessions
    - FTA per visit
    - Overall FTA (Failure to acquire)
    - FTC (Failure to capture) for O2, OF and OR

USABILITY RESULTS – ENROLMENT

Device	% users enrolled per each attempt				FTE	FTC
	Two attempts	Three attempts	Four attempts	Five attempts		
01	96 %	98 %	98.7%	99.25 %	0.74 %	---
02	95.53 %	98.2 %	98.7%	99.55 %	0.49 %	0.45 %
CS	74.19 %	82.38%	86.35 %	88.33 %	11.66 %	---
OF	91.79 %	96.24 %	97.74 %	97.74 %	2.25 %	4.37 %
OR	62.42 %	73.80 %	81,36 %	85.64 %	14.35 %	32.64 %

USABILITY RESULTS – SESSIONS

Device	FTA per visit			Overall FTA	FTC
	V1 FTA	V2 FTA	V3 FTA		
01	0.18 %	0.86 %	0.94 %	0.66 %	---
02	1.28 %	2.07 %	1,03%	1.45 %	1.82 %
CS	6.51 %	6.71%	7.05 %	6.85 %	---
OF	0.00 %	0.74 %	0.37 %	0.37 %	5.60 %
OR	3.53 %	4.45 %	3.74 %	3.99 %	23.93 %

USER'S QUESTIONNAIRES

- After the 3rd session
- Two parts:
  - Personal data questions: age, gender, level of utilization of biometric applications
  - User's opinion:
    - Images of the devices ("X" mark)
    - Aspects:
      - The easiest and the most difficult to use
      - The most comfortable and most uncomfortable
      - The fastest and the slowest
      - Which device you like the most and which the least
- Analysis considering different ages and gender and level of utilization of biometric applications

USER'S OPINION RESULTS – AGE AND GENDER

- Same opinion in relation to negative aspects (difficulty, lack of comfort, slowness, do not like)
  - OR: rolled fingerprints
- Different opinion in relation to positive aspects

Charasteristic	MALES			FEMALES		
	< 30	30-50	> 50	< 30	30-50	> 50
Easiness	01	0F	01	0F	0F	01
Comfort	01	01	01	01	0F	01
Speed	01	0F	01	02	0F	01
Like	0F	01	01	0F	02	01

USER'S OPINION RESULTS – LEVEL OF HABITUATION

- Same opinion in relation to negative aspects (difficulty, lack of comfort, slowness, do not like)
  - OR: rolled fingerprints
- Different opinion in relation to positive aspects

Charasteristic	HABITUATED			NON-HABITUATED		
	< 30	30-50	> 50	< 30	30-50	> 50
Easiness	0F	0F	01	02	0F	01
Comfort	01	0F	01	01	0F	01
Speed	02	0F	02	01	0F	01
Like	0F	01	01	0F	01	01

CONCLUSIONS (I)

- Basic performance
  - High performance for optical devices which entail a touch-flat interaction
  - High performance at the first visit when users are training
  - For the rest of visits: the more visits are conducted, the better performance is
- Interoperability performance
  - Performance is higher for devices that use the same sensing technique and the same type of interaction
  - If different devices are used for enrolment and for verification, it will be better to use devices with similar sensing technique

CONCLUSIONS (II)

- Usability
  - Usability errors are more dependent on the type of interaction than the sensing technique
  - The number of acquisition errors are higher for devices that require a non-static interaction:
    - Touch -roll
    - Swipe
- User's opinion
  - Users do not like devices that require a complex interaction
  - User's opinion is dependent of the age of the user but other parameters such as gender and level of habituation do not influence in their opinions

THANK YOU
FOR YOUR ATTENTION

ACKNOWLEDGEMENT

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