Challenges of Integrating NFIQ into an Existing Biometric Application

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NIST Biometric Quality Workshop
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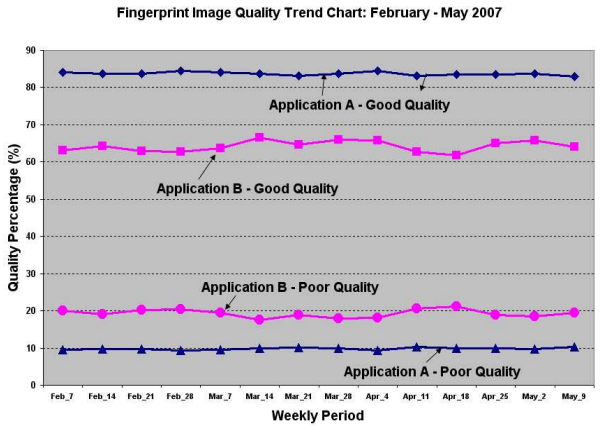
Agenda

- **Overview**
  - US-VISIT Biometrics Quality Assurance
  - Use of Fingerprint Image Quality Scores in US-VISIT
- **NFIQ and IDENT Scores**
  - Score Range and Initial Mapping
- **Where NFIQ Encounters Challenges**
  - Score Mapping and Correlation of NFIQ = 3
- **Desired Characteristics of an Image Quality Score Algorithm and Its Score Range**
- **Summary**

IDENT Image Quality Monitoring, Reporting and Analysis

Image Quality Reports:

- By application
- By site/terminal
- By capture device
- By new or repeated subject
- By matcher enrollment
- By finger and between fingers
- Trend analysis



#	Application	FingerType	TotalImages	Good (Q1-Q4) %	Ave. (Q5-Q6) %	Poor (Q7-Q8) %
1	Application-A	F	9562	91.00	3.44	5.56
2	Application-A	R	490	69.80	11.43	18.78
3	Application-B	F	3554	89.62	3.97	6.42
4	Application-B	R	72	75.00	9.72	15.28
5	Application-C	R	1922	77.84	10.25	11.91
6	Application-D	R	40	17.50	27.50	55.00
7	Application-E	R	500	76.40	11.60	12.00
8	Application-F	F	6962	83.34	6.92	9.74

Summary Report

All Subject Encounters

Application	TotalImages	Q1%	Q2%	Q3%	Q4%	Q5%	Q6%	Q7%	Q8%
	1205636	29.71	21.01	18.35	15.98	3.61	2.41	1.88	7.03

Application	TotalImages	Good % (Q1-Q4)	Average % (Q5-Q6)	Poor % (Q7-Q8)
	1205636	85.06	6.03	8.92

Detailed Report by Site and by Terminal within the Site

SiteCode	SiteName	TerminalID	TotalImages	Good % (Q1-Q4)	Average % (Q5-Q6)	Poor % (Q7-Q8)
Site-A	JFK INTL AIRPORT (TERMINAL 4)	WJFK_A_T1	1338	88.27	5.16	6.58
Site-A	JFK INTL AIRPORT (TERMINAL 4)	WJFK_A_T2	2604	88.17	5.41	6.41
Site-A	JFK INTL AIRPORT (TERMINAL 4)	WJFK_A_T3	3054	88.54	5.40	6.06
Site-A	JFK INTL AIRPORT (TERMINAL 4)	WJFK_A_T4	3066	91.55	4.47	3.98
Site-B	MIAMI INTL AIRPORT	WMIA_B_T1	1690	85.03	6.45	8.52
Site-B	MIAMI INTL AIRPORT	WMIA_B_T2	3726	88.81	5.26	5.93
Site-B	MIAMI INTL AIRPORT	WMIA_B_T3	1572	88.30	4.77	6.93
Site-B	MIAMI INTL AIRPORT	WMIA_B_T4	1624	85.41	5.60	8.99
Site-C	DULLES INTL AIRPORT	WDIA_C_T1	896	78.35	6.36	15.29
Site-C	DULLES INTL AIRPORT	WDIA_C_T1	928	85.02	5.60	9.38
Site-C	DULLES INTL AIRPORT	WDIA_C_T1	984	81.91	6.91	11.18
Site-C	DULLES INTL AIRPORT	WDIA_C_T1	1870	83.74	6.36	9.89

Scanner	Application	TotalImages	Good % (Q1-Q4)	Ave. % (Q5-Q6)	Poor % (Q7-Q8)
A	App-X	862	48.96	24.01	27.03
B	App-X	13644	87.72	6.77	5.50
C	App-X	14346	91.64	4.41	3.95

	Good (Q1 - Q4) %	Average (Q5 - Q6) %	Poor (Q7 - Q8) %
Matcher A	76.68	9.14	14.18
Matcher B	87.20	5.77	7.03
Matcher C	88.49	6.06	5.45

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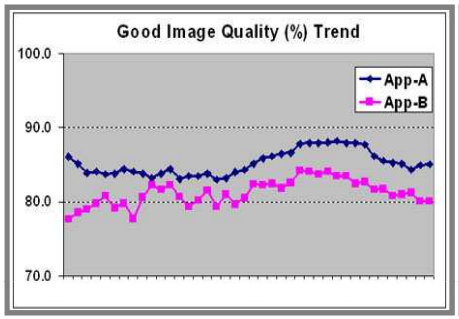
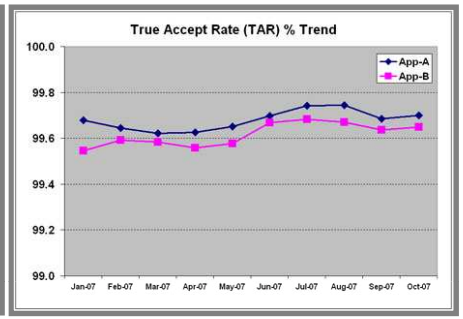
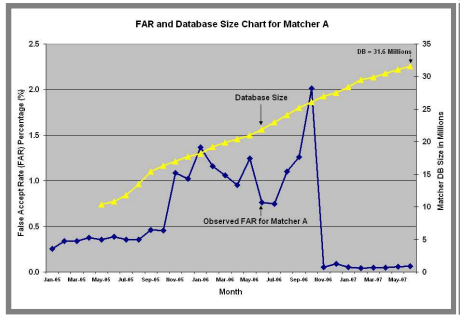
IDENT Matcher Accuracy Monitoring, Reporting and Analysis

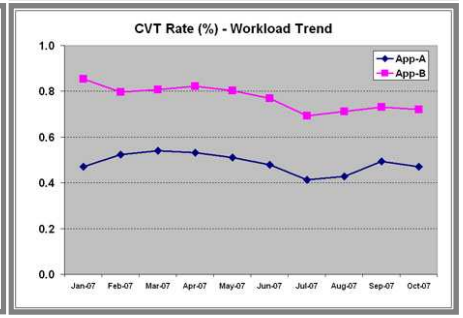
Accuracy, Performance and Trend:

- 1:1 True Accept Rate (TAR)
- 1:N False Accept Rate (FAR)
- Examiner (CVT) Workload
- FAR vs. Database Size









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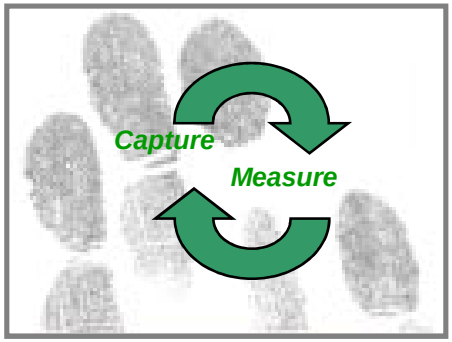
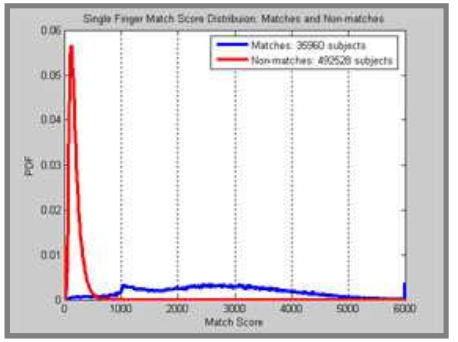
Use of Fingerprint Image Quality Scores in US-VISIT

Usages:

- Fingerprint Recapture
- Updating Prints on Matchers
- Match Accuracy Prediction/Optimization





Objectives:

- Ensure High Quality Fingerprint (Biometrics) Capture
- Ensure High Fingerprint (Biometrics) Identification Performance

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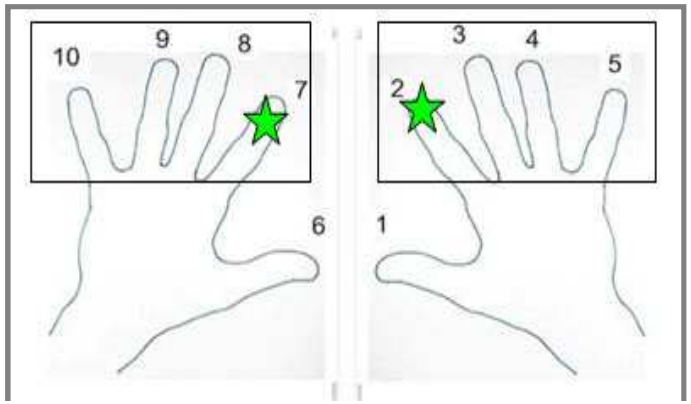
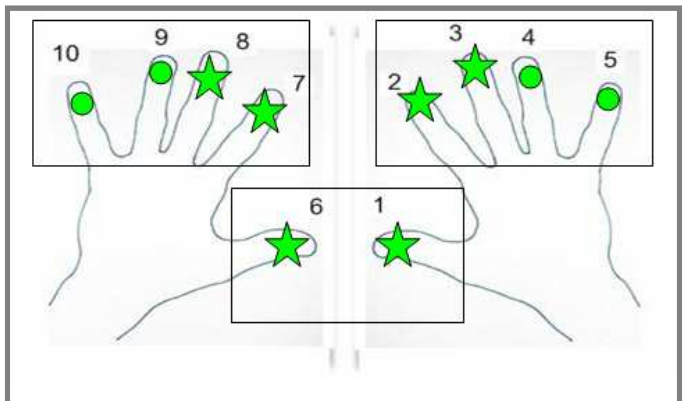
Fingerprint Recapture

Current 2-Print System



Emerging 10-Print System



Client Image Quality Checks

- Quality check of individual fingers
- Recapture requested if the specified thresholds for the individual fingers are not met

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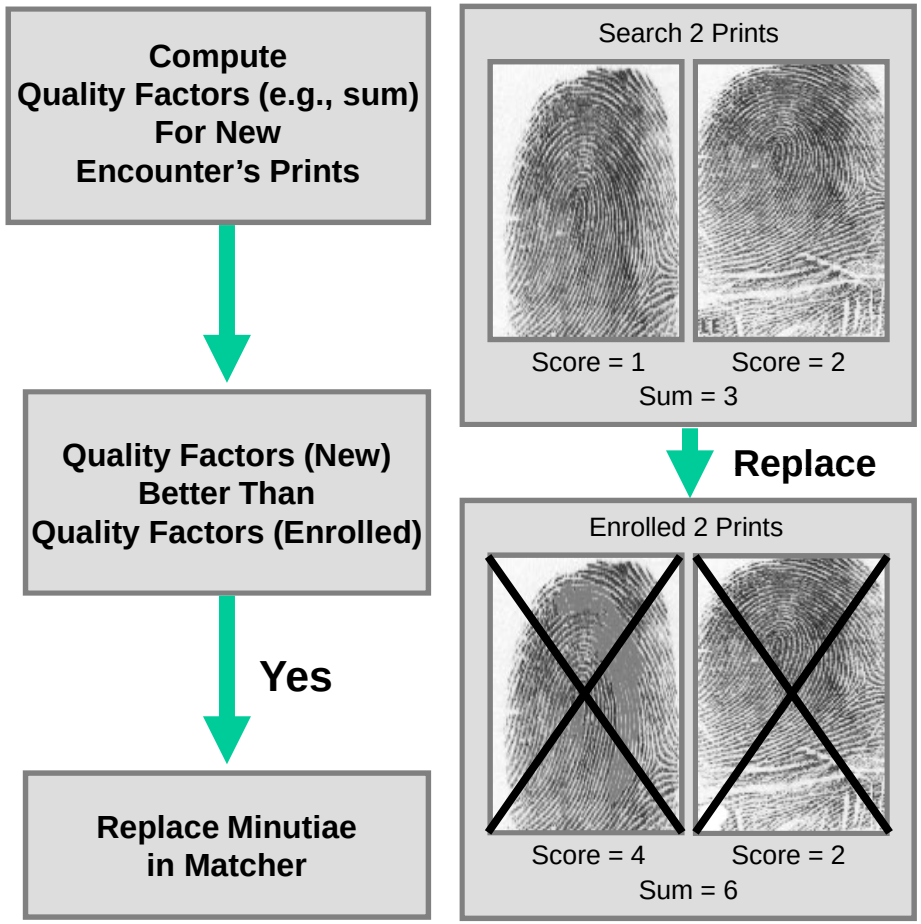
Fingerprint Updating Based on Quality

Existing Implementation:

- Perform best quality fingerprint updates when the sum of the IDENT quality scores is less than the sum of the scores of the enrolled prints

Proposed Implementation:

- When using NFIQ, similar replacement rules need to be developed



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NFIQ and IDENT Image Quality

IDENT Quality:

- Scores range from 1 to 127
  - 1 is the highest quality
  - 127 is the lowest quality
- Thresholds were created based on match accuracy

NFIQ:

- Scores range from 1 to 5
  - 1 is the highest quality
  - 5 is the lowest quality
- Similar thresholds were created to map to existing IDENT Quality thresholds*

*NFIQ thresholds were based on the following:

- NIST IR 7151 – "Fingerprint Image Quality"
  - NFIQ Scores 1,2,3,4,5
  - Excellent, Very Good, Good, Fair, Poor.
- NIST SP 800-76-1 – "Biometric Data Specification for Personal Identity Verification"
  - "NFIQ values of 1,2, or 3 (i.e., good quality)"

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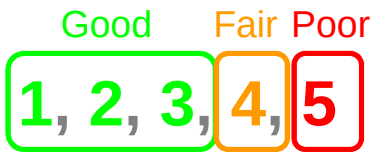
Differences Between NFIQ and IDENT Image Quality

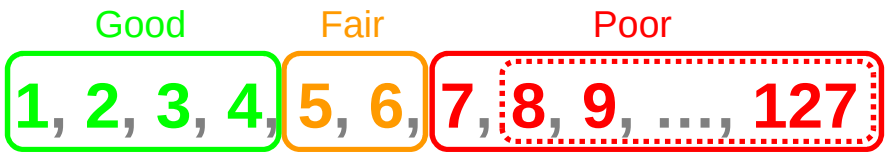
NFIQ Algorithm (1 to 5):



- Direction map
- Contrast map
- Flow map
- High curve map

Quality	1	2	3	4	5
Accuracy	99.4	98.4	88.1	59.4	27.8

IDENT Algorithm (1 to 127):



- Noise level of useful area of image
- Image contrast information
- Size of useful area of image
- Core position and confidence
- Poor quality image area percentage
- Average quality level for minutiae
- Number of minutiae and deleted low confidence minutiae
- Percentage of background image area

Quality	1	2	3	4	5	6	7	8-127
Accuracy	99.4	99.2	99.1	98.2	95.2	89.3	83.0	53.6

* Statistics from NIST IR 7110. "Matching Performance for the US-VISIT IDENT System Using Flat Fingerprints". Values are TAR at FAR 1.0%.

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Score Mapping and Correlation: IDENT vs. NFIQ

- Nice mapping in Very Good and Poor images
- Ambiguities occur in good and fair images (NFIQ = 3 and 4)

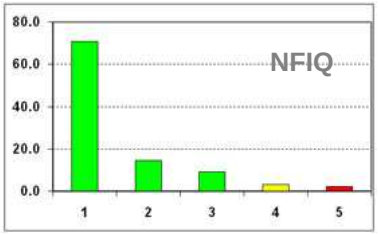
		F2+F7: Total 7364 fingerprints				
		NFIQ Score				
		1	2	3	4	5
IDENT Score	Mean	2.4	3.3	7.6	9.9	15.2
	Median	2	3	7	10	16
	Std.Dev.	1.5	1.9	2.9	3.4	2.8

Good Fair Poor

1, 2, 3, 4, 5

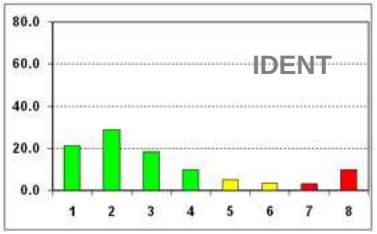
Count		F2+F7: Total 7364 fingerprints					
		NFIQ Score					
		1	2	3	4	5	
IDENT Score	1	1419	143	2	0	0	1564
	2	1816	274	8	4	0	2102
	3	1072	250	25	4	0	1351
	4	497	168	62	4	0	731
	5	198	107	63	11	0	379
	6	91	62	93	19	0	265
	7	58	30	125	23	0	236
	8	28	18	89	24	3	162
	9	10	13	70	15	4	112
	10	4	4	49	22	2	81
	11	3	4	37	26	9	79
	12	1	0	26	27	8	62
	13	1	1	14	23	16	55
	14	1	0	15	21	15	52
	15	0	0	5	7	21	33
	16	0	0	3	5	29	37
	17	0	0	5	0	23	28
	18	0	0	0	1	12	13
	19	0	0	1	0	10	11
	20	2	0	0	1	8	11
		5201	1074	692	237	160	

%tage		F2+F7: Total 7364 fingerprints					
		NFIQ Score					
		1	2	3	4	5	
IDENT Score	1	19.3	1.9	0.0	0	0	21.2
	2	24.7	3.7	0.1	0.1	0	28.5
	3	14.6	3.4	0.3	0.1	0	18.3
	4	6.7	2.3	0.8	0.1	0	9.9
	5	2.7	1.5	0.9	0.1	0	5.1
	6	1.2	0.8	1.3	0.3	0	3.6
	7	0.8	0.4	1.7	0.3	0	3.2
	8	0.4	0.2	1.2	0.3	0.0	2.2
	9	0.1	0.2	1.0	0.2	0.1	1.5
	10	0.1	0.1	0.7	0.3	0.0	1.1
	11	0.0	0.1	0.5	0.4	0.1	1.1
	12	0.0	0	0.4	0.4	0.1	0.8
	13	0.0	0.0	0.2	0.3	0.2	0.7
	14	0.0	0	0.2	0.3	0.2	0.7
	15	0	0	0.1	0.1	0.3	0.4
	16	0	0	0.0	0.1	0.4	0.5
	17	0	0	0.1	0	0.3	0.4
	18	0	0	0	0.0	0.2	0.2
	19	0	0	0.0	0	0.1	0.1
	20	0.0	0	0	0.0	0.1	0.1
		70.6	14.6	9.4	3.2	2.2	



Good Fair Poor

1, 2, 3, 4, 5, 6 7, 8, … 127



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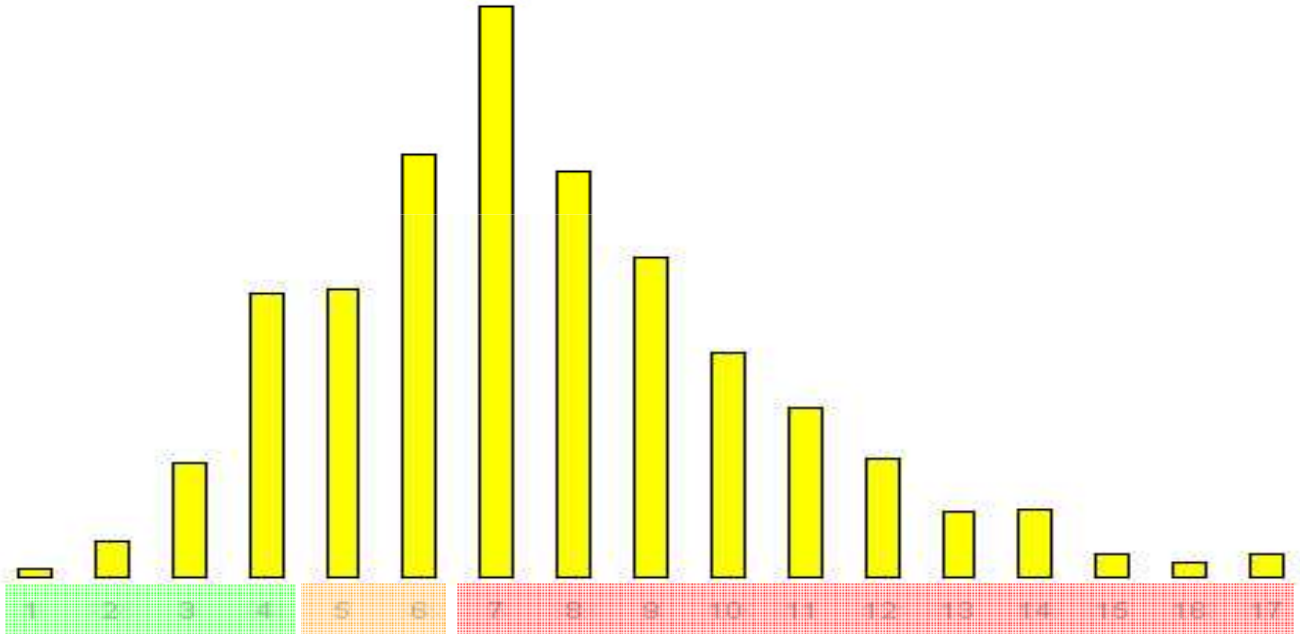
Score Mapping and Correlation: NFIQ = 3

- NFIQ Score 3 has a wide distribution across IDENT Quality Scores
  - For this reason US-VISIT Capture Guidelines differ from NIST PIV Capture Guidelines
    - US-VISIT does not recommend acceptance of NFIQ Score 3 on most important fingers (thumbs, index, and middle)

IDENT Quality Score Distribution of NFIQ=3 Samples



IDENT Score Value

Approximately 10% of images in the study are NFIQ=3

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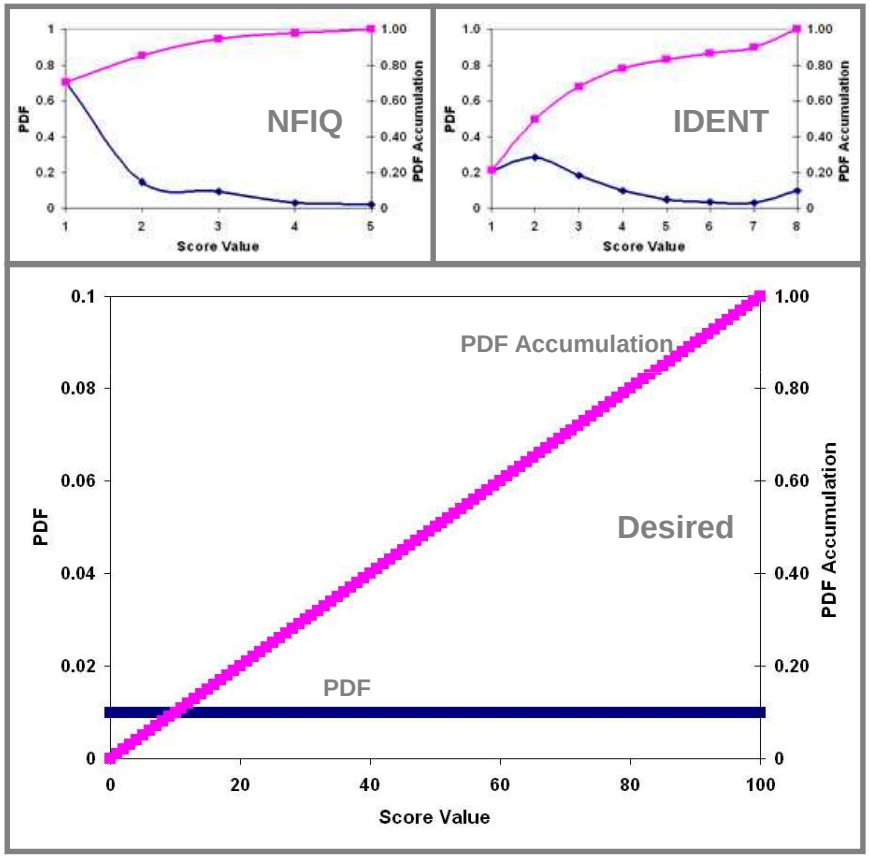
Desired Characteristics of a Fingerprint Image Quality Algorithm and its Score Range

- **High Scale Resolution**
  e.g., [0, …, 100] scale range
  - Easier to map between quality algorithms
  - ANSI/NIST-ITL 1-2007
- **Linear and Uniform Scale**

  Score difference could indicate both machine matching and human examiner inspection difference in linear and uniform scale



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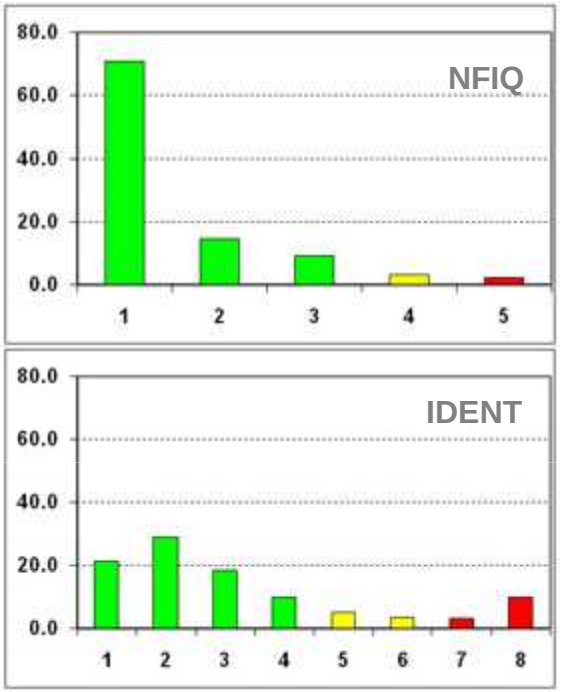
Summary

- In US-VISIT Fingerprint Quality Scores are primarily used for Fingerprint Recapture and Updating Prints on Matchers
- Currently integrating NFIQ into the IDENT system
- Challenges have been encountered when attempting to correlate scores
- More distinct quality levels will improve ability to correlate different quality algorithm scores
- Additional work is required for achieving interoperability of quality measures



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Comments or Questions?

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