

A Study of the Accuracy of Face Recognition for Processing U.S. Passports and Visas

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Face Recognition Study Participants

- **U.S. Department of State, Bureau of Consular Affairs, Consular Systems Division**
- **Creative Information Technology, Inc. (CITI)**
- **General Data Systems, Inc. (GDS)**
- **Mitretek Systems, Inc.**

Background

The New York Times
ON THE WEB

- **Passports and Visas to Add High-Tech Identity Features**

By JENNIFER 8. LEE (NY Times, Sunday Aug. 24, 2003)

WASHINGTON, Aug. 23 — Technologies that scan faces and fingerprints will become a standard part of travel for foreign visitors next year, and for all travelers in the near future... One deadline looms large — Oct. 26, 2004. In a little more than a year, the State Department and immigration bureau must begin issuing visas and other documents with the body-identifying technologies to foreign visitors... By the same deadline, the 27 countries whose citizens can travel to the United States without visas must begin issuing passports with computer chips containing facial recognition data or lose their special status.

Motivation for Study

- U.S. Department of State (DoS) is responsible for passport and visa issuance
- Mandates in USA PATRIOT Act of 2001 and Enhanced Border Security and Visa Entry Reform Act of 2002
 - ICAO has judged face recognition (FR) to be best choice for travel documents
 - Face images may be stored in U.S. passports using a PKI-protected, contactless memory chip
- Need to assess state-of-the-art FR for passport and visa processing and establish performance specifications
- Desire images representative of those in current DoS databases and anticipated in passport and visa applications

Justification for Use of Biometrics

- Increase border security
- Detect and deter fraud in application process
- Processing volumes:
 - 30 million non-immigrant visas (NIVs) in the database, with ~50,000 images being added every day
 - U.S. passport database totals 50 million, with 7 million issuances per year
 - Approximately 10 million Diversity Visa (DV) applications are expected to be received between November and December 2003

U.S. Passport Application Guidance

DS-11 Application for Passport

U.S. Department of State
APPLICATION FOR U.S. PASSPORT REGISTRATION
(Type or print all capital letters unless or unless told to do otherwise.)

1. NAME (Last, first and middle)
LAST FIRST MIDDLE
2. DATA PASSPORT (Do not print if you are 16 or older)
LAST FIRST MIDDLE
3. SEX M F
4. DATE OF BIRTH (Month, day and year)
5. DATE OF BIRTH (Month, day and year)
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Clear, front view, full face, normal street attire without a hat or dark glasses, printed on thin paper with a plain light (white or off-white) background

2" x 2" photo

1 in. ≤ bottom of chin to top of head ≤ 1 3/8 in.

Passport & Visa Photo Quality

- ❑ Photography Guide for U.S. passport and visa photos – brochure and web pages
(See <http://travel.state.gov>)

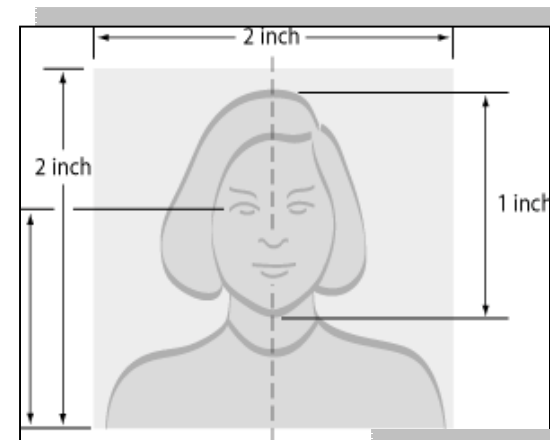
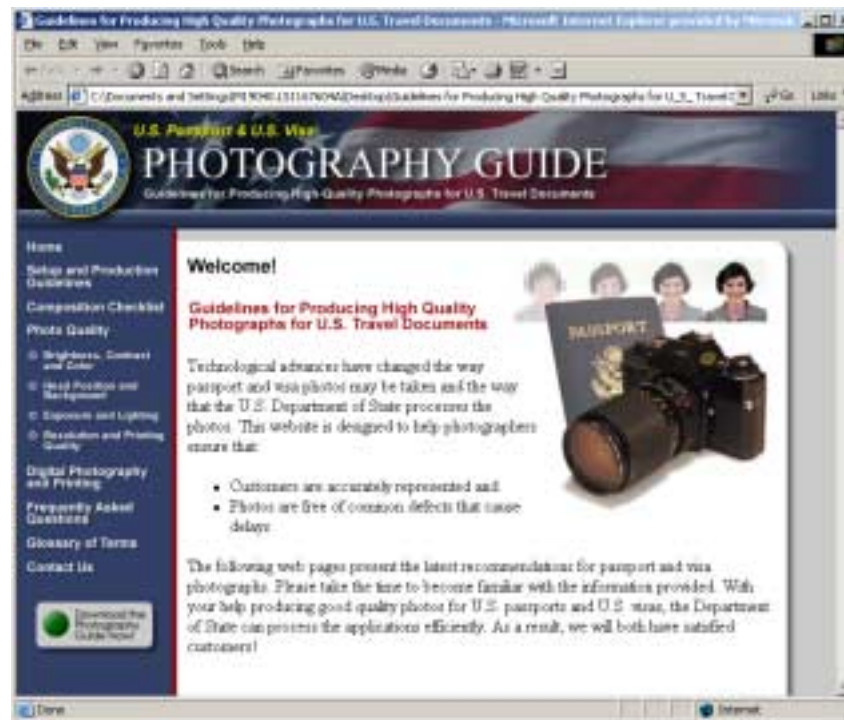
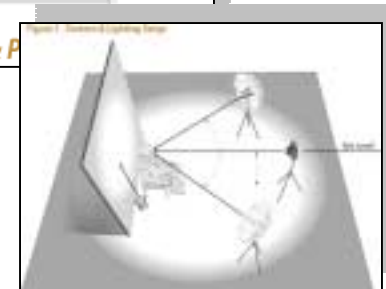


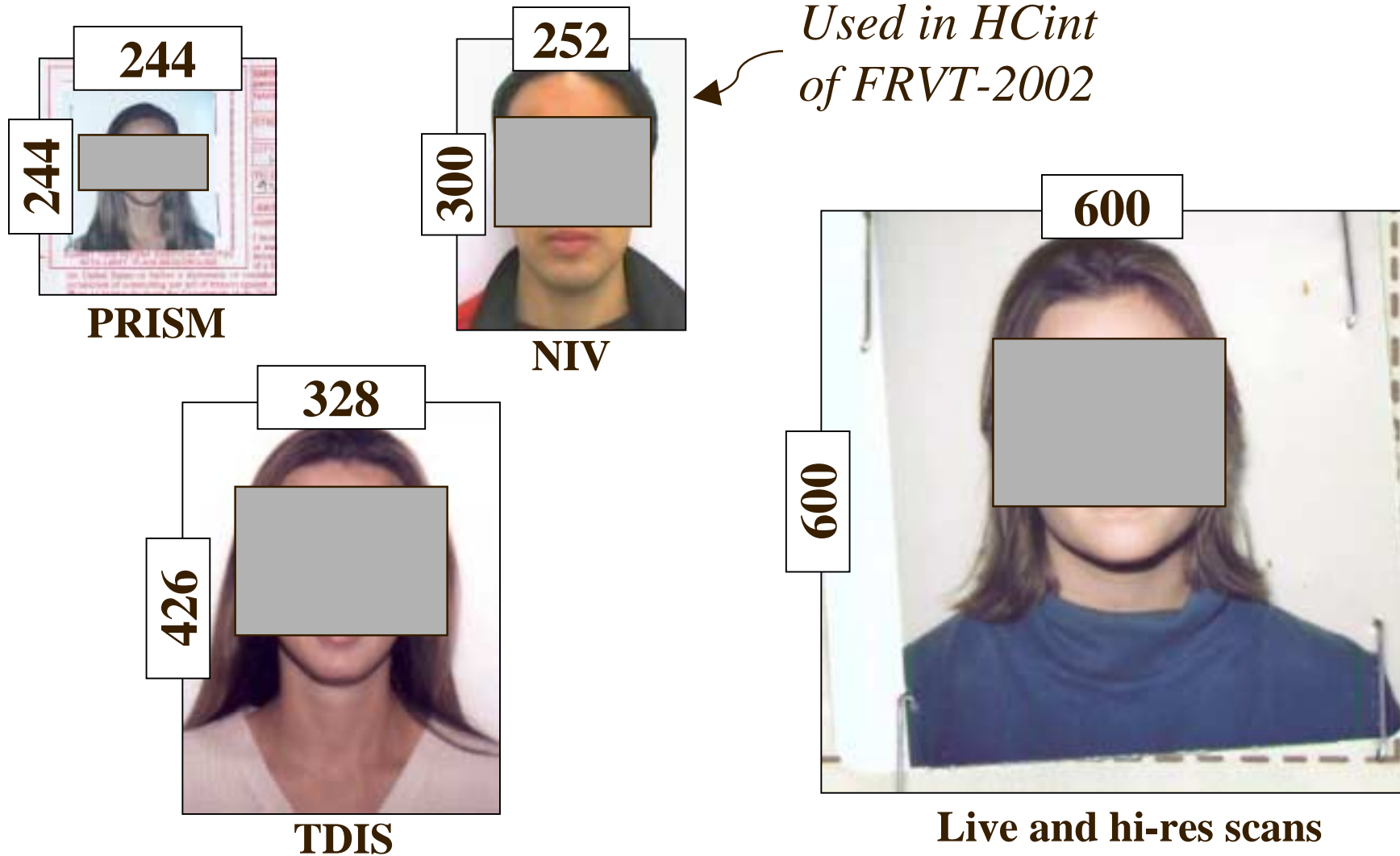
Figure 2. Head Position & Placement



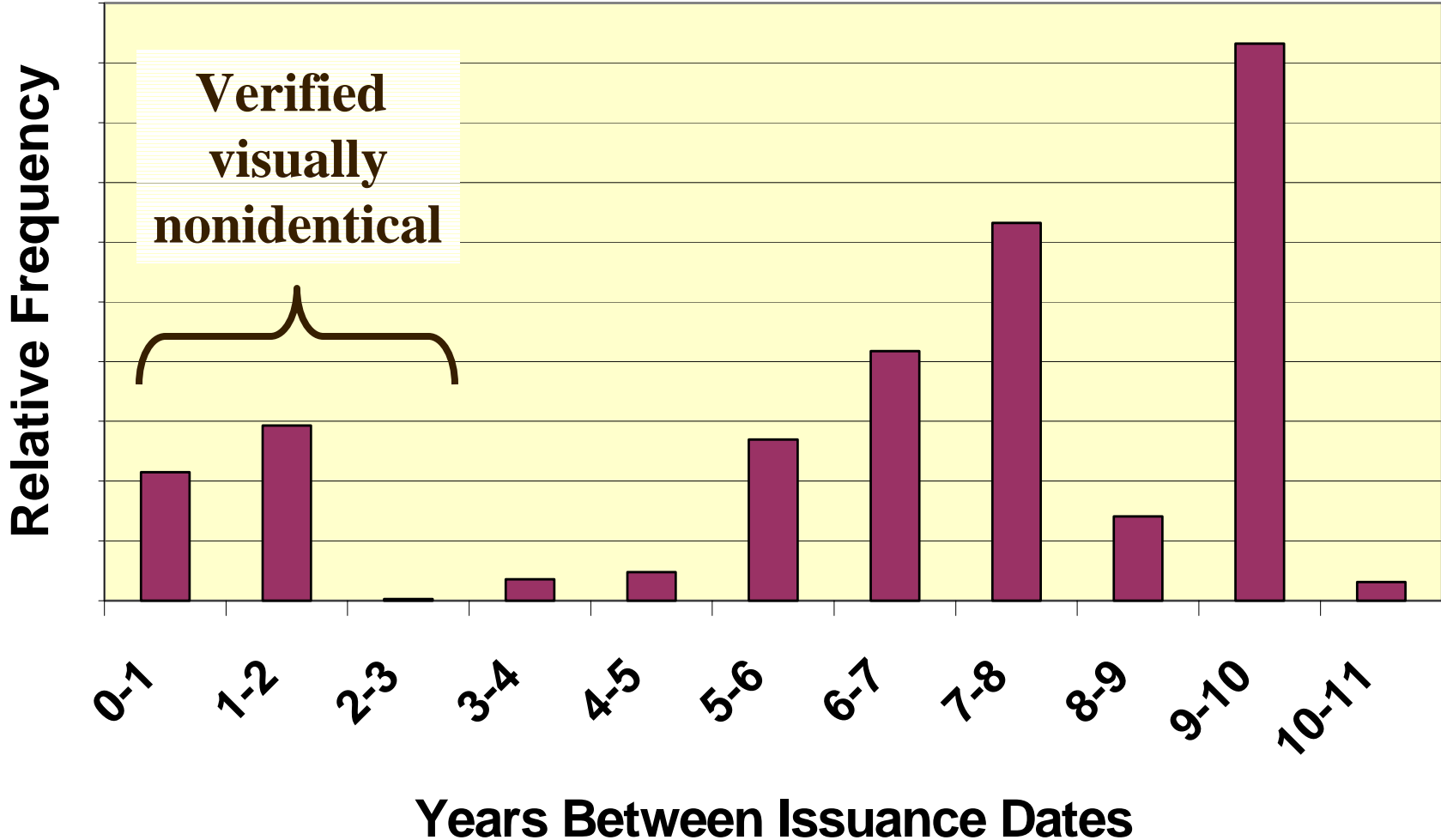
Approach

1. **Collect representative images and ensure accurate “ground truth”**
2. **Describe size and quantity of images for vendors**
3. **Procure systems and test at least three products**
4. **Conduct three tests per vendor: 50k, 500k, and 2M**
5. **Allow 0 to N mates**
6. **Use DoS-compatible platforms, specified by vendors**
7. **All FR processing done by vendors under supervised (proctored) conditions**
8. **Use RDB technology & FRVT-2002 similarity matrix approach, except with sparse matrices**
9. **Compute FTEs, CMCs, ROCs, & watch list performance**
10. **Compare results to those from HCint in FRVT-2002**

Images in DoS FR Testing Database

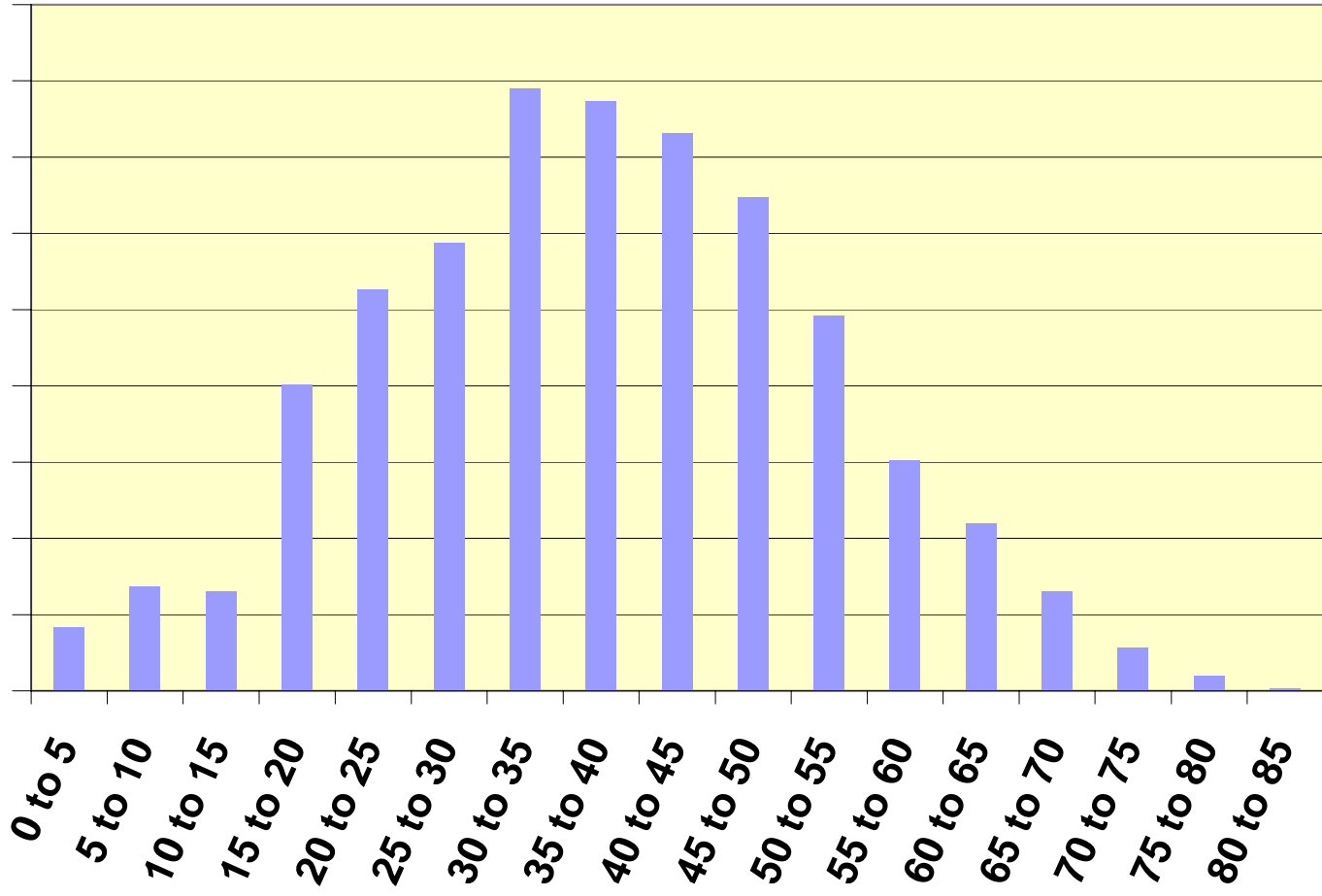


Distribution of Differences in Passport Issuance Dates



Distribution of Genders and Ages in Passport Images

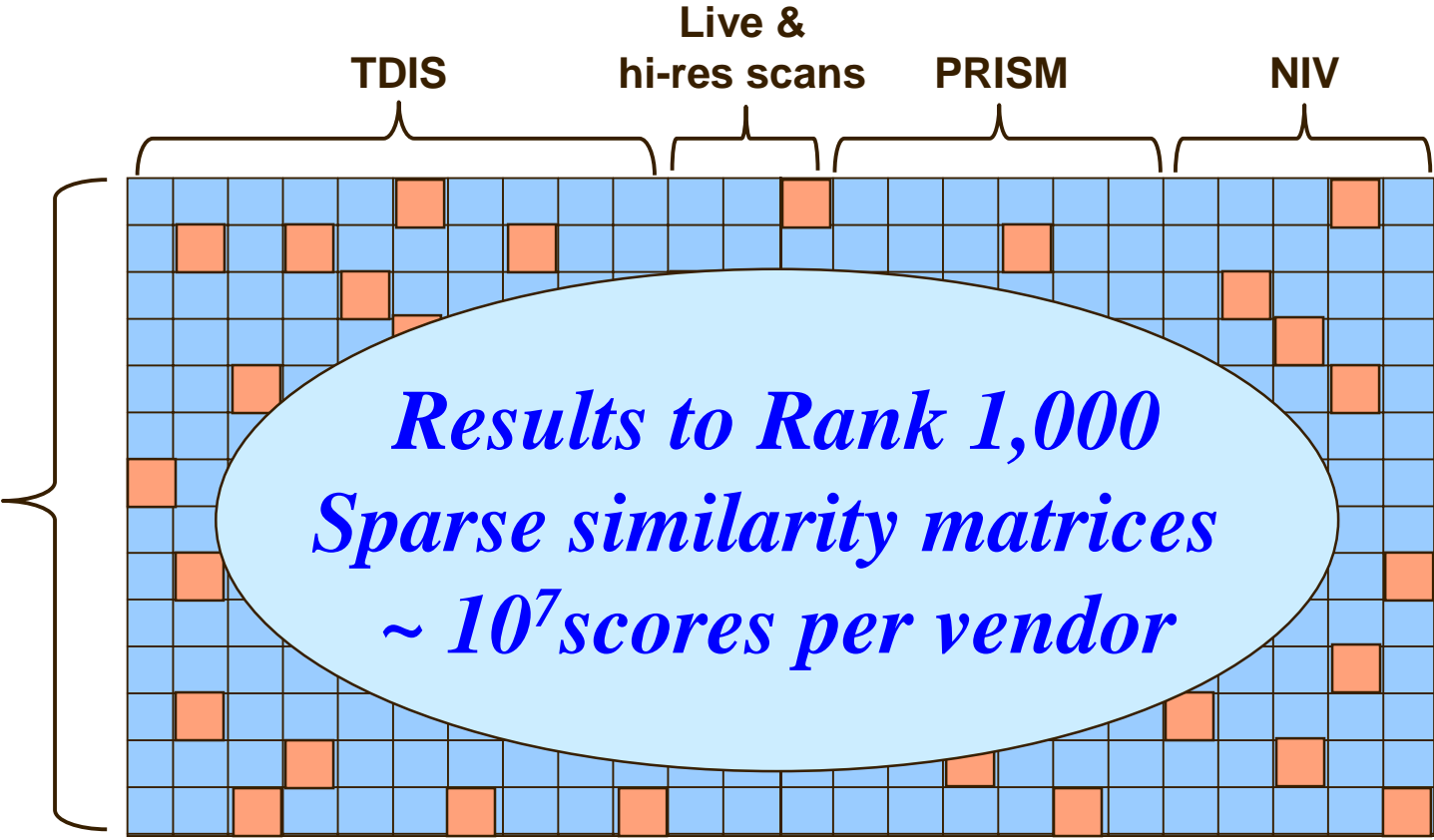
M = 68.6%
F = 31.4%



DoS FR Similarity Matrices

Galleries:
1.) 5×10^4 2.) 5×10^5 3.) 2×10^6

Probes & Impositors:
 $\sim 1 \times 10^4$



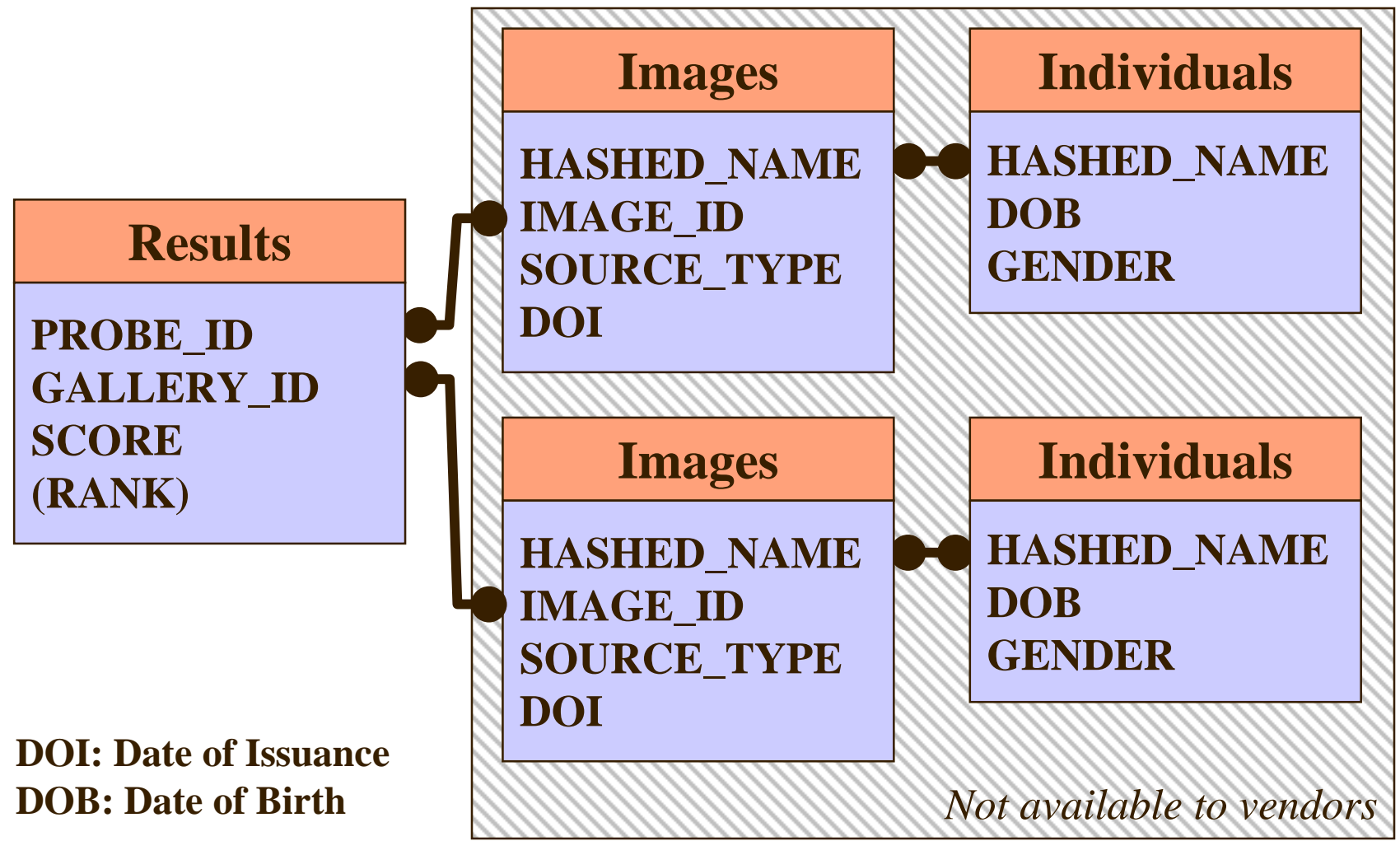
Analysis Tools

- **SQL Server**
- **Microsoft Access**
- **Microsoft Excel**

Custom software

- **SQL & Access queries**
- **C++ code**

Results Database Tables and Relationships



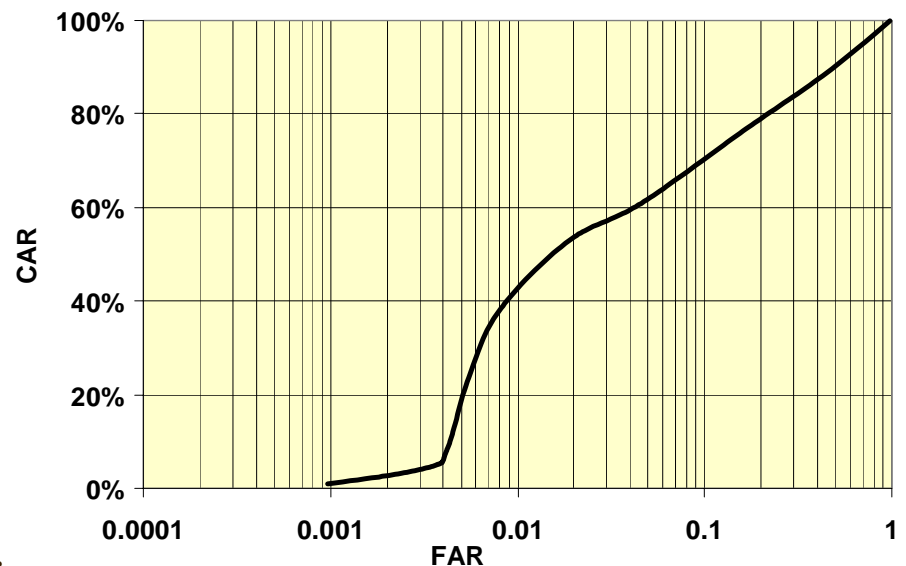
Tests (as described in FRVT 2002)

- Verification: Receiver Operating Characteristic (ROC)

$$\text{Verification rate } P_V(t) = \frac{|\{p_j : s_{ij} \geq t, id(g_i) = id(p_j)\}|}{|P_G|} \quad \forall p_j \in P_G$$

False Accept rate

$$P_{FA}(t) = \frac{|\{s_{ij} : s_{ij} \geq t\}|}{|P_N| |G|} \quad \forall p_j \in P_G$$



Source: P. Grother, R. Micheals, & P. J. Phillips,
 Face Recognition Vendor Test 2002 Performance Metrics,
 NIST IR 6982 (www.frvt.org/DLs/Avbpa_2003_evaluation_metrics.pdf)

Tests (as described in FRVT 2002)

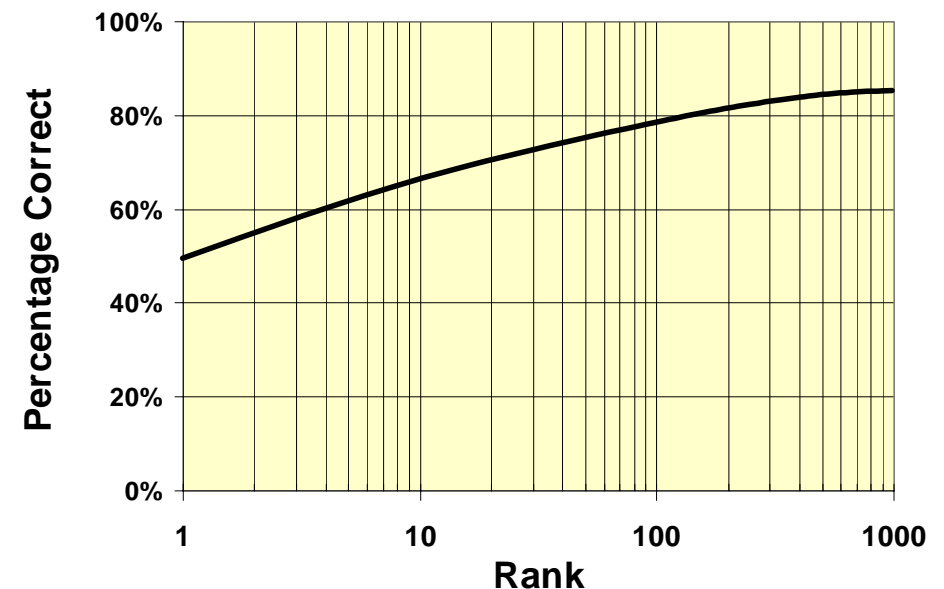
- **Identification: Cumulative Match Characteristic (CMC)**

Set of probes with match at rank less than or equal to r

$$C(r) = \{p_j : \text{rank}(p_j) \leq r\} \quad \forall p_j \in P_G$$

Identification rate
as a function of r

$$P_I(r) = \frac{|C(r)|}{|P_G|}$$



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Face Recognition Vendor Test 2002 Performance Metrics,
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Tests (as described in FRVT 2002)

- Watch List

Detection and Identification rate

$$P_{DI}(t, r) = \frac{|\{p_j : \text{rank}(p_j) \leq r, s_{ij} \geq t, \text{id}(p_j) = \text{id}(g_i)\}|}{|P_G|} \quad \forall p_j \in P_G$$

False Alarm rate

$$P_{FA}(t) = \frac{|\{p_j : \max_i s_{ij} \geq t\}|}{|P_N|} \quad \forall p_j \in P_N \quad \forall g_i \in G$$

Source: P. Grother, R. Micheals, & P. J. Phillips,
 Face Recognition Vendor Test 2002 Performance Metrics,
 NIST IR 6982 (www.frvt.org/DLs/Avbpa_2003_evaluation_metrics.pdf)

Planned “Virtual” Tests

- Image type
- Gender
- Age
- Time between dates of issuance
- Image compression

Plan to rerun matching whenever current maximum rank of 1,000 is limiting factor