FRGC and ICE Workshop

Dr. P. Jonathon Phillips - NIST

March 22-23, 2006
NRECA Conference Facility
Arlington, Virginia
Workshop Agenda Overview

DAY 1:
- FRGC Overview and Experiment Results
- Individual Organization FRGC Results
- Guest Speaker
  - Alice O’Toole, University of Texas at Dallas
    - Human verses Machine Face Recognition Performance

DAY 2:
- ICE Overview and v1.0 Experiment Results
- Individual Organization ICE v1.0 Results
- Guest Speaker
  - Philip Wasserman, NIST Consultant
    - Iris Imaging Platform Design
- Next Steps – ICE Phase II
FRGC, FRVT 2006 & ICE Sponsors

Executing Agency

National Institute of Standards and Technology

Sponsoring Agencies

Director of National Intelligence
Intelligence Technology Innovation Center

Federal Bureau of Investigation
www.fbi.gov

Homeland Security
– Science & Technology Directorate
– Transportation Security Administration

National Institute of Justice
The Research, Development, and Evaluation Agency of the U.S. Department of Justice

COMBATING TERRORISM
TECHNICAL SUPPORT WORKING GROUP
FRGC and ICE Team

• Program Manager for FRGC and ICE
  • P. Jonathon Phillips — NIST

• Evaluation Team
  • Todd Scruggs — SAIC
  • Matt Sharpe — SAIC
  • William Worek — SIAC
  • Kevin Bowyer — University of Notre Dame
  • Patrick Flynn — University of Notre Dame
  • Ross Beveridge — Colorado State University
  • Alice O’Toole — University of Texas at Dallas

• FRGC and ICE Liaison
  • Cathy Schott — Schafer Corp
Status Update

• FRVT 2006

• ICE 2006
FRVT 2006 Status Update

• The Face Recognition Vendor Test (FRVT) 2006
  – Began on 30 January 2006
  – Currently underway
    • Testing executables at this time
  – 22 Participants
    • 10 countries
    • 30% of Participants are from Academia
ICE Phase II = ICE 2006

• ICE 2006
  – Independent U.S. Government Evaluation
  – Planned start date is 15 June 2006
  – ICE 2006 protocol based on the FRVT 2006 protocol
ICE Participation

- Interested Groups: 66
- Access to v1.0: 42
- Results Submitted: 9

Participation
Face Recognition Grand Challenge Overview
Outline

• Overview of Face Recognition Grand Challenge (FRGC)

• Overview and Results of FRGC ver2.0

• Overview of the Face Recognition Vendor Test (FRVT) 2006

• Next Steps
FRGC and FRVT 2006

• What is the difference between FRGC and FRVT 2006?
  – FRGC (May 2004 – March 2006)
    - Still and 3D face recognition algorithm development project
  – FRVT 2006 (30 January 2006)
    • Independent government evaluation of face recognition systems
      - Measure progress since FRVT 2002
FRGC Background

- Renewed interest in developing new methods for automatic face recognition
  - Fueled by advances in
    - Computer vision techniques
    - Computer design
    - Sensor design
    - Interest in fielding face recognition systems
- New techniques have potential to significantly reduce error rates
FRGC Participation

- Access to v1.0a: 116
- Access to v2.0: 52
- Results Submitted: 22

Number

Participation
Background

- **Baseline**: July 2002
- **Technology Development**: May 2004 – Mar 2006
FRGC Goal and Objective

• The primary goal of the FRGC is to:
  
  Promote and advance face recognition technology to support U.S. Government face recognition efforts

• The primary objective of the FRGC is to:
  
  Develop still and 3D algorithms to improve performance an order of magnitude over FRVT 2002
Select Point to Measure

• Verification rate at:
  - False accept rate = 0.1%

• Current:
  - 20% error rate (80% verification rate)

• Goal:
  - 2% error rate (98% verification rate)
Measuring Accuracy w/Error Rate of 2%

- Non-match scores:
  - Sufficient
- Match scores:
  - Need to design collection for sufficient number

<table>
<thead>
<tr>
<th>Match Scores</th>
<th>Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000</td>
<td>~ 20</td>
</tr>
<tr>
<td>10,000</td>
<td>~ 200</td>
</tr>
<tr>
<td>50,000</td>
<td>~ 1,000</td>
</tr>
</tbody>
</table>

- Allows for error ellipses
- Minimal demographic analysis
FRGC Modes Examined

Single Still

Outdoor/Uncontrolled

Multiple Stills

3D Full Face

3D Single view
3D Images

3D Sensor

3D Image

Shape

Texture

3D Face Recognition Algorithm

MATCH
Data Collection & Distribution

• Total data collected at Notre Dame
  - 4950 subject sessions of 400+ subjects
    – 125,000 2D and 15,000 3D images
    – 125,000 irises (40,000 verified)

Minolta Vivid 900 / 910

3DMD “Qlonerator”

Nikon
Grand Challenge Architecture

**Accuracy of:**
- 3D Sensors
  - 3D from stills

**Preprocessing/Reconstruction Compression**

**Image Quality Measures**

**Comparison**
- Algorithms/Systems Modes

**Meta data**
- eye coordinates
- pose
- gender

**Human Performance**

**Advanced Statistical Analysis**
FRGC Experiments

Exp 1: Controlled indoor still versus indoor still

Exp 2: Multiple still versus multiple still

Exp 3: 3d versus 3D
  3t - Texture only
  3s - Shape only

Exp 4: Uncontrolled still versus indoor still
Training and Validation Partitions

- Academic Year 2002-03
  - 12,776 Large Still Training Set
  - 943 3D Subject Sessions

- Academic Year 2003-04
  - 16,028 Controlled Stills
  - 8,014 Uncontrolled Stills
  - 4,007 3D Scans
Three Data Sets

FRGC Challenge Problem

- Training
- Validation
  - Target
  - Query

FRGC Evaluation
Sequestered

- Validation
  - Target
  - Query
Demographics
(ver2.0 Validation Partition)

- **Gender**
  - Male: 43%
  - Female: 57%

- **Age Distribution**
  - 18 - 22: 18%
  - 23 - 27: 17%
  - 28+: 10%

- **Race**
  - Asian: 22%
  - White: 68%
  - Other: 10%

- **Year Range**
  - 18 - 22: 65%
  - 23 - 27: 18%
  - 28+: 17%
## Size of Faces
(Ver2 On Validation)

### Pixels between center of eyes

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Median</th>
<th>Std</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controlled</td>
<td>261</td>
<td>260</td>
<td>19</td>
</tr>
<tr>
<td>Uncontrolled</td>
<td>144</td>
<td>143</td>
<td>14</td>
</tr>
<tr>
<td>3D</td>
<td>160</td>
<td>161</td>
<td>15</td>
</tr>
</tbody>
</table>
Target / Query Sets
(ver2.0 Validation Partition)

466 Subjects; 4,007 Subject sessions; 32,056 Recordings

Subject Sessions 2003-04
Three ROCS

ROC I - Within Semesters

ROC II – Within Year

ROC III – Between Semesters

ROC I
Exp 1: 173k
Exp 3: 11k

ROC II
Exp 1: 346k
Exp 3: 22k

ROC III
Exp 1: 173k
Exp 3: 11k
FRGCv2 Exp 1

Exp 1 Composite Performance

Verification rate @ FAR = 0.001

Algorithm

 ROC I
 ROC III
FRGCv2 Exp. 1

Exp 1 Composite Performance

Verification rate @ FAR = 0.001

Algorithm
FRGCv2 Exp. 2

Exp 2 Composite Performance ROC III

Verification rate @ FAR = 0.001
Exp. 3, 3s, and 3t

Exp 3 Composite Performance ROC III

Exp 3 (Texture) Composite Performance ROC III

Exp 3 (Shape) Composite Performance ROC III
Exp 4 and 6

Exp 4 and 6 Composite Performance ROC III

Verification rate @ FAR = 0.001

Algorithm
Scientific Questions

High Resolution

Computer Vision vs Pattern Recognition
Scientific Questions

High Resolution

Effects of Training Set Size
Training Set Size - Exp 1

![Graph showing VR @ FAR=0.1% for different training set sizes]

- Different training set sizes: 512, 1024, 2048, 4096, 8192
- VR @ FAR=0.1% vs. # of Eigens Used
Training Set Size - Exp 1

- Number of Training Images:
  - 512
  - 1,024
  - 2,048
  - 4,096
  - 8,192

- VR @ FAR=0.1%:
  - 0.6
  - 0.66
  - 0.7
  - 0.7
  - 0.7
Training set size - Exp 4

Courtesy C. Liu 2005
Training set size - Exp 4

![Graph showing verification rate versus number of training images.]

Verification Rate

<table>
<thead>
<tr>
<th>Number of Training Images</th>
<th>Verification Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,623</td>
<td>0.64</td>
</tr>
<tr>
<td>3,194</td>
<td>0.7</td>
</tr>
<tr>
<td>6,388</td>
<td>0.76</td>
</tr>
</tbody>
</table>

Courtesy C. Liu 2005
FRVT 2006

- Latest in a series of large scale independent evaluations for face recognition systems
  - Previous evaluations in the series were the FERET, FRVT2000, and FRVT 2002
- Primary goal is to
  - Measure progress of prototype systems/algorithms and commercial face recognition systems since FRVT 2002
  - Conduct comparison across modalities
  - Compare performance with FRGC goals
Performance Goals and Progress

Independent Evaluations (Gold Standard)

Starting Point 80%
Measured in FRVT 2002

FAR = 0.1%
Performance Goals and Progress

Independent Evaluations (Gold Standard)

Goal
To be measured by FRVT 2006

Starting Point
80%
Measured in FRVT 2002

FAR = 0.1%

80%

98%
Performance Goals and Progress

Independent Evaluations (Gold Standard)

- Goal: 98%
  - To be measured by FRVT 2006

Starting Point: 80%
- Measured in FRVT 2002
- FAR = 0.1%

Face Recognition Grand Challenge (Qualified Results)

- 99.99% Multi-Still (Mar 06)
- 99% High Resolution Still (Mar 06)
- 98% Three-Dimensional (Mar 06)

* First set of results after 4 months in a 12 month period
Starting Point 80% 
Measured in FRVT 2002

80% Starting Point
Measured in FRVT 2002

FAR = 0.1%

Independent Evaluations (Gold Standard)

Goal 98%
To be measured by FRVT 2006

Face Recognition Grand Challenge (Qualified Results)

99.99% Multi-Still (Mar 06)

99% High Resolution Still (Mar 06)

98% Three-Dimensional (Mar 06)

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Summary

• Face Recognition Grand Challenge
  – Order of magnitude increase in performance
  – Systematically investigate still and 3D
  – Formulate series of challenge problems
  – Face Recognition Grand Challenge Completion March 2006
Next Steps

• FRGC Final Report
  – One more call for similarity files
    • Due 30 April 2006
  – Provide a list of papers you’ve published on this subject

• FRVT 2006 Final Report
  – Completion estimated in Fall 2006
Publication of FRGC Results

- Check with sponsors to determine if they want to be cited

- Please include FRGC reference: