Panel Discussion Questions

1. What are the biggest road-blocks to progress in multi-modal biometrics?

2. To overcome the paucity of multi-modal data, the practice has developed of creating multi-modal data by “randomly” matching together uni-modal samples to form multi-modal samples. Is this valid?

3. What are the advantages and disadvantages of signal, score, and decision level fusion?

4. In current research, developing a multi-biometrics algorithm requires a researcher to develop an algorithm for each modality and a fusion algorithm. Is this good for the field?

Panel Discussion Questions

5. Is now the appropriate time to develop a multi-biometric standard through international standards bodies?

6. Travel documents call for face, finger, and iris. Considering perceived accuracies of these modalities, what are the implications for multi-modal research?

7. How much data is needed?

8. How would you define a standard multi-modal data sample?

Multi-biometrics, Déjà Vu?

Panelists

P. Jonathon Phillips, NIST

Kevin Bowyer, Notre Dame

Douglas Reynolds, MIT Lincoln Labs

Paul Griffin, Identix

Multi-biometrics, Déjà Vu?

P. Jonathon Phillips

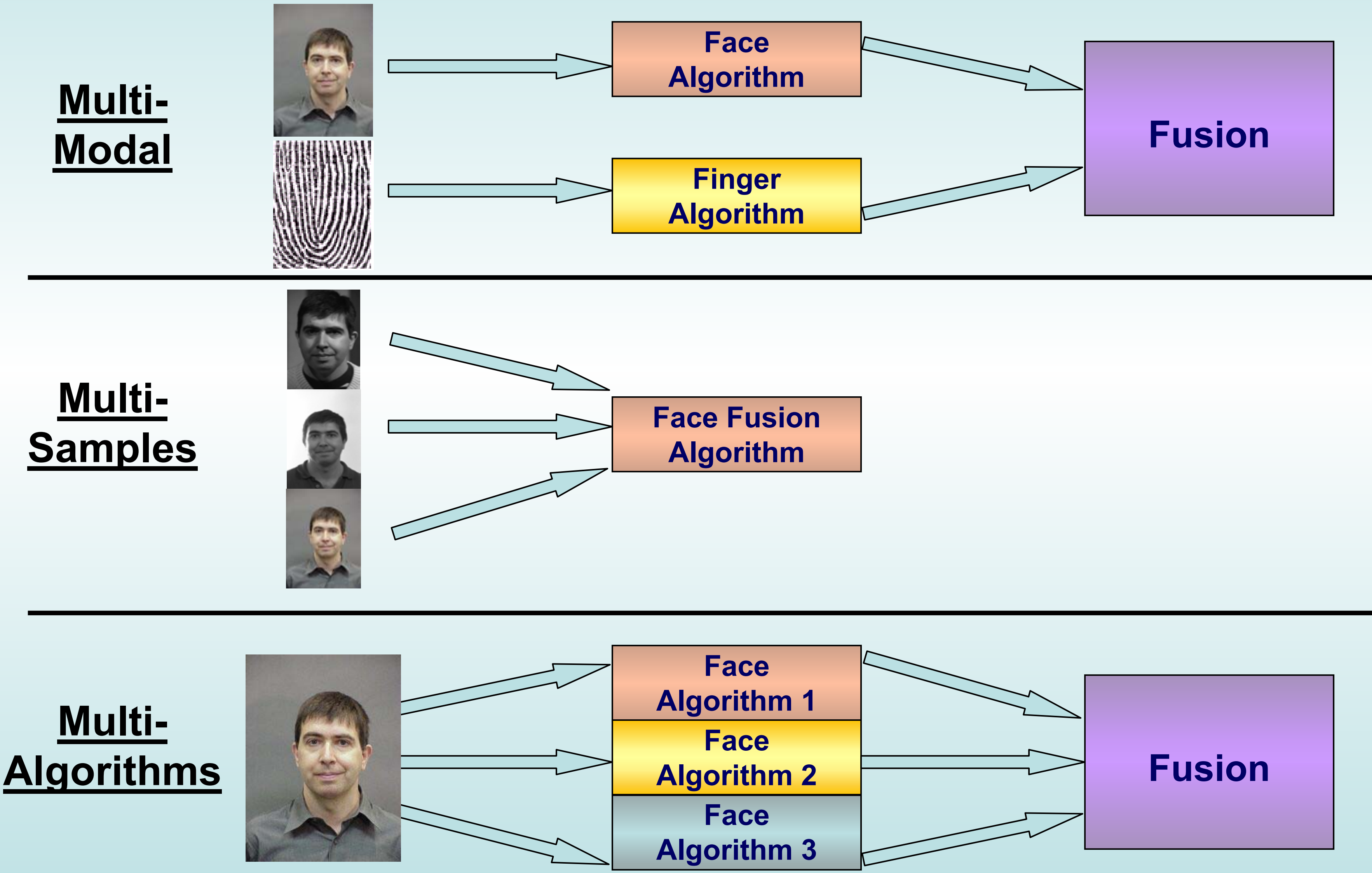
12 Dec 2003

Multi-biometrics, Déjà vu?

- Evidence multi-biometrics improve performance

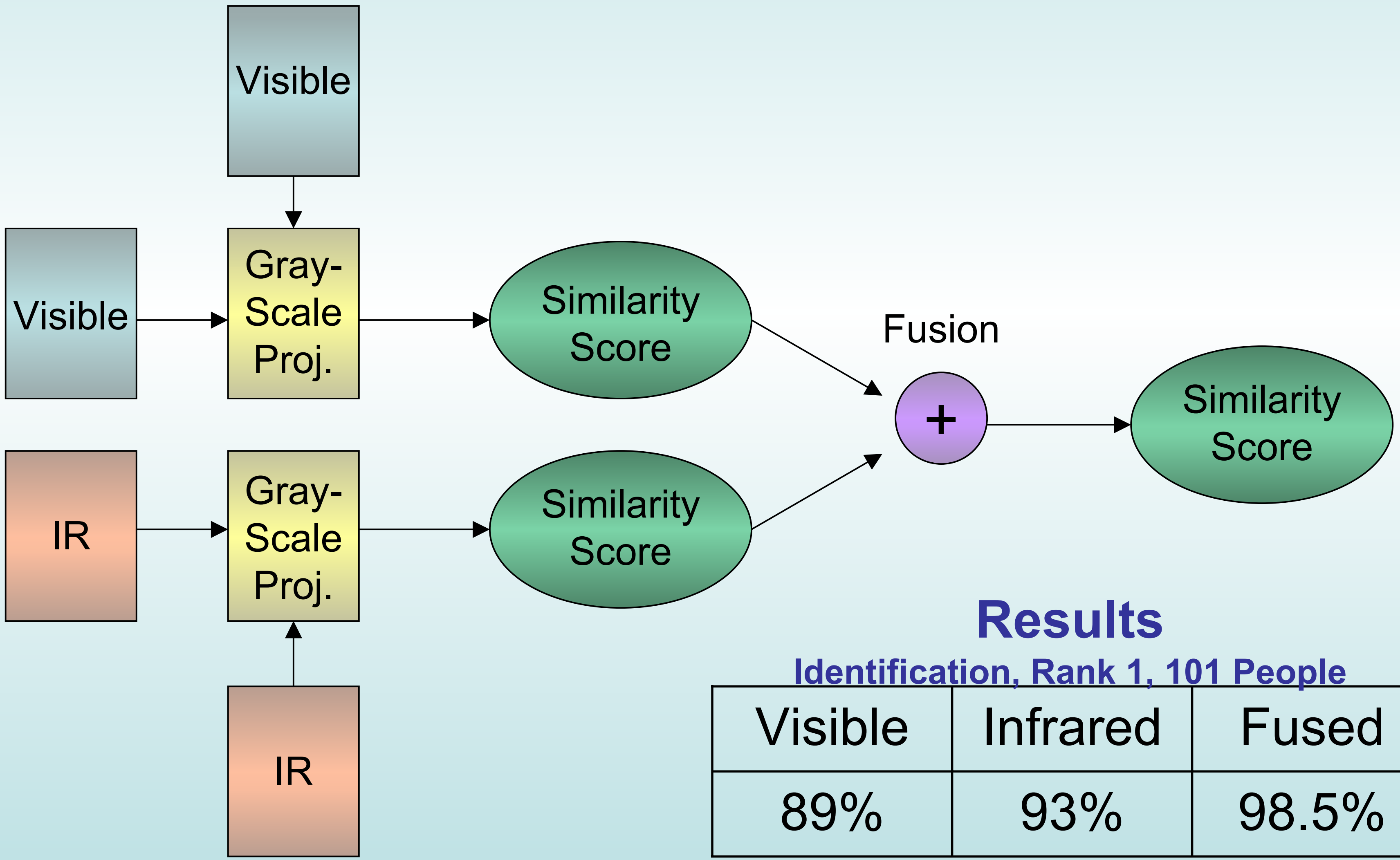
- Open questions:
  - Are some combinations “better” than others?
  - What is a good baseline to assess improvement?
  - How will we identify good combinations?

Multi-Biometrics



Early multi-biometrics approach

From Wilder, Phillips, Jiang, Wiener, 1996

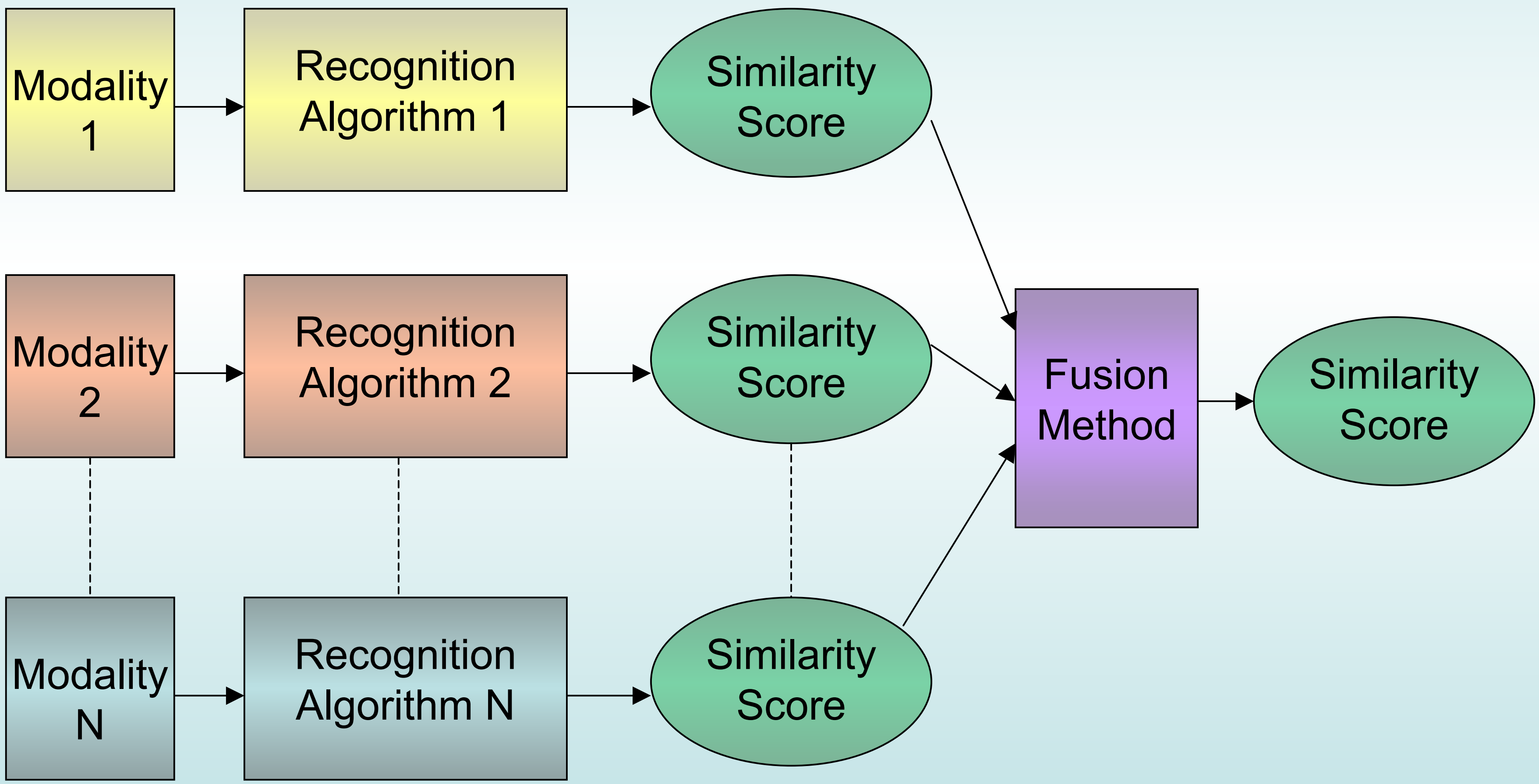


Results

Identification, Rank 1, 101 People

Visible	Infrared	Fused
89%	93%	98.5%

Prototype Multi-biometrics Algorithm



Factors Effecting Performance

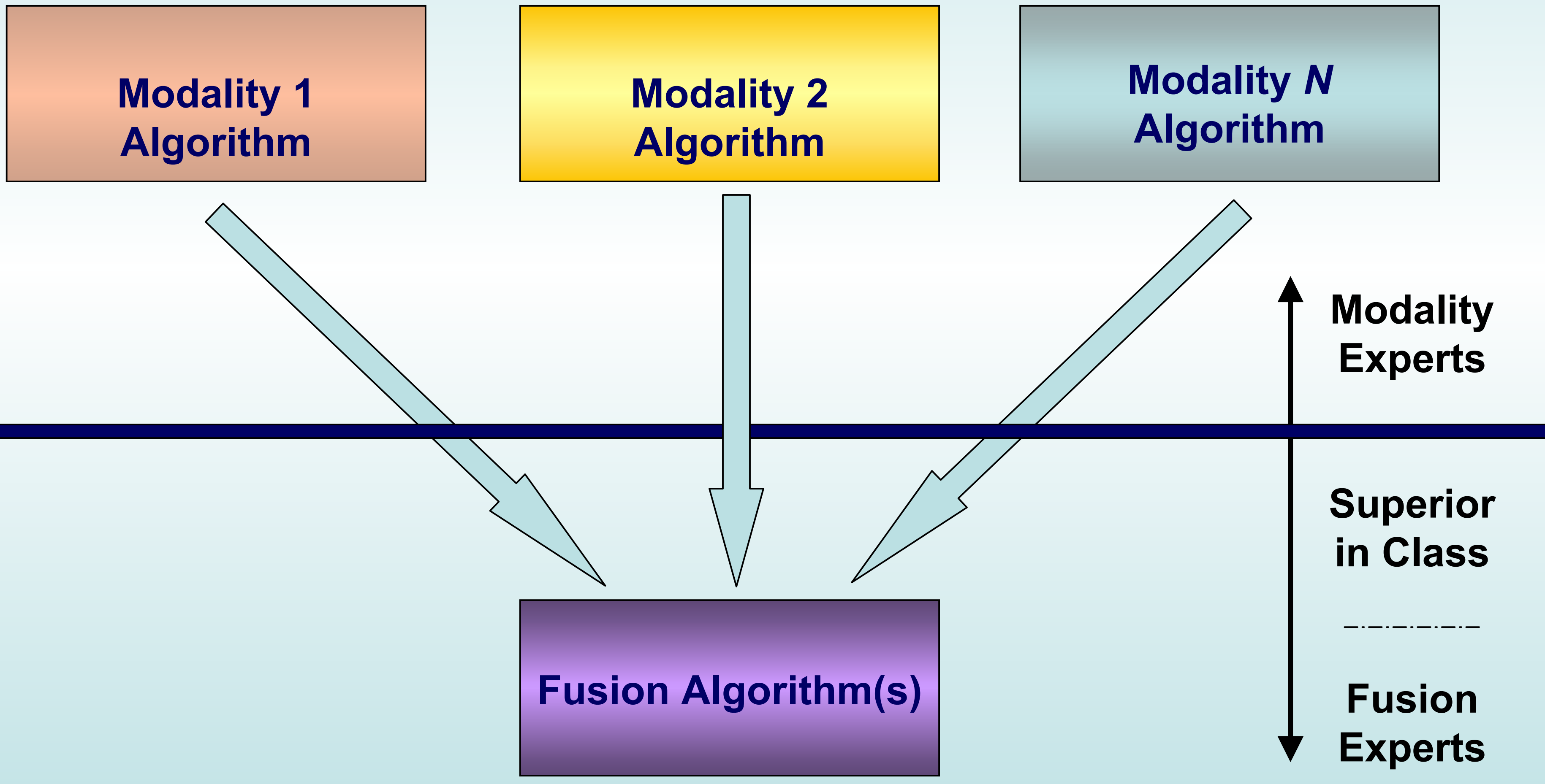
Modalities

Recognition Algorithms

Fusion Algorithm

Need to disentangle factors

Multi-Biometric Algorithm Development



First Step

- Multi-biometrics Challenge Webpage

- Goal: provide a resource for advancing and assessing multi-biometrics

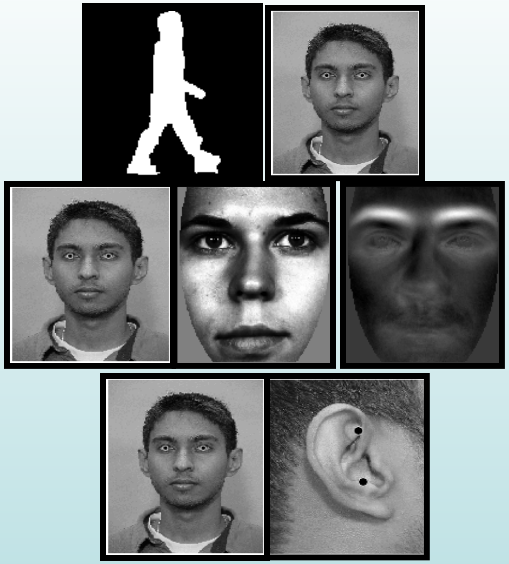
- Based on success of Gait Challenge Problem webpage (www.gaitchallenge.org)

Multi-biometrics Challenge Webpage

- Data Sets
  - Publicly available
  - Contemporaneously multi-modal
- Define
  - Challenge problems
  - Experiments
- Make available baseline algorithms and benchmark performance

Initial Data Sets and Problems

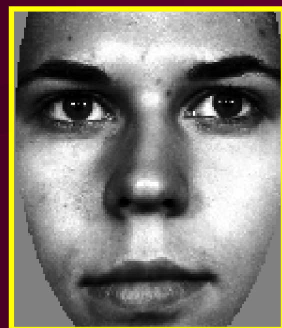
- Multi-modal
  - Gait and 2D face
  - 2D face, 3D face and Infrared
  - 2D face and ear
- Multi-sample and multi-algorithm
  - 2D face



When Is Multi-Modal Better Than Uni-Modal In Biometrics?

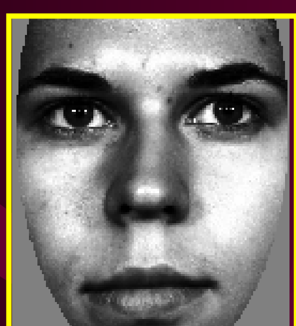
Professor Kevin W. Bowyer
Computer Science & Engineering
University of Notre Dame

Example: Face + Ear Biometric



= 83.3%
(FaceIt = 80%)

= 86.5%



+

= 98.7%
statistically signif.!

Example: Face + Ear Biometric

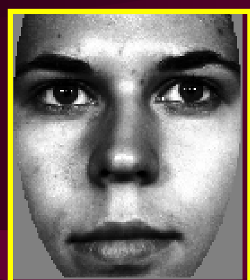
= 83.3%
(FaceIt = 8[illegible]%)

= 86.5%

= 98.7%
statistically signif.!

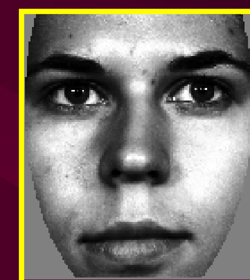
An Unfair Comparison

1 Gallery Image

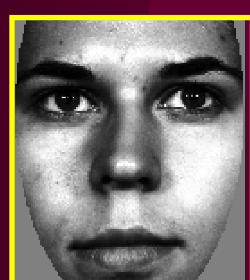


1 Matching

1 Probe Image

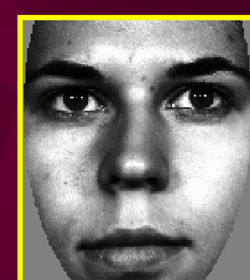


2 Gallery Images

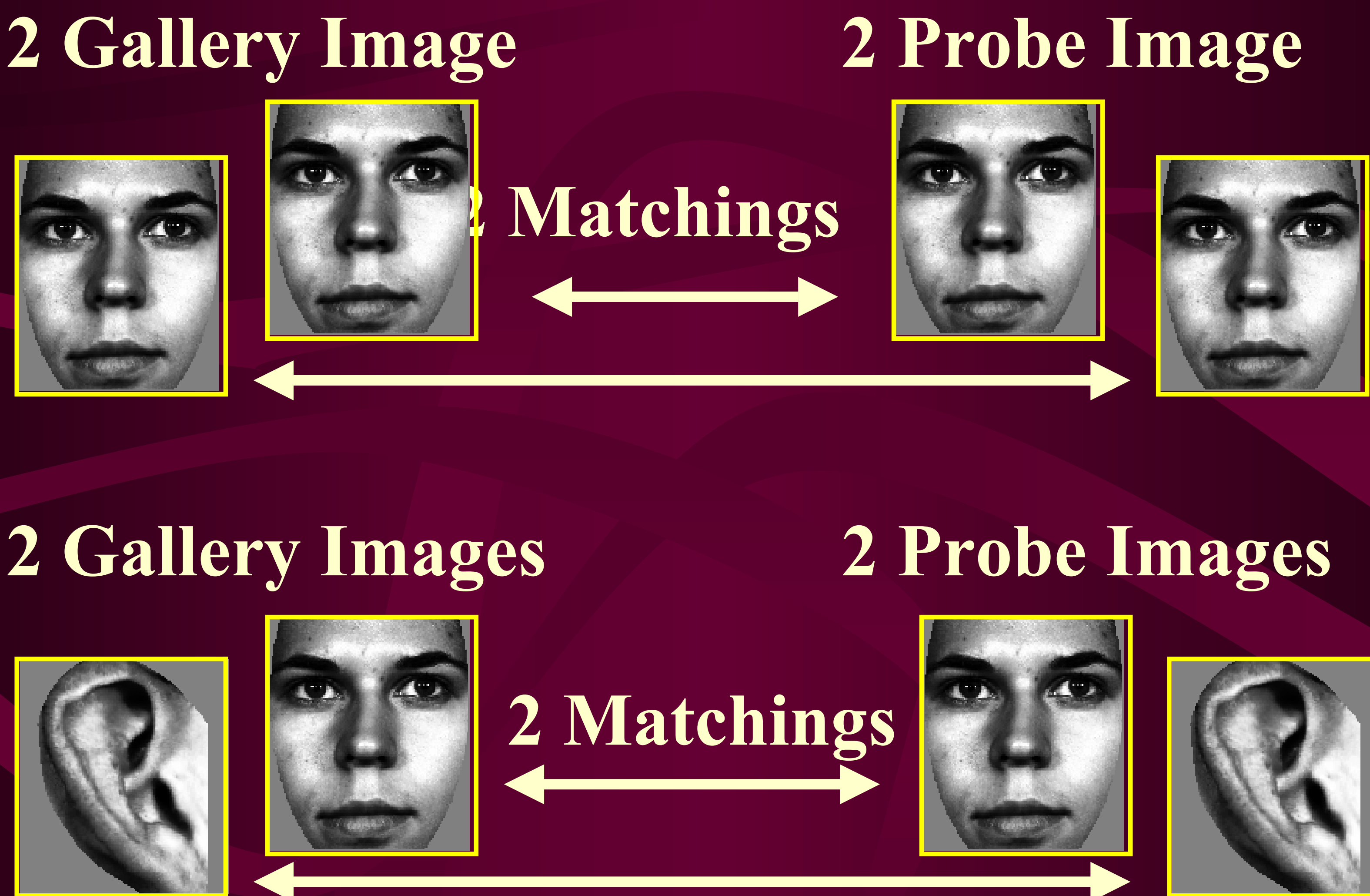


2 Matchings

2 Probe Images



A (more) Fair Comparison



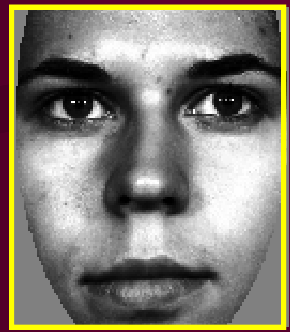
A (more) Fair Comparison

Control for number of probe images – combine results from two probes.

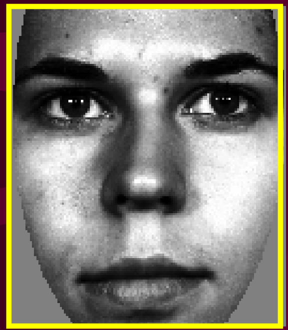
Control for number of matchings – use two gallery images per subject.

Questions of equivalent sampling of possible images of each type remain.

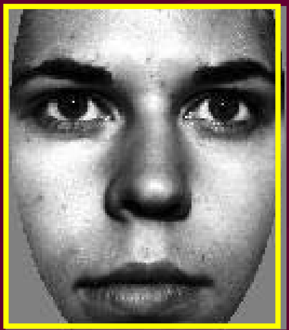
Face + Ear Recognition



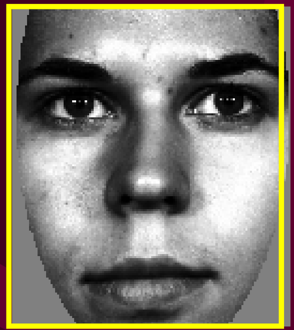
= 83.3%



+



= 91.6%
(Fa + Fb probes)



+

= 98.7%

When Is Multi-Modal Better Than Uni-Modal In Biometrics?

When multi-modal performance is statistically significantly greater than performance from the same number of uni-modal gallery and probe images.

Not yet shown in any published paper!

Multi-Modal Biometrics

Douglas Reynolds
Senior Member of Technical Staff
MIT Lincoln Laboratory

Outline

- When does fusion make sense?
- Why face and voice?
- What is needed to for further multi-modal R&D?

When does fusion make sense?

- For improved performance
  - More inputs for better decision making
- For improved robustness
  - Fall back systems when one mode degrades
- When an application allows it at low “cost”
  - Scenario can easily accommodate more sensors
  - Benefits outweigh cost of additional sensors

Why face and voice?

- Most natural way we recognize each other
  - Unobtrusive, standoff sensors
- Low cost sensors
  - Cheap audio and video recording devices and storage
- Complementary information
  - Studies have shown accuracy improvement with both
  - Relatively disjoint channels provide robustness
  - Two different inputs make spoofing more difficult
- Both convey static and dynamic information to exploit
  - Face: Facial structure + lip dynamics and visemes
  - Voice: Vocal apparatus + prosodics, accents, and idiolect
  - Potential gains for tighter integration and early fusion
- Lip-reading can help supply better spoken text to aid voice recognizer
  - Text-independent→ text-dependent

What is needed to for R&D?
Infrastructure

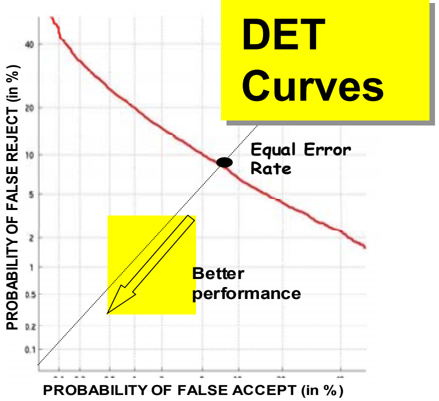
- Data
  - Synthetic multi-modal corpora OK for initial work
  - Some multi-modal corpora exist
    - XM2VTS , VidTIMIT
  - Future corpora need to better reflect realistic conditions (acoustic noise and lighting conditions)
- Evaluation measures – MoP vs. MoE
  - Should distinguish between technology-focused vs. application focused evaluation measure
  - Is multi-modal combination an application of technologies or a technology itself?
- Common recognition algorithms
  - To minimize barrier to entry
  - Perhaps some notion of standardized scores
  - Not ideal since it tends to focus on late fusion

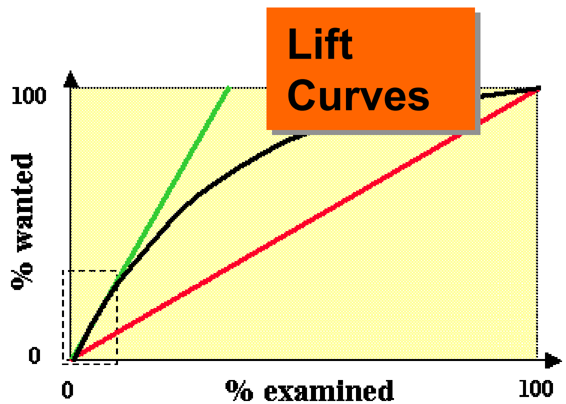
What is needed to for R&D?
Fusion Research

- Better theoretical framework
  - Statistical combination (learned parameters)
  - Rule-based
  - Event-based
- Early vs. late
  - Late: focused on fusion of separate system scores
  - Early: requires internals and probably new classifiers
- Use of external knowledge
  - Measures of channel quality and conditions to know when to discount mode
  - Modification of priors
  - When/how to adapt or update fusion
- Fusion or combination
  - Primary and secondary testing
  - Fast, more errorful first pass providing short-list for slow, more accurate second pass

Evaluation
MoPs to MoEs

- **MoP: Technology-focused Measures of Performance**
  - **Represents quantitative measure of core technology**
- **MoE: Application-focused Measures of Effectiveness**
  - **Represents quantitative/qualitative measure of how technology helped final application**





Easy to repeat	Repeatable, given priors	Hard to repeat
Defined objective	Estimate benefit	Fuzzy objective
Cheap	Cheap	Expensive
Suited to machine consumer	Intermediate	Suited to human consumer

Topics for Multi-Biometric Research

Paul Griffin

Chief Technology Officer, Identix Corporation
Paul.Griffin@Identix.com

12 Dec 2003

Problem #1: Border Security

- Multi-biometric systems are too expensive for most IT and PAC applications.
- However, many countries are adopting multi-biometric systems for border security where high throughput makes MB systems cost effective.

United States	Finger (1+1,4+4)	Face
European Un.	Finger (1+1 likely)	Face
Japan	Iris	Face
United Kingdom	Iris?	Face?
Korea	Finger	Face
Canada	Finger	Face
Israel	Hand	Face
Australia	None…	Face

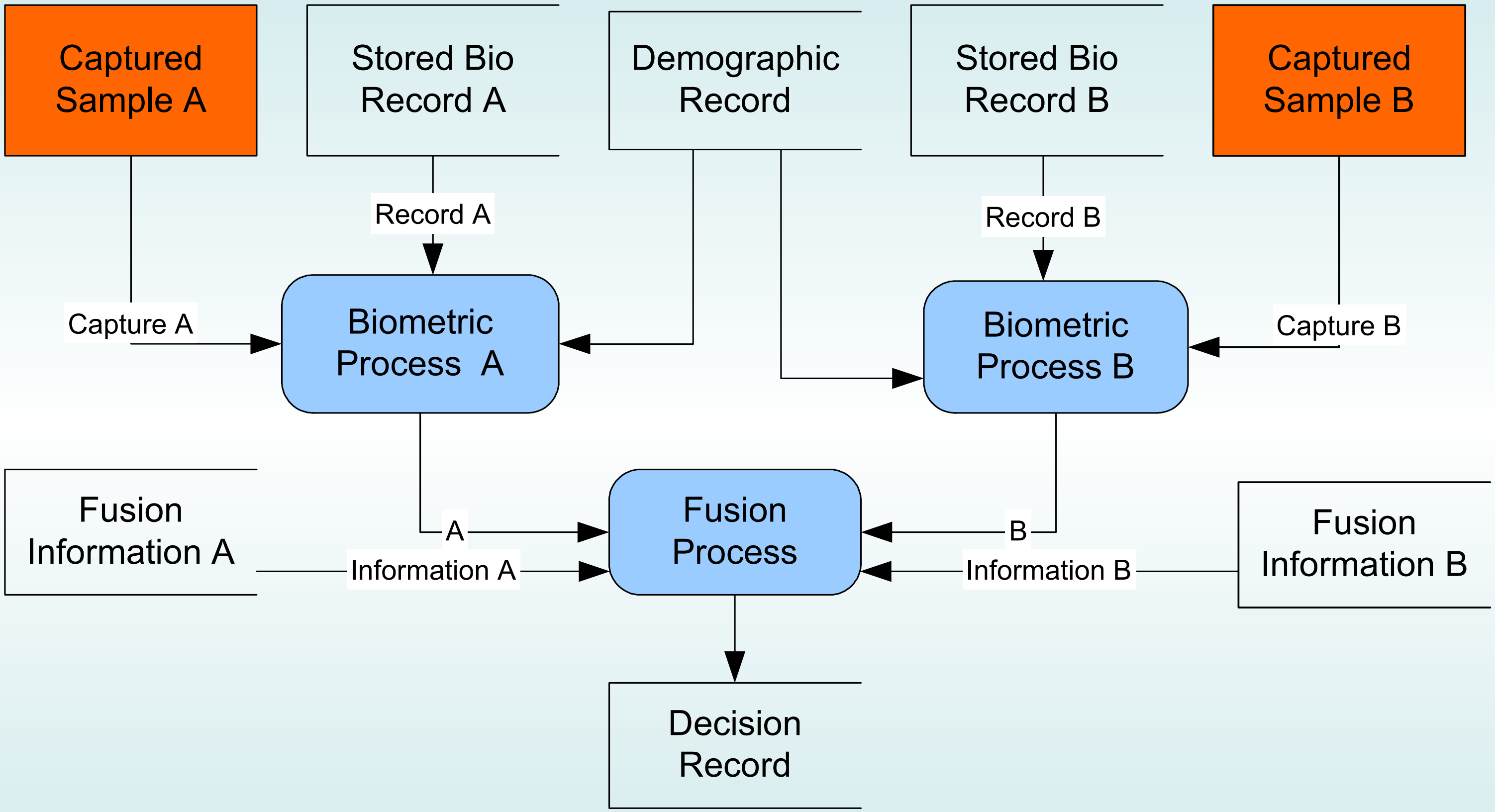
Problem #2: Sensitive Information

- There is a limited market for biometric systems for access to sensitive information.
- A typical requirement is FAR<.01% and FRR<.1%.
- No single “known” biometric can achieve this.
- For these markets, high cost ($1000) can be justified for “C2” certified biometric systems.
- Certification would consider fraud prevention, overall system performance as well as raw biometric performance.

Topic 1. Risk Analysis

- Generating an ROC or CMC curve is only half the solution. One also has to determine the operating point on that curve!
- Risk analysis is a well defined topic in statistics. The field of biometric statistical analysis would address the problem of reducing risk using biometric systems, and determining systems which minimize risk problem statements.
- This topic would be a collaborative effort between “biometricists” (experts in biometrics), sociologists, statisticians, and government.
- Relevant to multi-biometric systems because performance is a driving factor in system development. Performance reduces risk/cost.
- The problem should drive the choice of biometric in a well-defined way. How is this quantified?
- Expertise in pattern matching is not required.

Topic 2. Fusion



A fusion process must be determined for every use modality - verification, identification, watch-list, reverse-surveillance, etc.

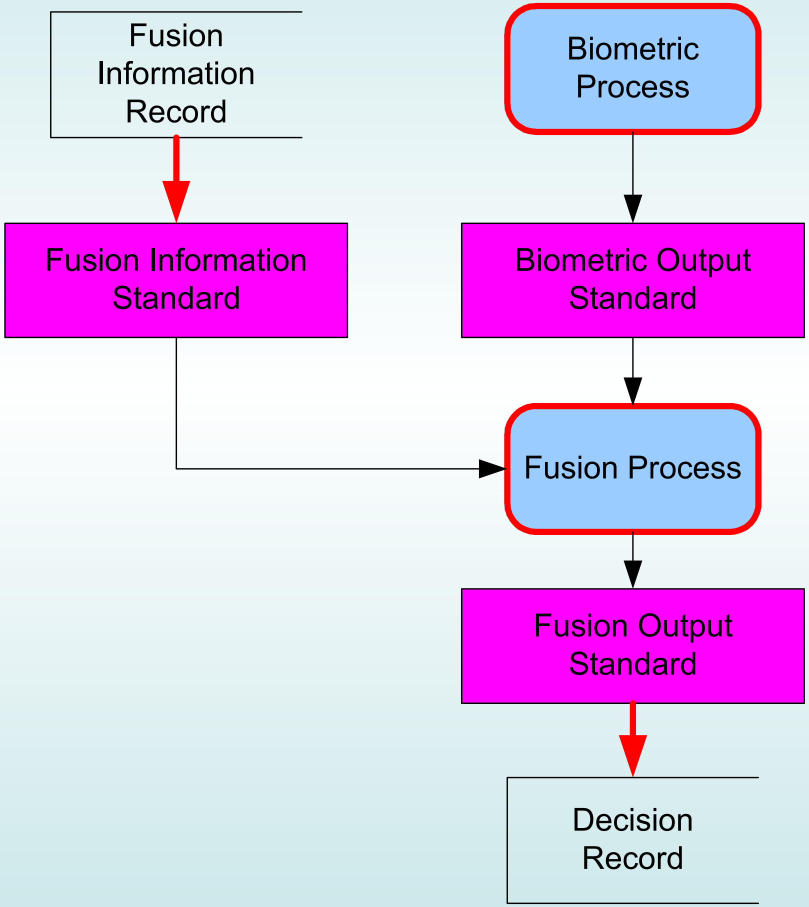
Fusion (continued)

- While the Bayes and Neyman Pearson theorems provide roadmaps for decision making, the instantiation of optimal fusion for each biometric modality is incomplete or non-existent.

Process	Correlation	Optimal Fusion Methodology Proposed?
Verification	None,Weak,Strong	Yes, No, No
Identification	None, Weak, Strong	No, No, No
Watchlist	None, Weak, Strong	No, No, No

- Significant mathematically groundbreaking work remains to be performed.
- The field may be suffering from an over reliance on computers to solve problems via brute force.

Topic 3. Mix and Match



- Because performance is expected to be so good, it may be cost prohibitive to retest a good system whenever a biometric subunit is upgraded!

- For Verification, Identification, or any other biometric modality,
  - How does one define a universal score (Biometric Output)?
  - What information is truly required to “plug in” a biometric? (Fusion Info)?
  - What is the correct biometric independent score (Fusion Output)?