Evaluation of Latent Fingerprint Technologies: Fusion

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Introduction

- Fusion:
  - Consolidating information from multiple sources (e.g. multiple fingers, multiple algorithms).
- Principle Goals:
  - Improve identification rate.
  - Improve rank ordering to reduce workload on the human examiner.

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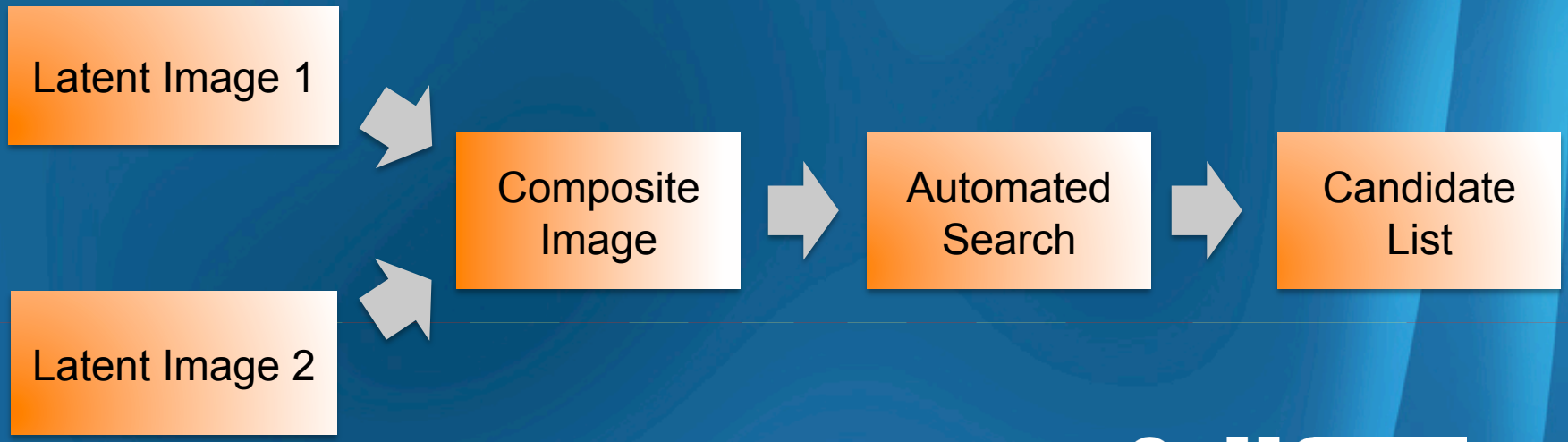
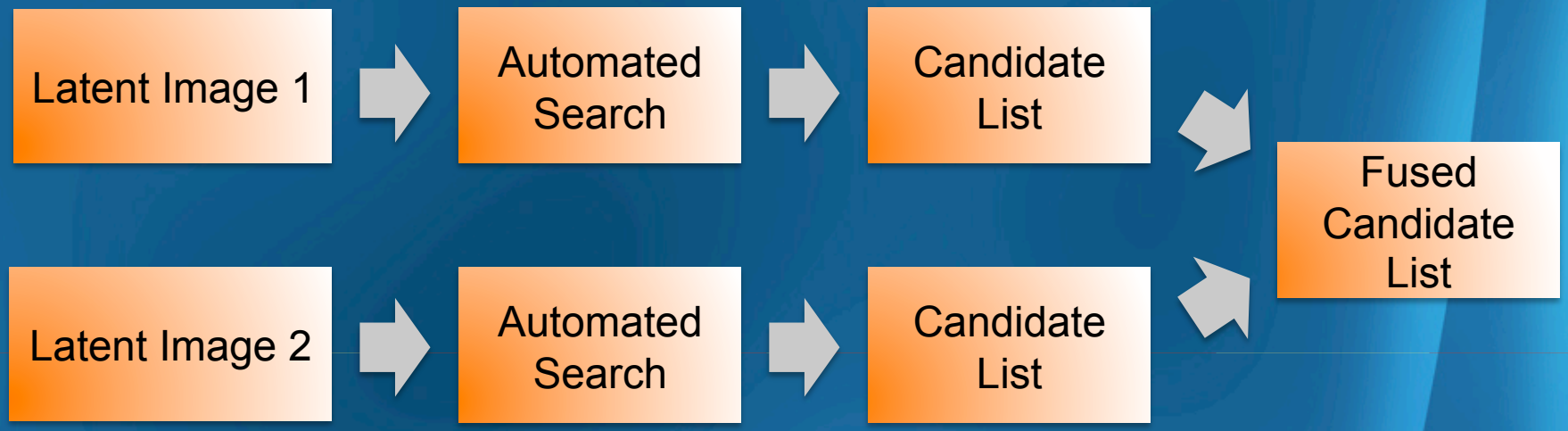
Fusion Levels

- Fusion can can occur at various stages during the matching process.
- In the diagram below, fusion occurs at the image level. Multiple latent images of the same finger are combined to create a new composite image.



Rank Level Fusion

- ELFT focused on fusion at the rank / score level, which occurs after invocation of the automated matcher(s).
- In the diagram below, the latent images are searched independently of each other. Their candidate lists are then "fused".



Rank and Score Level Fusion schemes

A candidate receives a rank and a score on each candidate list. These scores or ranks are fused to produce an overall score.

- Sum Score: $s_{fused} = s_1 + s_2 + \ldots + s_n$
- Minimum Rank: $s_{fused} = \min(r_1, r_2, \ldots, r_n)$
- Logistic Regression: $s_{fused} = w_1 \cdot r_1 + w_2 \cdot r_2 + \ldots + w_n \cdot r_n$
- Borda Count: $s_{fused} = (c - r_1) + (c - r_2)$

where s_i = subject's score on ith candidate list.

r_i = subject's rank on ith candidate list.

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Multi-Finger Fusion

- Fusion using multiple fingers (not multiple impressions of the same finger).
- Two or more latent impressions are often available for a subject. For the Phase II dataset, latent images for more than one finger were available for 121 of the 588 subjects.
- For AFEM, multi-finger fusion requires little additional work on the part of the latent examiner.

Two-Finger Fusion

For the 121 subjects, two fingers were chosen randomly. The rank of the correct mate was determined for each finger.

Rank of correct mate for first finger

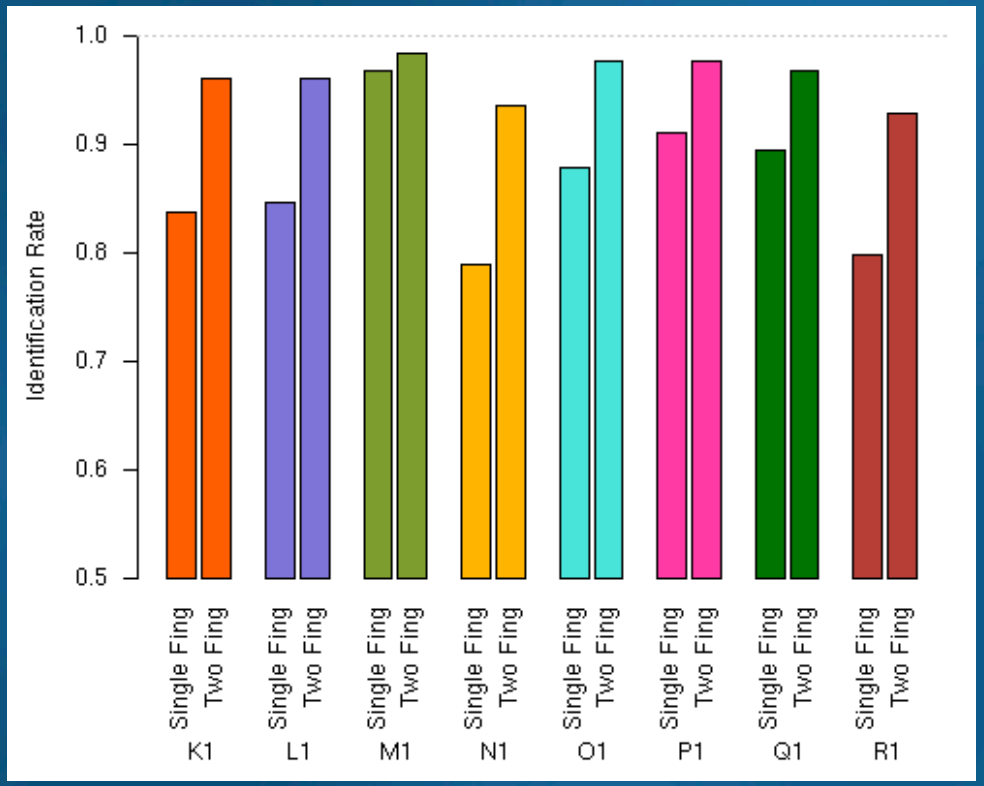
Rank of correct mate for second finger	1	2-10	11-20	21-50	Miss
1	86	0	2	1	12
2-10	0	0	0	0	0
11-20	0	0	0	0	0
21-50	1	0	1	0	0
Miss	14	0	2	0	3

K1

- The correct mate was almost always:
  1) at rank one on at least one of the candidate lists.
  2) not on either candidate list.

- The Fusion method should place a high value on the rank one candidates from the unfused lists.

Two-Finger Fusion



Rank 10 identification rate.
(Gallery size 5,000; latent image resolution 500 ppi)

Multi-Algorithm Fusion

- Searching with multiple algorithms.
- Requires no additional information from the source (i.e. the subject).
- More computationally expensive.
- A smaller improvement in matching accuracy is expected due to a high level of correlation.
- It is better to combine algorithms that are less similar.

Multi-Algorithm Fusion

Pairing algorithms improves matching performance.

	K1	L1	M1	N1	O1	P1	Q1	R1
K1	.84	.90	.98	.90	.94	.95	.94	.90
L1	.90	.83	.98	.89	.93	.94	.93	.88
M1	.98	.98	.97	.98	.99	.98	.98	.98
N1	.90	.89	.98	.79	.92	.93	.93	.88
O1	.94	.93	.99	.92	.87	.96	.94	.92
P1	.95	.94	.98	.93	.96	.90	.96	.94
Q1	.94	.93	.98	.93	.94	.96	.88	.92
R1	.90	.88	.98	.88	.92	.94	.92	.81

Rank 10 identification rate.
(Gallery size 5,000; latent image resolution 500 ppi)

Multi-Algorithm Fusion

- Highlights from Table:
  - Q1: 0.88
  - P1: 0.90
  - Q1 + P1: 0.96
  - M1: 0.97
  - M1 + O1: 0.99

Conclusions

- We see a potential for both multi-finger and multi-algorithm fusion to improve matching accuracy.
- More research to be done.
- Future methods of rank / score level fusion should use longer candidate lists.