Face Retrieval for Security Applications

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Face Recognition Technology

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Detection of faces

Extraction of face features


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<17.9, 12.1, -9.1, 692.0, …>


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Indexing face features

Similarity Search Technology

Face Recognition Technology

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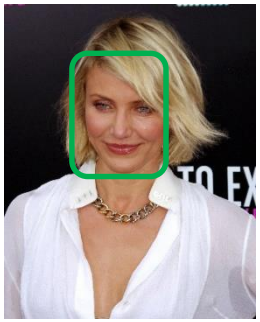
Similarity Search Technology

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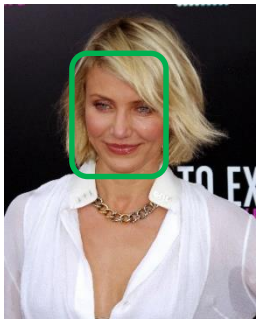


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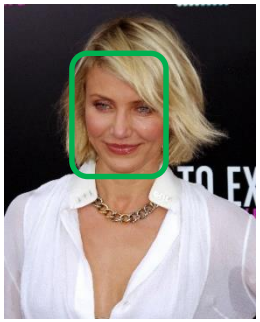


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Similarity search

Visualization of the most similar faces


0.12

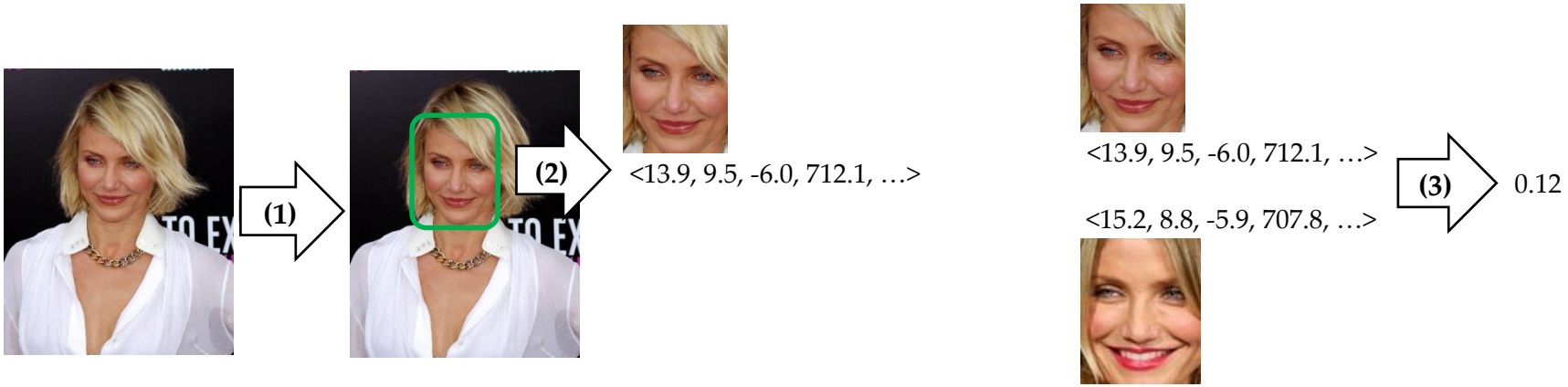

0.17


0.18


0.23

Face Recognition Technology: Components

- Components of general face recognition technology
  1) Face detection function
     - Localizes bounding boxes of faces within a static image
  2) Feature extraction function
     - Extracts a characteristic feature of a face image
  3) Face recognition function
     - Computes similarity score between features of two faces



Our Face Recognition Technology

- Our objective – to effectively and efficiently retrieve the most similar faces to a query face(s)

- Improvement of detection/recognition components:
  1) Face detection function – combining multiple state-of-the-art approaches for more effective detection
  2) Feature extraction func. – aggregating multiple features
  3) Face recognition function
     - Combining multiple approaches for more effective recognition
     - Multi-face query evaluation for more effective retrieval
     - Pre-selection of candidate set and its re-ranking for more efficient retrieval

Our Face Recognition Technology: Face Detection

- Aggregation of existing detection approaches to increase recall/precision

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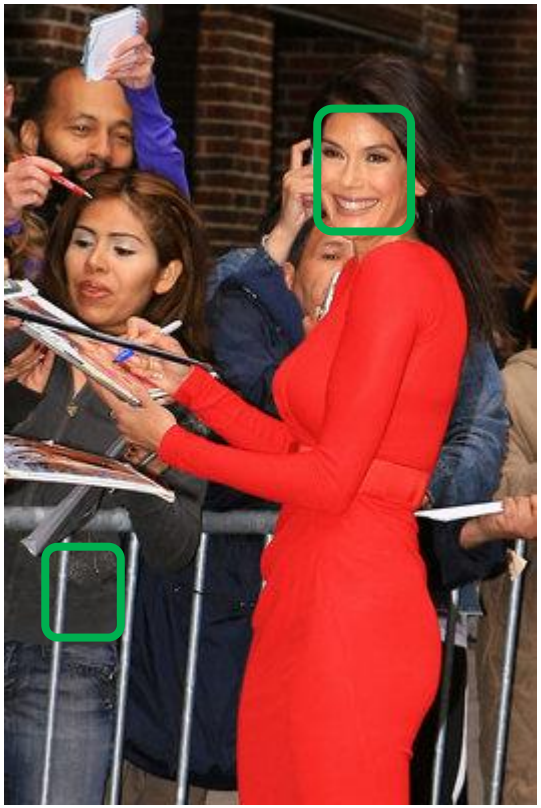

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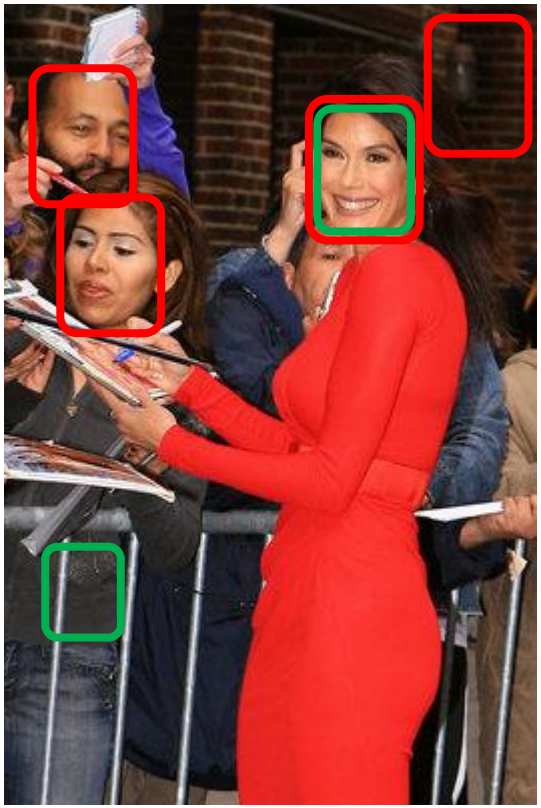

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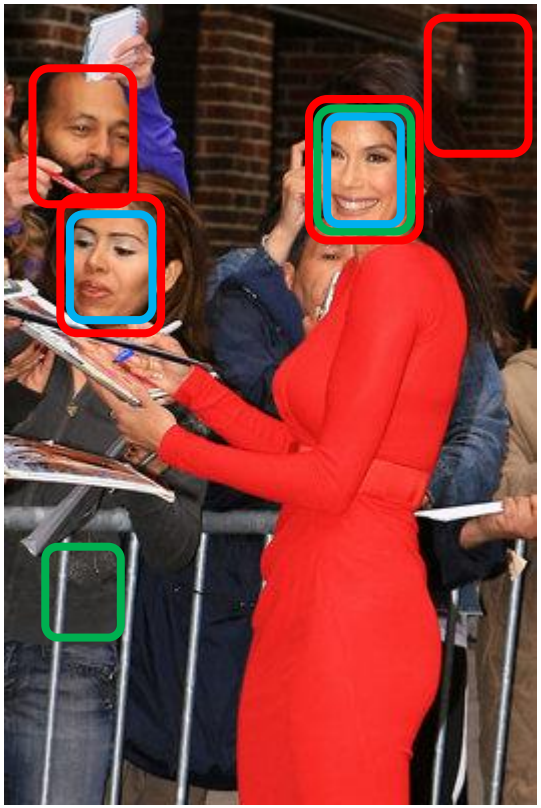

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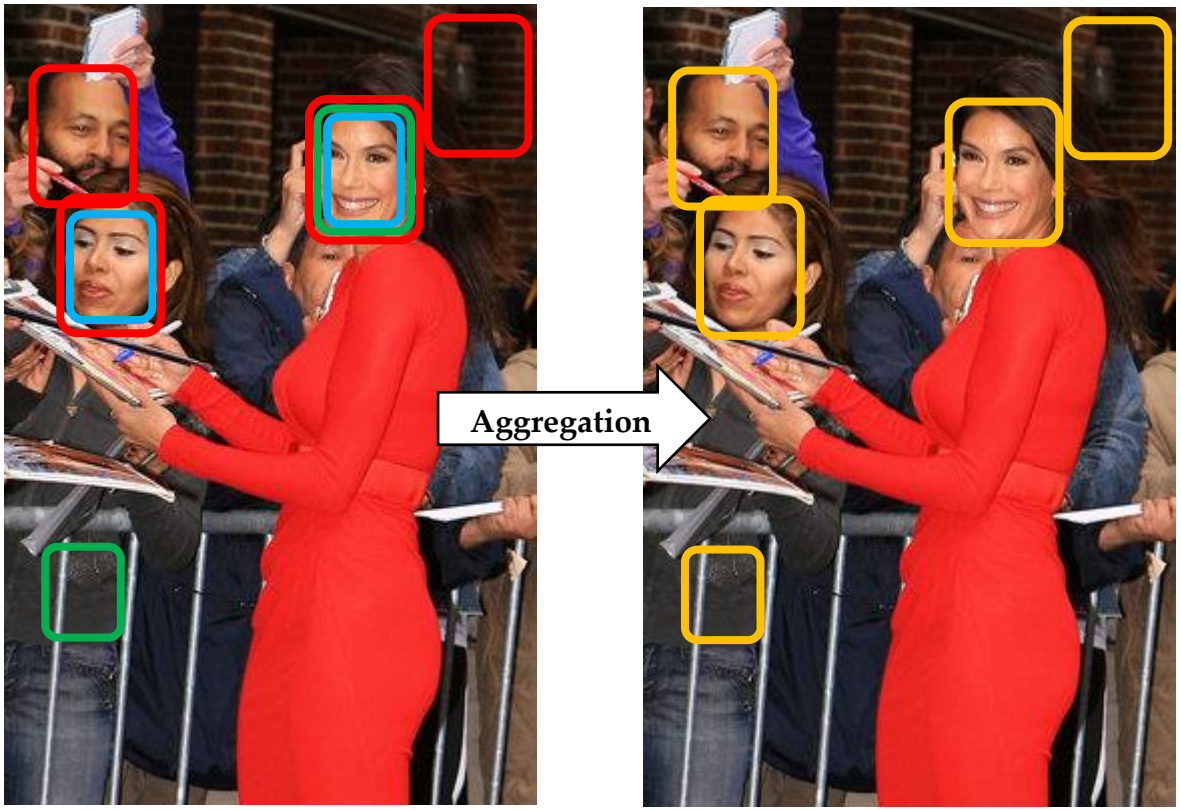

Union aggregation
recall: 100%
precision: 60%

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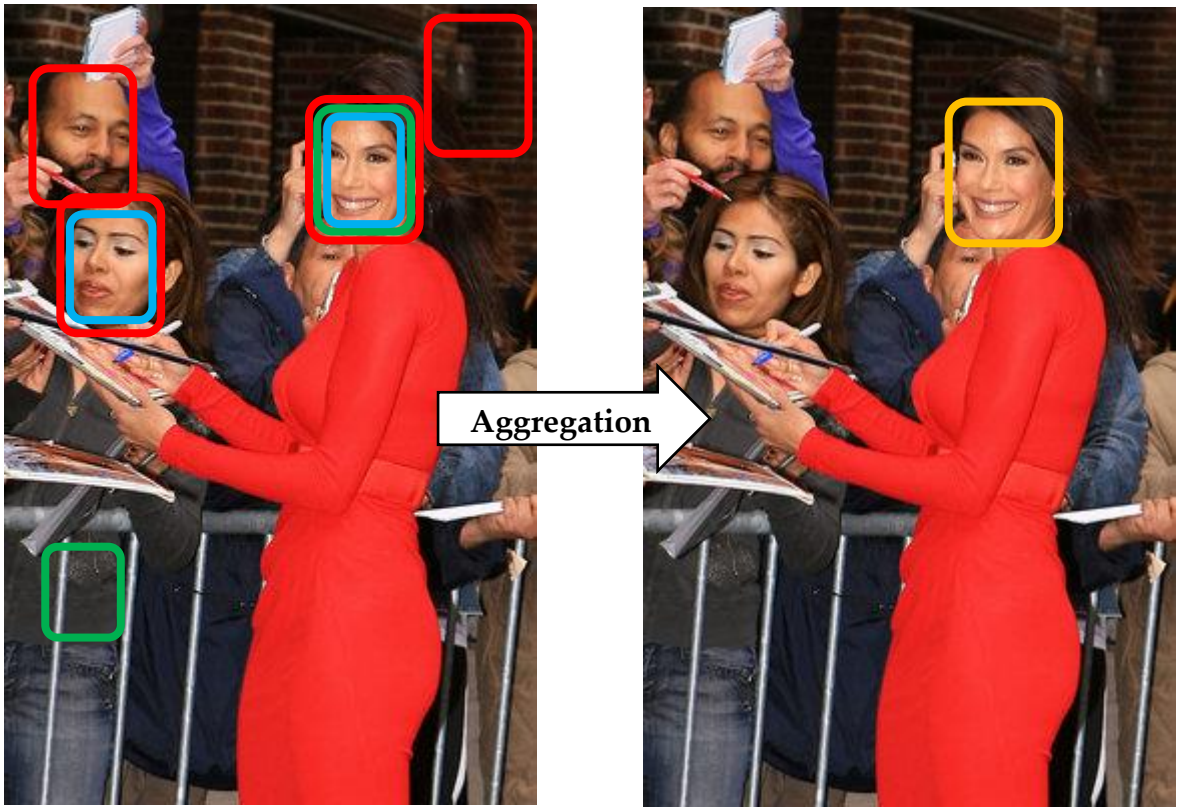

Union aggregation
recall: 100%
precision: 60%

Intersection aggregation
recall: 33%
precision: 100%

Our Face Recognition Technology: Face Detection

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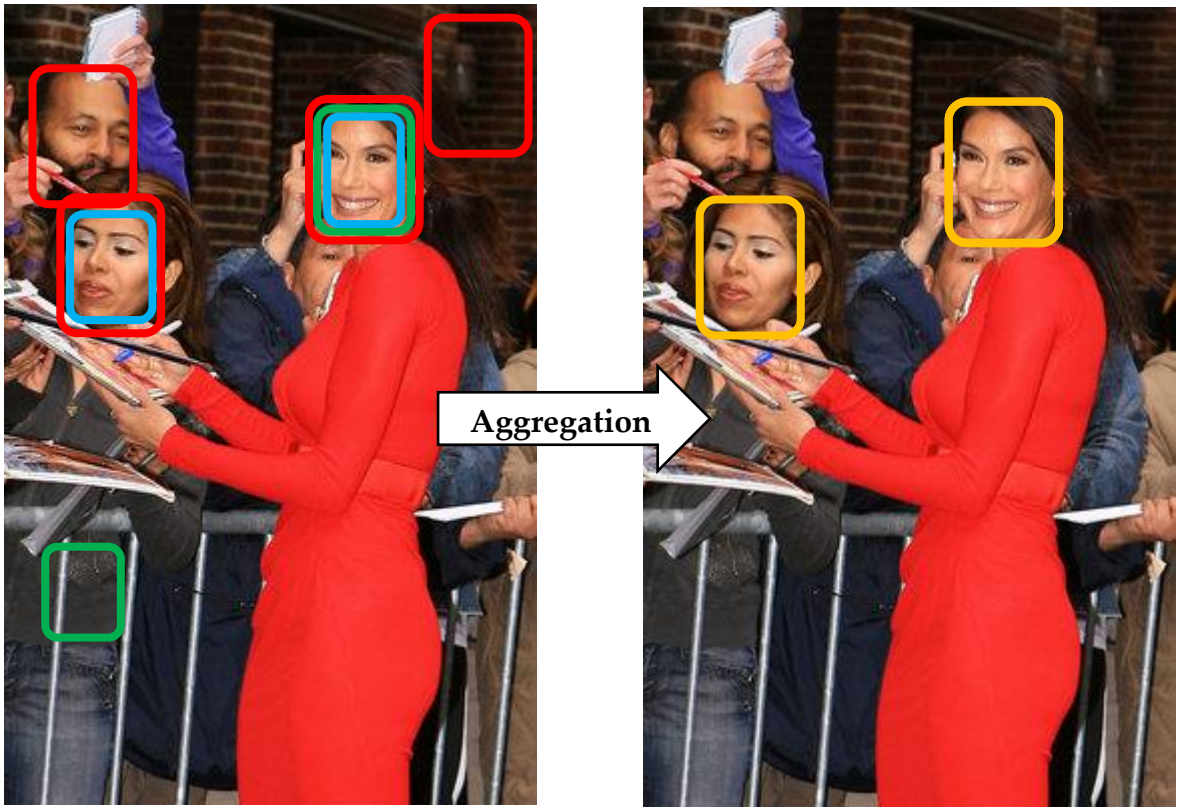


Union aggregation
recall: 100%
precision: 60%

Intersection aggregation
recall: 33%
precision: 100%

2/3 aggregation
recall: 66%
precision: 100%

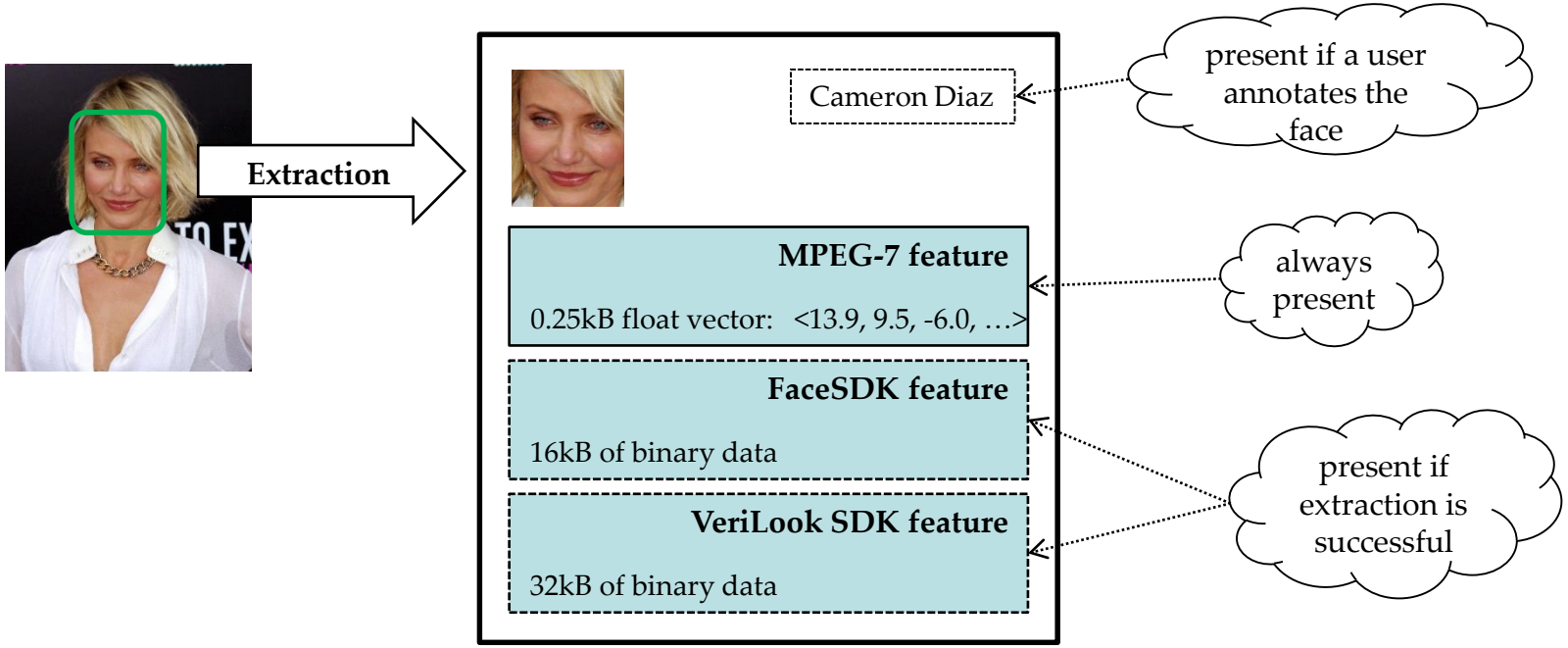
Our Face Recognition Technology: Face Detection (cont.)

- Current implementation:
  - Aggregation of at least 2 approaches out of 3
    - OpenCV – open source from Computer vision library
    - FaceSDK – commercial software from Luxand
    - VeriLook SDK – commercial software from Neurotechnology

	Low-quality face images # of faces: 1000		**High-quality face images # of faces: 10,000**	
	Recall	**Precision**	**Recall**	**Precision**
OpenCV	55	89	92	86
FaceSDK	63	83	95	94
VeriLook SDK	73	84	100	96
Our aggregation	**62**	**98**	**97**	**100**

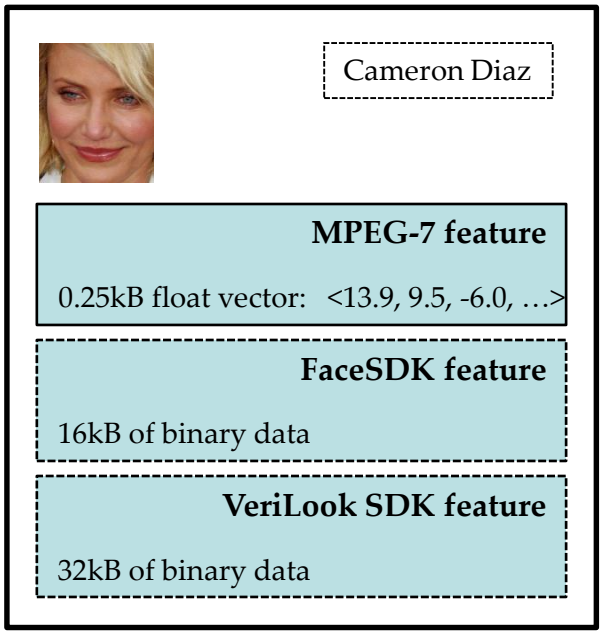
Our Face Recognition Technology: Feature Extraction

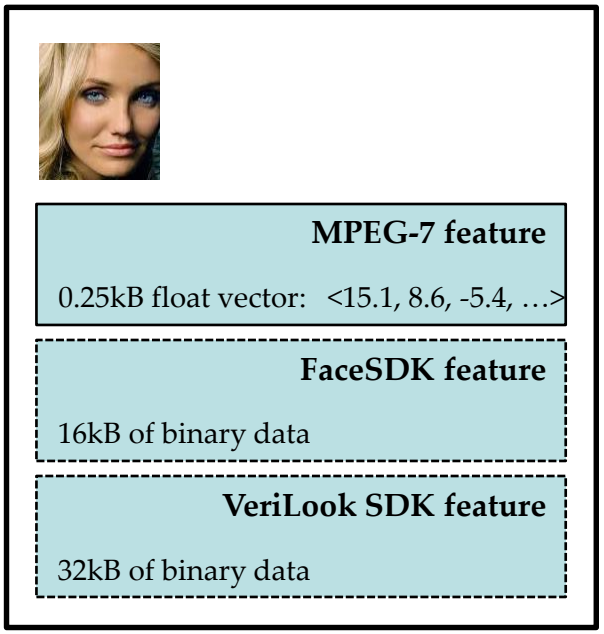
- Utilization of existing extraction approaches to characterize a face by a set of different features
- Current version integrates three approaches of MPEG-7, FaceSDK and VeriLook SDK features



Our Face Recognition Technology: Face Recognition

- Similarity of two faces is computed as aggregation of normalized inner similarities between features





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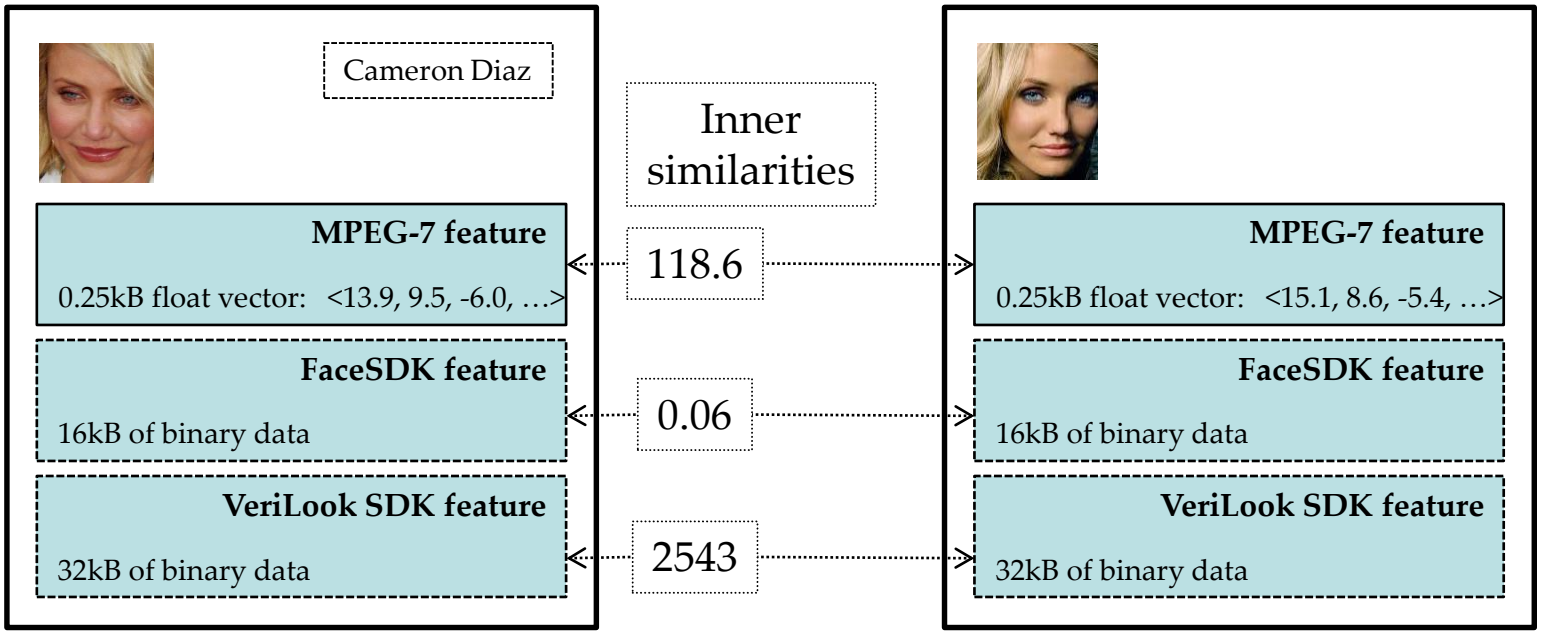

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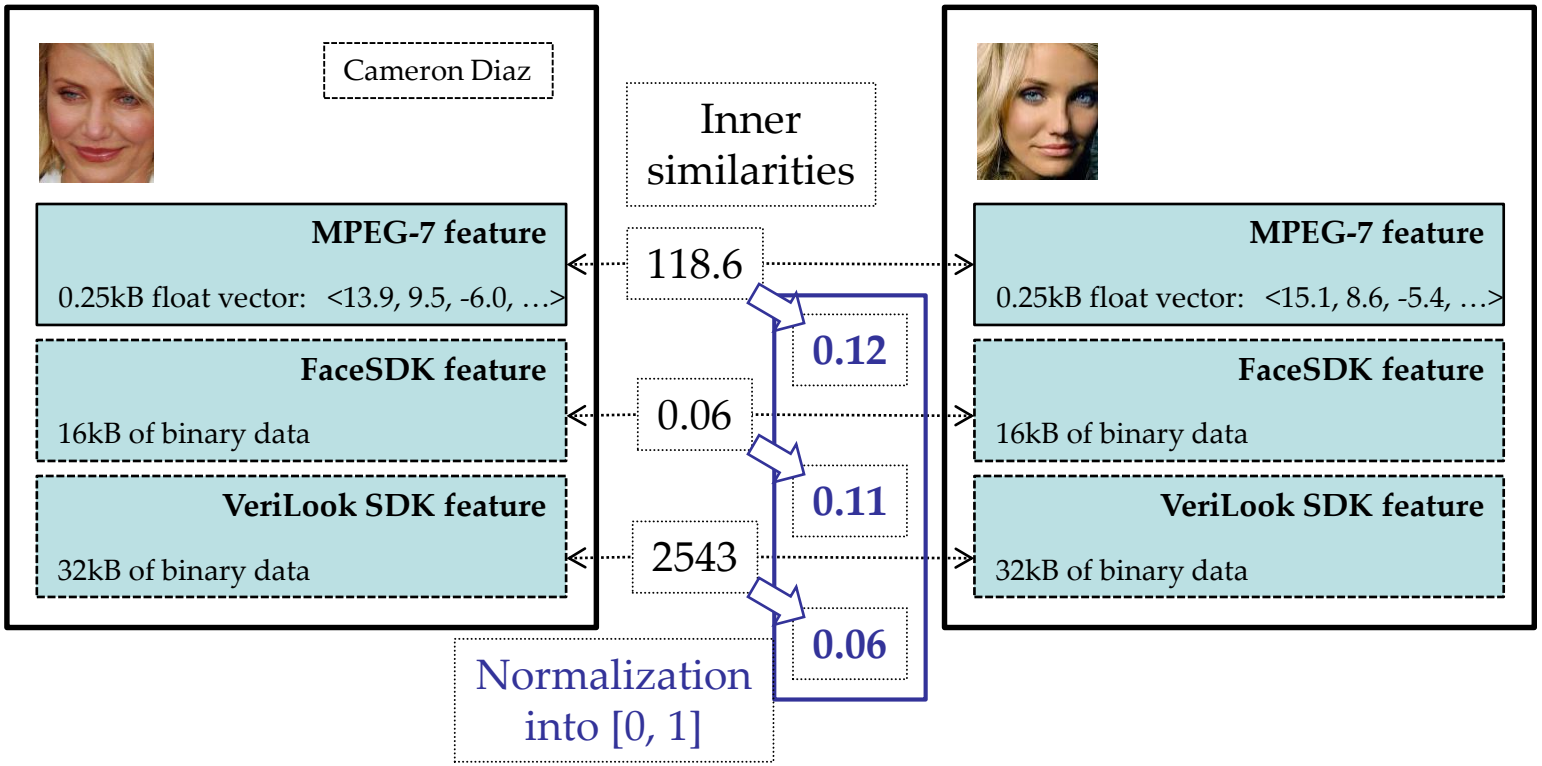

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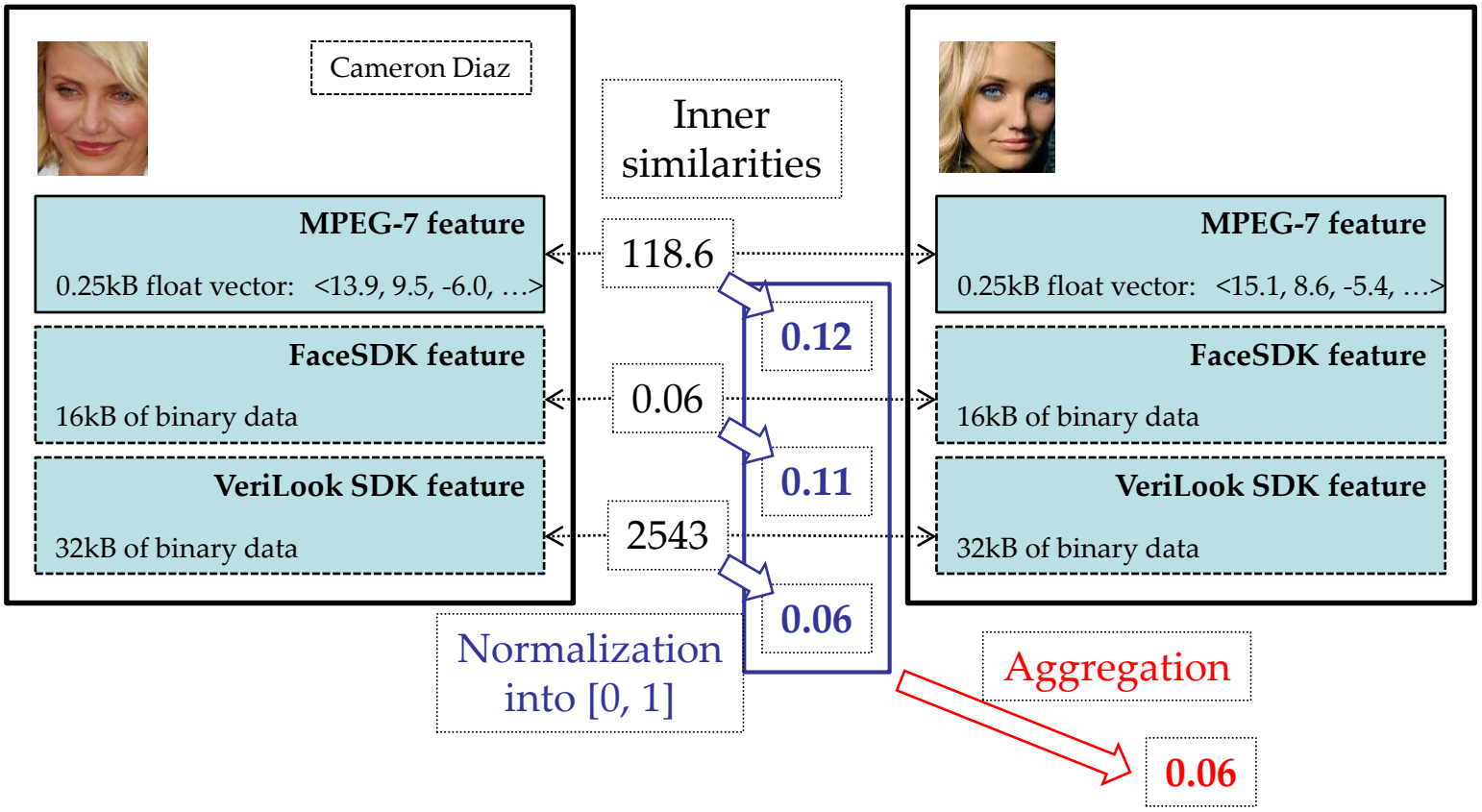
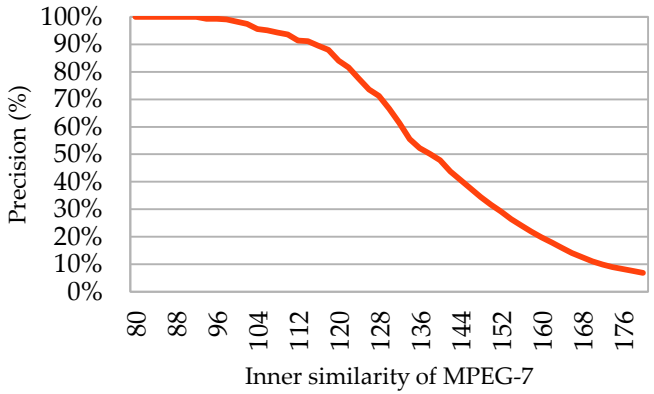


Our Face Recognition Technology: Face Recognition (cont.)

- Inner similarities are computed by integrated recognition approaches themselves
- Each inner similarity is then normalized according to specifically learned normalization function
  - Normalization func. learned from training data (example)



Normalized value =
100% - <precision of inner similarity>

Example:
inner similarity = 118.6 ⇒ precision = 88% ⇒
normalized value = 100% - 88% = 12% ⇒ 0.12

- Aggregation is minimum of normalized similarities

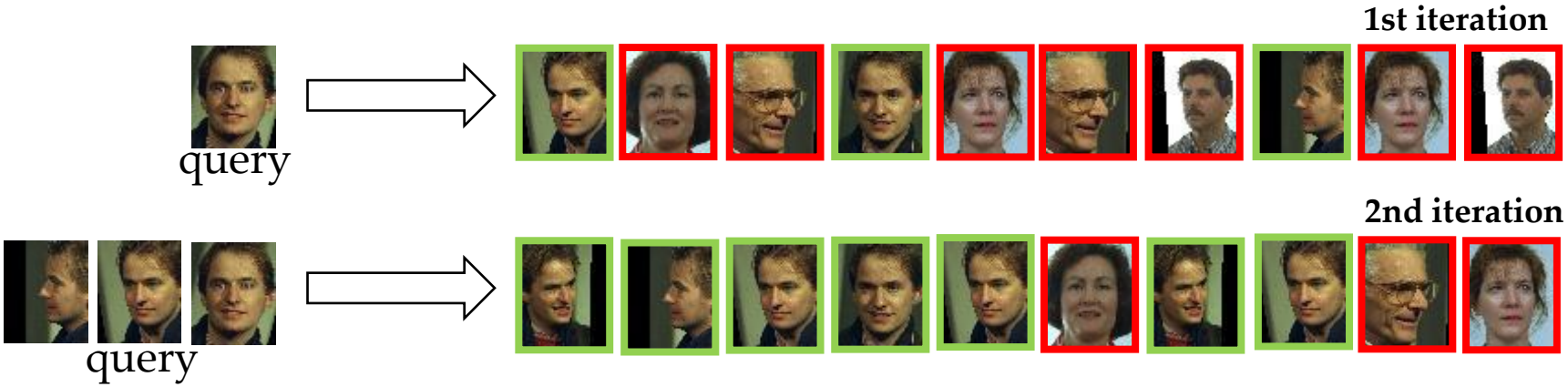
Our Face Recognition Technology: Face Recognition (cont.)

- Aggregation approach increases the quality of face recognition in terms of recall and precision
- Face images of high/low quality have a distance between eyes >100/<30 pixels

	Low-quality face images # of faces: 1000		**High-quality face images # of faces: 10,000**	
	Recall precision=85%	**Recall** precision=95%	**Recall** precision=85%	**Recall** precision=95%
MPEG-7	24	14	8	3
FaceSDK	23	16	14	0
VeriLook SDK	12	11	53	51
Our aggregation	**31**	**24**	**54**	**51**

Our Face Recognition Technology: Face Recognition (cont.)

- Multi-face query:
  - Query composed of a number of reference faces



  - Relevance feedback on 1M dataset:
    - Manual selection of positive (correct) retrieval results
    - Iterative search where positive results represent query faces
    - 1st iteration: **precision=6%**, 5th iteration: **precision=30%** (k=100)

Our Face Recognition Technology: Face Recognition (cont.)

- Preprocessing (indexing) phase:
  - All faces are indexed according to the MPEG-7 feature
    - M-index (Novak, 2012) structure is utilized
    - Indexing of 1M faces takes ~10minutes
- Efficient (scalable) retrieval of 100 faces:
  - Candidate set of 10,000 the most similar faces is efficiently retrieved by M-index (only MPEG-7 feature is utilized)
    - Retrieval out of 1M faces takes ~0.15s (~10s without M-index)
  - Retrieved 10,000 faces are sorted (re-ranked) according to our aggregation approach
  - Top-ranked 100 faces are returned

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Increases efficiency

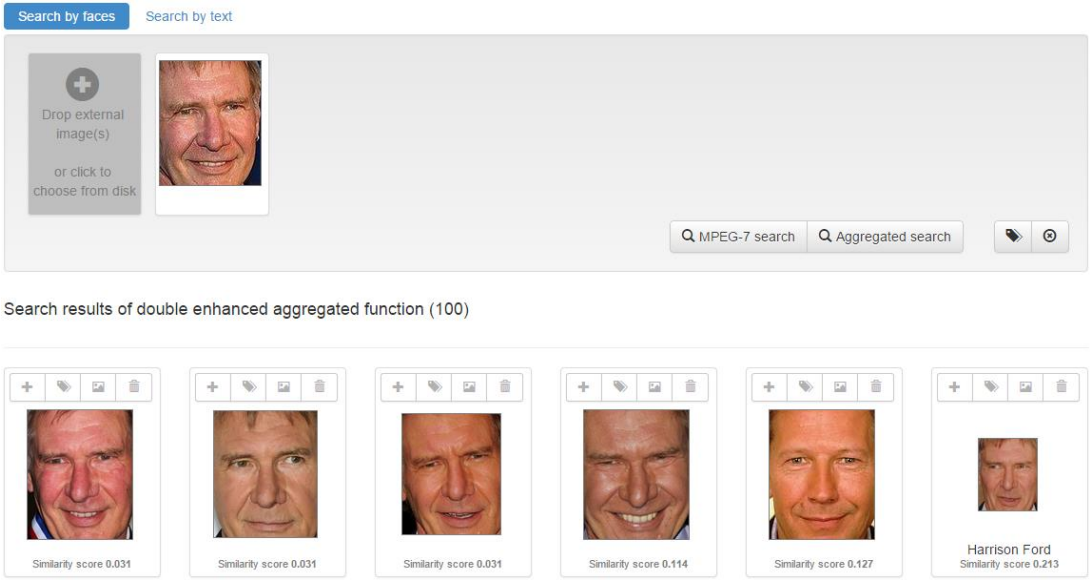
Increases effectiveness

Our Face Recognition Technology: Summary

- Advantages against other face recognition systems:
  - Support for multi-face query evaluation
  - Aggregation of multiple existing approaches for more accurate detection and recognition
    - Significant improve in the recognition accuracy (naive approach: 6% accuracy, our approach: 40% accuracy)
  - Tradeoff between the recognition accuracy and performance can be controlled by a user
    - Online search within millions of faces

Our Face Recognition Technology: Demonstration Application

- Demonstrated by an online web application:
  - Implemented within Java + Apache Tomcat
  - Commercial licenses of FaceSDK and VeriLook SDK
  - 1 million database of extracted faces
  - http://disa.fi.muni.cz/FaceMatch/



Questions?

Thank you for your attention.

Try our online web application:
http://disa.fi.muni.cz/FaceMatch/