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Topology Preserving Graph Matching for Partial Face Recognition

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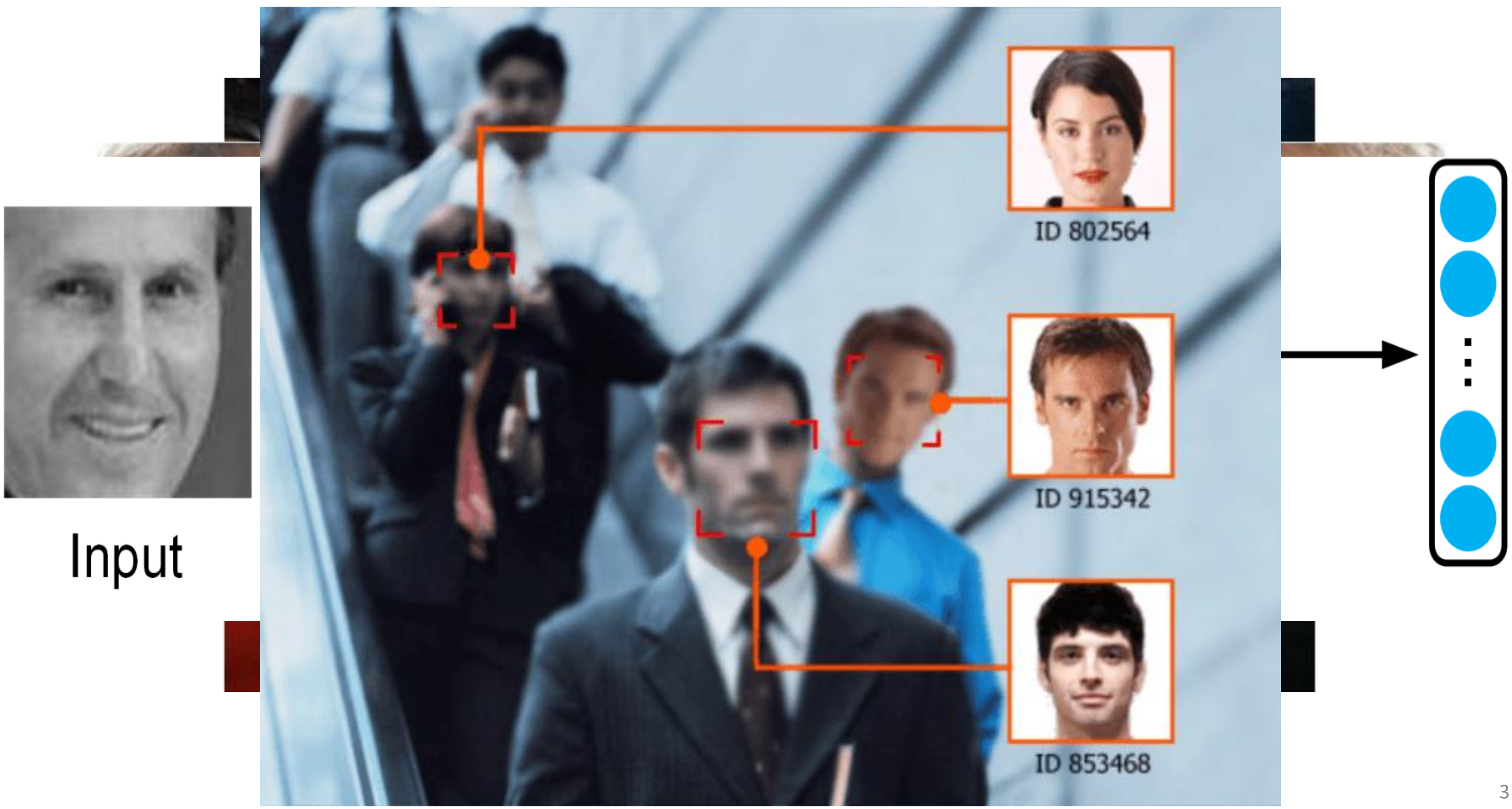
Face Recognition

- Access control
- Surveillance
- Eas

Typical Face Recognition System

- Face detection → Face alignment → Face representation → Face classification



Partial Faces Exist in the Wild

- Under crowded scenes:

- Occ

Challenges

Challenges

- Unreliable face alignment
  - Most face alignment approaches require landmark detection
  - Missing landmarks in partial faces

- Less discriminative description
  - Different facial parts of the same person → Large intra-class distance
  - Description of the occluded objects → Small inter-class distance

Challenges

The LFW dataset

- HDLBP: 84.08%
- VGG-16: 97.27%

The partial LFW dataset

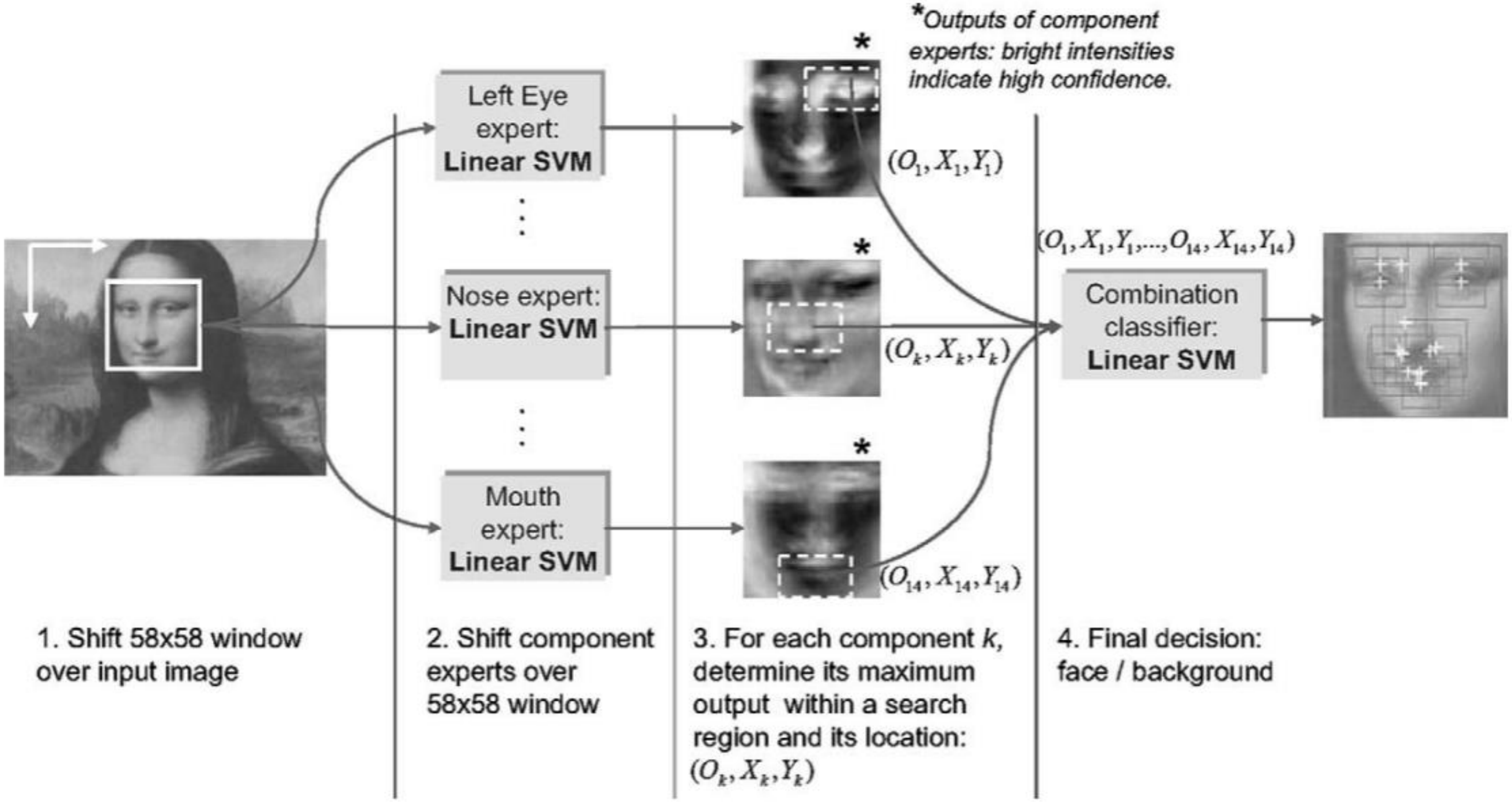
- HDLBP: 49.32%
- VGG-16: 71.27%

Partial faces deserve more attention!

Possible Solutions

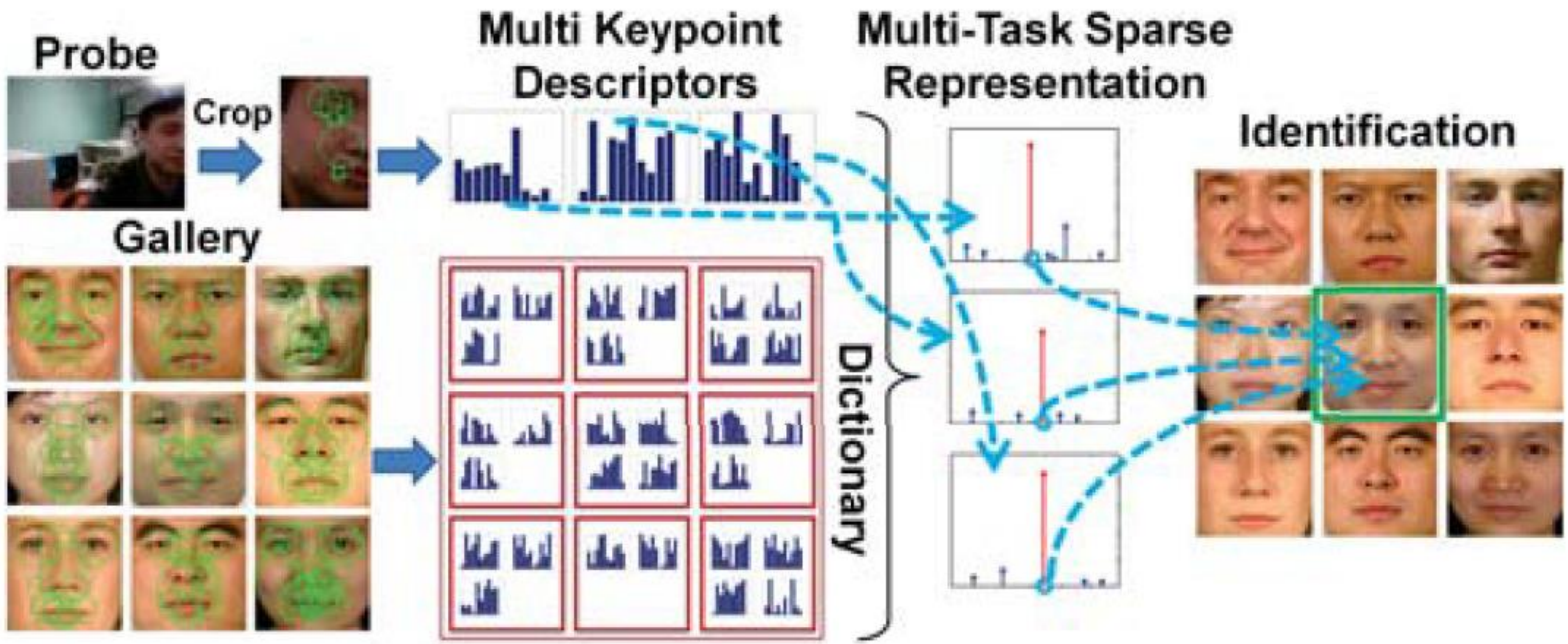
- Only describe the common facial parts
- Occlusion removal?
  - Difficult to detect occlusions from an unaligned face accurately
  - Description of different facial parts for the same person
- Component-based methods?

Component-Based Methods [1]



[1] Bernd Heisele, Purdy Ho, Jane Wu, and Tomaso Poggio, Face Recognition: Component-Based Versus Global Approaches, CVIU, vol. 91, no. 1, pp. 6-21, 2003.

Keypoint-Based Methods [2,3]



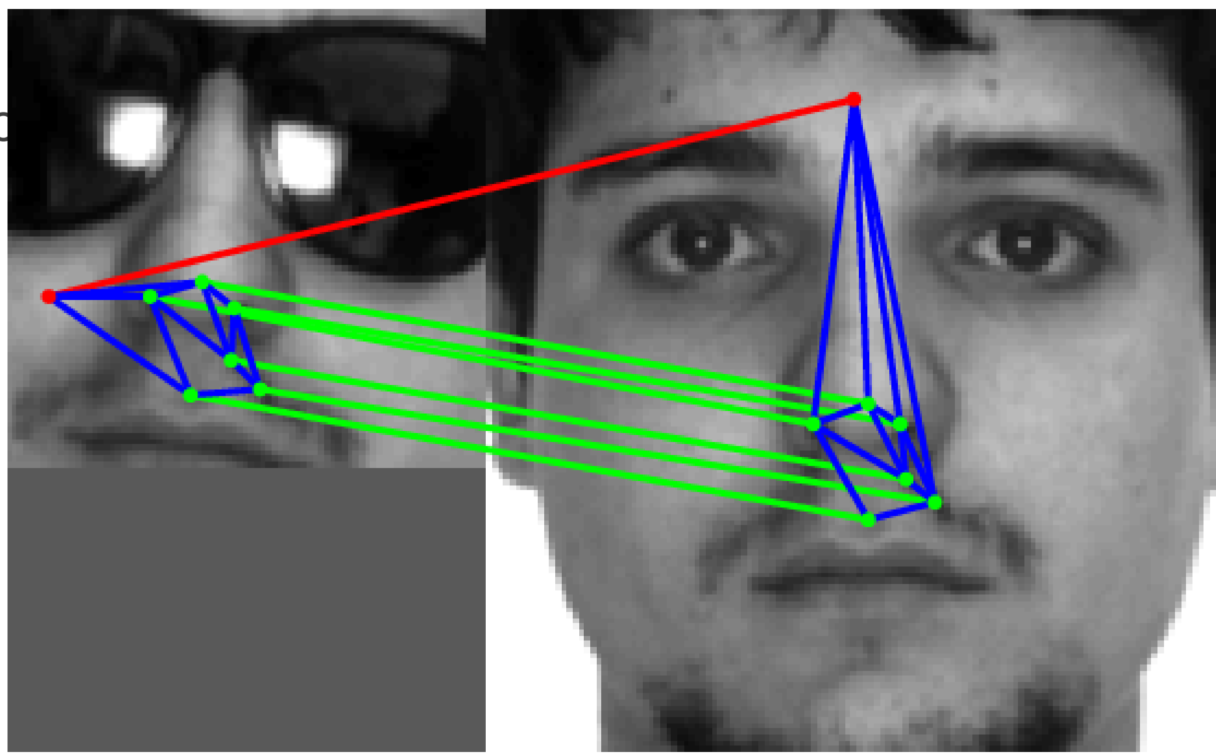
[2] Shengcai Liao, Anubhav K Jain, and Stan Z Li, Partial Face Recognition: Alignment-Free Approach, TPAMI, vol. 35, no. 5, pp. 1193-1205, 2013.

[3] Renliang Weng, Jiwen Lu, and Yap-Peng Tan, Robust Point Set Matching for Partial Face Recogniton, TIP, vol. 25, no. 3, pp. 1163-1176, 2016.

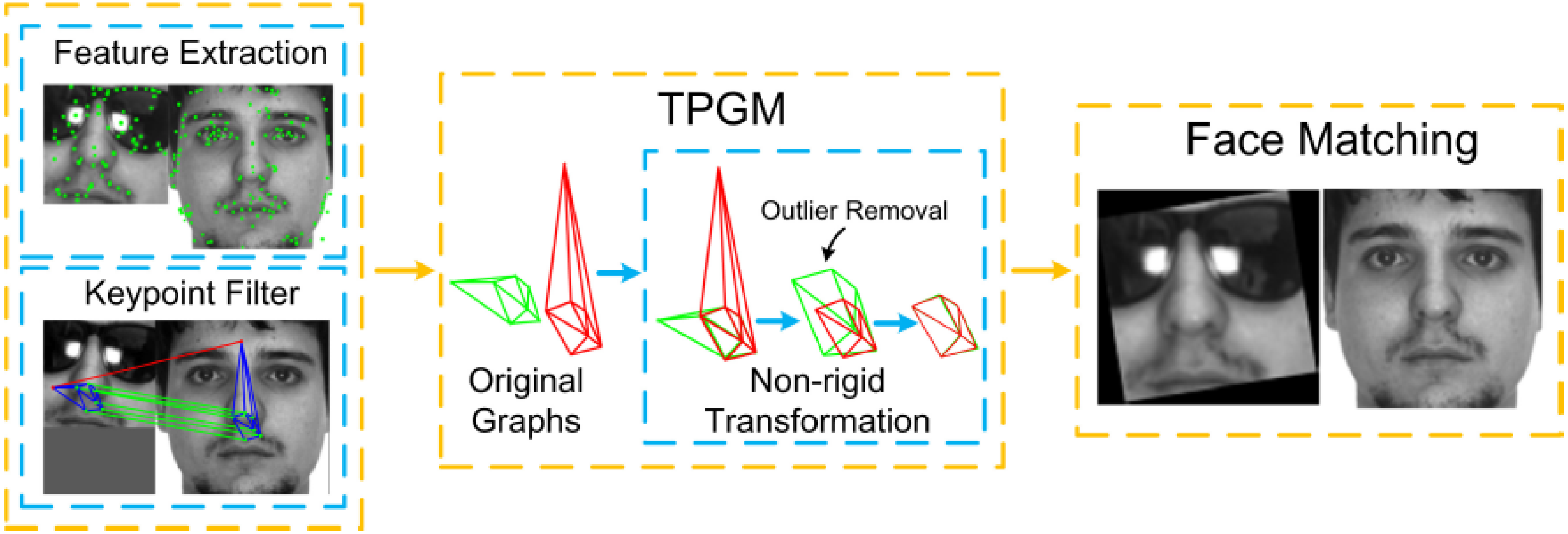
Motivation

- Existing local keypoint-based approaches rely heavily on the descriptors, ignoring the topological structural information

- The able,
  whic tching

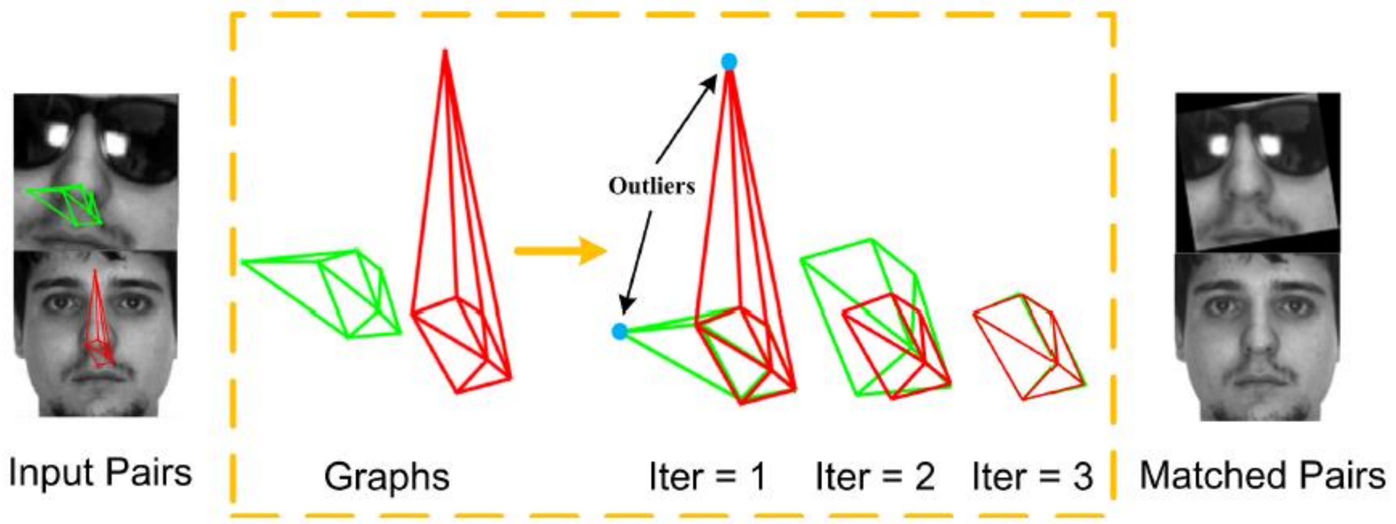


Flowchart



- **Feature Extraction**
  - SIFT keypoint detector and SiftSurfSILBP descriptor
- **Keypoint Filter**
  - Lowe's matching algorithm to remove obvious outliers
  - Lowe's matching relies on descriptors, which fails to exploit the geometric information
- **Topology Preserving Graph Matching**
  - Delaunay triangulation to construct the graph
  - Estimate a non-rigid transformation from the probe image to the gallery image
- **Face Matching**

Topology Preserving Graph Matching



- Estimate a non-rigid transformation to match the graphs
- Objective function:
  - Textural cost
  - Node-wise matching cost
  - Edge-wise matching cost

$$\begin{aligned} \min J \quad &= \quad K_t(\mathbf{t}^P, h^t(\mathbf{t}^P)) + \lambda_p K_p(f^p(\mathbf{p}^P), h^p(\mathbf{p}^P)) \\ &+ \quad \lambda_q K_q(f^q(\mathbf{q}^P), h^q(\mathbf{q}^P)) \ . \end{aligned}$$

- Outlier removal

Face Matching

- We compute the distance between probe and gallery faces as follows:

$$d = \frac{\bar{d}}{\sum_{i,j} \mathbf{X}_{ij}} = \frac{J_{min}}{(\sum_{i,j} \mathbf{X}_{ij})^2} = \frac{K_t + \lambda_p K_p + \lambda_q K_q}{(\sum_{i,j} \mathbf{X}_{ij})^2}$$

- In proportion to the average loss
- Inverse proportion to the number of matching pairs

Experimental Results

LFW

- 13233 labeled faces of 5749 subjects
- Random transformation

PubFig

- 58797 images of 200 people
- Random transformation

AR

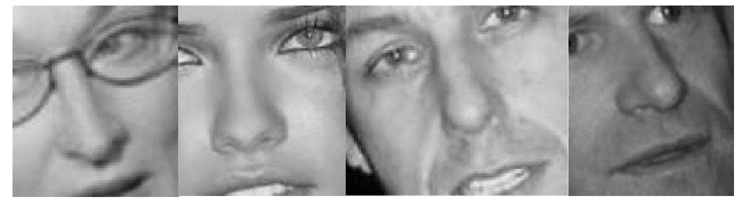
- 126 identities with 70 males and 56 females
- 13 facial images for an identity in a session:
  - 4 with different expressions
  - 3 under various illuminations
  - 3 wearing sunglasses
  - 3 wearing scarves

Evaluation on LFW and PubFig

☐The partial LFW dataset

Method	VR $\pm S_E$
HDLBP	49.32 ± 1.09
CNN	71.27 ± 1.38
CPD-SiftSurfSILBP	61.62 ± 1.19
MKD-SRC-GTP	68.18 ± 1.77
MLERPM-SiftSurf	65.55 ± 1.53
MLERPM-SiftSurfLBP	67.22 ± 1.83
LAIRPM-SiftSurf	70.40 ± 1.02
LAIRPM-SiftSurfSILBP	70.73 ± 1.68
RPSM-SiftSurf	70.81 ± 1.46
RPSM-SiftSurfSILBP	71.65 ± 1.57
TPGM-SiftSurfSILBP	$\mathbf{73.48 \pm 1.12}$

☐The partial PubFig dataset



Method	rank = 1	rank = 10	rank = 20
SiftSurfSILBP	25.00	49.29	57.86
CPD	28.36	51.93	62.29
MLERPM	27.86	52.86	64.29
MKD-SRC-GTP	38.57	62.14	72.14
LAIRPM	37.14	64.29	72.86
RPSM	42.86	65.00	74.29
TPGM	**43.57**	**66.43**	**75.71**

Evaluation on AR

- The AR dataset

Method	S1-G	S1-S	S2-G	S2-S
CPD	71.00	75.67	49.33	61.00
MLERPM	75.00	78.33	53.33	66.67
LAIRPM	87.33	88.33	56.33	81.33
MKD-SRC-GTP	82.33	83.33	57.67	76.33
RPSM	88.67	90.33	63.67	85.67
TPGM	**89.33**	**91.00**	**65.00**	**86.67**

Future Works

- The keypoint-based approach
  - Exploit higher order structural information for the graph
  - Deep graph matching approaches to learn reliable transformation
  - Usage of facial structure as strong prior knowledge

- Learning alignment-free local facial descriptor

- Partial face alignment

Thanks!