



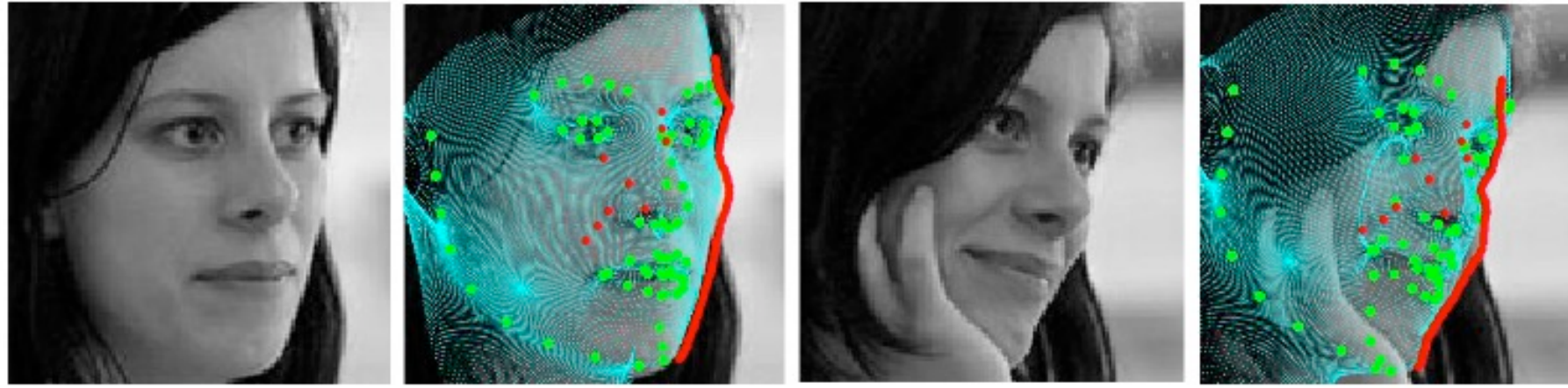
Dense Face Alignment

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Introduction



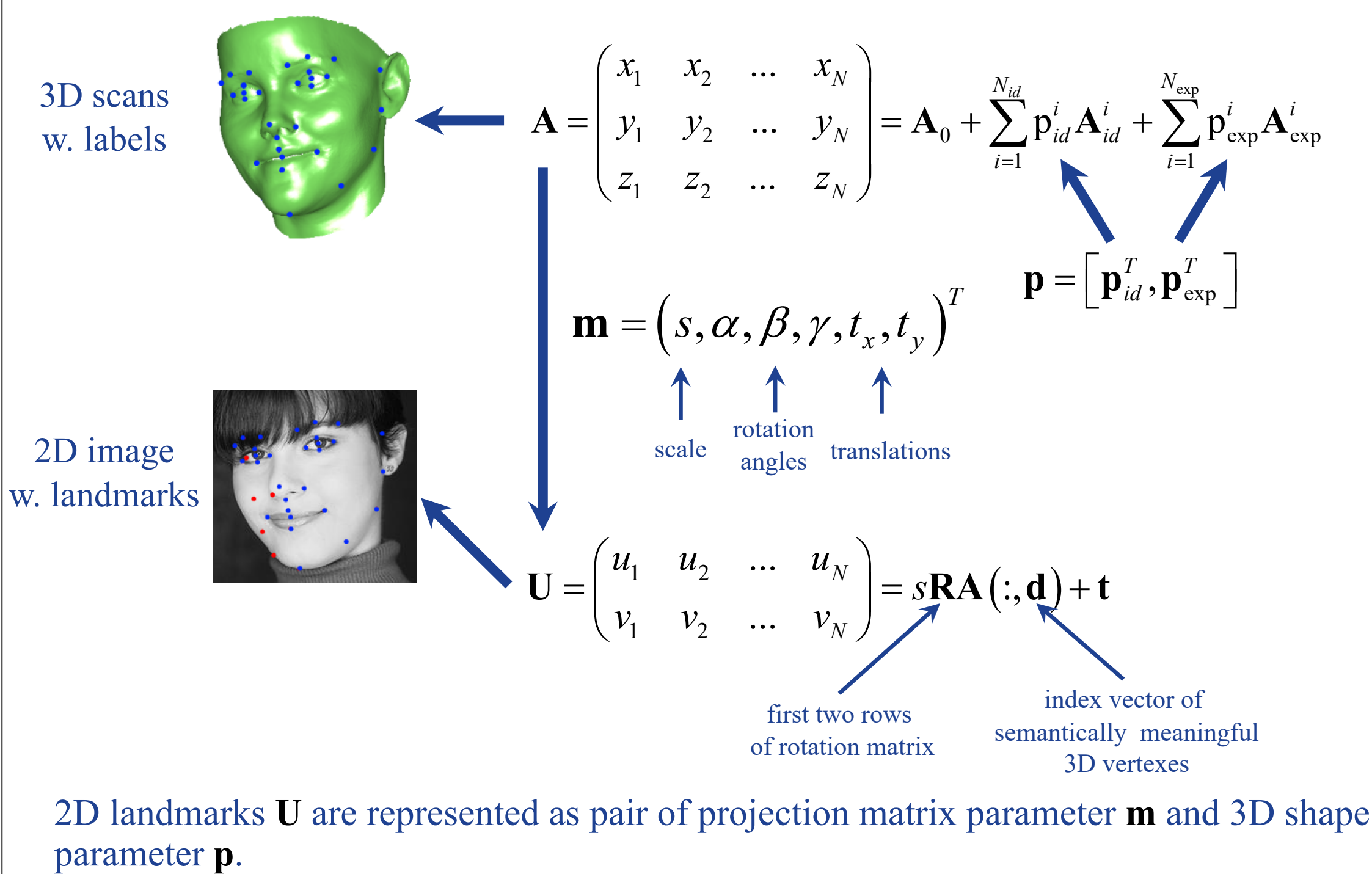
The main contributions of proposed method:

- Define a new problem of dense face alignment and predict dense shape of the face.
- DeFA model can adopt multiple constrains and leverage multiple datasets.
- Best performance on challenging large-pose face alignment.

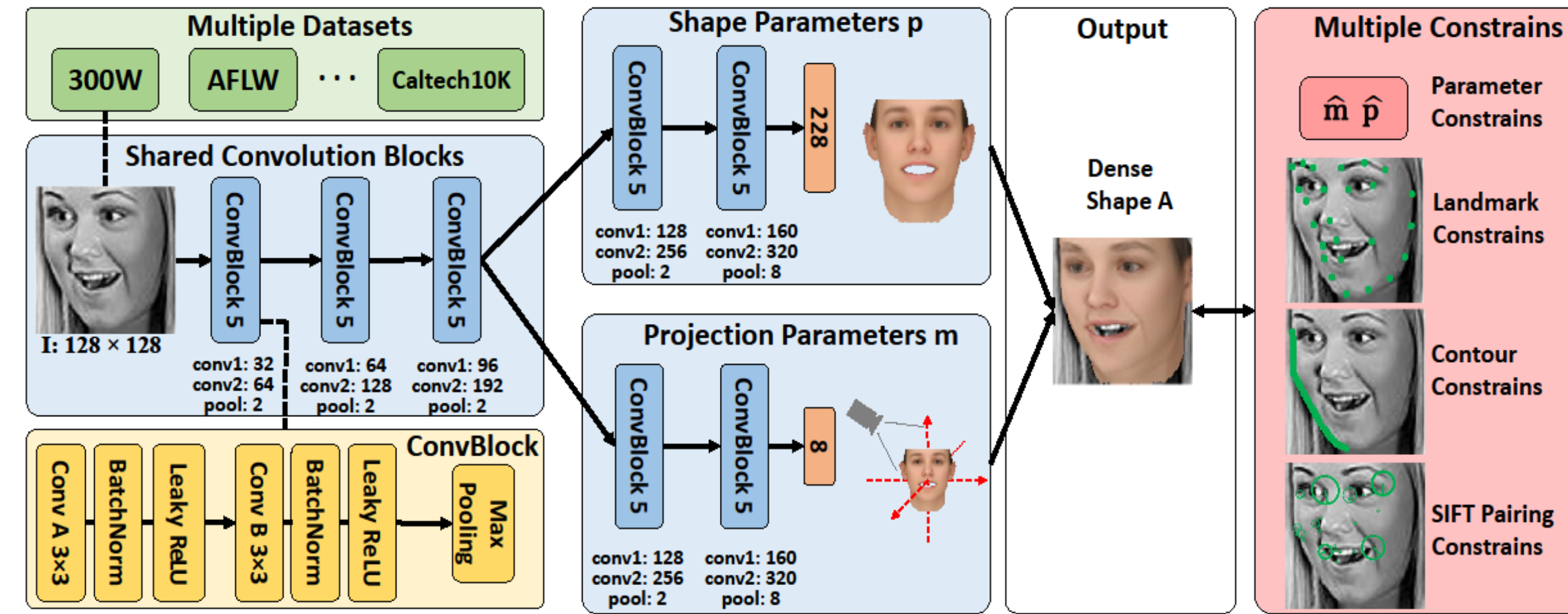
Face Alignment Databases

Training				Testing			
Databases	Pose range	Landmark #	Images #	Databases	Pose range	Landmark #	Images #
300W	Near-frontal	68	3148	300W	Near-frontal	68	689
AFLW-LFPA	All poses	34	3901	AFLW-LFPA	all poses	34	1299
Caltech10K	Near-frontal	4	10524	AFLW2000-3D	all poses	68	2000
300W-LP	All poses	68	96268	IJB-A	all poses	3	25795
COFW	Near-frontal	29	1007	LFW	Near-frontal	0	34356

3D Face Representation



Proposed DeFA Model



➤ Loss Function

$$\arg \min_{\hat{\mathbf{m}}, \hat{\mathbf{p}}} J = J_{pr} + \lambda_{lm} J_{lm} + \lambda_c J_c + \lambda_s J_s$$

Multiple Constraints

➤ Parameter Constraint (PC)

$$J_{pr} = \left\| \begin{bmatrix} \mathbf{m}^T \\ \mathbf{p}^T \end{bmatrix} - \begin{bmatrix} \hat{\mathbf{m}}^T \\ \hat{\mathbf{p}}^T \end{bmatrix} \right\|^2$$

➤ Landmark Fitting Constraint (LFC)

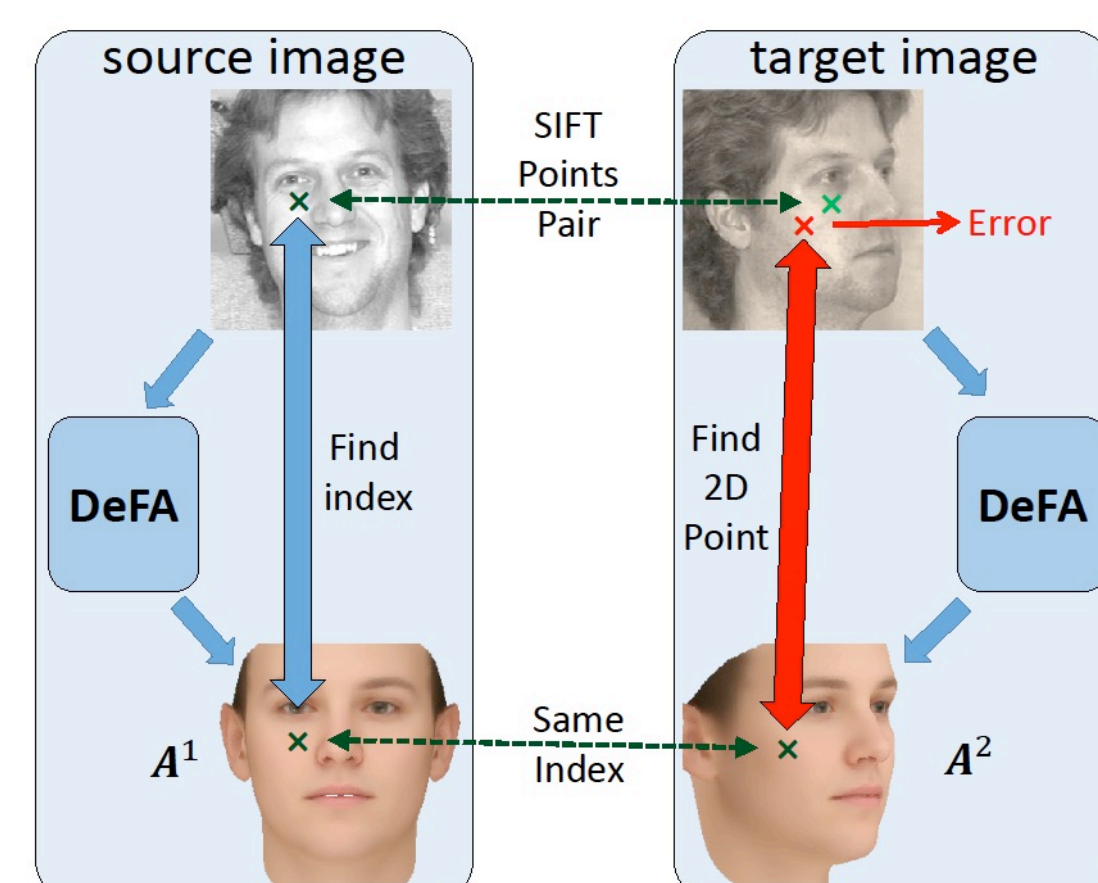
$$J_{lm} = \frac{1}{L} \cdot \|\mathbf{PrA}(:, \mathbf{i}_{lm}) - \mathbf{U}_{lm}\|_F^2$$

➤ Contour Fitting Constraint (CFC)

$$J_c = \frac{1}{L} \sum_j \min_{k \in \mathbf{i}_c} \|\mathbf{PrA}(:, k) - \mathbf{U}_c(:, j)\|^2$$

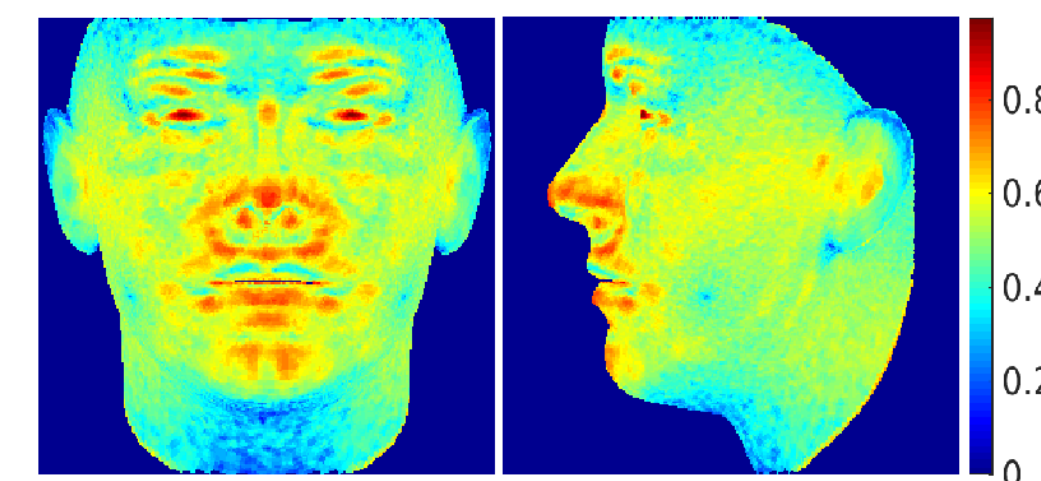
$$= \frac{1}{L} \sum_j \|\mathbf{PrA}(:, \arg \min_{k \in \mathbf{i}_c} \|\mathbf{PrA}(:, k) - \mathbf{U}_c(:, j)\|^2) - \mathbf{U}_c(:, j)\|^2$$

➤ SIFT Pairing Constraint (SPC)



$$J_s(\hat{\mathbf{m}}^j, \hat{\mathbf{p}}^j, \hat{\mathbf{m}}^i, \hat{\mathbf{p}}^i) = \frac{1}{L_{ij}} (\|\mathbf{A}^i\{\mathbf{i}_s^i\} - \mathbf{U}_s^i\|_F^2 + \|\mathbf{A}^j\{\mathbf{i}_s^j\} - \mathbf{U}_s^j\|_F^2)$$

$$\mathbf{i}_s^i = \arg \min_{i \in \{1, \dots, L_{ij}\}} \|\mathbf{A}^i\{\mathbf{i}_s^i\} - \mathbf{U}_s^i\|_F^2$$



Training Procedures

Stage	Dataset 1	Dataset 2	Dataset 3	Constraint
Stage 1	300W-LP			PC
Stage 2	300W-LP	Caltech 10k	COFW	PC, LFC
Stage 3		AFLW-LFPA	300W	LFC, SPC, CFC

Experimental Results

➤ Evaluation on large-pose face alignments

Test on three challenging large-pose datasets

	Baseline	CFSS [36]	PIFA [9]	CCL [38]	3DDFA [40]	PAWF [10]	Ours
AFLW-LFPA	-	6.75	6.52	5.81	-	4.72	3.86
AFLW2000-3D	-	-	-	-	5.42	-	4.50
IJB-A	-	-	-	-	-	6.76	6.03

➤ Evaluation on medium-pose face alignments

Method	Common set	Challenging set	Full set
RCPR [6]	6.18	17.26	7.58
SDM [28]	5.57	15.40	7.50
LBF [18]	4.95	11.98	6.32
CFSS [36]	4.73	9.98	5.76
RAR [26]	4.12	8.35	4.94
3DDFA [39]	6.15	10.59	7.01
3DDFA+SDM	5.53	9.56	6.31
DeFA	5.37	9.38	6.10

