Continuous Supervised Descent Method for Facial Landmark Localisation

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https://github.com/moliusimon/csdm

Problem

Facial landmark localisation consists on locating points of interest inside the facial region, usually corresponding to high saliency locations such as the nose tip, eye and mouth corners. This is a challenging problem because of the high variability in image conditions like in the case of:

- Highly rotated head poses
- Illumination changes
- Self-occlusions

Proposed Method

We propose Continuous SDM [1] a cascaded regression approach exploiting the second partial derivative wrt. the main modes of variation of the features. We show that this is a natural extension to the Supervised Descent Method (SDM) [3] which adapts the regressors for individual instances to rotation and illumination changes.

Using the Khatri-Rao product, the problem is formulated as a least-squares problem, where a truncated hessian matrix R_j^{iT} is learnt at each cascade step for each target parameter.

$$\arg\min_{\mathbf{R}_j^i} ||(\Delta\widetilde{\mathbf{\Phi}^i} \odot \Delta\mathbf{\Phi}^i)vec(\mathbf{R}_j^{i\intercal}) - \Delta\mathbf{X}_j^i||_2^2$$

Main Contributions

We formulate the problem as a continuous space of linear regressors, where a regressor is defined as a weighted combination of regressor bases. The method is based on [2]. Our main contributions are:

- Continuous, more adaptive approach to regressor selection
- Smaller memory footprint
- Reduced need for training instances

Evaluation

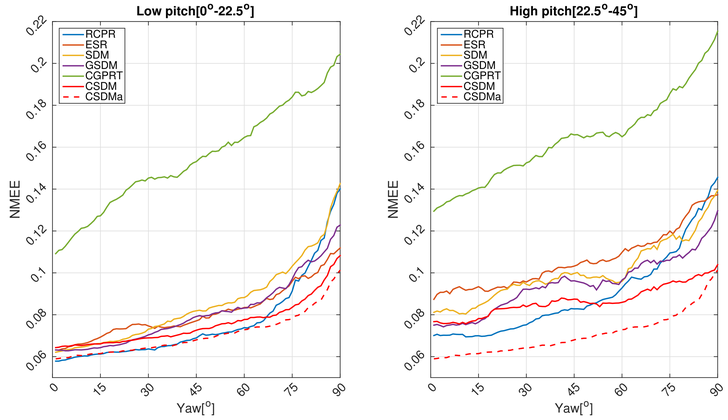
1 Quantitative Results

	ESR	RCPR	SDM	ERT	LBF	CGPRT	CFSS	GSDM	Ours
300W	7.58	8.38	7.52	6.40	6.32	**5.71**	5.76	6.96	6.40
BU4DFE-S	9.45	8.61	9.57	-	-	15.81	-	9.01	**7.62**

The method has been compared to the most recent state of the art approaches, using the Mean Euclidean Error measure normalised by the (3D) inter-ocular distance. For near-frontal datasets like 300-w, the accuracy is on par with the other state of the art methods, while for highly rotated faces (BU4DFE-S [1]) the proposed approach out-performs all the other methods for which source code was available.

[1] BU4DFE-S is a dataset with synthetic rotations generated from BU4DFE, introducing rotations between -90 and 90 degrees in yaw, and between -45 and 45 degrees in pitch.

2 Robustness to Rotation

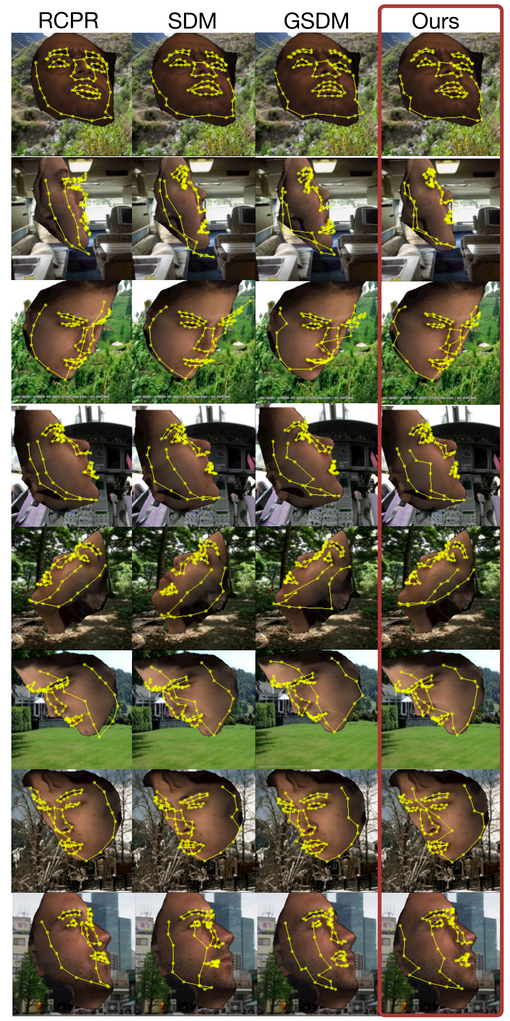


By plotting the NMEE on faces with increasing rotations we show superior robustness of the proposed method to other state-of-the-art methods. The only method still far from, but approaching the accuracy obtained by the proposed approach is RCPR. It can be seen that RCPR fails on heavily rotated faces.

Take Away

- **Main Idea:** Extension of cascaded regression approaches for facial landmark localisation by introducing the second order derivative over the main modes of variation of the features.
- **Closed-form solution:** Closed-form solution to the face alignment problem.
- **Competitive performance on frontal faces:** The accuracy for near-frontal faces is comparable to state of the art results.
- **Robust to head pose:** The robustness to large head pose variations is greatly increased, surpassing current state of the art methods
- **Small model:** The learnt models are smaller than those from other similar approaches.
- **Small memory footprint:** Memory usage increases *linearly* with the number of bases of the subspace while for GSDM [2] the increase is *quadratic*.

Qualitative Results



References

[1] M. Oliu, C. Corneanu, L. Jeni, J. Cohn, T. Kanade, S. Escalera. Continuous supervised descent method for facial landmark localisation In ACCV '16
[2] X. Xiong, F. De la Torre. Global supervised descent method In CVPR '15
[3] X. Xiong, F. De la Torre. Supervised descent method and its applications to face alignment CVPR '13