Multimodal Point Distribution Model for Anthropological Landmark Detection

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ABSTRACT

Current landmark detection algorithms offer a good rough approximation of the landmark locations. However, the rough approximation is often unsufficient for the use in biological research, as many of the general purpose landmark detection algorithms are not driven by anatomical principles.

We created a Multimodal Point Distribution Model (MPDM) that uses image information to improve the landmark detection. We show that improving the accuracy of the initial vertices to which MPDM is then fitted increases both overall accuracy and stability of the landmark detection.

METHODOLOGY

Training — MPDM contains mean landmark configuration and statistical information from the training dataset, namely a matrix of eigenvectors computed from a covariance matrix of the training set.

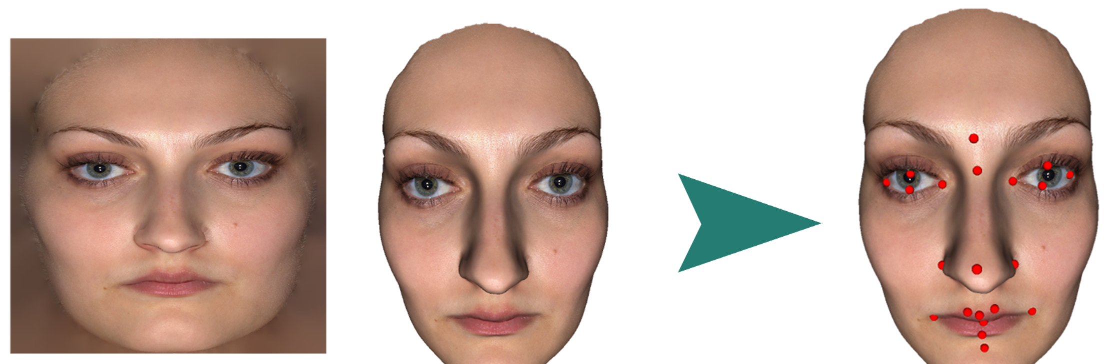
Fitting — To fit MPDM to an unknown face we first detected inner eye corners and a tip of the nose to which MPDM is then registered. Detecting eye corners in 2D texture allows us to avoid noise in 3D mesh.

Evaluation — MPDM is evaluated on 150 faces from FIDENTIS Database [1]. We compare our results to approaches by Nair et al. [2] and Sukno et al. [3] on the same data.

[1] Petra Urbanová, Zuzana Ferková, Marie Jandová, Mikoláš Jurda, Dominik Černý, and Jiří Sochor, "Introducing the Fidentis 3d face database," Anthropological Review, 2018

[2] P. Nair and A. Cavallaro, "3-D face detection, landmark localization, and registration using a point distribution model," IEEE Transactions on Multimedia, 2009

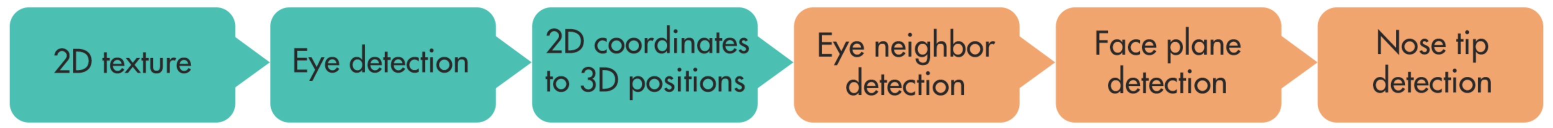
[3] F. M. Sukno, J. L. Waddington, and P. F. Whelan, "3-D facial landmark localization with asymmetry patterns and shape regression from incomplete local features," IEEE Transactions on Cybernetics, 2015.



MPDM uses 3D mesh with corresponding 2D texture to detect landmarks in unknown face.

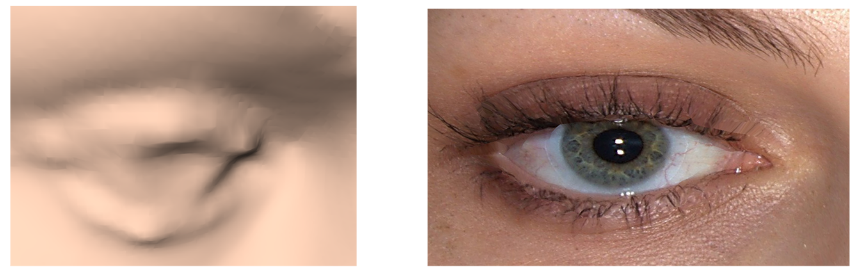
MULTIMODAL PDM FITING

To fit MPDM we first detect initial vertices in 3D facial mesh.



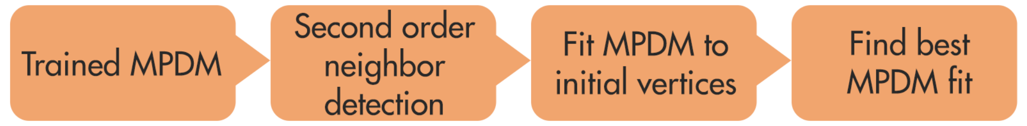
MPDM initial vertices detection.

We use 2D texture for the inner eye corners detection as 3D mesh proved to be noisy due to the capturing process. Eye corners from 2D textures are then projected to 3D, where they are used to find the face plane. The face plane allows us to find face orientation and hence the nose tip.



Right eye in 3D mesh (left) and 2D texture (right). 3D mesh is noisy due to the capturing process.

Initial vertices are then used to fit trained MPDM into an unknow face via Procrustes superimposition.



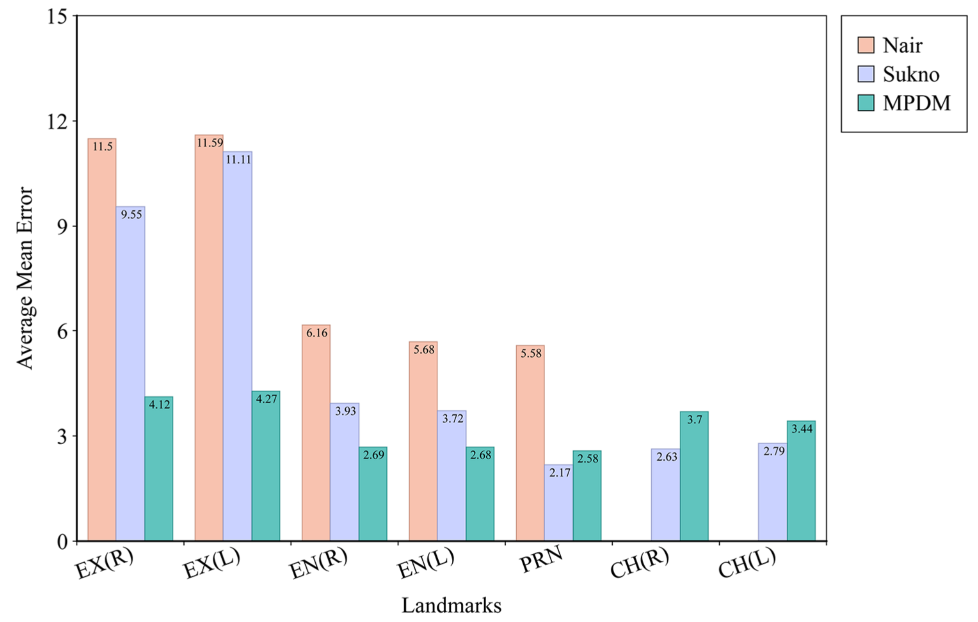
MPDM fitting to an unknow face.

RESULTS

Biological research requires not only an accurate landmark detection, but also a low average mean error across all detected landmarks.
We compared landmark detection accuracy on landmarks detected by both Nair (5 biological landmakrs) and Sukno (7 biological landmarks) approaches.

Namely, we evaluated **inner eye corners** (right, **EN(R)** and left **EN(L)**), **outter eye corners** (right **EX(R)** and left **EX(L)**), **tip of the nose (PRN)**, and **mouth corners** (righth **CH(R)** and left **CH(L)**).

Comparison of results for FIDENTIS Database. Nair (left), Sukno (middle) and MPDM(right).



MPDM shows lower average mean errors on most detected landmarks.More importantly the mean average error across all detected landmarks is the lowest from the compared approaches.