Hybrid Approach for 3D Head Reconstruction: Using Neural Networks and Visual Geometry

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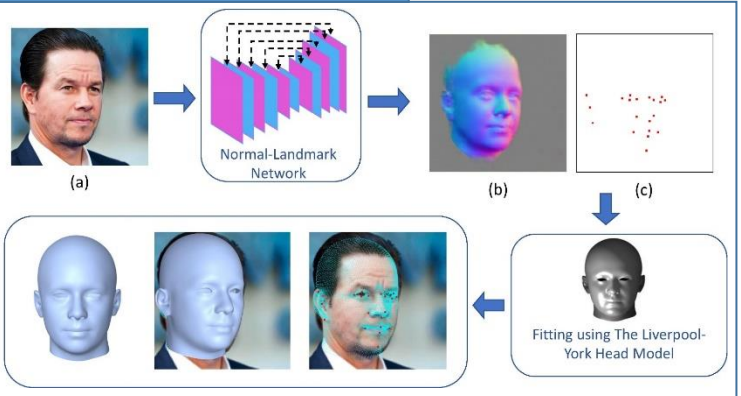
Abstract

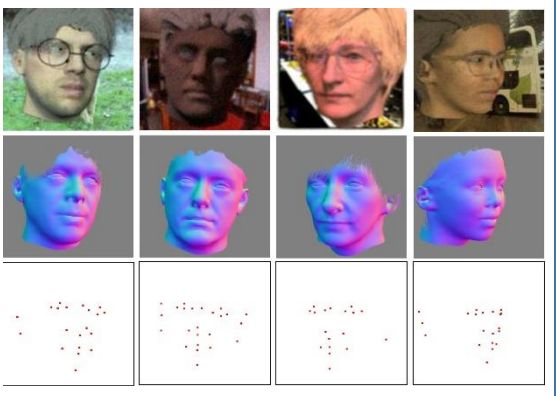
- We present a novel method for reconstructing 3D heads from a single or multiple image(s) using a hybrid approach based on deep learning and geometric techniques.
- We propose an encoder-decoder network based on the U-net architecture and trained on synthetic data only. It predicts both pixel-wise normal vectors and landmarks maps from a single input photo. Landmarks are used for the pose computation and the initialization of the optimization problem, which, in turn, reconstructs the 3D head geometry by using a parametric morphable model and normal vector fields.
- State-of-the-art results are achieved through qualitative and quantitative evaluation tests on both single and multi-view settings.

Overview of the Proposed Framework



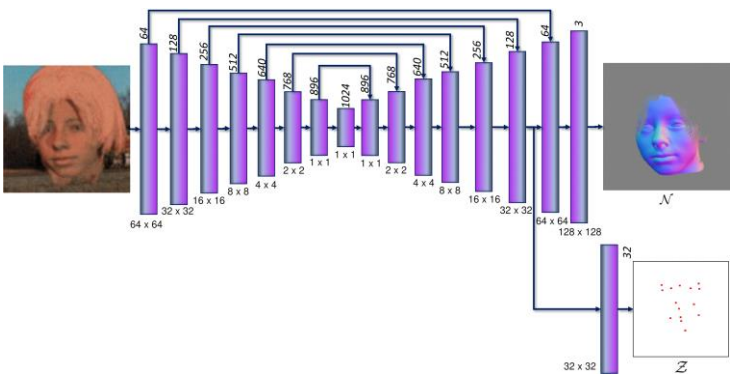
Given an input facial image (a), we estimate two different maps (normal surface map *N* (b), Landmarks map *Z* (c)) used to reconstruct the 3D facial shape via a fitting process with the LYHM [1] morphable model.

Synthetic Dataset



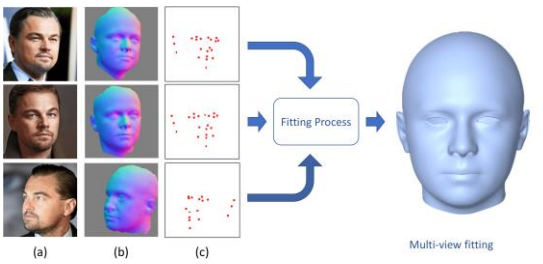
Training data samples. From top to bottom: Synthetic facial images, Normal surface maps *N* and Landmarks maps *Z*.

Normal-Landmark Network



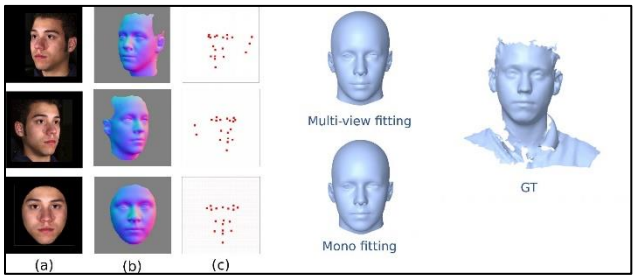
Our encoder-decoder architecture produces two different maps (*N* and *Z*) (shown on the right) from a facial input image (shown on the left). The spatial size and number of layers are shown below and above each block, respectively.

Multi-view Fitting Process



Our method can be used in mutli-view process. We estimate the two maps *N* (b) and *Z* (c) from each input image (a), then we use them in the same fitting process to get a unique 3D head reconstruction.

Stereo vs Mono Fitting



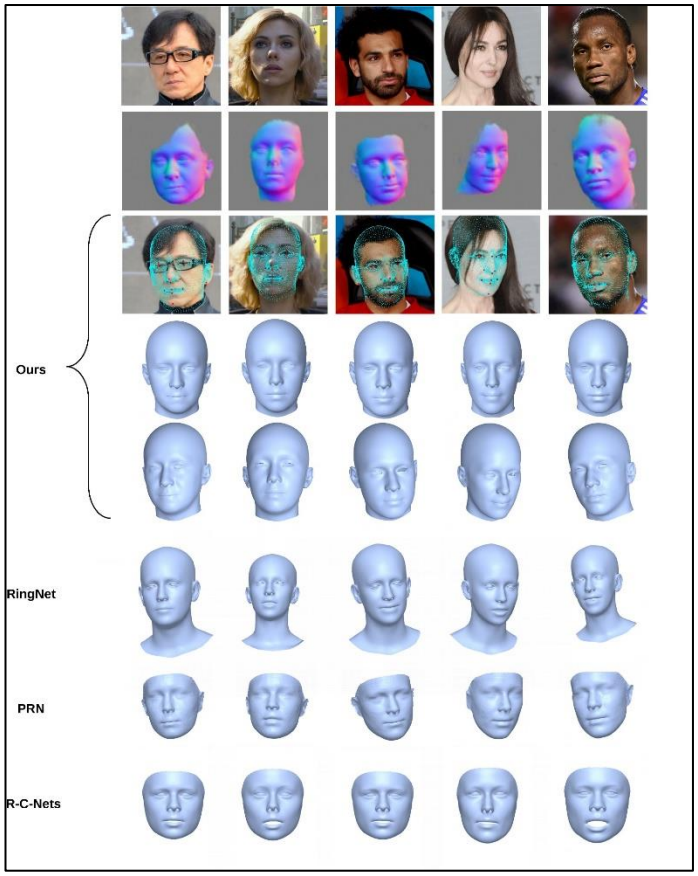
- (Multi-view fitting): 3D head reconstruction using all images in the same fitting process.
- (Mono fitting) : 3D head exploiting only the frontal image in the fitting process (third row).
- (GT) : the ground-truth of the 3D head mesh.

Quantitative Evaluation

Method	Ours (Mono)	Ours (Multi)	RingNet [3]	PRN [4]	R-C-Nets [5]
RMSE	1.74±0.44	1.67±0.43	1.90±0.49	1.86±0.47	1.60±0.41
μ	2.21	2.17	3.42	1.83	1.64
σ	1.08	1.04	1.58	1.70	1.69
m̃	2.09	2.05	3.23	1.43	1.27
$\delta_{90\%}$	3.61	3.53	5.60	3.46	3.00

Quantitative comparison on the BU-3DFE [2] dataset. Lowers are better

Qualitative Evaluation



Visual comparisons from some celebrities facial images with other methods. Rows contain in order; input image, predicted *N* map, input image with predicted landmarks (red squares) and dense alignment results. Ours (frontal view), Ours (aligned) RingNet [3], PRN [4] and R-C-Nets [5]

References

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