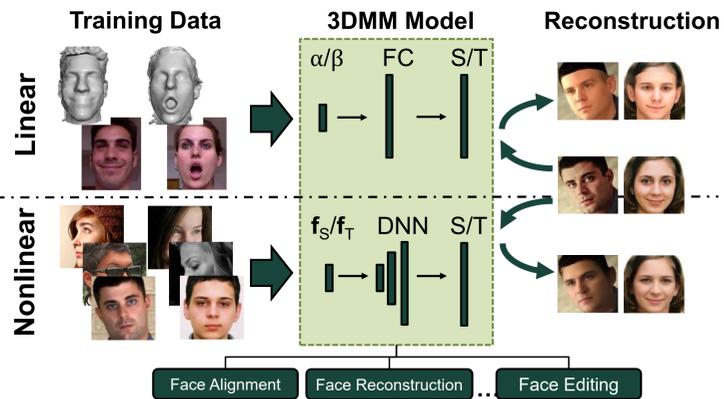


Problem & Contributions



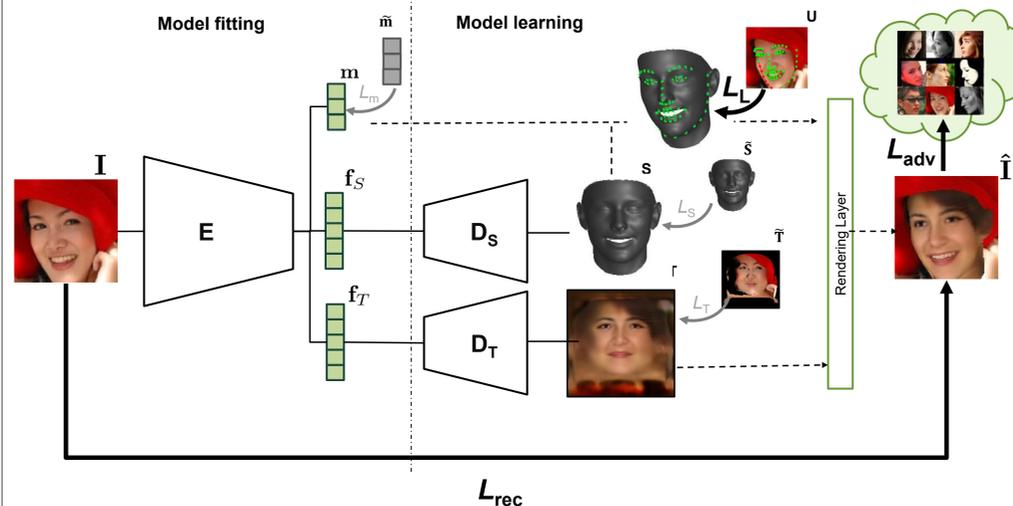
- We learn a **nonlinear** 3DMM model with greater representation power than the traditional linear model.
- Jointly learn model & fitting algorithm via **weak supervision**, leveraging a large 2D images collection
- Novel rendering layer enables end-to-end training.
- Improves performance in related tasks: face alignment & face reconstruction.

Related Works

- Linear 3DMM**
 - Linear*: PCA models
 - Learned with small number of 3D scans
- Improve linear 3DMM**
 - Gaussian Mixture 3DMM *Koppen et al.*
 - In-the-wild texture *Booth et al.*
 - Deep Boltzmann Machines: *Duong et al.*
- 2D Face Alignment**
 - 3DMM provide strong priors of the face shape
 - Iterative approaches: *Jourabloo et al.*, *Zhu et al.*
- 3D Face Reconstruction**
 - Image collection: *Roth et al.*
 - Single image: *Richardson et al.*, *Tewari et al.*

Nonlinear 3DMM Learning

Overall Architecture

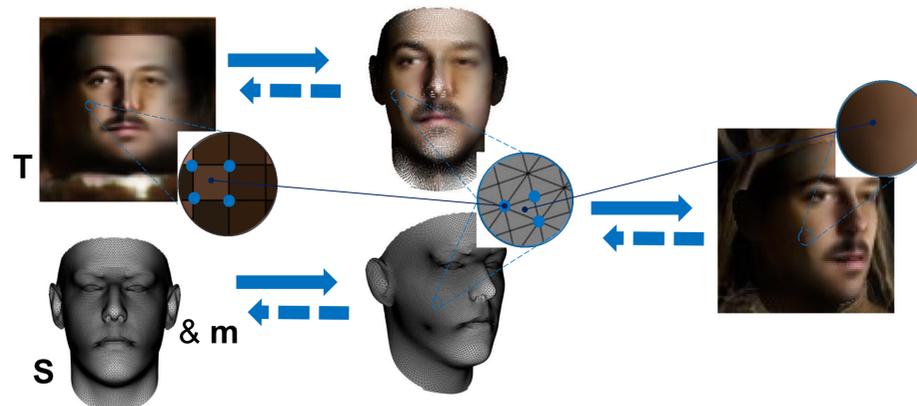


Texture Representation



- | | | |
|-----------------------|-----------------------|---------------------------|
| (i) Point cloud | (ii) 2D Frontal Face | (iii) Unwarped 2D texture |
| ✓ Completed | ✗ Limited information | ✓ Completed |
| ✗ High dimension | ✗ of 2 sides | ✓ Convolvable |
| ✗ No spatial relation | ✓ Convolvable | |

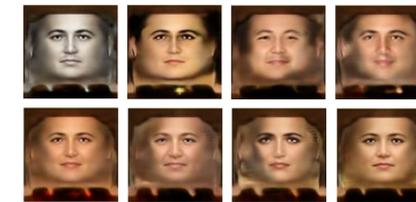
In-network Rendering Layer



Experimental Results

Expressiveness

Texture

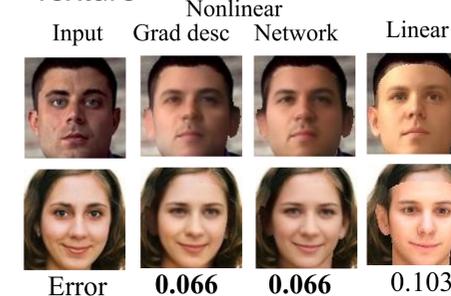


Shape

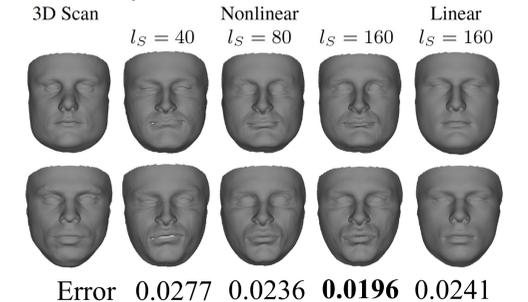


Representation power

Texture

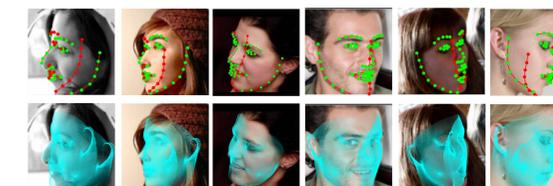


Shape



Application

2D Facial Landmark Alignment



Method	NME
Linear	5.61
SDM	6.12
3DDFA	5.42
Nonlinear	4.70

3D Face Reconstruction



Conclusions

- We propose an alternative approach to 3DMM learning, where a nonlinear 3DMM can be learned from a large set of unconstrained face without collecting 3D face scans.
- The model fitting algorithm can be learnt jointly with 3DMM, in an end-to-end fashion thanks to a novel rendering layer.