Alive Caricature from 2D to 3D

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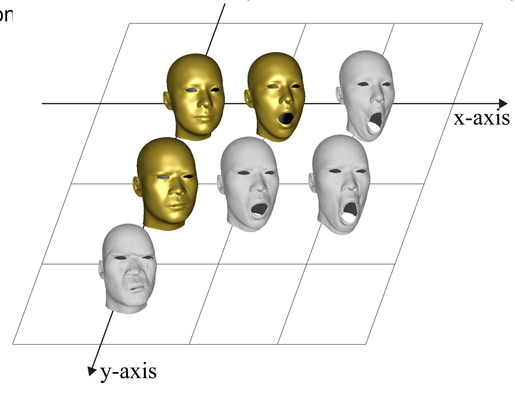
Introduction

- We presented an efficient algorithm for generating a 3D caricature model from a 2D caricature image with minimum user interaction.

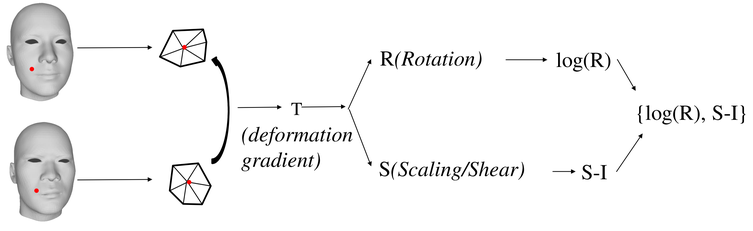
- Our Contributions:
  - Introduced an intrinsic deformation representation that has the capability of extrapolation



  - Proposed an optimization framework to generate 3D caricature
  - Based on standard 3D face dataset, instead of creating 3D caricature training dataset.

Deformation Representation

- Key idea: using decomposition parts of *deformation gradient* to represent deformation.



Optimization Framework

- We define the deformation energy E_{def} as follows:

$$E_{def}(P', w) = \sum_{v_i \in V} \Big(\sum_{j \in N_i} c_{ij} \| (p_i' - p_j') - T_i(w)(p_i - p_j) \|^2 \Big)$$

- Here $P' = \{p_i'\}$ represents the positions of deformed vertices and the combined deformation gradient $T_i(w)$ defined:

$$T_i(w) = \exp\Big(\sum_{l=1}^{n} w_{R,l} \log R_{l,i}\Big)\Big(I + \sum_{l=1}^{n} w_{S,l}(S_{l,i} - I)\Big)$$

- By minimizing this energy, we are able to determine P' given weights $w = \{w_R, w_S\}$ or obtain the combination weights w given the deformed mesh P'.
- P'-$step$: Given combination weights w, find best P'. It equals to solve a linear least squares problem for P'.
- w-$step$: Given deformed 3D model P', find best weight w. This is a non-linear least squares problem because of $T_i(w)$. With the Jacobian matrix w.r.t. to the rotation weight w_R and scaling/shear weight w_S, we can use non-linear least squares algorithm to solve it.

3D Caricature Generation

- Build upon our deformation representation, we generate 3D caricature based on 2D facial landmarks L. With projection parameters Π, r, t, we define landmark energy as:

$$E_{lan}(\Pi, r, t, P') = \sum_{v_i \in L} \| \Pi r p_i' + t - q_i \|^2$$

to measure the distance of projected 3D landmarks and 2D landmarks

- The generation problem is formulated as an optimization problem:

$$\min_{P', w, \Pi, r, t} E_{def}(P', w) + \lambda E_{lan}(\Pi, r, t, P')$$

To solve it, we also iterate P'-$step$ and w-$step$ to obtain 3D model.

- Here are some results of our 3D caricature generation algorithm.