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3D Face Modeling from One or More Images

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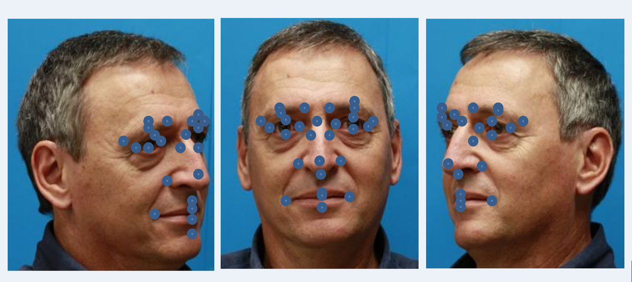
1. Introduction

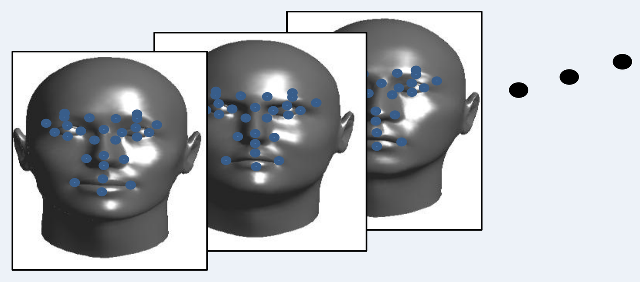
- **Why 3D face modeling ?**
  - Addresses most limitations of 2D face recognition
  - Pose, illumination, expression (PIE), aging, …
- **Goal: 3D face model from low-res. image(s)**
  - Current 3D face modeling techniques require high resolution images, videos, or many images
- **Our approach**
  - Morphable face model from a 3D face database
  - Pose estimation using affine camera model (1 or N images)
  - Update using view transfer and image features (if multiple images)

2. 3D head pose estimation from 1 or N images

• **2D image(s) with detected landmarks**



• **3D face models with pre-defined landmarks**



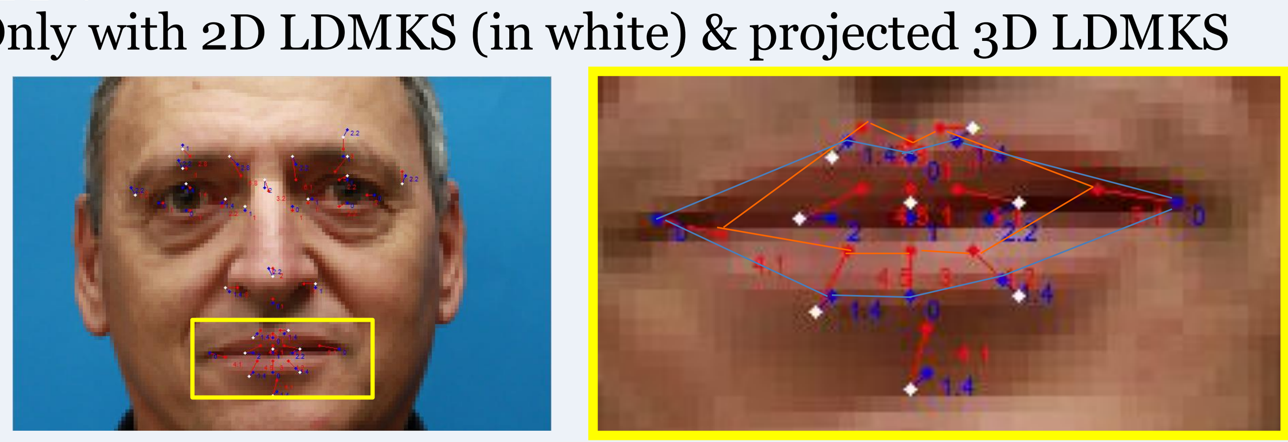
• If (iteration =1) Start from randomly selected 3D model
Else Start from the previous minimum distance error model

• **Pose estimation with a chosen 3D model**

$$\mathbf{p}_{2D} = \mathbf{A}\ \mathbf{P}_{3D} + \mathbf{t} = (\mathbf{s}\ \ \mathbf{R})\ \mathbf{P}_{3D} + \mathbf{t}$$

- $\mathbf{p}_{2D}$: 2D landmarks(LDMKS)
- $\mathbf{P}_{3D}$: 3D landmarks(LDMKS)
- $\mathbf{t}$: translation vector
- $\mathbf{A}$: affine matrix
- $\mathbf{s}$: scaling matrix
- $\mathbf{R}$: rotation matrix

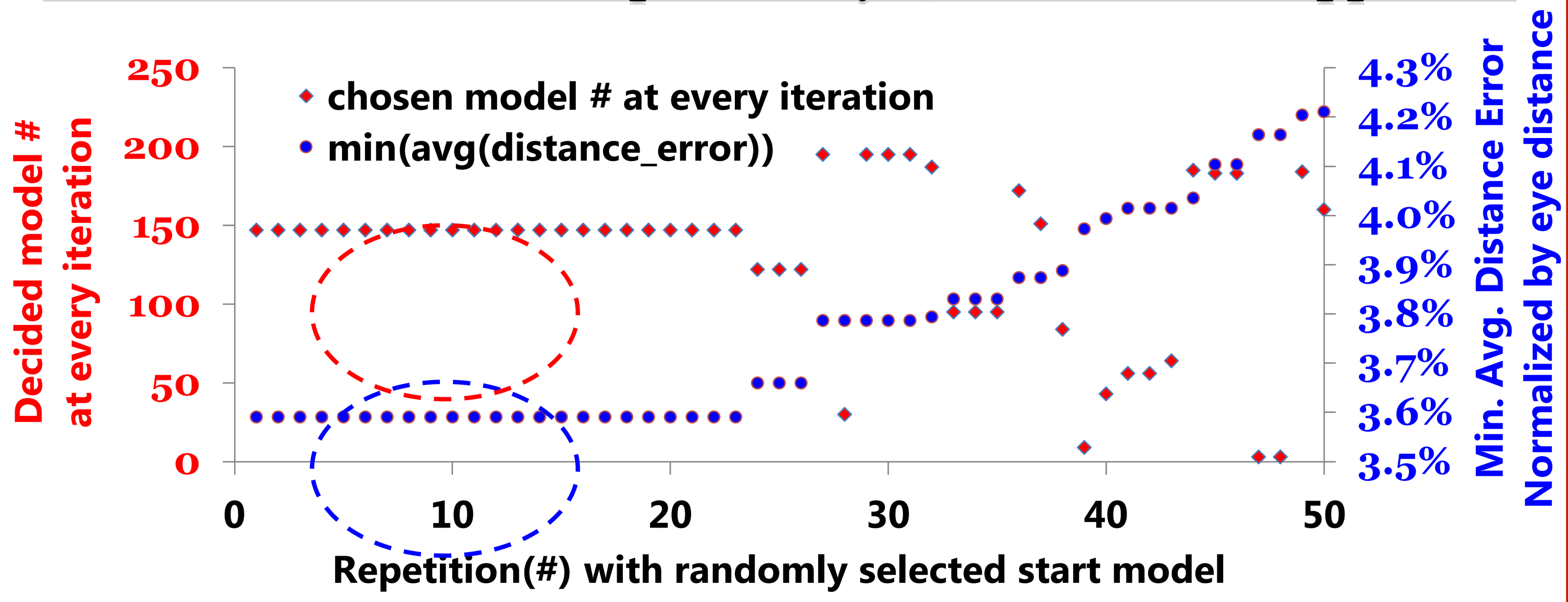
• **Local feature approach**
- **Purpose: Find min. avg. distance error model**
- **Apply "A & t" to 3D models**
- Only with 2D LDMKS (in white) & projected 3D LDMKS



(Blue: minimum distance case, Red: Maximum distance case)

• If (start model ≠minimum distance model) iteration +=iteration;
Else { iteration=1; save Affine & Local approach results}
• Repeat the whole sequence until convergence

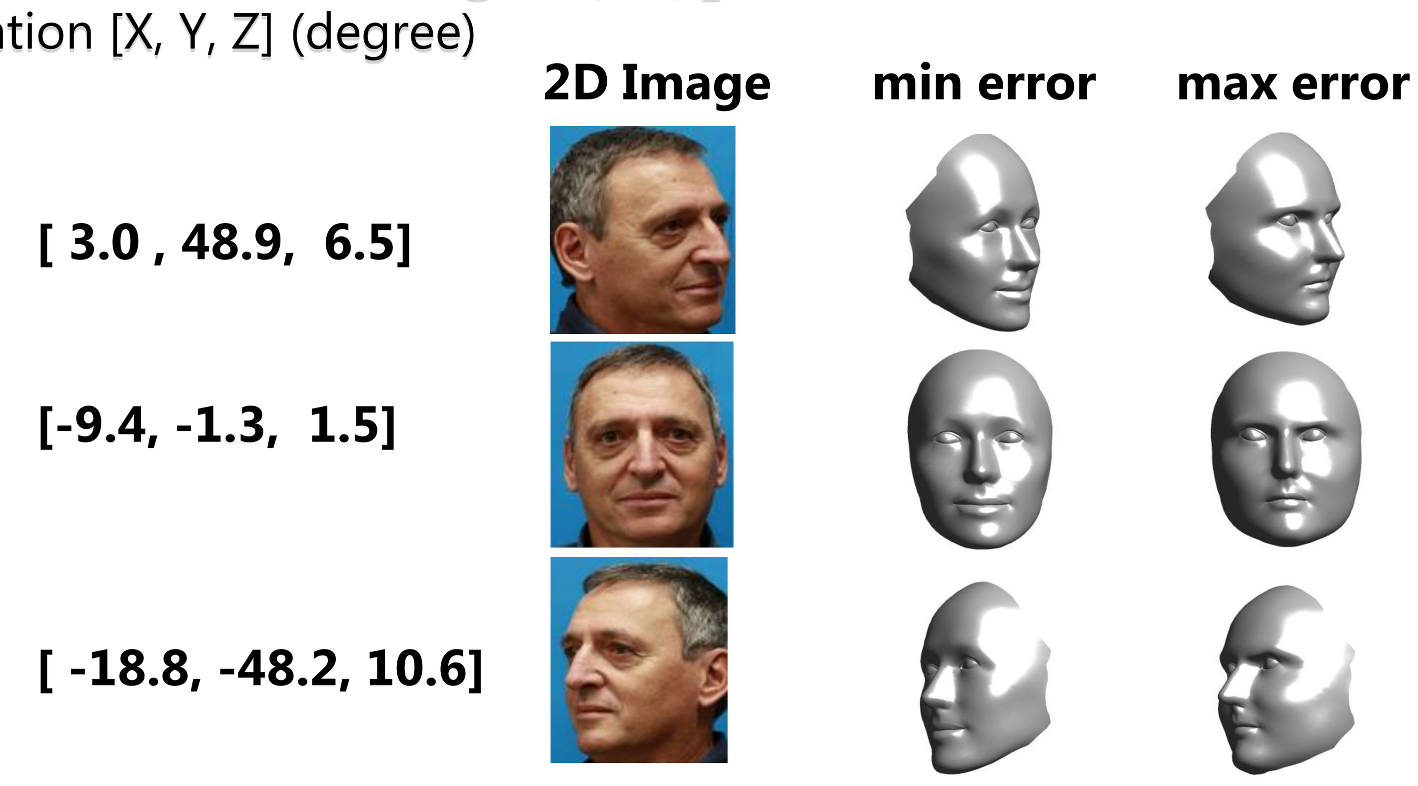
- **Min. distance error & repeatability @ Local feature approach**



(Sorted by the distance error with decided model#)

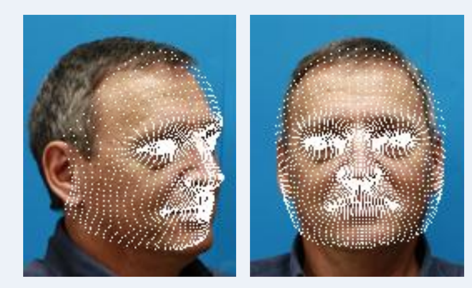
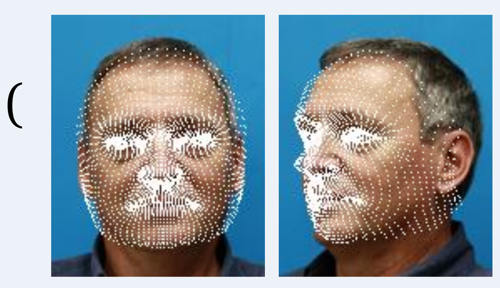
- **Pose estimation: (range: ±70°, pose error: < ±6°)**

Rotation [X, Y, Z] (degree)

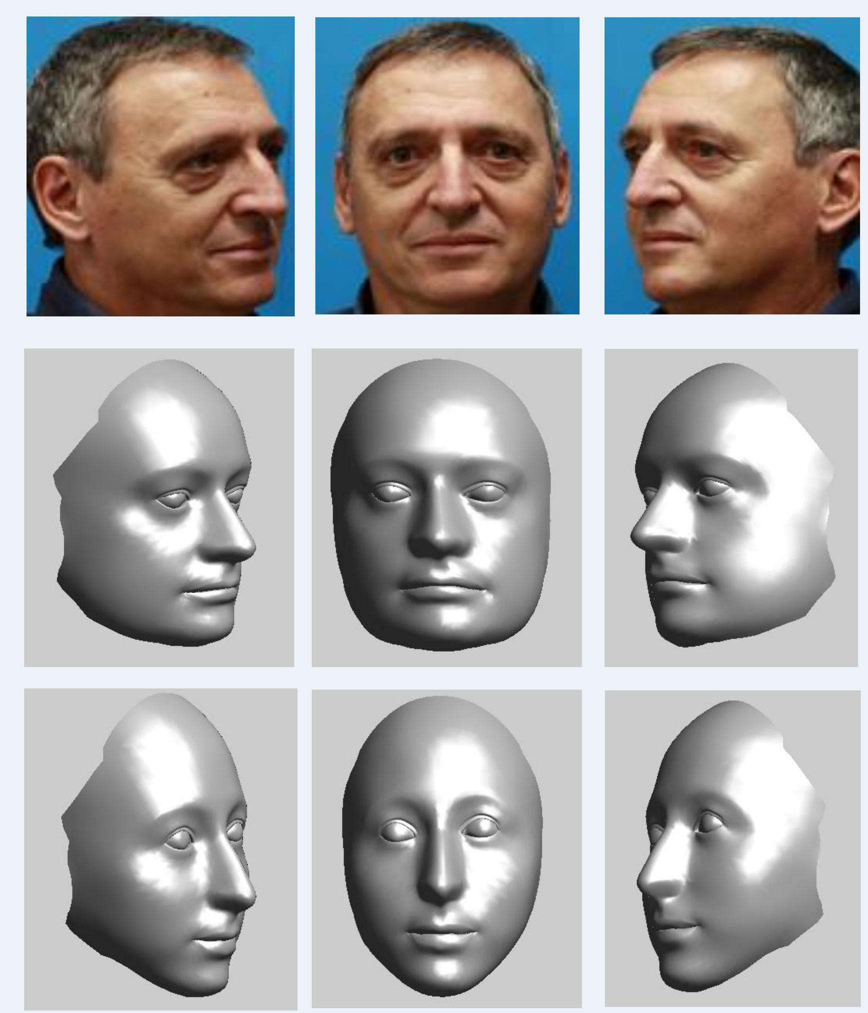


3. Global method using view transfer with N images

• **View transfer**
- Using the camera motion and 3D model, pixels in view (i) are transferred to the corresponding pixels in view (j).
- We find a set of 3D face models that provide consistency across views.
  - 2D image features (color values, features descriptors, …)
  - Example: the score is the sum of pixel correlation coefficients

correlation () + correlation ()

- **Example of chosen model**



4. 3D face modeling

• **Embedding/Mixing**
- Local feature approach: fast
- Global surface approach: slow and complex, but better results

• **Morphable 3D face modeling**
- For initial experiments, we use 1649 3D face models
- From selected models (e.g., 85 models), the final model is built by the maximum sum of correlation coefficients.

• **Texture mapping**

5. Future Work

- Performance evaluation with ground truth data
- Face expression normalization and neutralization
- Global method with more complex 2D features
- Improvement of deformable 3D face model
- Real application and performance for face recognition

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