Landmark Locating using Deformable Registration

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Course Project EE 577

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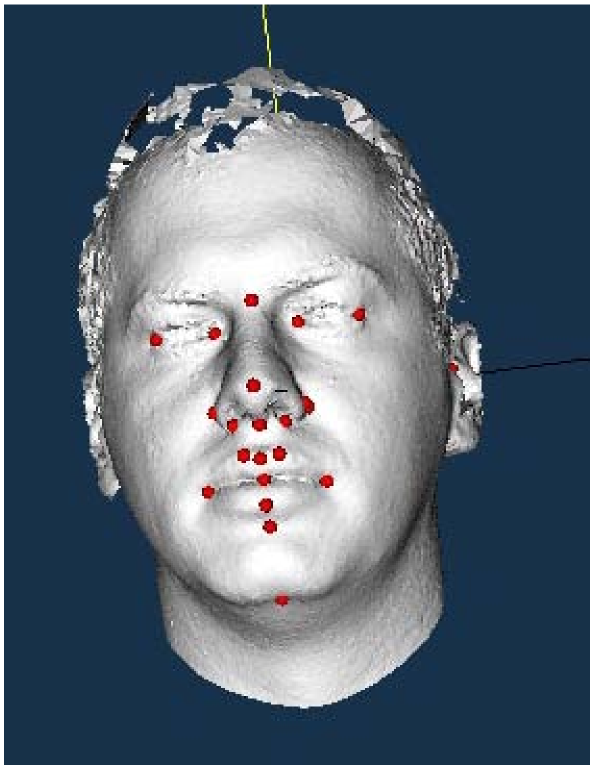
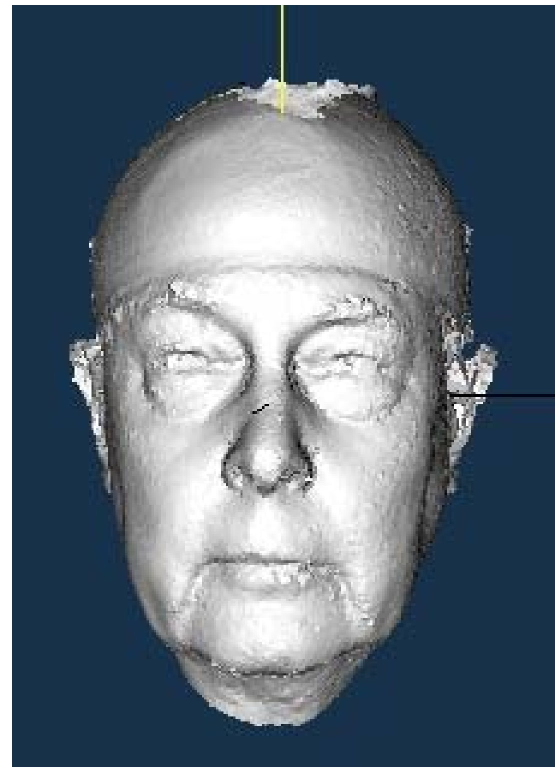
Problem Statement

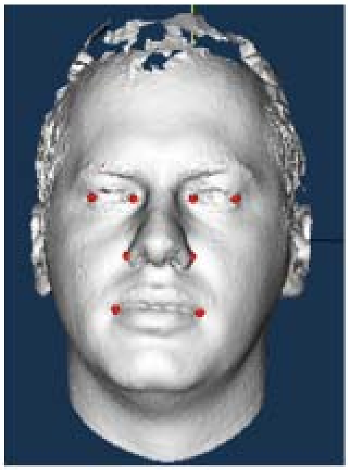


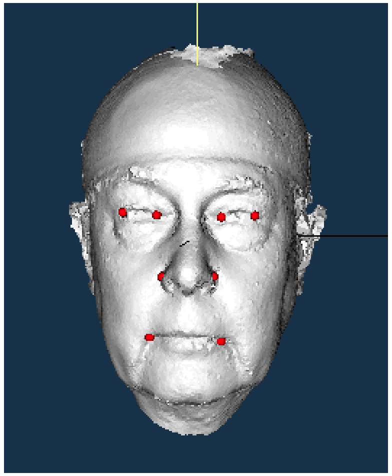
Example mesh
Landmarks on it



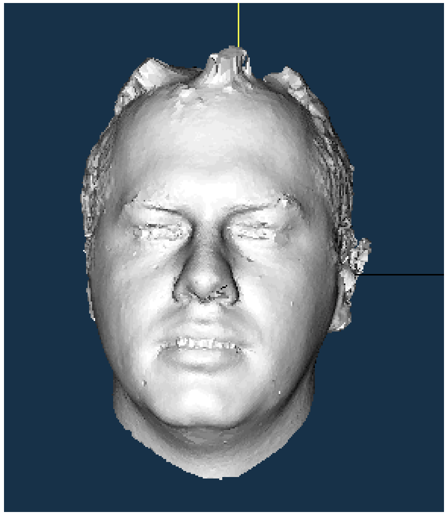
Given a new mesh,
where are the landmarks?

Method: Deformable transformation





Deformable transform



Overview (Allen's paper)

- Goal: to fit a template surface $\mathcal{T}$ to a scanned example surface $\mathcal{D}$.
- Each surface is represented as a triangular mesh
- The matching is accomplished by an optimization framework
- Each vertex v_i is influenced by a 4 x 4 affine transformation matrix T_i.
- The algorithm must find a set of transformations that move all of the points in $\mathcal{T}$ to a deformed surface $\mathcal{T}'$ such that $\mathcal{T}'$ matches well with $\mathcal{D}$.

Energy Function: $E = \alpha E_d + \beta E_s + \gamma E_m$

data error

$$E_d = \sum_{i=1}^{n} w_i \, \mathrm{dist}^2(\mathbf{T}_i \mathbf{v}_i, \mathcal{D}), \qquad (1)$$

where dist() computes the distances from $T_i v_i$ to the closest compatible point on $\mathcal{D}$, where compatible means the surface normals are no more than 90 degrees apart, and the distance is less than a threshold.

smoothness error

$$E_s = \sum_{\{i,j \mid \{\mathbf{v}_i, \mathbf{v}_j\} \in edges(\mathcal{T})\}} ||\mathbf{T}_i - \mathbf{T}_j||_F^2 \qquad (2)$$

where $|| \; ||_F$ is the Frobenius norm and measures the distance between transformations.

marker error (if markers)

$$E_m = \sum_{i=1}^{m} ||\mathbf{T}_{\kappa_i} \mathbf{v}_{\kappa_i} - \mathbf{m}_i||^2 \qquad (3)$$

Procedure

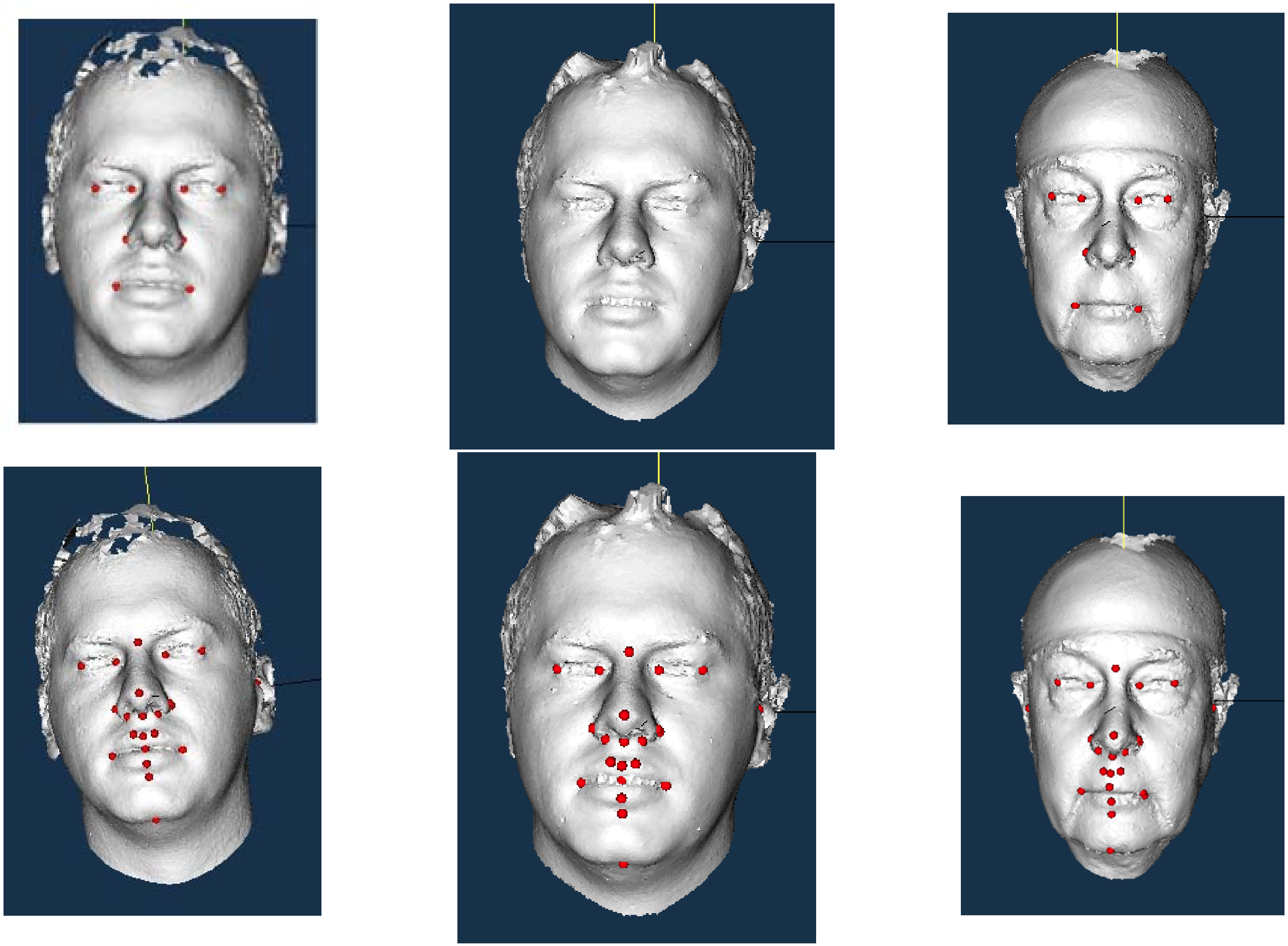
At low resolution

1. Fit the markers first: α=0, β=1, γ=10
2. Allow the data term to contribute: α=1, β=1, γ=10

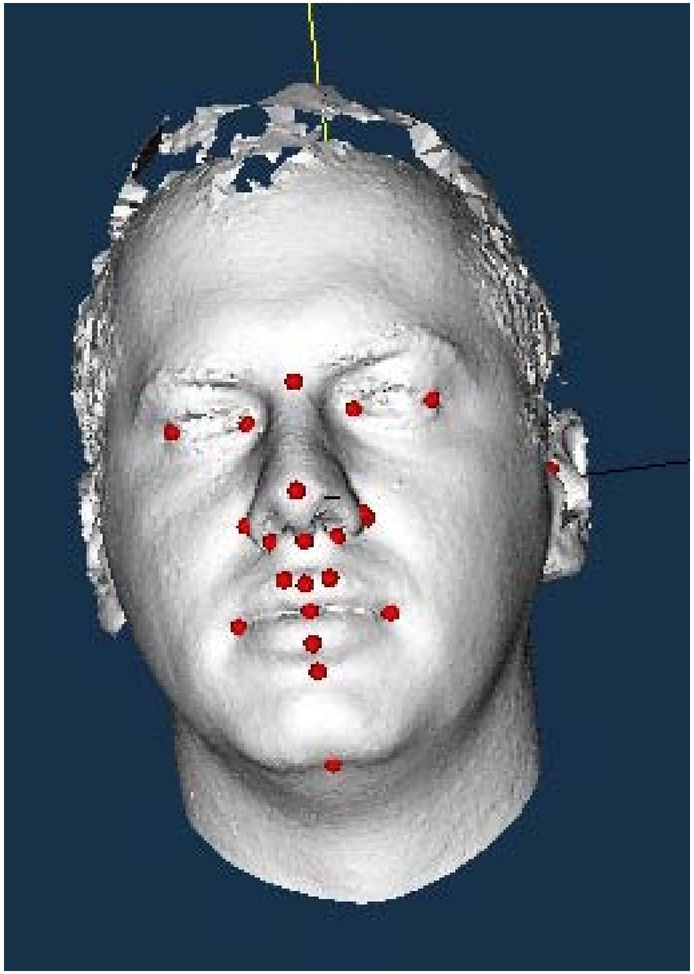
At high resolution

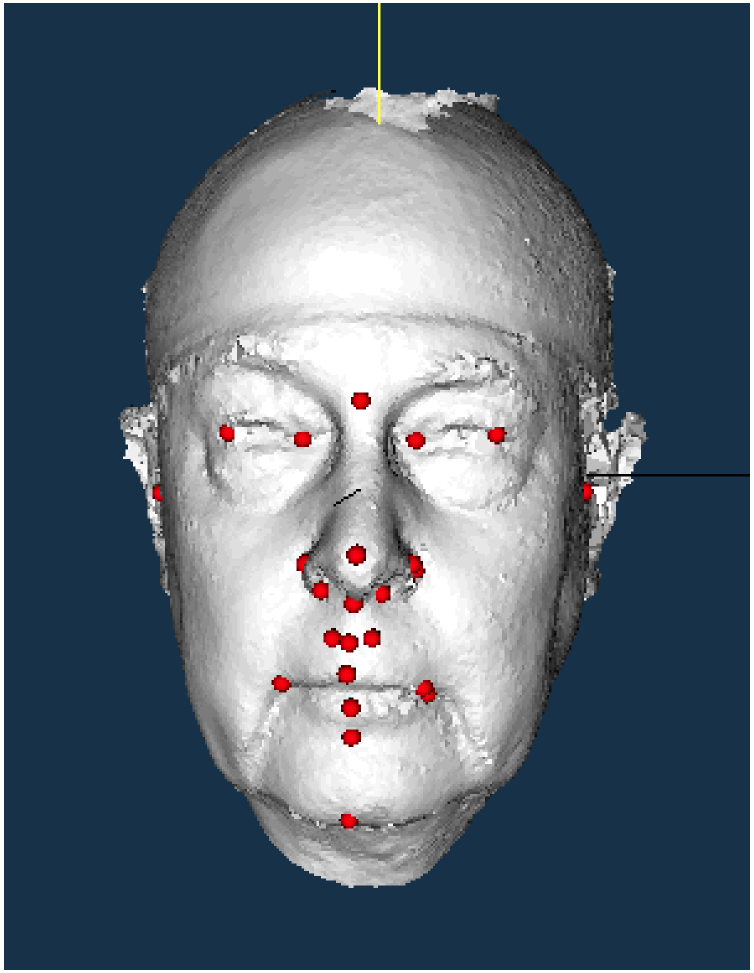
3. Continue the optimization: α=1, β=1, γ=10
4. Allow the data term to dominate: α=10, β=1, γ=1

Method: Deformable transformation

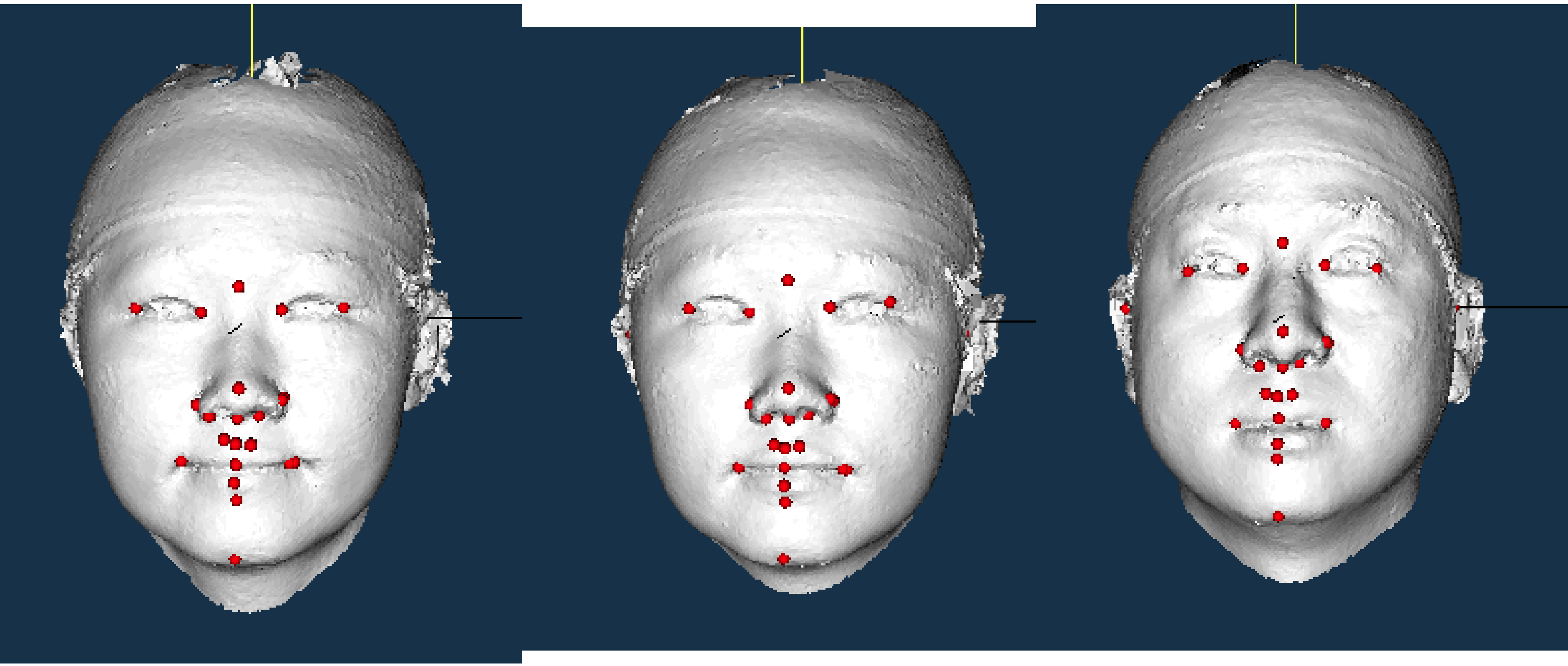


Landmark transfer result

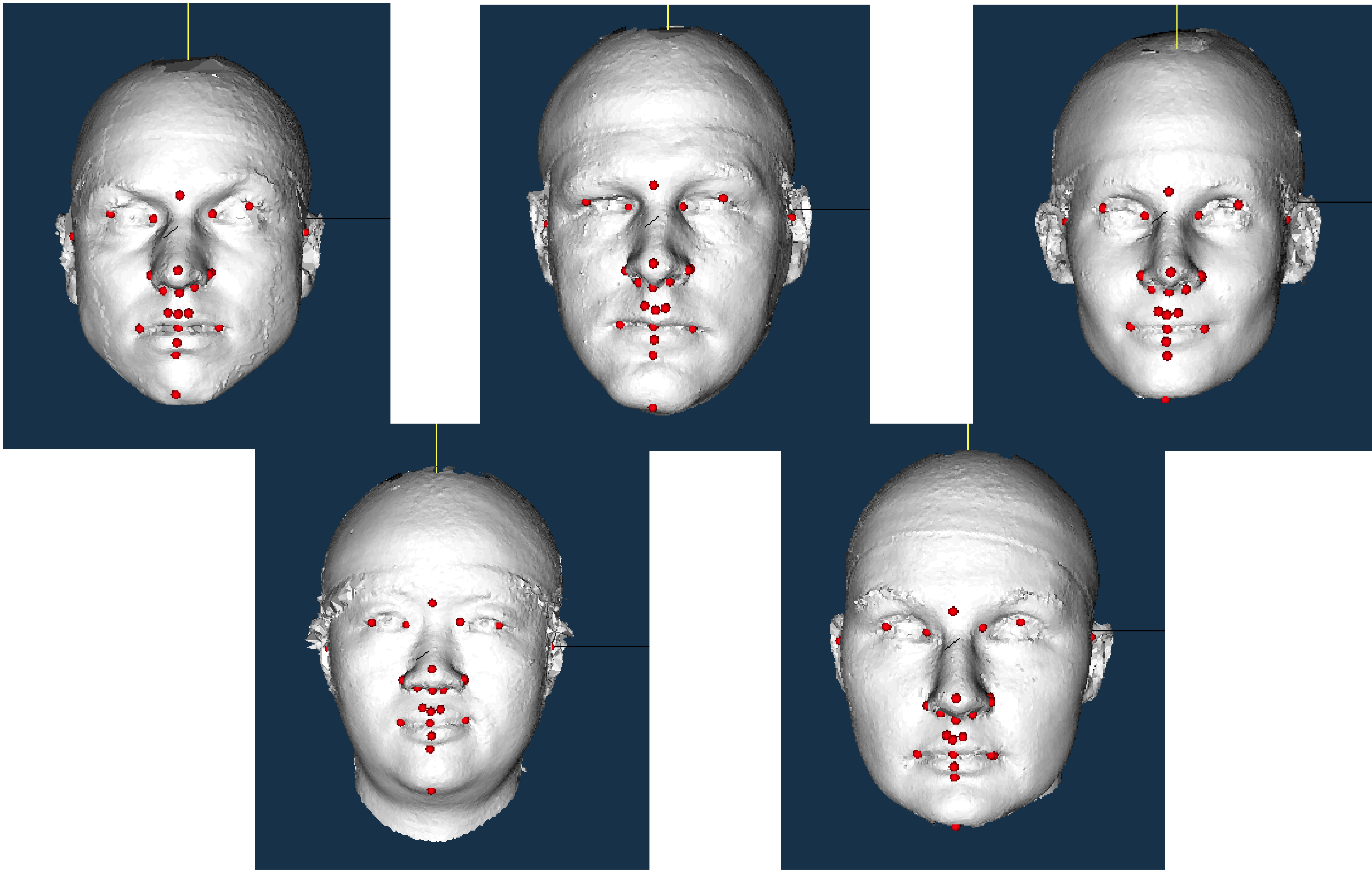




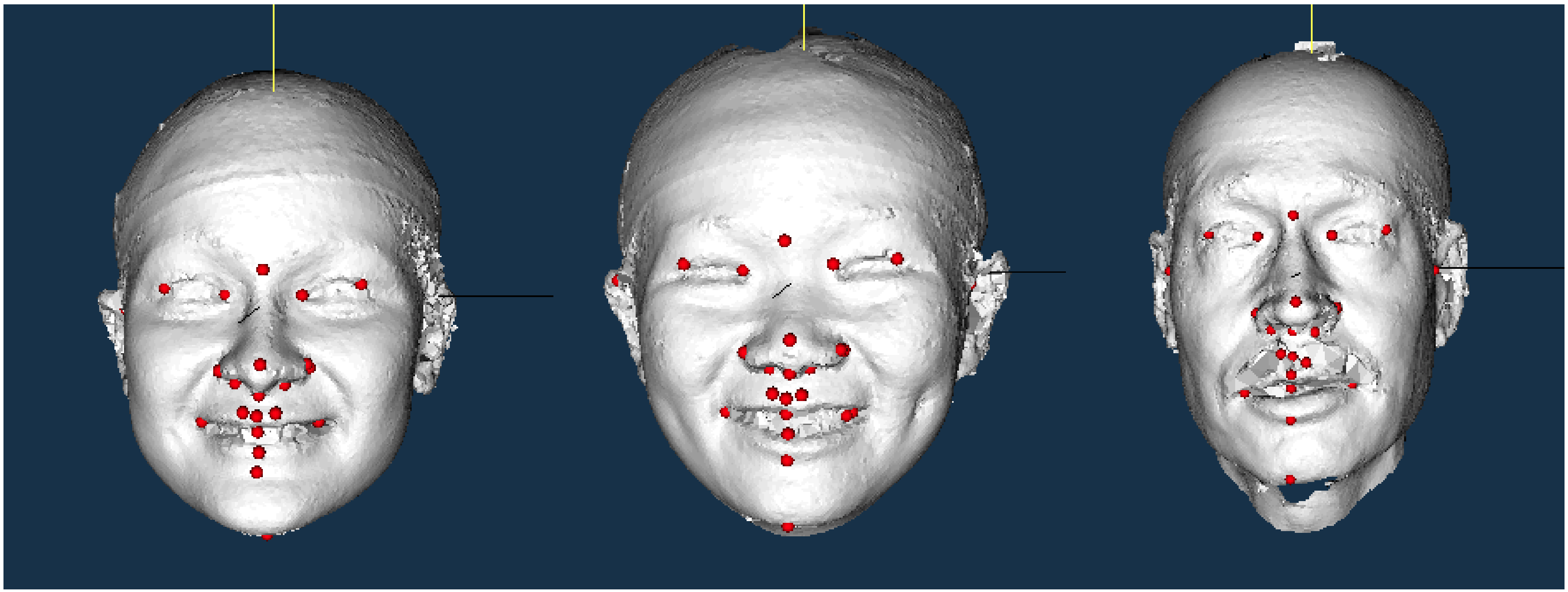
Results



Results



Results



Results