GHUM & GHUML: Generative 3D Human Shape and Articulated Pose Models

Hongyi Xu, Eduard Gabriel Bazavan, Andrei Zanfir,

William T. Freeman, Rahul Sukthankar, Cristian Sminchisescu

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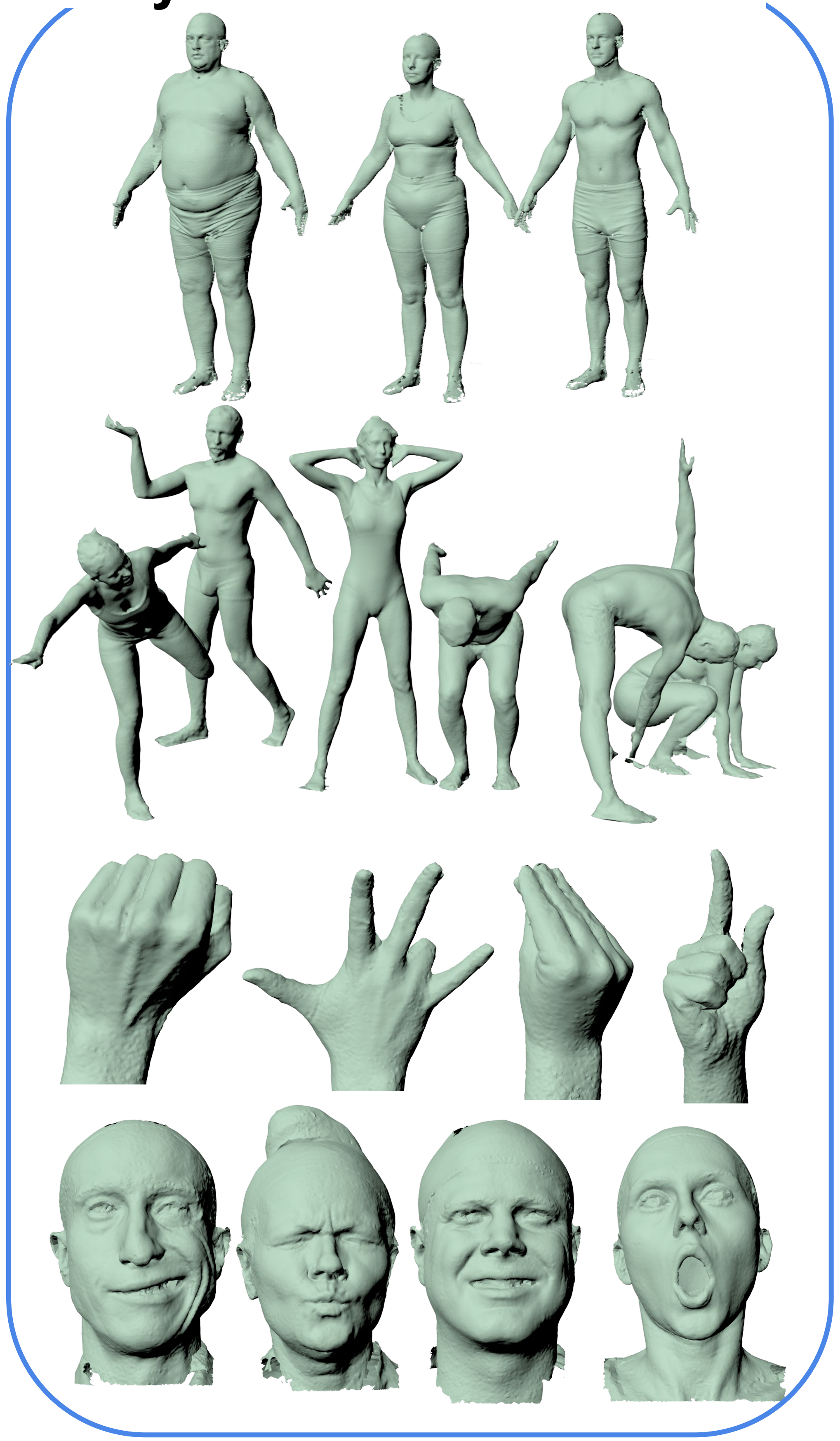
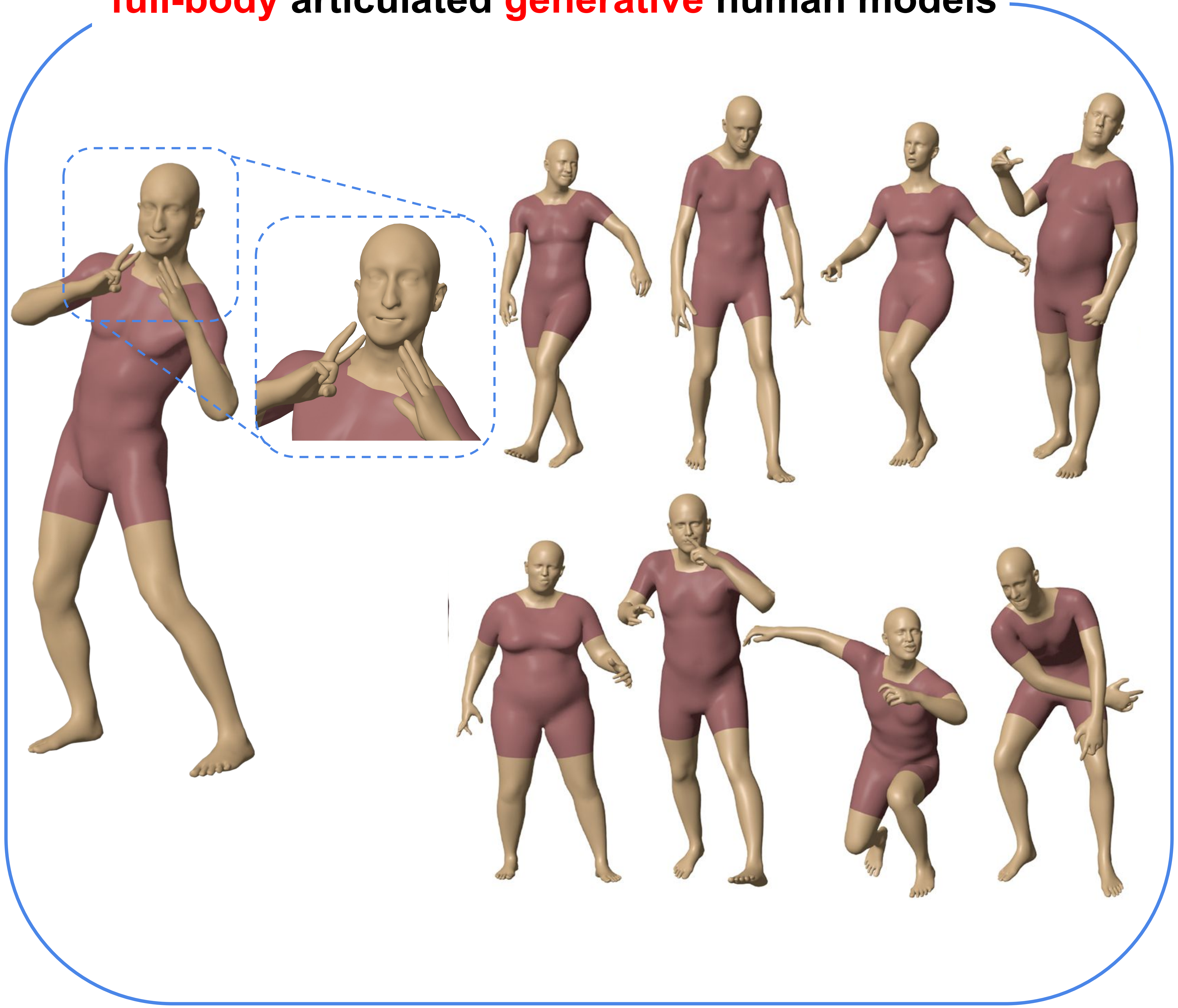
GENERATIVE HUMAN MODELING PIPELINE

dynamic human scans

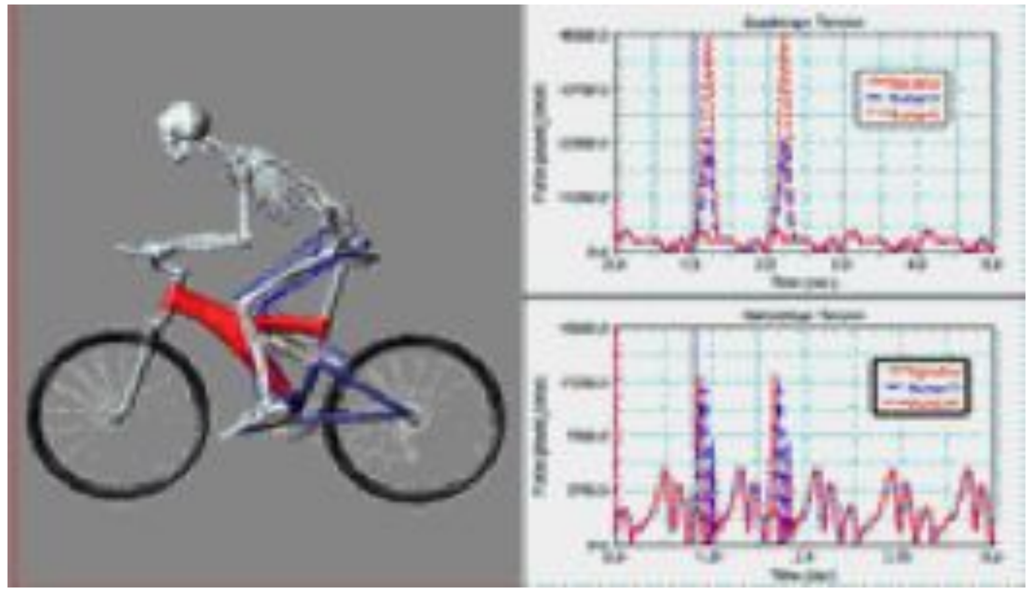


end-to-end deep learning

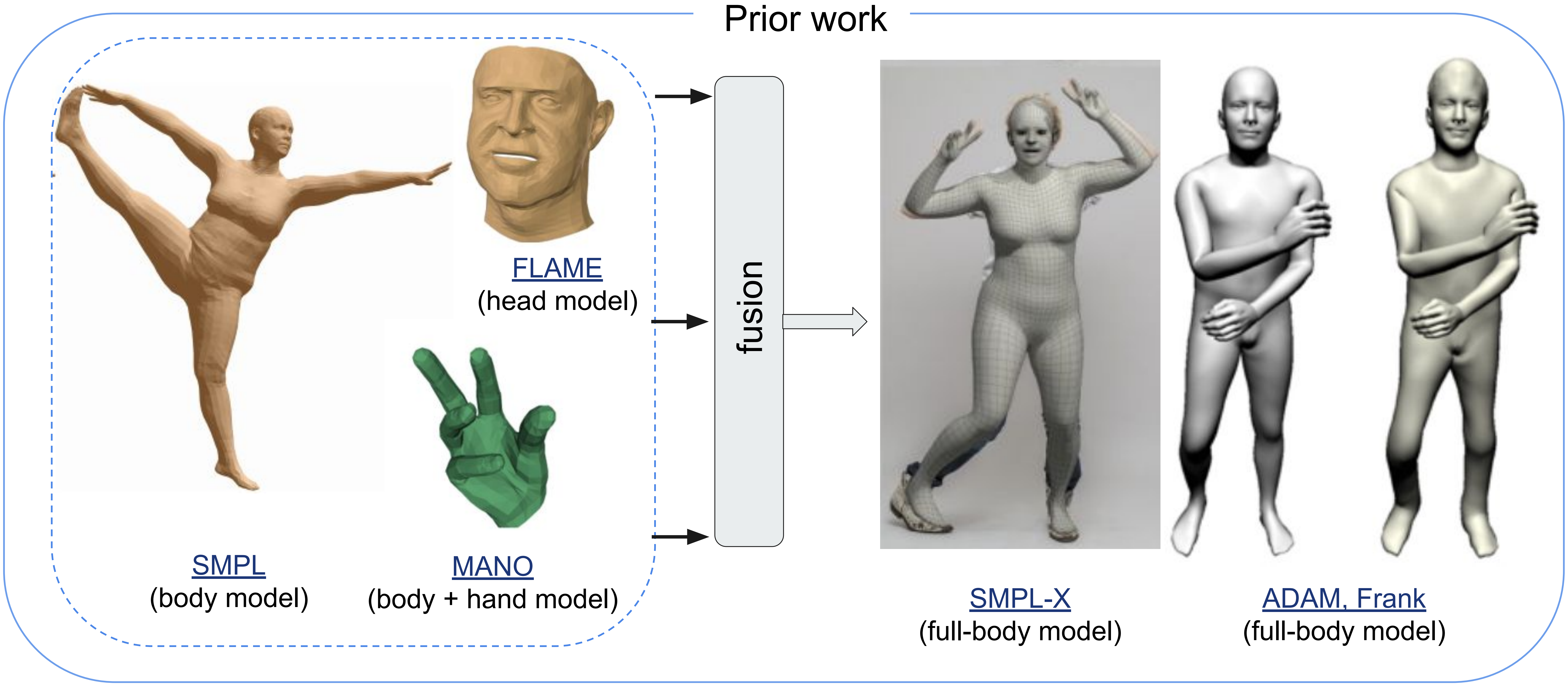
full-body articulated generative human models



Motivation: 3D Human Sensing



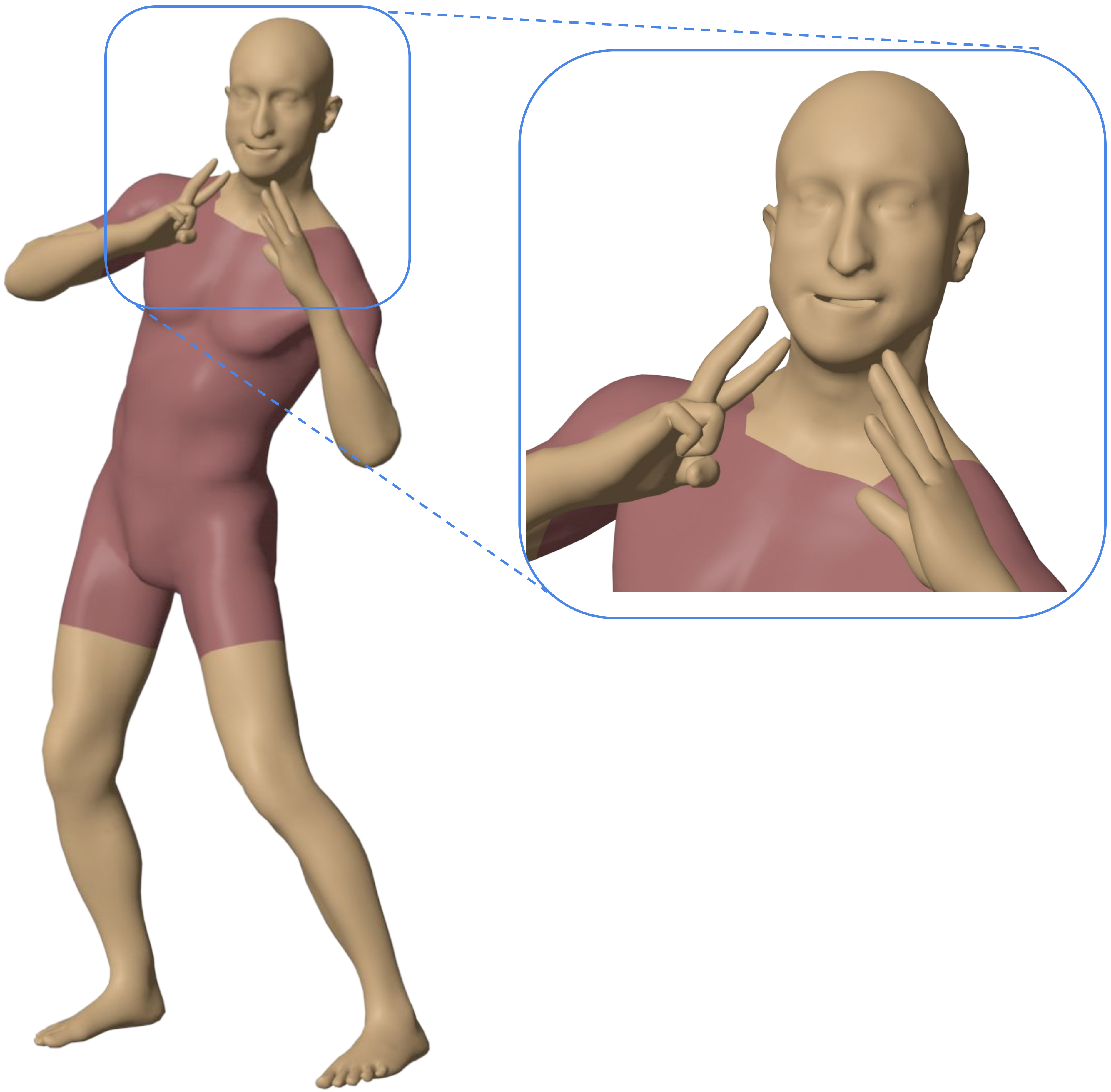
GENERATIVE HUMAN MODELS: PRIOR WORK



TOWARDS FULL-BODY GENERATIVE HUMAN MODEL

★ Full-body generative human model

★ All model components trained in a single consistent learning loop



END-TO-END TRAINING PIPELINE

Trainable modules:

- body shape VAE
- expression VAE
- pose-space deformation
- joint centers predictor
- skinning weights

Model parameters:

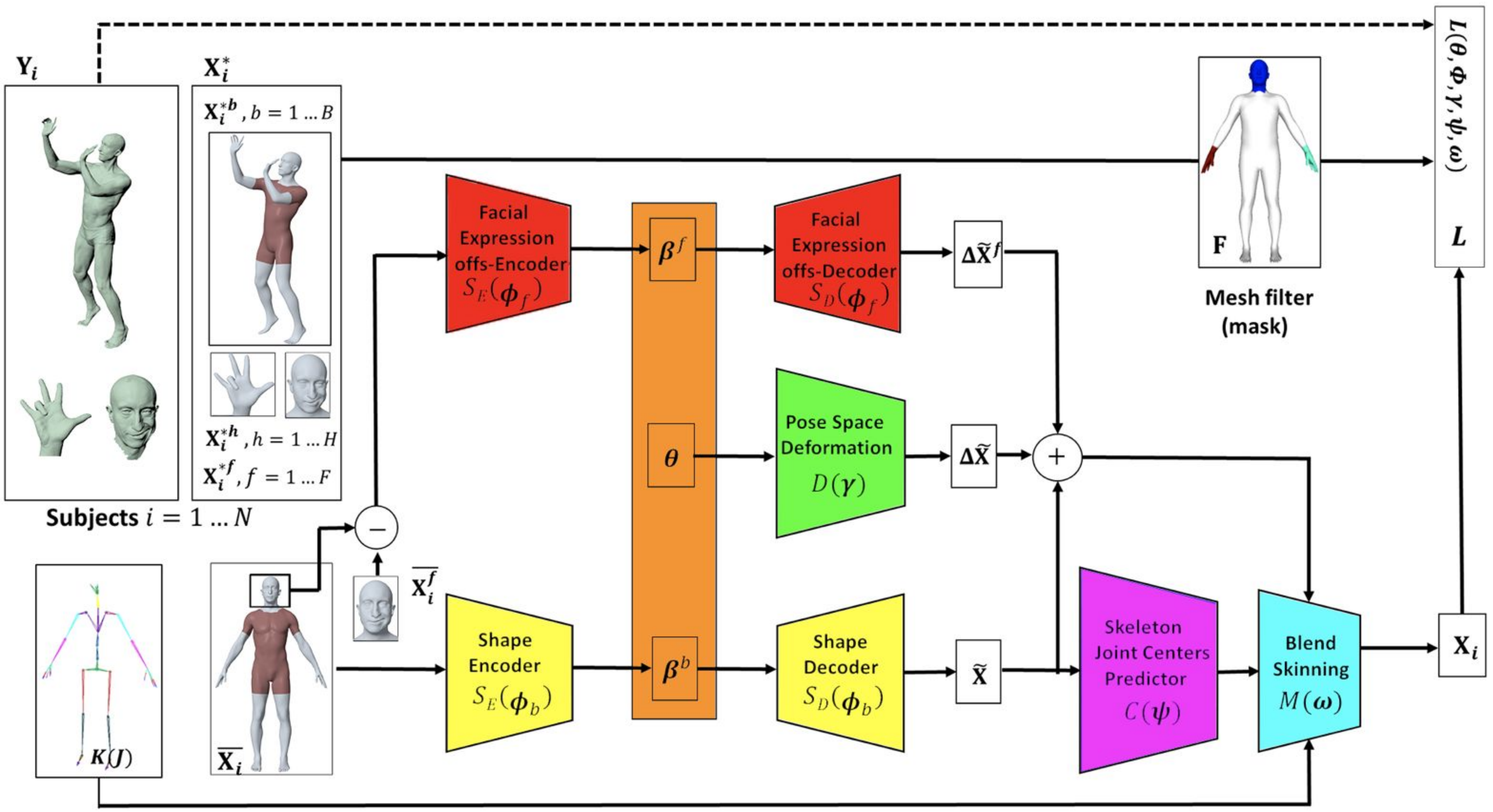
- latent codes: β^b, β^f
  pose: θ

Losses:

masked reconstruction loss

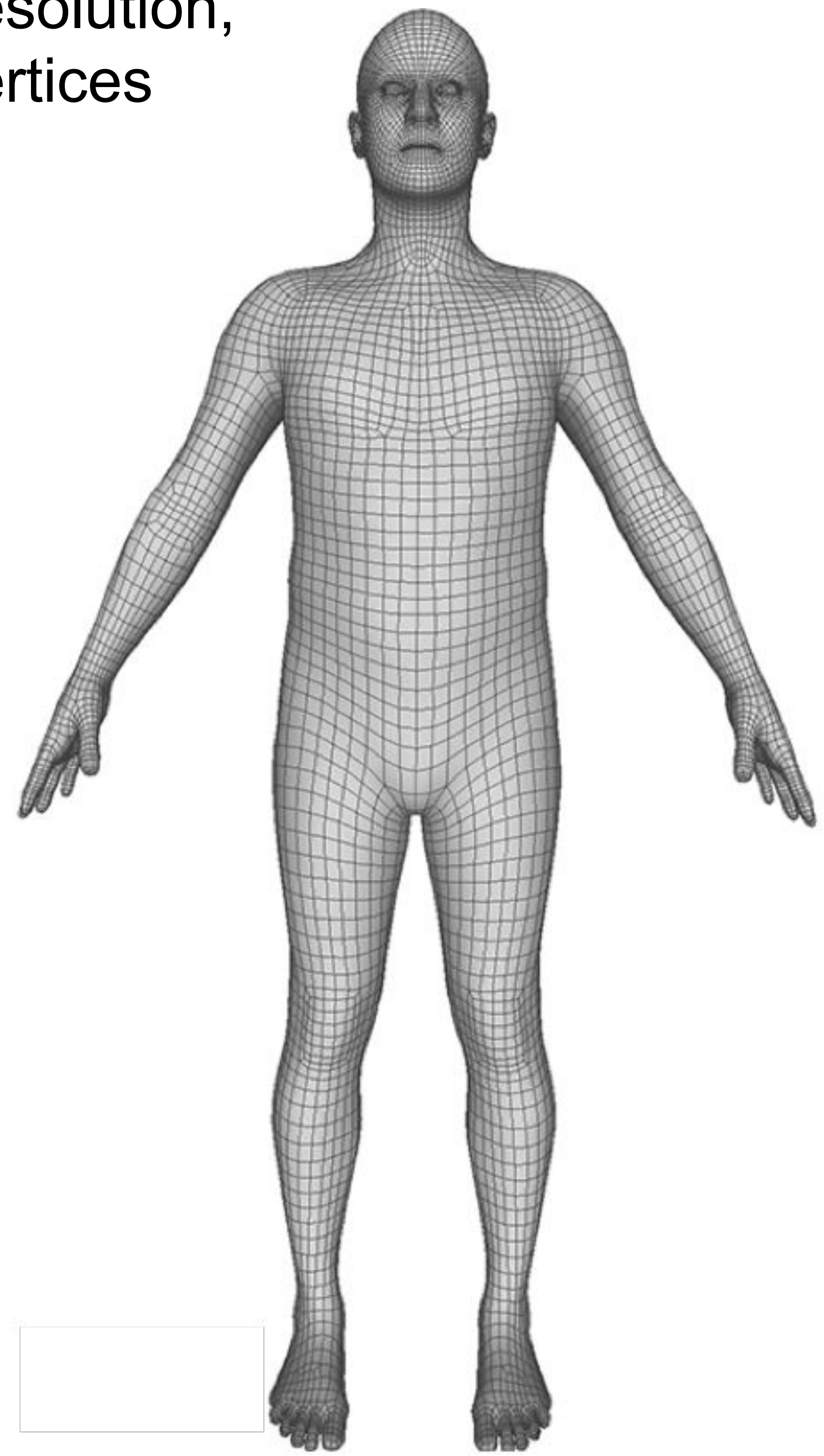
$$\frac{1}{N}\sum_{i}^{N} \|F_i(X_i^* - X_i(\beta^b, \beta^f, \theta))\|$$

+ parameters regularizers

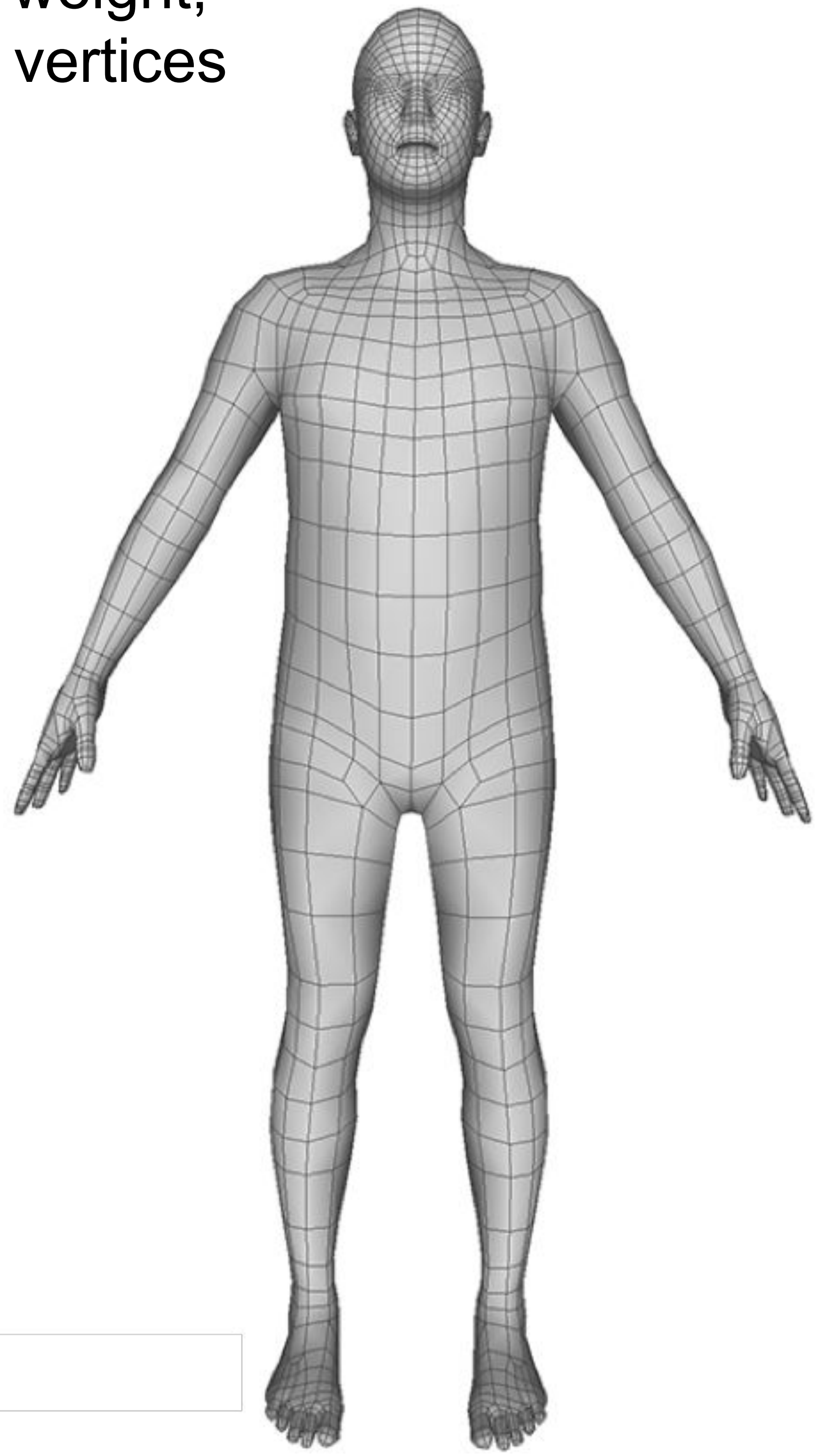


GHUM AND GHUML(ite): TEMPLATES

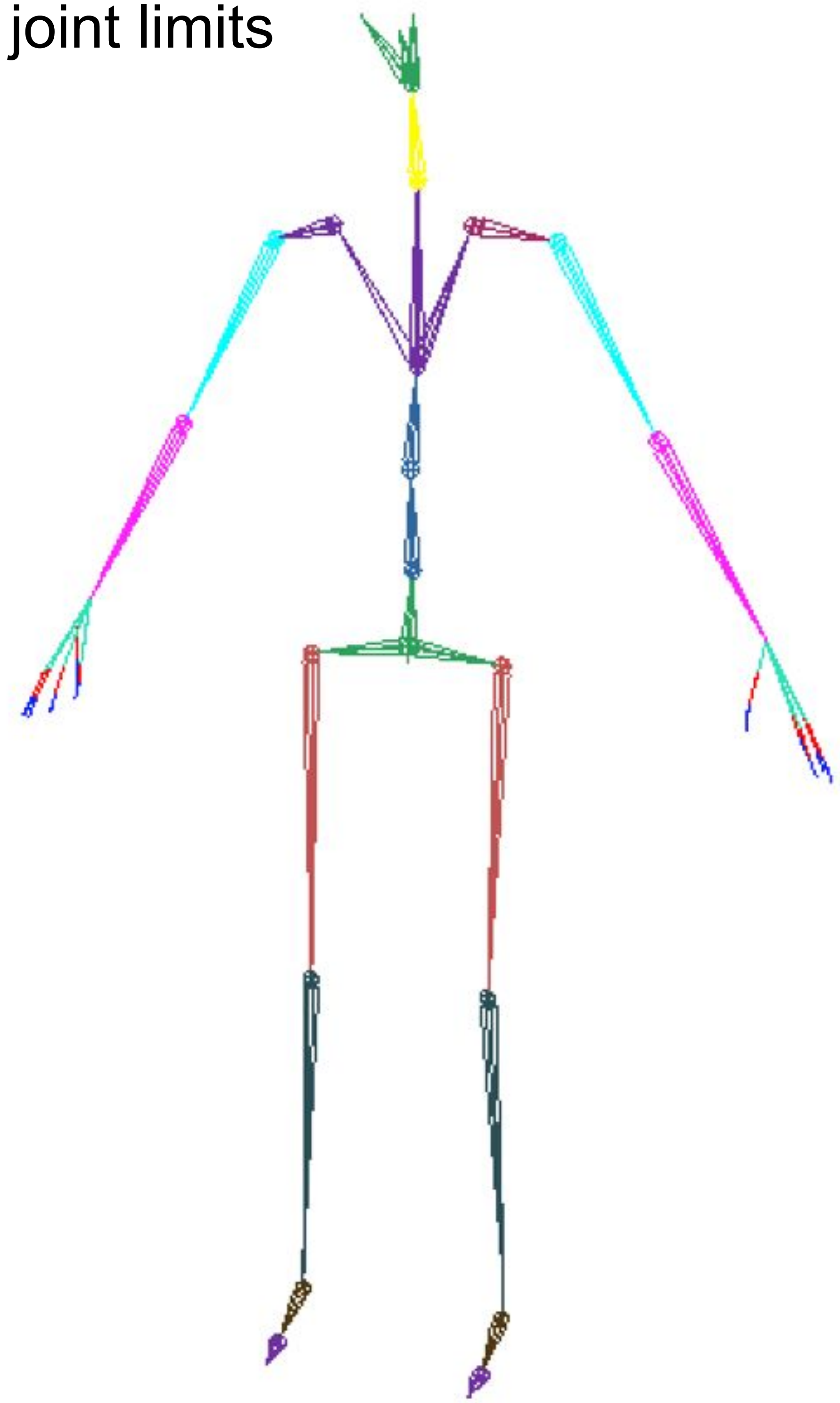
GHUM:
moderate-resolution,
10168 vertices



GHUML(-ite):
light-weight,
3190 vertices

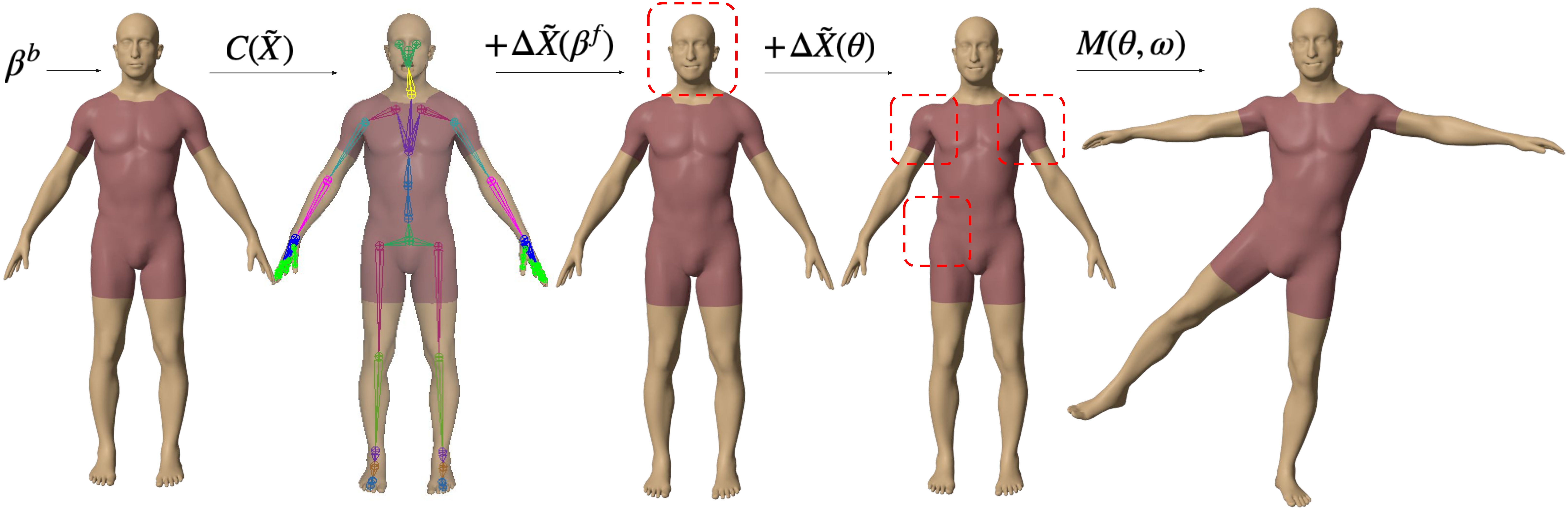


Shared skeleton:
minimal parameterized,
anatomical joint limits



GHUM AND GHUML(ite): MODEL FORMULATION

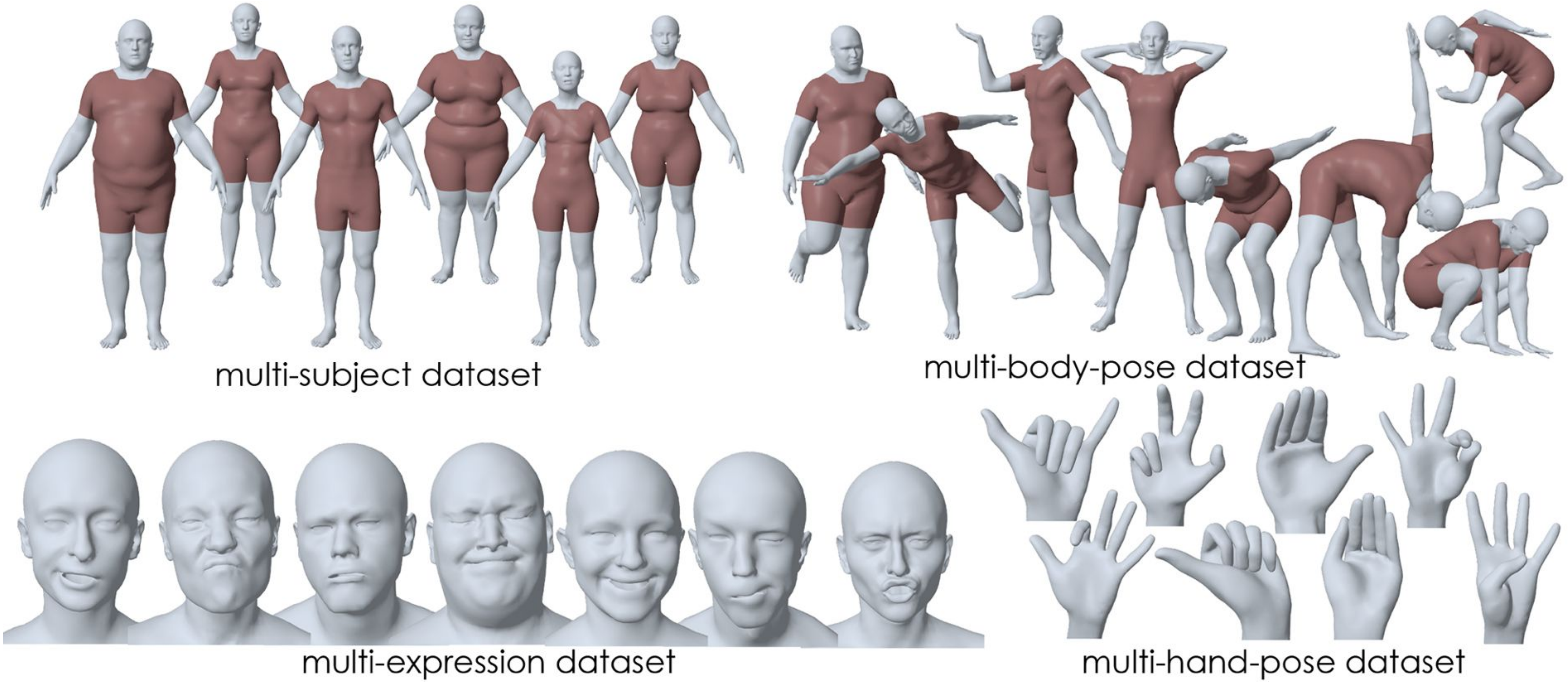
$$X(\beta^b, \beta^f, \theta) = M(\tilde{X}(\beta^b), \Delta\tilde{X}(\beta^f), \theta, \Delta\tilde{X}(\theta), C(\tilde{X}), \omega)$$



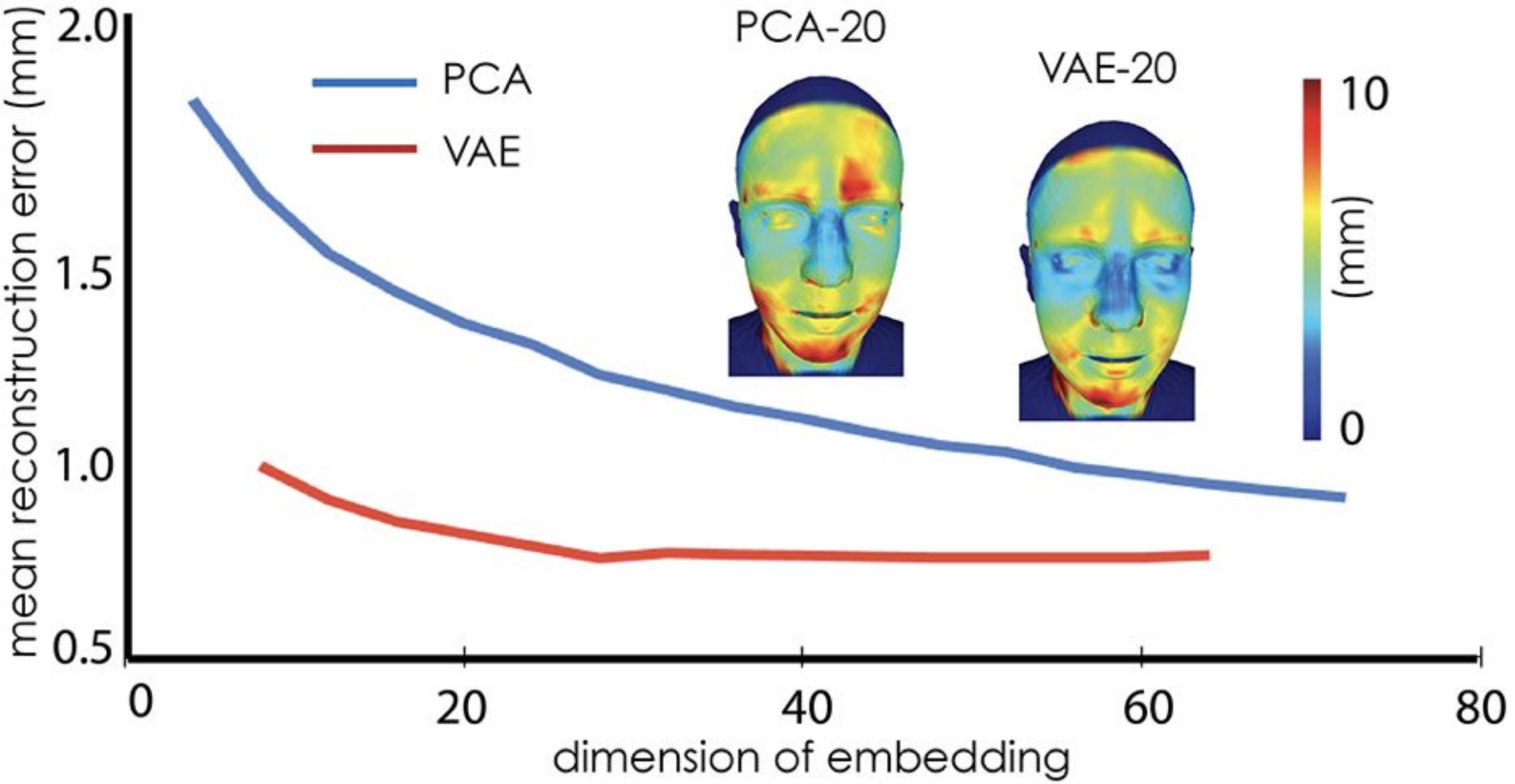
rest shape	joint centers	+ facial expression	+ pose-space deformation	output posed shape
$\tilde{X}(\beta^b)$	$C(\tilde{X})$	$\tilde{X}(\beta^b) + \Delta\tilde{X}(\beta^f)$	$\tilde{X}(\beta^b) + \Delta\tilde{X}(\beta^f) + \Delta\tilde{X}(\theta)$	X

REGISTRATION TO GHS3D + CAESAR

4.3K subjects, **60K** high-resolution dynamic human scans, including close-up head and hand scans.



VARIATIONAL SHAPE AND EXPRESSION AUTOENCODER



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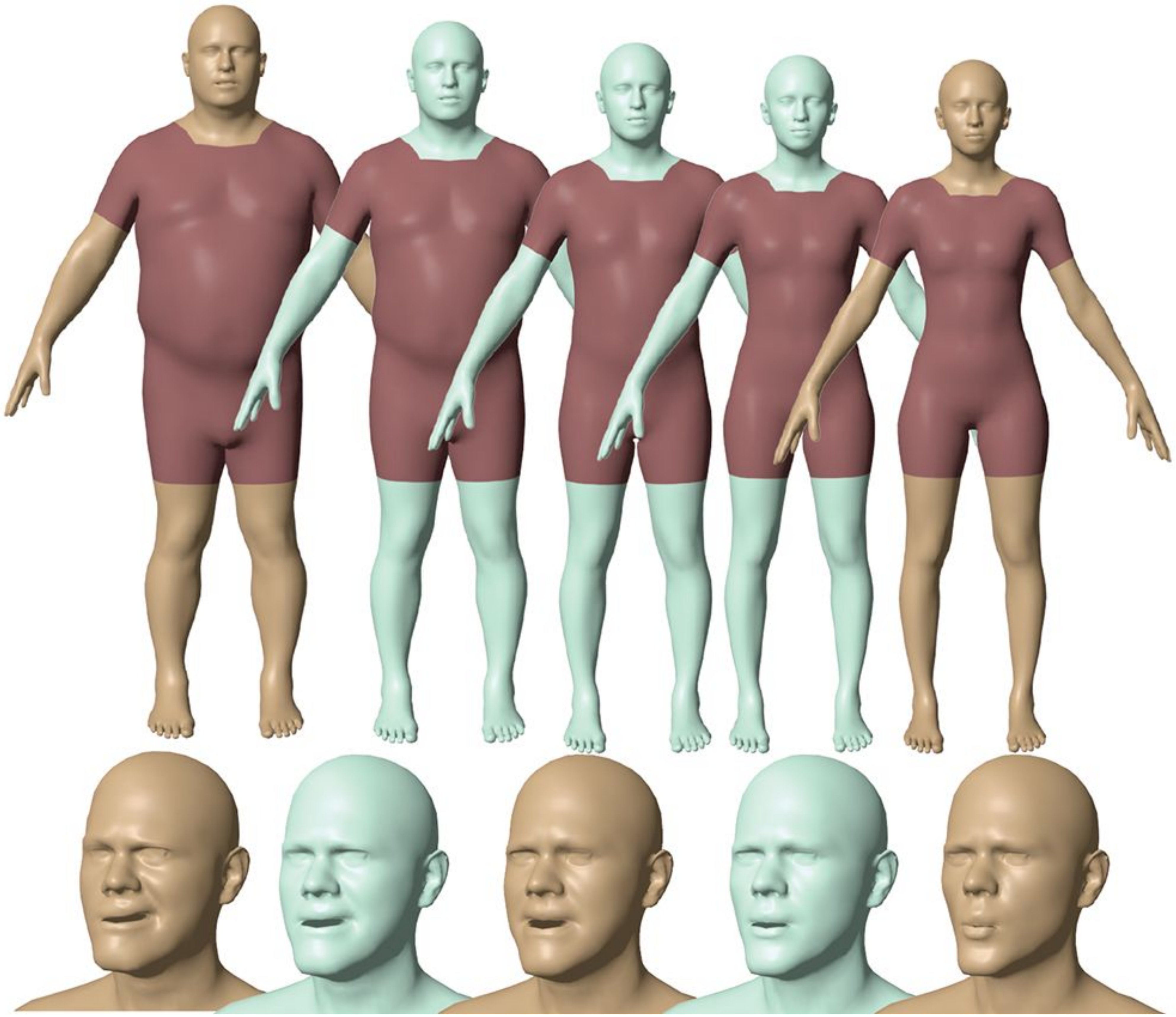
LATENT SPACE INTERPOLATION



(brown: samples; green: interpolation)

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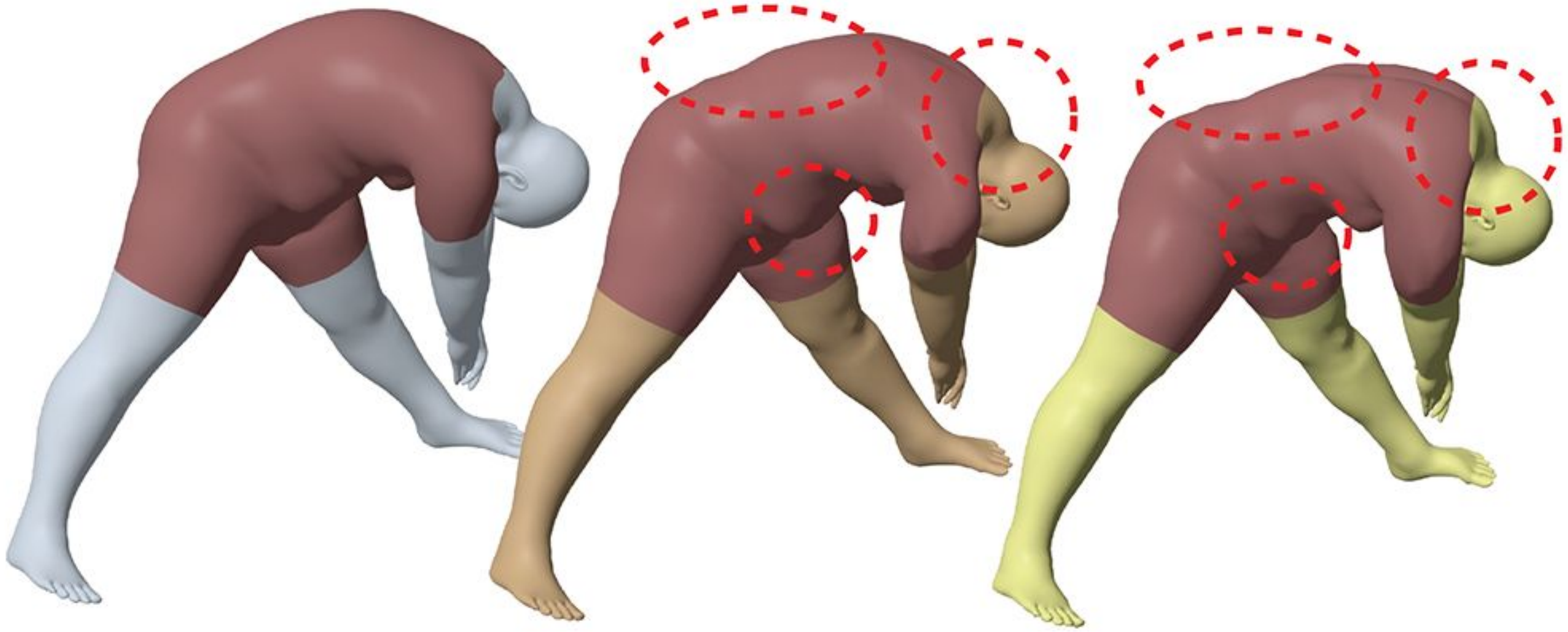
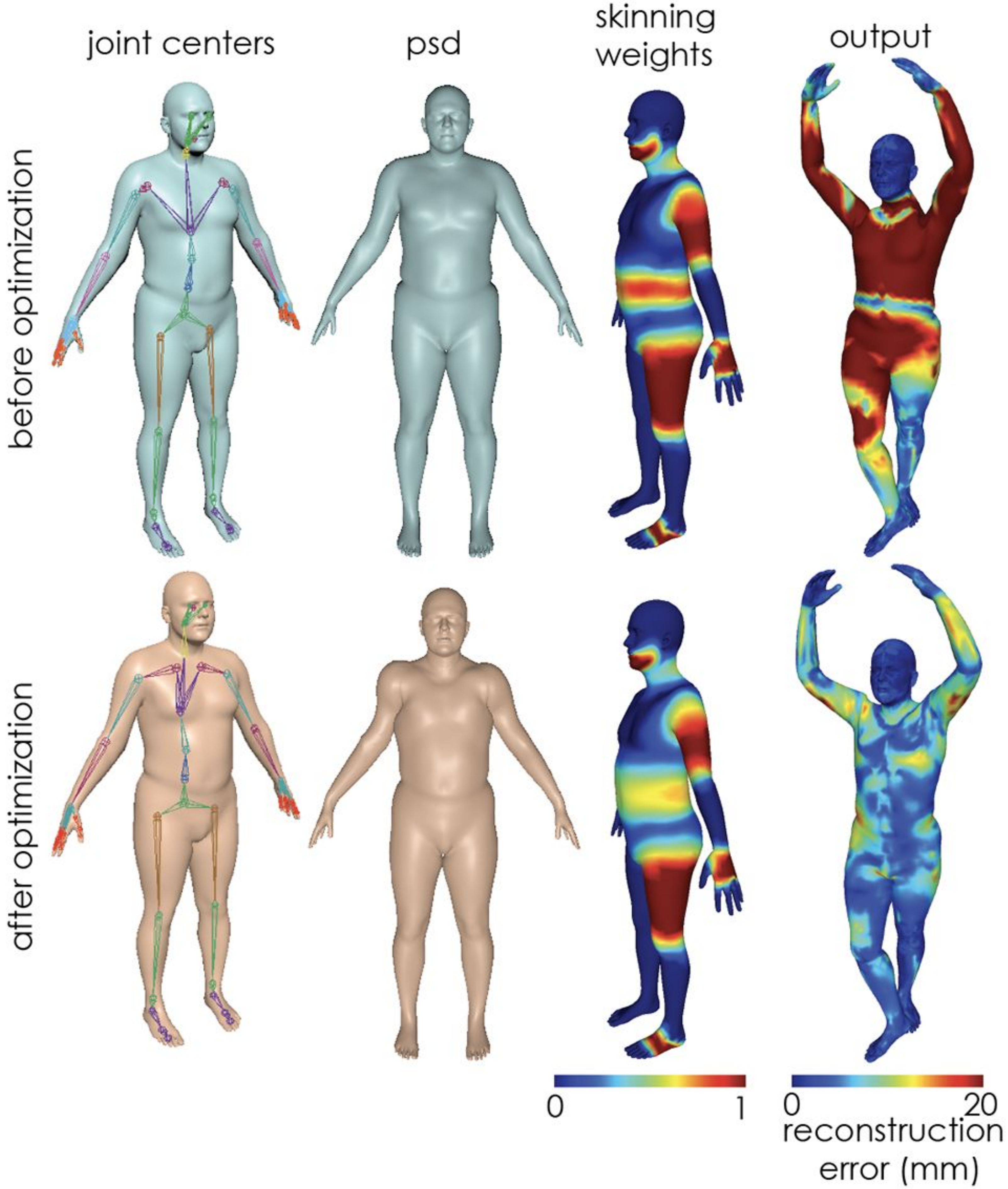
Optimized Skinning



registration GHUM with PSD GHUM without PSD



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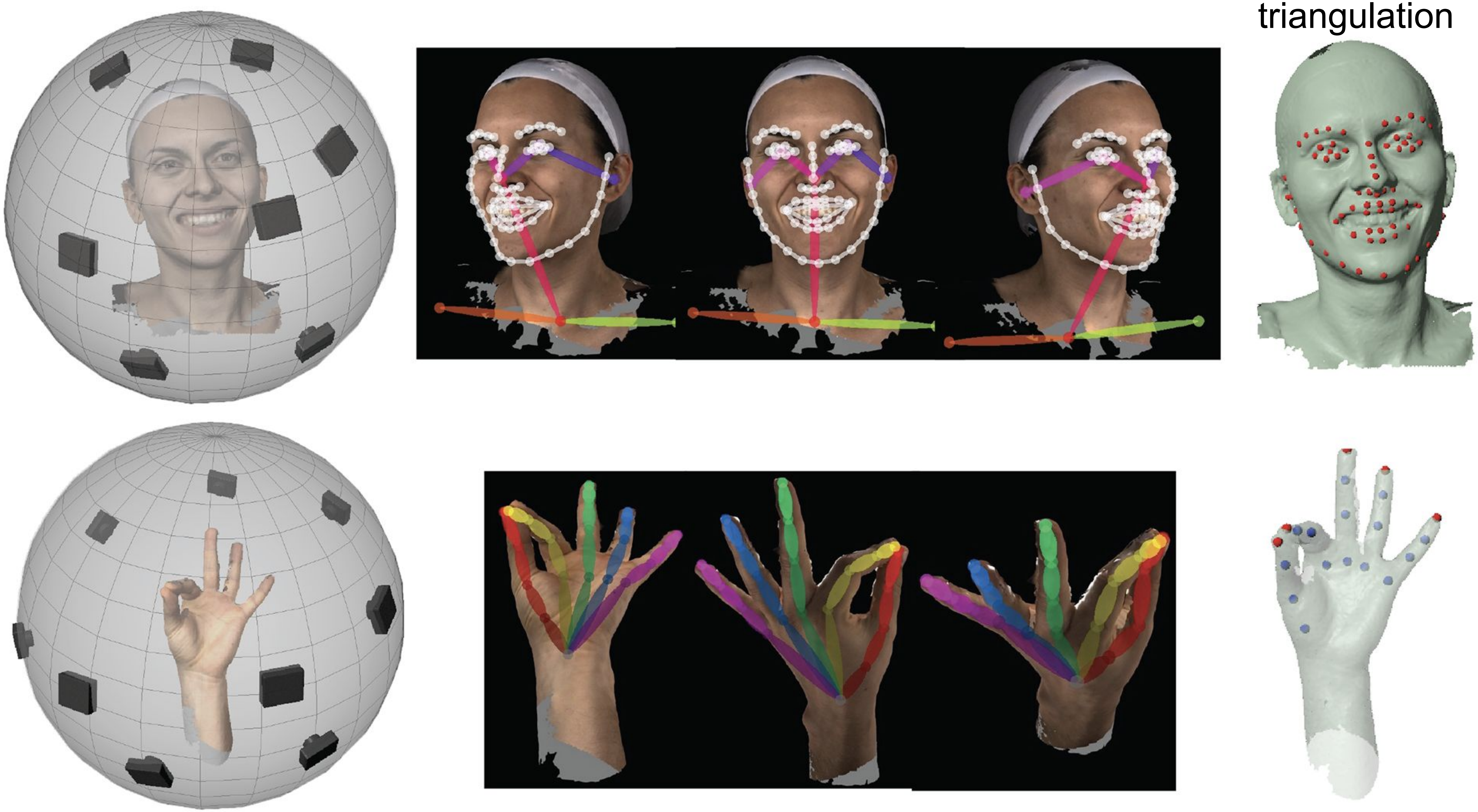
AUTOMATIC 3D LANDMARKS DETECTION

Mutiview renderings

2D landmarks detection

3D landmarks triangulation



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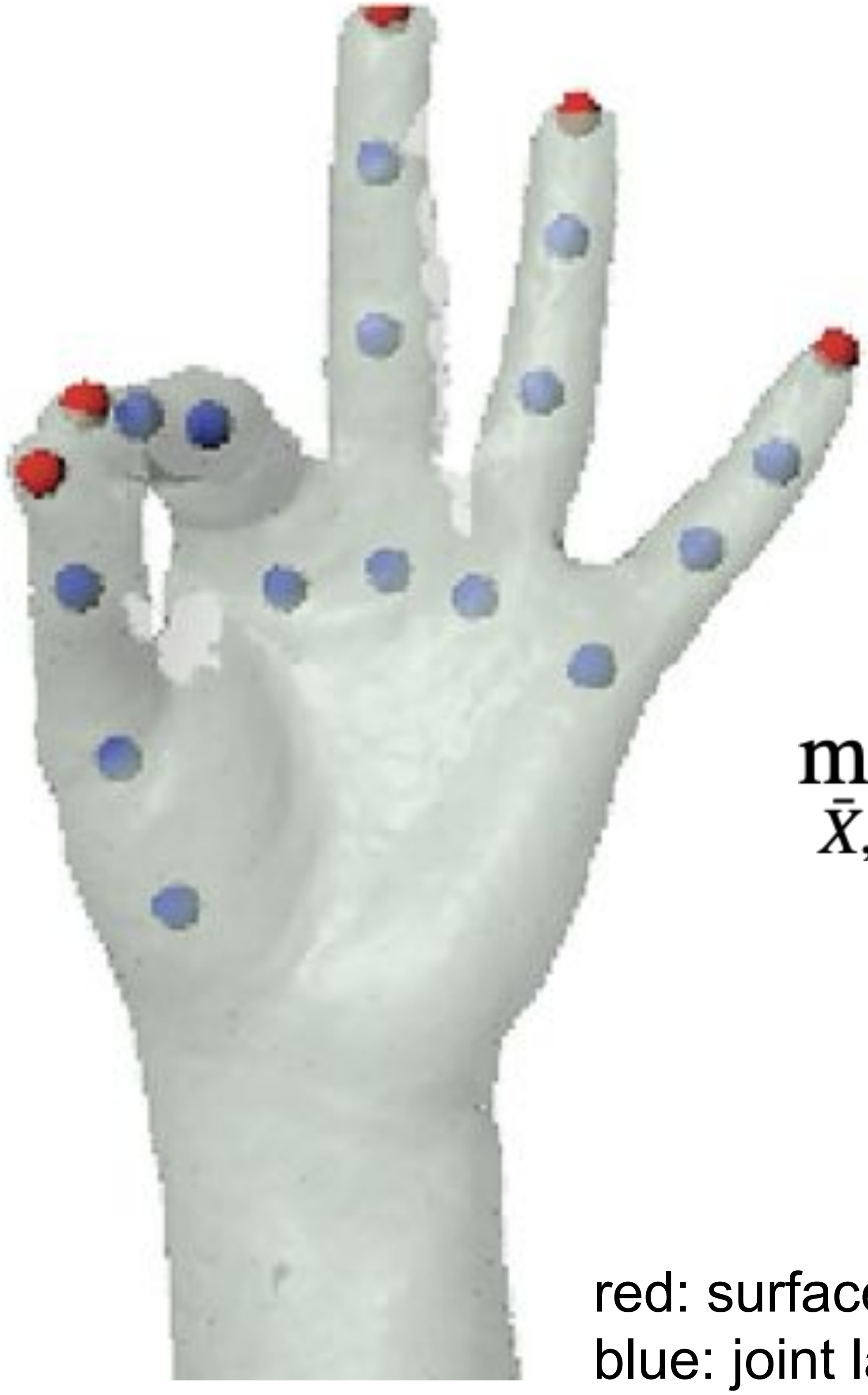
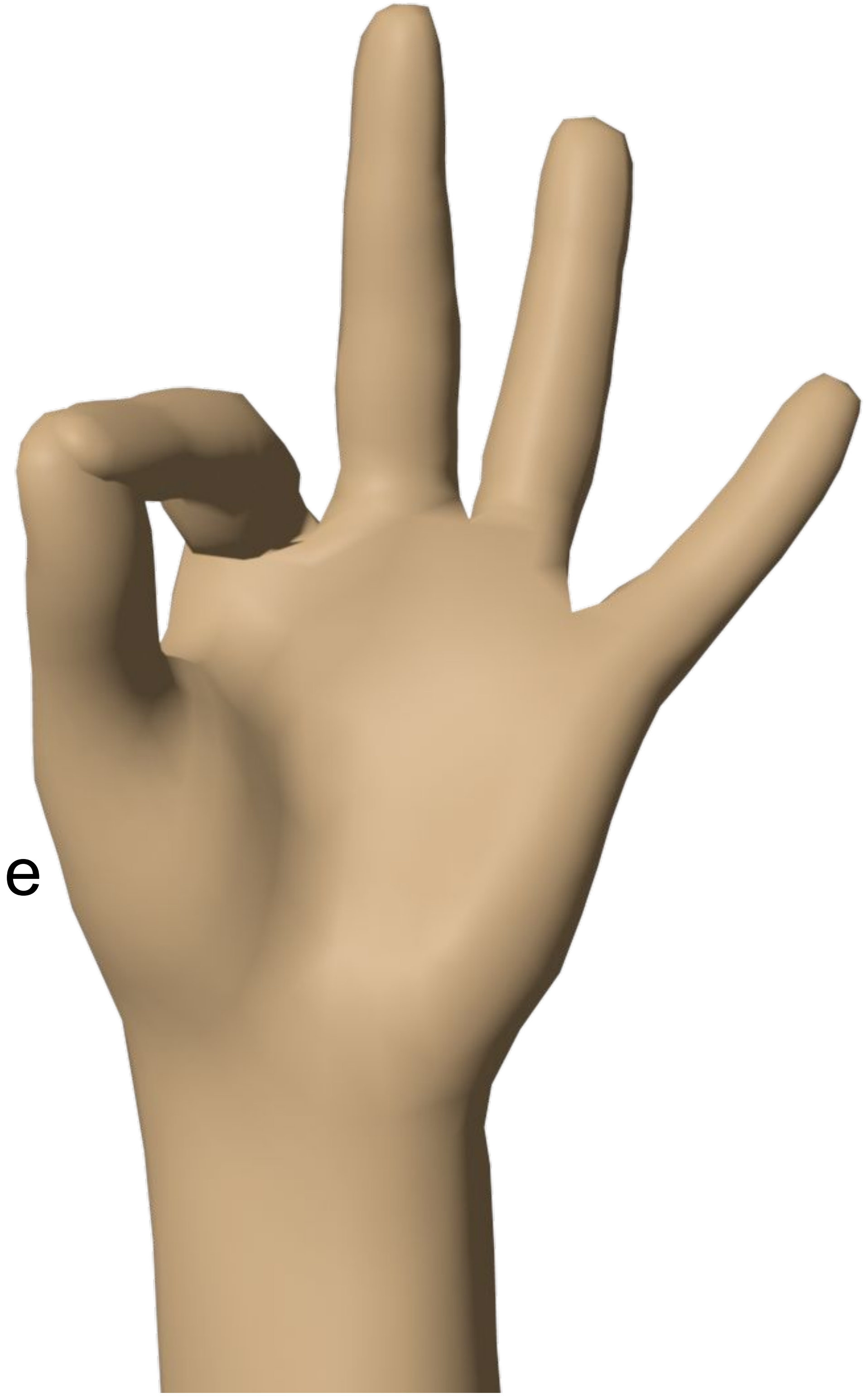
ARTICULATED AS-CONFORMAL-AS-POSSIBLE REGISTRATION



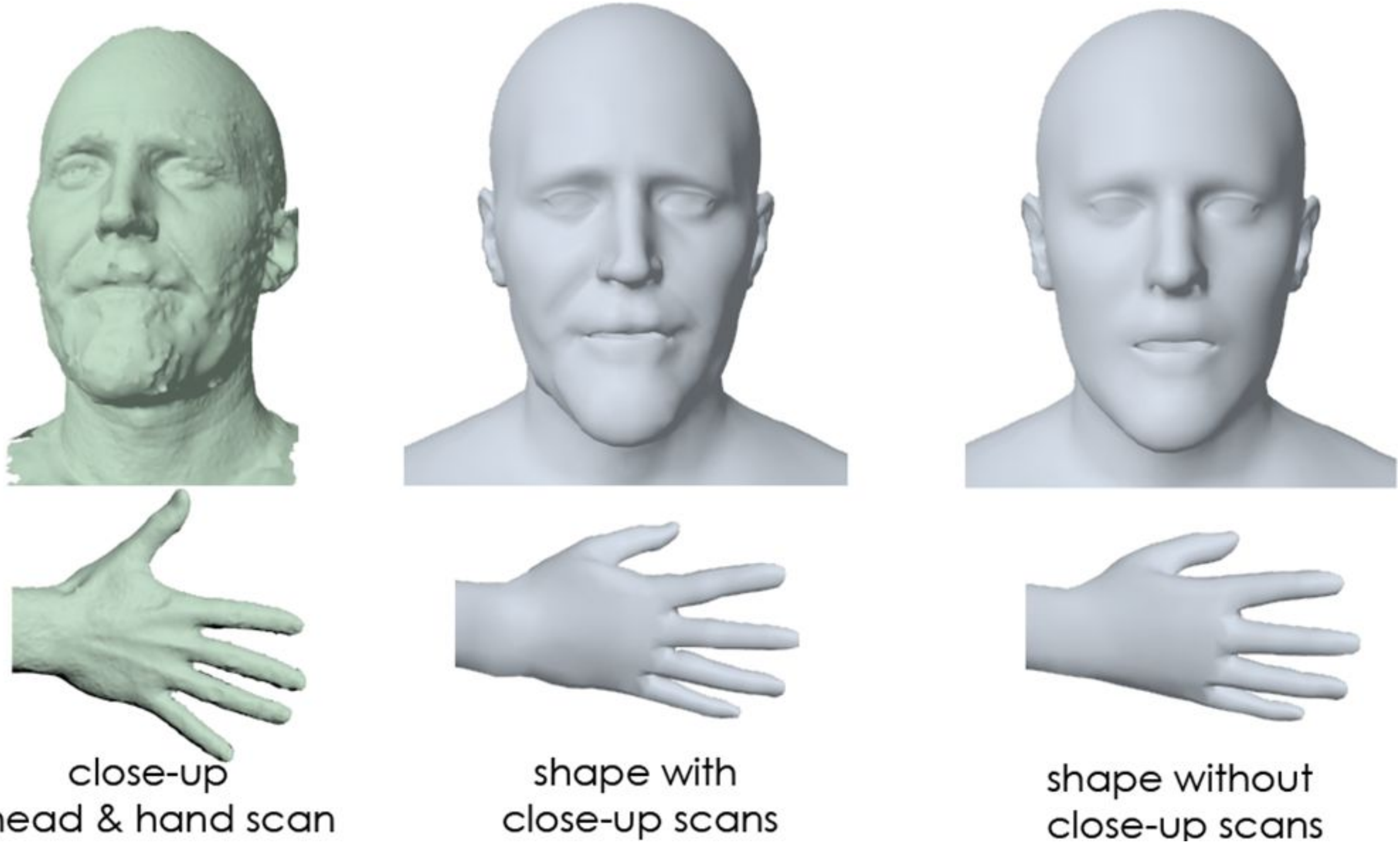
$$\min_{\bar{X},\theta} \xrightarrow[\text{+ shape prior: as-conformal-as-possible}]{\text{data term: ICP + landmarks}}$$



red: surface landmarks
blue: joint landmarks

FULL-BODY SHAPE ESTIMATION

We estimate full-body shape at A pose by fusing body scan with close-up head and hand scans

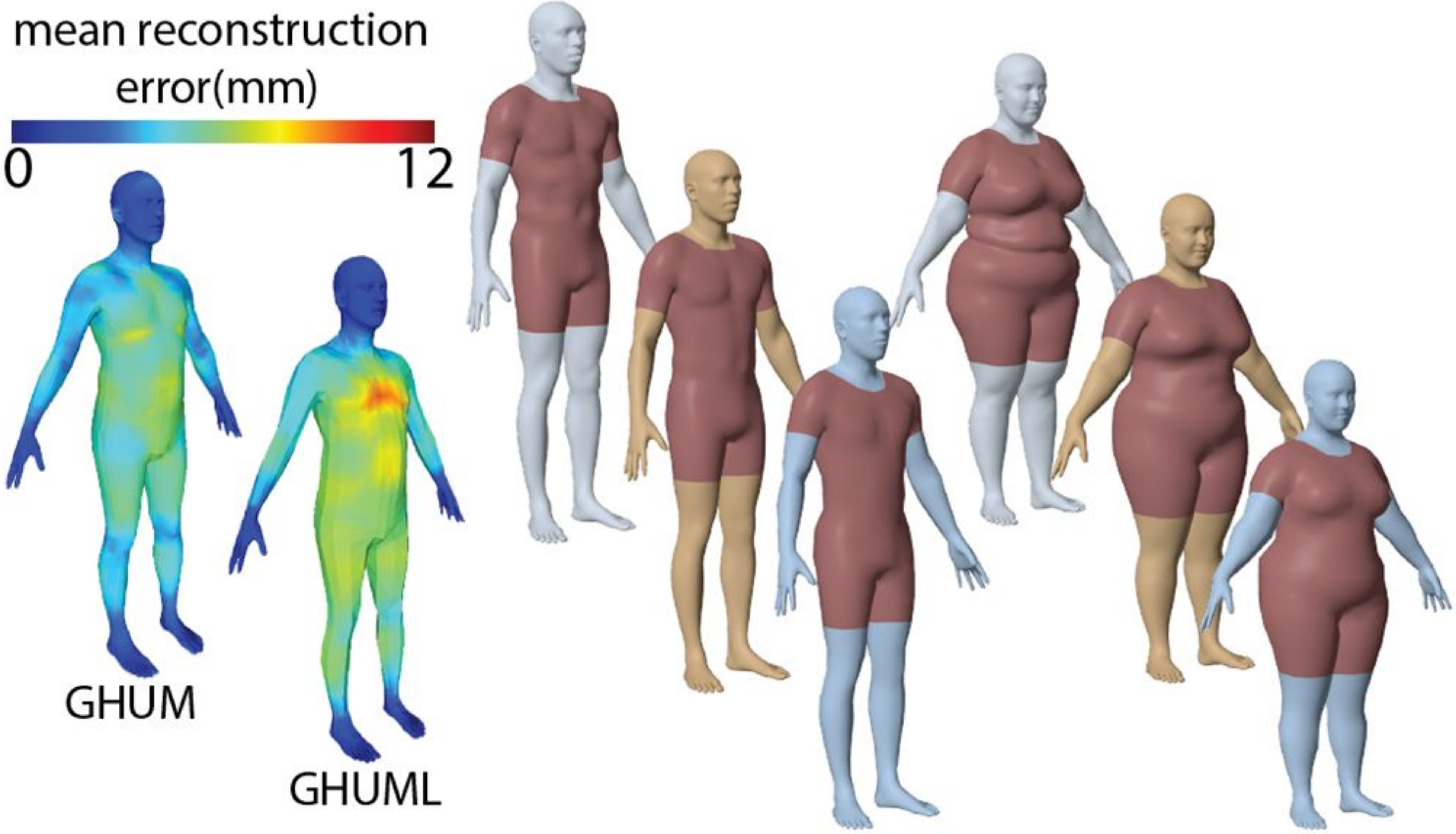


EVALUATION: CAESAR RECONSTRUCTION

mean vertex reconstruction error to registrations:

GHUM 2.81 mm

GHUML 3.27 mm



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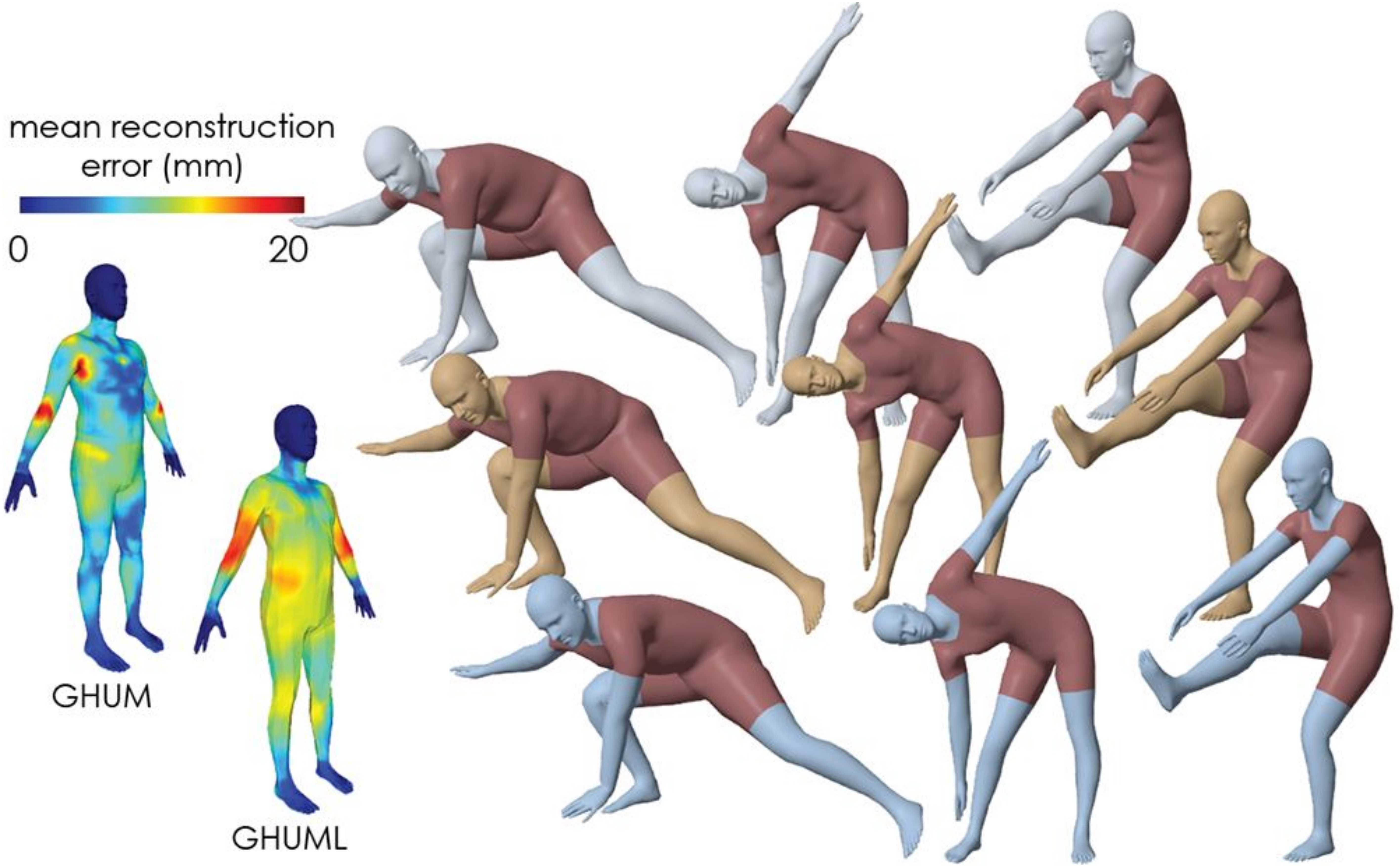
EVALUATION: GHS3D BODY RECONSTRUCTION

mean vertex reconstruction error to registrations:

GHUM 5.21 mm

GHUML 6.32 mm

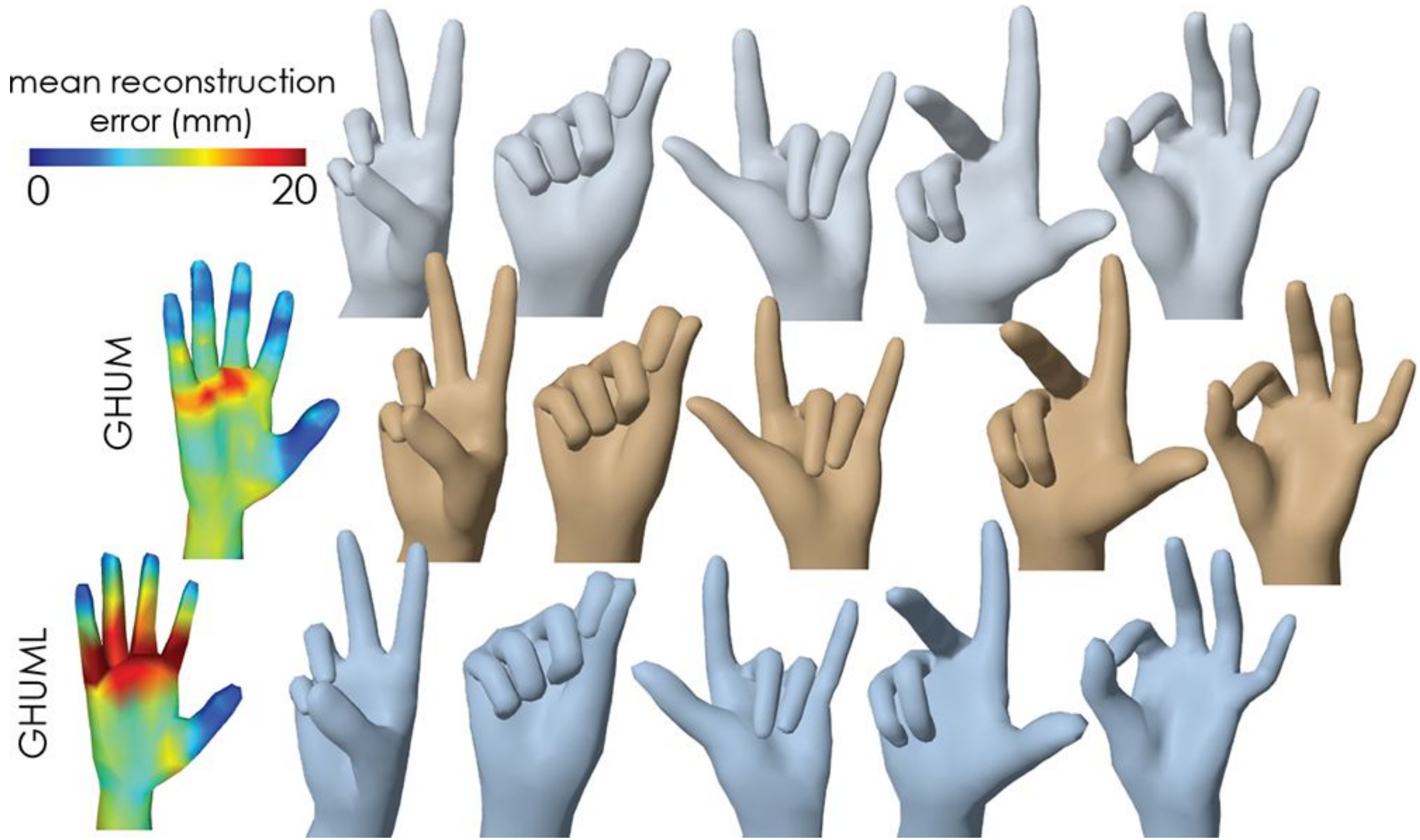


EVALUATION: GHS3D HAND RECONSTRUCTION

mean vertex reconstruction error to registrations:

GHUM 2.22 mm

GHUML 2.81 mm



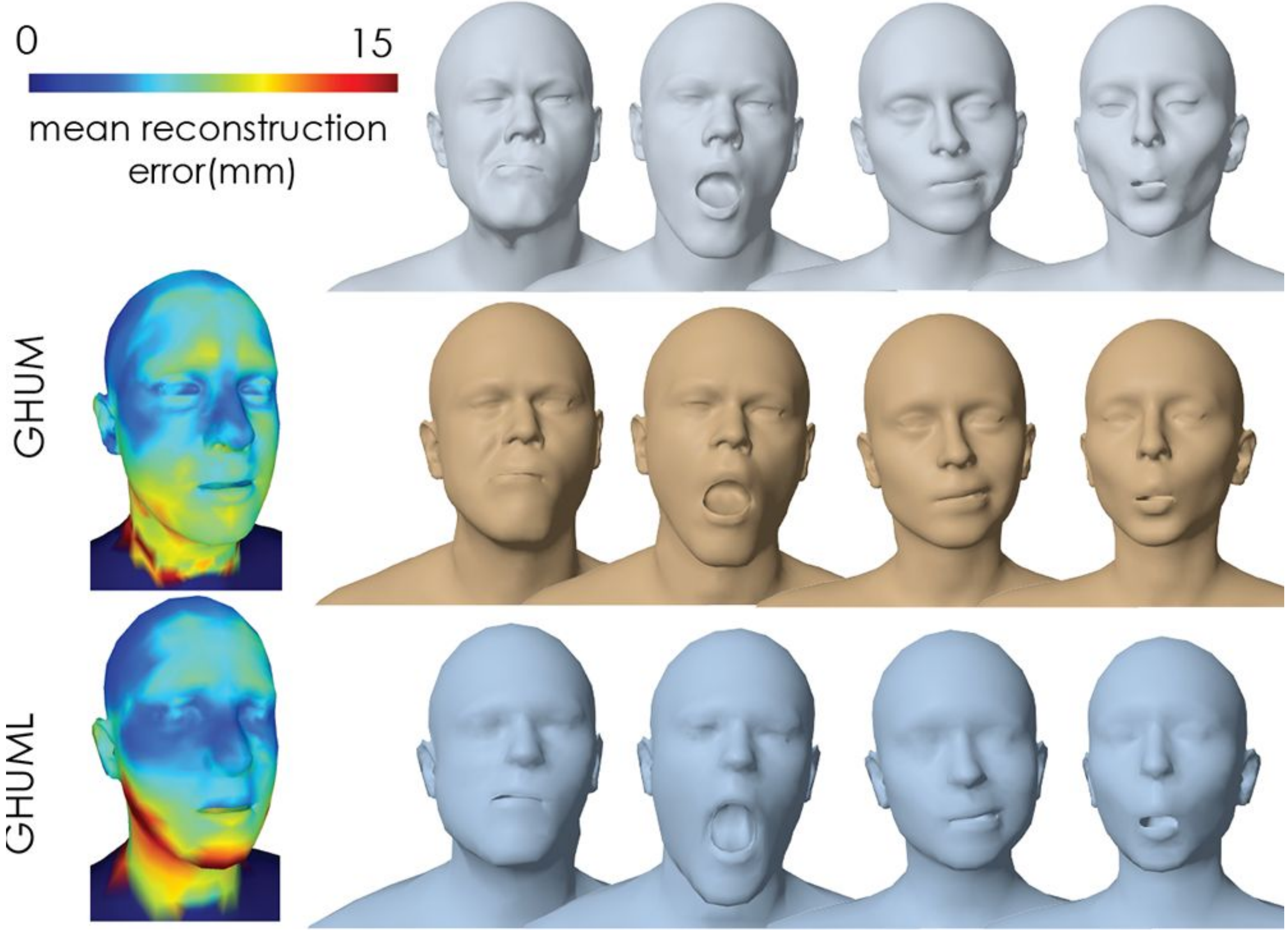
EVALUATION: GHS3D HEAD RECONSTRUCTION

Head motion =
joints (jaw, eyelids, neck) articulation +
facial expressions

mean vertex reconstruction error to registrations:

GHUM 2.96 mm

GHUML 3.82 mm



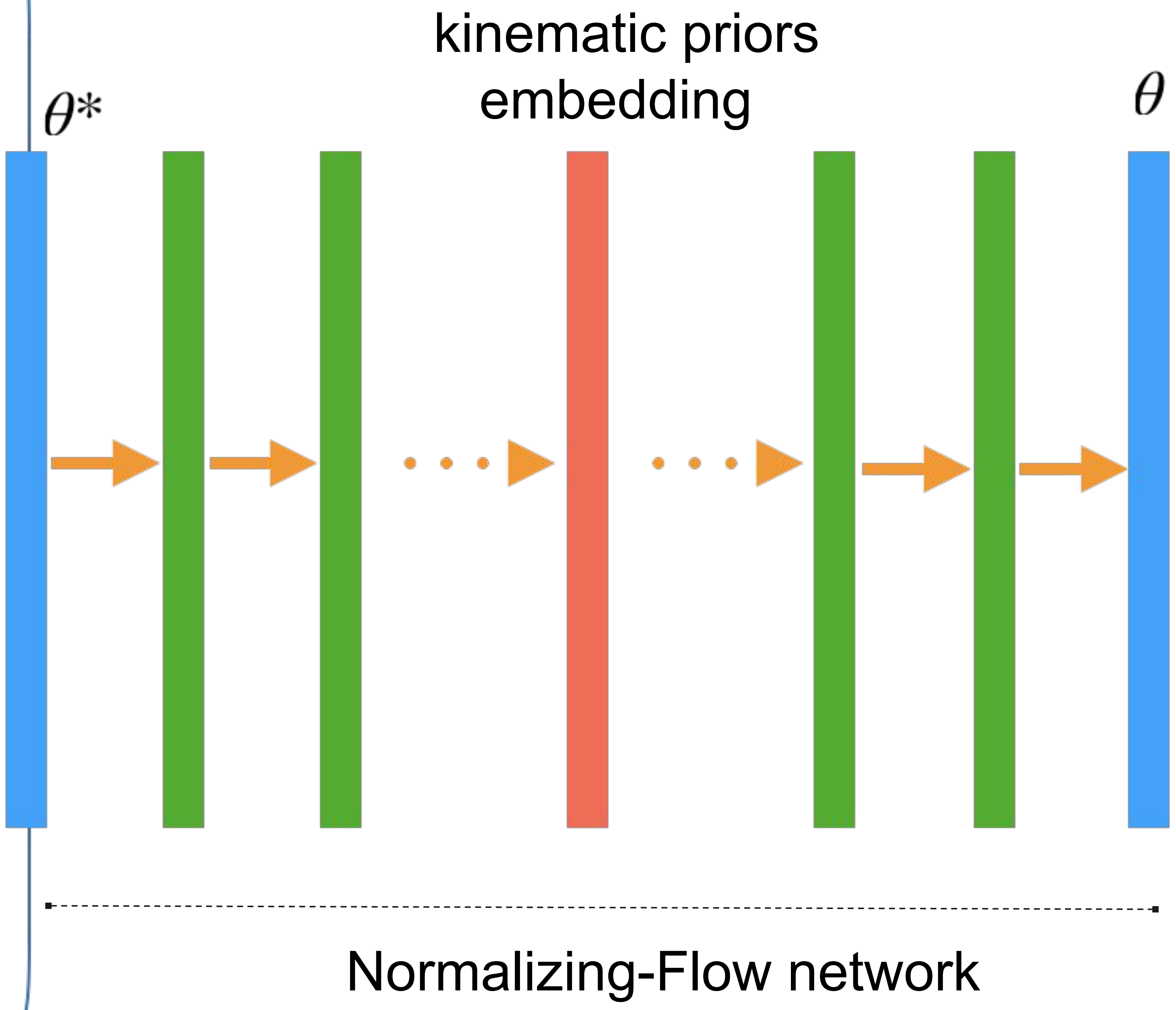
GHUM VS SMPL

- GHUM is close (or slightly better) to SMPL in skinning visual quality
- Vertex point-to-plane error (body-only)

  GHUM: 4.23 mm
  SMPL: 4.96 mm

MOTION RETARGETING AND KINEMATIC PRIORS

We retarget our models to ***2.8M*** CMU and ***2.2M*** Human36M motion capture frames.



FULL-BODY RECONSTRUCTION IN MONOCULAR IMAGES

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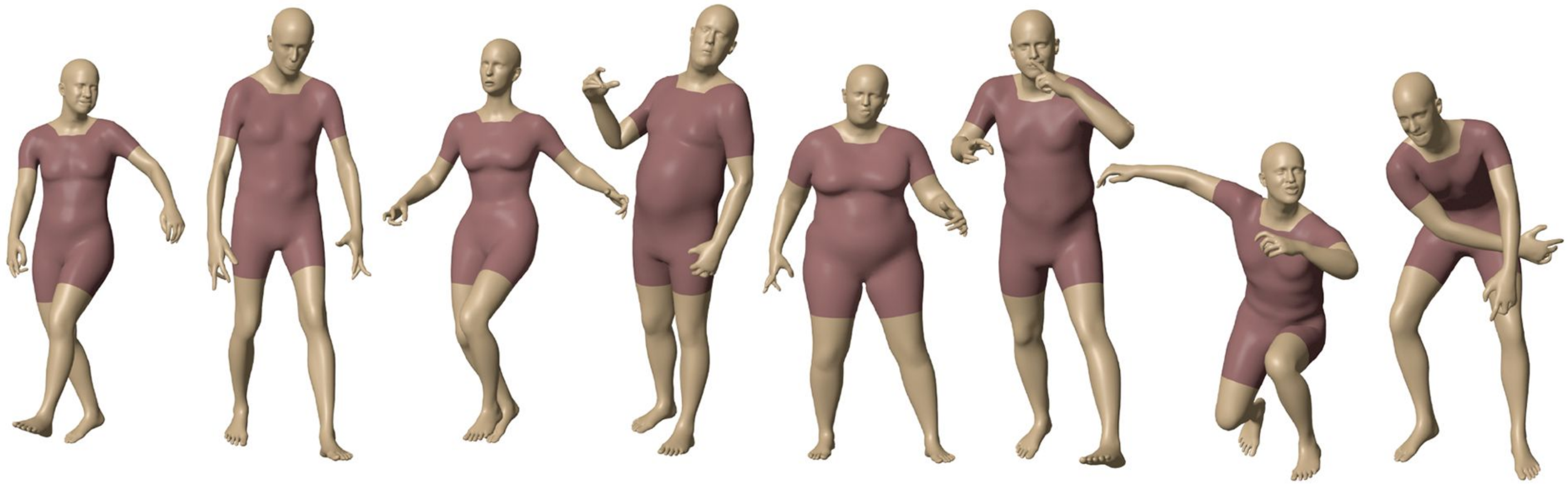
[A.Zanfir et al. 2020] Weakly Supervised 3D Human Pose and Shape Reconstruction with Normalizing Flows

CONCLUSION

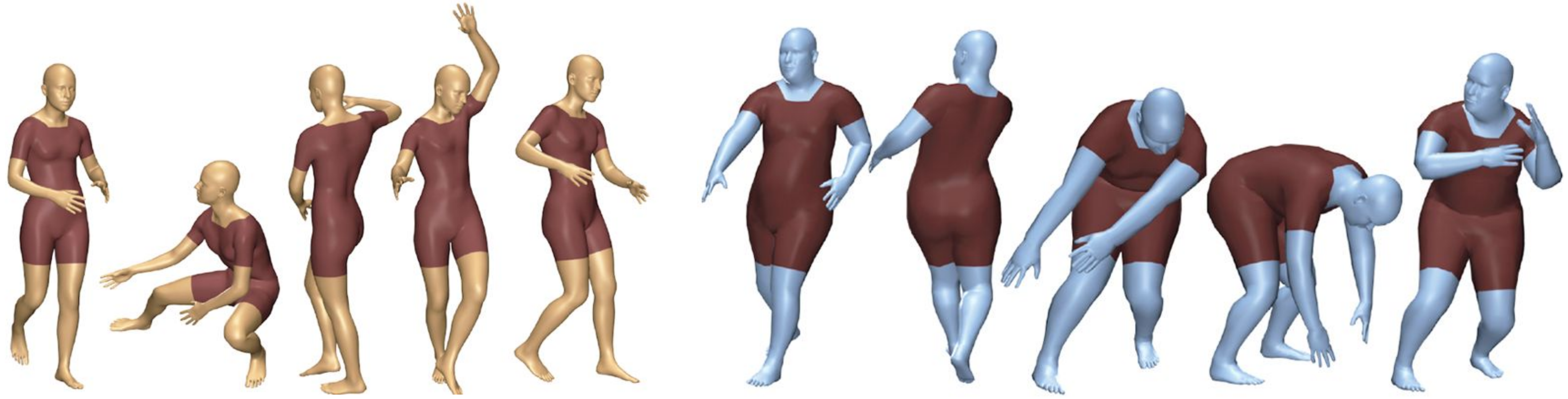
- An end-to-end generative, articulated 3D human shape learning pipeline.

- GHUM & GHUML: two high-quality full-body generative human models, available for research (https://github.com/google-research/google-research/ghum).



Thank You

Website: https://github.com/google-research/google-research/ghum



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