CADANS seminar 2015

HUMAN BODY MODELING

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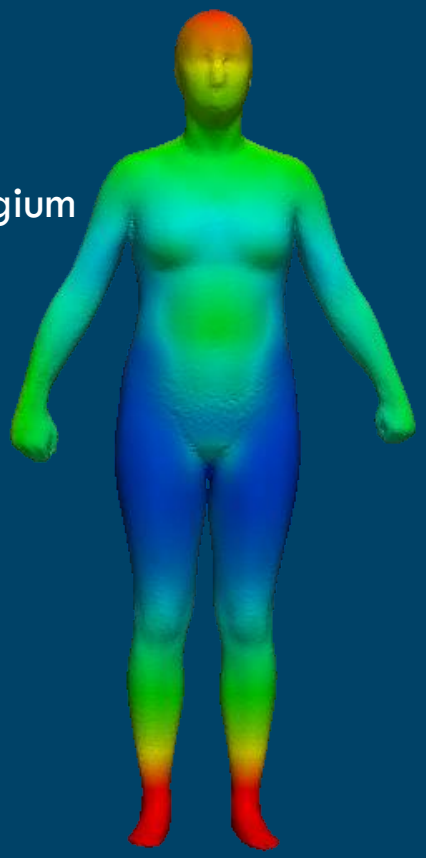
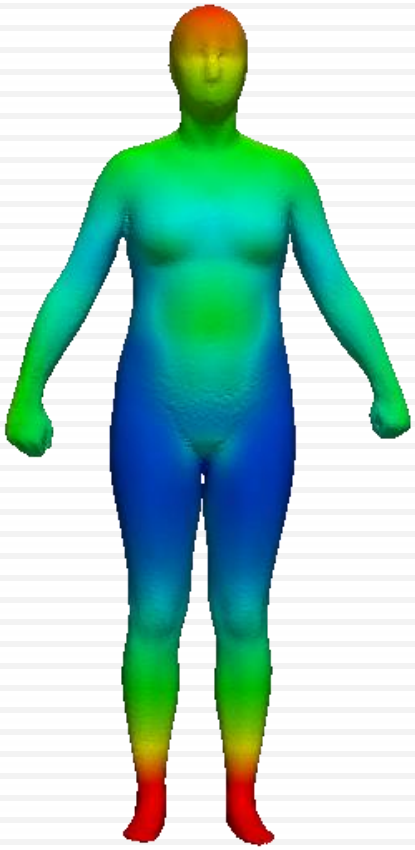


02/06/2015

Overview

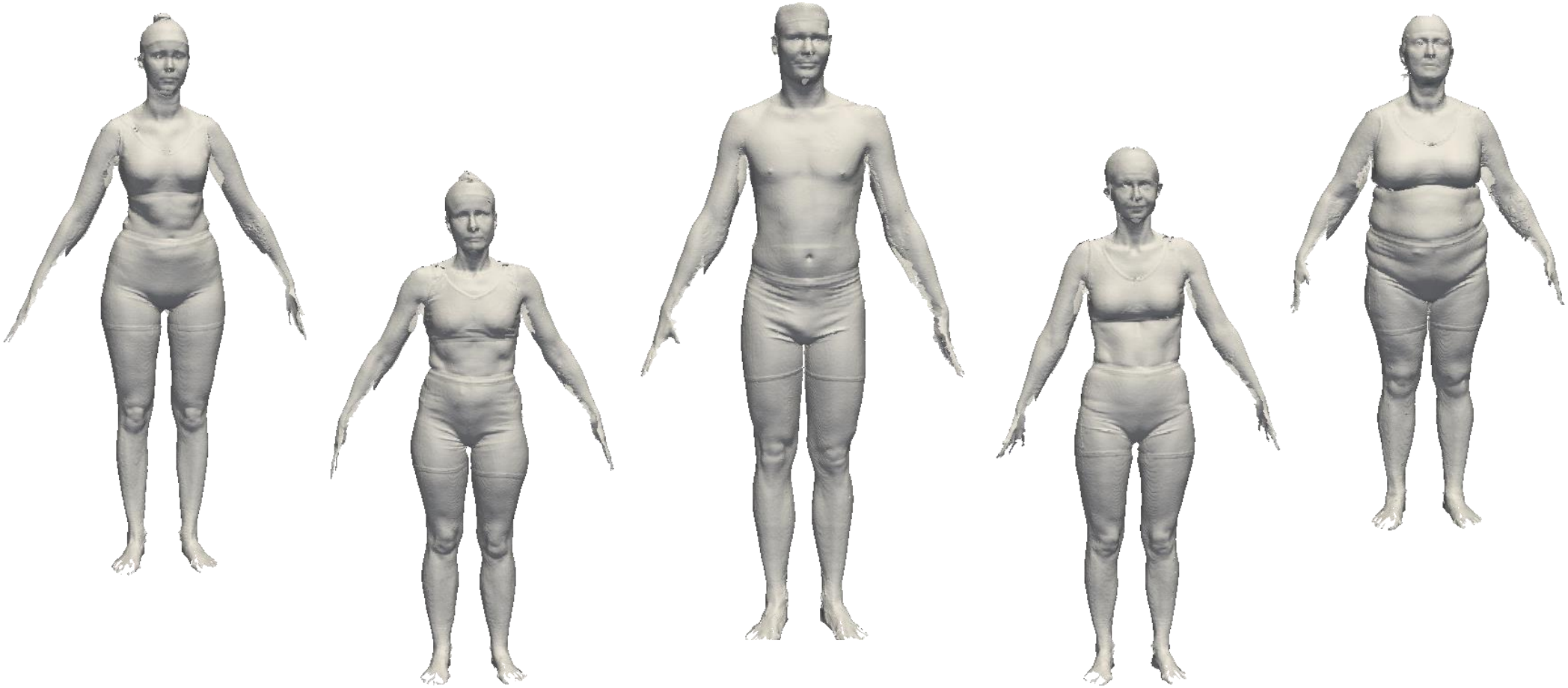
- Introduction
- Correspondence preserving elastic surface registration
- Building a shape model
- Shape prediction from features
- Conclusions and future work

Introduction



Introduction

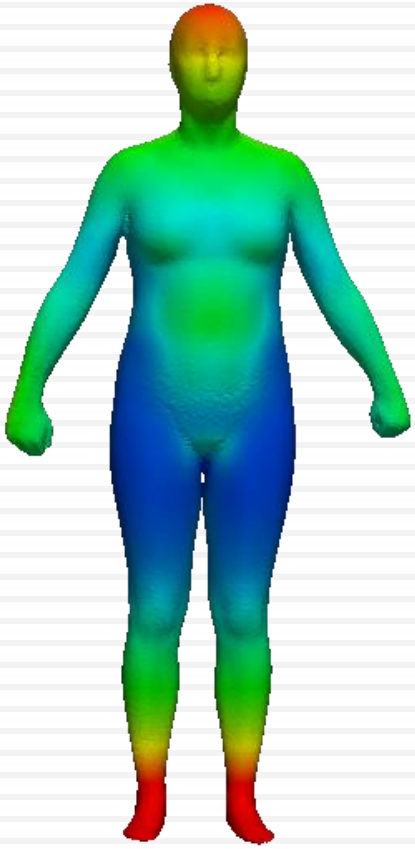
- Capturing shape variability
- Predict a shape based on a simple set of features



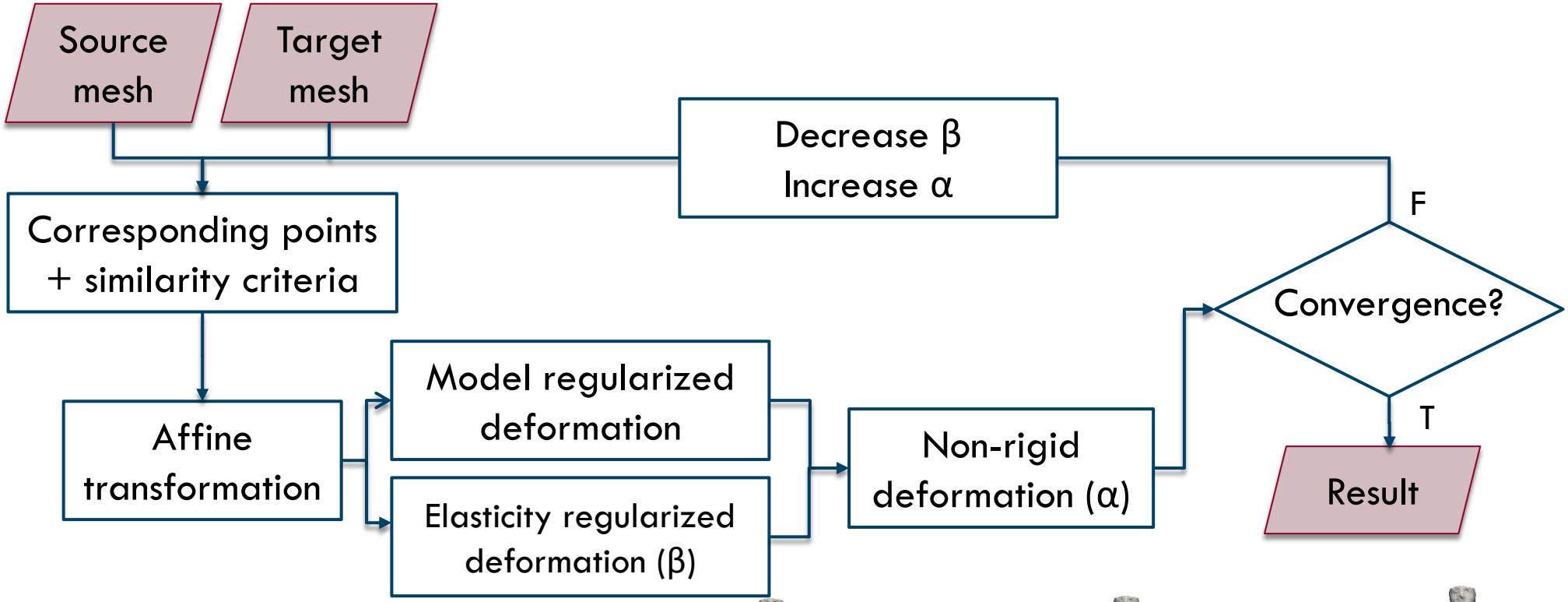
Applications

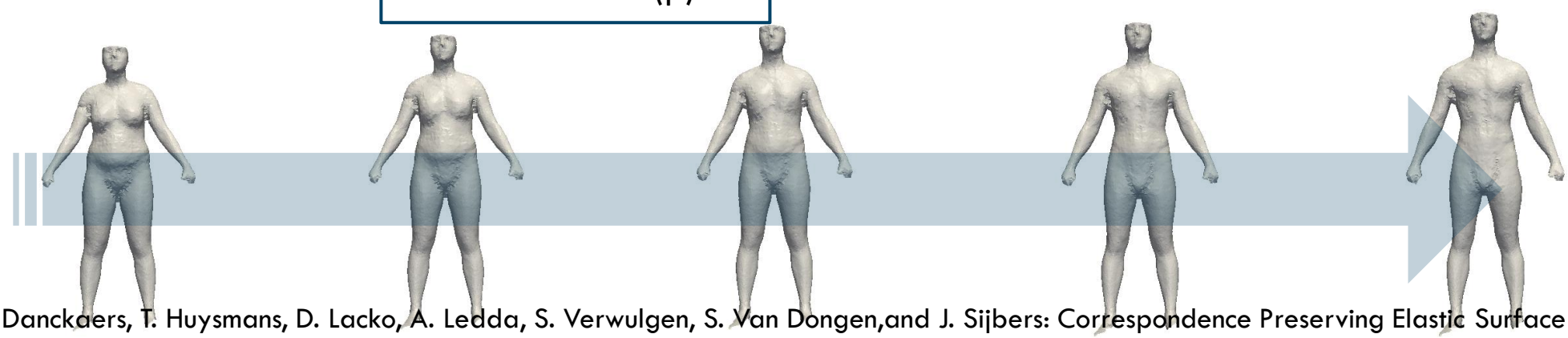
- Early validation of near-body product design, such as chairs, backpacks, clothing,…
  - Virtual validation for wide range of body shapes by linking CAD design on mannequin
  - Improved fit leads to increased comfort
- Development of sizing systems for retail
  - For e.g. furniture
  - Based on body type

Correspondence Preserving Elastic Surface Registration



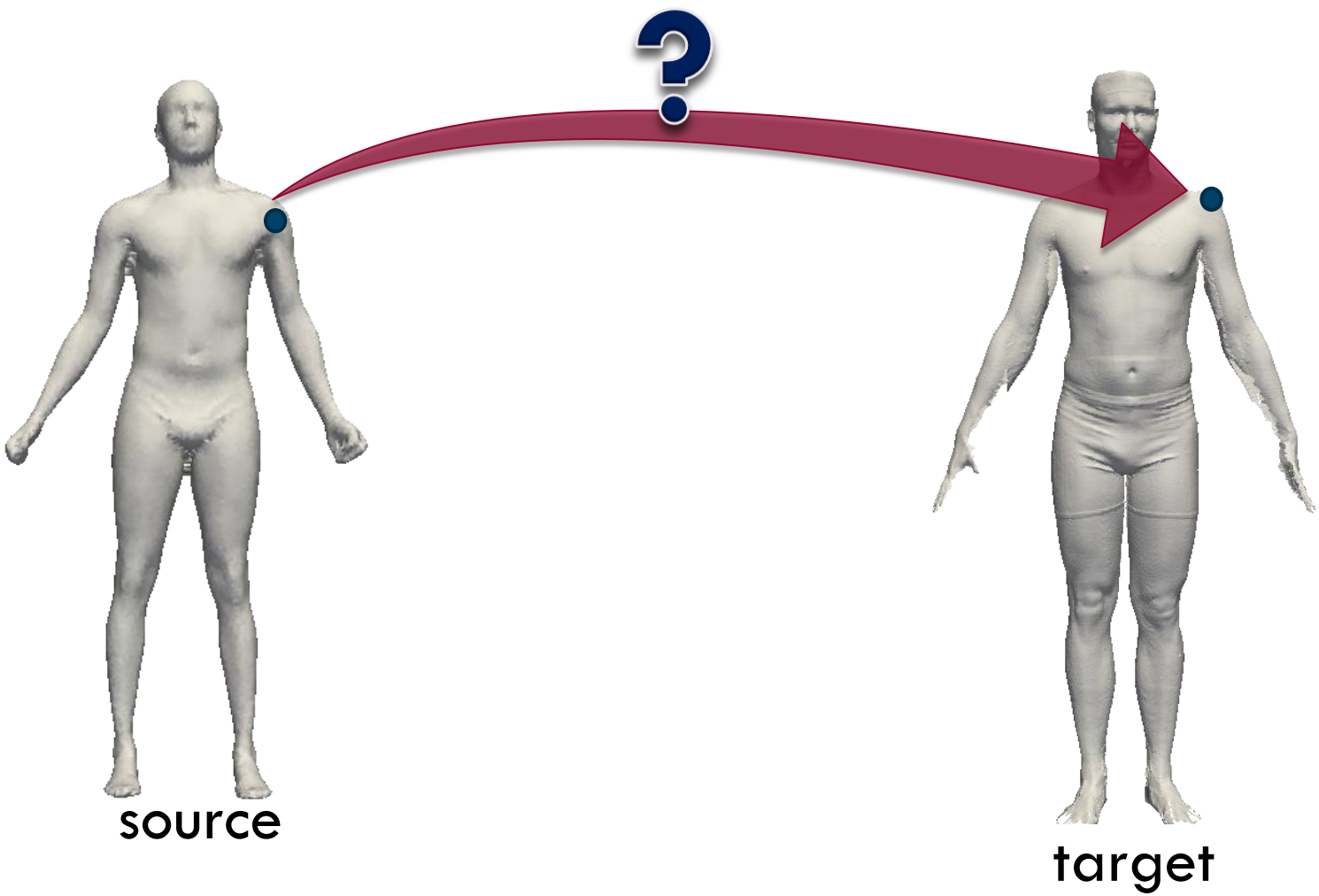
Surface Registration Framework





F. Danckaers, T. Huysmans, D. Lacko, A. Ledda, S. Verwulgen, S. Van Dongen,and J. Sijbers: Correspondence Preserving Elastic Surface Registration with ShapeModel Prior. ICPR 2014.

Find Corresponding Points



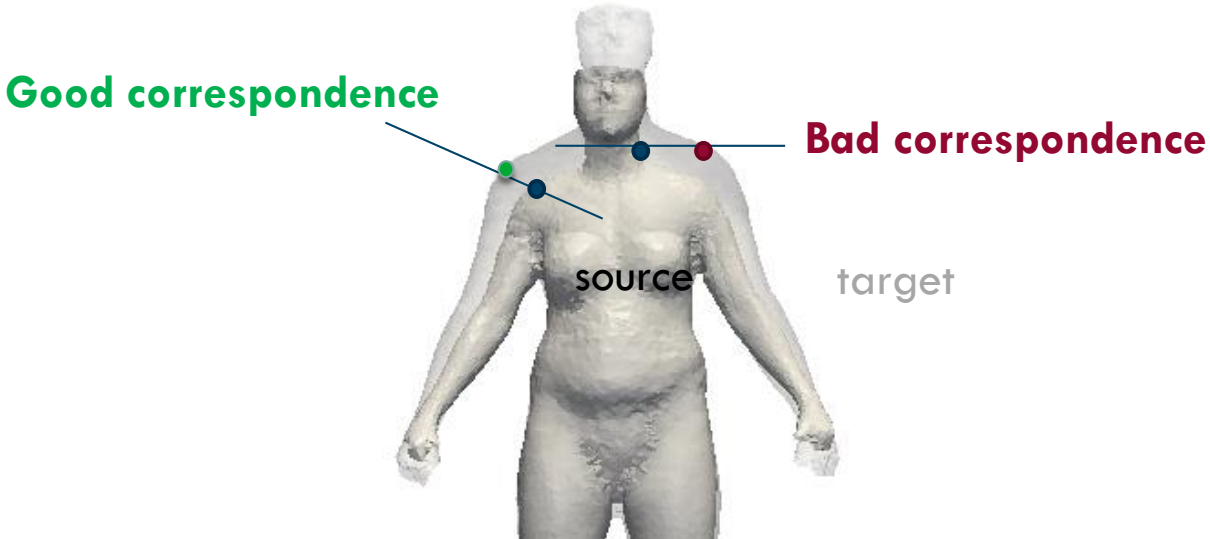
corresponding points

affine alignment

elastic deformation

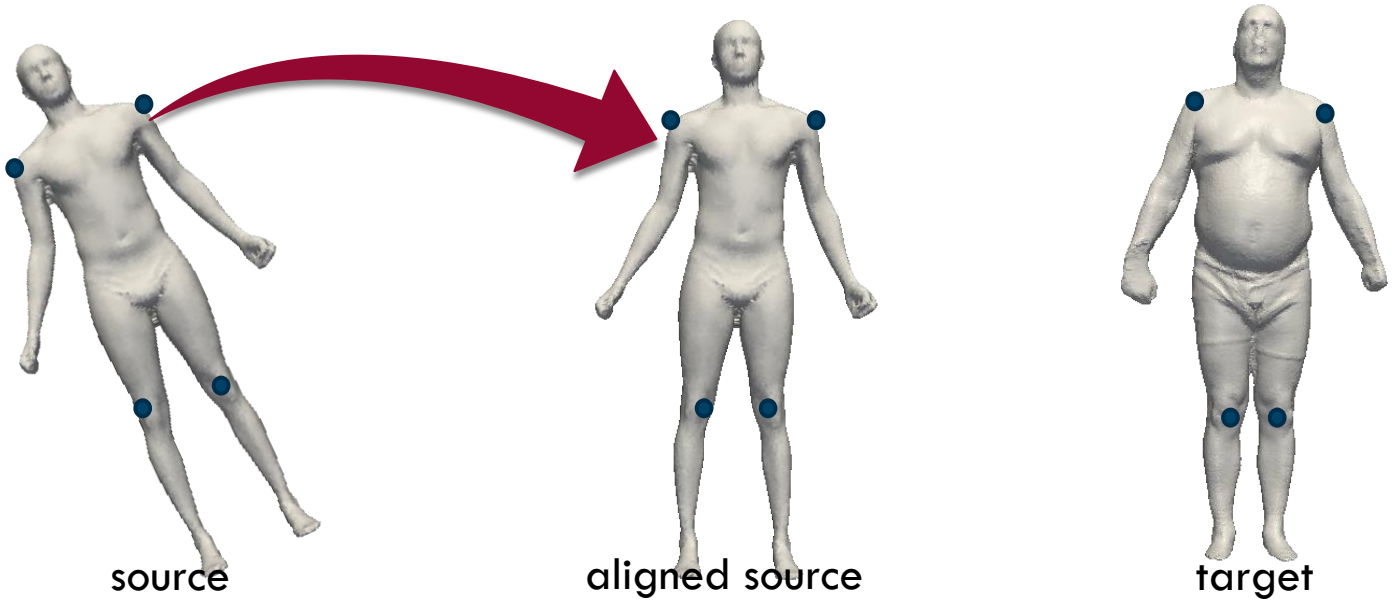
Find Corresponding Points

- Cast a ray in the direction of the normal from source points to target surface
- Constraints
  - Maximum angle between source and target normal
  - maximum distance from source
  - no intersections allowed between source and target



Affine Alignment

- Surface alignment based on corresponding points
  - affine transformation
  - least squares solution



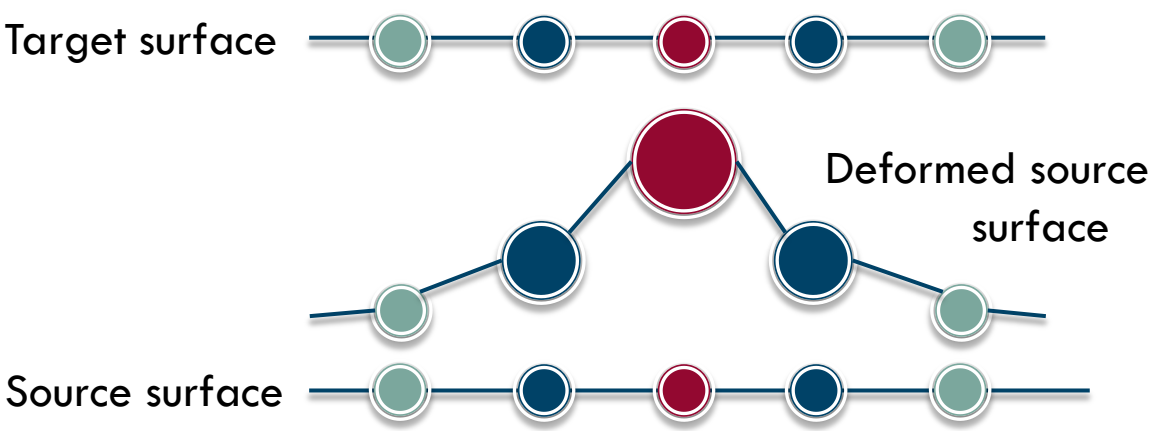
corresponding points

affine alignment

elastic deformation

Elastic Deformation

- displace each vertex separately
  - translation vector per vertex
- stiffness
  - neighboring vertices forced to move along
  - decreases as iterations progress



* B. Amberg, S. Romdhani, T. Vetter. Optimal Step Nonrigid ICP Algorithms for Surface Registration. In Proc. Conf. Computer Vision and Pattern Recognition, 2007.

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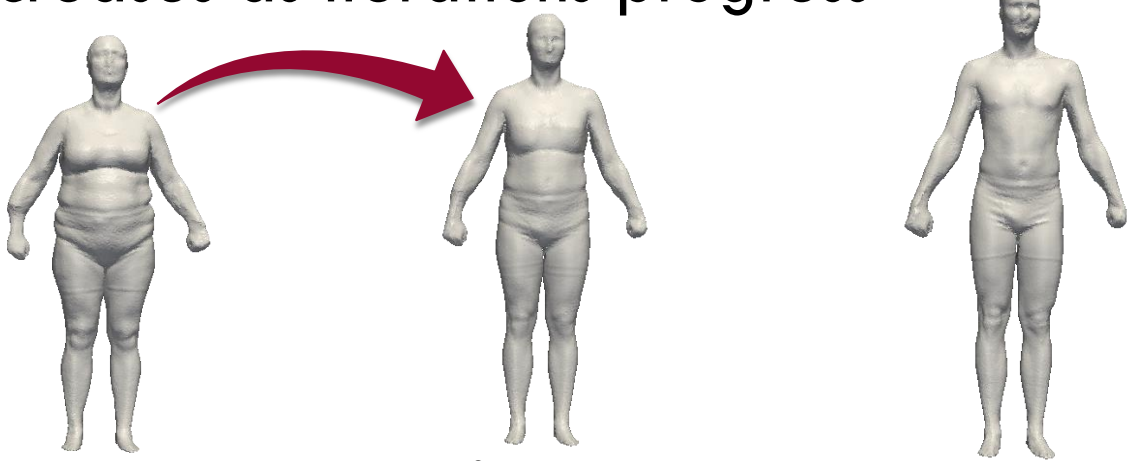


source deformed source target

corresponding points

affine alignment

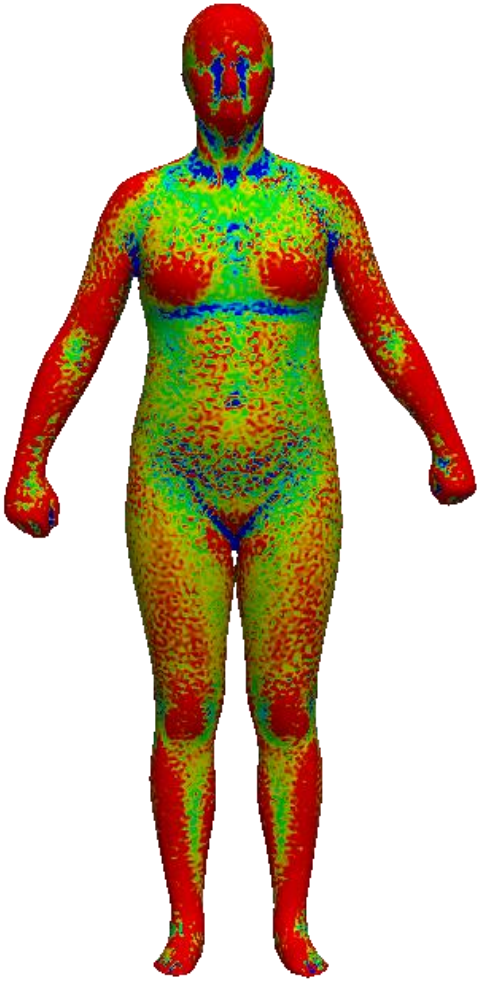
elastic deformation

* B. Amberg, S. Romdhani, T. Vetter. Optimal Step Nonrigid ICP Algorithms for Surface Registration. In Proc. Conf. Computer Vision and Pattern Recognition, 2007.

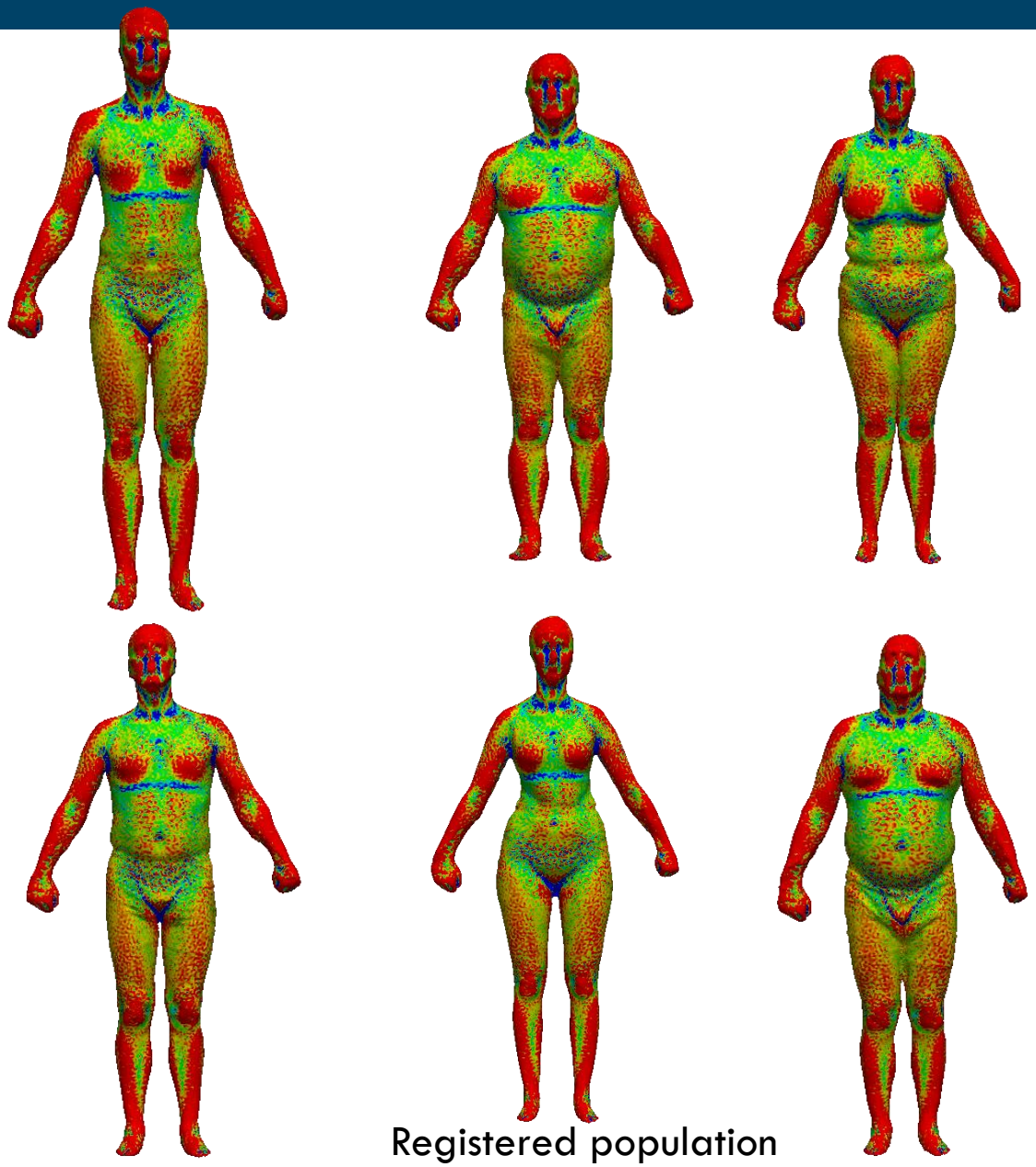
Surface Registration Framework

- affine alignment **r** + elastic deformation **e**
  - surface at iteration i:
    $$\boldsymbol{s}_i = (\alpha - 1)\mathbf{r}(\boldsymbol{s}_{i-1}) + \alpha\mathbf{e}(\boldsymbol{s}_{i-1}, \beta)$$
  - stiffness factor β to control elasticity
  - influence of elastic deformation α
- no surface parameterization involved
  - applicable to complex topologies
  - not sensitive to topological noise

Correspondences

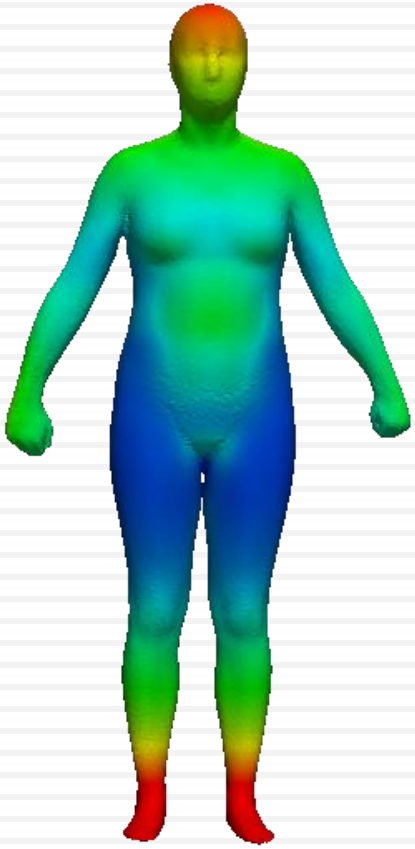


Average surface



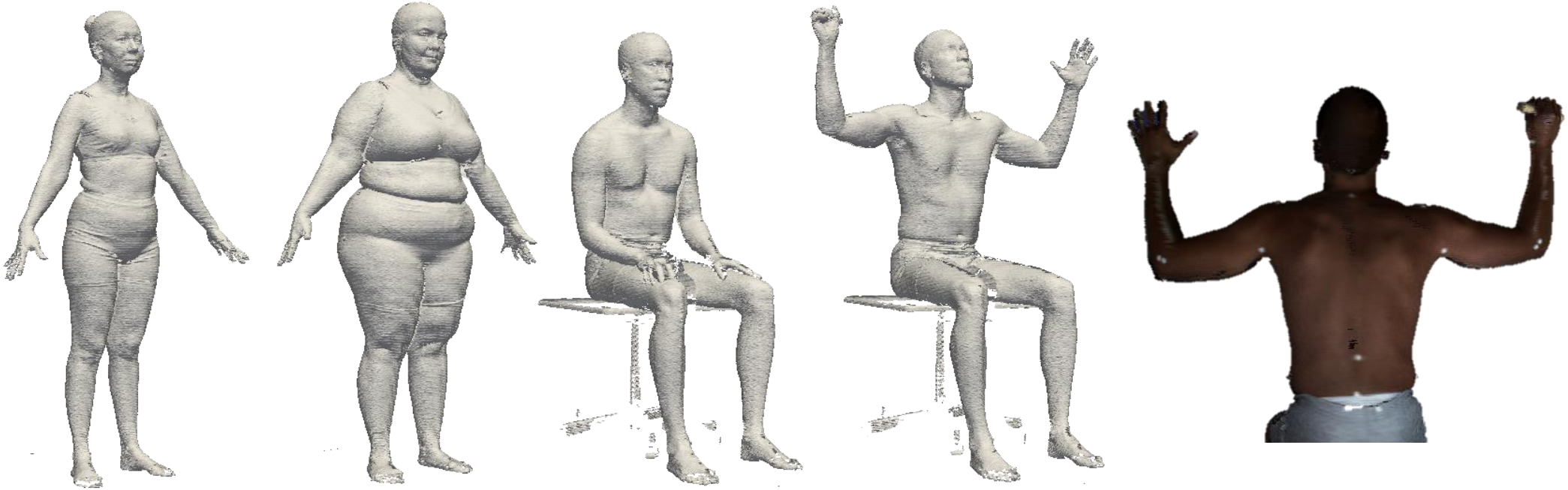
Registered population

Building a Shape Model

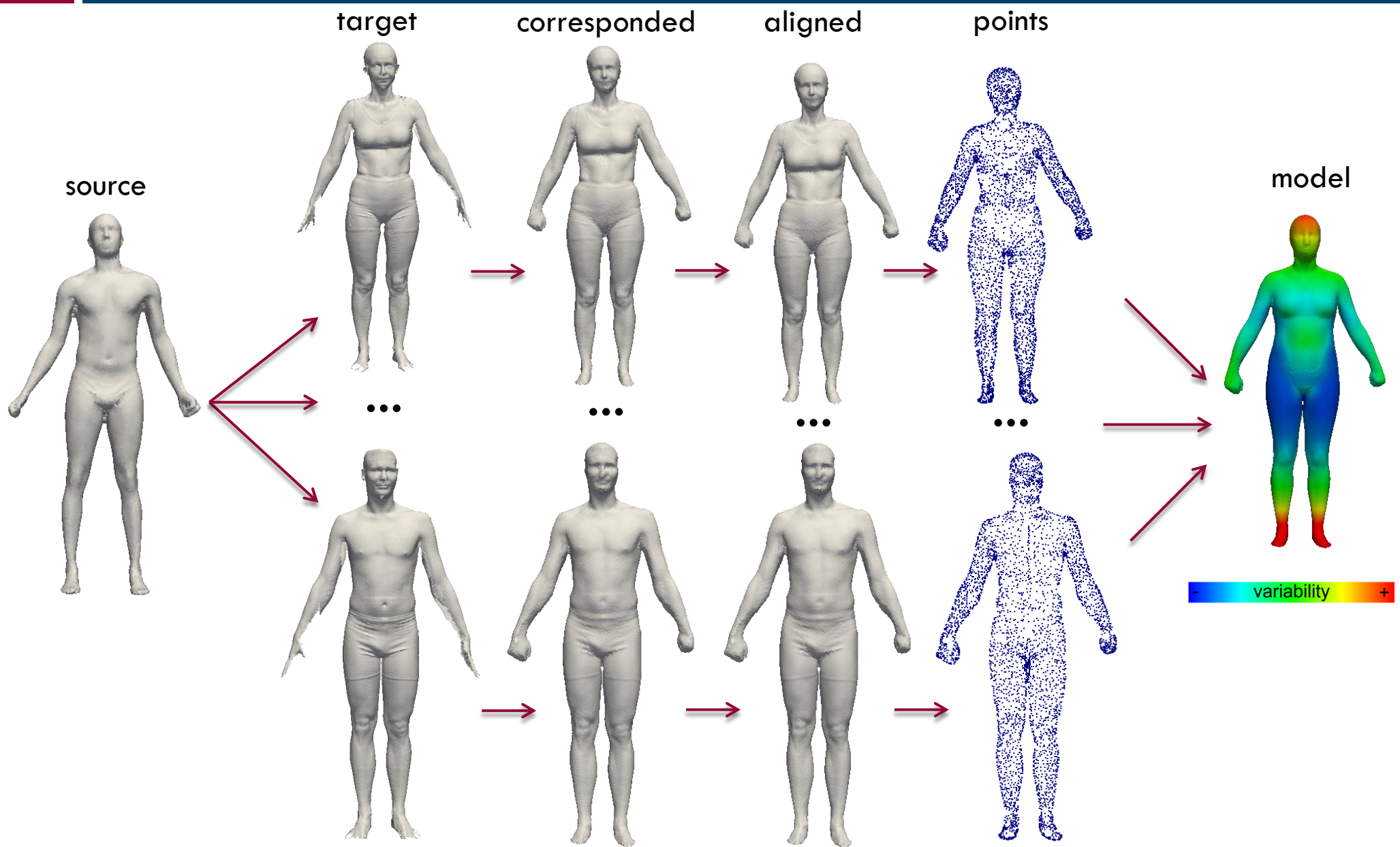


Data

- CAESAR database
  - Standing and seated pose
  - Antropometrical measures + meta-data
  - Markers (annotated + 3D coordinates)
  - In our current model: 147 men and 265 women

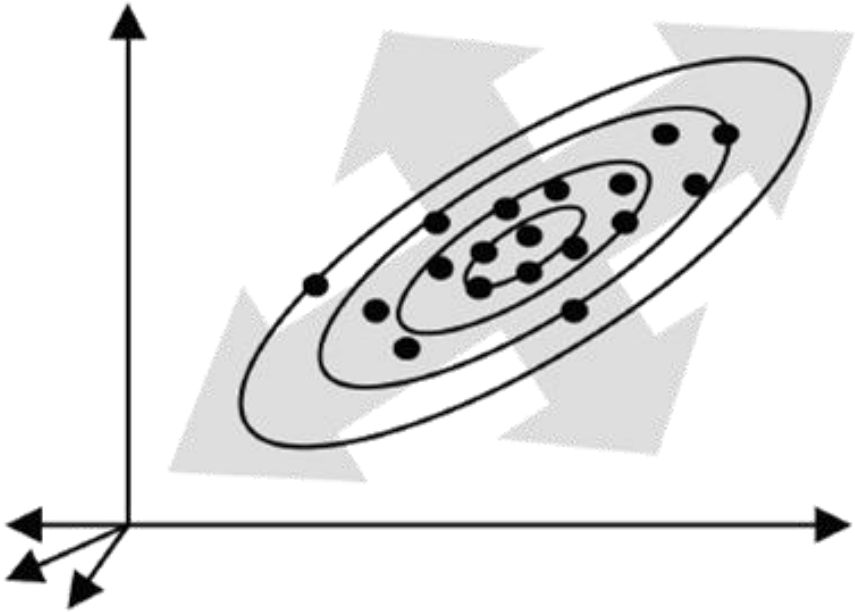


Population Correspondence



Population Correspondence

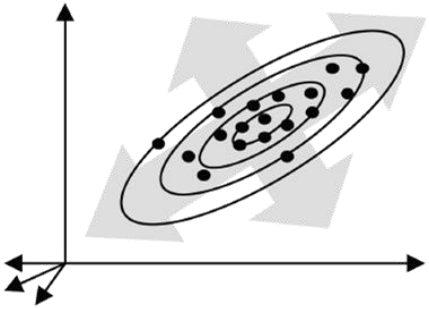
- statistical shape model
  - mean surface $\bar{\boldsymbol{X}}$
  - modes of variation
  - Instance $\boldsymbol{Y} = \bar{\boldsymbol{X}} + \boldsymbol{\Phi b}$
    - Eigenvector matrix: $\boldsymbol{\Phi}$
    - Parameters of instance: $\boldsymbol{b}$

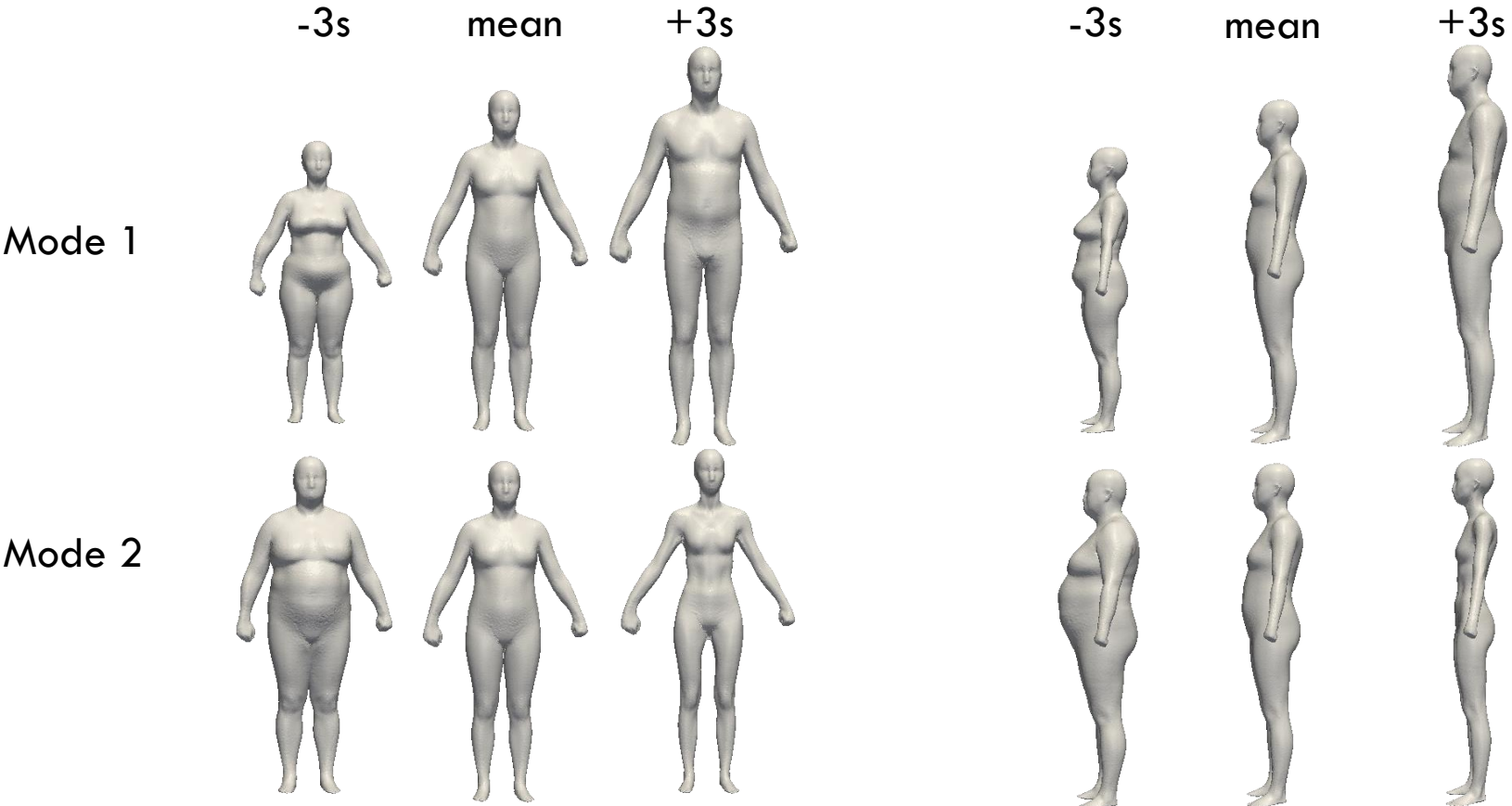


- model parameters
  - size and shape
  - position normalization via Procrustes alignment
    - iterative affine alignment to population mean

Shape Modes all subjects

- Principal Component Analysis





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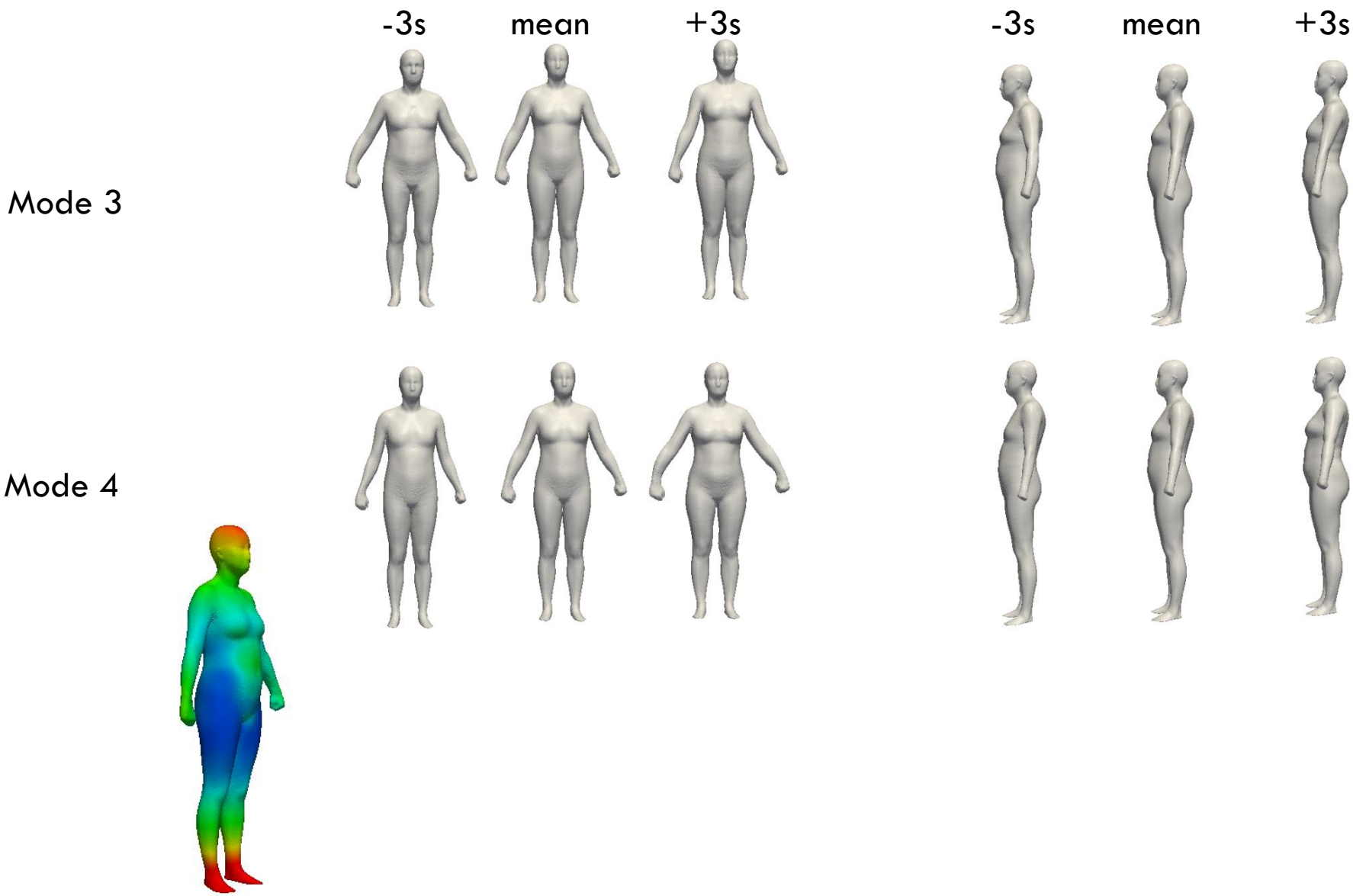
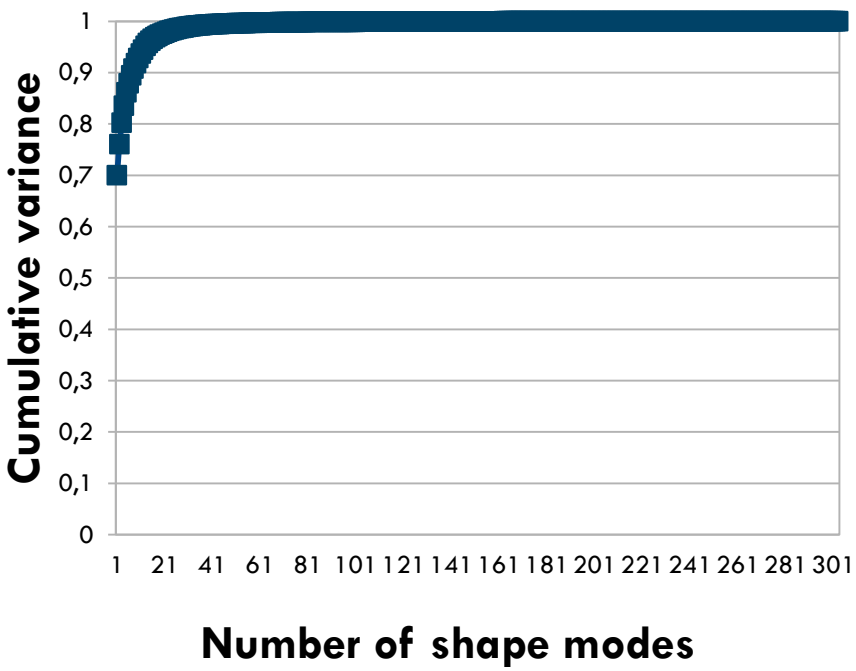
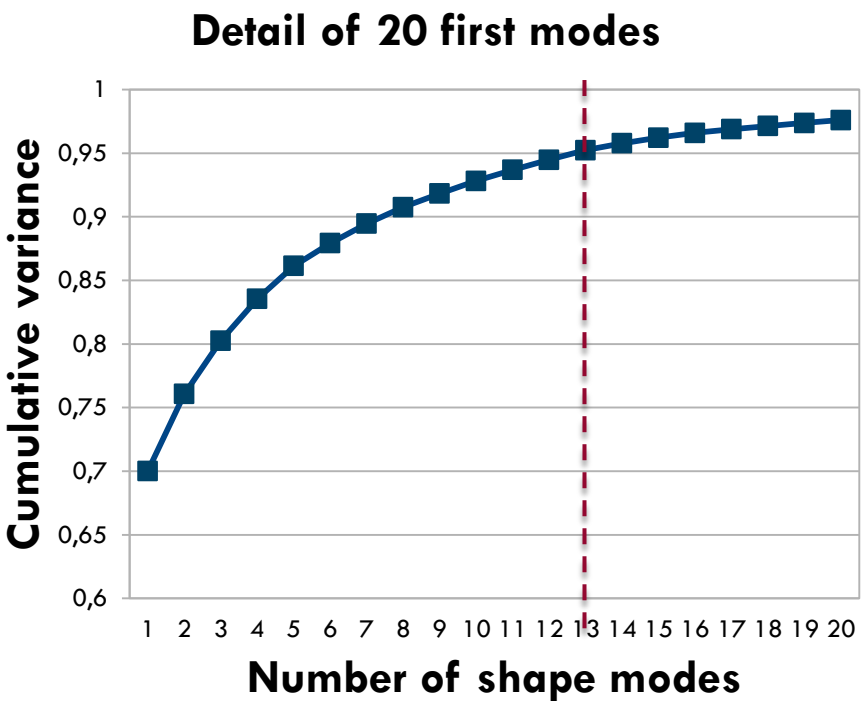


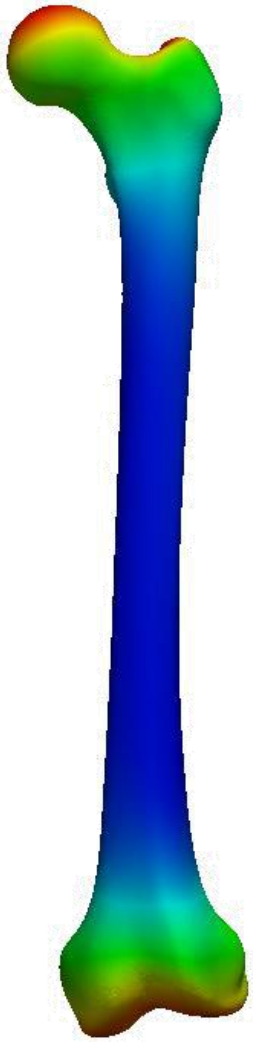
Model Performance - compactness

- The compactness of the model measured by the cummulative variance



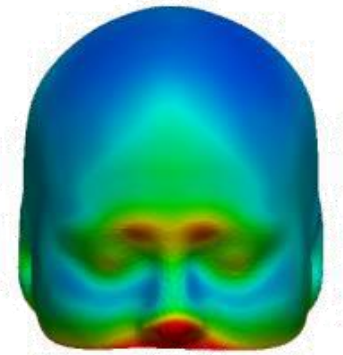


Other Shape Models

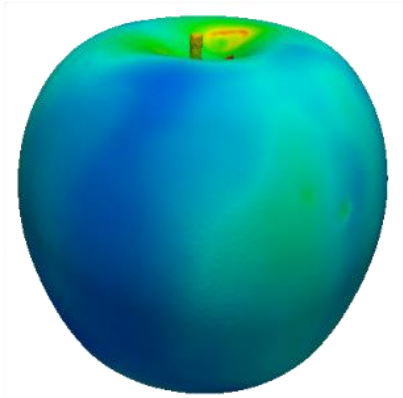


LAZER HELMETS

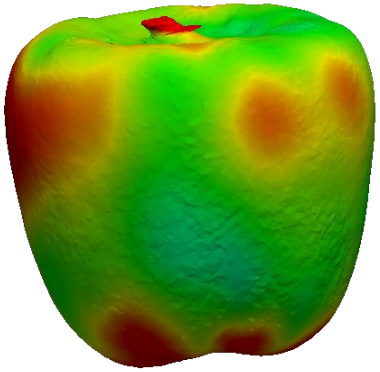
pinkoliv



PHILIPS

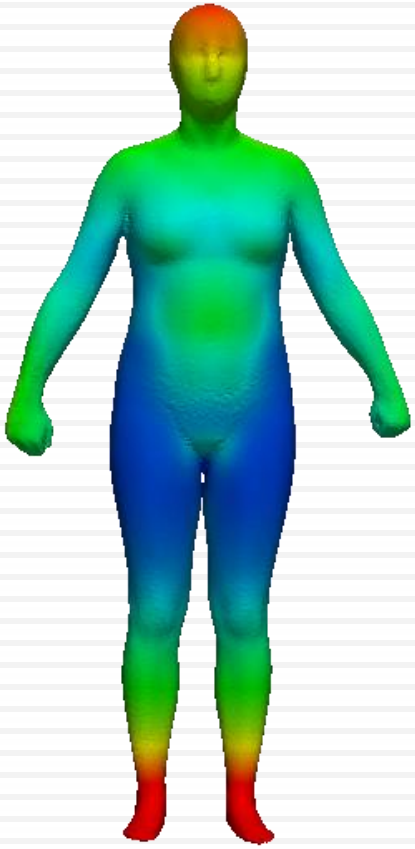


KU LEUVEN TomFood



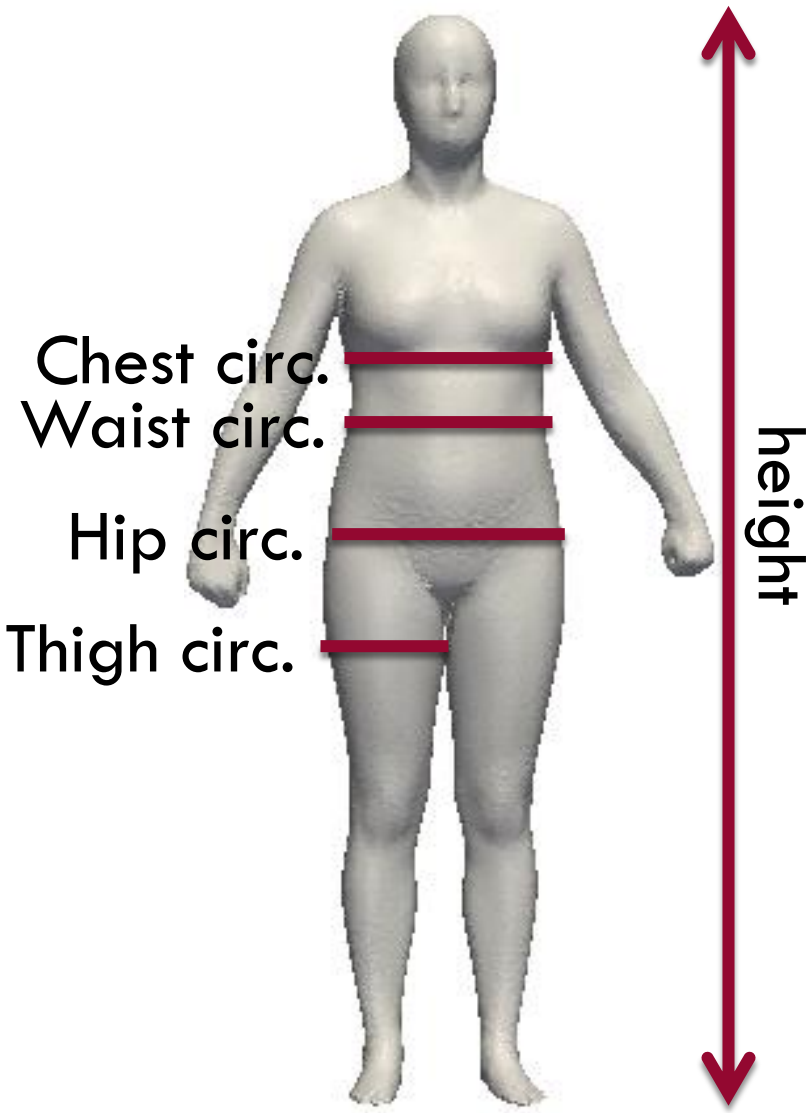
Materialise UZA acumed DePuy a Johnson & Johnson company

Shape Prediction from Features



Input feature parameters

- Gender
- Height
- Weight
- Age
- Waist circumference
- Chest circumference
- Hip circumference
- Thigh circumference
- Other interesting features?

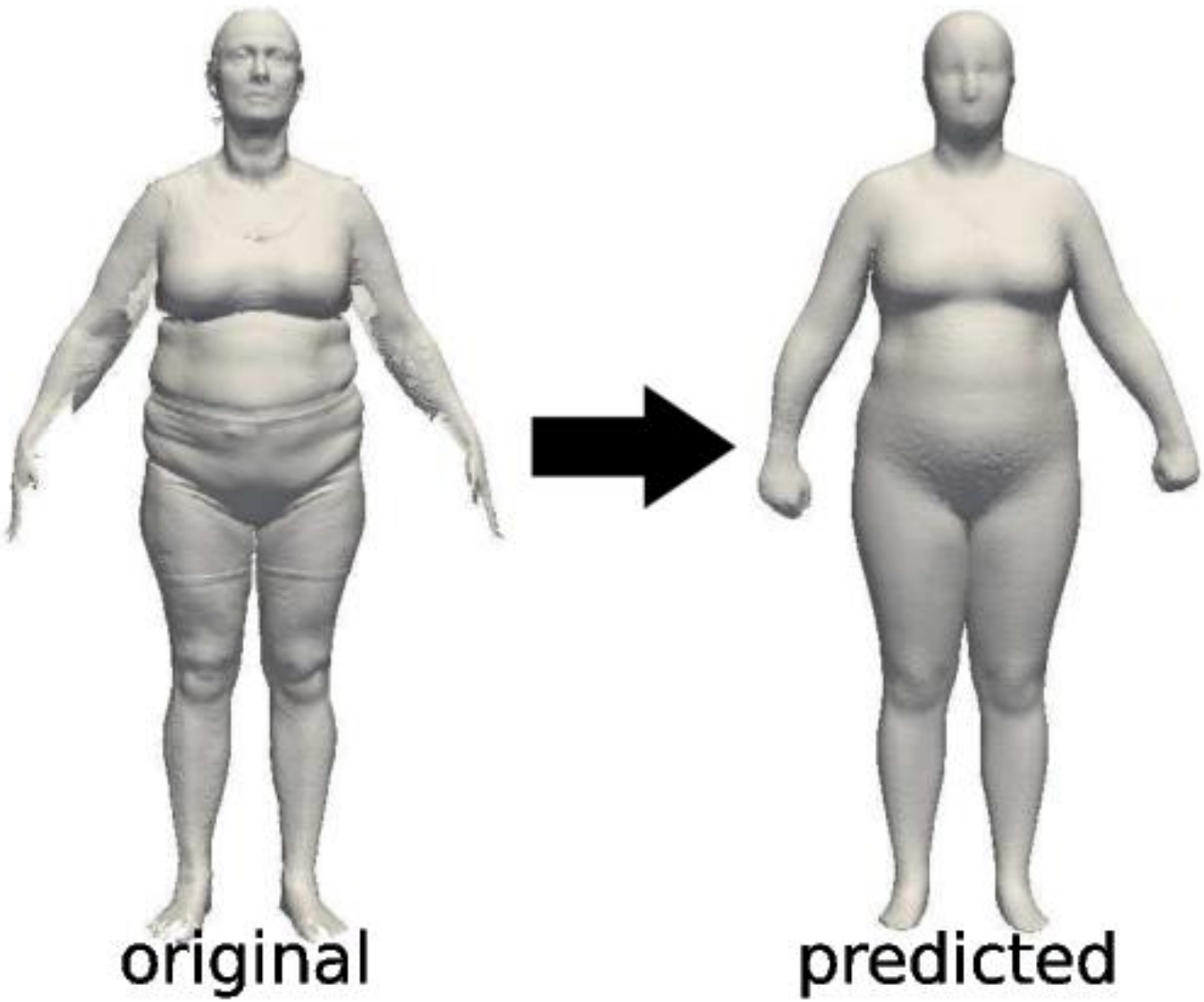


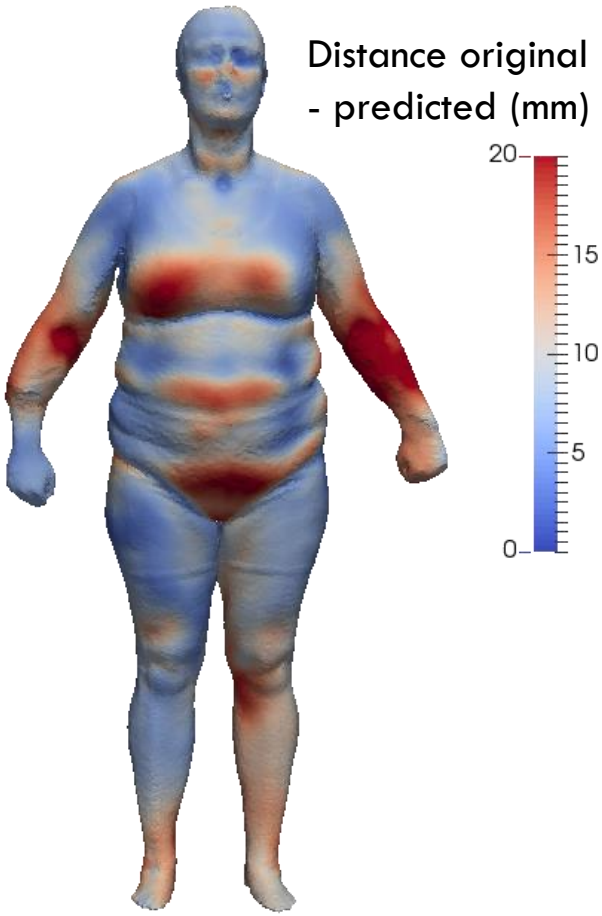
Predict Shape from Features

- Build mapping matrix $\boldsymbol{M}$
  - $\boldsymbol{M} = \boldsymbol{B}\boldsymbol{F}^{+}$, with $\boldsymbol{B}$ the PC weights of each surface and $\boldsymbol{F}$ the feature matrix of each surface from the population
- Calculate new weights
  - $\boldsymbol{b} = \boldsymbol{M}\boldsymbol{f}$, with $\boldsymbol{b}$ the individual PC weights and $\boldsymbol{f}$ the desired feature vector
- Calculate new surface $\boldsymbol{x}'$
  - $\boldsymbol{x}' = \overline{\boldsymbol{x}} + (\boldsymbol{P} \cdot \boldsymbol{b})$, with $\overline{\boldsymbol{x}}$ the mean surface and $\boldsymbol{P}$ the PC vectors

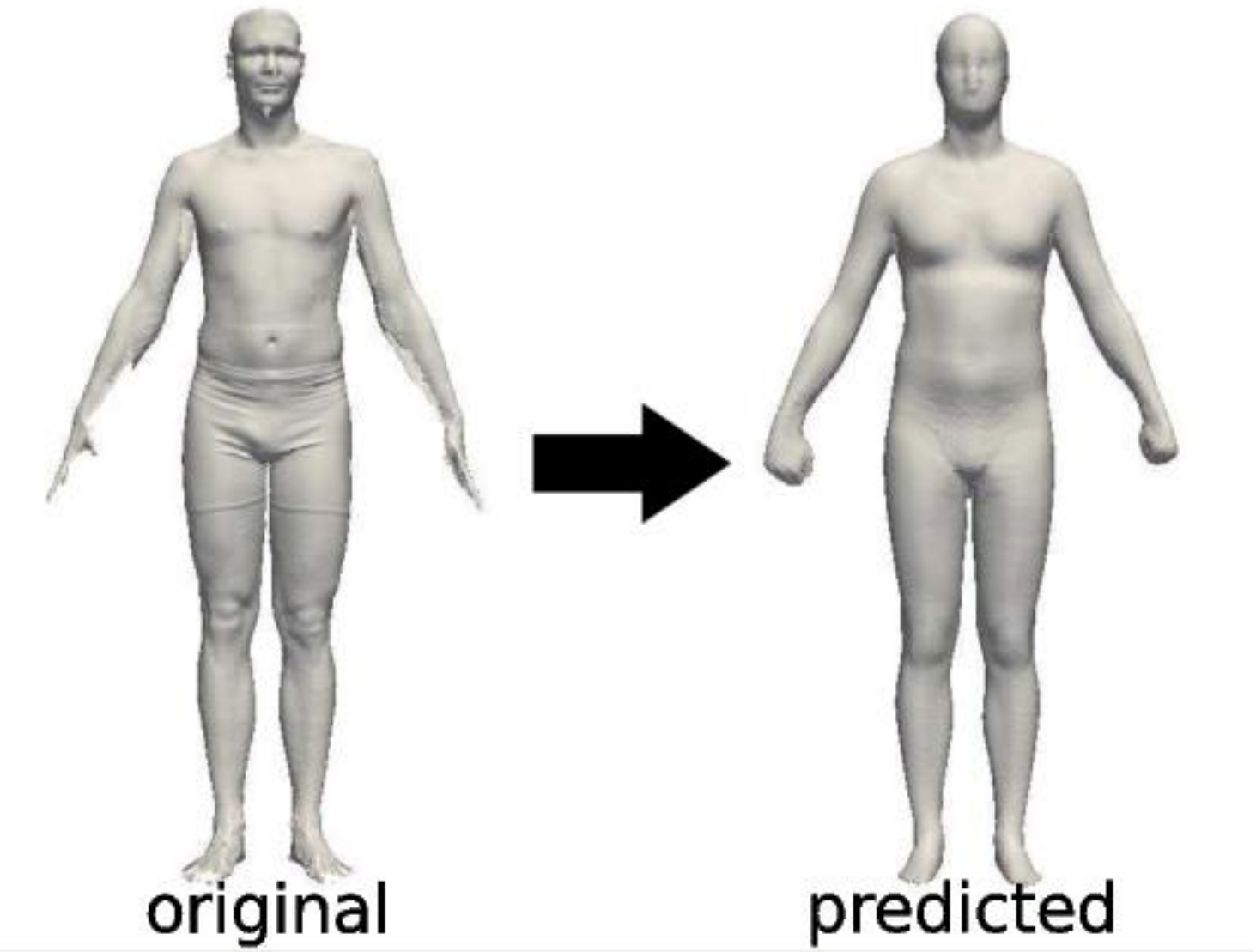
Allen, B., Curless, B., Popovic, Z., The Space of Human Body Shapes: Reconstruction and Parameterization from Range Scans. ACM SIGGRAPH, 2003, pp,1-8

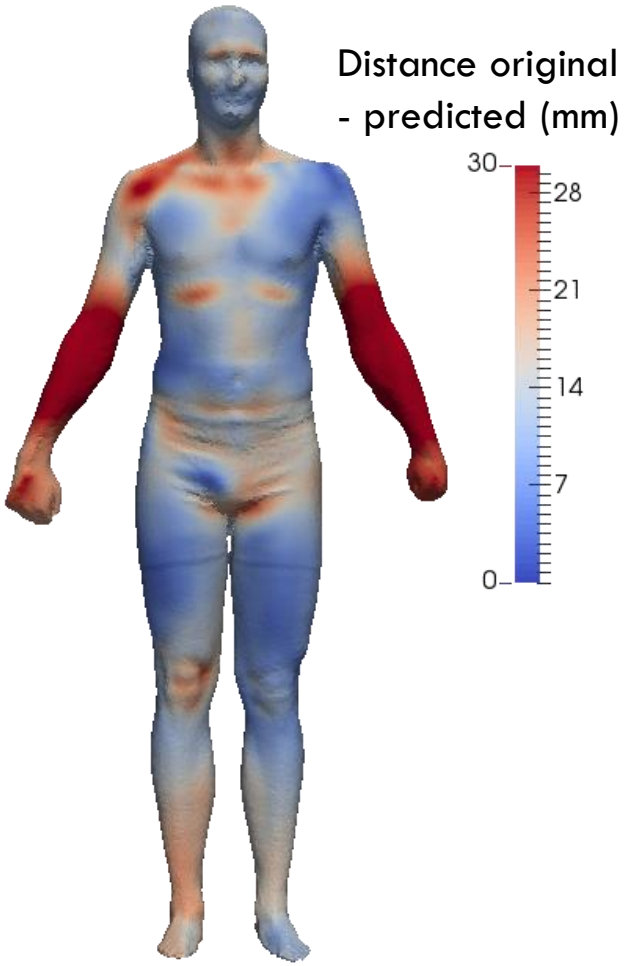
Predicted shape from features



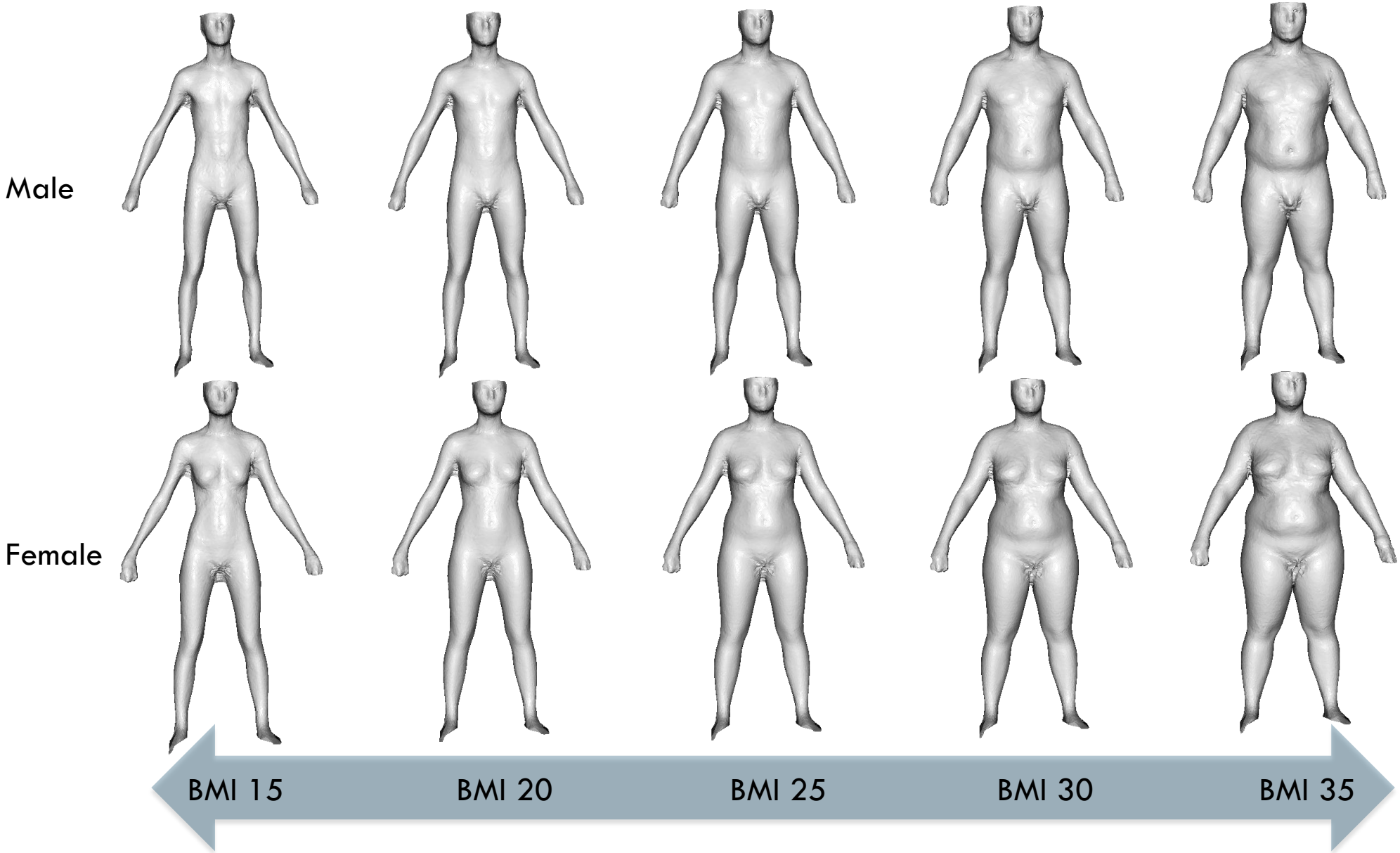


Predicted shape from features

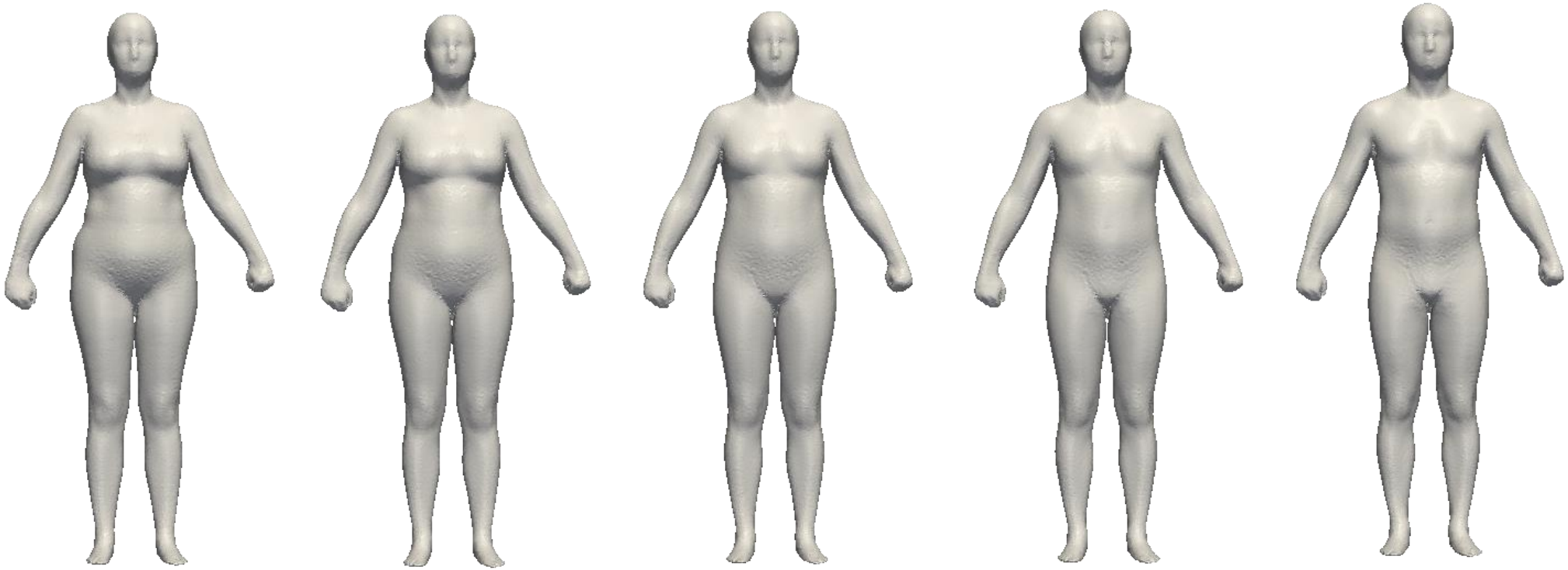




BMI Variation

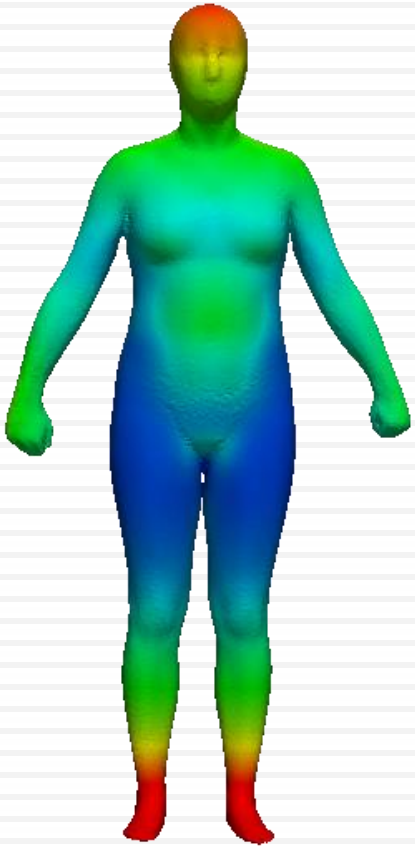


Gender Variation



female average male

Conclusion and Next Steps



Conclusions

- Surface registration leads to accurate correspondences
- Statistical shape model can be used to describe the population
- New shapes can be generated from a given set of features

Next Steps

- More complex modeling of feature modification
  - E.g. Via subpopulations or non-linear models
- Shape clustering
  - Distinguish different body types
- Pose normalization
  - More accurate shape clusters
  - More accuracy on feature influence
  - Deducing asymmetry