

Selective Feature Preserved Elastic Surface Registration In Complex Geometric Morphology

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Department Of Mechanical and Aeronautical Engineering

Acknowledgements and Thanks

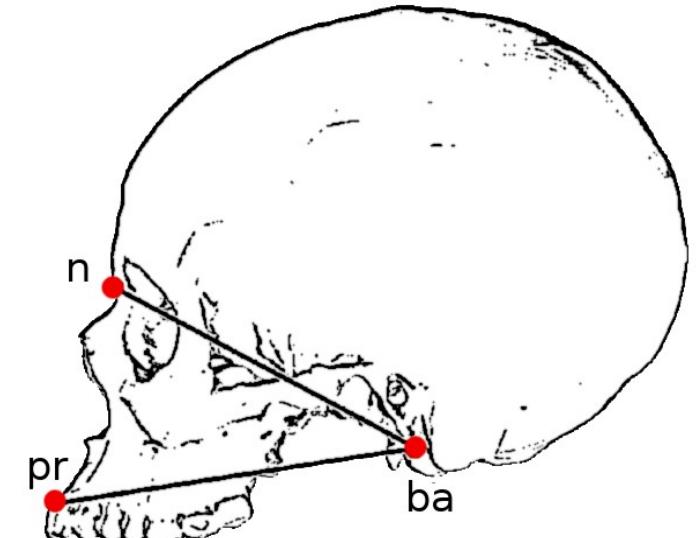
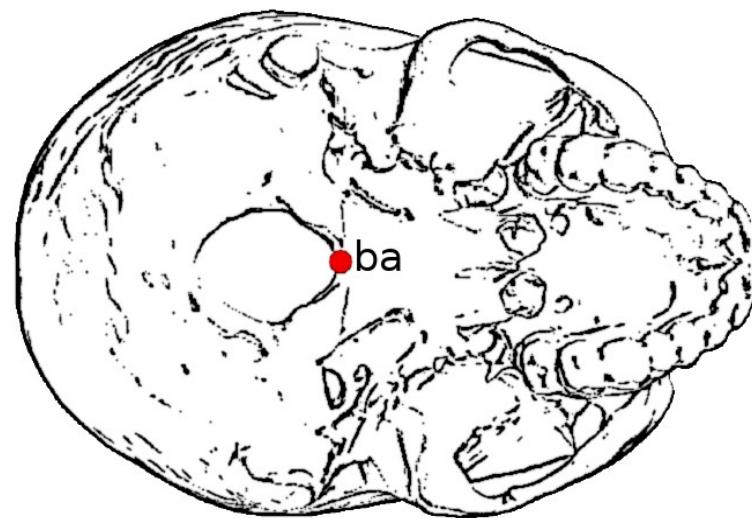
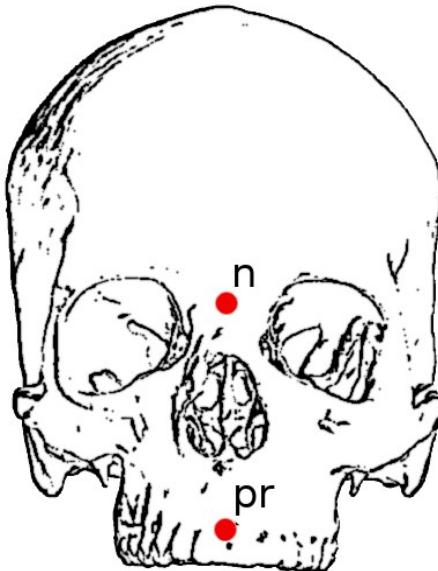
- Supervisors
 - Dr. S. Kok, Dr. D.N. Wilke
- CSIR
 - MDS Advanced Mathematical Modelling
- University of Pretoria, Dept. of Anatomy
 - Prof. M. Steyn and M.L. MacKay

Presentation Layout



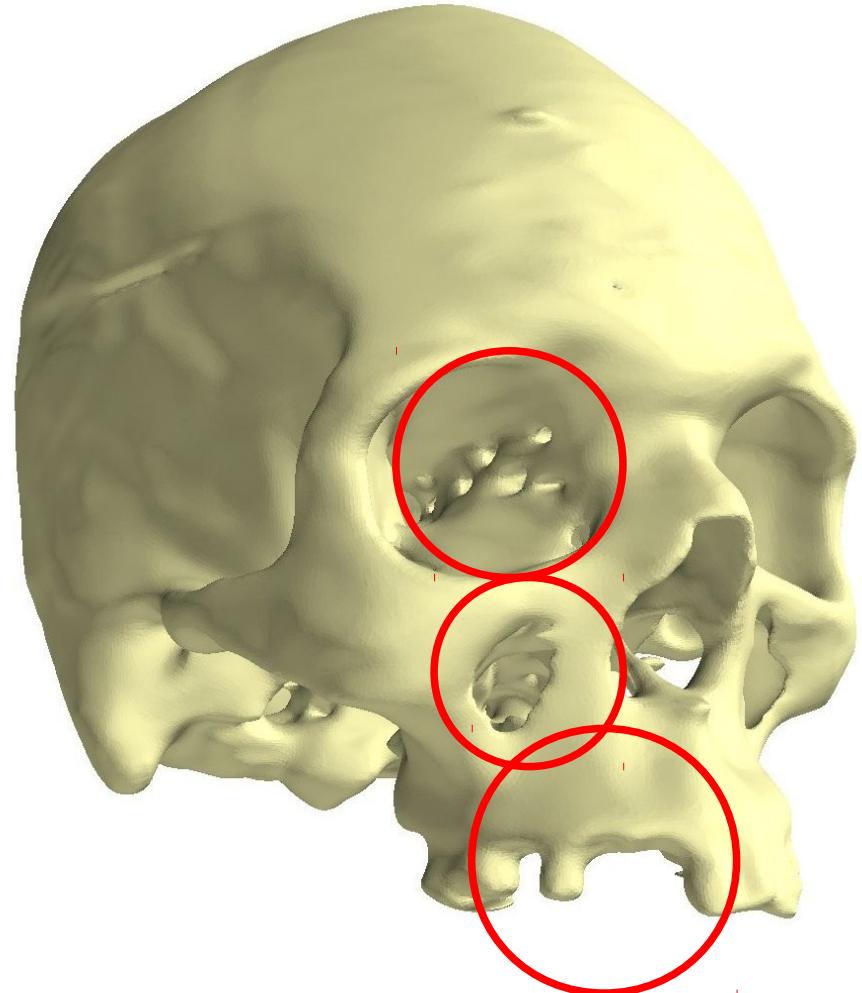
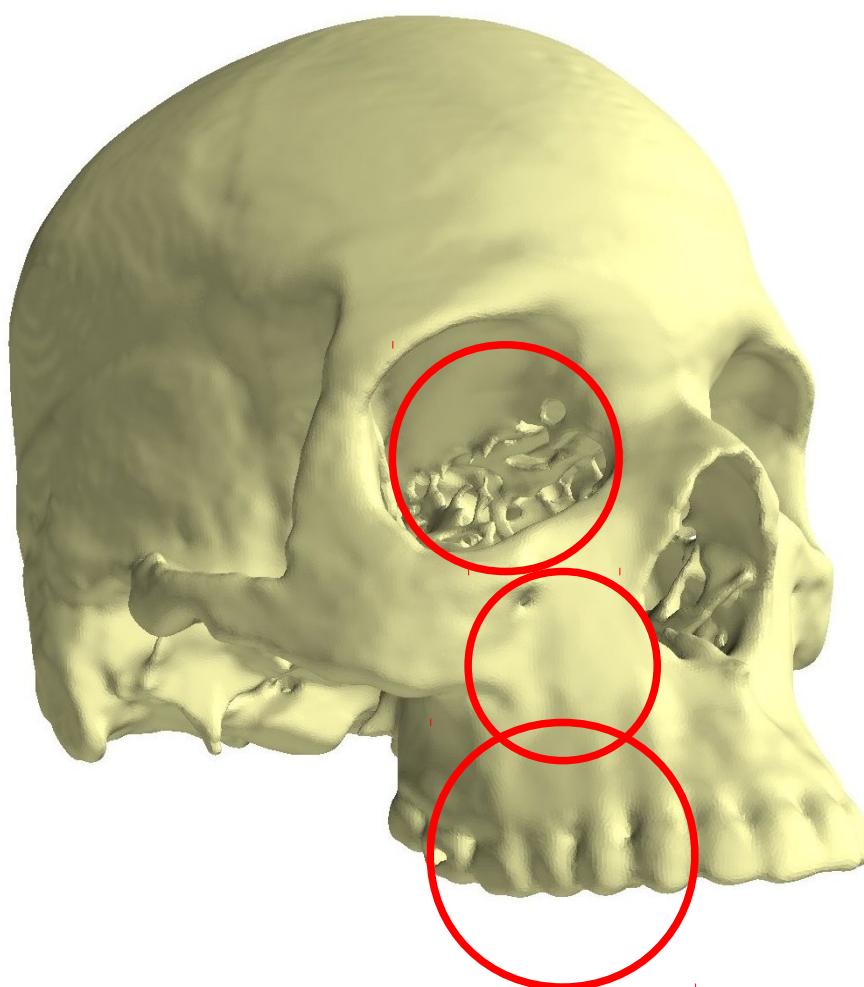
- Prognathism and stress
- Problems in comparing stress in reconstructed geometries
- Elastic Registration
 - Feature Registration
 - Topological differences
- FEA

Background and Motivation



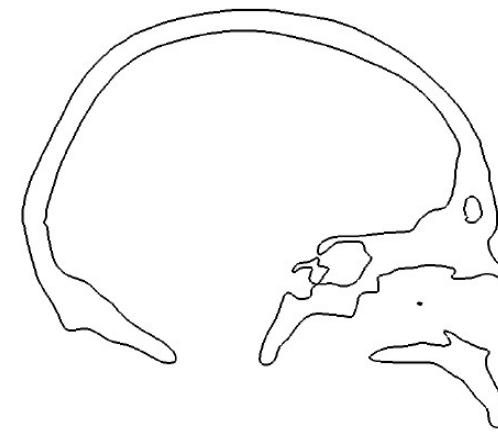
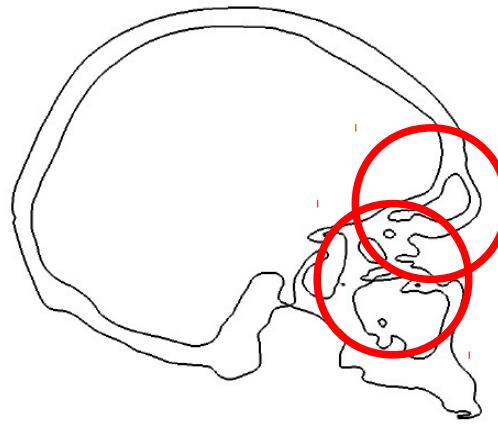
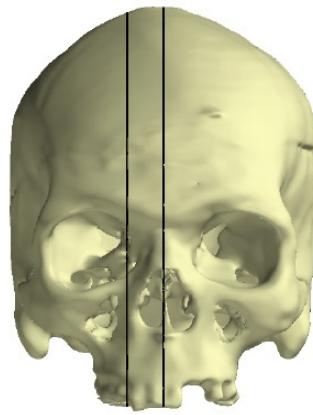
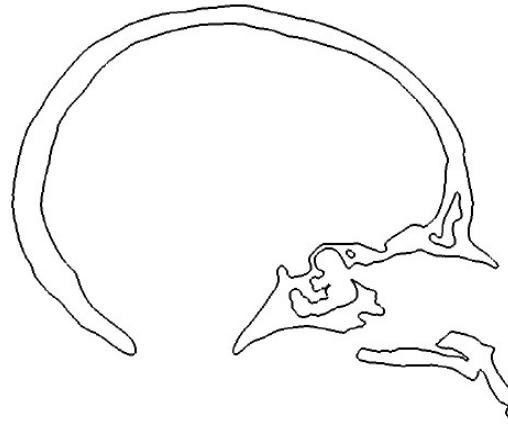
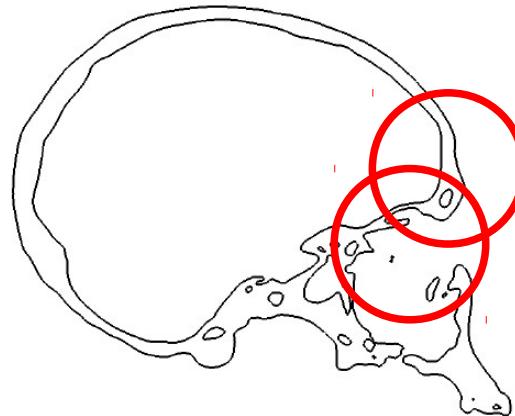
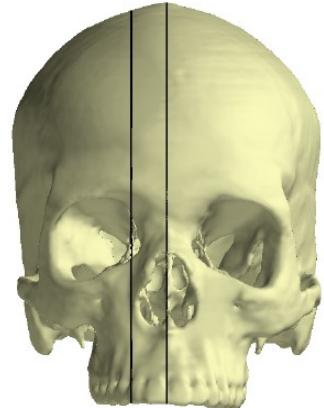
What is prognathism?

Background and Motivation



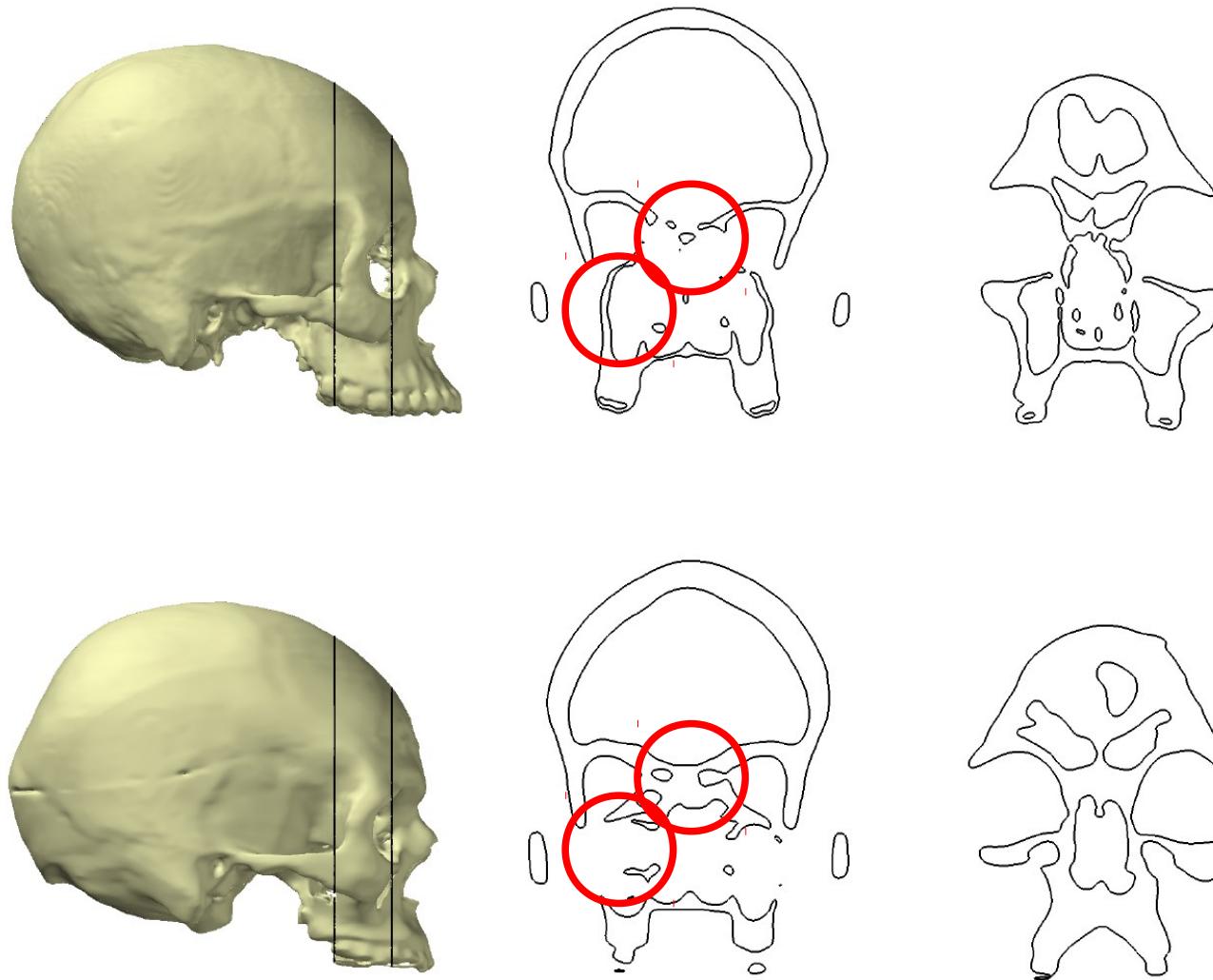
Comparing skulls. Varying topology due to dentition, decay and sinus

Background and Motivation



Comparing skulls. Varying topology due to dentition, decay and sinus

Background and Motivation



Comparing skulls. Varying topology due to dentition, decay and sinus

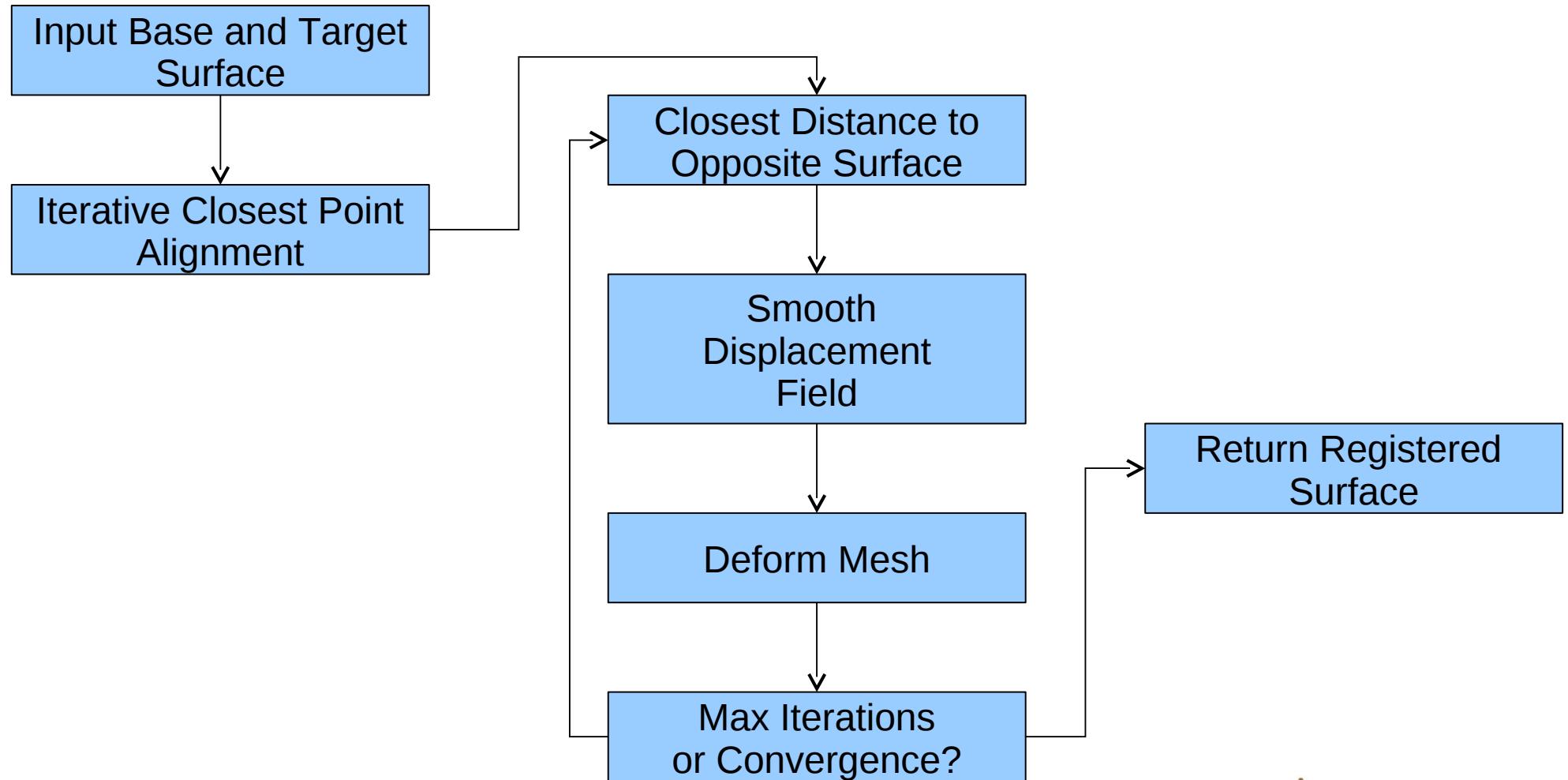
Elastic Surface Registration



- Updating nodal coordinates only
- Consistent topology
- Recent paper - statistical FEA on femur*
- Modifications

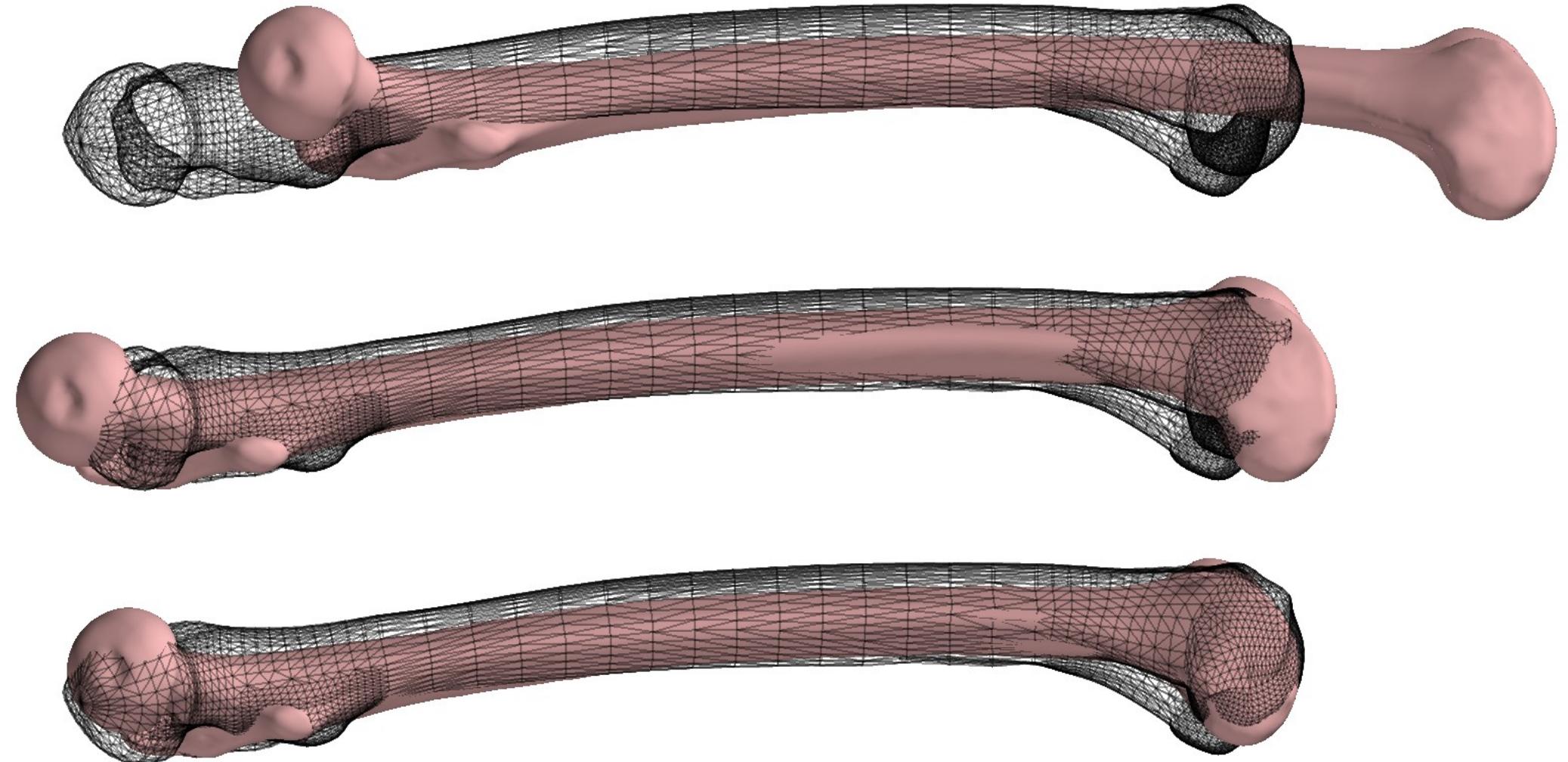
* R. Bryan, P.S. Mohan, A. Hopkins, F. Galloway, M. Taylor, and P.N. Nair,
Statistical modelling of the whole human femur incorporating
geometric and material properties. *Mechanical Engineering and Physics*, 32:5765,2010.

Elastic Surface Registration



Registration procedure flow diagram

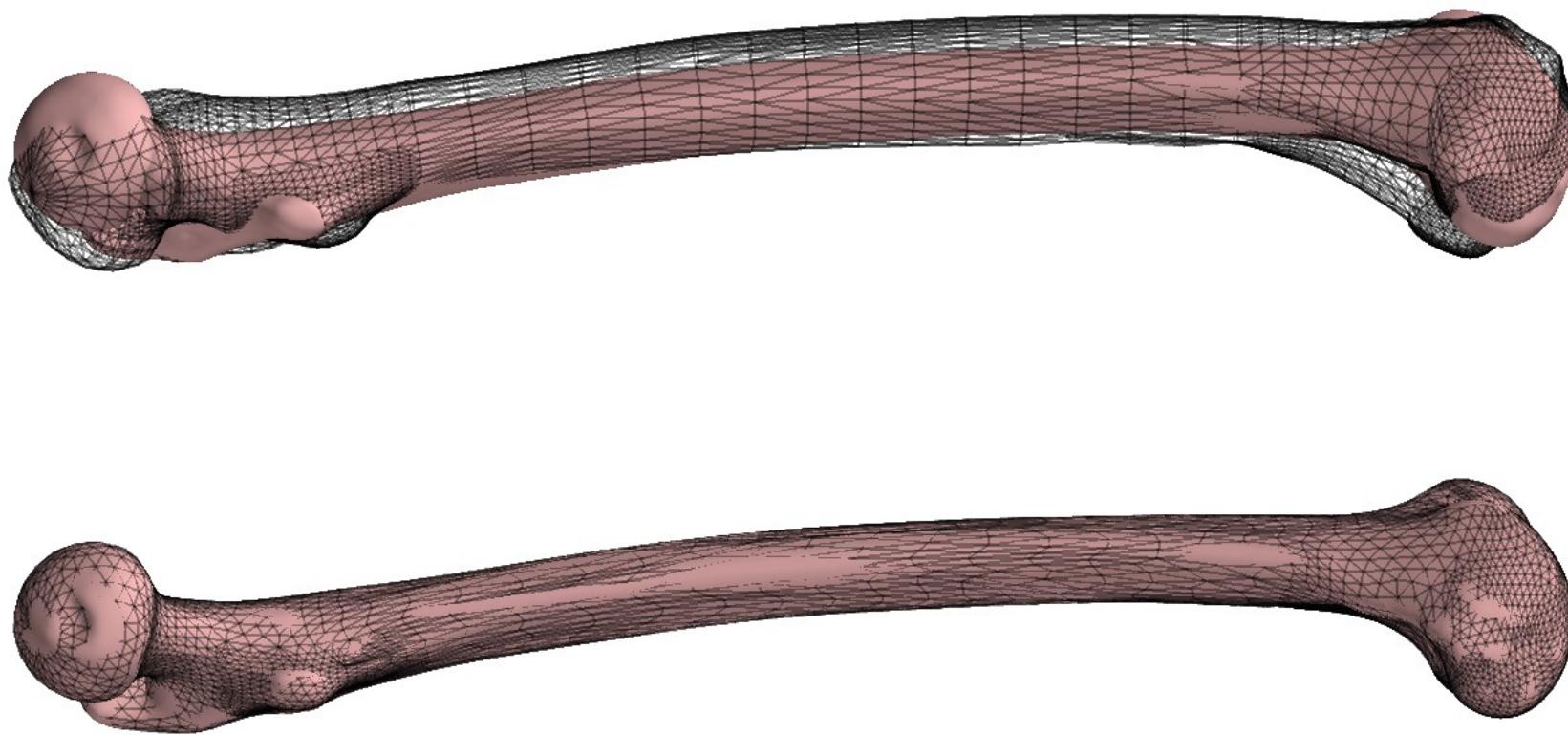
Elastic Surface Registration



* INRIA shape repository, www-roc.inria.fr/gamma/download/

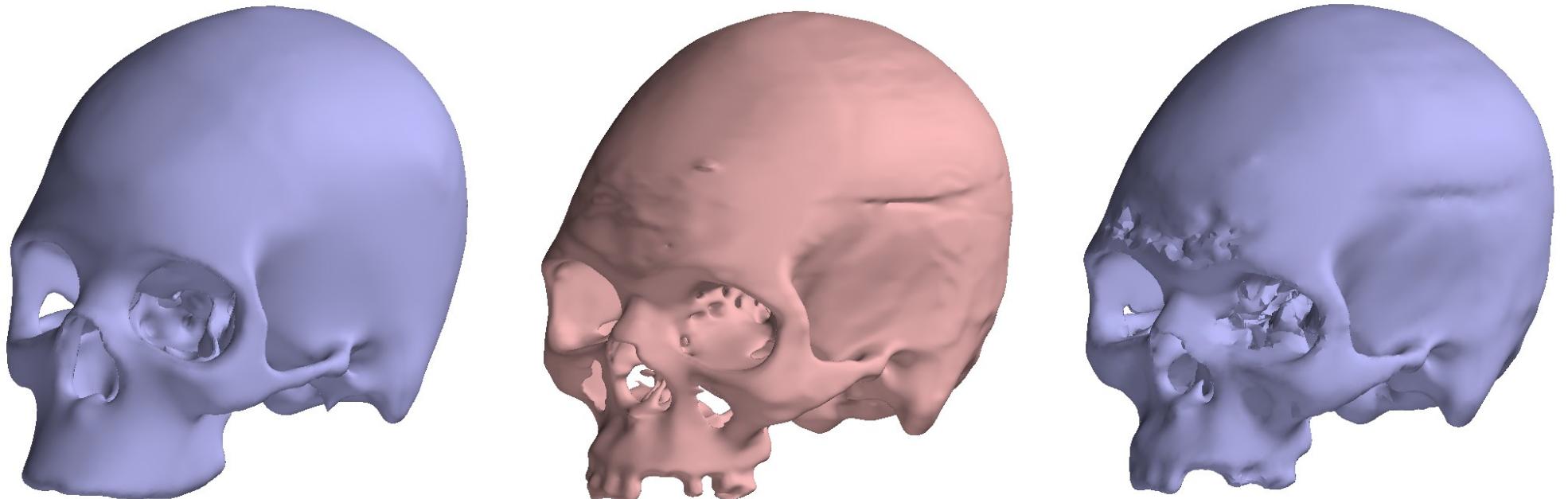
Test case: Registration on a femur geometry

Elastic Surface Registration



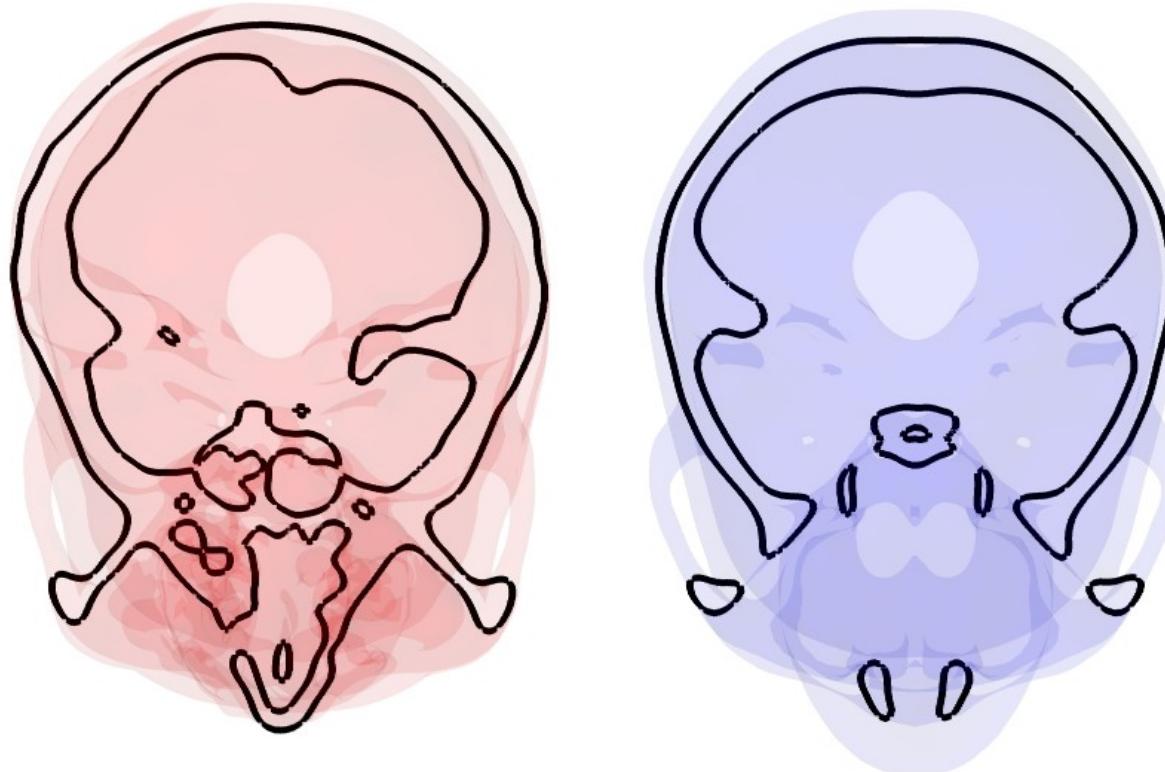
Test case: Registration on a femur geometry

Generic and Target Shape



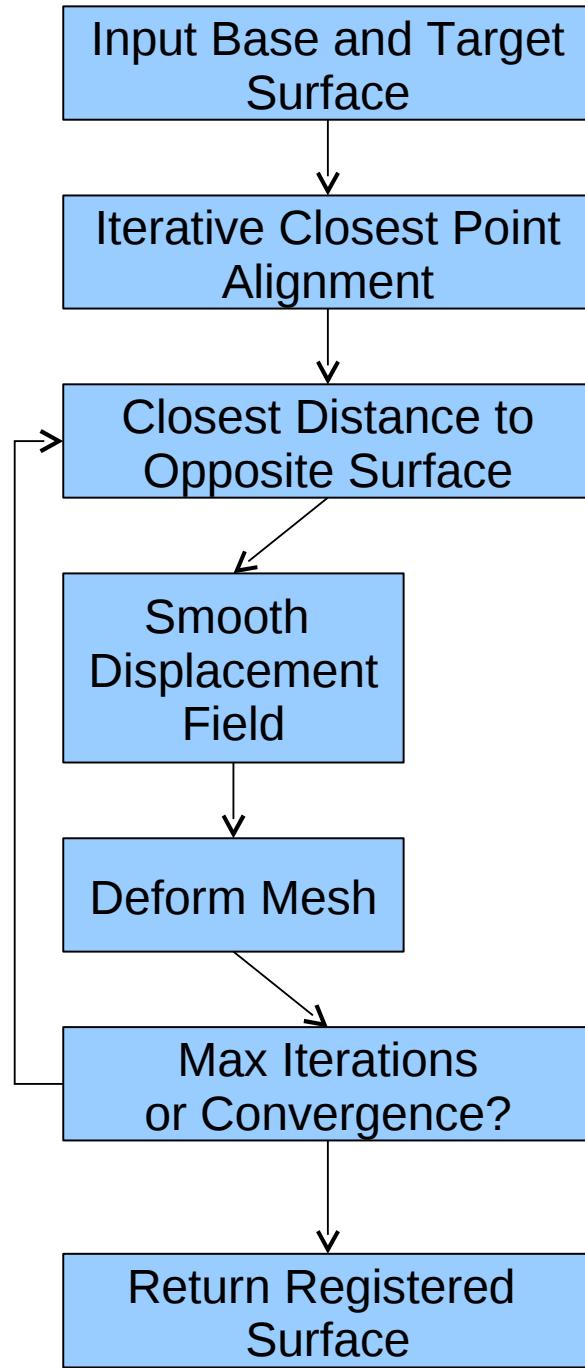
Registering and deforming a smoothed symmetric skull mesh to represent the orthognathic target surface

Generic and Target Shape

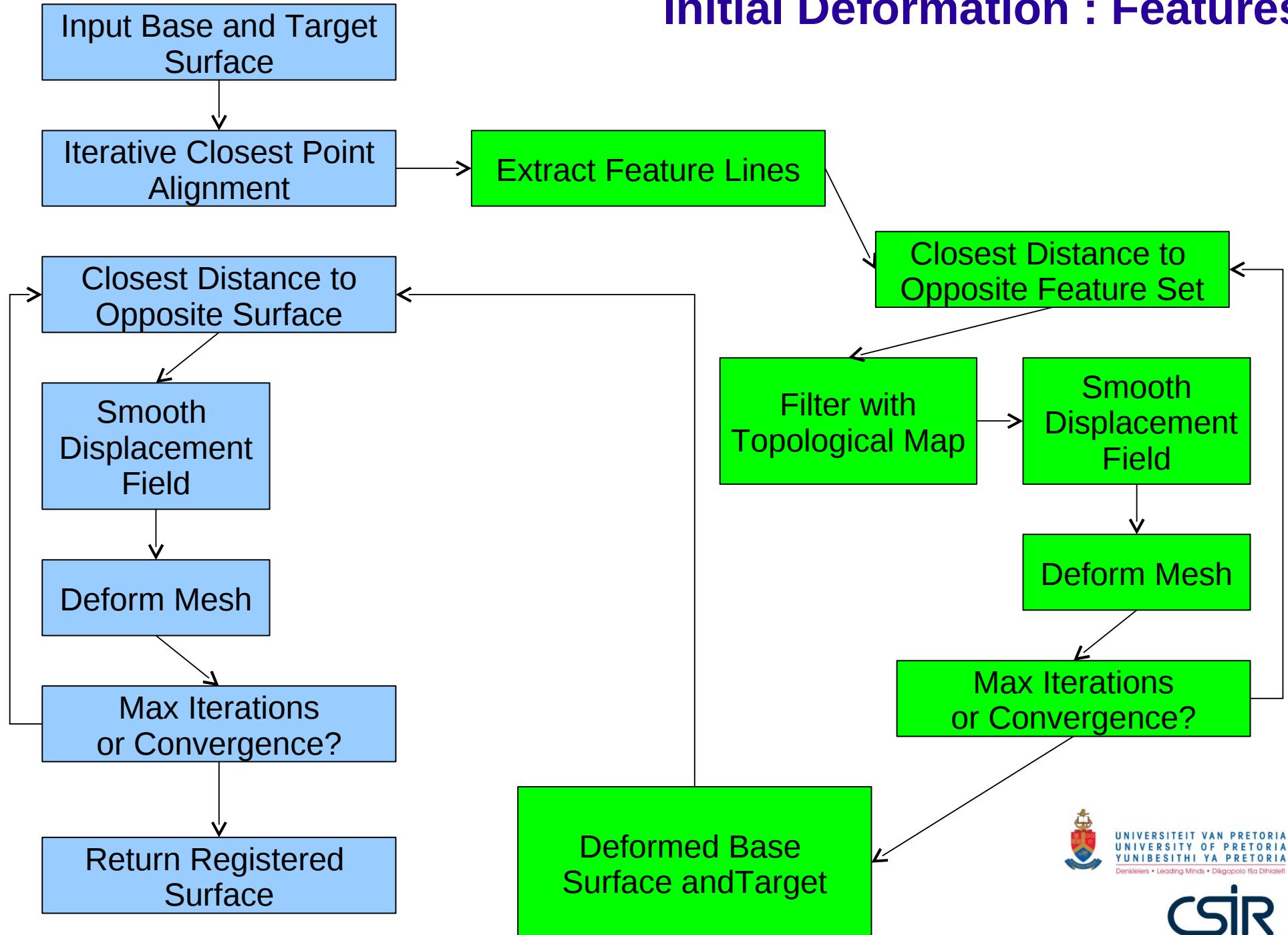


Registering and deforming a smoothed symmetric skull mesh to represent the orthognathic target surface – Difference in topology

Elastic Surface Registration

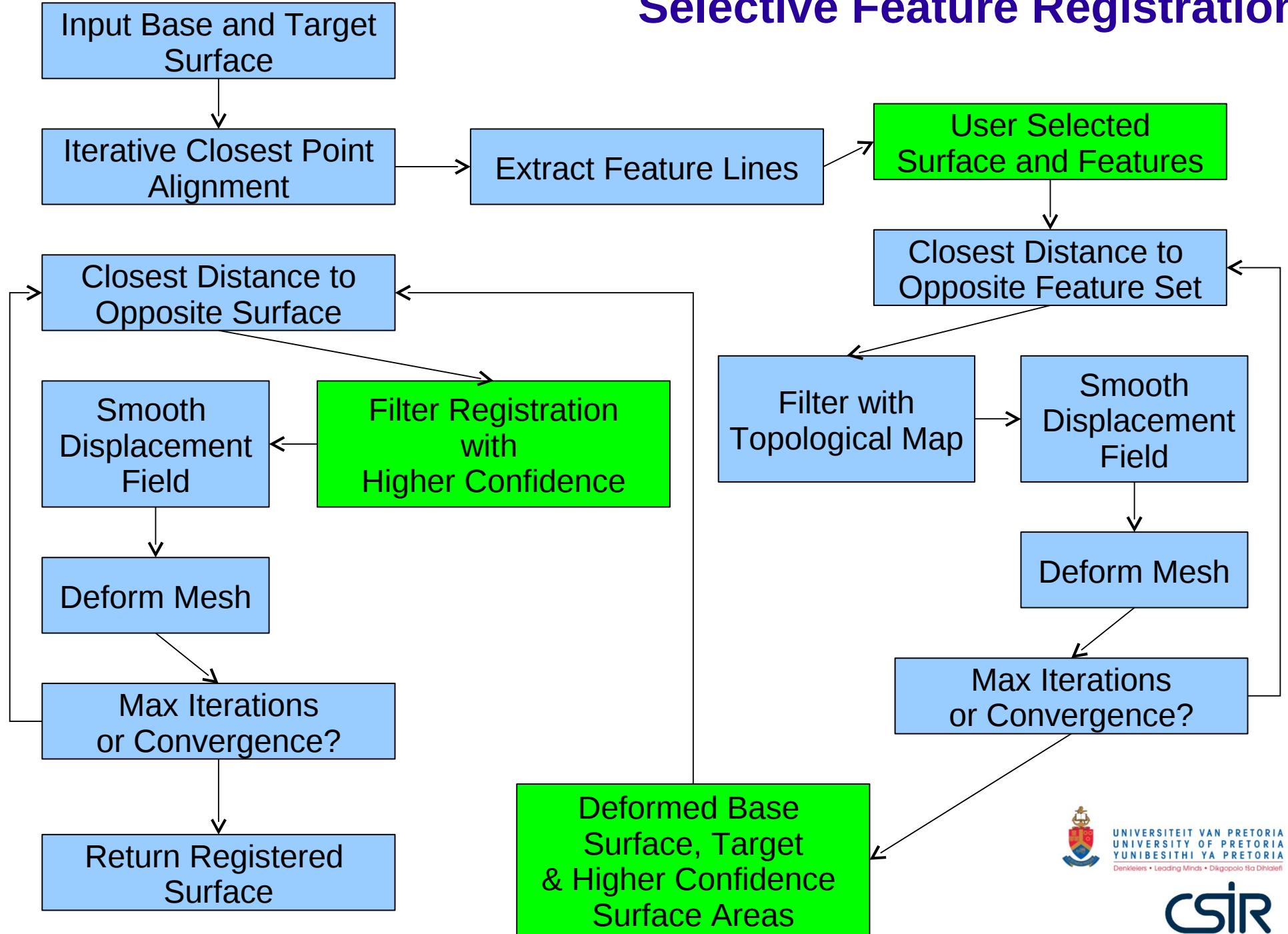


Initial Deformation : Features



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Selective Feature Registration



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Selective Feature Surface Registration

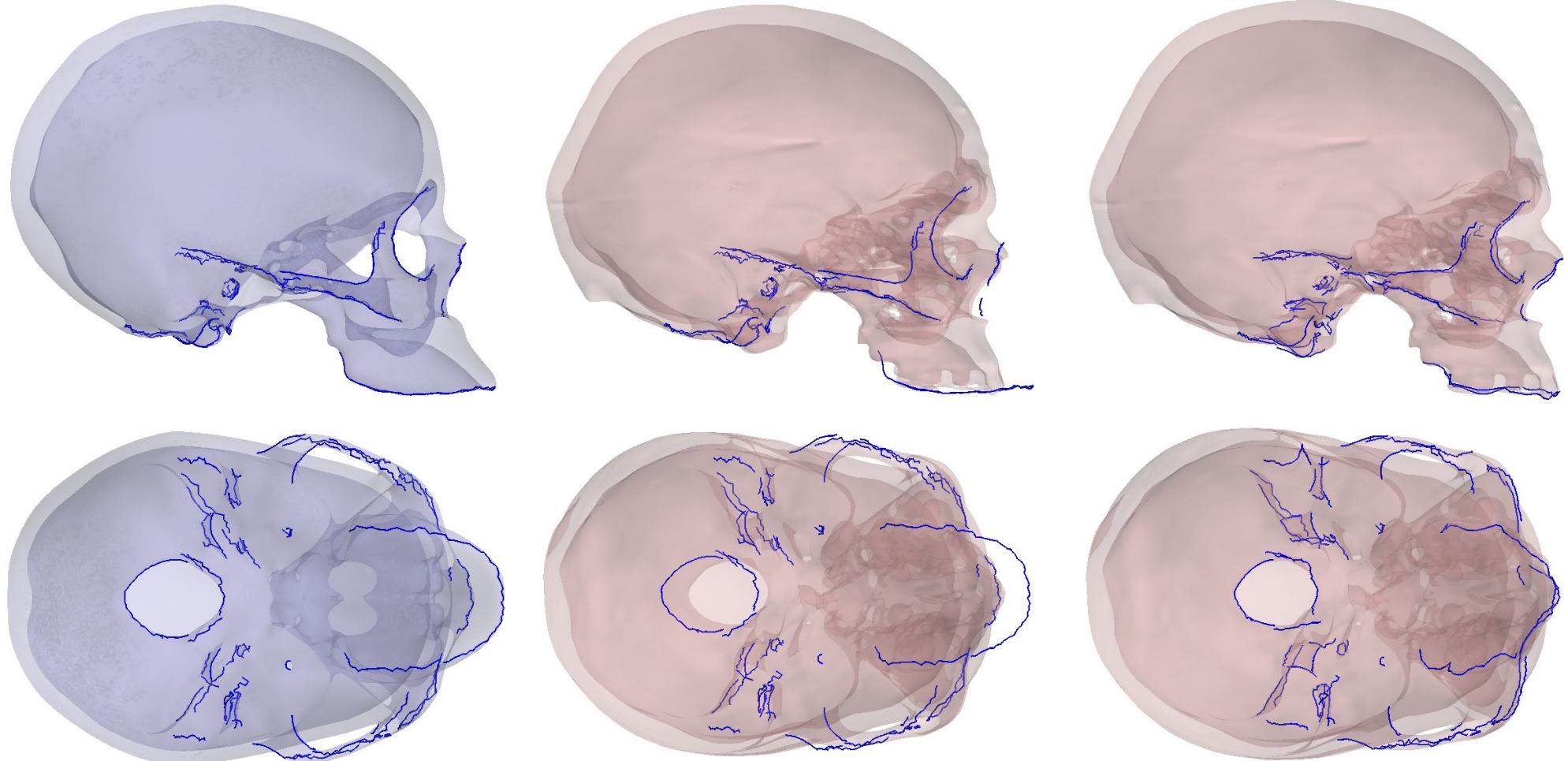


- Feature extraction*
- User specified allowable features
- Feature registration**
- Curvature information
- Elastic Surface Registration

* S. Yoshizawa, A. Belyaev, H. Yokota, and H. Seidel. Fast, robust, and faithful methods for detecting crest lines on meshes. *Computer Aided Geometric Design*, 25:545560, 2008.

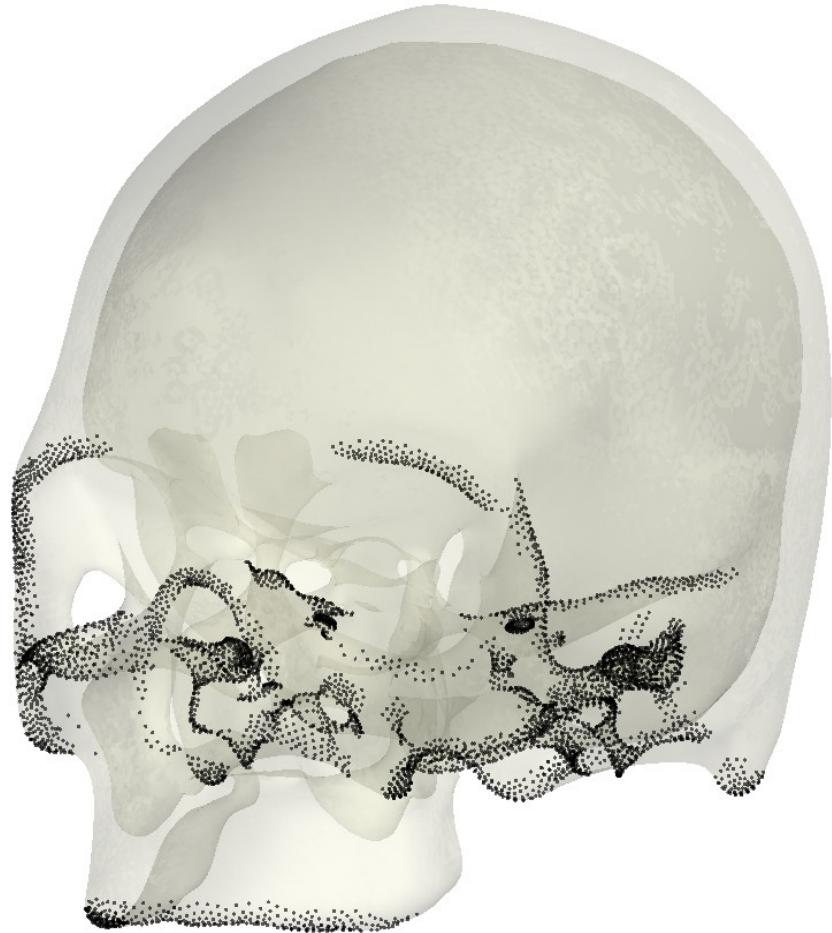
** G. Subsol, J.P. Thirion, and N. Ayache. A general scheme for automatically building 3d morphometric anatomical atlases: application to a skull atlas. *Medical Image Analysis*, 2:3760, 1998.

Selective Feature Registration



Selected feature registration on the orthognathic target surface

Selective Feature Registration

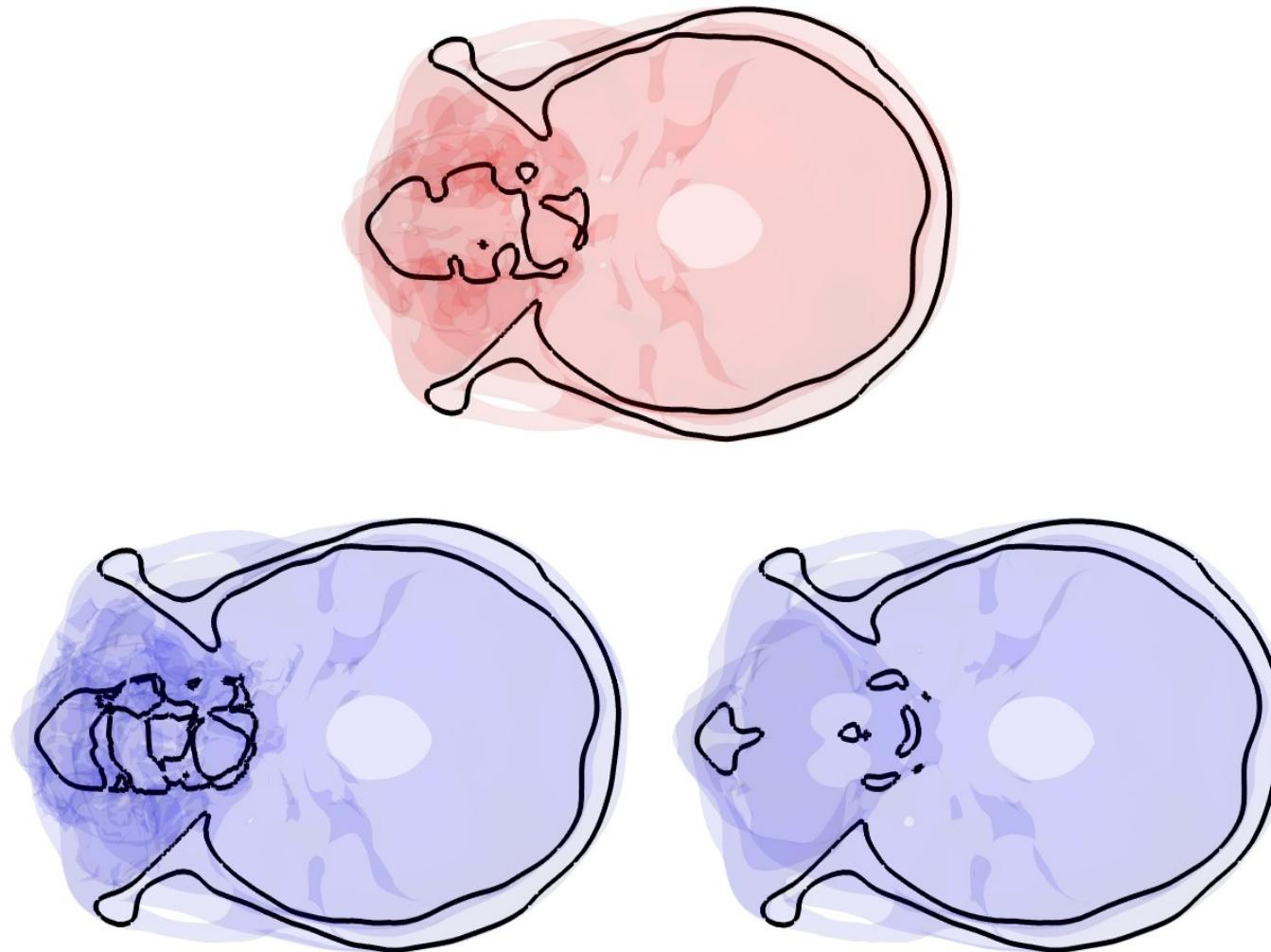


Selected feature areas on the generic skull surface

Selective Feature Registration

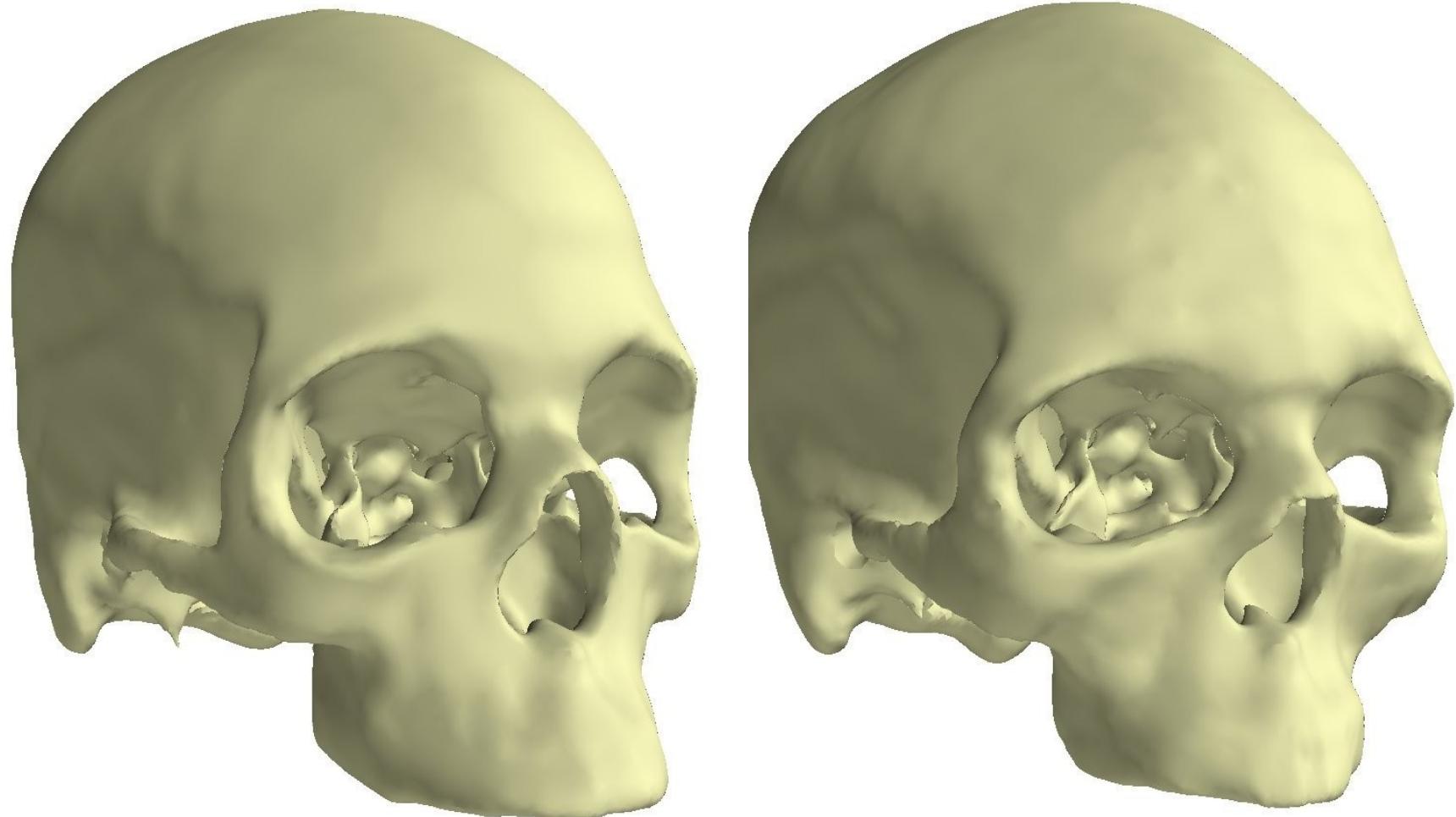


Automatic extraction of selected features on the orthognathic target



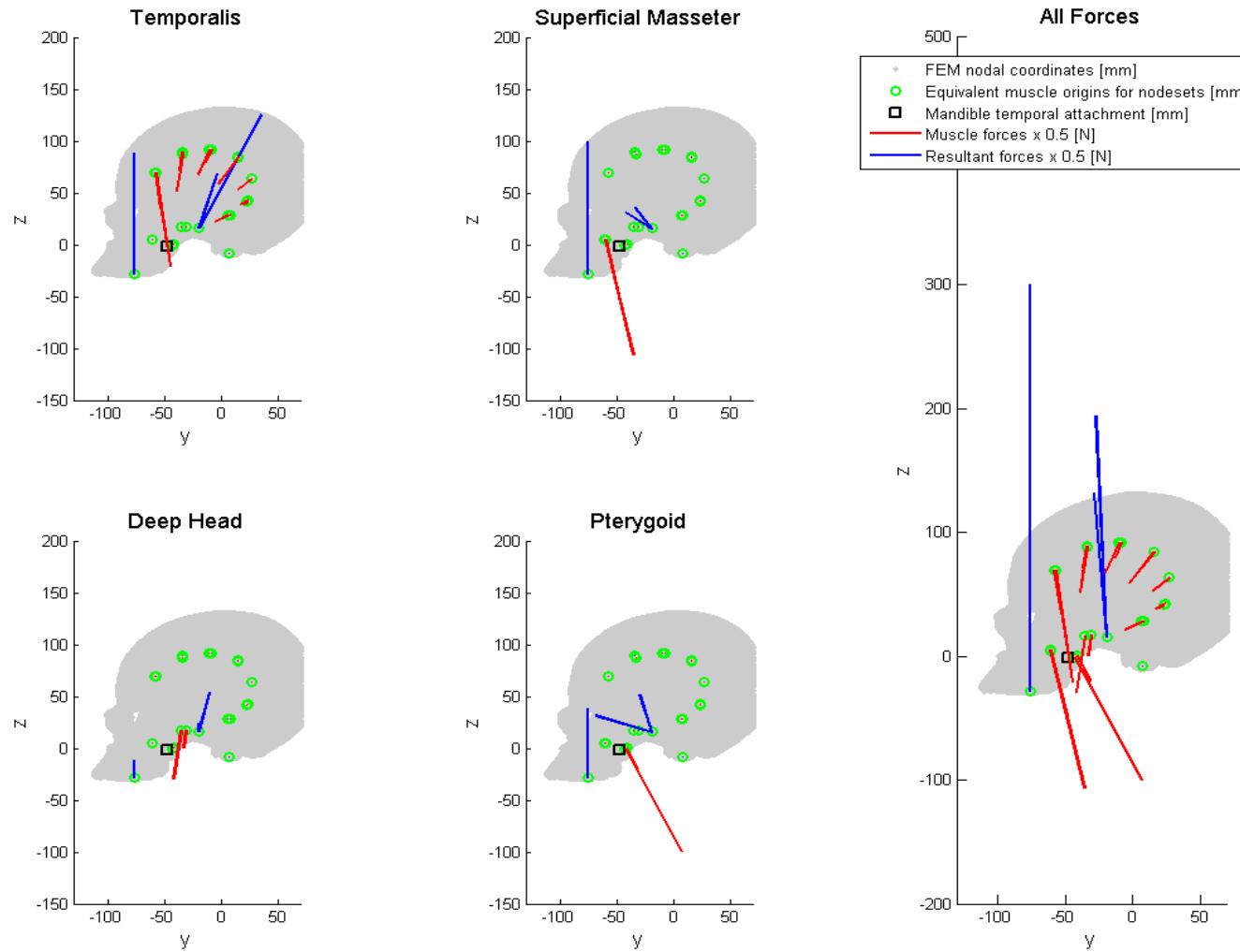
Comparison between full initial registration and selected feature preserved registration – maintain generic shape topology

Symmetric Geometries



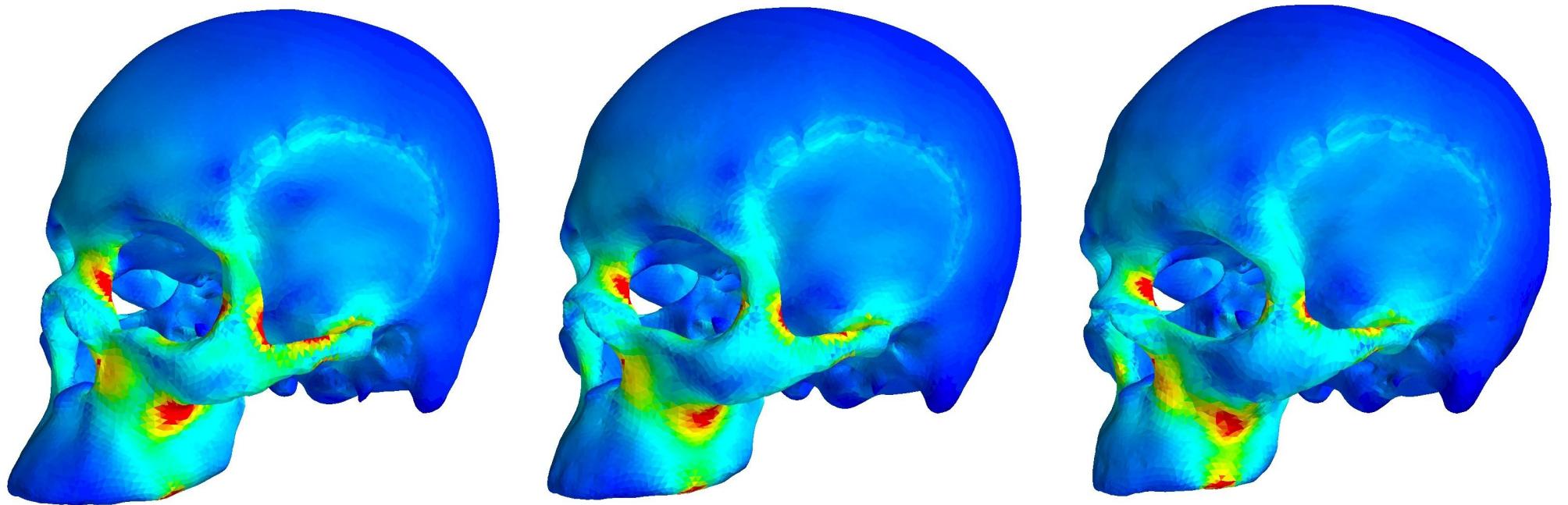
Symmetric prognathic and orthognathic shapes with one-to-one map

Prognathism and Stress



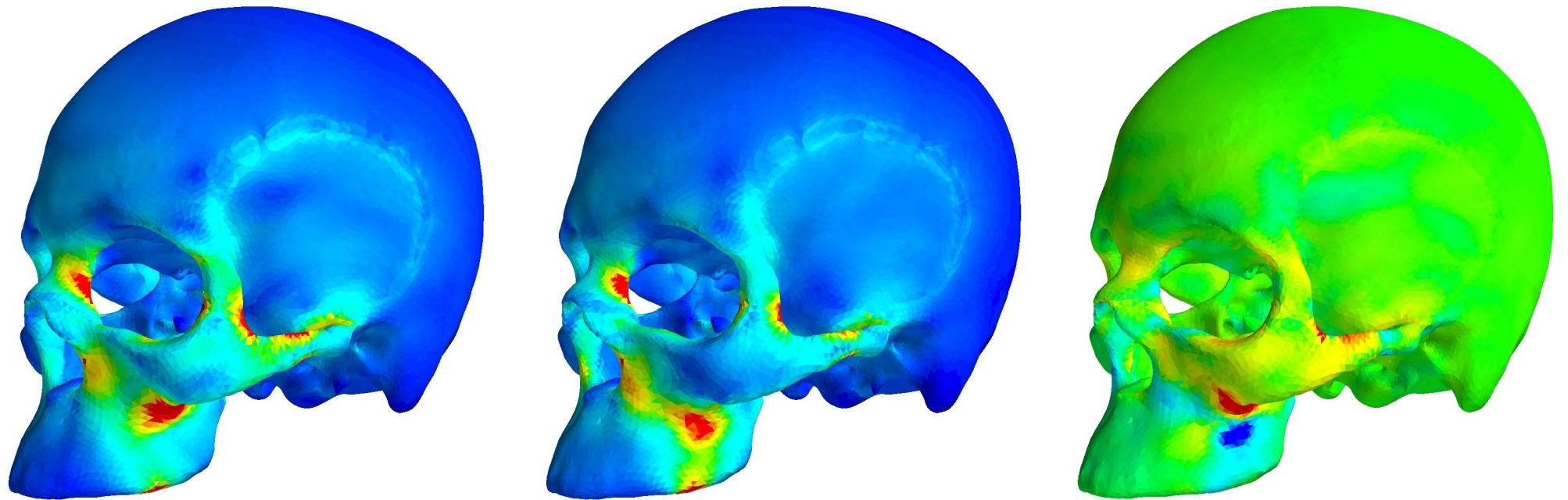
Boundary conditions. Muscle and reaction forces.

Prognathism and Stress



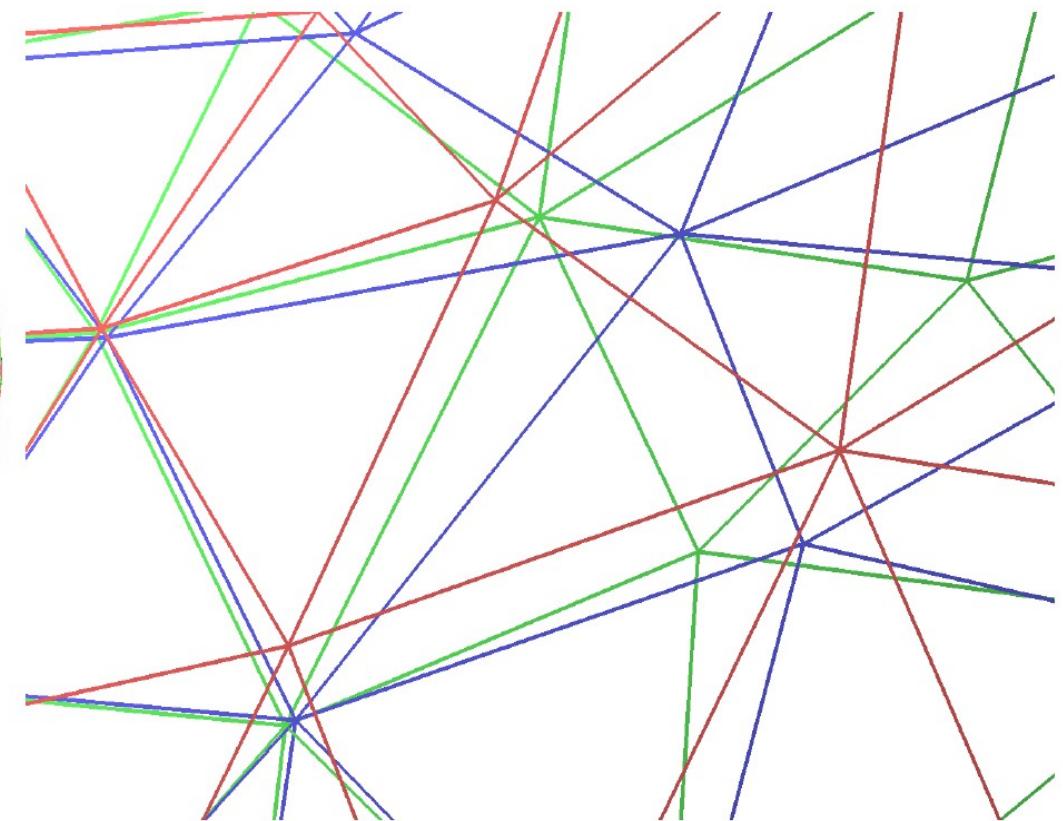
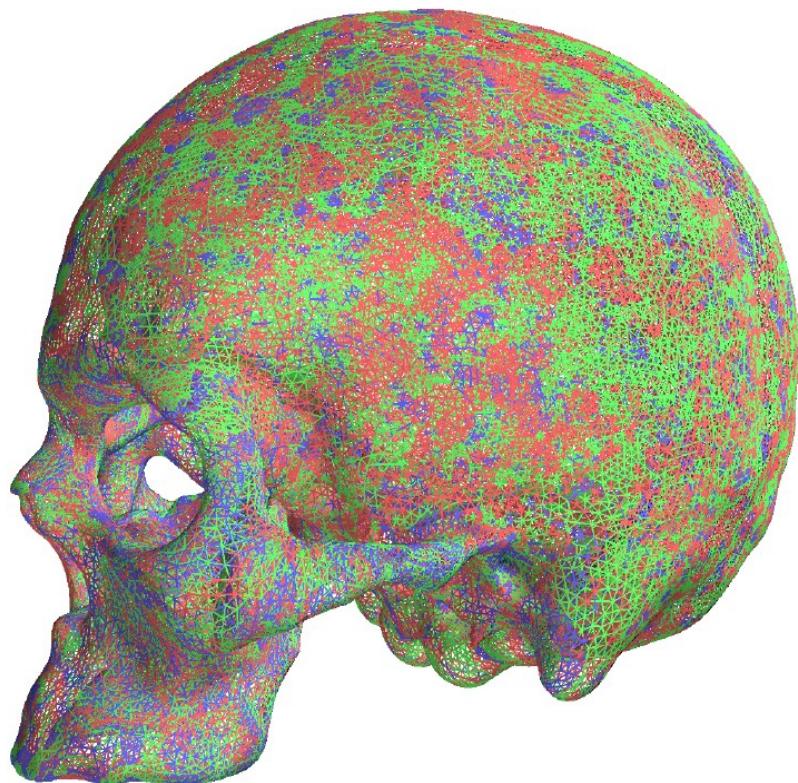
FEA on prognathic, average and orthognathic skull representation

Prognathism and Stress



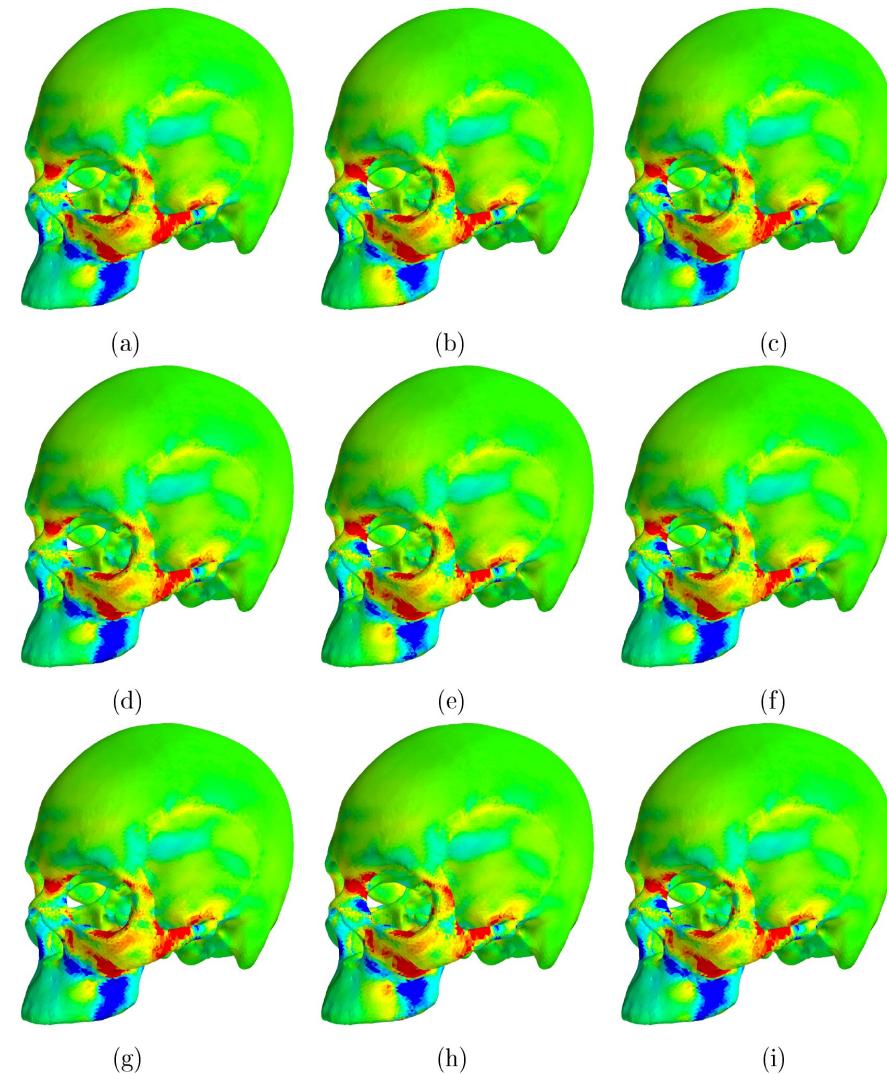
Identical connectivity allows direct comparison

Registration Uncertainty



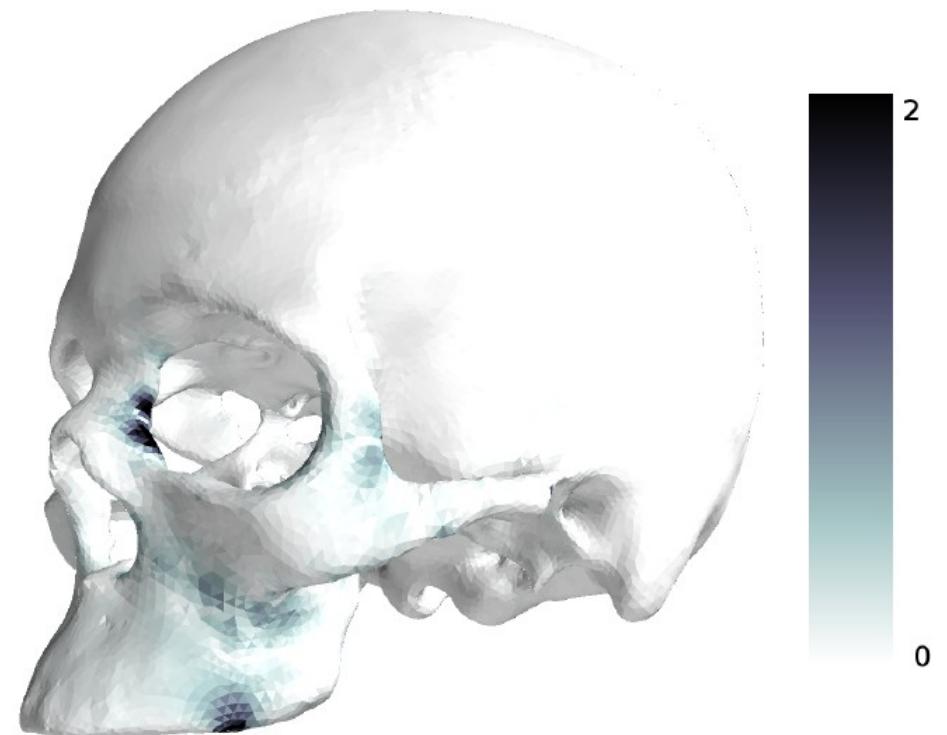
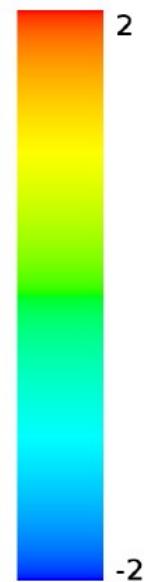
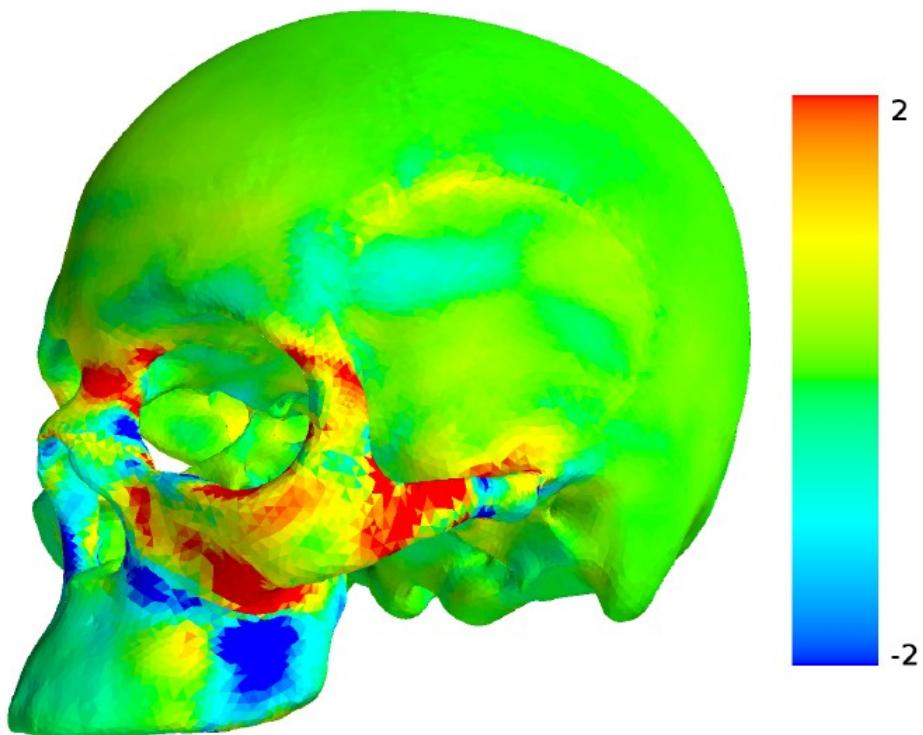
Multiple mesh generation

Registration Uncertainty



Comparing three prognathic with three orthognathic representations

Registration Uncertainty



Average and standard deviation difference in von Mises stress

Possible Future Applications



- Statistical sample of skulls
- Transient data of geometry change during fluid structure interaction

Thank You

