# Landmark-free 3D method for comparison of fossil hominins and hominids based on endocranium and EDJ shapes

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ANTHROPOLOGIE MOLÉCULAIRE ET IMAGERIE DE SYNTHÈSE



# Surface comparison

- **Quantitative shape analysis based on the statistical analysis of landmark coordinates**
  - Fred L Bookstein. ***Morphometric Tools for Landmark Data: Geometry and Biology***. Cambridge University Press, 1997
  - Philipp Gunz and Philipp Mitteroecker. ***Semilandmarks: a method for quantifying curves and surfaces***. Hystrix, the Italian Journal of Mammalogy, 2013
- **Automatic geometric correspondences**
  - Doug M. Boyer et al., ***Algorithms to automatically quantify the geometric similarity of anatomical surfaces***. Proceedings of the National Academy of Sciences, 2011

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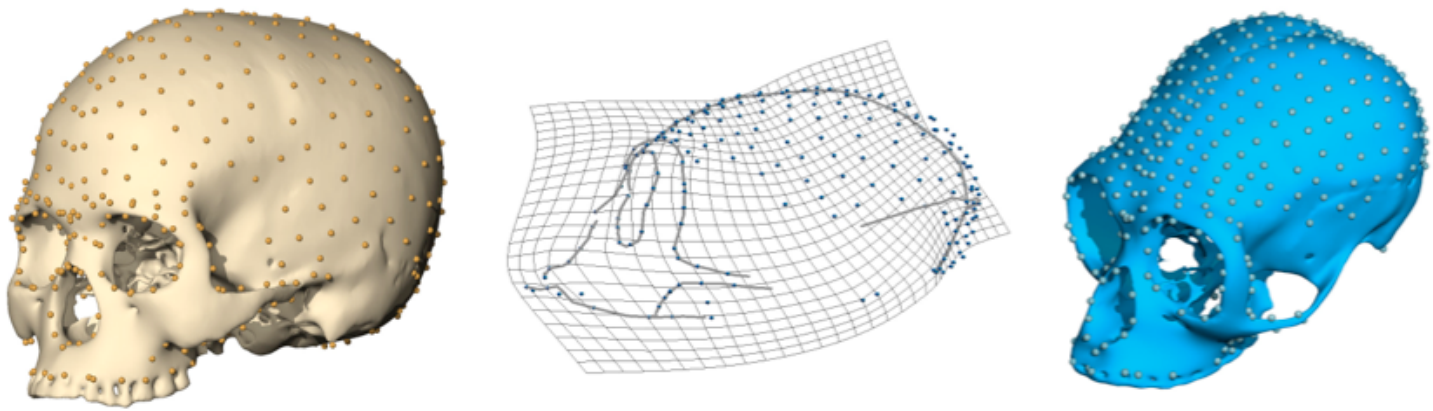

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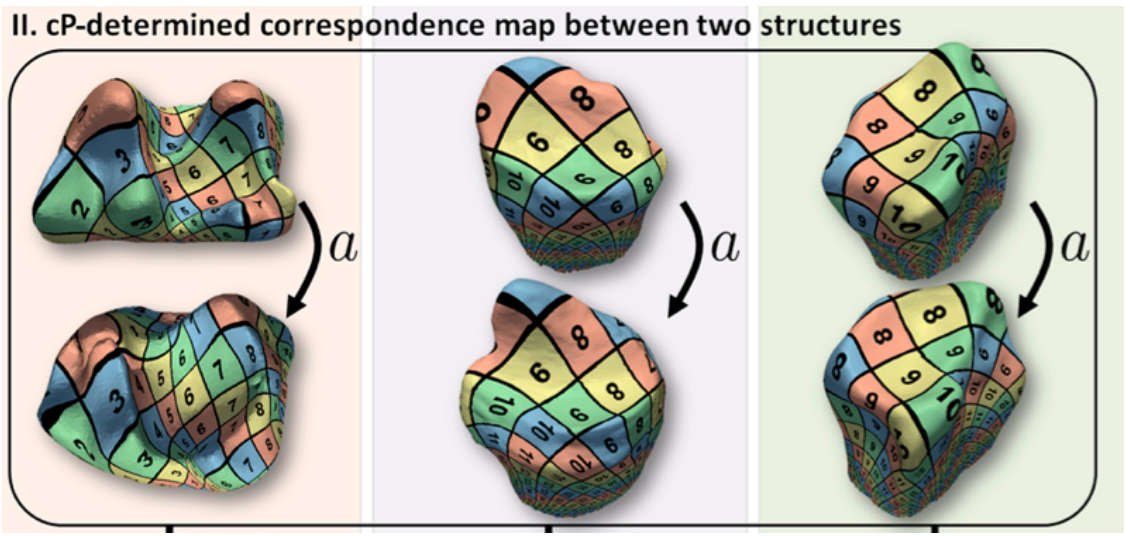
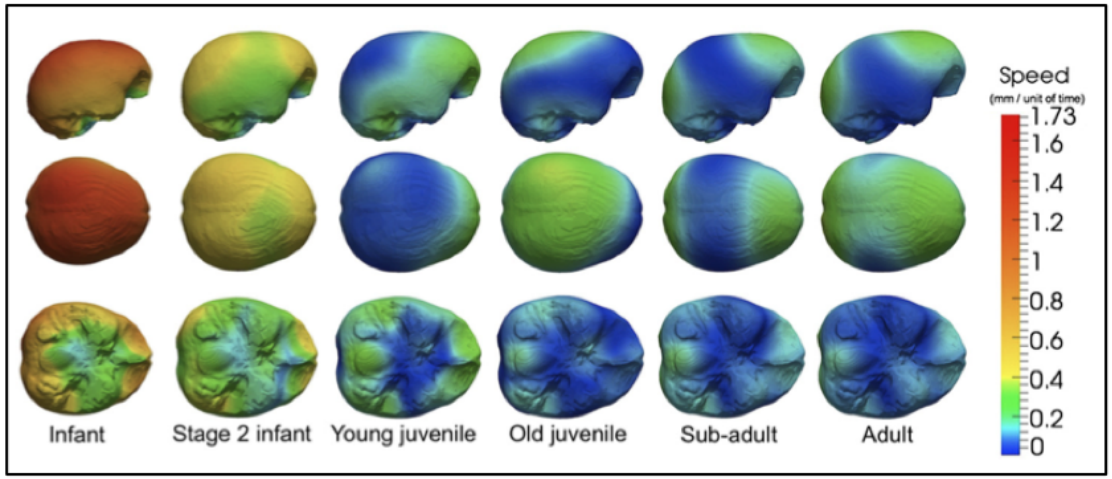
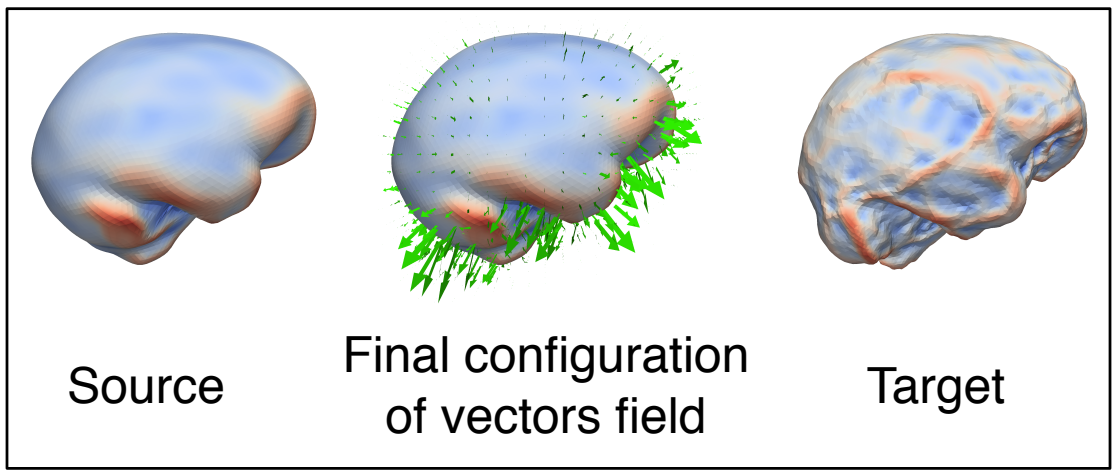


# Our surface-matching algorithm




S. Durrleman et al., Journal of Human Evolution, 2011

- Deformation computed from the whole mesh
- Additional data : curves, point set, and volume
- Deformation parameters used in statistics



# Applications

| Type of data | Fossil | Comparative modern (number of samples) | Method |
|---|---|---|---|
| EDJ of right mandibular molars and premolars | STS 52 (*A. africanus*), SKW 5 (*P. robustus*) | *Homo sapiens* (n=1), *Pan troglodytes* (n=1), *Pan paniscus* (n=1) | Surface registration |
| Endocranium | STS 5 (*A. africanus*) | *Homo sapiens* (n=10), *Pan troglodytes* (n=10), *Pan paniscus* (n=10) | Atlas model |

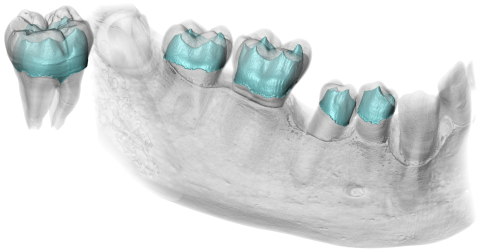
STS 52
(*Australopithecus africanus*)

SKW 5
(*Paranthropus robustus*)

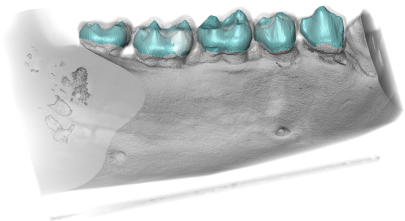
STS 5
(*Australopithecus africanus*)

# Enamel-dentine junction sample

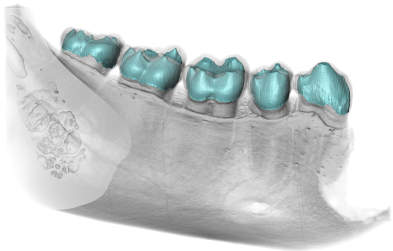
*Homo sapiens*



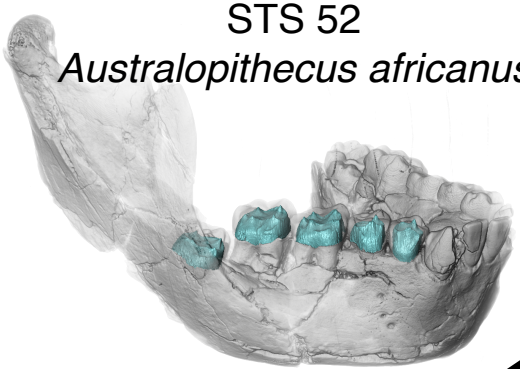
*Pan paniscus*



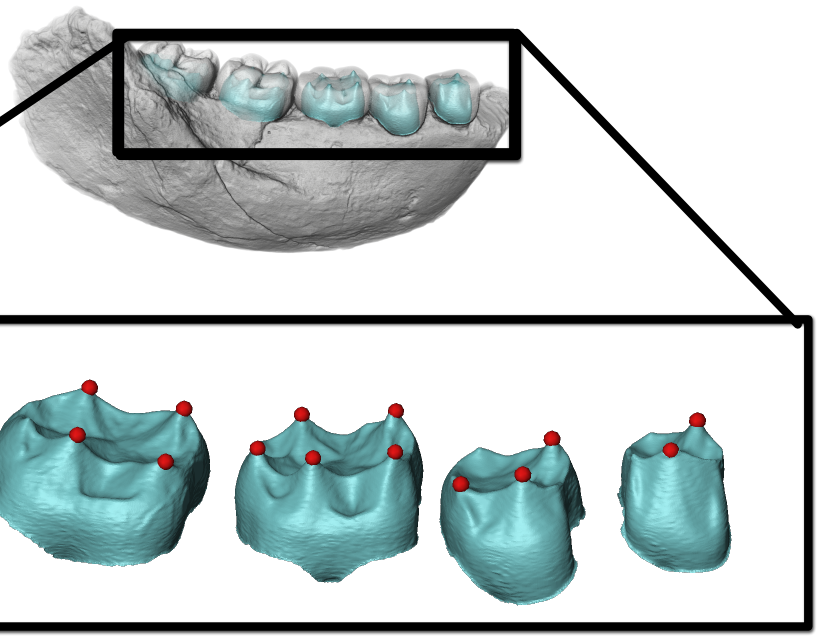
*Pan troglodytes*



STS 52
*Australopithecus africanus*

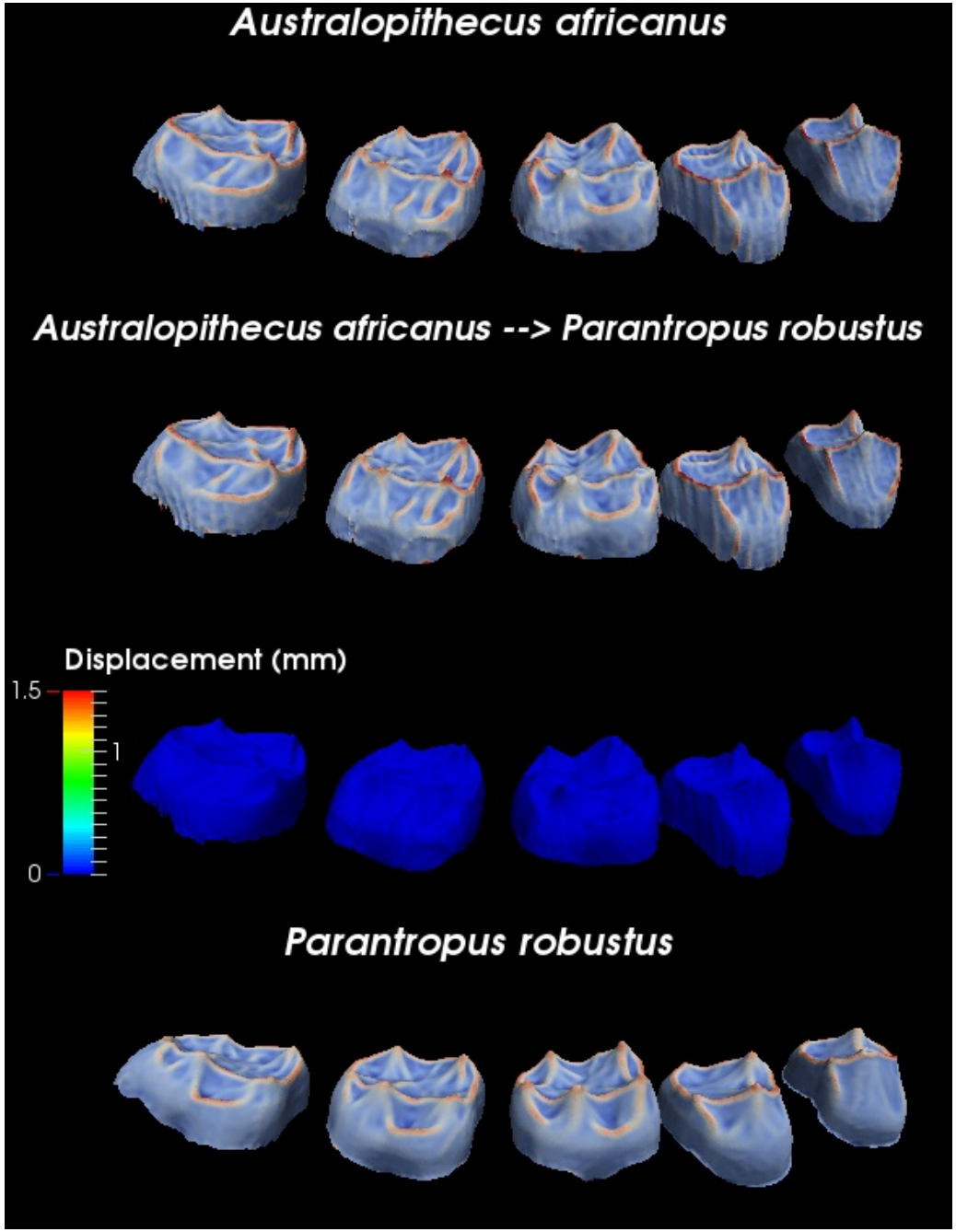


SKW 5
*Paranthropus robustus*



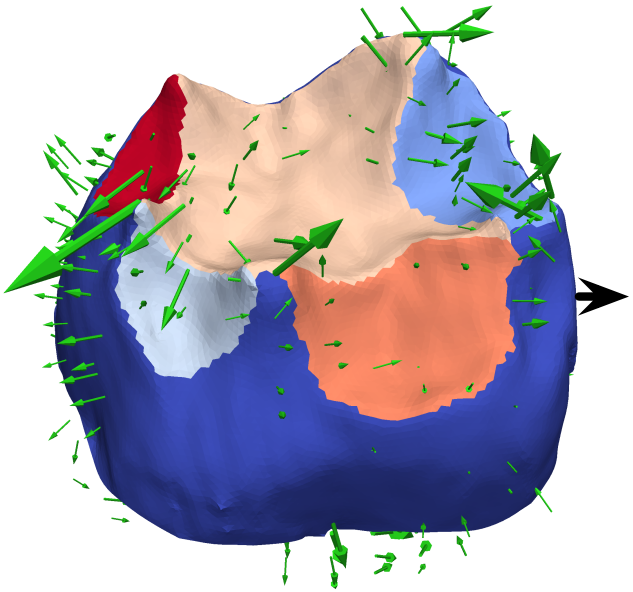
Right mandibular molars and premolars from five specimens

# Surface-to-surface registration

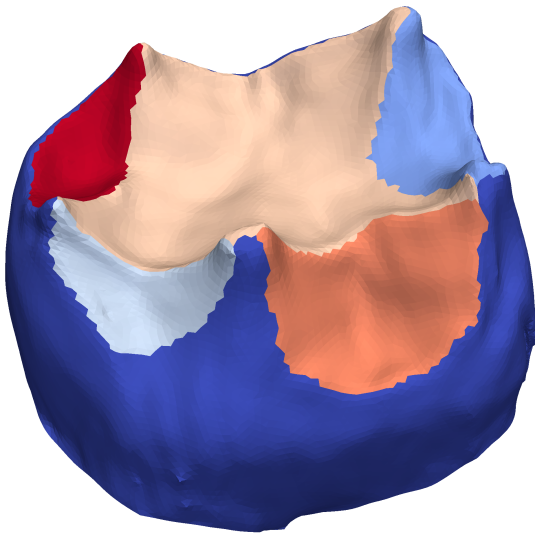


# Surface comparison - Visual approach

Source with deformation field

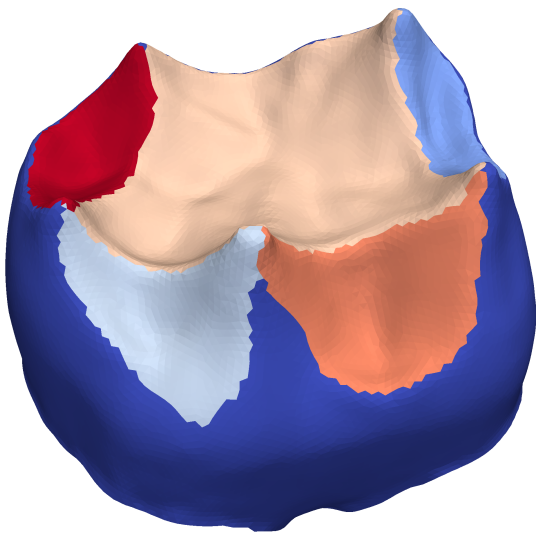


Deformed source



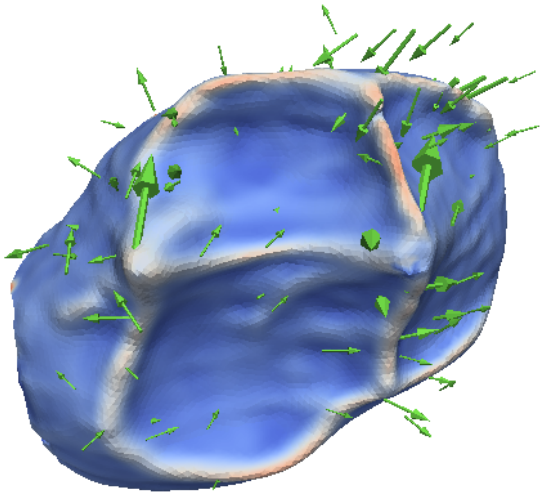
Correspondence map from the first molar of *Australopithecus africanus* to *Paranthropus robustus*

Target

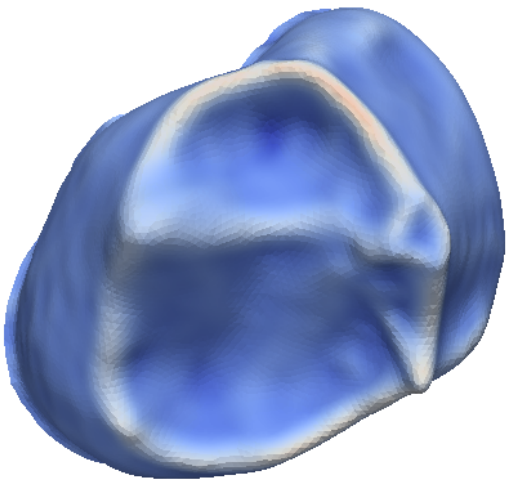


First molar of *Paranthropus robustus*

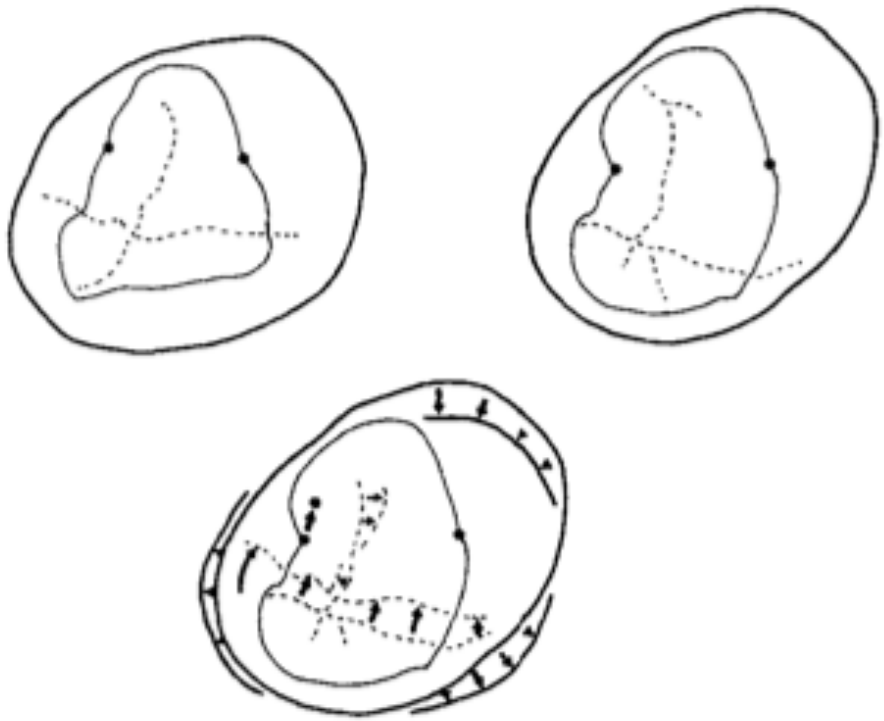
# Comparison of *A. africanus* and *P. robustus* third premolar



EDJ P3s of *A. africanus*

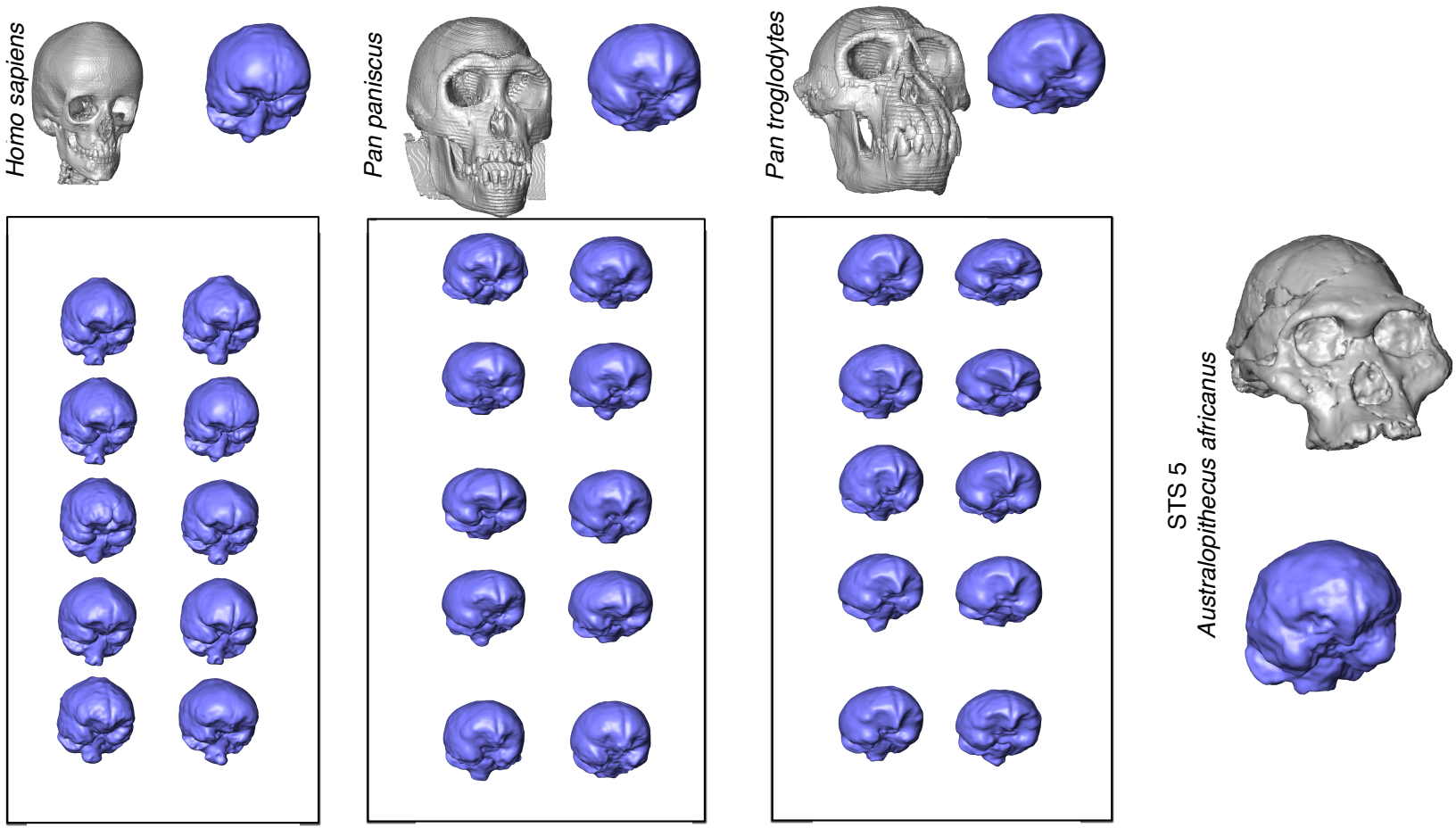


EDJ P3s of *A. robustus*



Schematic comparison of *P. robustus* (left) and *A.africanus* (right) mandibular P3s.
Gen Suwa, AJPA, 1996

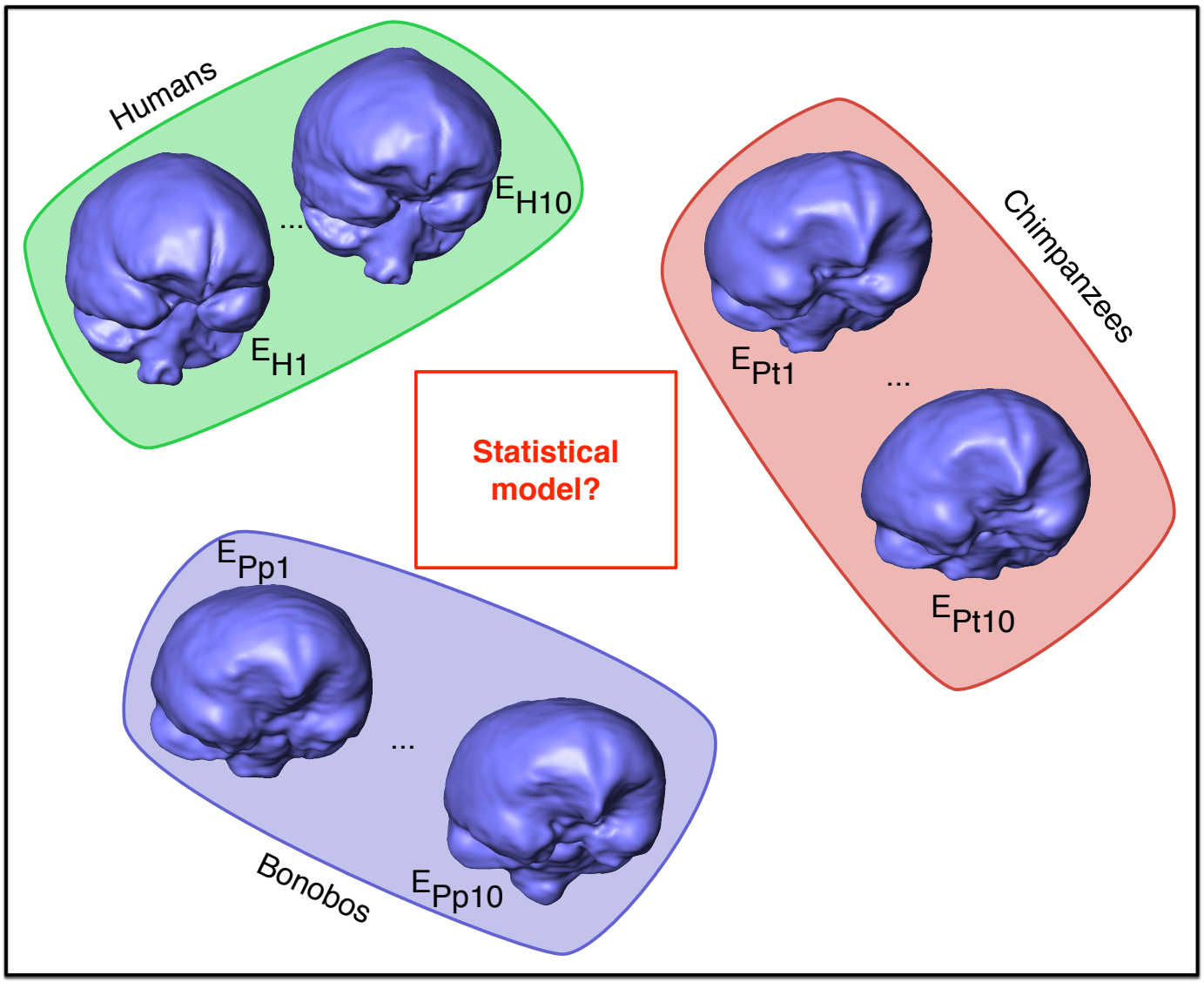
# Endocranium sample




Five males and five females endocrania* have been extracted for each extant species.

*Segmented with Endex: http://liris.cnrs.fr/gilles.gesquiere/Endex/

# Endocranium - Atlas model



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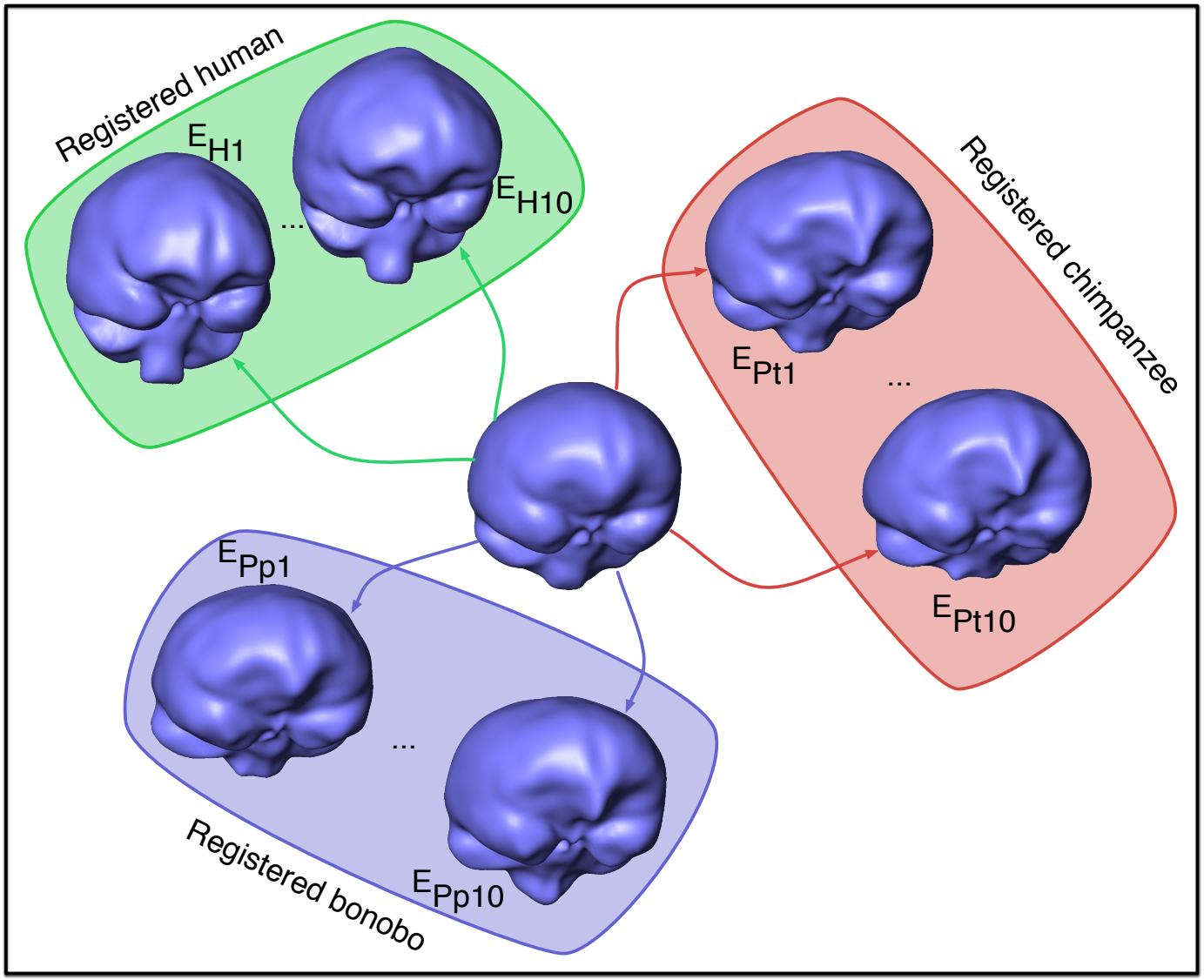
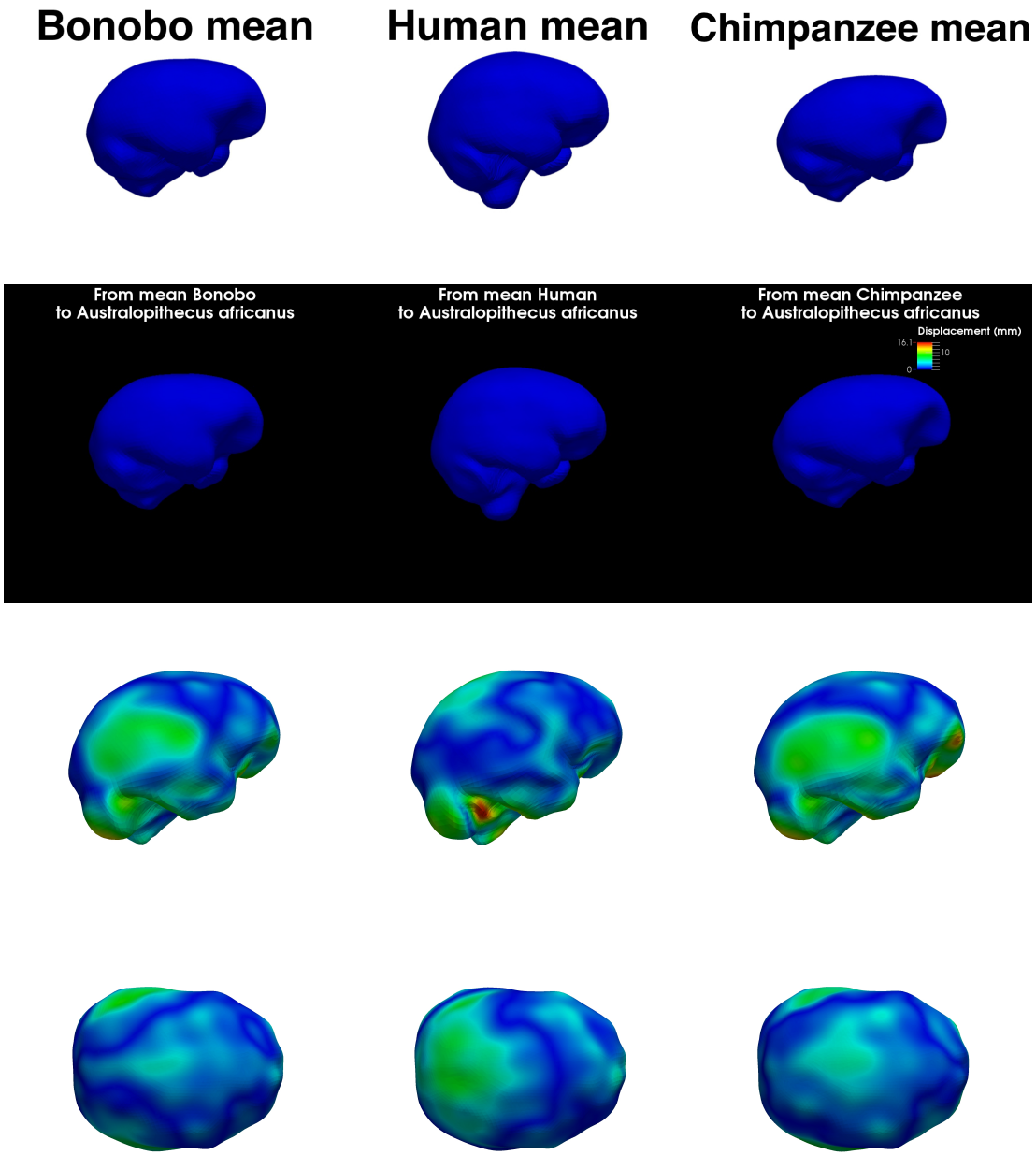


# Comparison with STS 5

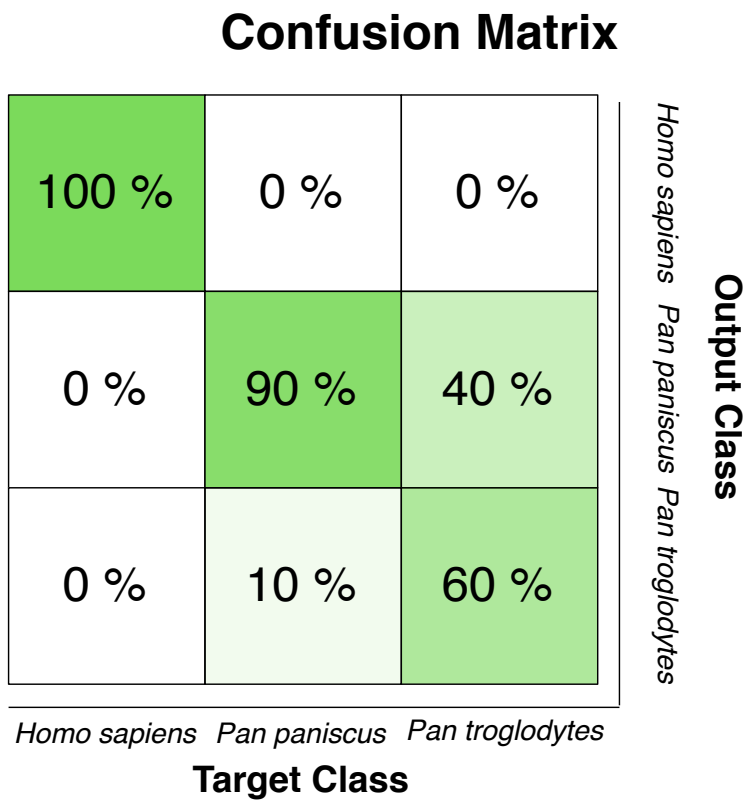
Deformations to STS5

Lateral and superior views of final deformation maps



# STS 5: a more ape-like brain?

- 2-means: human vs bonobo and chimpanzee: 100% of appropriate classification. STS 5 is classified as ape.
- 3-means: human vs bonobo vs chimpanzee:

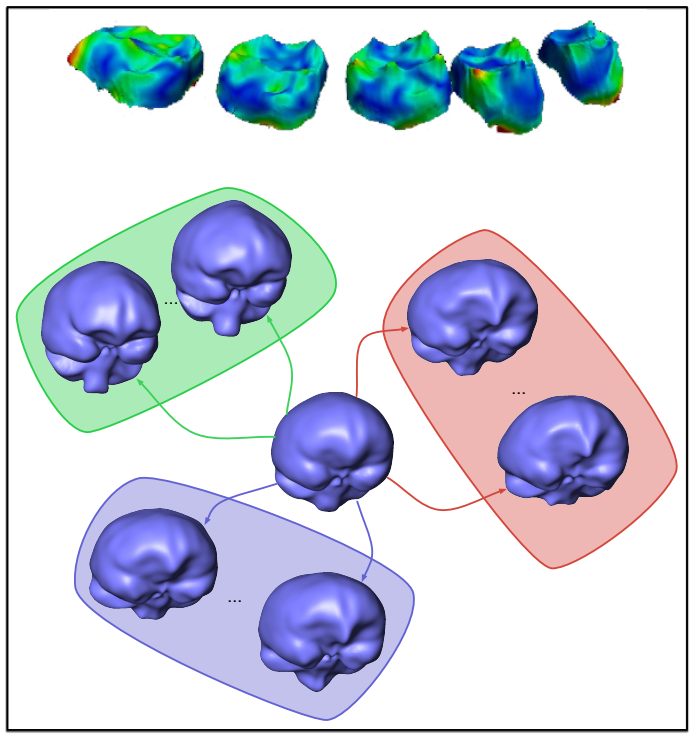



This classification discriminates *Australopithecus africanus* as belonging to our bonobo sample.

# Conclusion / Further work

- No manual and expert-based processing
- Information over all the surface, not only landmarks
- Code soon available
- Efficient tool for taxonomy

- Combining cranial anatomical features
- Reconstruct missing parts using statistical shape models



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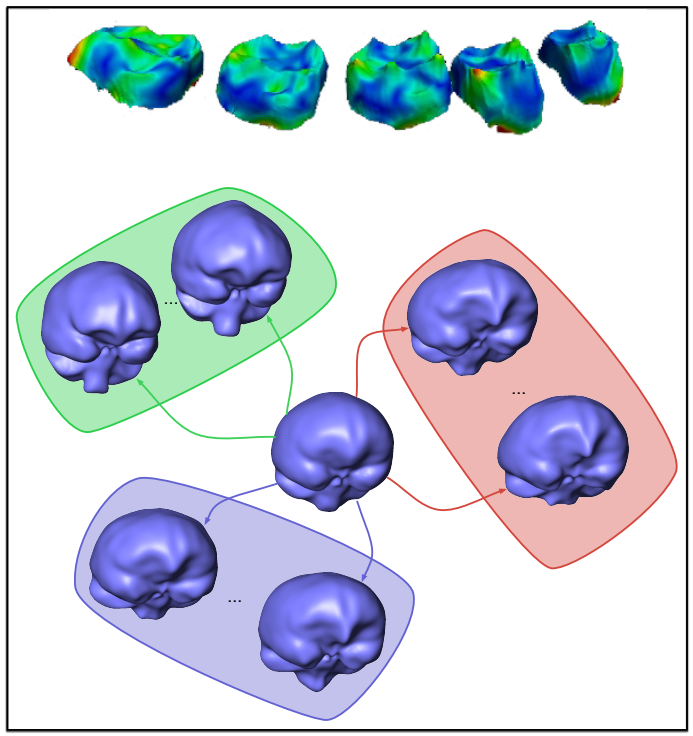

# THANK YOU FOR YOUR ATTENTION!

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