PyCranium

A 3D PHOTOGRAMMETRY TOOLBOX FOR CRANIAL SHAPE ANALYSIS

Three-dimensional (3D) stereophotogrammetry is a novel imaging technique that has gained popularity in the medical field as a reliable, non-invasive, and radiation-free imaging modality. It uses optical sensors to acquire multiple 2D images from different angles which are reconstructed into a 3D digital model of the subject's surface. The technique proved to be especially useful in craniofacial applications, where it serves as a tool to overcome the limitations imposed by conventional imaging modalities and subjective evaluation methods. The capability to acquire high-dimensional data in a quick and safe manner and archive them for retrospective longitudinal analyses, provides the field with a methodology to increase the understanding of the morphological development of the cranium, its growth patterns and the effect of different treatments over time.

Practical tools for clinicians which enable quick and objective analysis of 3D meshes are still lacking. PyCranium, an open-source toolbox, is therefore being developed in close collaboration with clinical departments in the Erasmus MC. This toolbox provides the clinician with the necessary tools to facilitate the use of cranial 3D photogrammetry data in a clinically relevant manner.

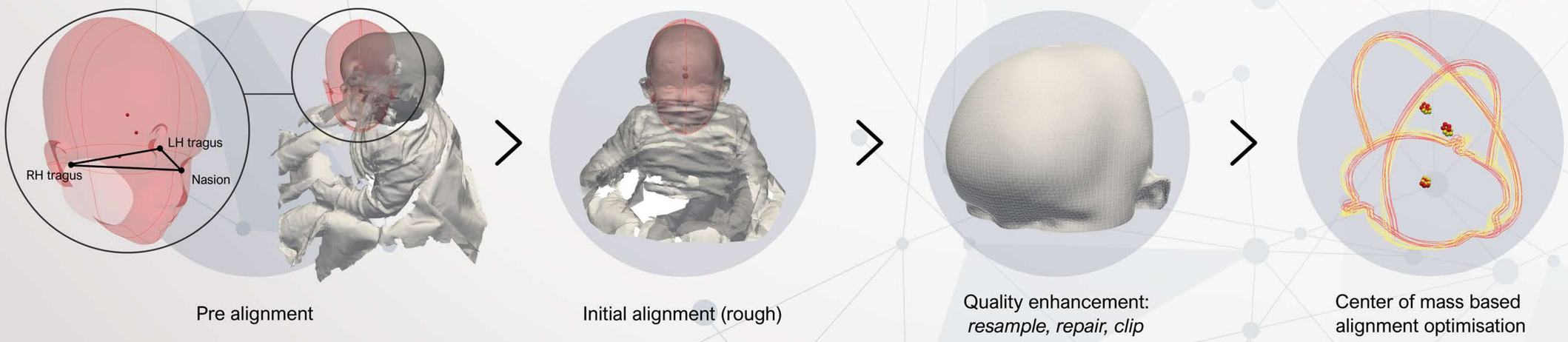
Image Acquisition

Over the past 15 years, the Erasmus MC has collected one of the largest 3D photogrammetry datasets worldwide to analyse craniofacial anomlies.

Each 3D mesh is reconstructed from multiple 2D photographs. The type of acquisition system, in combination with a large variation in subjects desire a reliable pre-processing pipeline. This pipeline takes care of mesh alignment, resampling, repair and clipping. The resulting mesh can be used to obtain basic cephalometric measurements (normally obtained by hand in clinic) or for more complex shape analysis.

Mesh Alignment

An initial alignment is obtained based on three prominent landmarks: the nasion and both tragi. These landmarks are easily detectible on 3D surface images and form a commonly used cephalometric reference plane.
The target used for alignment is an average healthy subject from a statistical shape model (visualized in red). This 3D model is then resized based on the approximated intracranial volume of the subject. The centroid of the triangle formed by the three landmarks on the template forms the origin of the reference frame.



Pre alignment

Initial alignment (rough)

Quality enhancement:
resample, repair, clip

Center of mass based
alignment optimisation

Craniometrics

Craniometric measurements can be automatically extracted from the processed mesh.
These measurements include:
- occipitofrontal head circumference (OFC)
- cephalic index (head width / head length)
- intracranial volume approximation

Shape Analysis

Each mesh imported into PyCranium can be visualized as a unit sphere of normal vectors. A clear advantage of this simple representation is that it captures the shape information while it is invariant to the size of the object. This enabels shape comparison between meshes of different sizes (e.g. in longitudinal studies to evaluate the effect of reconstructive surgery). In our current project, we apply this representation to detect and quantify pathological shape patterns.

Authors

T. Abdel-Alim[1,2], M.L.C. van Veelen[1], G.V. Roshchupkin[2]

Erasmus University Medical Center, Rotterdam, the Netherlands

[1] *Department of Neurosurgery*

[2] *Department of Radiology and Nuclear Medicine*

More Information

Contact: t.abdelalim@erasmusmc.nl

Further reading: ***Three-Dimensional Stereophotogrammetry in the Evaluation of Craniosynostosis: Current and Potential Use Cases***

doi: 10.1097/SCS.0000000000007379