Modeling the growth of a human cranium

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Abstract. By the creation of models, representing the process of growth of an individual human cranium, the appreciation of aetiopathology would become possible. In the paper at hand, a new method for estimating the growth of human crania was worked out, combining functional approaches with geometrical methods working on three dimensional models. The goal is, to give a prognosis of the patient's appearance for time steps in the future. Pathological evolution, caused by diseases like craniosynostosis, as well as healthy growth was analyzed, improving the options of medical diagnostics.

1 Purpose

As diseases, like craniosynostosis, cause deformations of the head, the surgeon has to decide whether an operation is necessary and which point in time is most suitable. By three dimensional modeling of the evolution process, the surgeon could be assisted by such a decision. Inverting the growth process, an individual reference object can be generated for the operation planning system. The different goals, which should be reached by modeling growth are shown in figure 1. Approaches trying to

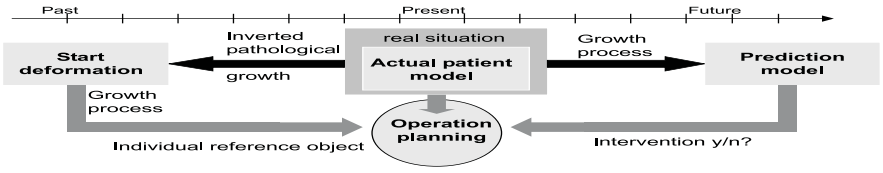

Fig. 1. Goals of the research work

define an analytical description for the evolution process had been made, e.g. shown in [5] or in [1]. Geometrical approaches are based on calculations of the growth by defining the variation of identified landmarks in time and an interpolation of the triangle mesh, representing the shape. Examples for surface based modeling are given in [2] or [4]. At the moment, there are neither approaches giving a mathematical description of the evolution of pathological crania nor any provided method to combine a functional, physical analysis with a 3-D surface modeling.

2 Methods

Based on surface and volume models of the patient's head created due to CT data, the modeling of growth, presented in the paper at hand, relies on a two step, discrete and iterative algorithm. In the first step, the inner pressure of the head is risen regulated by a functional, physical based, context, describing the variation of the volume of the brain. In the second step, the bone structure of the head enlarges

as a consequence of the former action at those parts of the cranium, where growth is possible. For an healthy child the points of growth are especially the regions of the sutures. The areas of enlargement are appointed by a defined density function, showing the measure of resistance of the bone structure at different points on the surface. The iterative procedure is shown in figure 2.

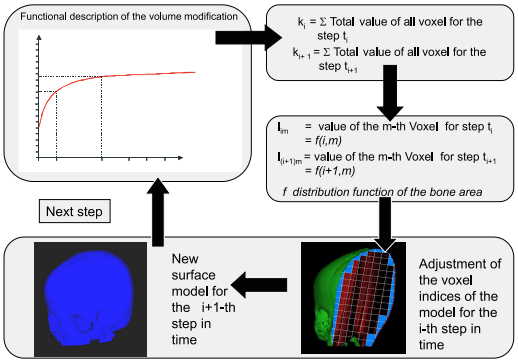

Fig. 2. Procedure for modeling the growth

3 Results

The accuracy of the created surface models used as training data is less than one millimeter. Different image sets are classified into form classes by a clustering algorithm due to a complex parameter range. The results are used as training sets for the parameters of the growth model. The sorting of the form classes is accomplished by aspects like age, sex, or parentage. Data representing the average evolution are available. By the algorithm shown in [3] artificial series of models in time can be produced. So, a realistic behavior of the geometrical model can be obtained. The presented method is part of latest research work, so the accuracy of the outcoming models and the model itself are still in the process of improvement.

4 Conclusion

Within the presented method, the potential of medical diagnosis will increase. As the process is affected by several parameters, the basic model has to be extended by additional parameters in future.

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