Grid-enabled Medical Simulation Services (GEMSS) in der MKG-Chirurgie

Grid-enabled Medical Simulation Services (GEMSS) in Oral & Maxillofacial Surgery

Thomas Hierl[1]; Wollny, G.[2]; Berti, G.[3]; Schmidt, J.-G.[3]; Fingberg, J.[3]; Schulz, Th.[4]

[1]Klinik und Poliklinik für Mund-, Kiefer- und Plastische Gesichtschirurgie, Universitätsklinikum Leipzig AöR
[2]MPI for Human Cognitive and Brain Science, Leipzig
[3]C&C Research Labs, NEC Europe; St. Augustin
[4]Klinik und Poliklinik für Diagnostische Radiologie; Universitätsklinikum Leipzig AöR

A major problem in the treatment of complex malformations in Oral & Maxillofacial Surgery is the discrepancy between the ease of planning virtual bony changes and the difficulty to predict the final aesthetic outcome. To overcome the limitations of computational power at the surgeon´s hand and to allow the visualization of complex operations in almost real-time,grid-computing could be a solution. Therefore, a first application for Oral & Maxillofacial Surgery has been developed within the GEMSS project funded by the European Commission.

Methods

As a test-bed for grid-computing distraction osteogenesis (DOG) of the midface was chosen. DOG is the treatment of choice in complex midfacial hypoplasia and retrusion, often associated with craniofacial syndromes or cleft lip and palate. As these patients need large advancements of their midface (10 - 30 mm), distinct aesthetic changes have to be anticipated. To integrate the aesthetic aspects into operation planning, a modular tool-chain was developed as follows: 3-D-analysis of the individual pathology, segmentation and meshing, virtual bone cutting tool, FEM simulation, and visualization of the soft tissue changes. The basis for operation planning will be CT-scans acquired in DICOM format which are needed to evaluate the malformation. These are analyzed in a volume-rendered model where coordinates of bony and soft tissue landmarks are acquired which are the basis of a 3-D cephalometric analysis. Thus the individual pathology, asymmetries, and deficiencies are depicted. These form the rationale for the bone cutting tool described

later. Before that, the CT-data has to be segmented, meshed, and transferred into a volumetric FEM model. As clinicians typically do not have the knowledge to perform image processing, meshing and FEM analysis, the toolchain has been largely automated.
The virtual bone cutting tool was devised on top of OpenDX due to its extensibility and wide range of visualization features. The surgeon specifies bony cuts by selecting points on the bone surface which form closed polygons (fig. 1). Then the parts to be advanced are moved (fig. 2). Simulation of the distraction process is done by Finite Element analysis on a PC cluster with up to 64 nodes For a fast estimation, the result of a linear elastic material model is delivered to the surgeon within minutes.
For a more detailed analysis a viscoelastic model based on geometrically nonlinear hyperelasticity can be chosen which needs some hours of computation on the remote parallel PC cluster (fig. 3). The secure transport of data is handled by the GEMSS middleware layer.

Results

By now the first clinical setting has been established to connect a surgeon at a university hospital to the remote parallel machine. Test simulations have been performed successfully to evaluate the workflow.

Discussion

The above described system could help to present a solution for the delivery of high performance computing to a medical environment. The GEMSS middleware allows extension to any medical task, where time or space limitations of single PC systems are present. Regarding its application to Oral & Maxillofacial surgery simulation, the next step will be the evaluation of the accuracy of the simulations.