A hip surgery simulator based on patient specific models generated by automatic segmentation

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Background

Skills acquisition by training in simulator systems has been shown to improve the technical proficiency in image-guided surgical procedures [1]. For hip fracture surgery increased experience leads to fewer mistakes made during actual surgery as well as a reduction in radiation exposure time. Training and planning in a simulator would thus increase the safety for both patient and surgeon. To fully exploit these systems the virtual models must refer to the anatomy of individual patients. Patient specific models are essential if the systems are to be used as pre-operative planning tools. Individual models are important also in the education and training phase as the variety of anatomical cases to practice on is extended.

Tools and Methods

In this work we present a hip surgery simulator based on *patient specific models* of the femur and pelvis. The models are generated using an *automatic segmentation* method.

The system consists of a haptic device connected to the surgical tool for tactile feedback from the virtual models, 3D graphical models of the data, simulated fluoroscopy images, and sound reproduction. In the original system a hand-made polygon model based on generic data is implemented. The surgeon can use this system to practice the positioning of nail implants in the femoral bone. In this work the system is extended to include patient specific models generated from actual patient data. The virtual models are generated by segmenting the femur and pelvis from computer tomography (CT) data.

To obtain patient specific models of the anatomy one could simply segment the CT data from a specific patient manually and generate a model from that. This is, however, a very tedious and time consuming operation. For pre-operative planning it is necessary to obtain these models fast, which means that this step must be handled automatically. To accomplish this, a non-rigid registration algorithm, the Morphon method, has been employed [2, 3]. The method can be described as a general registration technique, where a prototype image/volume, is iteratively deformed to fit the corresponding structure in the target image/volume. In this application the prototype is a volume that describes the femur and pelvis as two objects clearly separated from the surrounding tissue. This representation is deformed to match the pelvis and femur in the CT volume of a specific patient. The registration is an iterative process where each iteration consists of the following steps: displacement estimation, deformation field accumulation and regularization, and prototype deformation. The algorithm is initiated on a coarse scale to capture large, global deformations, and moves on to finer scales making the registration more and more precise. The process is completely automatic and requires no user input during the registration. The result of the morphing is a volume with a segmented representation of the femur and pelvis from the specific patient. The final step is to generate a polygon model from this volume for the simulator.

Results

Figure 1 demonstrates snapshots from the simulator view where the generic model has been replaced by models generated from two different patients. The images on the top row shows models from one patient and the images on the bottom row are from another patient. More images and information can be found on the project webpage: www.imt.liu.se/mi/Research/simulator.

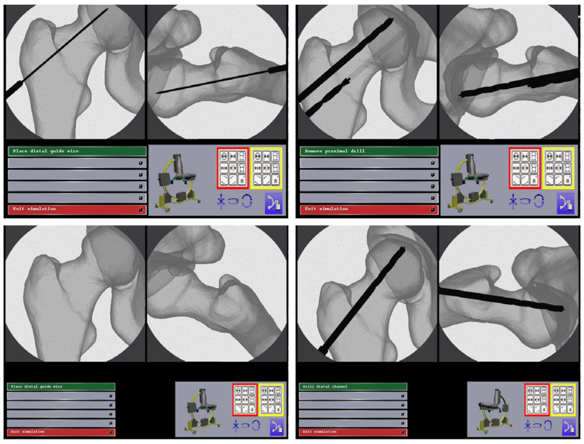

Figure 1: Snapshots from the simulator system with models generated from two patients (top and bottom row, resp.).

Conclusions

We have presented a hip surgery simulator based on *patient specific virtual models*. These models were *automatically segmented* and generated from patient CT data. The proposed method provides an efficient way to produce individual anatomical models for surgery simulation. In this way the simulator offers an excellent environment for examination of patient anatomy before surgery, as well as for training and education. Future work involves automatic segmentation of bones with cervical fractures and evaluation of the system with the new models.

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References

[1] G. Ahlberg, *The Role of Simulation Technology for Skills Acquisition in Image Guided Surgery*, Ph.D. Thesis, Karolinska Institutet, Sweden, 2005, Diss. 05:183

[2] A. Wrangsjö, J. Pettersson, H. Knutsson, *Non-Rigid Registration Using Morphons*, in Proc. of SCIA 2005

[3] J. Pettersson, H. Knutsson, M. Borga, *Generation of Patient Specific Bone Models from Volume Data Using Morphons*, in Proc. of NBC 2005