

Computergestützte Planung und Navigation neurochirurgischer Eingriffe an der Wirbelsäule

Computer based Planning and Navigation of Neurosurgical Incisions at the Spine

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Purpose

Surgical intervention at the cervical spine bear a high risk of neurological deficits for the patient while the size of the operation field decrease, because of the trend towards minimal invasive surgery. Although conventional intraoperative imaging techniques, such as fluoroscopy have proven useful, they are limited in that they do not provide information continuously. Because of the intraoperative movement of the spine an orientation for the surgeon is very difficult regardless of imaging technology. An improvement is to extend the navigation system with an intraoperative warning system for risk structures. Since the location of the risk structure varies with the progress of the operation the internal model of the operation field will be updated through soft tissue simulation. With this the movement of the spine and the deformation of the surrounding soft tissue can be calculated [1]. Furthermore we analyze the drill noise to increase the safety of pedicle screw placement [2].

Methods

Our approach provides the surgeon continuously with information of the operation field. We use segmented vertebrae and intervertebral discs from the preoperative planning step for geometric modeling of the cervical spine. During the operation we will track the movement of few structures in the operation field. That is sufficient because our 3D spine model allows us to reconstruct the locations of all other structures by using anatomical

knowledge. A real-time non-linear elastic finite-element model is used to simulate the biomechanical behavior of the spine intraoperatively and the surrounding soft tissue. Our aim is to provide the surgeon with reconstructed spine in short regular intervals. The spine model is implemented by the use of our medical simulation framework MEDIFRAME, which allows us to visualize and to interact easily with the “virtual” spine. Drilling in a vertebra with high accuracy to place pedicle screws is supported by an analysis of drill noise. The sound generated by the drill provides significant information about tissue.

Transitions between areas of different bone densities are highly correlated with the change of drill sound. Additionally this powerful add-on gives redundant information in case the navigation system should be improper or even fail. The methods we used to analyze the sound data are based on neural networks, support vector machines, and hidden markov models.

Results and Conclusion

We proposed a new method for risk reduction in neurosurgery of the cervical spine by using soft tissue modeling and analysis of the drill noise. First results prove the capability of the new methods. In the future we will improve the accuracy of the soft tissue model by taking into account more and more soft tissue structures especially the ligaments and the muscles. The sound analysis system will also be useful in training of unskilled surgeons.

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- [2] I. Boesnach, M. Hahn J. Moldenhauer, Th. Beth: “Analysis of Drill Sound In Spine Surgery”, MRNV2004, Remagen, Germany, 2004



