Real-Time Non-Radiation Based Navigation Using 3D Ultrasound for Pedicle Screw Placement

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Advances in imaging techniques and computed navigation systems have improved the accuracy of pedicle screw placement. However, currently available navigation systems, based on intraoperative radiography, exposes both the patient and the operating team to ionizing radiation. Furthermore, the clinical accuracy requirements for certain levels of spine still exceed the accuracy of the current image guided navigation systems. Therefore, the specific studies proposed in this work are intended towards the design of a new cost-effective and non-radiation based navigation system for spinal fusion surgeries. This new system will have the ability to provide continuous validation and accuracy assessment during pedicle screw placement resulting with a system accuracy acceptable for all levels of spine.

We hypothesize that an integrated guidance system, based on intra-operative real-time 3D ultrasound (US) imaging, with improved modeling, segmentation and registration tools can provide enhanced guidance facilitating high precision pedicle screw placement in all levels of spine by allowing continuous clinical decision making during the procedure. In order to achieve the stated objective of this proposal, we will take an incremental engineering approach and divide our objective into two smaller tasks. In task one we will develop robust and accurate machine learning techniques for automatic identification of important anatomical landmarks and highlight target sites in real-time 3D US volumes based on their unique image signatures. These highlighted features will provide real-time guidance during the procedure. The second task will involve the development of registration method for registering a statistical shape model of the spine to the intra-operative 3D US data in real-time. This will allow for additional augmentation during the surgery and pedicle insertion. The proposed system will be validated on cadaver studies. The proposed work will provide a guidance platform for improved clinical outcome in spinal fusion surgeries by significantly increasing the accuracy during pedicle screw insertion. Furthermore, the application of our proposal is not limited to spine surgery, as the technology may be applied to other image-guided orthopedic surgeries (pelvic ring fracture, scoliosis surgery, complex femur fracture).