Robot assisted prostate surgery using augmented reality with deformable models

Release 0.00

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June 20, 2012

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Abstract

We present preliminary results of our work to develop an augmented display for improved visualization of the prostate and surrounding critical anatomy for robot-assisted prostate surgery. Prostate cancer is the second leading cause of cancer-related deaths in men in the United States. Early stage prostate cancer is potentially cured by surgery, which can be performed in a traditional, open fashion or laparoscopically. Recently, robot-assisted laparoscopic radical prostatectomy (RALP) using the da Vinci surgical robot system has gained wide acceptance. Robotic systems improve surgeon dexterity by incorporating additional degrees of freedom at the end of the tools and offer increased precision and stability of movements. However, since the procedure is performed through small incisions, this technique reduces free sight and tactile feedback compared to open surgery. Surgeons also lose the ability to palpate the prostate to locate tumors and other critical structures such as neurovascular bundles (NVB). Surgeons must rely on visual cues from the video monitor and mentally correlate them with the underlying anatomy, often using information from medical images obtained prior to the procedure. Further complications arise from local deformations in the prostate tissue that occurs throughout the prostatectomy procedure due to the interaction between the surgical instruments and the prostate tissue. Subsequently, the anatomical model generated pre-operatively will need to be updated during the procedure to reflect this deformation. To address the clinical need for more accurate and reliable guidance, we are developing a navigation system that provides surgeons with an augmented reality (AR) view that fuses a pre-operative MRI model of the prostate, tumor and surrounding tissues with the da Vinci system laparoscopic video, while compensating for non-rigid prostate tissue deformation using intra-operative transrectal ultrasound (TRUS) imaging. The work focuses on three components: (i) Developing and evaluating algorithm for registration of MRI and ultrasound images (2) Building and testing an augmented reality, with 3D Slicer, Surgical Assistant Workstation (SAW) and the da Vinci surgical robotic system. (3) Evaluate the system using a multi-modality prostate phantom.