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Laser Registration and Supervisory Control of neuroArm Robotic Surgical System

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Abstract : This paper illustrates the concept of an algorithm to register specified markers on the neuroArm surgical manipulators, an image-guided MR-compatible tele-operated robot for microsurgery and stereotaxy. Two range-finding algorithms, namely time-of-flight and phase-shift, are evaluated for registration and supervisory control. The time-of-flight approach is implemented in a semi-field experiment to determine the precise position of a tiny retro-reflective moving object. The moving object simulates a surgical tool tip. The tool is a target that would be connected to the neuroArm end-effector during surgery inside the magnet bore of the MR imaging system. In order to apply flight approach, a 905-nm pulsed laser diode and an avalanche photodiode are utilized as the transmitter and receiver, respectively. For the experiment, a high frequency time to digital converter was designed using a field-programmable gate arrays. In the phase-shift approach, a continuous green laser beam with a wavelength of 530 nm was used as the transmitter. Results showed that a positioning error of 0.1 mm occurred when the scanner-target point distance was set in the range of 2.5 to 3 meters. The effectiveness of this non-contact approach exhibited that the method could be employed as an alternative for conventional mechanical registration arm. Furthermore, the approach is not limited by physical contact and extension of joint angles.

Keywords : 3D laser scanner, intraoperative MR imaging, neuroArm, real time registration, robot-assisted surgery, supervisory control
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