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Development of a Real-Time Simulink Based Robotic System to Study Force Feedback Mechanism during Instrument-Object Interaction

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Abstract : Robotic surgery is used to enhance minimally invasive surgical procedure. It provides greater degree of freedom for surgical tools but lacks of haptic feedback system to provide sense of touch to the surgeon. Surgical robots work on master-slave operation, where user is a master and robotic arms are the slaves. Current, surgical robots provide precise control of the surgical tools, but heavily rely on visual feedback, which sometimes cause damage to the inner organs. The goal of this research was to design and develop a real-time simulink based robotic system to study force feedback mechanism during instrument-object interaction. Setup includes three Velmex XSlide assembly (XYZ Stage) for three dimensional movement, an end effector assembly for forceps, electronic circuit for four strain gages, two Novint Falcon 3D gaming controllers, microcontroller board with linear actuators, MATLAB and Simulink toolboxes. Strain gages were calibrated using Imada Digital Force Gauge device and tested with a hard-core wire to measure instrument-object interaction in the range of 0-35N. Designed simulink model successfully acquires 3D coordinates from two Novint Falcon controllers and transfer coordinates to the XYZ stage and forceps. Simulink model also reads strain gages signal through 10-bit analog to digital converter resolution of a microcontroller assembly in real time, converts voltage into force and feedback the output signals to the Novint Falcon controller for force feedback mechanism. Experimental setup allows user to change forward kinematics algorithms to achieve the best-desired movement of the XYZ stage and forceps. This project combines haptic technology with surgical robot to provide sense of touch to the user controlling forceps through machine-computer interface.

Keywords : surgical robot, haptic feedback, MATLAB, strain gage, simulink
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