A Novel Haptic Actuator for Robotic Surgery: Utilizing Soft Robotic Pneumatic Networks, a Closed Loop Control System, and an Electro-Pneumatic Control Board to Accurately Restore an Operator's Sense of Touch

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The novel haptic robotic surgical controller developed in this research is the only robotic gripper prototype to offer a surgeon the intuitive ability to remotely grasp an object, and to accurately replicate the pressure that the end effector encounters on the operator's hand. Though 652,000 minimally invasive robotic surgeries were performed in 2015, each surgeon operated without the benefit of the sense of touch. Recent meta-analyses of haptic (touch) prototypes have demonstrated that significant (67%) improvements might be realized if a device can be designed which incorporates haptic benefits, with improvement specifically desired for tumor palpation in cancer surgeries and delicate tissue handling during heart surgeries. This novel prototype represents the first design to successfully deliver "bio-mirroring" capabilities: haptic input, haptic force feedback, grasping control, a compliant end effector, pliable haptic output and a closed loop control system. This prototype made the first-ever use of soft robotic pneumatic networks in a haptic grasper and was pressurized with an electro-pneumatic control board. It utilizes MATLAB and Arduino to read and control fingertip sensor values. This interdisciplinary robotics experiment combined mechanical engineering, electrical engineering and computer programming. The results demonstrate that the remote actuator was correctly controlled by the user's hand motions, and haptic feedback was accurately provided to the user. The Flex Input Sensor values predict Flex Output Sensor values (average r = 0.926 +/- 0.0406) and the force measured by the Haptic Input Sensor predicts the force measured by the Haptic Force Feedback Sensor (average r = 0.986 +/- 0.0200) with a very high correlation and statistical significance.

Awards Won:

International Council on Systems Engineering - INCOSE: First Award of $1,000

International Council on Systems Engineering - INCOSE: First Award of $3,000

Office of Naval Research on behalf of the United States Navy and Marine Corps: Second Award of $1,500

First Award of $5,000

Intel ISEF Best of Category Award of $5,000