World Academy of Science, Engineering and Technology
International Journal of Mechanical and Industrial Engineering
Vol:12, No:02, 2018

Accuracy/Precision Evaluation of Excalibur I: A Neurosurgery-Specific Haptic Hand Controller

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Abstract : This study reports on a proposed method to evaluate the accuracy and precision of Excalibur I, a neurosurgery-specific haptic hand controller, designed and developed at Project neuroArm. Having an efficient and successful robot-assisted telesurgery is considerably contingent on how accurate and precise a haptic hand controller (master/local robot) would be able to interpret the kinematic indices of motion, i.e., position and orientation, from the surgeon's upper limp to the slave/remote robot. A proposed test rig is designed and manufactured according to standard ASTM F2554-10 to determine the accuracy and precision range of Excalibur I at four different locations within its workspace: central workspace, extreme forward, far left and far right. The test rig is metrologically characterized by a coordinate measuring machine (accuracy and repeatability < ± 5 μm). Only the serial linkage of the haptic device is examined due to the use of the Structural Length Index (SLI). The results indicate that accuracy decreases by moving from the workspace central area towards the borders of the workspace. In a comparative study, Excalibur I performs on par with the PHANToM PremiumTM 3.0 and more accurate/precise than the PHANToM PremiumTM 1.5. The error in Cartesian coordinate system shows a dominant component in one direction (δx, δy or δz) for the movements on horizontal, vertical and inclined surfaces. The average error magnitude of three attempts is recorded, considering all three error components. This research is the first promising step to quantify the kinematic performance of Excalibur I.

Keywords : accuracy, advanced metrology, hand controller, precision, robot-assisted surgery, tele-operation, workspace
Conference Title : ICEREA 2018 : International Conference on Experimental Robotics and Engineering Applications
Conference Location : Dublin, Ireland
Conference Dates : February 15-16, 2018