AbstractID: 3606 Title: Design and Quantitative Analysis of a Novel Brachytherapy Robot

Purpose: To design a novel brachytherapy robot and compare its static manipulability characteristics to two well-known robotic manipulators: the Puma560 and the Stanford Arm.
Methods and Materials: The open-source 3-D Slicer program was used to model the prostate from clinical CT data. Workspace dimensions were determined and applied to the design of a new robot. The robot was modeled mathematically using the modified Denavit and Hartenberg representation of robotic manipulators. The static force and velocity manipulability ellipsoids were calculated for all three robots in several different poses using the Robot Toolbox for Matlab® (P.I. Corke, CSIRO, Australia, 2002). The force and velocity transformation ratios were computed and compared for similar poses. A small transformation ratio indicates the robot is sensitive to errors in control tasks, but not well-suited for actuation tasks. The manipulability measure was also calculated. The manipulability measure is a quantitation of the range-of-motion of a robot in a given pose.
Results: The calculations show the brachytherapy robot can implant a needle with a good balance of force and velocity with a high percentage of the maximum values. The Puma560 is relatively balanced, however most transformation ratios are less than 10% of the maximum. The Stanford Arm is not well balanced in both configurations studied. The Stanford Arm's transformation ratios are also relatively low percentages of the maximum. The manipulability measures for the brachytherapy robot were between 1.6 and 5 times higher than the other robots.
Conclusion: Several robots have been developed for brachytherapy implantations. None have provided quantitative comparisons to other robots. Here, static manipulability calculations compare different robots with a specific pose (initial task-oriented configuration). Our brachytherapy robot has balanced transformation ratios and also shows a high degree of manipulability. Initial calculations show that this robot is well configured for needle insertion tasks.