Design and optimization of a brachytherapy robot

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Trans-rectal ultrasound guided (TRUS) low dose rate (LDR) interstitial brachytherapy has become a popular procedure for the treatment of prostate cancer, the most common type of non-skin cancer among men. The current TRUS technique of LDR implantation may result in less than ideal coverage of the tumor with increased risk of negative response such as rectal toxicity and urinary retention. This technique is limited by the skill of the physician performing the implant, the accuracy of needle localization, and the inherent weaknesses of the procedure itself. The treatment may require 100 or more sources and 25 needles, compounding the inaccuracy of the needle localization procedure. A robot designed for prostate brachytherapy may increase the accuracy of needle placement while minimizing the effect of physician technique in the TRUS procedure. Furthermore, a robot may improve associated toxicities by utilizing angled insertions and freeing implantations from constraints applied by the 0.5 cm-spaced template used in the TRUS method.

Within our group, Lin *et al.* have designed a new type of LDR source. The "directional" source is a seed designed to be partially shielded. Thus, a directional, or anisotropic, source does not emit radiation in all directions. The source can be oriented to irradiate cancerous tissues while sparing normal ones. This type of source necessitates a new, highly accurate method for localization in 6 degrees of freedom. A robot is the best way to accomplish this task accurately.

The following presentation of work describes the invention and optimization of a new prostate brachytherapy robot that fulfills these goals. Furthermore, some research has been dedicated to the use of the robot to perform needle insertion tasks (brachytherapy, biopsy, RF ablation, etc.) in nearly any other soft tissue in the body. This can be accomplished with the robot combined with automatic, magnetic tracking.