

Adam Clayton

March 12, 2012

Critical Review

Introduction

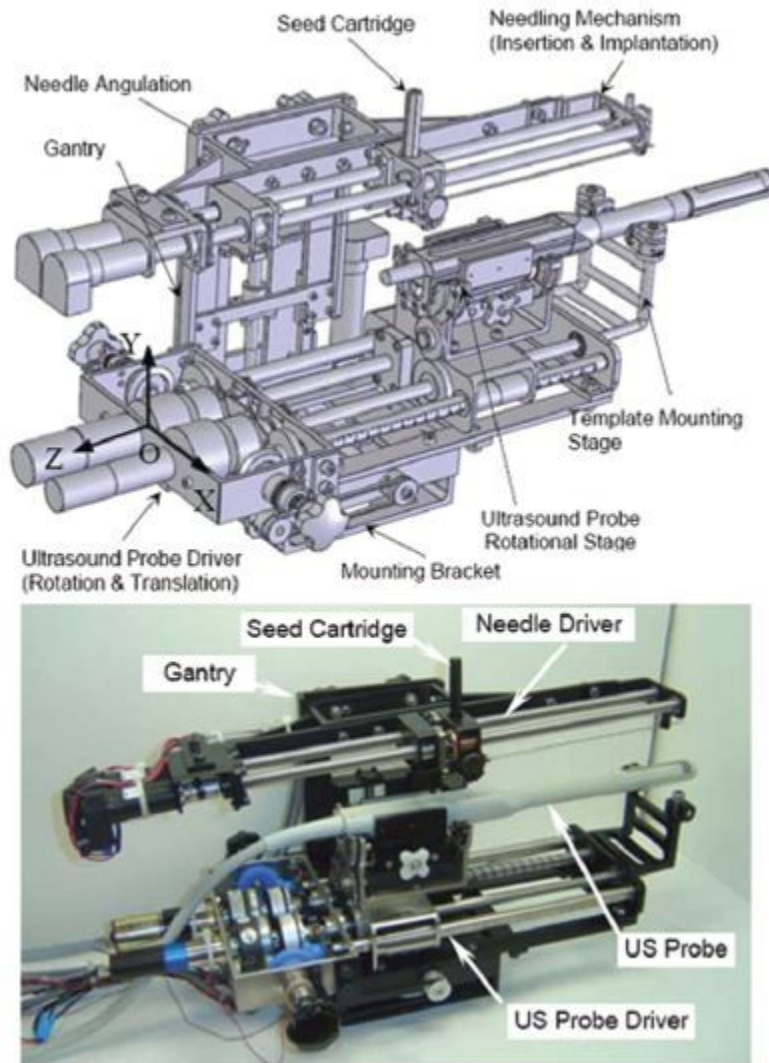
The paper I am reviewing is Robotic system for prostate brachytherapy authored by Y. Yu, T. K. Podder, Y. D. Zhand, W. S. Ng, V. Mistic, J. Sherman, D. Fuller, D. J. Rubens, J. G. Strang, R. A. Brasacchio, & E. M. Messing presented in the scientific journal of Computer Aided Surgery. The paper presents a prototype robotic system, named the Euclidean, designed to perform prostate brachytherapies. The paper gives a detailed technical analysis of the robotic system as well as the benefits the system would provide in the operating room. The paper also presents the results of experiments designed to test the accuracy and reliability of seed placement. The paper did a good job at presenting the robot with all of the technical details as well as the results of the experiments.

Summary

In the introduction the paper begins by describing the current state of conventional non-robotic prostate surgery. Radioactive seeds are manually injected into the prostate using a physical template and transrectal ultrasound (TRUS) for guidance. While the conventional approach has worked well it has a number of flaws and limitations. There is a lack of inflexibility and maneuverability induced by the physical template. This lack of inflexibility and maneuverability makes it difficult to avoid the pubic arch. Another flaw is that the consistency and efficiency of the treatment depends on the clinicians doing the operation. There are a number of robotic systems that could mitigate these problems. A robotic system could improve accuracy, consistency, and efficiency even with less skilled or inexperienced surgeons. A robotic system built specifically for prostate brachytherapy was built by Fichtinger et al. and Stoianovici et al., but this system lacked precise encoding for needle depth. Another system was built using an industrial robot to position and orient a single-hole template. The problem with this system was the fact that industrial robotics could lose dexterity when working in the confined space in the operating room. The purpose of the paper is to present the detailed design and development of a prototype robotic system called Euclidean, the sequence of operations when using Euclidean in clinical procedures, and the results of preliminary experiments to evaluate Euclidean's accuracy and repeatability in prostate seed implantation.

The objectives of the the Euclidean system are to improve accuracy of needle placement and seed delivery, improve avoidance of critical structures (urethra, pubic arch, bladder, etc.), update dosimetry after each needle is implanted (automatic seed localization), detect tissue heterogeneities and deformation via force sensing and imaging feedback, reduce trauma and

edema, reduce radiation exposure, reduce the learning curve, and reduce OR time. Some important functional requirements for this system include "provision for reverting to conventional manual brachytherapy method at any time," "visual/haptic force feedback during needle insertion," and "ability to steer the needle by automatic feedback control." The robot consists of two modules, the positioning module and the surgery module. The positioning module consists of a 3-DOF cart and a 6-DOF platform. The 3-DOF cart can rotate on the vertical axis and the translate in the horizontal x-y plane. The 6-DOF platform connects the surgery module to the cart, and is able to translate and robot in all directions. The surgery module a 2-DOF ultrasound probe driver, a 3-DOF gantry, a 2-DOF needle driver, a seed pusher, and a teach-pendant. The 2-DOF ultrasound probe can be rotated and translated by two servo motors. The 3-DOF gantry connects the needle platform to the positioning platform. The gantry can translate in the x-y direction and rotate.



After testing the results of the "assessment of the deposited seeds revealed that the

accuracy (rms error) of seed placement is 0.67mm (SD=0.58mm) in the x direction, 0.13mm (SD=0.12mm) in the y direction, and 0.11mm (SD=0.11mm) in the z direction. The 3D (Euclidean) rms error is 0.69 mm, which is quite small in comparison to the clinically acceptable (or desirable) value of 2.0 mm."

Critique

The introduction for this paper was excellent. It started off with a description of conventional prostate brachytherapy, then progressed on to the problems with the conventional approach, then on to how robotic systems could mitigate those problems, then on to the previously developed robotic prostate brachytherapy systems and their weaknesses, then finally on to the system that was being presented in this paper. This progression clearly laid out the purpose of the paper, the relevance their research has to prostate brachytherapy, and the previous work that has been done on the subject.

The System design and development section was very good at explaining the design of system, but it contained many details that did not add to the subject to the paper. Stating the design goals of the system was a good, but including the complete functional requirements was superfluous. While general requirements like a "provision for quick and easy disengagement" are definitely important for any device in the operating room, they are not what makes the robot good for prostate brachytherapy. The authors continue to go provide superfluous facts about the system throughout this section. Examples include facts like the specific the processor class and clock rate, as well as the RAM of the robots computer.

In addition to being superfluous some of the items listed as functional requirements are too vague to be good functional requirements. Items such as improved prostate immobilization techniques are very open to many interpretations especially since what the techniques that need to be improved are not explicitly stated.

Conclusions

Overall the research and development that the paper reported on seems be very good, but the paper itself is has some serious flaws. The authors went into far too much detail in explaining the system design, but far too little detail in the experiments section. Had I been the editor of the journal, I would have requested that the author resubmit the paper with more detail in the experimental results.