

Medical Image Analysis Assignment 2

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1 Summary and Goals

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. Misic, J. Sherman, D. Fuller, D. J. Rubens, J. G. Strang, R. A. Brasacchio, and E. M. Messing, which was published in the Journal of Computer Aided Surgery. The paper presents a prototype robotic system, named the Euclidean, designed to perform prostate brachytherapies. It 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.

2 Summary

In the introduction the paper begins by describing the current state of conventional non-robotic prostate surgery. They briefly describe the process of how radioactive seeds are manually injected into the prostate using a physical template and transrectal ultrasound (TRUS) for guidance. Following the brief description of the conventional approach they begin to point out the flaws and limitations of it. They point out the lack of inflexibility and maneuverability induced by the physical template, the difficulty in avoiding the pubic arch, and the fact that the consistency and efficiency of the treatment depends on the clinicians doing the operation. Having pointed out the problems of the conventional approach the authors point out robotic systems could mitigate these problems. They point out that a robotic system could improve accuracy, consistency, and efficiency even with less skilled or inexperienced surgeons. Now having established the benefits of robotic prostate brachytherapy the author begins to describe the previously developed robotic prostate brachytherapy systems. They describe the system built by Fichtinger et al. and Stoianovici et al., and how the system lacked precise encoding for needle depth. They briefly describe a system built using an industrial robot to position and orient a single-hole template. The problem they pointed out regarding this system was the fact that industrial robotics could lose dexterity when working in the confined space in the operating room. Following these brief descriptions of previously developed systems, the authors finish the introduction with a statement of purpose for the

paper. The purpose of the paper is to presents 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. Following the introduction the "System design and development system" section explains the goals, functional requirements, and design of the Euclidean system. The objectives 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. The functional requirements of the systems are " Provision for quick and easy disengagement in case of emergency", "provision for reverting to conventional manual brachytherapy method at any time," " improved prostate immobilization techniques," "provision for periodic quality assurance checking," " Provision for updating the implantation plan after implanting the periphery of the prostate, or after most of the needles have

3 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 as applied 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 provide superfluous facts about the system throughout this section. Examples include facts like the specific 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 the techniques that need to be improved are not explicitly stated.

Aside from the problems mentioned above the System Design and Development section did a very good job at breaking down the system, explaining

each component and its function, and how the components fit together. This explanation left me with a good understanding of the design of the system, and how it operated.

In the results and discussion section, the phantom gel experiment lack many crucial details. The authors reported the accuracy statistics, but they did not report on how the data was compiled, they do not report the number of samples involved in the experiment, and they do not explain how they determined the accuracy of the seed insertion. They do report the depth in the phantom gel to which the seeds were injected but they do not define the axis in the data they reported.

4 Conclusion

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.