

Can We Do da Vinci-Like Surgery With Steerable Needles?

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Abstract—This paper is associated with an invited presentation at the Mini-Symposium entitled *Novel Technology Platforms for Improved Surgical Intervention & Guidance at the 36th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*. The presentation provides an overview of recent advances in the theory and application of concentric tube robots with emphasis on their use as teleoperated manipulators in surgical applications.

I. INTRODUCTION

The Mini-Symposium abstract (by organizer Michael Miga) is as follows:

“With the dramatic increases in high performance computing, extensive developments in digitization instrumentation and intraoperative imaging, advances in medical robotics design, and the continued need for the integration of patient-specific data within interventional and operating room theatres, the realization of new paradigms for the improved surgical care of patients is an area of active research. In this mini-symposia, three separate intraoperative frameworks will be presented that demonstrate procedure-specific novel technology integrations for the improvement of surgical care of patients. The advancements represent: (1) the integration of image analysis for intraoperative guidance and decision support, (2) the use of computational models for the enhancement of therapeutic delivery, and (3) the advent of miniature, steerable, nonlinear robotic effectors that can facilitate procedures not possible with traditional surgical robots. These talks will be cast within the context of otolaryngological, neurosurgical, pulmonary, abdominal, cochlear, and urological procedures. Going further, essential to the success of these frameworks is the inspiration, continued evaluation, and feedback provided by our clinical teams. To address this, the symposia will also include an overview from the surgeon’s perspective presented by Vanderbilt’s Director of Robotic Surgery who will provide a perspective on the integration of these technologies in the operating rooms of the future. Finally, we will conclude the symposia with all the speakers available for a panel discussion.”

II. PRESENTATION DESCRIPTION

The da Vinci robot of Intuitive Surgical has transformed the way urologists perform prostate surgery, and inroads are

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being made in other procedures. However, there remain areas of the body that cannot be reached by da Vinci manipulators because of their (relatively) large diameters and rigid tool shafts. A steerable needle technology using concentric, curved, elastic tubes promises to reduce the diameter of surgical robot manipulators to the size of a needle, while simultaneously endowing them with the ability to elongate and bend like a tentacle. This talk describes how these robots are designed and controlled. It also discusses several options for how surgeons can operate the robot. Lastly, we will discuss a variety of new procedures that these robots enable including endonasal surgery, lung surgery, neurosurgery and transurethral prostate surgery.

A thorough recent review of the history and applications of concentric tube robots is available in [1], and a review of the broader class of continuum robots (of which concentric tube robots are members) can be found in [2]. Concentric tube robots can be used as either manipulators or steerable needles. They were first proposed for use as steerable needles as far back as the mid 1980s when the Mammalok product came to market [3] and as robotic manipulators by two independent groups simultaneously in 2006 [4], [5]. Since then, a mature mechanics-based modeling framework has emerged [6], [7], and applications in cardiac, lung, endonasal, and neurosurgery have been studied in depth. A review of these and other applications can be found in [1].

The presentation concludes with the view that concentric tube robots are poised to extend the benefits of robotic surgery into areas of the body and surgical specialties that have not yet benefited from the robotic surgery revolution of the past several years.

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