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Introduction

Special issue on Surgical Robotics

Welcome to this Special Issue on *Surgical Robotics*.

Of the many opportunities offered by Robotics outside industrial applications, Medical Robotics, and in particular Robotic Surgery, is certainly the one that has achieved wider acceptance by the user community and that has generated positive responses from the scientific, medical and financial communities. Robotic Surgery is in the very favourable situation of still being a research area, of being routinely used in the clinical practice, and of generating significant revenues for its developers. These three factors together make Robotic Surgery a very active field where new ideas, applications and products are continuously presented and discussed.

For these reasons, a large amount of scientific material is produced and this special issue had the privilege of selecting its papers from a large pool of high quality candidates. Thus, in this special issue we are able to cover a few important aspects of Robotic Surgery with excellent papers by well known researchers in the field. The conceptual organization of the special issue starts with an **overview of mechanical designs of surgical** robot in the first paper, going to a more detailed description of **robotic instruments** in the second paper. Then in the third paper, we move to the **structure of the surgical robot**. With the fourth paper we start examining **robotic "systems"** for surgery, and in particular this paper focuses on neurosurgery. The fifth paper addresses the **surgeon perception**, especially when force feedback is present. The **generation of force feedback** is examined in more detail in the sixth paper and the **integration of all advanced features** in a complete system is described in the seventh paper. Finally, the last paper addresses the needs of **accurate organ modeling** and simulation. More in detail, a brief summary of each paper is presented next.

The first Paper "*Comparative review of endoscopic devices articulations technologies developed for minimally invasive medical procedures*", by J. Catherine, C. Rotinat-Libersa, and A. Micaelli, introduces a comparative performance analysis of the technological solutions normally used to build devices (distal active articulations) for minimally invasive medical procedures. A review of the different articulations developed in the field is presented and organized by both actuation technology and structural architecture. The devices are evaluated keeping as a reference some chosen required performances and characteristics for minimally invasive surgical procedures. Also, a quantified comparison chart of these devices is given regarding selected criteria of interest for minimally invasive surgical application.

The Paper "*An instrumented minimally invasive surgical tool: Design and calibration*", by Philip R. Roan, et al, describes the development of a minimally invasive surgical tool with integrated sensors for replicating ischemia detection measurements during routine manipulation of the tissue, providing real-time feedback and diagnosis to the surgeon, and that can be used in a real operating room. The design of the tool and choice of the sensors leverages existing work in physiological measurements and surgical tool design. The tool includes a thermistor for measuring the temperature, four LEDs and a photodiode for measuring local optical absorption, and four electrodes for measuring the electrical impedance. The sensors are properly located on a minimally invasive grasper. A strain gauge, optical encoder, and a motor, monitor and control the applied force and position of the tool, allowing the tool to control the tool-tissue interface.

In the third Paper of this Special Issue, "*Dionis: A novel remote-center-of-motion parallel manipulator for Minimally Invasive Surgery*", by R. Beira R, L.

Santos-Carreras, G. Rognini, H. Bleuler, and R Clavel, propose a compact and accurate positioning mechanism, named Dionis, to improve the usefulness of surgical robots in minimally invasive surgery (MIS). The proposed spatial hybrid mechanism based on a novel parallel kinematics can provide three rotations and one translation for single port procedures. Another important feature of the proposed positioning manipulator is that it can be placed below the operating table plane facilitating a quick and direct access to the patient, without removing the robotic system.

The Paper "*A master-slave haptic system for neurosurgery*", by V. Zanotto et al, presents a master-slave haptic robotic system for minimally invasive neurosurgery, which can aid surgeons in performing safer and more accurate stereotactic neurosurgical treatments. The Paper also presents experimental tests to prove the accuracy of the overall system and to assess the effectiveness of the control schemes synthesized.

C. Stauba et al., in their paper "*Remote minimally invasive surgery - haptic feedback and selective automation in medical robotics*", present a novel approach that extends human-machine skill-transfer by a scaffolding framework. The approach assumes a consolidated working environment for both, the trainee and the trainer. The trainer provides hints and cues in a basic structure that can already be understood by the learner. Meanwhile, the scaffolding is constituted by abstract patterns, which facilitate the structuring and segmentation of information during "Learning by Demonstration". Using this concept the concrete example of knot-tying for suturing is exemplified and evaluated. The authors also propose a XFEM-based incision force prediction algorithm that simulates the incision contact-forces in real-time and compensate the delayed force sensor readings. To demonstrate the proposed approach, the authors use as a platform a realistic 4-arm system for minimally invasive robotic heart surgery.

The Paper "*Teletactile system based on mechanical properties estimation*", by M. M. Sette, H. Van Brussel, and J. Vander Sloten, present a novel approach for Tactile feedback based on the direct estimation of the tissue mechanical properties and their presentation to the operator by means of an haptic interface. The approach exhibits different technical difficulties and some solutions are proposed: the implementation of a fast Young's modulus estimation algorithm, the implementation of a real time finite element model, and also the implementation of a stiffness estimation approach in order to guarantee the system's stability. Also, an experimental evaluation of the whole system is presented.

R. Konietschke et al, in the Paper "*Integration of new features for telerobotic surgery into the MiroSurge system*", presents the integration of computed-aided features into the minimally invasive robotic surgery platform MiroSurge. The system structure of MiroSurge is presented as well as the interfaces for the new functionalities. Some details about the modules for motion tracking and for soft tissue simulation are given. Results are shown with an experimental setup that includes a heart motion simulator and dedicated silicone organ models. Both features are integrated seamlessly and work reliably in the chosen setup. The MiroSurge platform thus also demonstrates the potential to provide valuable results in evaluating new functionalities for minimally invasive robotic surgery.

Finally, in the Paper "*Stomach simulator for analysis and validation of surgical endoluminal robots*", S. Condino et al, present a design of a silicone stomach model and a mechanical setup to simulate gastric contractile motion. The developed stomach simulator is validated and its usefulness is demonstrated by means of internal pressure measurements and self-assembly tests of mock-ups of capsule devices. The results demonstrate that the stomach simulator is helpful for quantitative evaluation of endoluminal robotic devices before *in-vitro/in-vivo* experiments.

Applied Bionics and Biomechanics warmly welcomes past, current, and new authors to the regular and Special Issues of this journal that it is truly international in scope with published manuscripts from all over the world. We hope that the regular issues, this Special Issue on *Surgical Robotics*, and other upcoming Special Issues, will continue to be of great interest, use, and benefit to you.

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