Preface

Special Issue on Platforms for Medical Robotics Research

Medical robotics have been around us for 3 decades, yet today there is an unprecedented rise in applications and systems. Surgical robotics is entering new domains such as single site surgeries and advanced decision making support, requiring highly sophisticated manipulation capabilities. The coming generations of medical and surgical robots may not only function as an agile extension of the human eyes and hands, but will also become a skillful and coordinated partner for their human counterpart. In the last couple of years, outreach and community formation activities are gradually following the individual technical developments, striving to establish an R&D ecosystem.

Shared hardware and software platforms for robotic systems can foster collaboration between groups and accelerate the progress of technology development. In the medical robotics community, a variety of common research platforms and software frameworks have emerged, such as the RAVEN-II, the da Vinci Research Kit (DVRK) and the KUKA Lightweight Arm. The goals of this Special Issue are to more broadly engage the medical/surgical robotics community, present the latest developments, and to define the road map for future enhancements to these platforms. Some of these initiatives are supported by government initiatives as well, such as the U.S. National Science Foundation (NSF) National Robotics Initiative (NRI) grant "Collaborative Research: Software Framework for Research in Semi-Autonomous Teleoperation", and social media initiatives, such as the SurgRob blog (http://surgrob.blogspot.com).

Probably the largest such existing group, the DVRK community, uses hardware from the da Vinci classic surgical robot with separately developed DVRK controllers (https://github.com/jhu-dvrk/sawIntuitiveResearchKit/wiki) to facilitate research uses. Its history started 15 years ago, with the first efforts at Johns Hopkins University, to create/re-create a da Vinci research version. In 2012, the first key sites were added to the group (WPI, Stanford, UBC), and the first non-American groups joined in 2014. The PIs regularly meet at IEEE ICRA, IROS conferences, at the Hamlyn Symposium and other key international forums. Today, there are over 35 research labs across the globe taking advantage of the open controllers that provide access to the first generation da Vinci. Research projects range from novel, intelligent tool development to deep learning based endoscope stream segmentation and processing. Key topics addressed in this issue include the kinematic modeling of the da Vinci, where the WPI group proposed a modeling method of the closed-loop kinematics, using the existing da Vinci kinematics and an optical motion capture link length calibration. The Johns Hopkins group developed a compliance model that relates displacement of the first two joints of the da Vinci Patient Side Manipulator to lateral forces applied to the instrument shaft, which enables compensation for the position errors based on the measured joint efforts, which are derived from the measured motor currents. The Universita degli Studi di Napoli Federico II researchers present the Portable DVRK, which is based on a V-REP simulator (from Coppelia Robotics) of the DVRK patient side and endoscopic camera manipulators which are controlled through two haptic interfaces and a 3D viewer. The team at Óbuda University developed a software framework to ease and hasten the automation of surgical subtasks implementation, based on the Robot Operating System (ROS).

The other popular platform is the Raven (http://applieddexterity.com/community/raven-sites). The Raven I and the Raven II surgical robots, as open research platforms, have been serving the robotic surgery research community since 2002. The related article in this issue briefly presents the Raven I and the Raven II robots, and reviews recent publications describing research performed with the Raven robots, research on improvements to the Raven robots, or research directly compared with the Raven robots, and uses the Raven robots as a case study to discuss the popular research problems in the research community and the trend of robotic surgery study.

Other contributions to this volume describe systems and surgical techniques, such as the article from the group at Queens University, presenting two open-source technologies based on electromagnetic tracking: a navigation system to help target needles using a tracked needle guide, and software for electromagnetic reconstruction of catheter paths.

The overall accuracy assessment methods of image-guided systems are discussed and a stochastic approach is provided by the article from Óbuda University. In another paper from UniÓbuda, a review of the manual and automated Robot-Assisted Minimally Invasive Surgery (RAMIS) skill assessment techniques is provided, focusing on their general applicability, robustness and clinical relevance.

All advanced development projects relate in some way to engineering standards. A new standard, IEC 80601-2-77, was recently issued to establish safety requirements for surgical robots under regulatory control, and is reported on in the paper by a senior researcher at the Japanese National Institute of Advanced Industrial Science and Technology (AIST).

The contributions in this book are evidence that this community will continue to grow and strive for many more years, providing significant R&D results to feed the innovation chain in medical robotics towards the goal of better outcomes for surgical patients.

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