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Russell Taylor & Dan Stoianovici talk with *ScienceWatch.com* and answer a few questions about this month's Fast Moving Front in the field of Engineering.

Article: Medical robotics in computer-integrated surgery
Authors: Taylor, RH;Stoianovici, D
Journal: IEEE TRANS ROBOTICS AUTOMAT, 19 (5): 765-781, OCT 2003
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SW: Why do you think your paper is highly cited?

This survey article described the state of the art in medical robotics and computer-integrated surgery at a time that this important research topic was beginning to experience rapid growth and interest. It was the lead article in a special issue on medical robotics in the leading engineering journal devoted to robotics. One of the coauthors (Taylor) was one of the founders of the field. The other author (Stoianovici) had already made many contributions to the design of medical robots. This perhaps gave the paper a high degree of credibility.

SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

This was a survey article summarizing the state-of-the-art and research themes in medical robotics and computer-integrated surgery. As such, it was more a synthesis of knowledge than a paper devoted to a single research innovation. In writing the paper, we focused strongly on the relationship between technology (robotic devices, imaging systems, computation, human-machine interfaces) and clinical application.

SW: Would you summarize the significance of your paper in layman's terms?

This survey paper provides a broad overview of medical robot systems used in surgery. As such, it provided a very useful guide to researchers wishing to enter the field. Although intended for an engineering audience, it is written in a way that should make it accessible to clinicians and non-specialized readers as well.

The survey uses two basic concepts, Surgical CAD/CAM and Surgical Assistance, to organize the discussion. "Surgical CAD/CAM" refers to the process of constructing a computer model of a patient from medical images and other information, using this model to plan an intervention, registering the computer model and plan to the actual patient, and using robots and other technology to help carry out the plan. "Surgical Assistance" refers to the use of robotics and information technology to enhance the ability of human surgeons to perform surgical procedures.

After introducing the concepts, the paper discusses some of the major design issues particular to medical robots. It then illustrates these issues and the broader themes introduced earlier with examples of current Surgical CAD/CAM and Surgical Assistant systems. Finally, it provides a brief synopsis of current research challenges and closes with a few thoughts on the research/industry/clinician teamwork that is essential for progress in the field.

Coauthor
Daniel Stoianovici

SW: How did you become involved in this research and were any particular problems encountered along the way?

Russell Taylor was one of the founders of the field of medical robotics. While at IBM Research in the 1980s, he became interested in the notion that medical robots and related technology could have the same sort of impact on surgery and interventional medicine that industrial robots and related technology have had on manufacturing.

After leading the development of the ROBODOC system for orthopedic surgery and early robot systems for minimally invasive surgery, he moved to Johns Hopkins in 1995, where he is the founding Director of the NSF Engineering Research Center for Computer Integrated Surgical Systems and Technology. Taylor's personal web site describes a number of his current research activities in medical robotics and computer-integrated interventional medicine.

Dan Stoianovici has had a manufacturing and robotics background before joining the cross-disciplinary medical robotics research group at Johns Hopkins in 1996. There he trained in urology research and built the Urology Robotics program in the Medical School. Medical applications rise challenging problems for robotic engineers above and behind traditional robotic developments, such as medical safety, sterility, compactness, and compatibility with medical imaging equipment.

Dan's design and hands-on manufacturing abilities gave him a competitive edge in the field, which was also fueled by his ideally matched passion. Today, his lab is a unique venue for medical robotic hardware and at the forefront in the field. His inventions include a new type of motor, PneuStep, capable of operating within Magnetic Resonance Imaging scanners.

SW: Where do you see your research leading in the future?

The technology in medical robots—the mechanisms, sensors, imaging, human-machine interfaces (HMI), etc.—will continue to see rapid development over the coming years. Several trends that seem especially important include: 1) development of very small, highly dexterous robotic devices for minimally invasive surgery; 2) development of extremely precise robots for microsurgery; 3) development of specialized robots for performing procedures inside MRI, CT, and other specialized imaging environments; 4) integration of all of these systems with the information infrastructure of the hospital, so that surgical procedures become truly computer-integrated; and 5) much greater exploitation of the information generated during robotic procedures to promote the improvement of surgical plans and techniques through the comparison of (eventually) known outcomes with analysis of what was done to improve surgical plans and processes.

SW: Do you foresee any social or political implications for your research?

Medical robots are already beginning to have significant impacts on surgery and other medical interventions. By improving accuracy and by enabling minimally invasive procedures that would otherwise be impractical or impossible, they promise to improve outcomes while improving safety and consistency of interventions. Despite the high capital costs associated with some systems, the improvements in outcomes will ultimately lead to more cost-effective treatments of serious medical conditions.

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