“Cognitive concepts for surgical robotics included in the OP:Sense platform”

Jörg Raczkowsky, Karlsruhe Institute of Technology
Institute for Process Control and Robotics

Abstract

A number of commercial systems for robot assisted surgery are currently available [1]. According to the specific needs of different surgical disciplines these systems are specialized on a certain type or class of surgical treatments. The integration level is pretty low. Important information about the working surrounding of the robot, e.g. the surgical personnel and their actions, are not integrated into any of the actual systems. Our approach, the research platform OP:Sense [2] as a future generation of modular surgical robotic systems is characterized as follows: (a) fast adaptation to different types of interventions due to its modularity, (b) enable the surgeon to choose the optimal control mode and (c) integrate sensing capabilities for the perception of actions and the surrounding of the robotic system. The modular research platform OP:Sense consists of different types of components classes: actuators (e.g. KUKA light weight robots (LWR), Stäubli RX90, PI hexapod system), human machine interfacing capabilities (e.g. haptic input devices by Force Dimension, hands-on by force/torque-sensing) and an extensive sensing system (e.g. different camera systems for tracking and 2/3D vision, ultrasound, force/torque-sensing), see Figure 1. For robot control, the OP:Sense system offers three different modes to the surgeon: telemanipulation, hands-on mode and automatic mode. The surgeon has the option to switch between the different modes. He can select the best fitting mode to perform the optimal action to the patient. The system concept and architecture of the OP:Sense system support the adaptability to different surgical scenarios. For example, to evaluate the feasibility of using a KUKA LWR for osteotomy, two different studies have been performed using a single light-weight robot, a haptic input device [3] and the marker based tracking system. For performing the ablation different effector are being used: a milling tool and a CO2 laser. A pre-planned trajectory was then executed, controlled either by telemanipulation mode or completely automatically. For expanding the sensing capabilities, an ultrasound probe was mounted onto the robot and guided along the anatomic region of interest, i.e. a human arm. This configuration is taking advantage of the internal torque sensing of the LWR. A force-based adaptive guidance could be achieved along the complete trajectory. This sensing system would allow the surgeon in future to mark starting and end pose on the skin surface to be scanned automatically by the robot. An on-line image processing and an adaptive probe control will guarantee an optimized 3D image acquisition. In these different surgical scenarios, the camera based supervision is designated to guarantee a safe interaction [4] between the surgical personnel, the patient and the robot even by sharing the same workspace. Currently we are working on a level-dependent interpretation of the different sensor data and a semantic integration for situation awareness. This will be part a workflow based master control of the complete operating room. In summary, the OP:Sense system presents a modular approach for robotic surgery, allowing the surgeon to optimally configure the system to the specific application needs of individual patient treatment. Different surgical concepts have already been evaluated or are under current research, including further topics such as workflow detection and enhanced safety features. This research will help to organize a high-automated operating room by preventing mental overload of the surgical personnel. The goal is an optimal interlocking of human and machine capabilities.
Figure 1. OP:Sense set up with two light-weight robots in hands-on mode and different camera systems

References


Speaker Bio

Dr.-rer.nat. Jörg Raczkowsky studied Mechanical Engineering at the Engineering School Karlsruhe from 1972 to 1975, then he continued his education on Electrical Engineering at the University of Karlsruhe with emphasis on Information Processing (1975 to 1981). He obtained his Diploma Degree in 1981. Until 1981 he was research assistant at the Institute for Real-Time Computer Control Systems and Robotics (IPR), Faculty for Computer Science of the University of Karlsruhe. He received his Doctoral Degree in Informatics in 1989. Since 1990, he holds a tenure position as ‘Akademischer Rat’ at the IPR and since 1995 the position of an ‘Akademischer Oberrat’. Now, he is the head of the Medical Robotics Group of the institute. Additionally Dr. Raczkowsky is managing the laboratories including the computer network of IPR. His field of research covers sensor systems for robotics with emphasis on autonomous systems, especially the application of methods to handle uncertainty of robot applications. Since 1994, he concentrated his research interests on the field of medical robotics/technology. Dr. Raczkowsky is the author or coauthor of over 100 scientific papers and has written a book on multi sensor data processing.