From mini-invasive surgery to endocavitary / endoluminal interventions – Part I: Research issues in endoscopic mini-invasive surgery

Description

Goals: Robotics should enable surgery and diagnostic to be less and less invasive. Many prototypes have been developed and validated these last years: robots to manipulate instruments within the abdomen or thorax through small incisions; image-guided percutaneous devices for therapy, biopsy, etc.; mini-robots dedicated to exploration, diagnostic, and therapy through endocavitary or endoluminal access. The objective of the tutorial is to present the key theoretical issues and practical research topics that are, or need to be, investigated.

Due to the large area covered, the tutorial is organized in 2 sessions of 3 hours. This first session will cover rather theoretical aspects on sensory-based robot control for minimally invasive surgery (MIS) while the second session will be more application-oriented and will present advanced works and trends for the design of the next generation of surgical robots and devices.

Provisional schedule

- **Visual servoing for physiological motions compensation**, Tobias Ortmaïer (DLR, Munich), Jacques Gangloff (LSIIT, Strasbourg)
- **Position and force control issue in minimally invasive surgery**, Philippe Poignet (LIRMM, Montpellier), Guillaume Morel (LRP, Paris)

Responsible organiser

Etienne Dombre, `dombre@lirmm.fr`

Detailed schedule

- **Visual servoing for physiological motions compensation**, Tobias Ortmaïer (DLR, Munich), Michel de Mathelin (LSIIT, Strasbourg)

  Minimally invasive robotic surgery offers substantial benefits for the patient and allows for new gentle operation techniques. Unfortunately, organ motions (especially during operations on the beating heart) challenge the surgeon's skills and lead to long operation durations and unsatisfactory results. Therefore, an important research topic concerns the compensation for the physiological motion by the robot. A potential solution is for the surgeon and robot to share tasks: the robot compensates for the disturbing organ motion and the surgeon focuses on the surgical intervention, now being performed on a virtually stabilized organ. Such an advanced robotic system has to be able to track the organ motion reliably as this is a prerequisite for motion compensation. This presentation focuses on robust motion tracking techniques based on surgical interventions on the beating heart and on a moving liver due to respiration. It is shown how a medical robot can track physiological motions of a moving liver and a beating heart by fast real-time visual feedback.

Jacques Gangloff received the Electrical Engineering degree from the Ecole Nationale Supérieure des Arts et Industries de Strasbourg in 1992. He obtained the agrégation in Electrical Engineering at the Ecole Nationale Supérieure de Cachan in 1995. He received the M.S. degree and the Ph.D. degree in robotics from the University Louis Pasteur, Strasbourg, France in 1996 and 1999 respectively. Since 1999, he is Maître de Conférences at the University of Strasbourg. He is member of the Robotics team at the LSIIT (Laboratoire des Sciences de l'Image, de l'Informatique et de la Télédétection). He received the Best Vision Paper Award at the IEEE International Conference on Robotics and Automation (ICRA'04) in April 2004. His research interests include mainly visual servoing, predictive and repetitive control, and medical robotics.

Tobias Ortmaier studied "Electrical Engineering and Information Technology" at the Munich University of Technology within the program of emphasis: "Automation and Autonomous Systems" 1993-1998). During this period I received a scholarship of the Catholic church ("Bischöfliche Studienförderung Cusanuswerk"). In 9/1998 he joined the "Institute of Robotics and Mechatronics" of the German Aerospace Center (DLR) in Oberpfaffenhofen and received my PhD in electrical engineering in 4/2003. His work includes the setup of a force-reflecting telepresence system for minimally invasive robotic surgery as well as the development of robust algorithms to capture the heart motion in beating heart surgery. The goal is to develop a robotic telepresence system which is capable of autonomously compensating for the heart motion. With such a system the surgeon will be able to focus on the surgical intervention without being disturbed by the undesired organ motion, as he operates on a virtually stabilized beating heart. Since 11/2003 he his holding a one year post-doctoral position at the "Laboratoire de Robotique de Paris" of the Université Paris 6. His main research interests are robotic surgery, control, kinematics, and computer vision.

http://www.robotic.dlr.de/Tobias.Ortmaier/

- **Position and force control issue in minimally invasive surgery**, Philippe Poignet (LIRMM, Montpellier), Guillaume Morel (LRP, Paris)

  This tutorial will focus on some basic and advanced control issues related to endoscopic surgery. The first part of the talk will concern the kinematic aspects of the problem: specific constraints apply to laparoscopic manipulation (e.g. the trocar kinematic constraint, the workspace constraints, ...), which have lead to different approaches for the design and control of both the inner and the outer degrees of freedom. The talk will provide a survey of the different research activities in this domain. A second part of the talk will focus on force control and haptic rendering issues. In laparoscopic manipulation, force control can be used either to autonomously control the interaction between the instrument and the organs, or within a force feedback teleoperation system with haptic rendering of the interaction forces to the surgeon through an actuated master device. The talk will cover the different research issues related to this problem: force measurement for endoscopic surgery; interaction modelling; control design; methodology for the experimental evaluation of the benefit of force feedback and haptic rendering for surgery.

Guillaume Morel has obtained a Master Degree in Electrical Engineering and a PhD in Robotics at the University of Paris 6 in 1990 and 1994, respectively. He then spent about two years at the Massachusetts Institute of Technology, in 1995-96, where he joined the Field and Space Robotics Lab as a Postdoctoral Research Assistant. After three years as an assistant professor at the University of Strasbourg I (1997-2000), he has served for one year as a research engineer for the French Company of Electricity (EDF). In 2001, he went back to the University of Paris 6, where he joined the Laboratoire de Robotique de Paris. During all these years, his research interests have concerned sensor feedback control of robots, specially force control and visual servoing. Applying these techniques to surgical robots is now the main focus of his research activity.

http://lrp6.robot.jussieu.fr/fra/personnel/morel/main.htm

Philippe Poignet received the M.E. and Ph.D. degrees in control engineering from the Ecole Centrale and the University of Nantes, France, in 1992 and 1995, respectively. From 1996 to 1998, he was with SEPRO Robotics Company, France. From 1998 to 2000, he was Assistant Professor at the

University of Orleans, France. He joined the Laboratoire d'Informatique, de Robotique et de Micro-électronique of Montpellier (LIRMM), France, in 2000 and is currently Assistant Professor at the University of Montpellier II, France. His research interests include robot identification, nonlinear control and the applications to medical robotics and artificial locomotion.
http://www.lirmm.fr/~poignet/