Computer-aided and image-guided medical interventions

Cutting-edge research and technological expertise in Switzerland…

Minimally invasive surgical techniques have many advantages and are developing rapidly. They allow minimising damage on the healthy tissue surrounding the pathology to be treated, lead to major reduction in mortality and morbidity and to substantial gain in patient recovery.

Nevertheless, as the surgeon loses direct contact with the operation site, interventions are increasingly difficult to perform and the information necessary for proper anatomical orientation has to be mediated by additional means. Image-guided surgery is a dynamically developing technology, providing a broad spectrum of information technology tools to help clinicians maintain safety and accuracy of surgical actions.

Improving medical image guidance and surgical navigation through information technology is the primary goal of the Swiss National Centre of Competence in Research (NCCR) Co-Me. Engineering, medical and biological research is conducted in order to improve intra-operative navigation leading to the further reduction of invasiveness and increased accuracy, to advance simulation tools for preoperational planning, and to combine image guidance with advanced surgical tools that enable entirely novel therapeutic approaches.

The NCCR Co-Me is a Swiss network of innovative scientists, engineers and clinicians. Established in 2001 by the Swiss National Science Foundation for a period of 12 years, it relies on several clinical and engineering sites located in Switzerland and involves more than 200 researchers. A strong focus is on collaboration between engineers and surgeons and on exchange of knowledge and technology among the network partners. The NCCR Co-Me is hosted at ETH Zurich, one of the leading international universities for technology and the natural sciences. Co-Me is recognised in the academic field through a considerable publication activity, presence at congresses and international cooperations with other leading research institutions.

During the past nine years, advanced cutting-edge technologies and new high-fidelity surgical tools for training, planning and intra-operative support have been developed. An important aspect was the translation of cutting-edge scientific results from the bench to the bedside, contributing to the quick introduction of these technologies into daily clinical practice. Some highlights are:

Brain surgery using sound waves

In a groundbreaking clinical study, a research team of the NCCR Co-Me has shown that chronic pain can be alleviated through a revolutionary new surgical method that permits fully non-invasive brain interventions. Using a specialised device in conjunction with magnetic resonance imaging (MRI), high-intensity ultrasound beams are focused onto small areas of malfunctioning brain tissue, destroying it by heating without cutting the skin or opening the skull. In Zurich 10 patients suffering from chronic therapy-resistant neuropathic pain received the treatment. They remained awake and responsive during the entire intervention.

The MIT Technology review rated the experiment as 'one of the four most important incidents in biomedicine in 2009' and Nature Reviews featured the study in a two page article. Newspapers, internet platforms, radio and TV stations in many countries reported on these promising clinical trials. This novel technology now opens up new horizons allowing developing non-invasive intervention procedures for a variety of brain diseases such as Parkinson's and Alzheimer's.

Robot performing virtual autopsies

Virtobot is a forensic hi-tech helpmate that is used to perform virtual autopsies. It was developed in collaboration with the NCCR Co-Me at the University of Bern's Institute of Forensic Medicine. The industrial robot provides forensic experts with a high precision, three-dimensional image of cadavers. For the first time ever, cadavers can be digitally preserved and autopsies conducted again, even years later, for instance when new evidence turns up in an unsolved case. The US forces have already installed a Virtopsy laboratory at Dover Air Force Base in Delaware to assess the cause of death of soldiers sent back from Iraq and Afghanistan.

Virtual environments for training surgeons

Another research group of the NCCR Co-Me at ETH Zurich has developed the hysteroscopy simulator HystSim, a virtual reality-based training system of highest possible realism for training minimally invasive diagnostic and therapeutic procedures in gynaecology. It allows surgeons to practise skills without any risk for patients. The system provides an instructional teaching environment for performing complete interventions while using the original surgical instruments. It

confronts surgeons with emergency scenarios for all relevant complications and offers them objective performance feedback for best learning results.

After eight years of basic research and product development, researchers of the NCCR Co-Me have founded the start-up company Virtamed AG to commercialise the system. The mission of Virtamed is to develop additional applications for other minimally invasive procedures. A new training module for endoscopic surgery in urology has just been launched. In 2009 Virtamed joined forces with Simbionix, one of the world's leading providers of medical education and simulation training products, to provide gynaecologist and urologist surgeons with the most advanced training system for endoscopic surgery that is currently available.

This is just one example for a successful cooperation with industry. Several other Co-Me technologies have emerged from the laboratory and they are being clinically validated and commercialised through various industrial channels. Among the partner companies, there are not only global leaders in many key business areas but also start-up companies and small enterprises are well represented. Virtamed is just one of eight start-up companies established by partners of the Co-Me network.

MedTech experts for industry and academia

The NCCR Co-Me is training undergraduates, graduate students, and postdoctoral fellows for future leadership roles in teaching, research, and industry. A main achievement in the field of education is the successful establishment of Master's programmes in biomedical engineering at ETH Zurich and the Universities of Bern and Basel, educating a continuously rising number of students every year.

Due to the increasing demand for continuing education in medical engineering, the courses are also open to industry professionals. This is highly appreciated in a country like Switzerland where the medical technology sector occupies a leading position worldwide with more than 600 companies involved. Top qualified engineers help them to ensure their position at the forefront of tomorrow's promising global medical technology market.

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