Computer-Integrated Surgical Systems

Surgical Robotics
2nd Summer European University
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Research direction and map for computer-integrated surgery

1. Image processing and presentation
2. Modeling and segmentation
3. Registration and navigation
4. Mechanism
5. Tele-care/tele-surgery and macro-micro tele-operation
Medical Robots  M. Mitsuishi, The University of Tokyo

△ Neurosurgery system in the deep surgical field

△ Bone cutting robot for total knee arthroplasty (TKA)

△ Robot to assist femur fracture reduction
Hand surgery system

Remote minimally invasive surgical system
Tele-micro-surgical system

Remote ultrasound diagnosis system
Contents

1. Micro-neurosurgical system in the deep surgical field
2. Minimally invasive bone cutting system for TKA/UKA
3. Remote minimally invasive surgical system
4. Computer-Integrated Femoral Head Fracture Reduction System
Registration and surgical CAD/CAM system for minimally invasive orthopedic surgery are necessary.

To reduce the radiation: CT, X-ray, or without them?
Discussions in ICRA2003

- Collaboration: surgeons, engineers, industries
- Training of a surgeon
- Technologies: safety, light weight robot, advance control, sterilization/irrigation, etc.
  - Actuator (small, ex. hydraulic actuator), material of mechanical parts (ex. for MRI)
  - Manufacturing process for small mechanical parts
- Economics: cost effectiveness
- Standardization: user interface, software (ex. CORBA), hardware?(module), etc.
Snakelike Slave Manipulator
R.Taylor, John Hopkins, US

(r=17.7 mm)

(73.5°)

(r=28.5 mm)

Φ4.2
Needle Guiding Robot
T. Dohi, Univ. of Tokyo, Jpn
Sakuma, Univ. of Tokyo, Minimally invasive surgical system
Slave manipulator to hold forceps
Remote laparoscopic surgical system with force feedback
Hyper finger for laparoscopic surgery
Micro-active forceps for retina surgery

Active laparoscope
Hyper-endoscopy

Virtual endoscopic system with force feedback
Small slave robot

• 4 d.o.f.: 3 translation d.o.f. + 1 rotational d.o.f.
• The robot can be attached to the fixture: Motion by breathing is canceled.

AC servo motor with encoder
In vivo experiment to compensate for the internal organs motion

Mini Slave Robot

Heart Stabilizer
Crawling Robot on Heart
N.A. Paronik, Carnegie Mellon Univ., U.S.A.
Dario, Pisa, Italy, Micro endoscope

• L. Phee, D. Accoto, A. Menciassi, C. Stefanini, M.C. Carrozza, P. Dario
Inchworm Locomotion

Distal clamper

Central elongator

Proximal clamper

Typical colonoscopy prototype
Diameter : 24 mm
Retracted Length : 115 mm
Elongated Length : 195 mm
Stroke: 80 mm
A mechatronic system for the control of the feed rate based on position, force and temperature sensing, has been embedded in the drill.
Endoluminal Microrobotics
P. Dario, Pisa, Italy

Aims to define theory and design methods, and to develop suitable fabrication technologies
Navigation of HIFU Applicator

I. Sakuma, Univ. of Tokyo, Jpn
SRI International
Dr. Green, P.S.
Mobile Telepresence Surgery
Remote Surgical Unit and a Surgeon
da Vinci: Intuitive Surgical System
Slave manipulators  Master manipulators

Endoscope  7 d.o.f. hand
VR Cockpit
N. Suzuki, Jikei Univ., Jpn
Tele-medicine

Tele-radiology
Tele-pathology
Tele-mentoring
Tele-surgery
Tele-education
Medical system of the 21st century

Remote surgery, remote diagnosis

Intelligent operation room (doctors and medical robots)

Multi-media cockpit (doctors)

Intelligent operation room (doctors and medical robots)

Space station

Communications satellite

Communications satellite/high-speed radio communication network

Emergency helicopter

Emergency care

Ambulance

Home care

Local medical service difference correction

Teamwork medical care

Multi-media cockpit (foreign doctors)

Data-base (personal information, medical information)

Foreign countries

Elderly persons, babies and pregnant women
Intelligent operation room

High-level medical education

Patient load reduction

Doctor load reduction

High-speed network

Medical education

High-speed simulator

Surgical robot

Open-MRI

Manipulators for a doctor

Doctor

Intelligent operation room
Technology trends to support the human life for the security, safety, health and amenity

- **Miniaturization**: Bio-nano system using DNA, Real-time multipoint measurement of brain functions using ultra-precise electrodes
- **Distribution**: Remote medical system
- **Mobilization**: Home care
- **Functionalization**: Low-invasive laser coagulation treatment
- **Process Intensification**: Noninvasive medical therapy using ultrasound
- **Diversification**: Health care chip
- **Individualization**: Tailor-made medicine
Enrich Human Life
Workshop on Medical Robotics and Welfare
Part 1: Medical Robotics in the Surgical Theater

IEEE 2005 International Conference on Robotics and Automation
Barcelona, Spain, April 18, 2005

Co-organizers:
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Medical Robotics and Welfare
Part 1: Medical Robotics in the Surgical Theater

1. Technical Aspects of Computer-Integrated Surgery: Surgical and Legal Requirements and Regulations
2. Advanced Apparatus and Systems for Laparoscopic and Endoscopic Surgery
3. Advanced Apparatus and Systems for Head Surgery
4. Image-Guided Surgery and Advanced User Interfaces
Discussions

• Standardization: Risk management
• Training of a surgeon
• Social requirement
  – Cost-effectiveness
  – Socio-economic assessment
  – Global standard rules to assess technologies and to agree the devices as manufactures
  – Medical bill and insurance on the advanced medicine for not particular person
• Grand Unified System
  – Real-time patient-specific models
  – Surgical total information awareness
  – Active human-machine partnerships
  – Correlate performance to outcome
  – Micro-interventions on tiny structures: Miniature robot
• Better outcome and cost effectiveness
• Augmenting surgeon’s capabilities by means of hand-held instruments
• Extending surgeon’s capabilities and reducing invasiveness
• Advanced technologies:
  – Skilled human assistant
  – Motion compensation
  – Light weight robot
  – High dexterity
  – Haptic feedback
  – Modeling