Computer-Integrated Surgical Systems

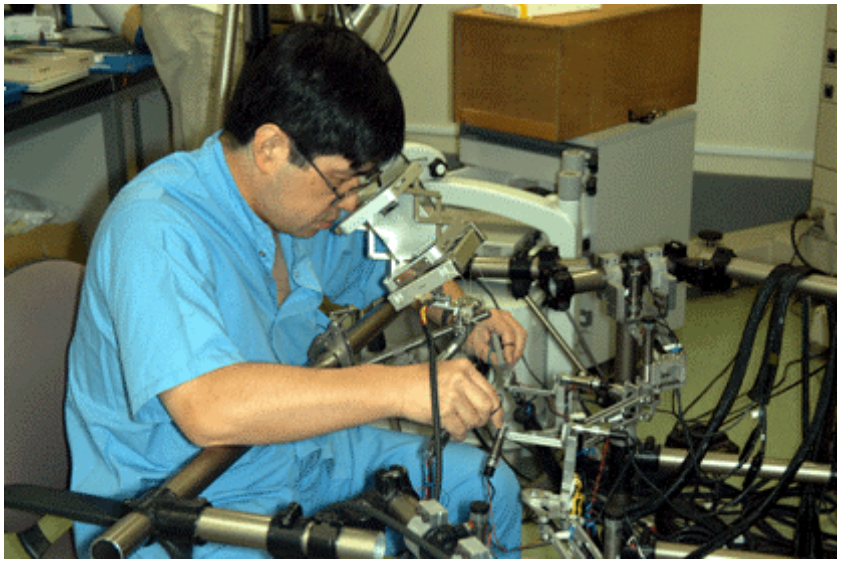
Surgical Robotics
2nd Summer European University
Montpellier, France
May 15-18, 2005

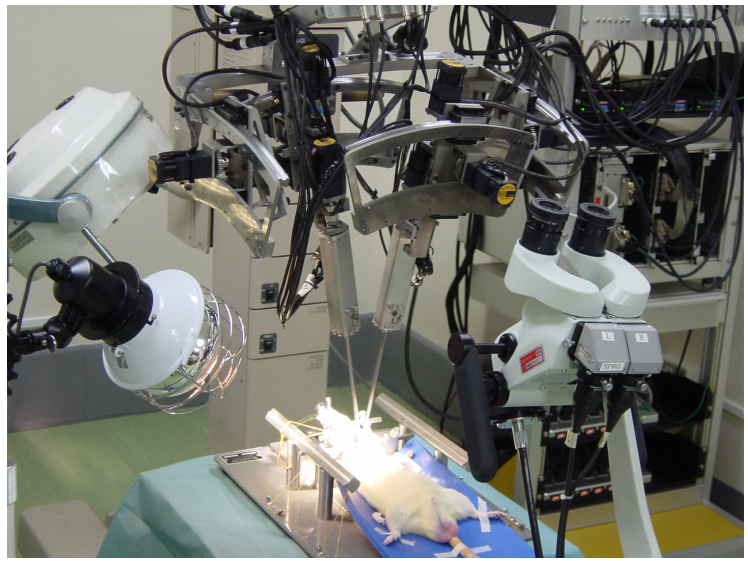
Mamoru MITSUISHI
Department of Engineering Synthesis
School of Engineering
The University of Tokyo

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

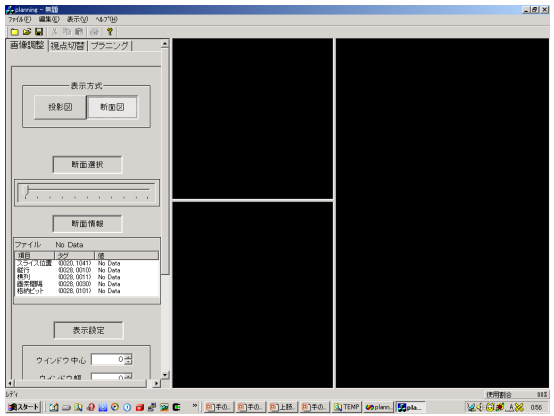


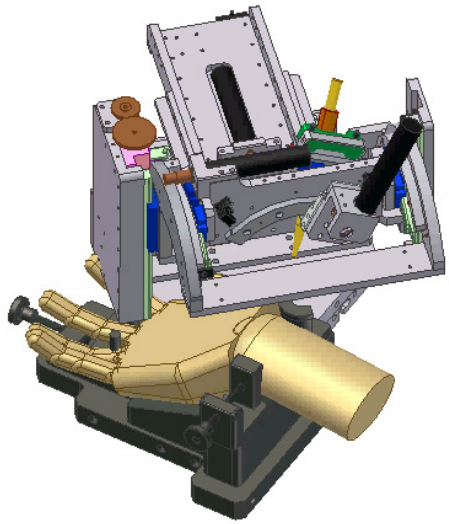


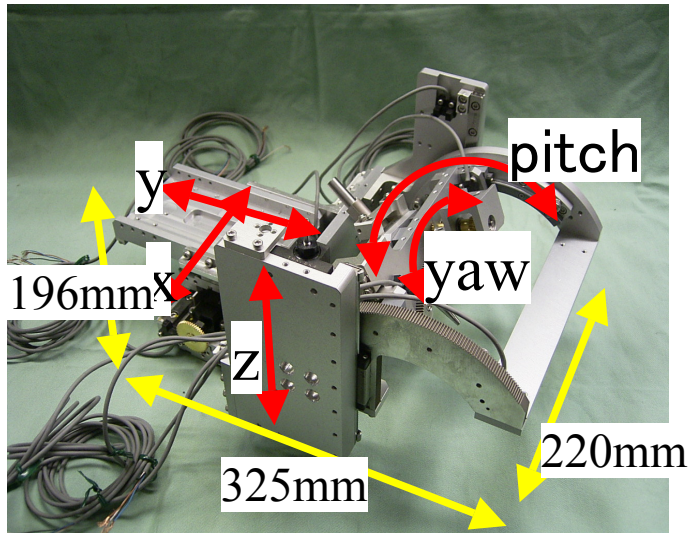
△ Neurosurgery system in the deep surgical field

△ Bone cutting robot for total knee arthroplasty (TKA)

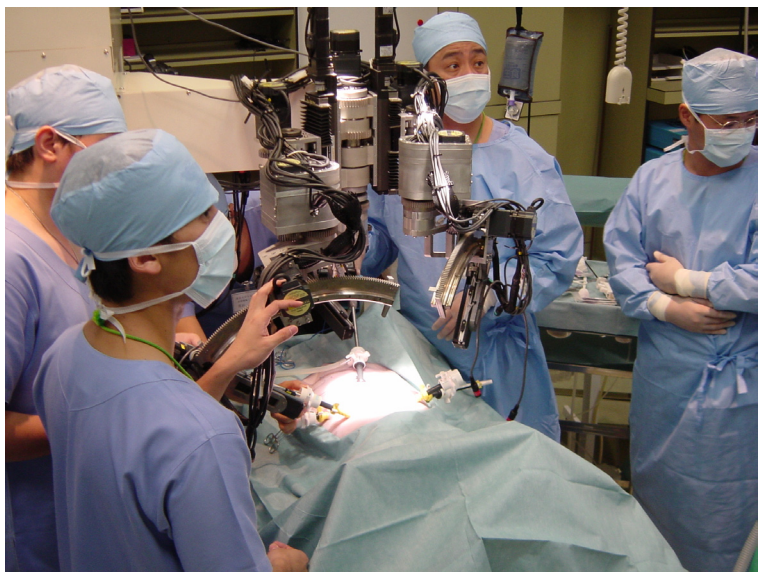
△ Robot to assist femur fracture reduction

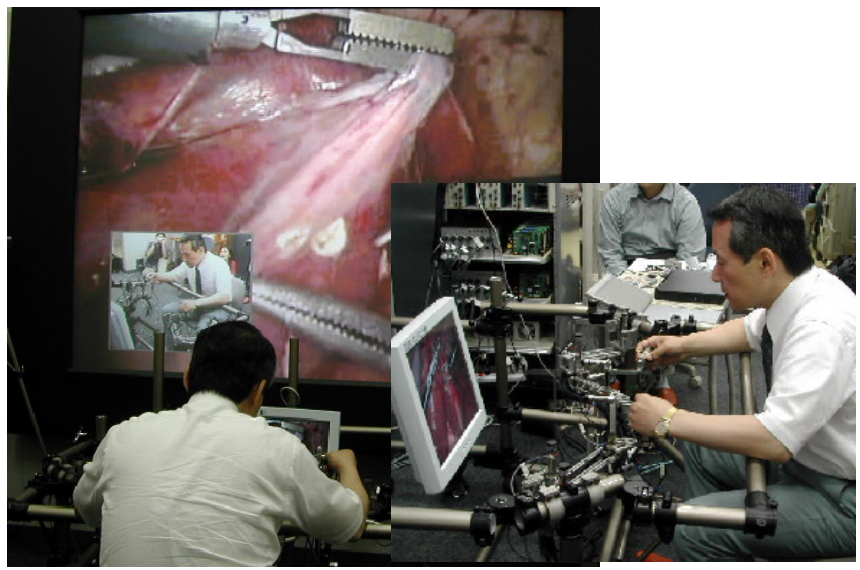




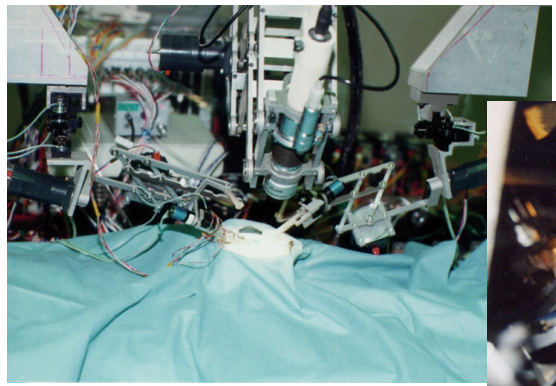


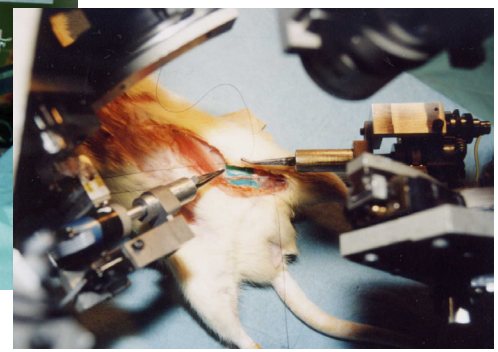
△ **Hand surgery system**



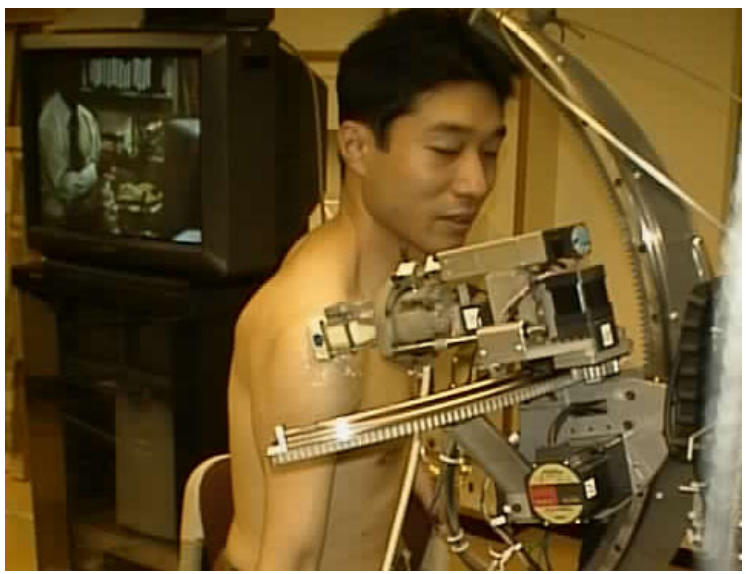


△ **Remote minimally invasive surgical system**



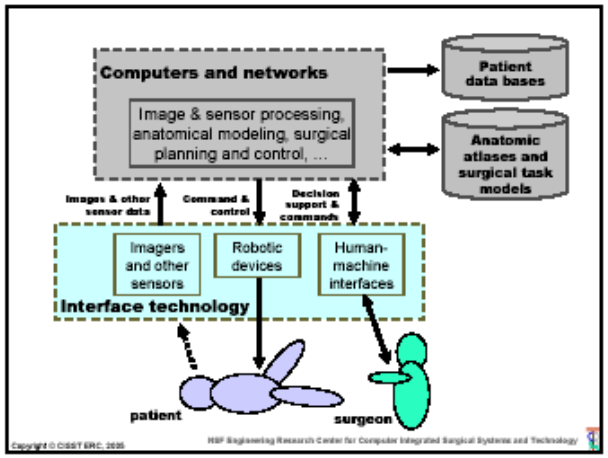


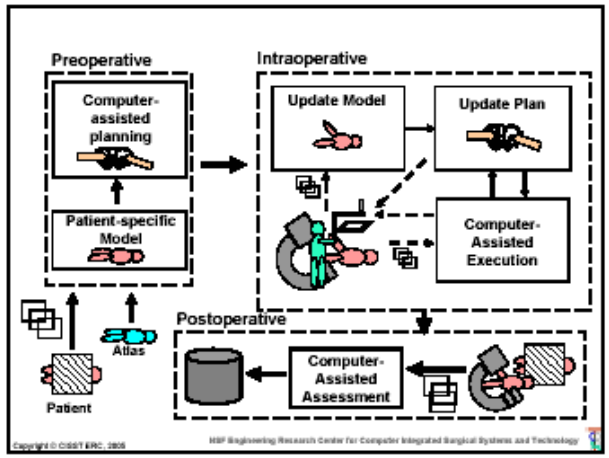
△ Tele-micro-surgical system



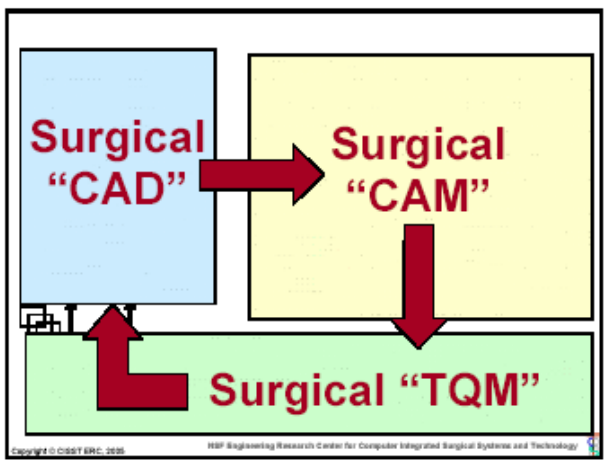
△ Remote ultrasound diagnosis system

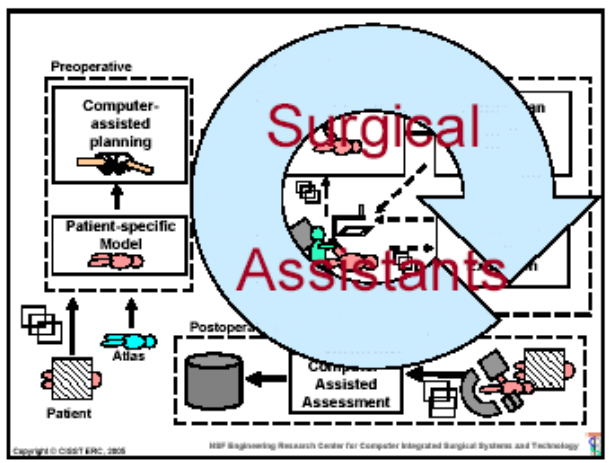
Contents





Professor R. Taylor



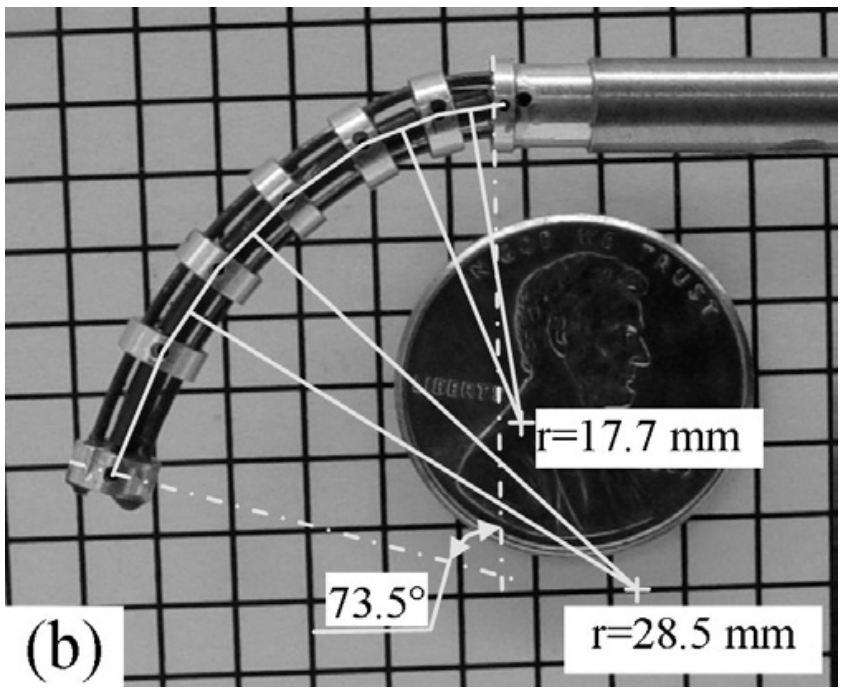


- **Registration and surgical CAD/CAM system for minimally invasive orthopedic surgery are necessary.**
- **To reduce the radiation: CT, X-ray, or without them ?**

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



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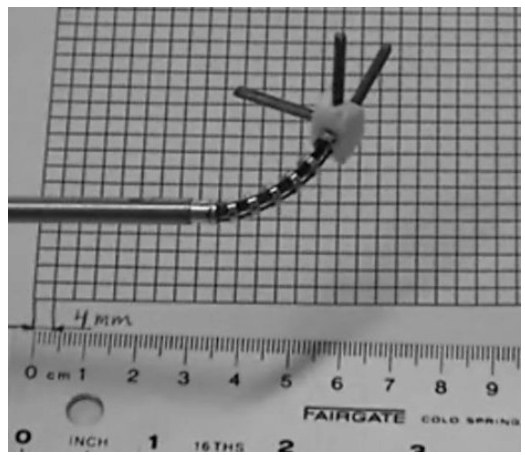
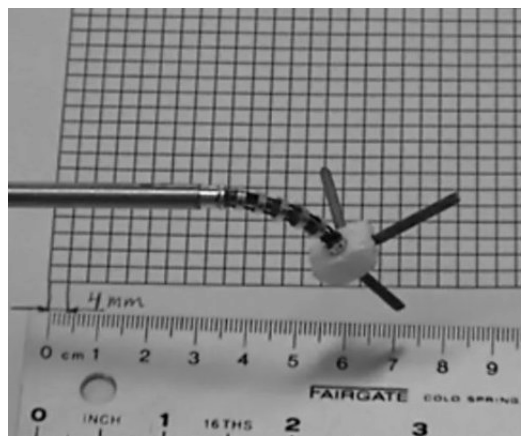
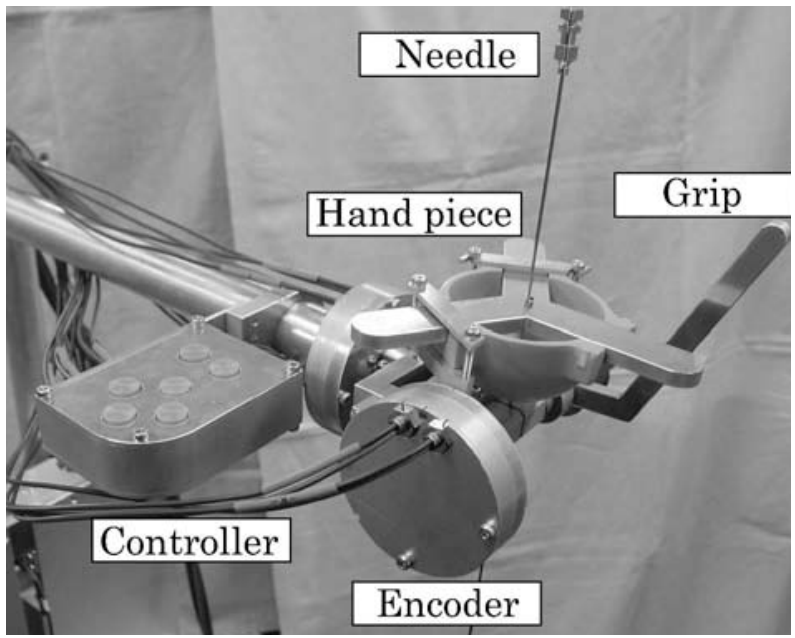
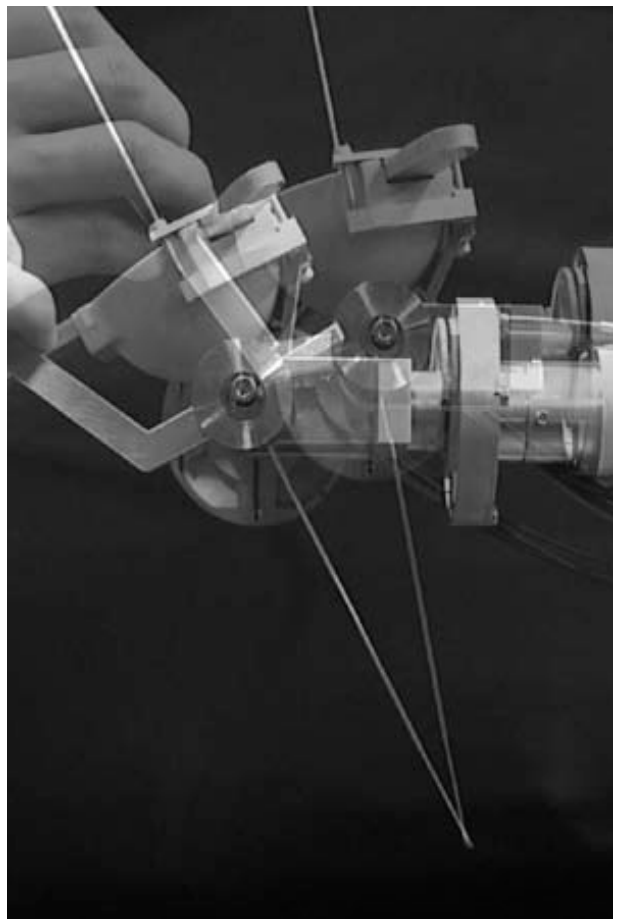


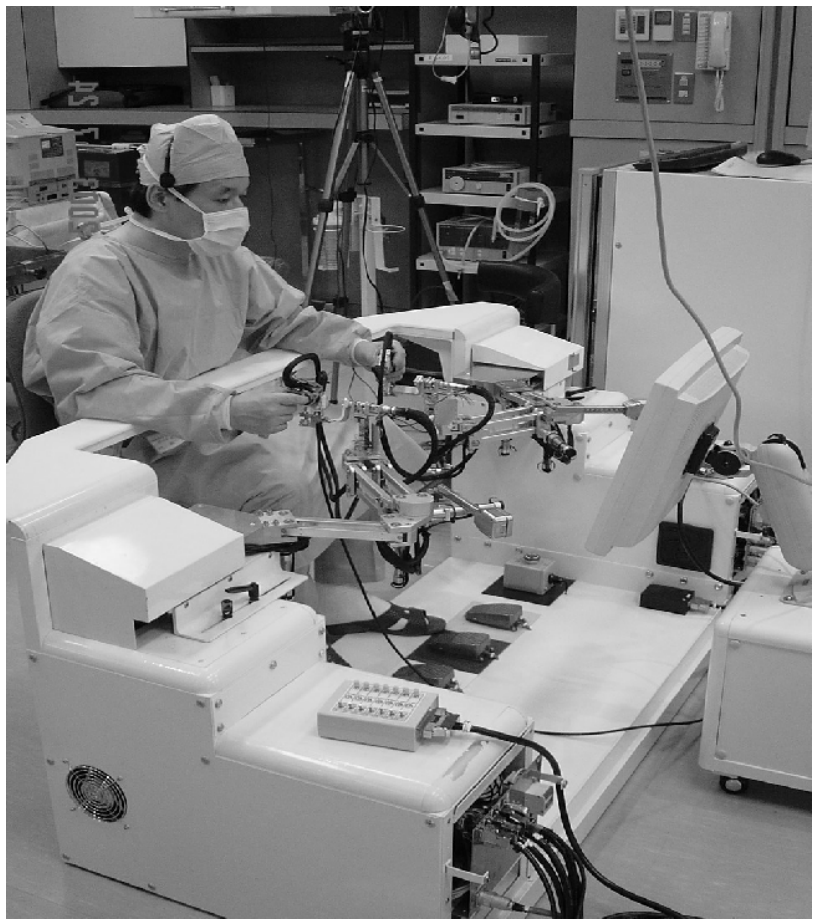


Needle Guiding Robot
T.Dohi, Univ.of Tokyo, Jpn

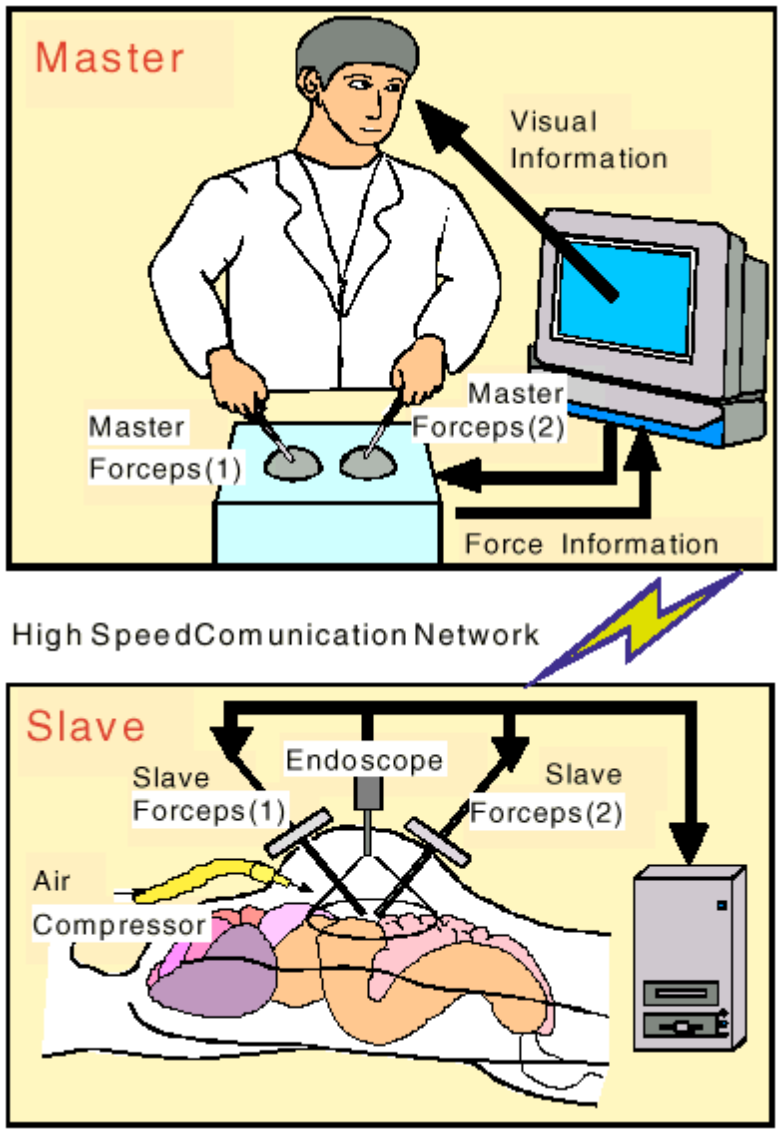


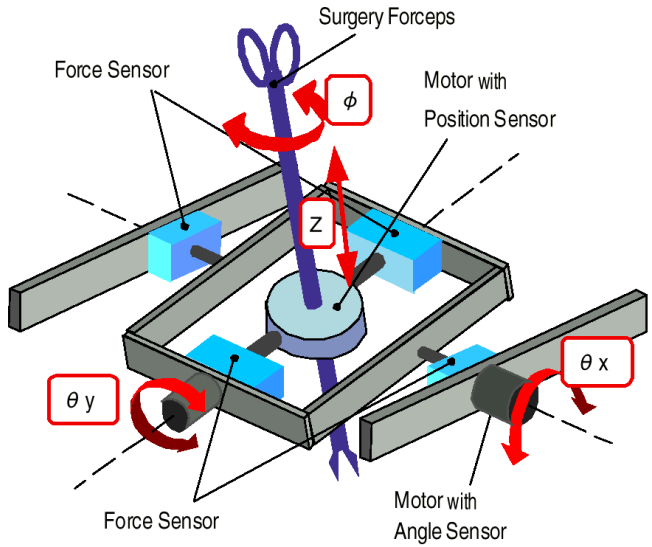


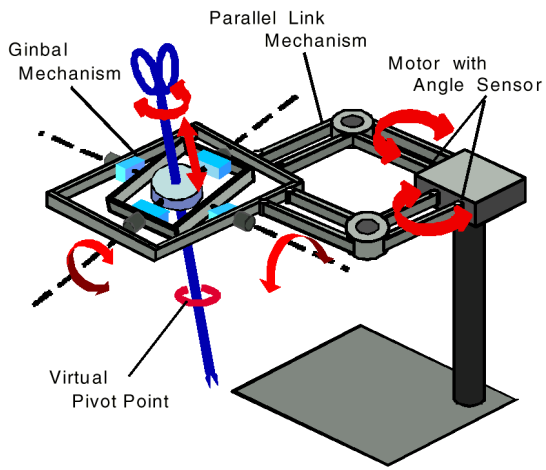
Sakuma, Univ. of Tokyo, Minimally invasive surgical system



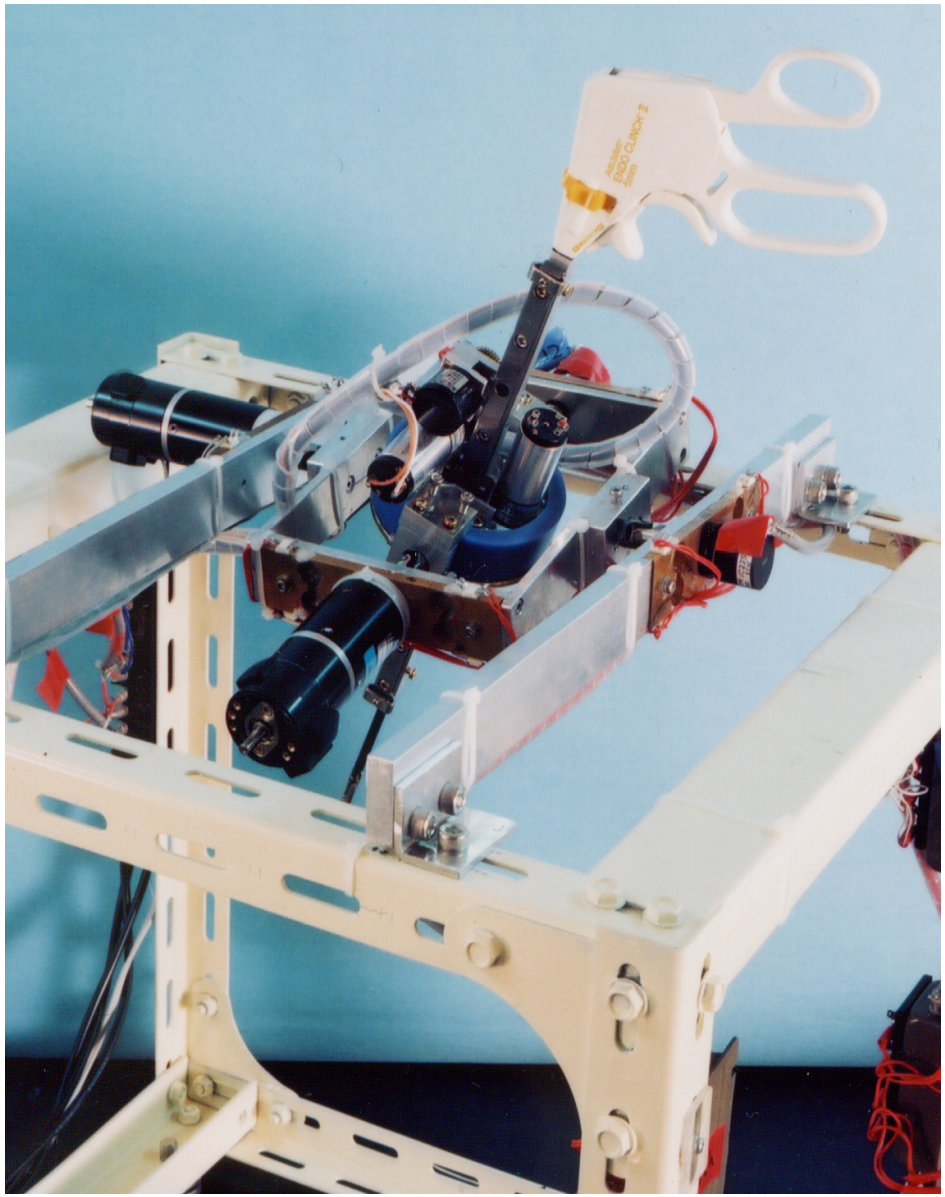
Nagoya Univ., Prof. Ikuta,K.





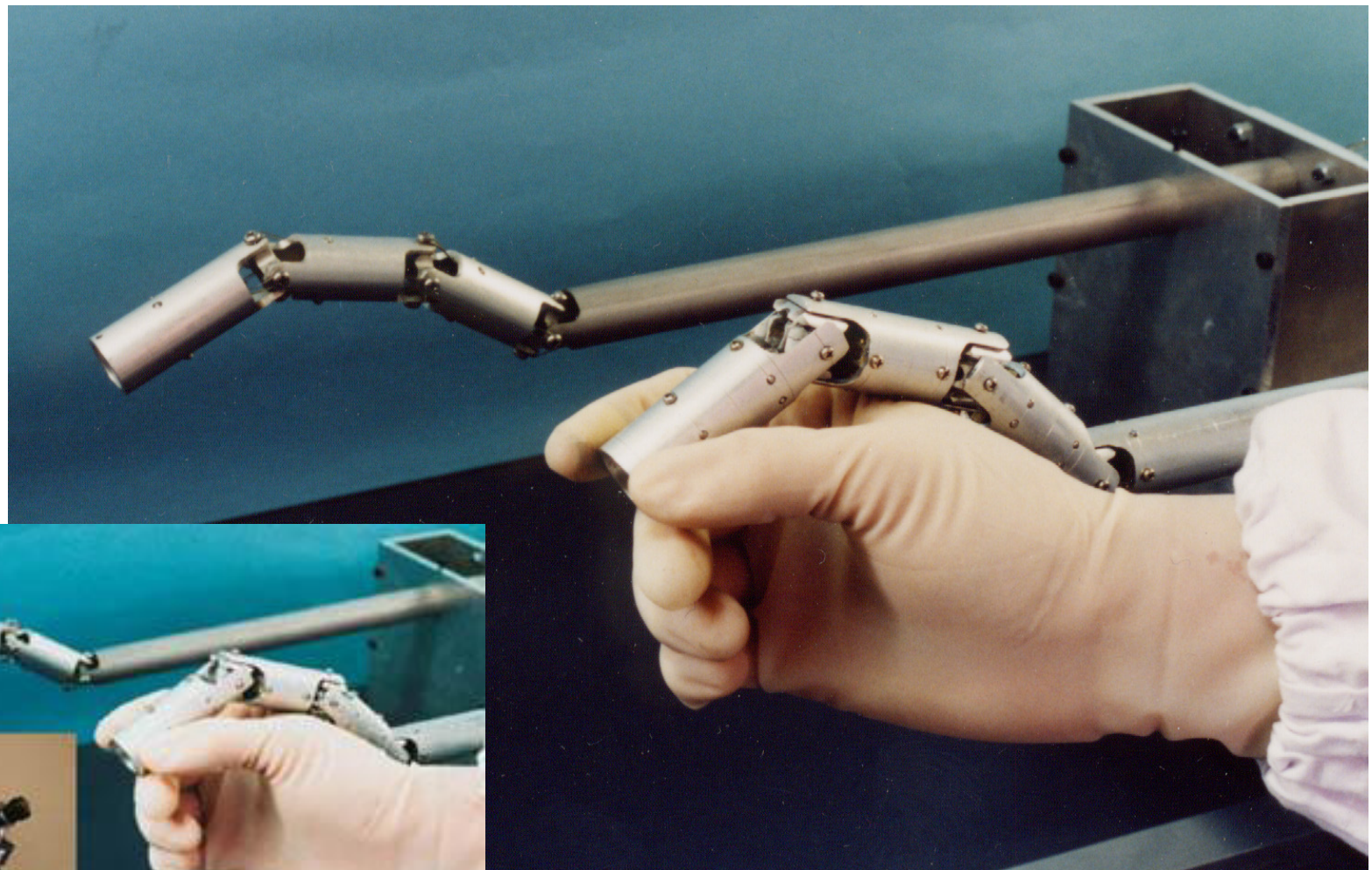


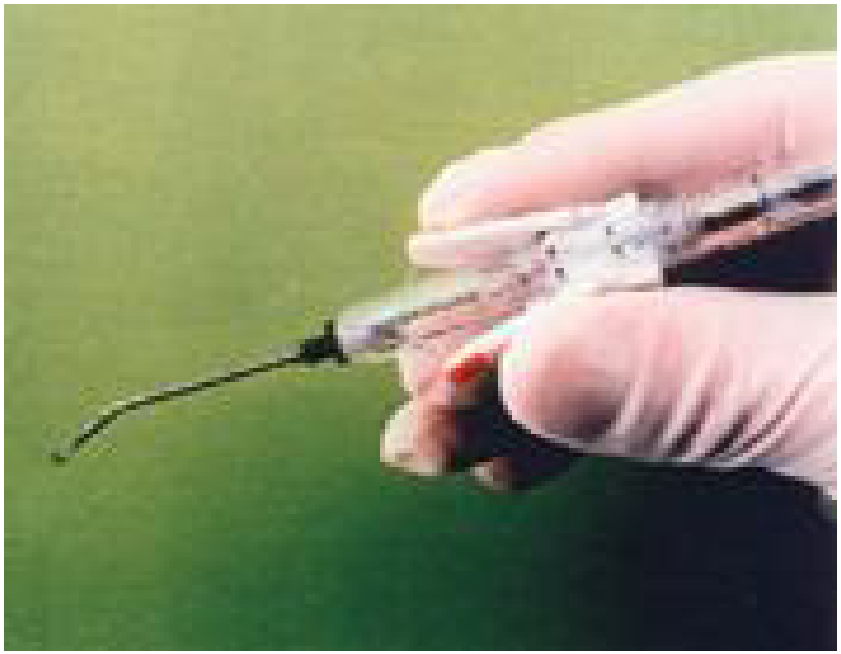
Slave manipulator to hold forceps



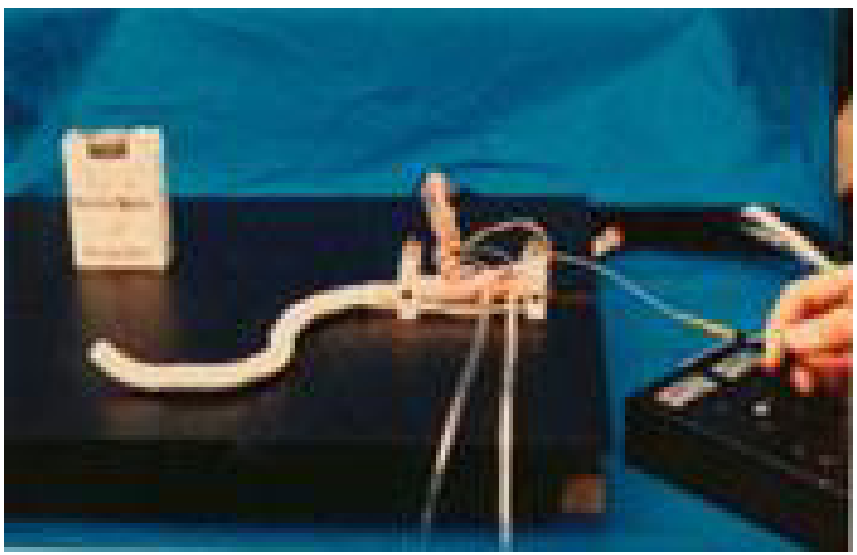
Remote laparoscopic surgical system with force feedback

Hyper finger for laparoscopic surgery





Micro-active forceps for retina surgery



Active laparoscope

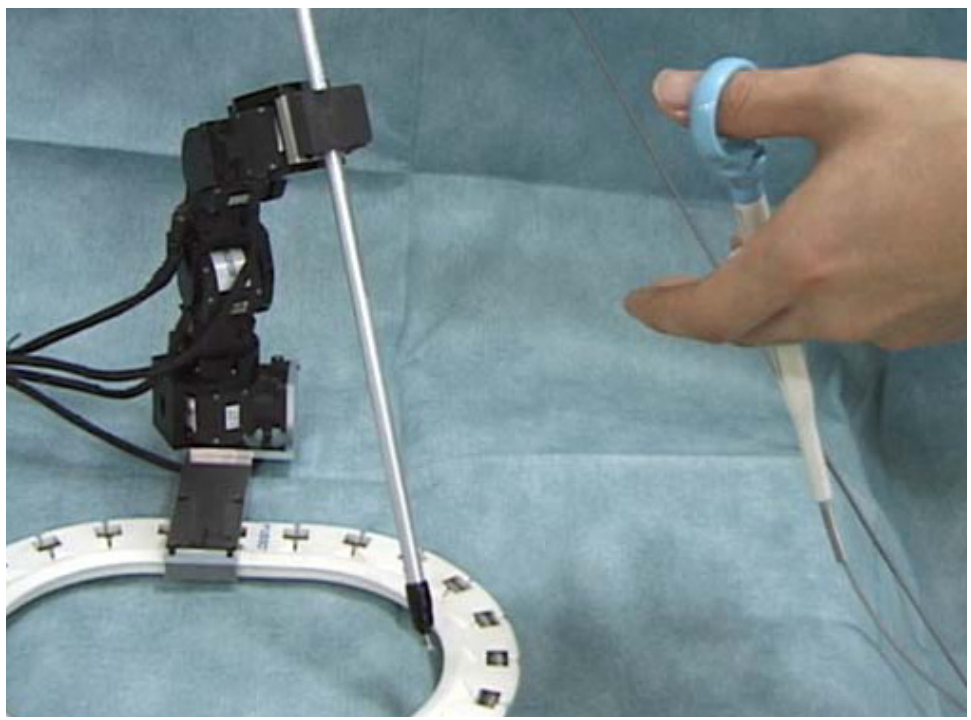
Hyper-endoscope

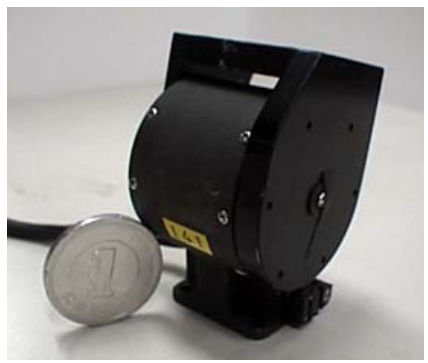
Virtual endoscopic system with force feedback

Prof. Nakamura, The Univ. of Tokyo

Small slave robot

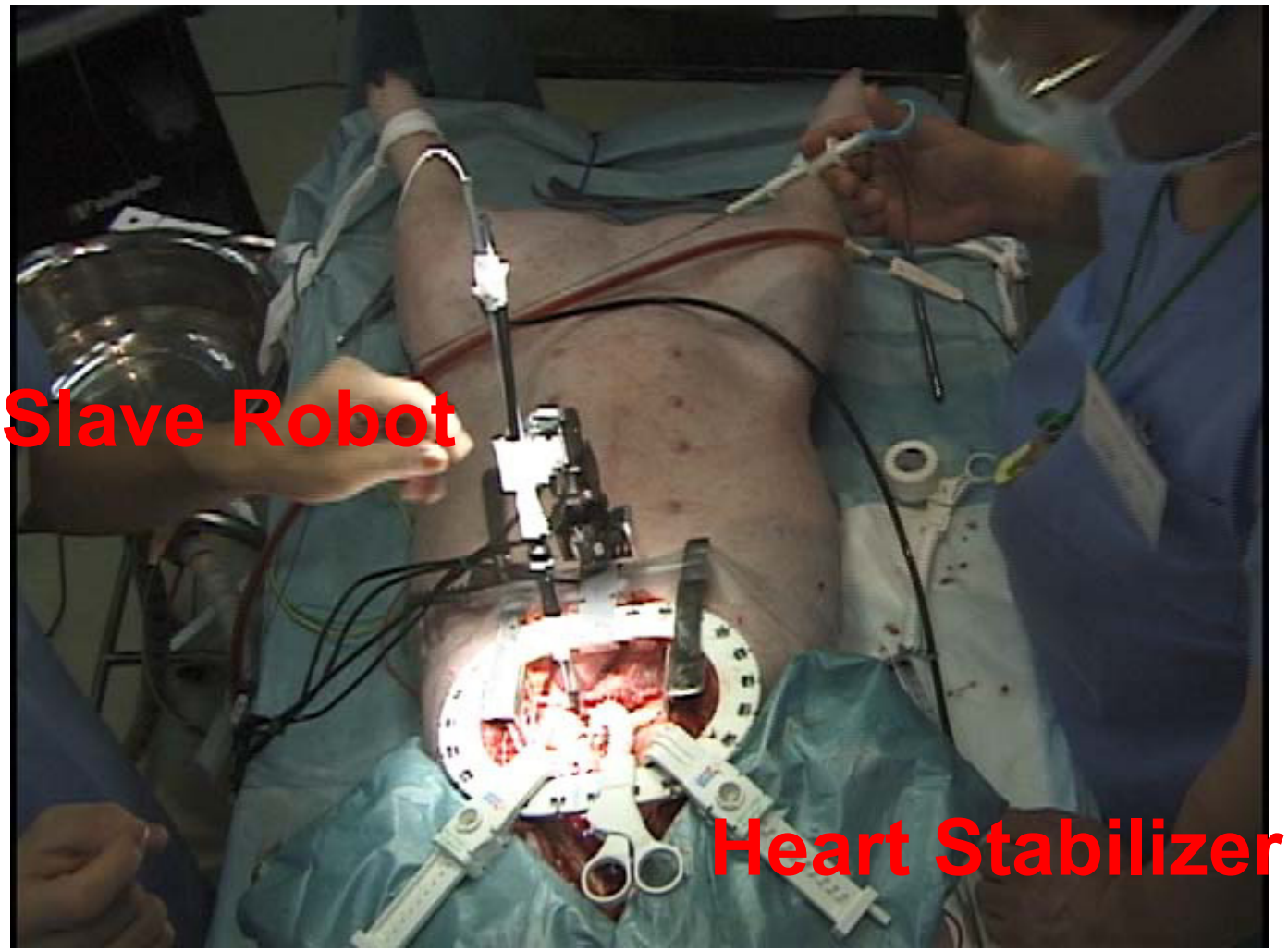
- **4 d.o.f.: 3 translation d.o.f. + 1 rotational d.o.f.**
- **The robot can be attached to the fixture: Motion by breathing is canceled.**





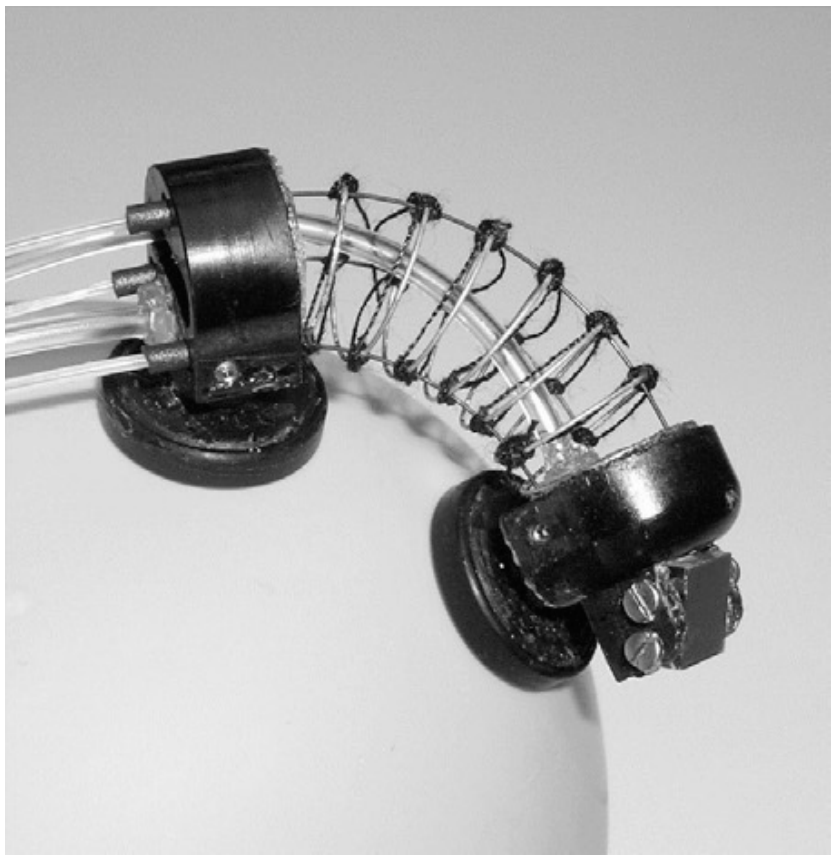
AC servo motor with encoder

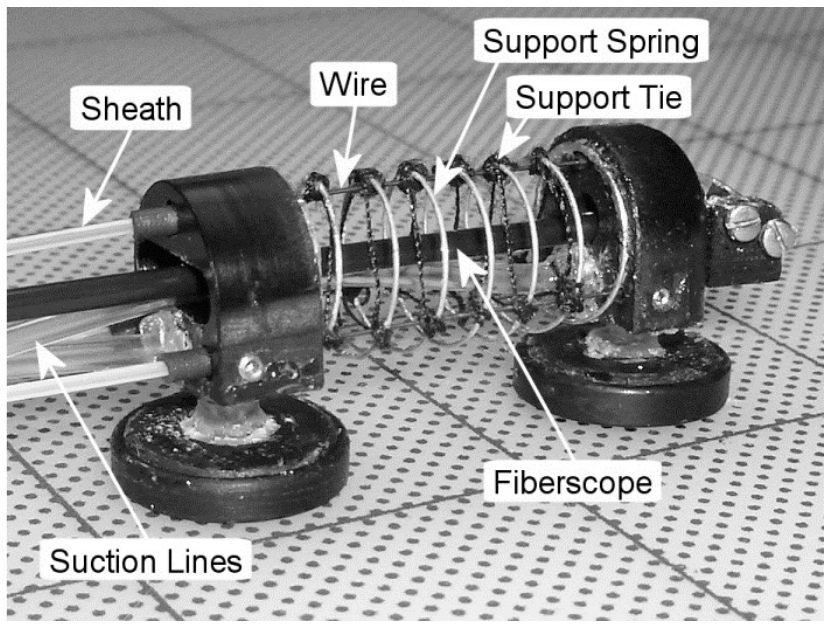
In vivo experiment to compensate for the internal organs motion



Crawling Robot on Heart

N.A.Paronik, Carnegie Mellon Univ., U.S.A.





Dario, Pisa, Italy, Micro endoscope

•Dario P., Carrozza M.C., Pietrabissa A., "Development and in vitro testing of a miniature robotic system for computer assisted colonoscopy", *Computer Aided Surgery, Vol. 4, (1999)*

• Dario P., Carrozza M.C., Pietrabissa A., Magnani B., Lencioni L. "Endoscopic Robot", *United States Patent No. 5,906,591, May 25, 1999*

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

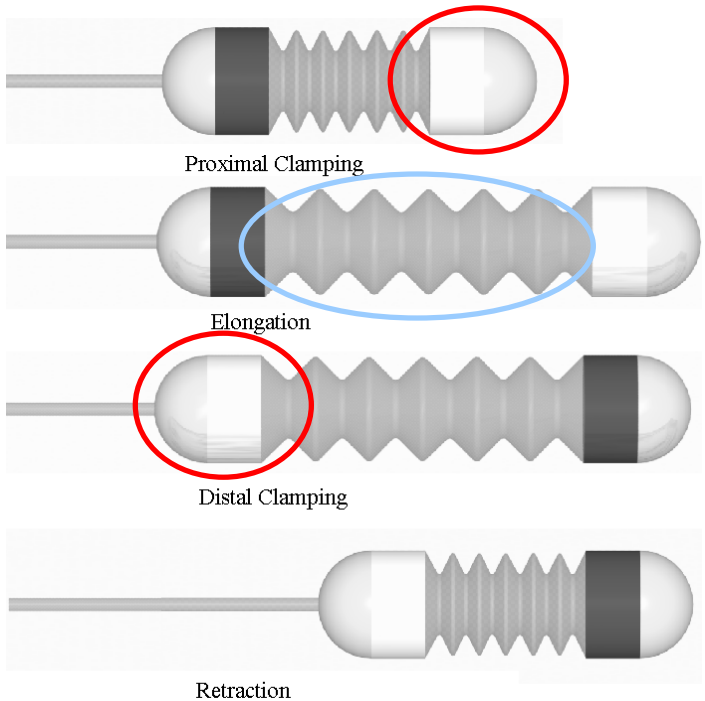
"Analysis and Development of Locomotion Devices for the Gastrointestinal Tract" *IEEE Trans. Biomed. Eng., June 2002*

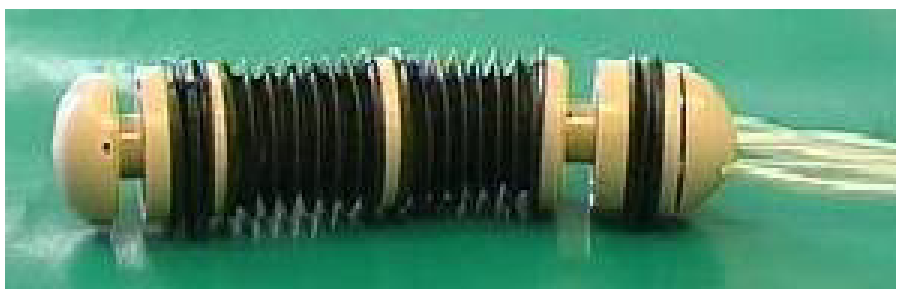
Inchworm Locomotion

Distal clamper

Central elongator

Proximal clamper





Typical colonoscopy prototype

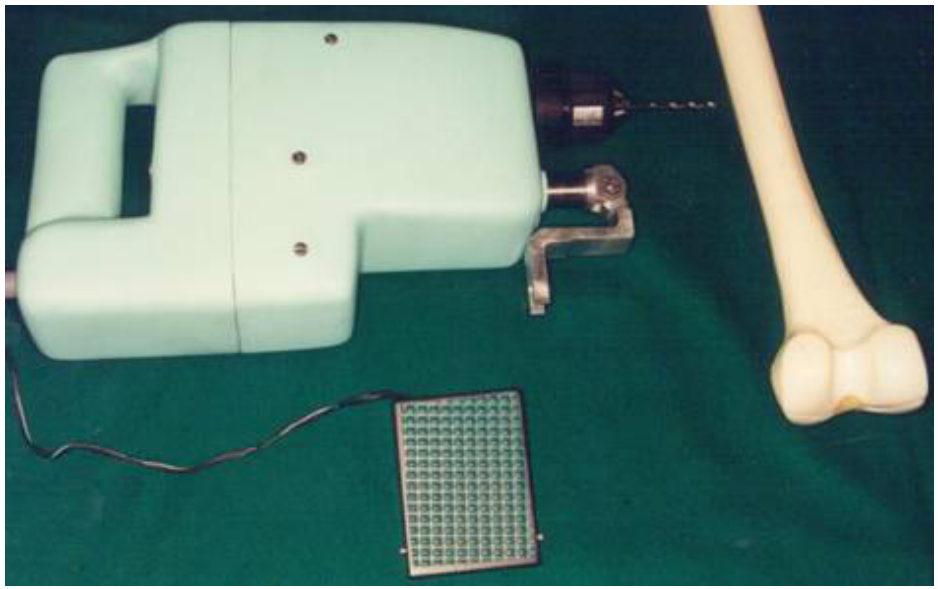
Diameter : 24 mm

Retracted Length : 115 mm

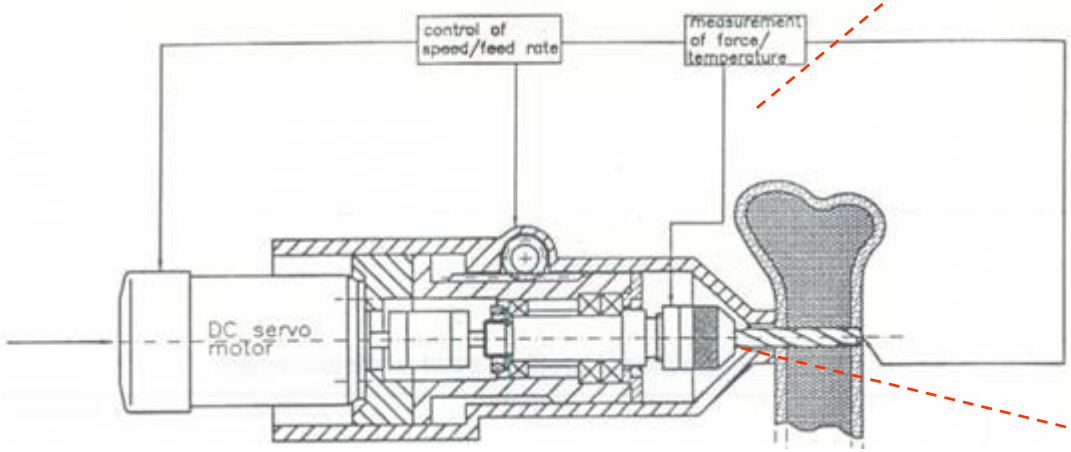
Elongated Length : 195 mm

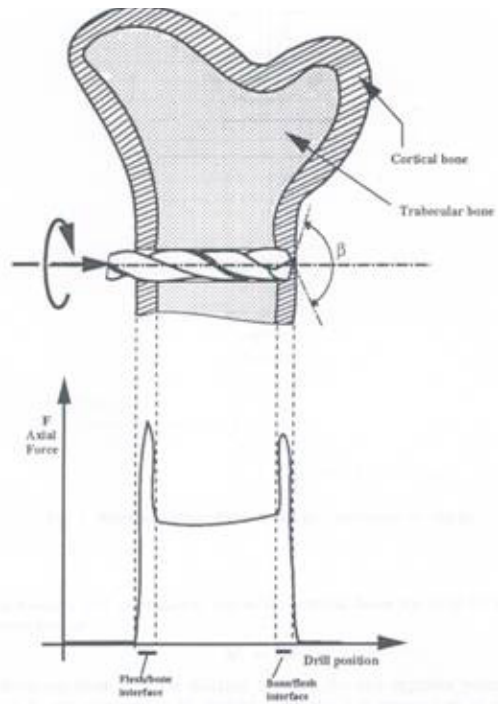
Stroke: 80 mm

Mechatronic Drill for Bone
P.Dario, Pisa, Italy

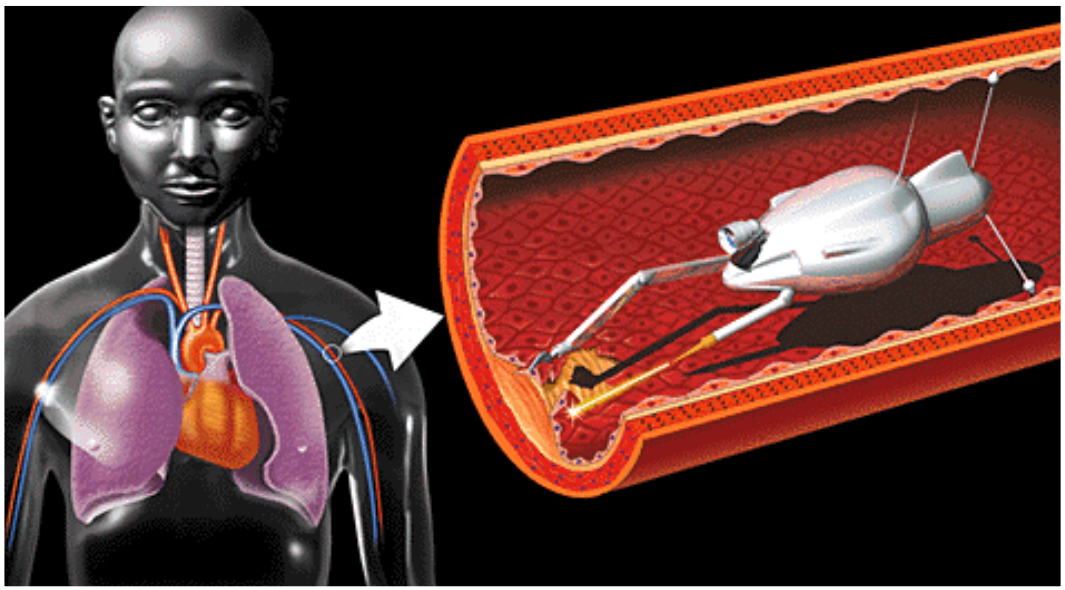


A mechatronic system for the control of the feed rate based on position, force and temperature sensing, has been embedded in the drill



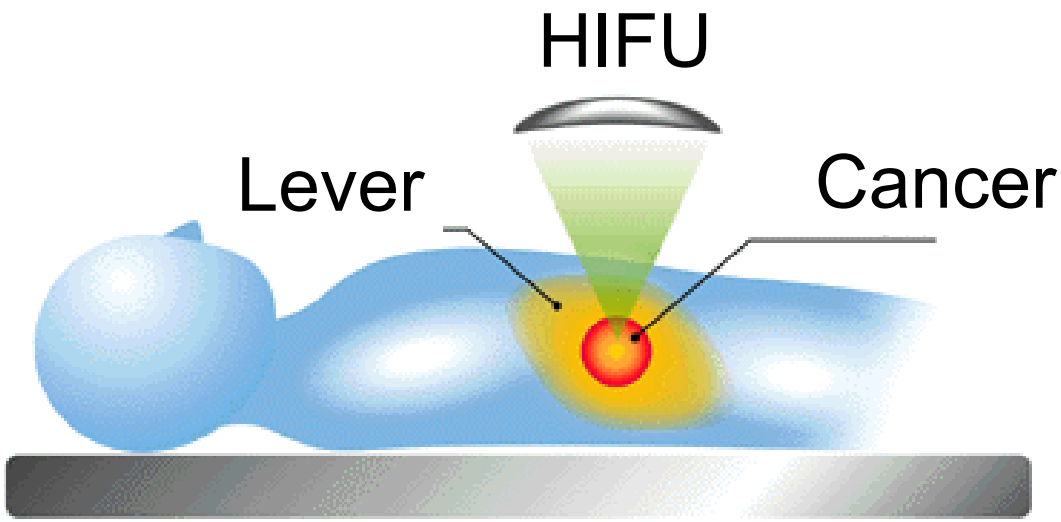


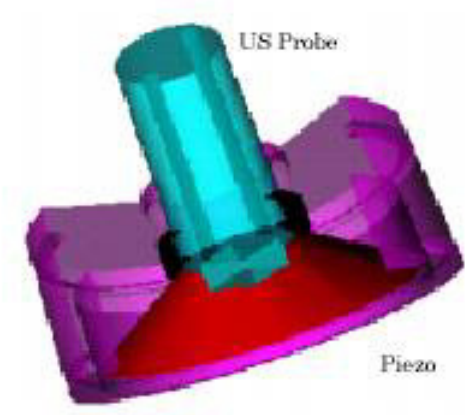
Endoluminal Microrobotics
P.Dario, Pisa, Italy



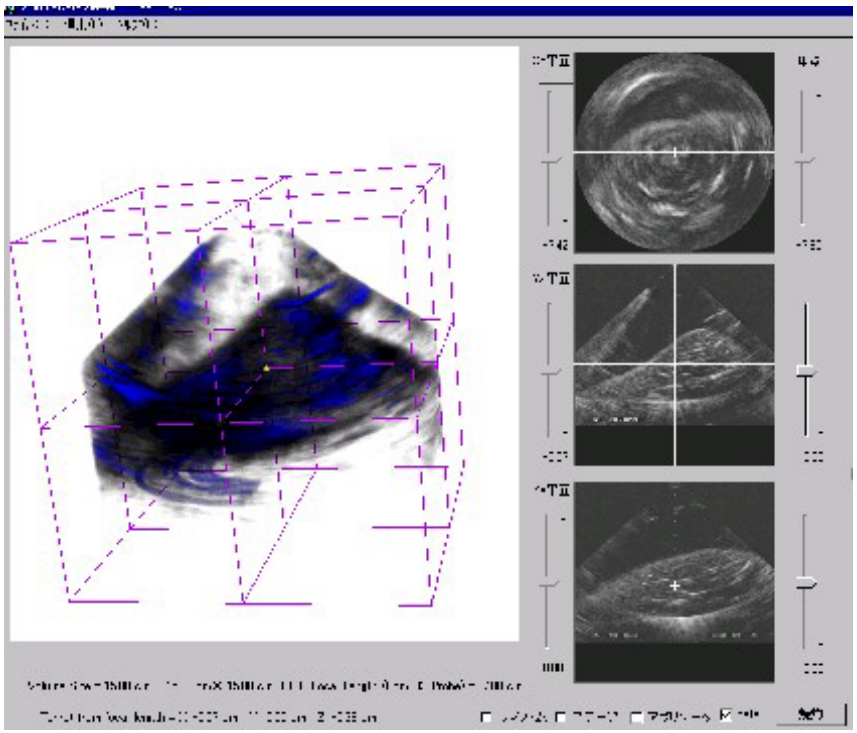
Aims to define theory and design methods, and to develop suitable fabrication technologies

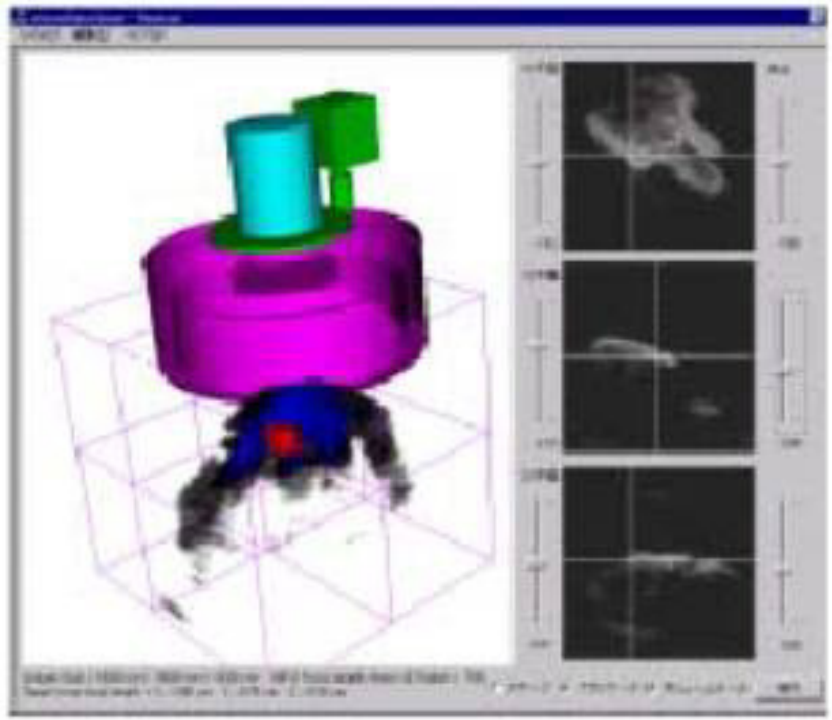
Navigation of HIFU Applicator
I.Sakuma, Univ. of Tokyo, Jpn



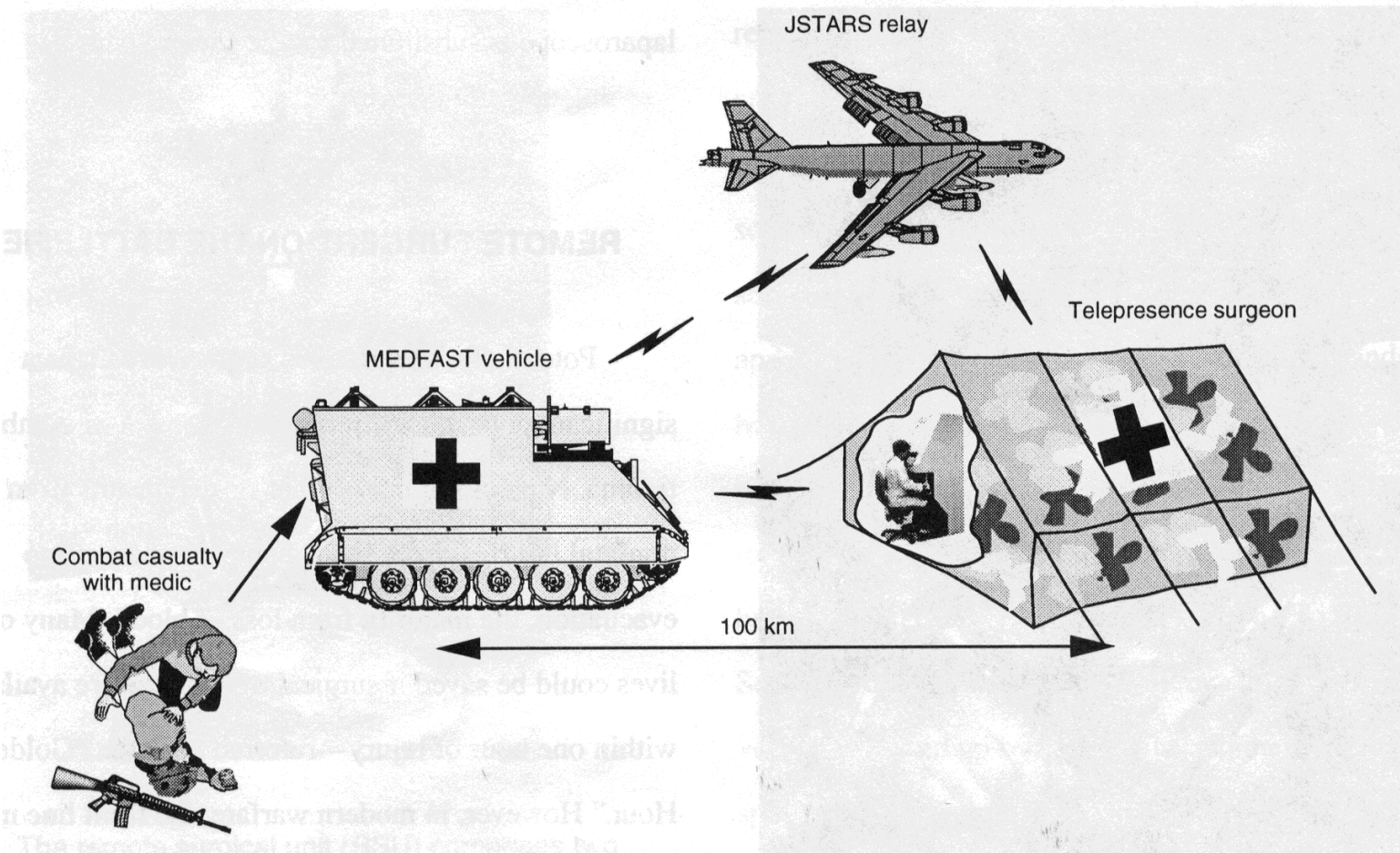


HIFU

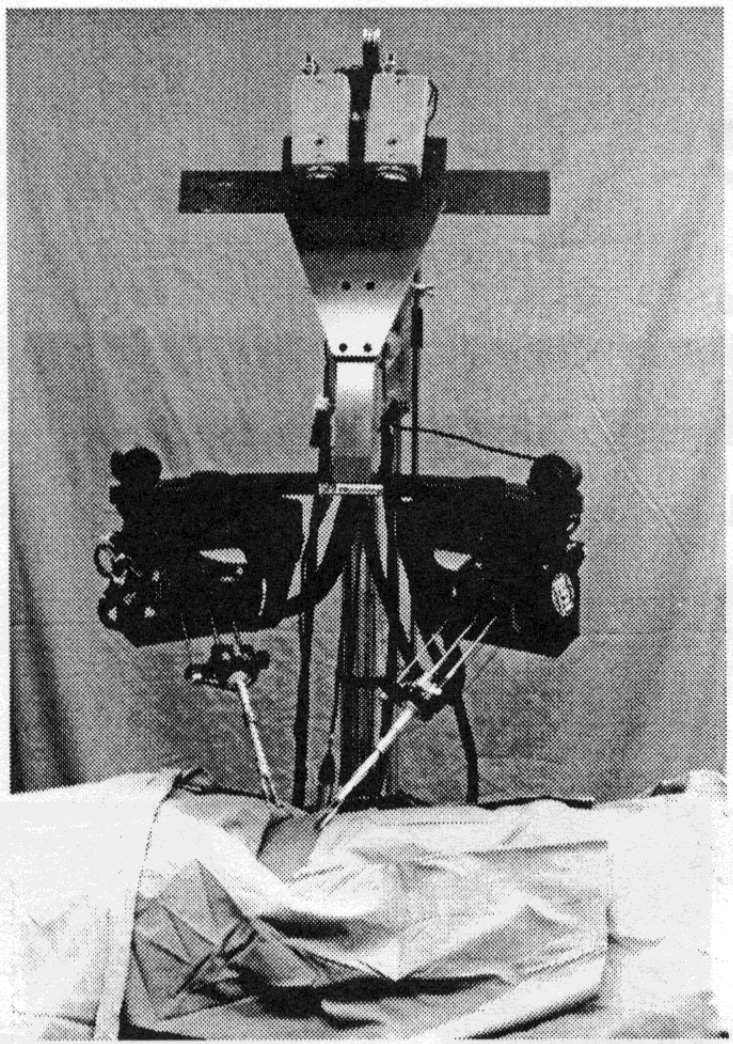


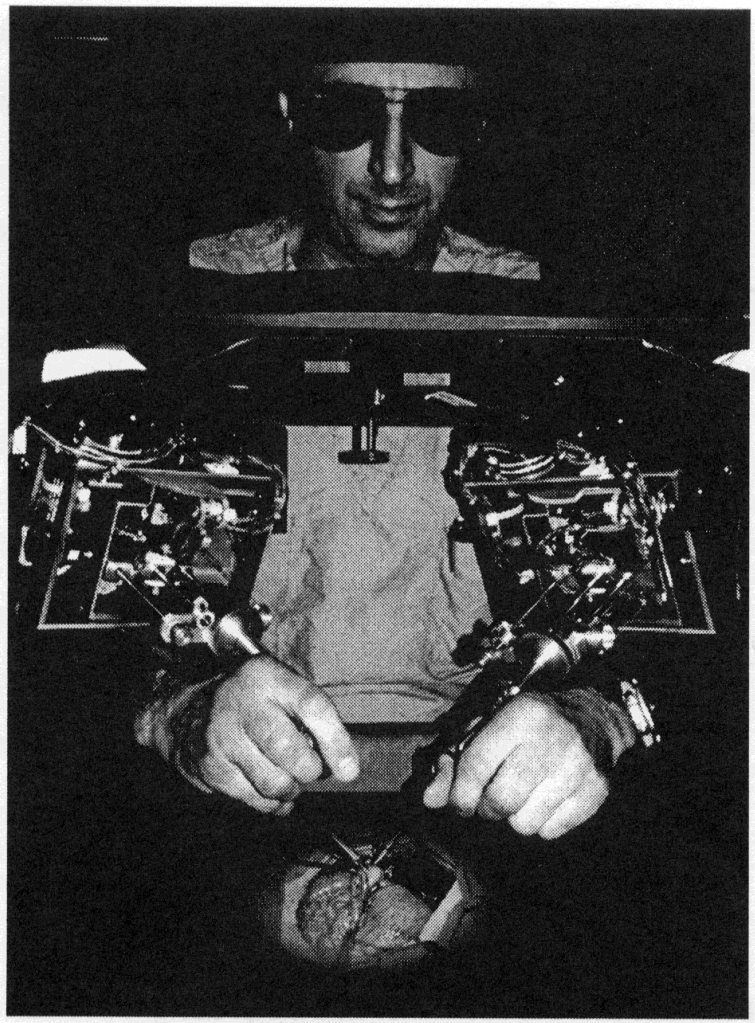


SRI International
Dr. Green,P.S.
Mobile Telepresence Surgery

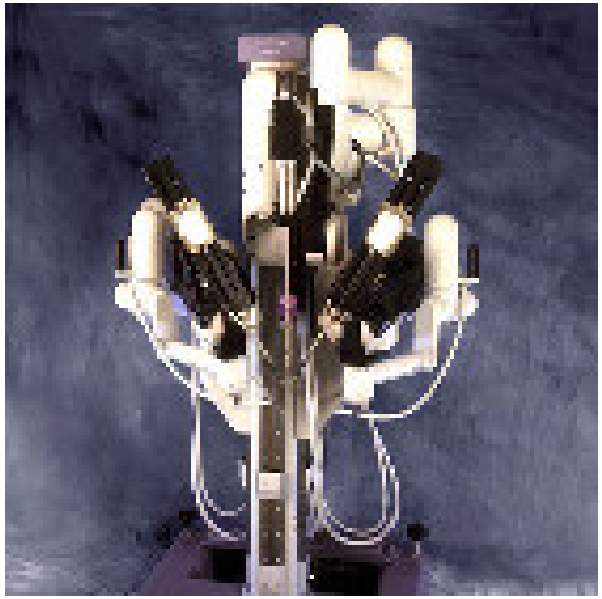


Remote Surgical Unit and a Surgeon





da Vinci: Intuitive Surgical System



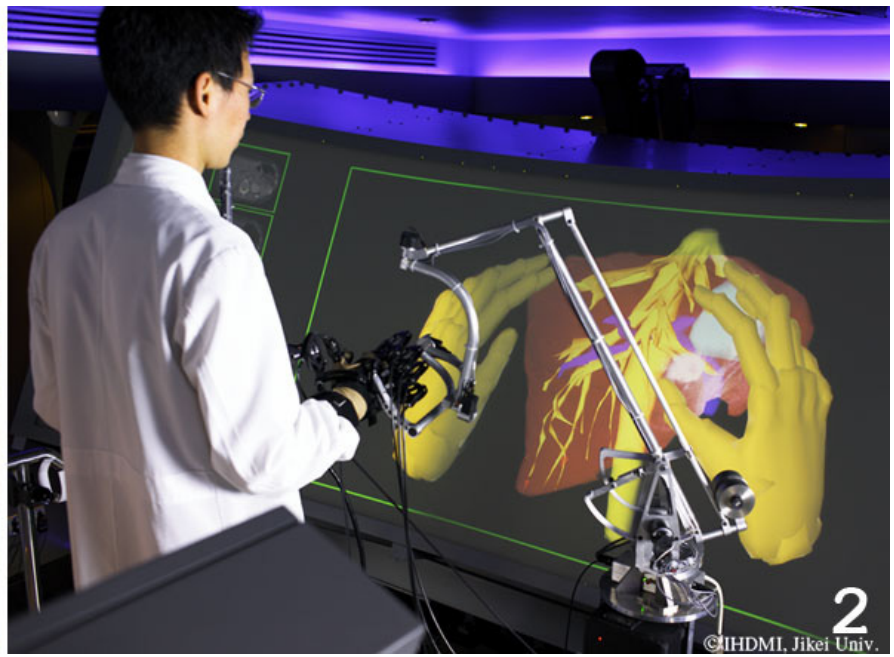
Slave manipulators

Master manipulators

Endoscope

7 d.o.f. hand

VR Cockpit
N.Suzuki, Jikei Univ., Jpn



Tele-medicine

Tele-radiology

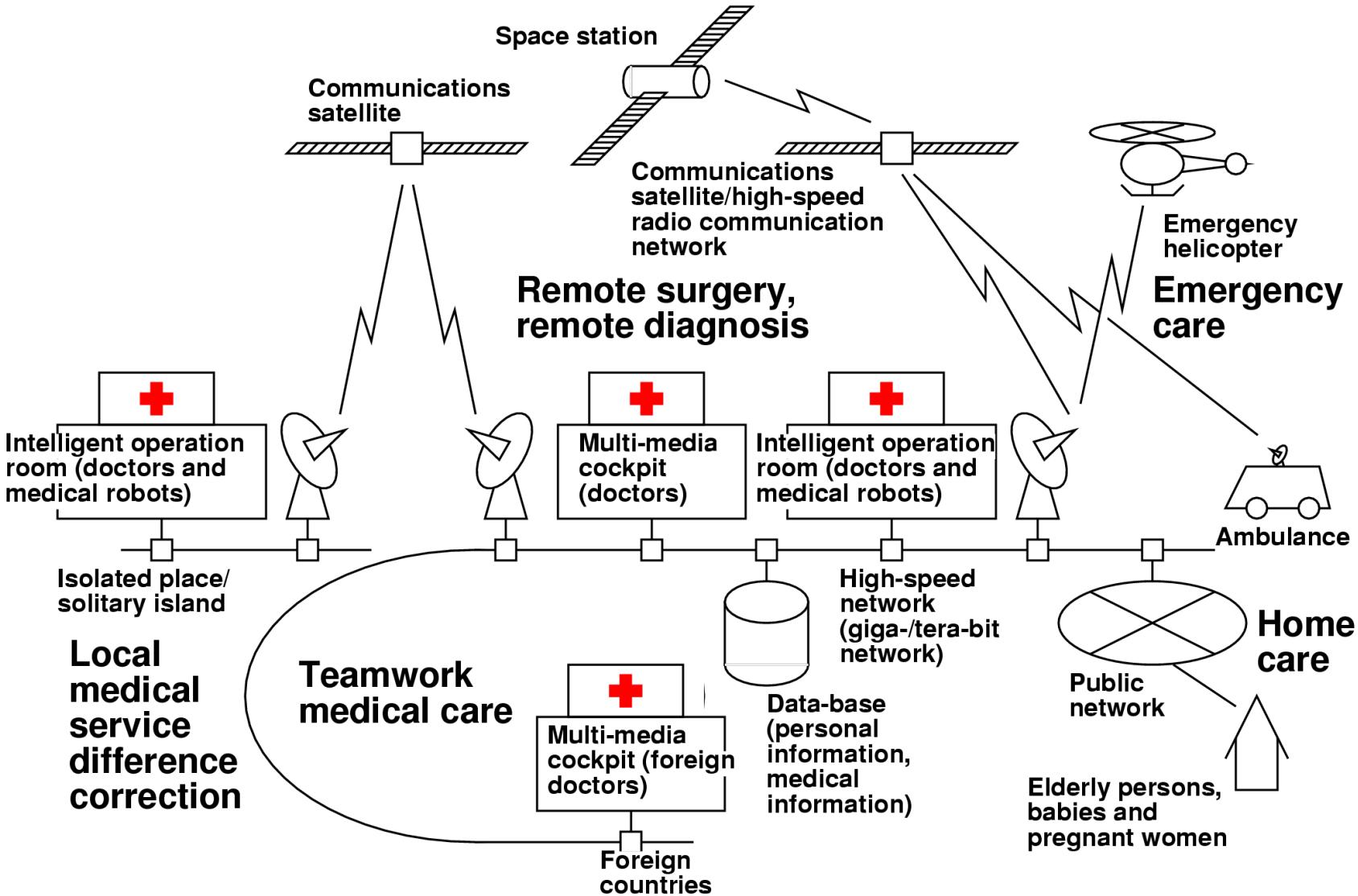
Tele-pathology

Tele-mentoring

Tele-surgery

Tele-education

Medical system of the 21st century

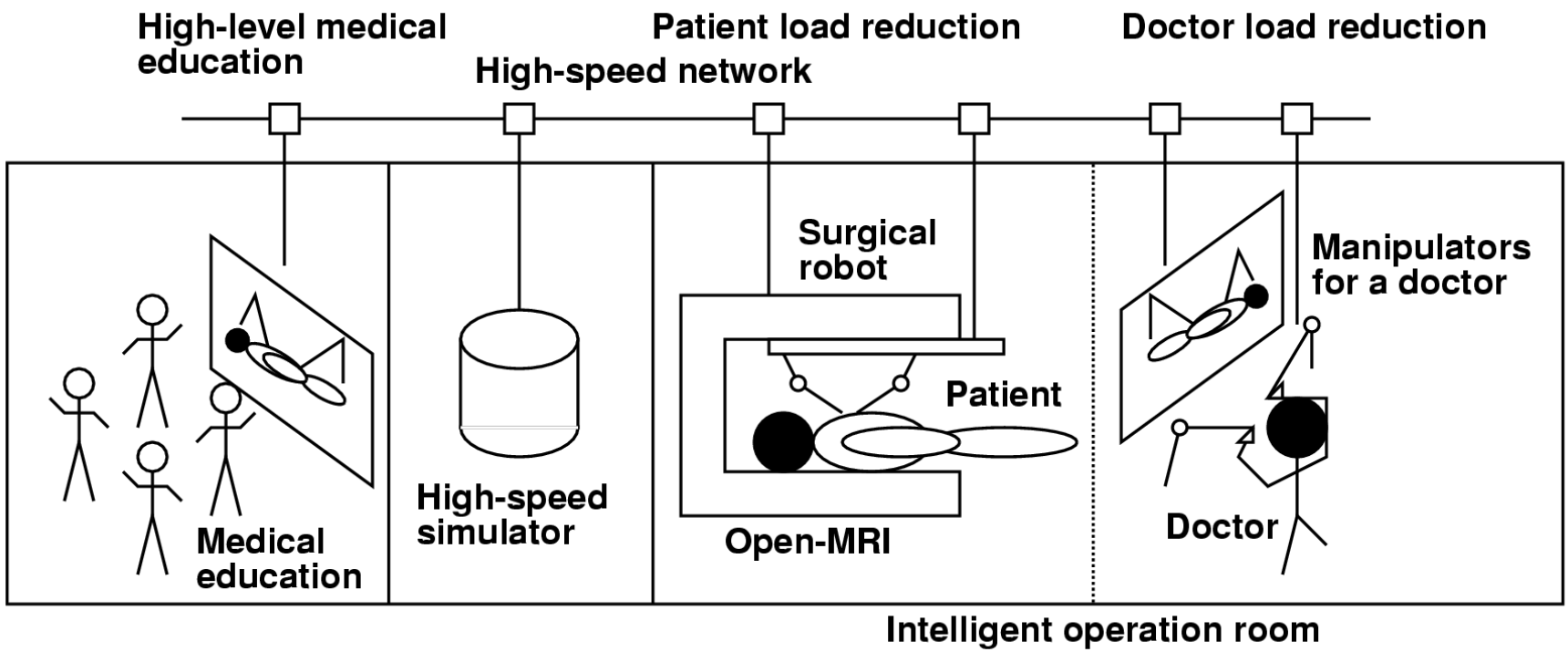


Intelligent operation room

High-level medical education

Patient load reduction

Doctor load reduction



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

豐富人類生活

Enrich Human Life

The 21st Century COE Program
Mechanical Systems Innovation
The University of Tokyo

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:
Mamoru MITSUISHI
Werner KORB
Stefan HASSFELD

Medical Robotics and Welfare
Part 1: Medical Robotics in the Surgical Theater

1. **Technical Asptects of Computer-Integrated Surgery: Surgical and Legal Requirements and Regulations**
2. **Advanced Apparatus and Systems for Laparoscopic and Endscopic 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