Journées du GDR Robotique

November 9-10,2010

CNRS, Campus G. Mégie, 3 Rue Michel Ange, Paris, France

Future Trends in Surgical Robotics

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Outline

- The evolution of robotic surgery: state of the art
- From external robots to endoluminal robots
- Concluding remarks

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- From external robots to endoluminal robots
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Guest Editorial and Guide to the Issue

…on "Medical Robotics"

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IEEE/ASME TRANSACTIONS ON MECHATRONICS, VOL. 12, NO. 4, AUGUST 2007

FOCUSED SECTION ON MEDICAL MECHATRONICS

GUEST EDITORIAL

Guest Editorial: Introduction to the Focused Section on Medical Mechatronics . . . *. . . P. Dario and A. Menciassi*

REVIEWS IN ADVANCE

The International Journal of Robotics Research

http://ijr.sagepub.com

Editorial: Special Issue on Medical Robotics

Jaydev P. Desai and Nicholas Ayache

The International Journal of Robotics Research 2009; 28; 1099 originally published online Jul 7, 2009;
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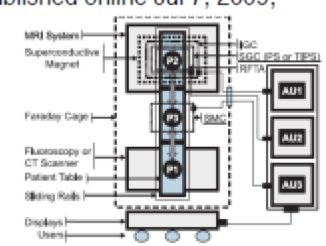

Image-Guided Interventions: Technology Review and Clinical Applications

Kevin Cleary[1] and Terry M. Peters[2]

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Springer Handbook of Robotics

52. Medical Robotics and Computer-Integrated Surgery

Russell Taylor, Arianna Menciassi, Gabor Fichtinger, Paolo Dario

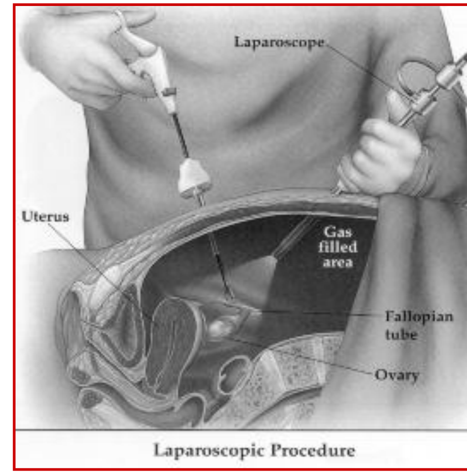
The growth of medical robotics since the mid-1980s has been striking. From a few initial efforts in stereotactic brain surgery, orthopaedics, endoscopic surgery, microsurgery, and other areas, the field has expanded to include commercially marketed, clinically deployed systems, and a robust and exponentially expanding research community. This chapter will discuss some major themes and illustrate them with examples from current and past research. Further reading providing a more comprehensive review of this rapidly expanding field is suggested in Sect. 52.4.

Medical robots may be classified in many ways: by manipulator design (e.g., kinematics, actuation); by level of autonomy (e.g., preprogrammed versus teleoperation versus constrained cooperative control), by targeted anatomy or technique (e.g., cardiac, intravascular, percutaneous, laparoscopic, microsurgical); or intended operating environment (e.g., in-scanner, conventional operating room). In this chapter, we have chosen to

Modern Surgery results from the "convergence" of Science and Technology

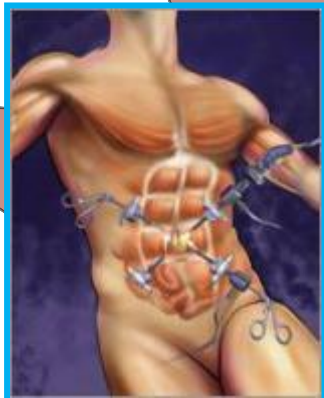
- **Anesthetics** → Modern surgery
- **Antiseptics** → Modern surgery
- **Anticoagulants** → Modern surgery
- **Antibiotics** → Modern surgery
- **Analgesics** → Modern surgery
- **Endoscopic instruments** → Minimally invasive surgery
- **Imaging and robotics** → Computer-assisted surgery

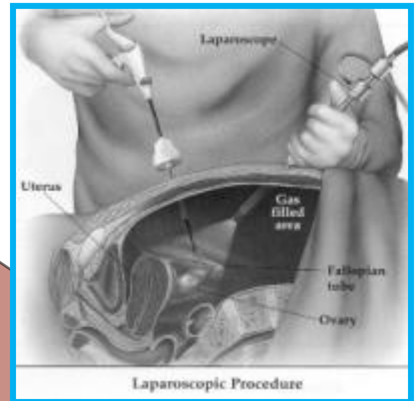
Modern surgery → **Minimally invasive surgery** → **Computer-assisted surgery**



The Evolution of Surgery

TRADITIONAL TECHNIQUES





LAPAROSCOPIC SURGERY

ROBOTIC SURGERY

Surgery

Why Robotics in surgery?

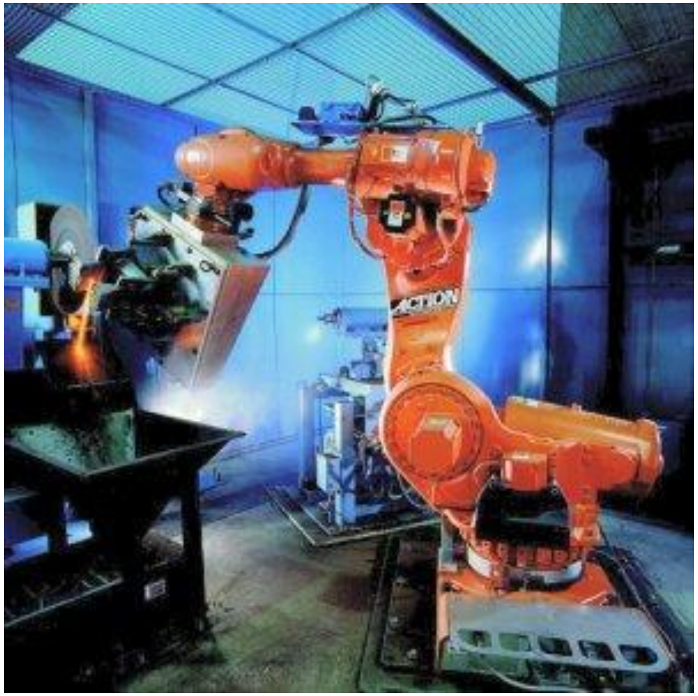
- The concept of precision and accuracy from manufacturing processes towards medical applications

+ Accuracy

+ Predictability

+ Repeatability

= Quality



Aliens_movie

Supernormal performance

History of laparoscopy and robotic surgery

- 1985: Erich Mühe
  1st laparoscopic cholecystectomy
- **1985**: Kwoh, Young et al.
  1st robot (Puma 560) in neurosurgery

NEUROMATE (by Renishaw)

neuromate® has been used in thousands of electrode implantation procedures for Deep Brain Stimulation, and Stereotactic Electroencephalography, as well as stereotactic applications in neuro-endoscopy, radiosurgery, biopsy, and Transcranial Magnetic Stimulation.

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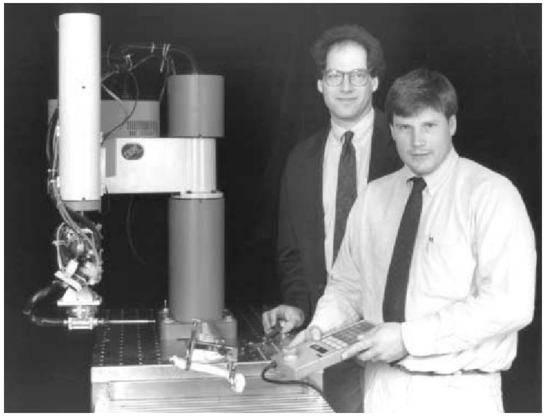
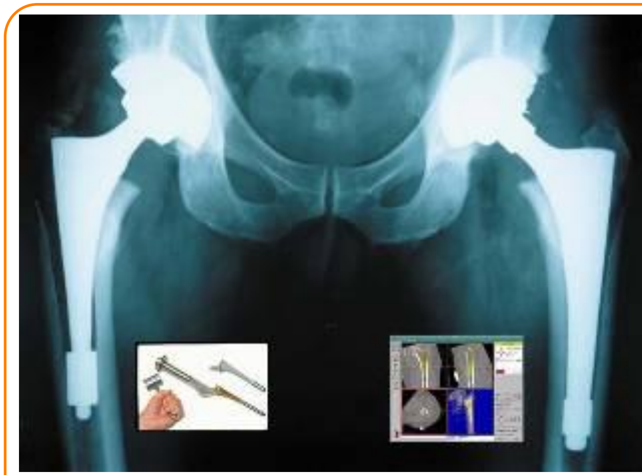
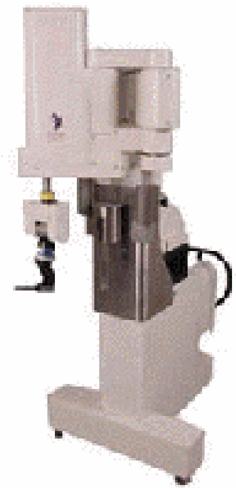
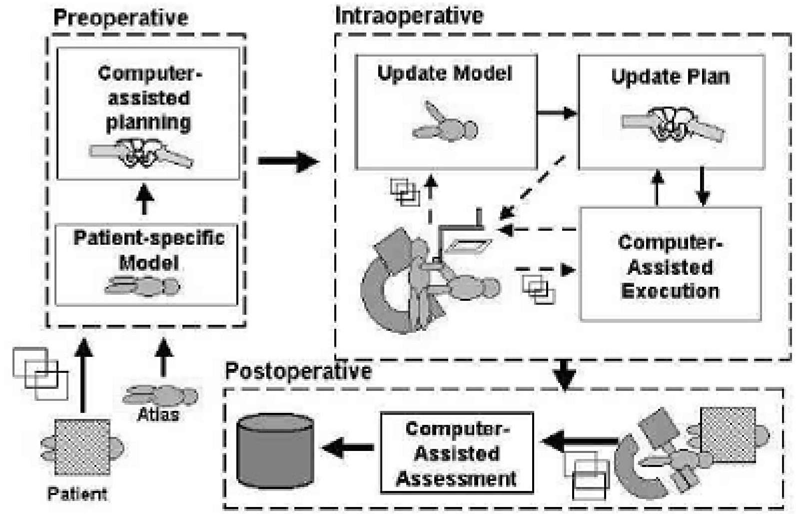
- **1992**: Integrated surgical systems
  1st hip surgery with ROBODOC

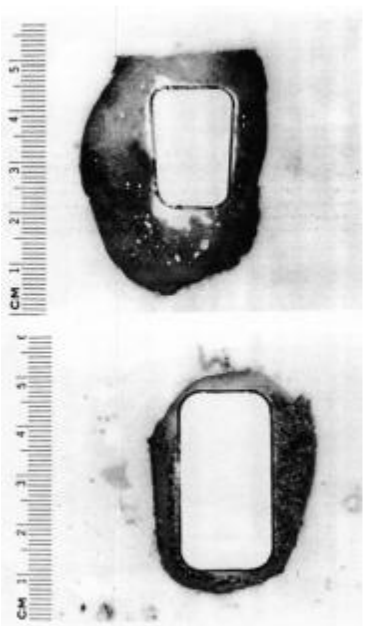


ROBODOC Surgical System







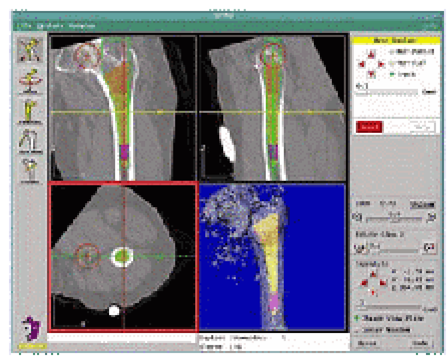


Bone implant comparison

Manual broach method
20% contact surface
1-4 mm gap size

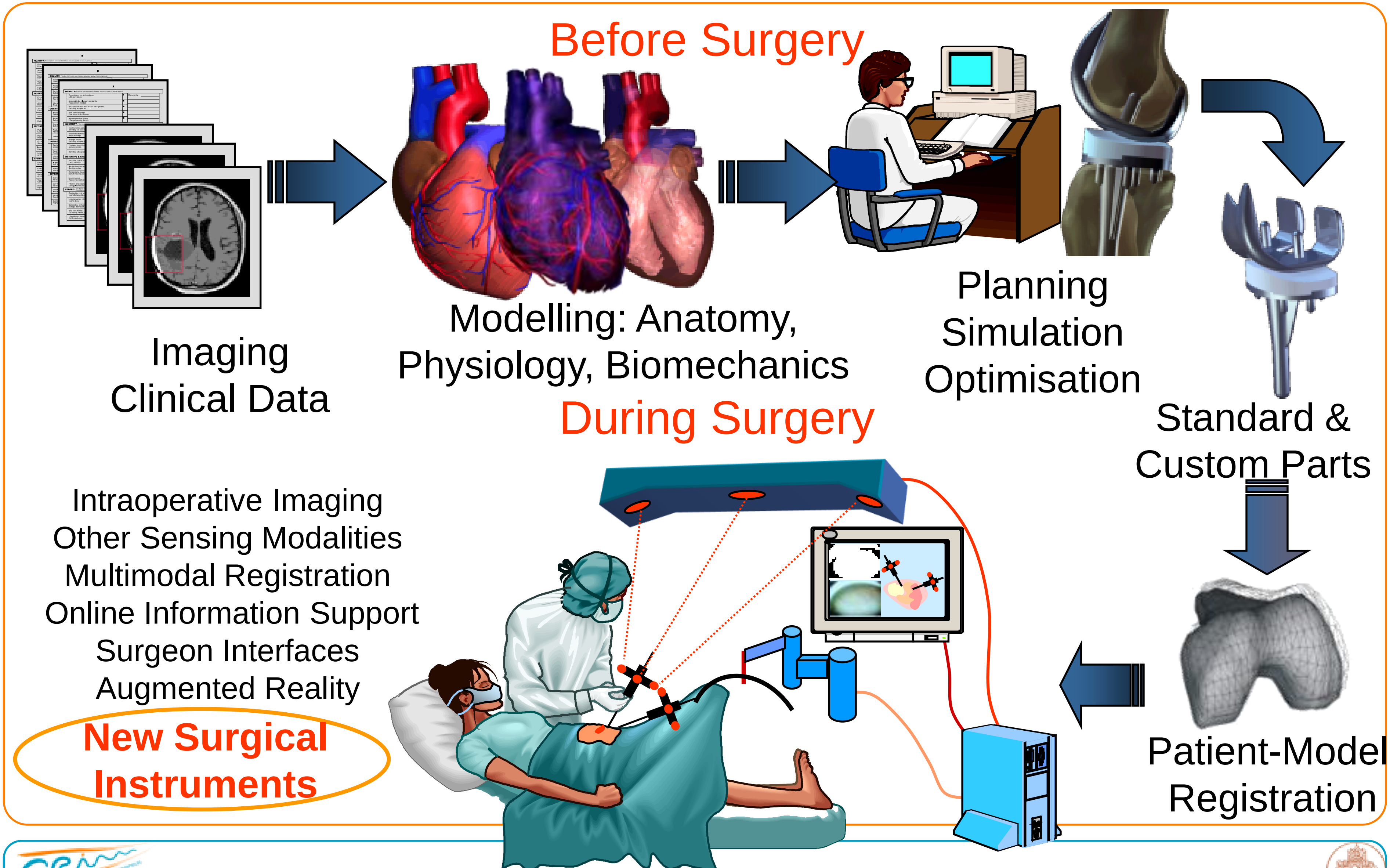
ROBODOC method
96% contact surface
0.05 mm gap size

ORTHODOC Pre-surgical planning station

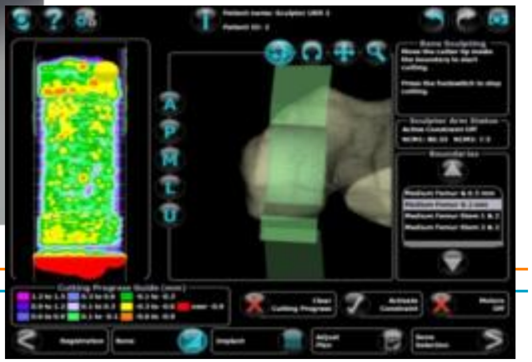


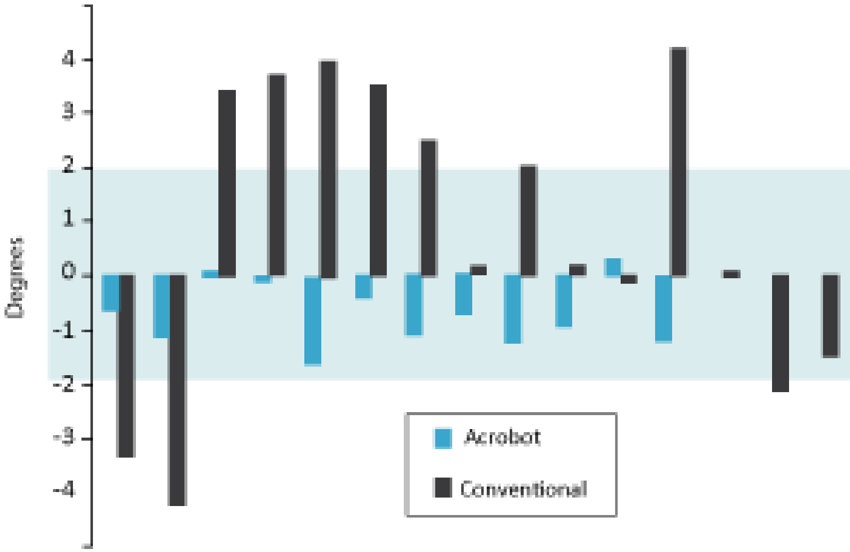
INTEGRATED SURGICAL SYSTEMS
Redefining Surgery...

The Scenario of computer-assisted surgery



ACROBOT (www.acrobot.co.uk) – knee surgery





Bar chart showing the difference in tibiofemoral alignment between planned and achieved in the coronal plane. One of the Acrobot cases has a value of 0°.

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- 1994: Computer Motion Inc.
  1st FDA clearance: AESOP laparoscope holder

AESOP, assistant robot for laparoscope

Other examples of robotic camera holders

FreeHand - giving you total control

FreeHand puts the surgeon in direct control of the scope position.

The scope is moved by the hands-free controller, worn on a head band or attached to a surgical cap, and an activation pedal. Mounted on the stack next to the monitor, an indicator unit shows the direction selected for the scope movement.

Tilt and pan movement

The surgeon simply selects the direction of tilt and pan using head movements, then initiates the movement using the activation pedal. As soon as the foot is removed from the pedal the movement stops. The scope is now held stationary until the pedal is pressed again providing completely stable, rock stea

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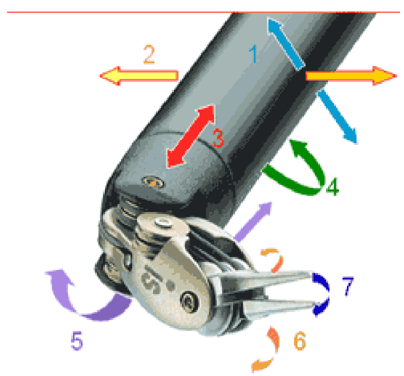
  1st FDA clearance: AESOP laparoscope holder
- **1998**: Intuitive Surgical, Inc.
  1st st totally endoscopy CABG using the daVinci ROBOTIC SYSTEM

A success story in surgical robotics: the "daVinci" system

The main reasons for success:

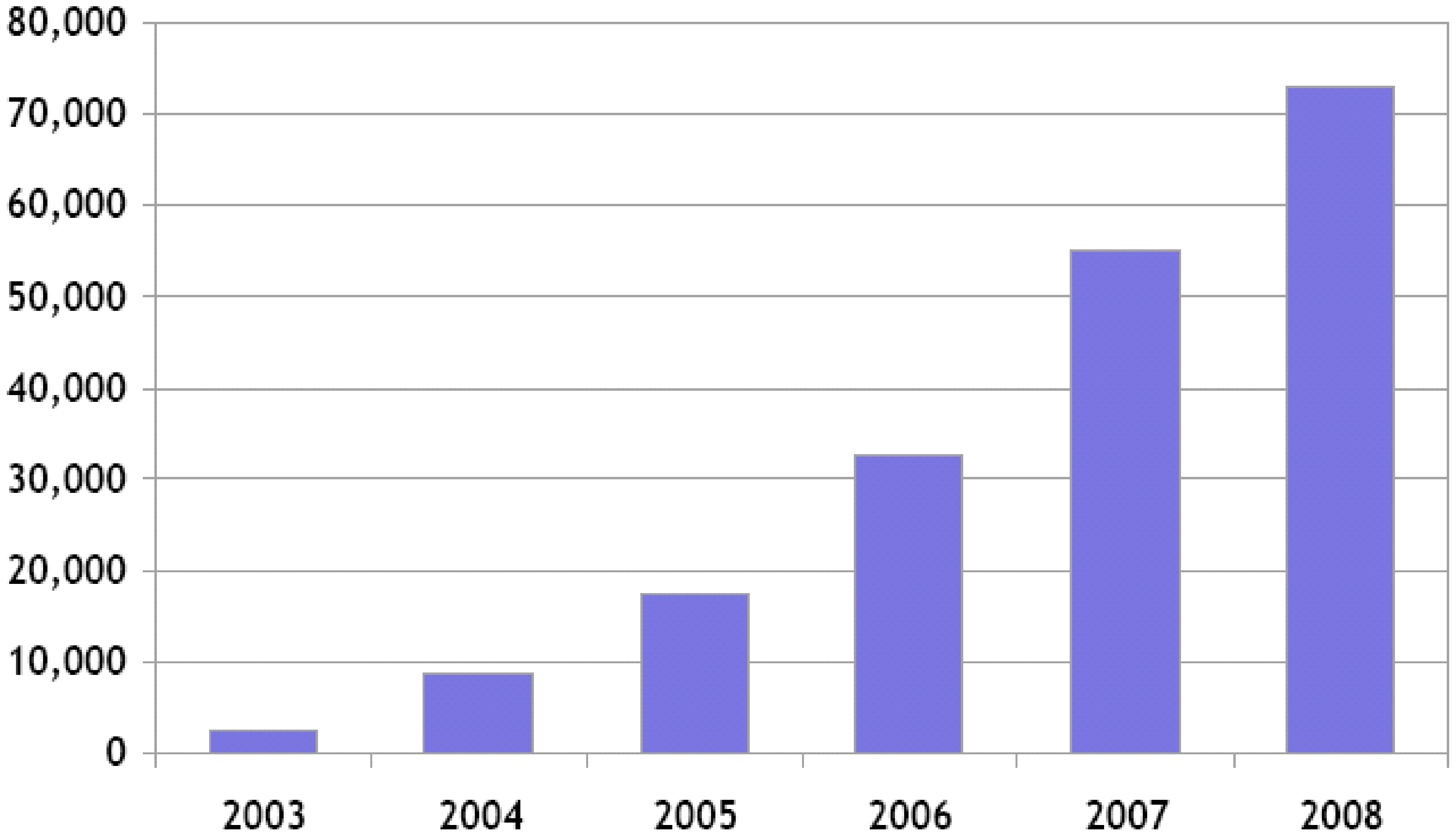
- **VERY HIGH SURGICAL PRECISION**
- **Minimal invasiveness**
- **Intuitive control**

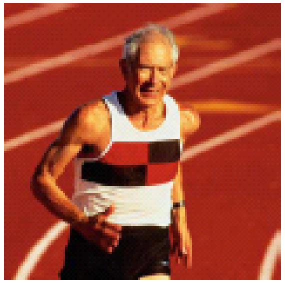
The DaVinci System

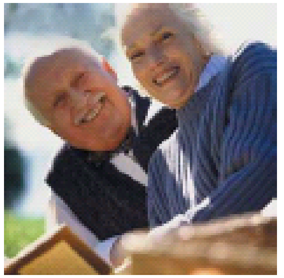


- External arms with Remote Center of Motion: the movement is mechanically constrained around a pivot point;
- 3 DOFs moved by the external arms (2 orientations and 1 translation considering the roll as internal DOF);
- 3 DOFs internal, actuated by a cable-driven system:
  - 1 Roll
  - 1 Pitch
  - 2 coaxial yaw (used also for open-close of the gripper)

da Vinci® Prostatectomy Procedure Growth

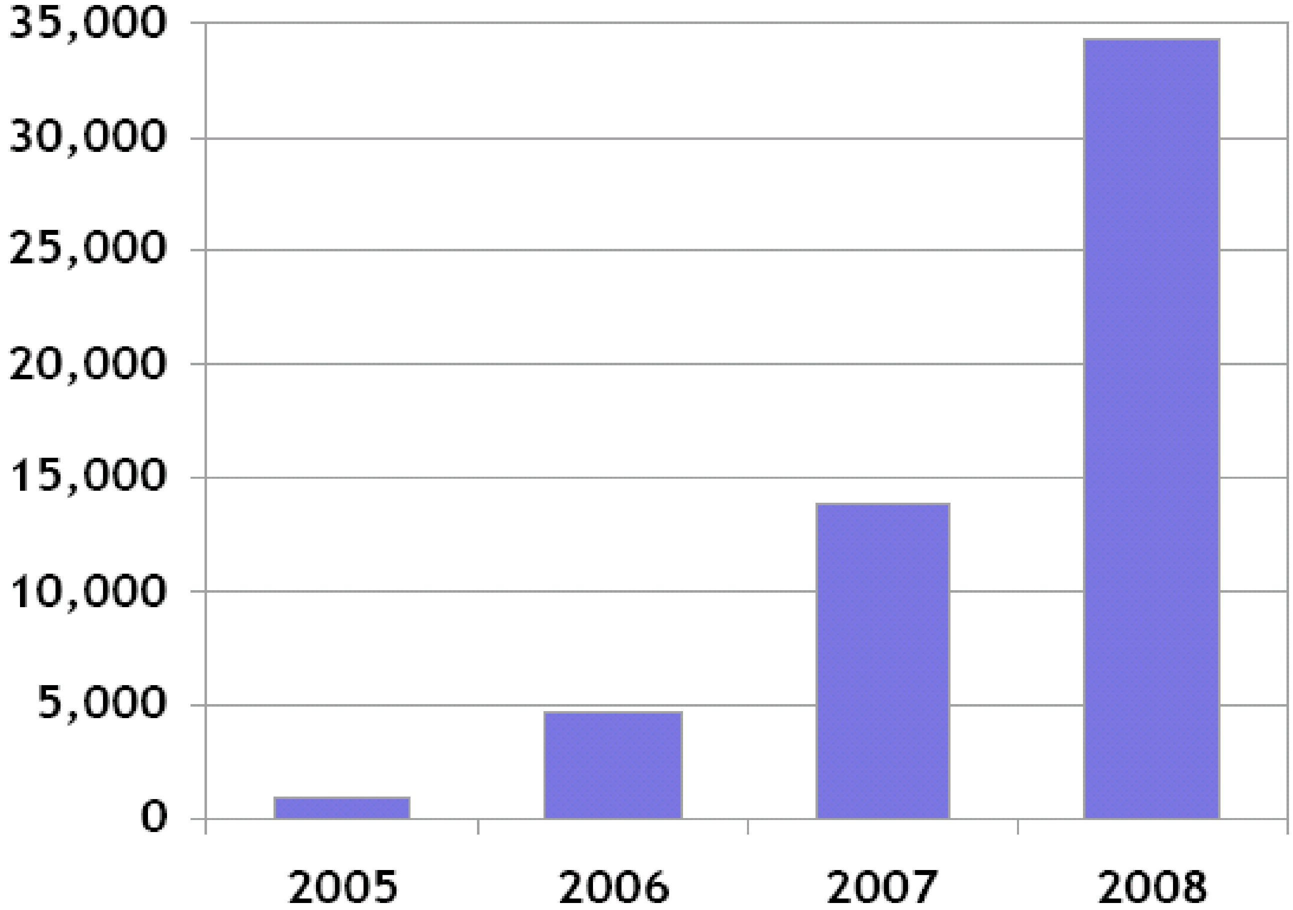






INTUITIVE SURGICAL®

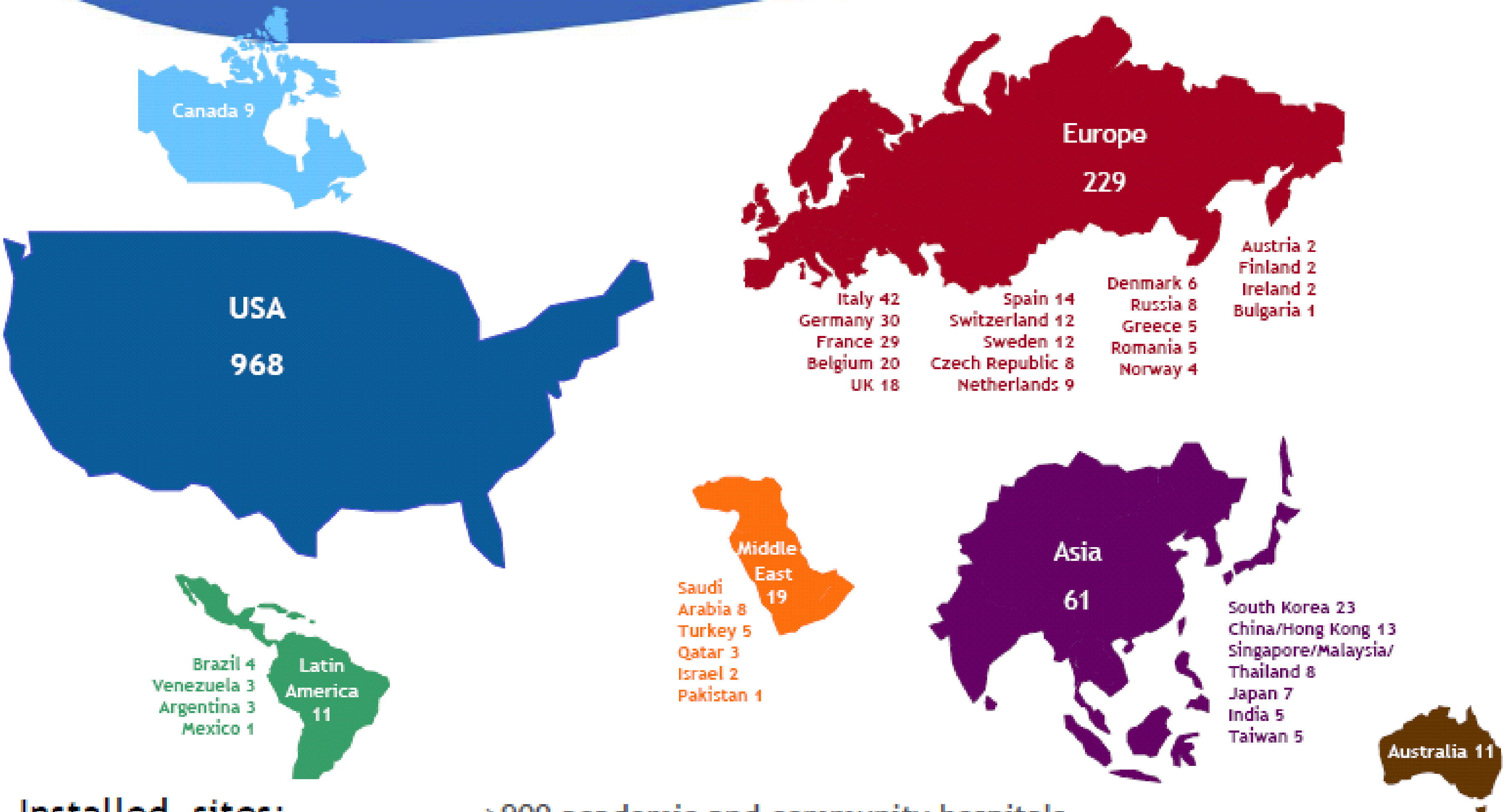
da Vinci® Hysterectomy Procedure Growth



* Figures based on Company estimates.

INTUITIVE SURGICAL®

Installs by Country and Region



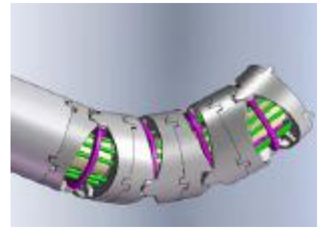
- Installed sites: >900 academic and community hospitals
- Installed systems: >1500
- Employees: >1400

INTUITIVE SURGICAL®

Recent trends: Intuitive's heuristic expression of patient value

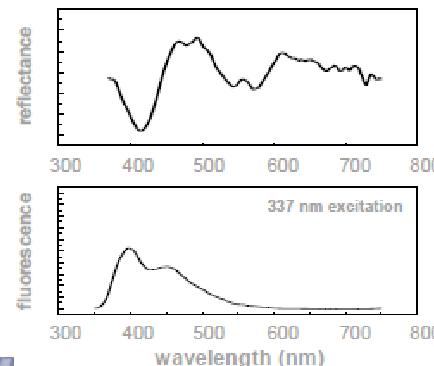
New instrumentation

- Integrated Energy Instruments
  - Monopolar Energy
  - Bipolar Energy
  - Advanced Bipolar
  - Harmonic
  - Advanced Graspers
  - Laser



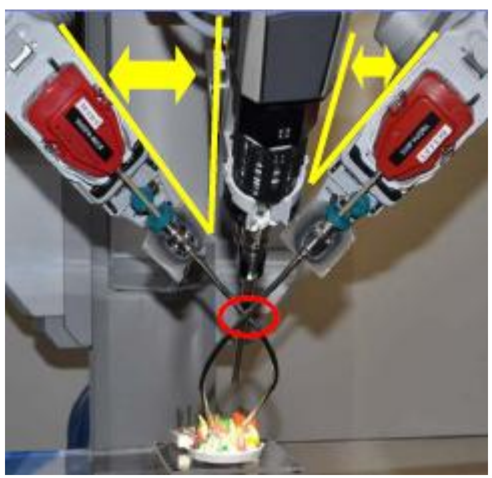
Tissue Spectroscopy

$$\textbf{Patient Value} = \frac{\textbf{Efficacy}}{\textbf{Invasiveness}^2}$$

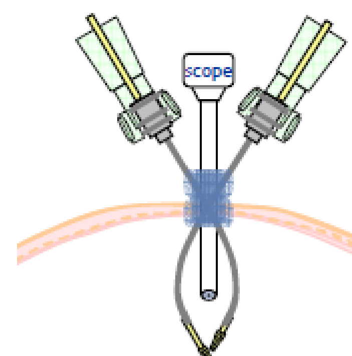


- Using *da Vinci Si* system with 8.5mm 3D HD endoscope.
- Curved Instrument Cannulae.
- 5mm, non-wristed, semi-rigid instruments.

Limiting incisions



SPL robotic system by Intuitive Surgical



Originally, da Vinci-like systems were intended for **Telesurgery**

7/09/2001: Lindbergh operation

Cholecystectomy on a 68 years old women

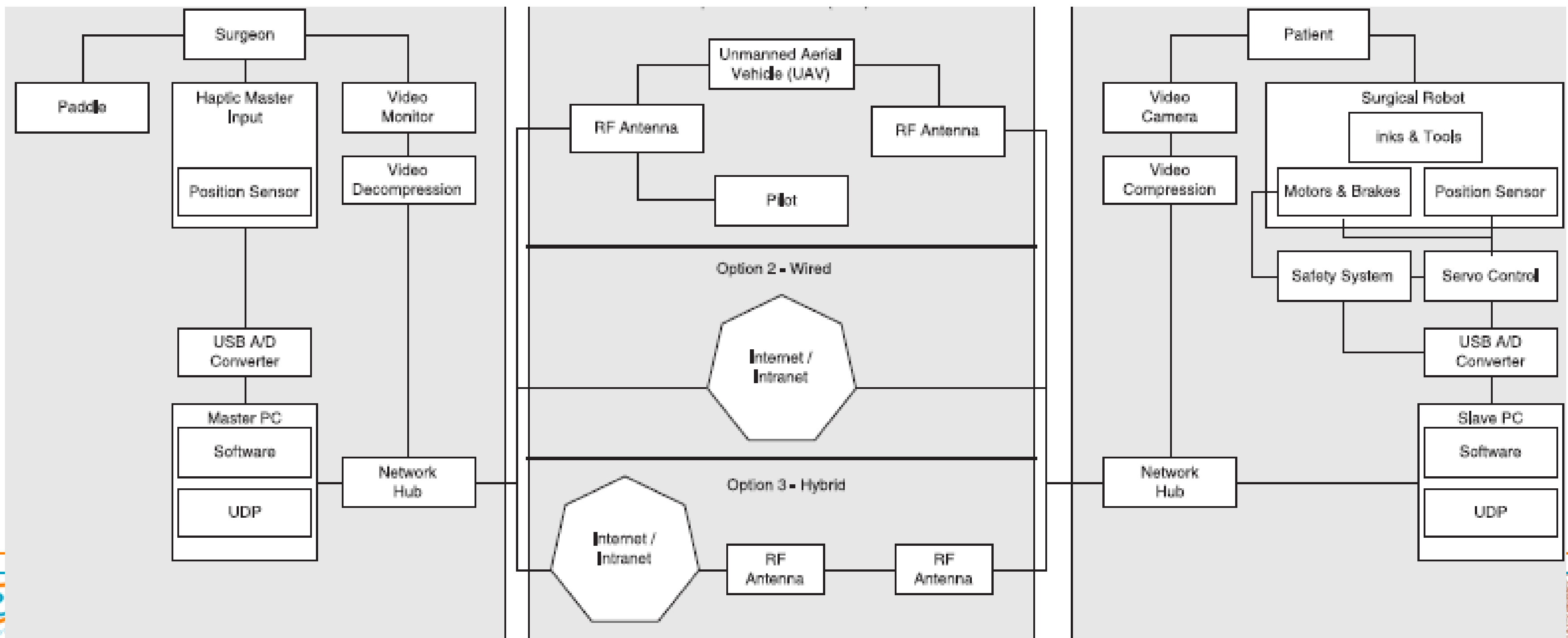
Distance: more than 6200 km
(New York – Strasbourg)

Delay: 155 ms (300 ms was the safety threshold) with optical fibres connection. Surgeons do not perceive delays smaller than 6 ms.

For more than 10.000 km, some semiautomatic tasks must be implemented

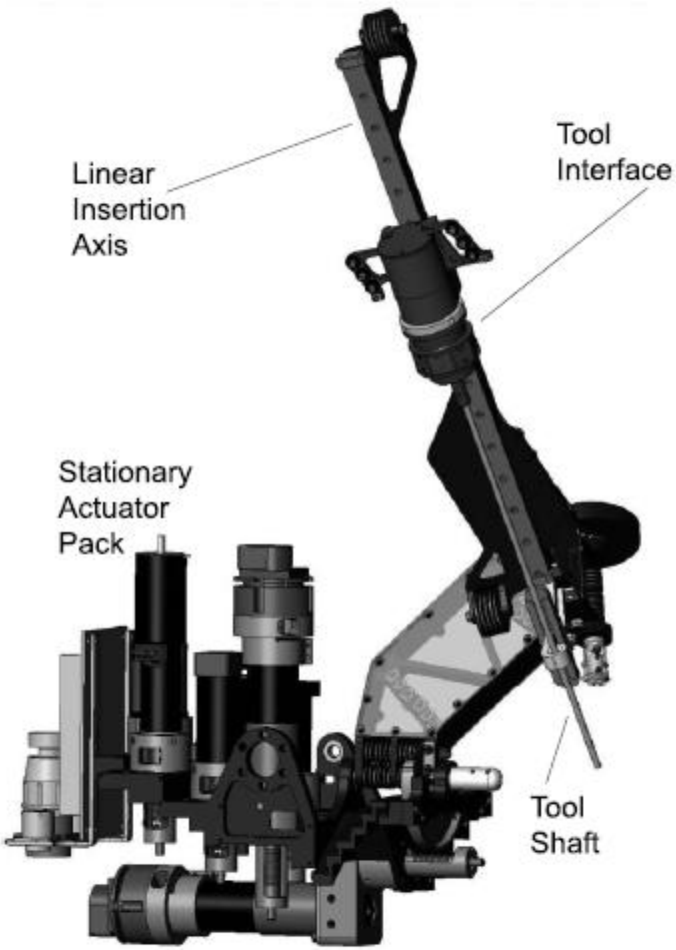
The RAVEN System – Biorobotics Lab Seattle (B. Hannaford)

The RAVEN patient site and the surgeon site



The RAVEN System – Biorobotics Lab Seattle (B. Hannaford)

Experiment	Date(s)	Patient site	Surgeon site	Communication layer
				Video
HAPs/MRT	June 5–9, 2006	Field, Simi Valley, CA	Field, Simi Valley, CA	HaiVision Hai560
ICL	July 20, 2006	BioRobotics Lab, Seattle, WA	Imperial College, London, England	iChat or Skype
Animal Lab	March 8, 2007	CVES, Seattle, WA	CVES, Seattle, WA	Direct S-video
NEEMO Aquarius	May 8–9, 2007	Aquarius Undersea Habitat, 3.5 miles off Florida Keys, 60 ft depth	University of Washington, Seattle	HaiVision Hai1000
NEEMO NURC	May 12–13, 2007	National Undersea Research Center, Key Largo, FL	University of Washington, Seattle	HaiVision Hai200



Mean network latency (ms): approx. 70 ms

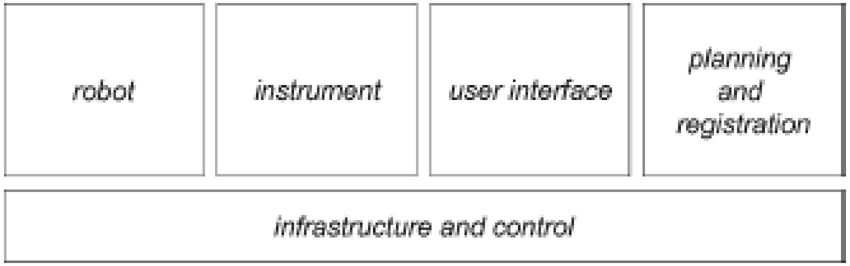
1. the shoulder joint (rotational);
2. the elbow joint (rotational);
3. tool insertion/retraction (translational);
4. tool rotation (rotational);
5. tool grasping (rotational);
6. tool wrist-1 actuation (rotational);
7. tool wrist-2 actuation (rotational).

RavenDemo_Final.mov

MIROSURGE system by DLR - Germany

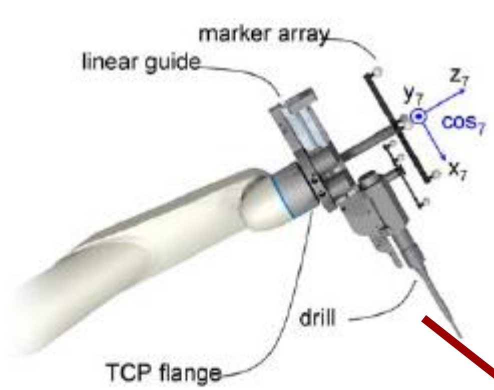
The DLR MiroSurge robotic system, consisting of three MIRO robots, actuated minimally invasive instruments MICA and a stereo endoscope. The endoscopic video stream can be stabilized by optical tracking in real time so that a virtually stationary video picture can be presented to the surgeon.

The DLR MiroSurge command devices for the surgeon

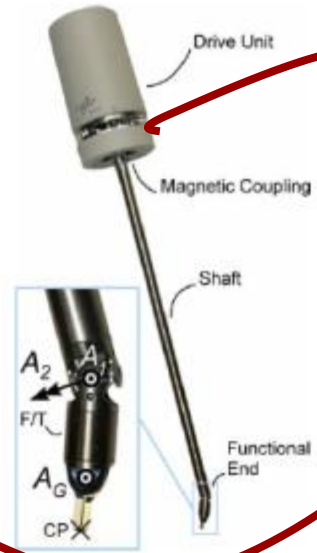


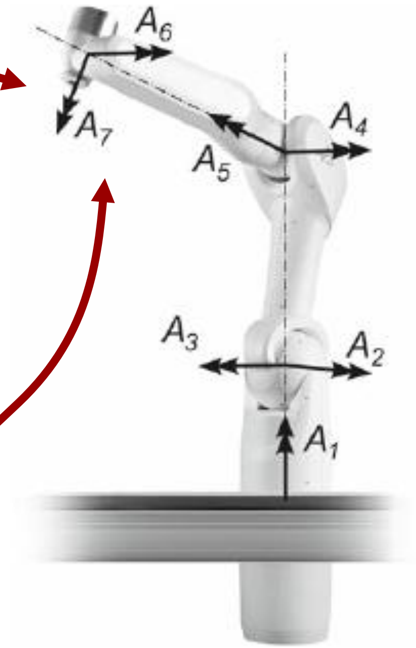
Video: DLR_MIRO_in_the_MiroSurge_System.mp4

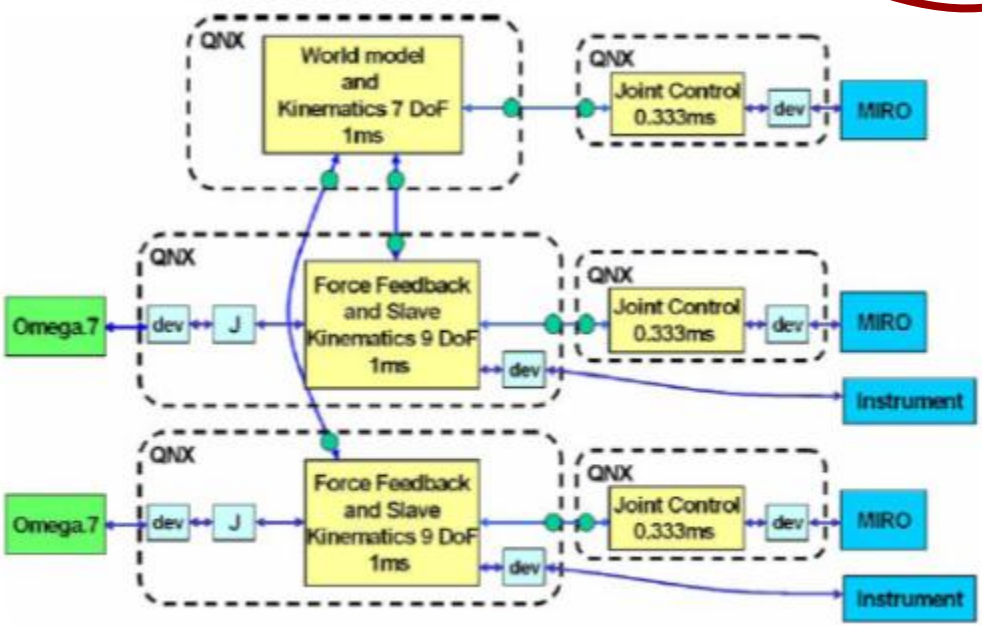
MIROSURGE system by DLR - Germany



The DLR MIRO wrist design:
configuration for conventional instruments (left) ; with MICA dedicated tool (right)







Parameter	Value
Number of joints	7
Mass	10 kg
Maximum payload	3 kg
Length $(\overline{A_2A_4}+\overline{A_4A_6})$	0.76 m
Position sensors	Motor-sided, joint-sided
Cartesian speed	0.5 m/sec
Torque Sensors	Joint-sided
Safety brakes	Motor-sided
Control modes	Position, torque, and impedance
Control cycle	3 kHz

How to improve current robots for surgery

-Training of users (importance of simulators)

- Tuning the robot features based on the environment where it has to operate (tissue biomechanics)

- Limiting the invasiveness and overall robot size still preserving (and augmenting!) functionalities

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Problems encountered while using the Da Vinci system

" … a small regional hospital, Wentworth-Douglass (Dover, New Hampshire) has used the da Vinci Robot about 300 times in four years. That's **a fraction of the usage rate of some big medical centers**. One patient operated on days after an hockey game required four more procedures to repair the damage. Two patients suffered lacerated bladders. There's no evidence to suggest the injuries at Wentworth-Douglass were caused by technical malfunctions. Surgeons who use the da Vinci regularly say **the robot is technologically sound** and an asset in the hands of well-trained doctors. But they caution that it **requires considerable practice** … "

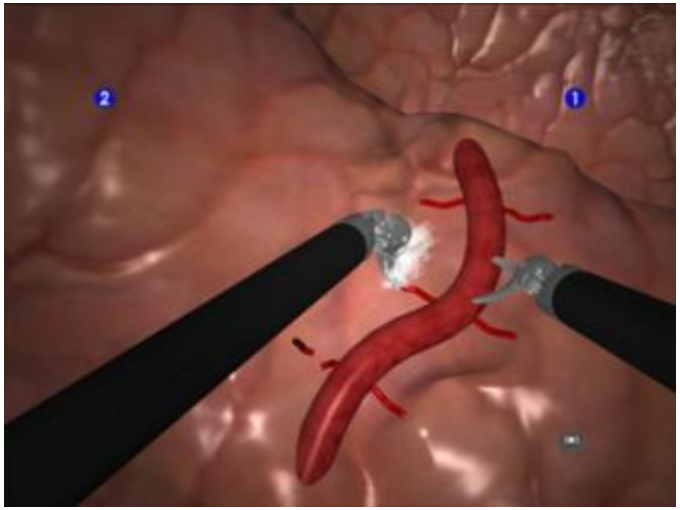
Source: John Carreyrou, the Wall Street Journal, May 4, 2010

Mimic's dV-Trainer™

Overview

dV-TRAINER™

- **Skills trainer for robotic surgery**
  - Simulates the Surgeon Console of the *da Vinci*® Surgical System
  - Cost-effective "off-line" alternative to learning directly on robot
- **Target Users**
  - Surgeon with < 10 robotic cases
  - Surgery residents / fellows
- **Target Applications**
  - da Vinci training for novices
  - Skill retention / rehearsal
  - Surgeon credentialing / privileging
  - Academic research
- **Currently placed at 21 Beta Sites**



da Vinci® is a registered trademark of Intuitive Surgical, Inc.

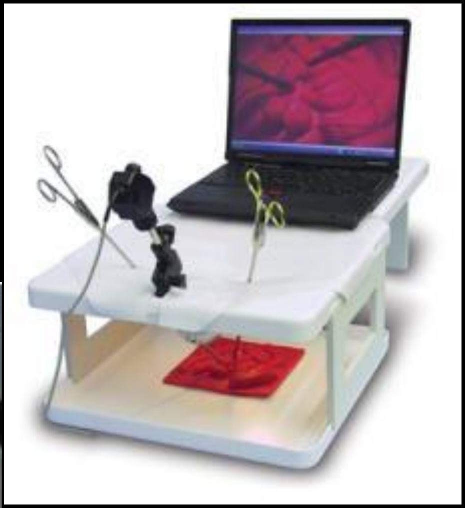
mimic

MIS Trainers Takes Two Paths

- Virtual Trainers
  - MIST - Mentice
  - LapVR – Immersion (sold to CAE)
  - LapSim – SurgicalScience
- Box Trainers
  - LapTrainer – Simulab
  - MITS – 3DMed

LapSim by SurgicalScience

LapTrainer by Simulab



SIMULAB CORPORATION

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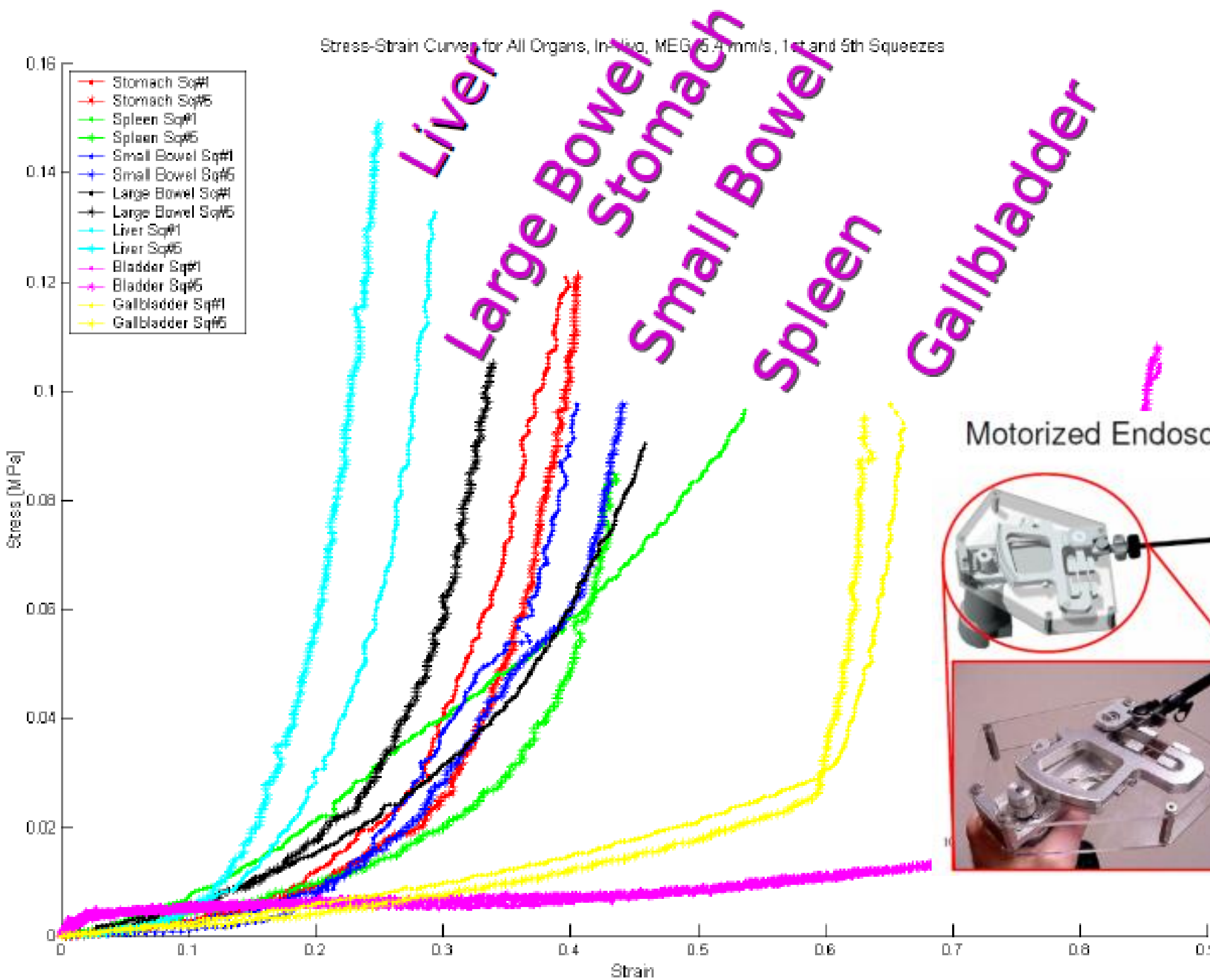
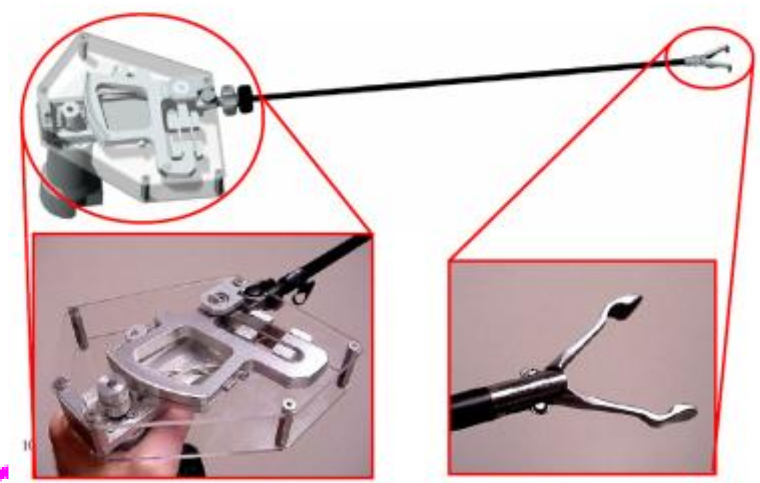
Typical Stress-Strain Curves

All organs, 1st & 5th Squeezes, 5 mm/s, MEG, *in-vivo*

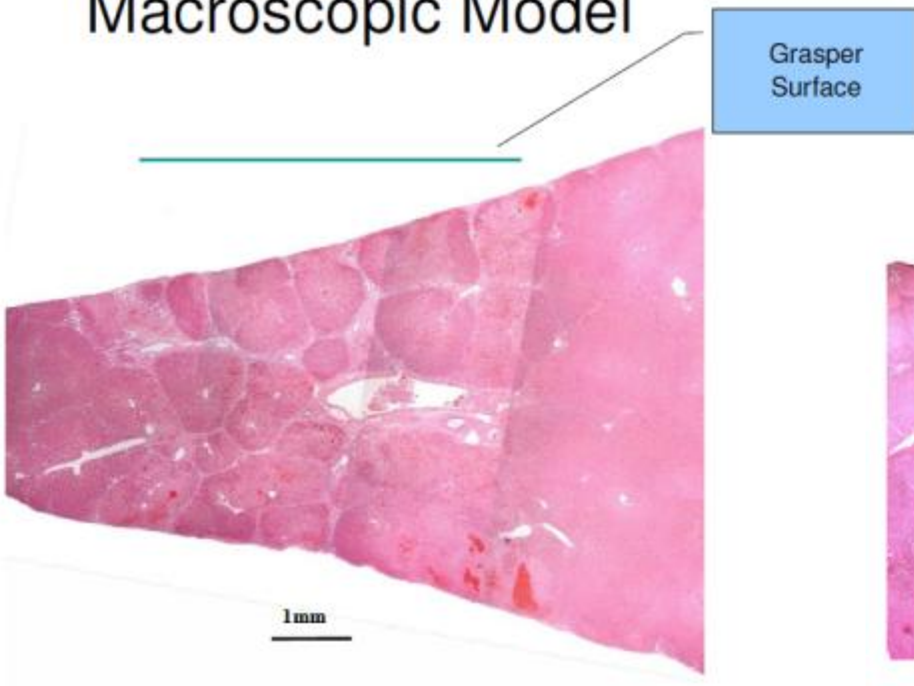
Hannaford / U. of Washington



Motorized Endoscopic Grasper (MEG)



Macroscopic Model



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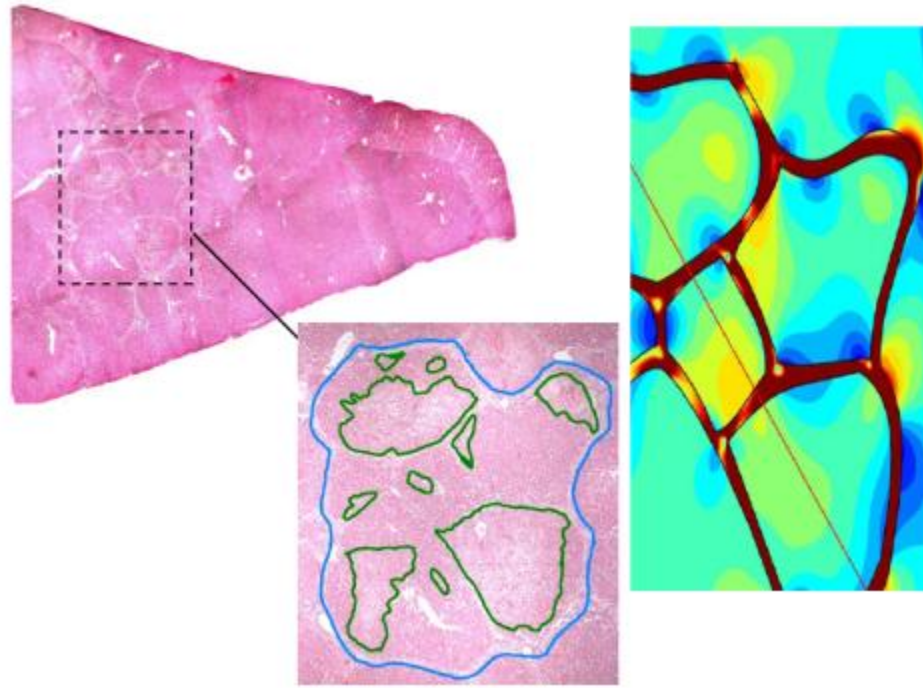
Microscopic Model



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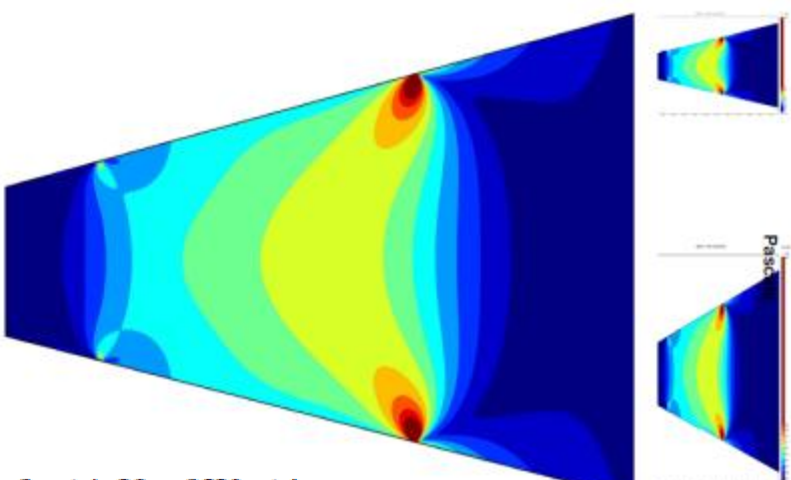

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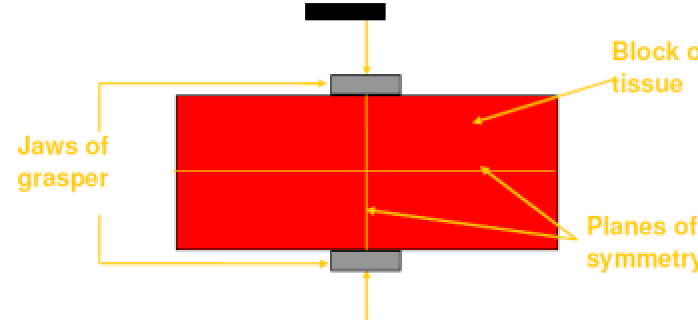

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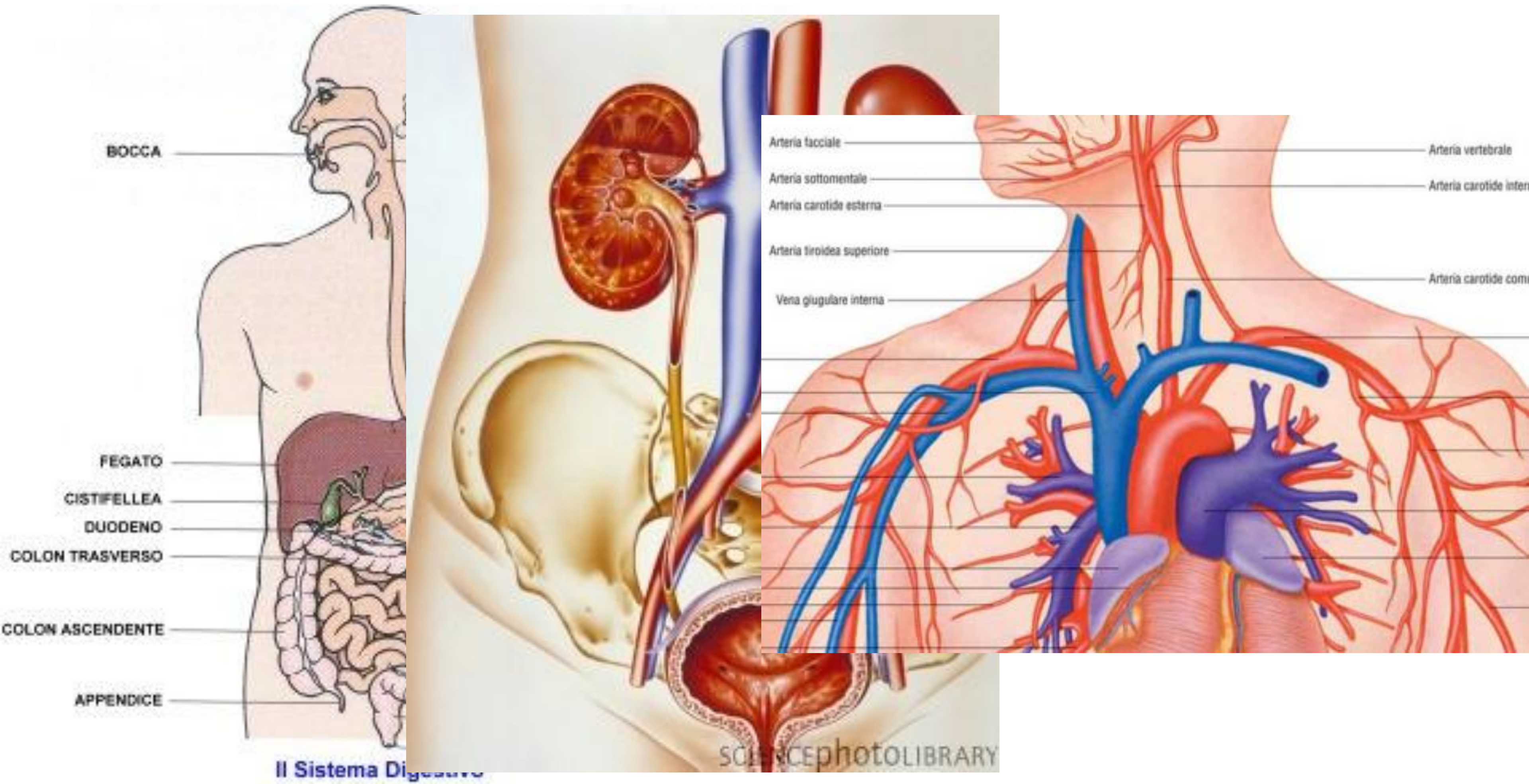
Why only LARGE robots?
Could we obtain the same advantages (precision, early diagnosis and therapy, accuracy) with smaller, friendly, scarless robots?



The CyberKnife (towards no incisions…)

Image-Guidance System + Multi-Jointed Robotic Arm

6MV linear accelerator for X-ray tumor ablation

6 d.o.f.s KUKA KR 210-2

- Robotic targeting precision <0.2mm
- Overall precision of treatment
  - <0.95mm for cranial and spinal lesions
  - 1.5mm for moving targets with respiratory tracking

Outline

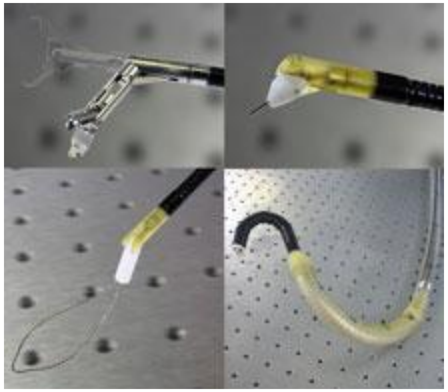
- The evolution of robotic surgery: state of the art
- From external robots to endoluminal robots
- Concluding remarks

Endoluminal Therapy and Surgery

Endoluminal procedures consist of bringing a set of advanced therapeutic and surgical tools to the area of interest by navigating in the *lumens* of the human body, such as the gastrointestinal tract, the urinary apparatus, the circulatory system, etc.

PillCam for GI tract endoscopy

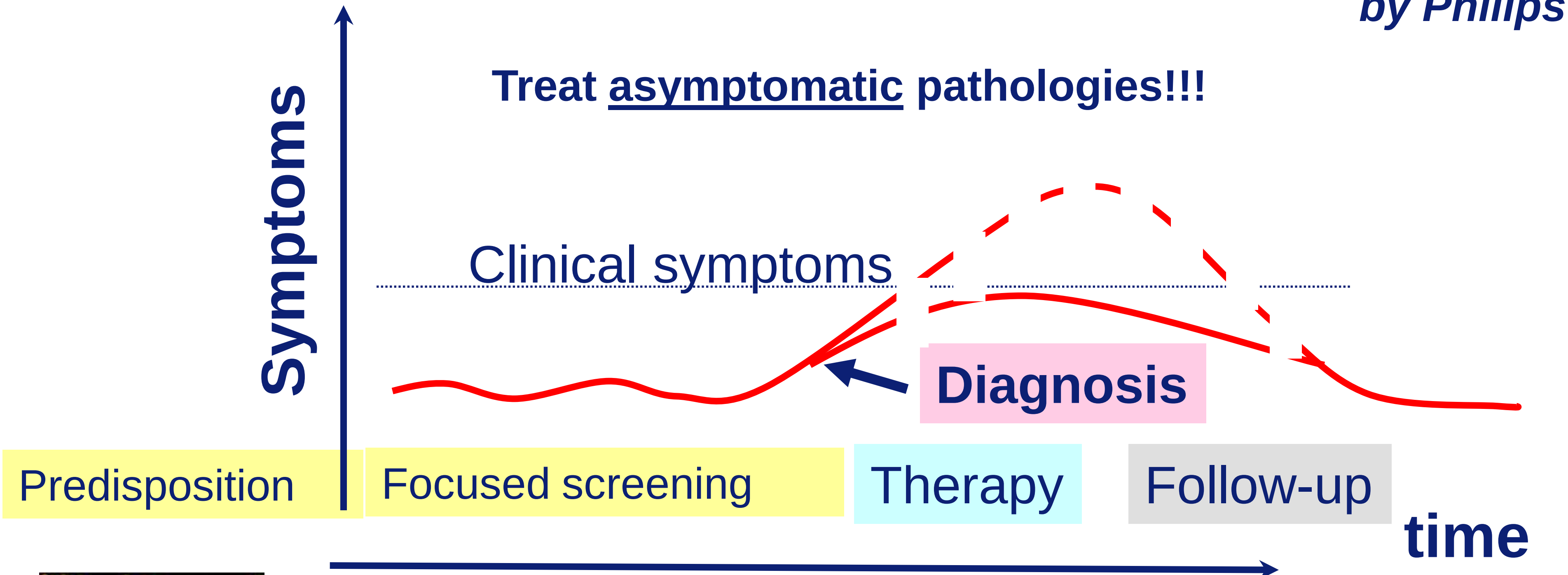
Instrumentation for endoscopic surgery and NOTES (Natural Orifices Transgastric Endoscopic Surgery)

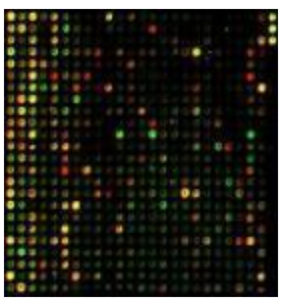


Clip for endoscopic surgery

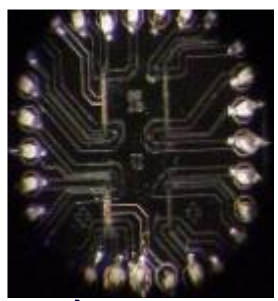
Prevention: the role of <u>modern medicine</u>

Courtesy by Philips

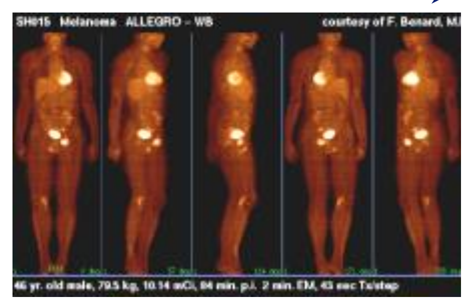




Gene Chip



Biosensor



PET-CT

Molecular Diagnostics

Molecular Imaging

Tomorrow's technology: Molecular diagnosis and imaging & molecular therapy

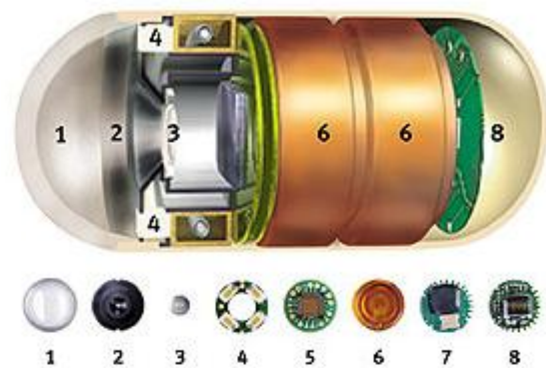
Outline

- The evolution of robotic surgery: state of the art
- **From external robots to endoluminal robots**

Case 1: endoscopy of the GI tract

May 2000: Given Imaging (now PillCam) capsule for endoscopy

Graphic provided by Given Imaging, Inc.



Inside the M2A Capsule

1. Optical dome
2. Lens holder
3. Lens
4. Illuminating LEDs (Light Emitting Diode)
5. CMOS (Complementary Metal Oxide Semiconductor) imager
6. Battery
7. ASIC (Application Specific Integrated Circuit) transmitter
8. Antenna

State of the Art of Wireless Capsule Endoscopy

SmartPill

SmartPill GI Monitoring System for pressure, temperature and pH of GI tract

Jinshan Science and Technology Group

OMOM Capsule Endoscopy System for video acquisition inside small bowel

Kyungpook National University

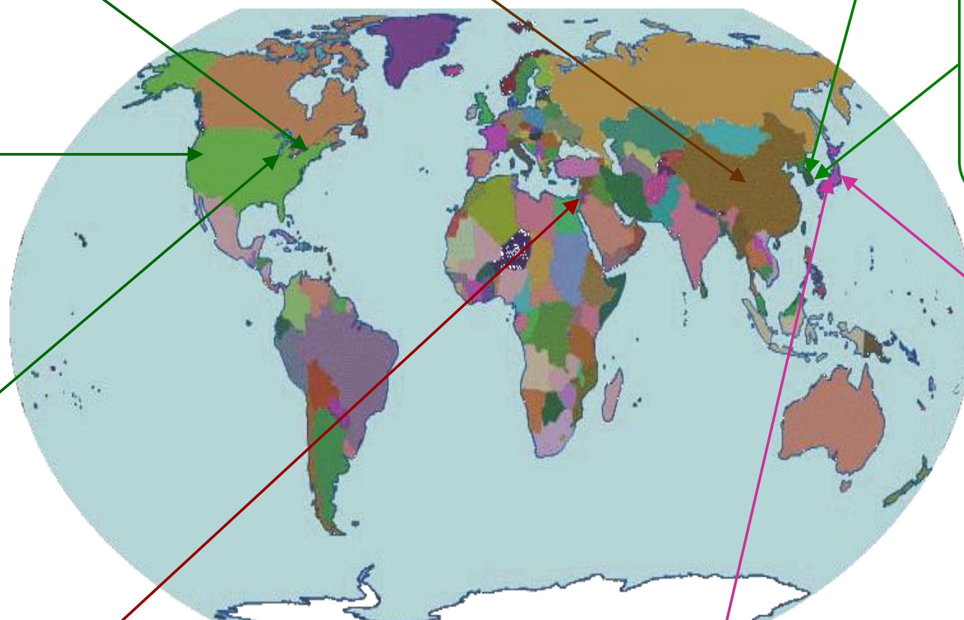
WCE driven by electrical stimuli and for video acquisition

Mini Mitter

VitalSense® system for temperature monitoring

Intelligent Microsystem Center

MiRO for video acquisition inside small bowel

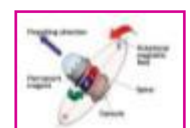


Medtronic

Bravo™ pH Monitoring System for GERD screening

Olympus

Endo Capsule for video acquisition inside small bowel and esophagus

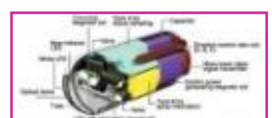


Active and battery free pill for diagnosis inside the whole GI tract

Given Imaging

PillCam™ SB, PillCam™ ESO for video acquisition inside small bowel and esophagus. PillCam™ COLON for colon.

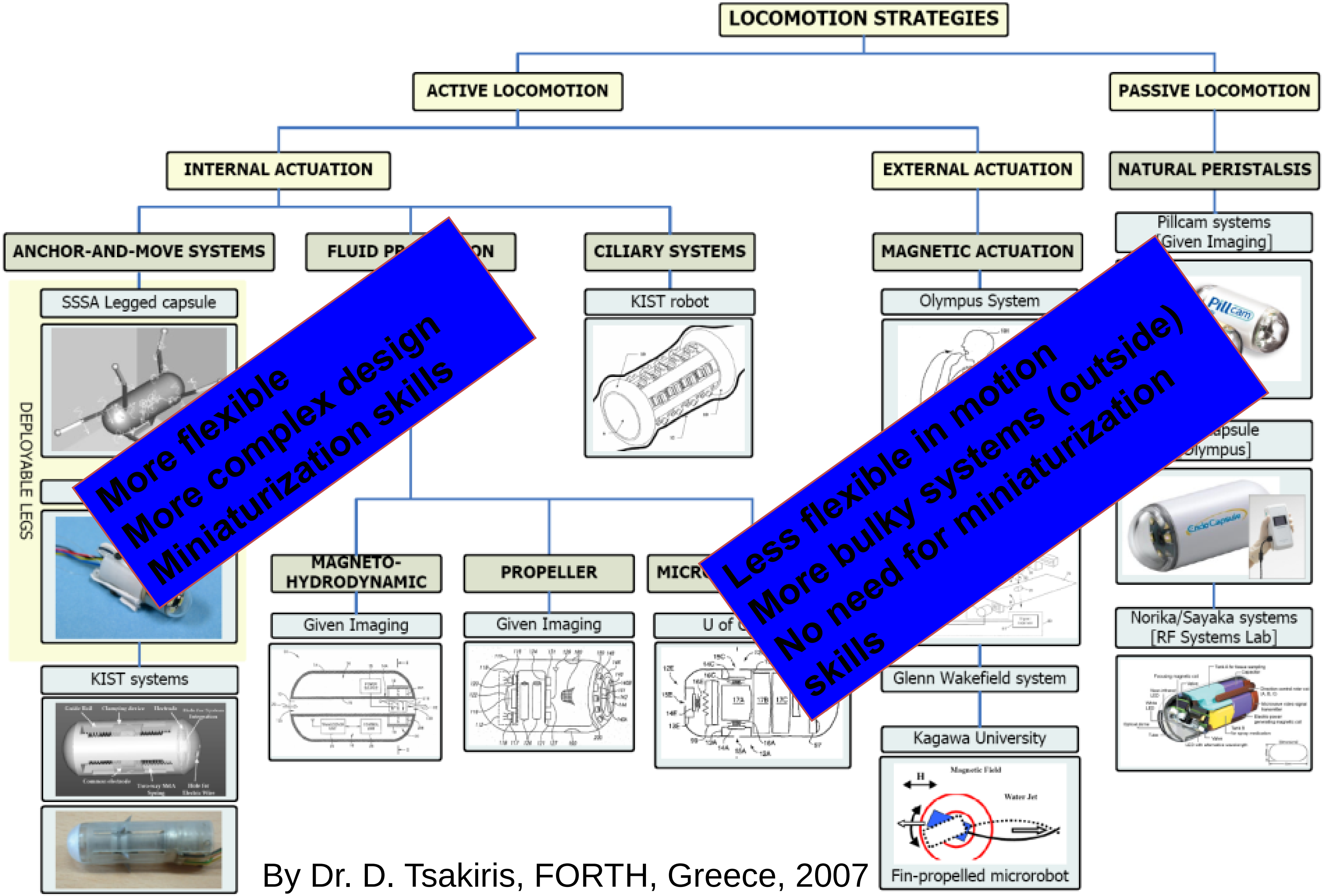
RF SYSTEM Lab



Norika: active and battery free pill for diagnosis inside the whole GI tract

A. Moglia, A. Menciassi, M.O. Schurr and P. Dario. *Wireless Capsules: from Passive Diagnostic Tools to Robotic Medical Platforms*. Biomed Microdevices (2007) 9:235–243

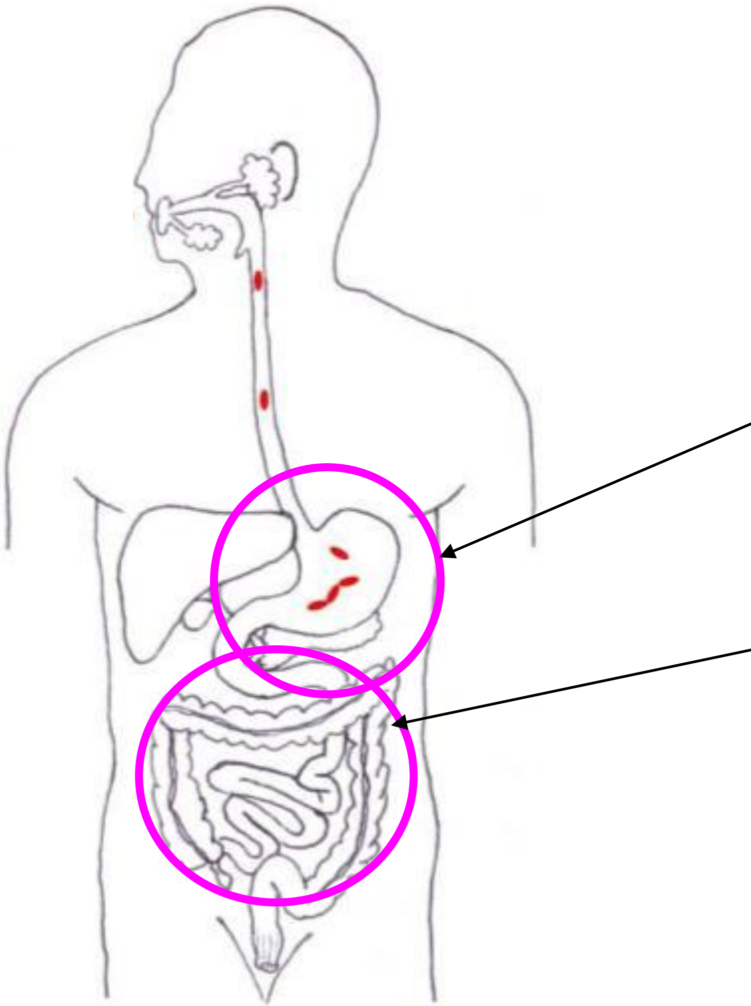
LOCOMOTION STRATEGIES FOR CAPSULE ENDOSCOPY



By Dr. D. Tsakiris, FORTH, Greece, 2007

Internal Locomotion Approach

Due to **space constraints** we decided to pursue different strategies optimized for the 2 targeted districts:

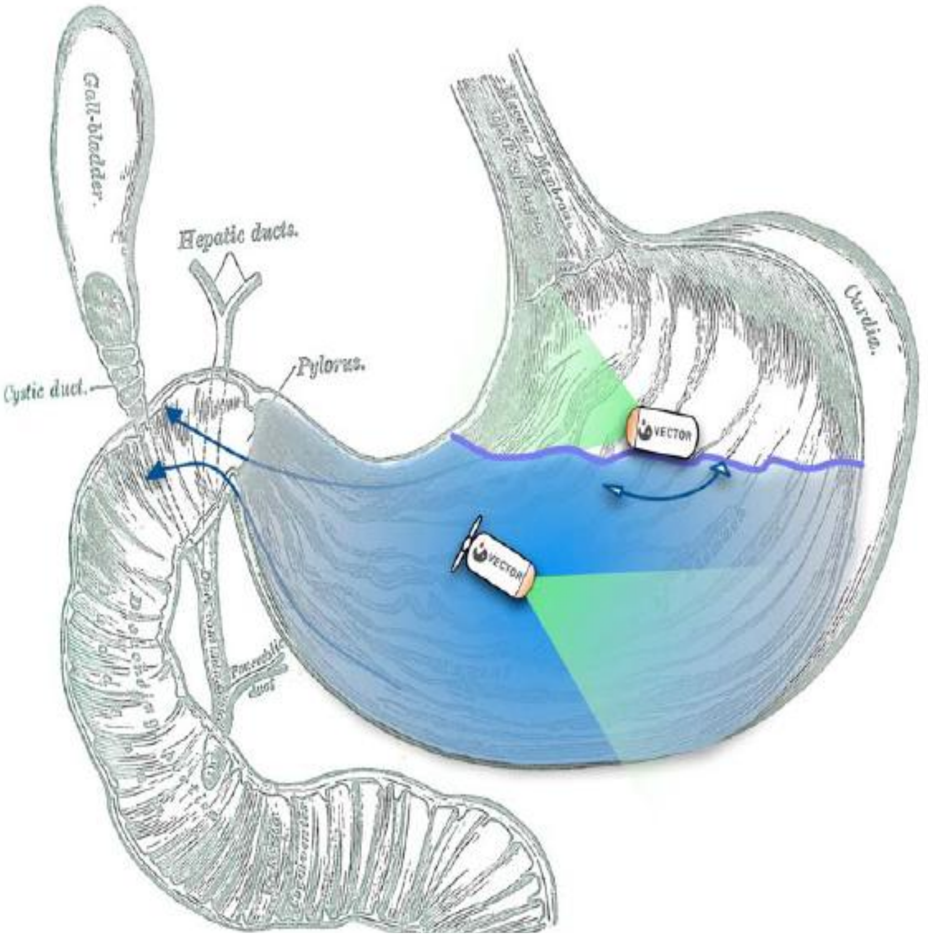


Locomotion in the Stomach:
The capsule swims in a liquid environment

Locomotion in the Colon:
The capsule moves by 12 legs

Internal Locomotion Approach in the stomach

Ingestion of liquid in context with the examination allows to obtain organ distension, thus making possible a low power 3D locomotion in the stomach



Concept: Liquid filling

Mechanism:

- Wireless capsule
- Gastric distension through liquid ingestion
- Capsule diving or floating

Possible challenges:

- Debris in water impairs vision.
- Steering of capsule inside water
- Coordination between endoscopic procedure steps and fluid intake

Research conducted:

- In vivo animal labs with prototypes
- Human voluteer study with off-the-shelf devices on the clinical fasibility of underwater capsule endoscopy.

Internal Locomotion Approach in the stomach

In the capsule:

Control/Telemetry module

TI CC2430 (Zigbee + μC)

4 DC brushless motors

Didel MK04S-24, 2400rps

3.0V, 15mA/V no load

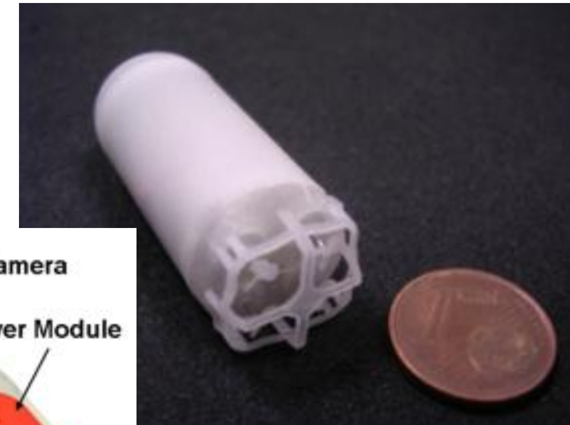
4 propellers in the rear side

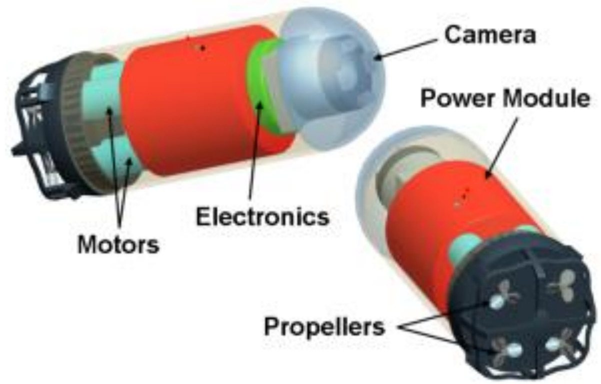
1 battery: LP20, Plantraco Ltd., 20mAh,3.7V; or a power module for inductive power supply

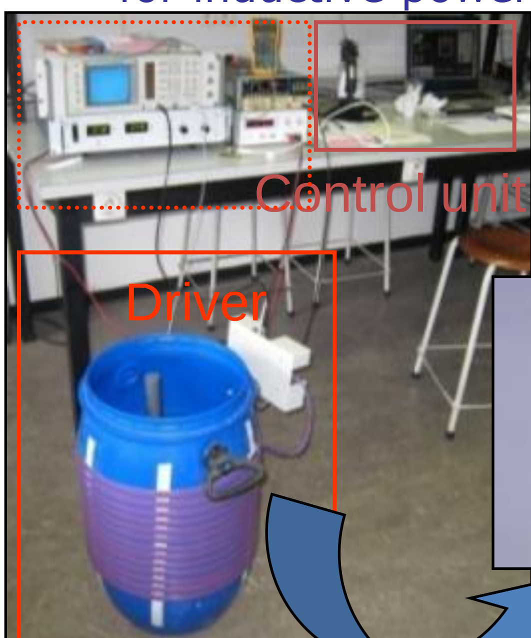
External "dongle":

TI CC2430 (Zigbee + μC)

USB front-end







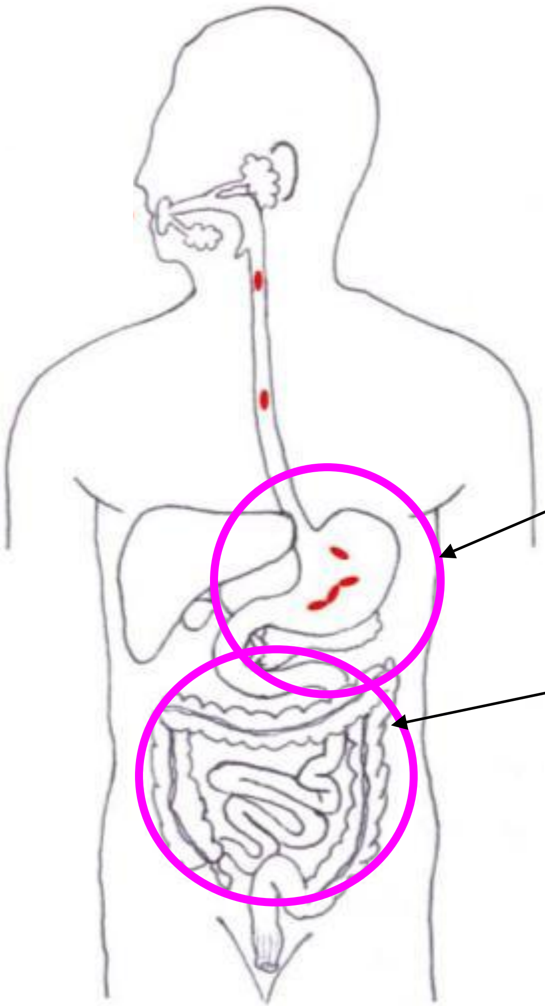
Fine control of steering and speed in 3D

Ex vivo test in stomach of pig filled with water

[in collaboration with Prof. Puers, Leuven Univ., Belgium]

Internal Locomotion Approach

Due to **space constraints** we decided to pursue different strategies optimized for the 2 targeted districts:



Locomotion in the Stomach:
The capsule swims in a liquid environment

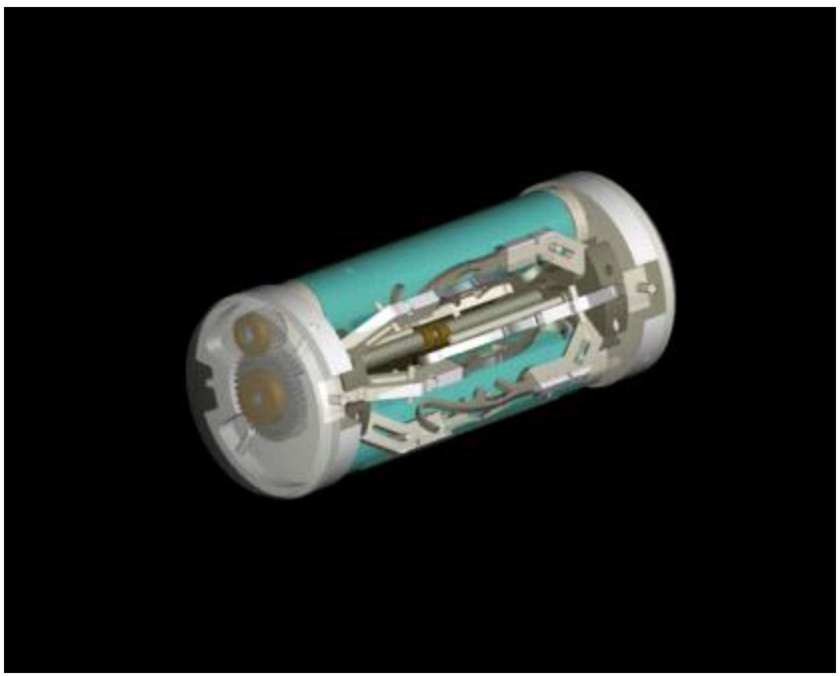
Locomotion in the Colon:
The capsule moves by legs

Developing of legged locomotion system

Colon capsule approach: legged capsule for tubular organs

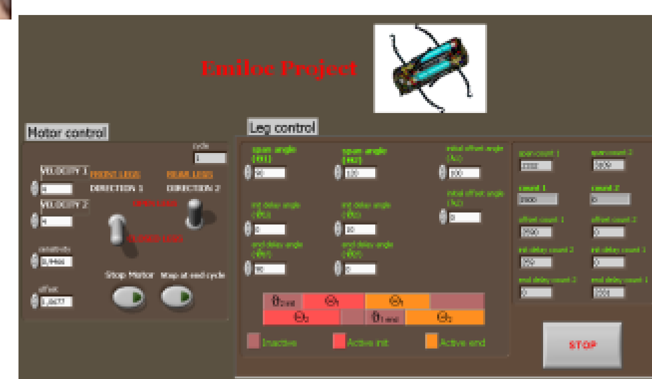
Obtaining an active locomotion in tubular organs of the GI tract, that cannot be inflated or filled with water, means having propulsion mechanisms able to open and distend the tissue around the capsule.

1. **Diameter: 11.1 mm;**
2. **Length: 28 mm (+camera);**
3. **12 legs;**
4. **2 DC brushless motors (NAMIKI);**
5. **Force at the leg's tip of about 1N;**
6. **On board electronics drivers;**
7. **Power consumption: 0.66 W.**



M. Quirini et al., ICRA 2007

Patent filed



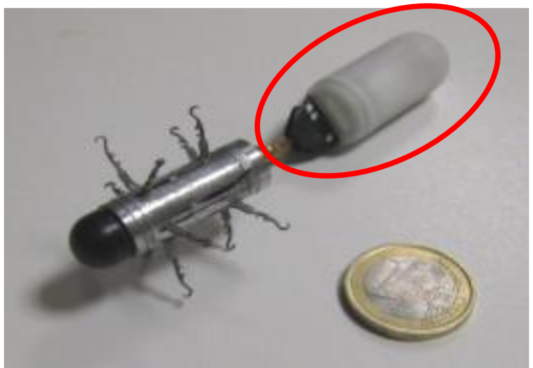
Colon capsule approach: legged capsule for tubular organs

Simulator test

Colon test (5 cm/min)

M. Quirini, S. Scapellato, A. Menciassi, P. Dario, F. Rieber, C.-N. Ho, S. Schostek, M.O. Schurr, “Feasibility proof of a legged locomotion capsule for the GI tract”, GASTROINTESTINAL ENDOSCOPY, 67(7), 2008

By considering the power budget for all the capsule functions (vision, locomotion, communication), the single capsule approach shows dramatic limitations: new battery / powering technologies would be necessary!



Evolution and merging of concepts

Legged locomotion

- Flexible
- Problems in power supply
- Poor adaptability for additional functional modules

Magnetic assisted locomotion

- Less flexible
- Less problems in power supply
- More room in the pill for functional modules

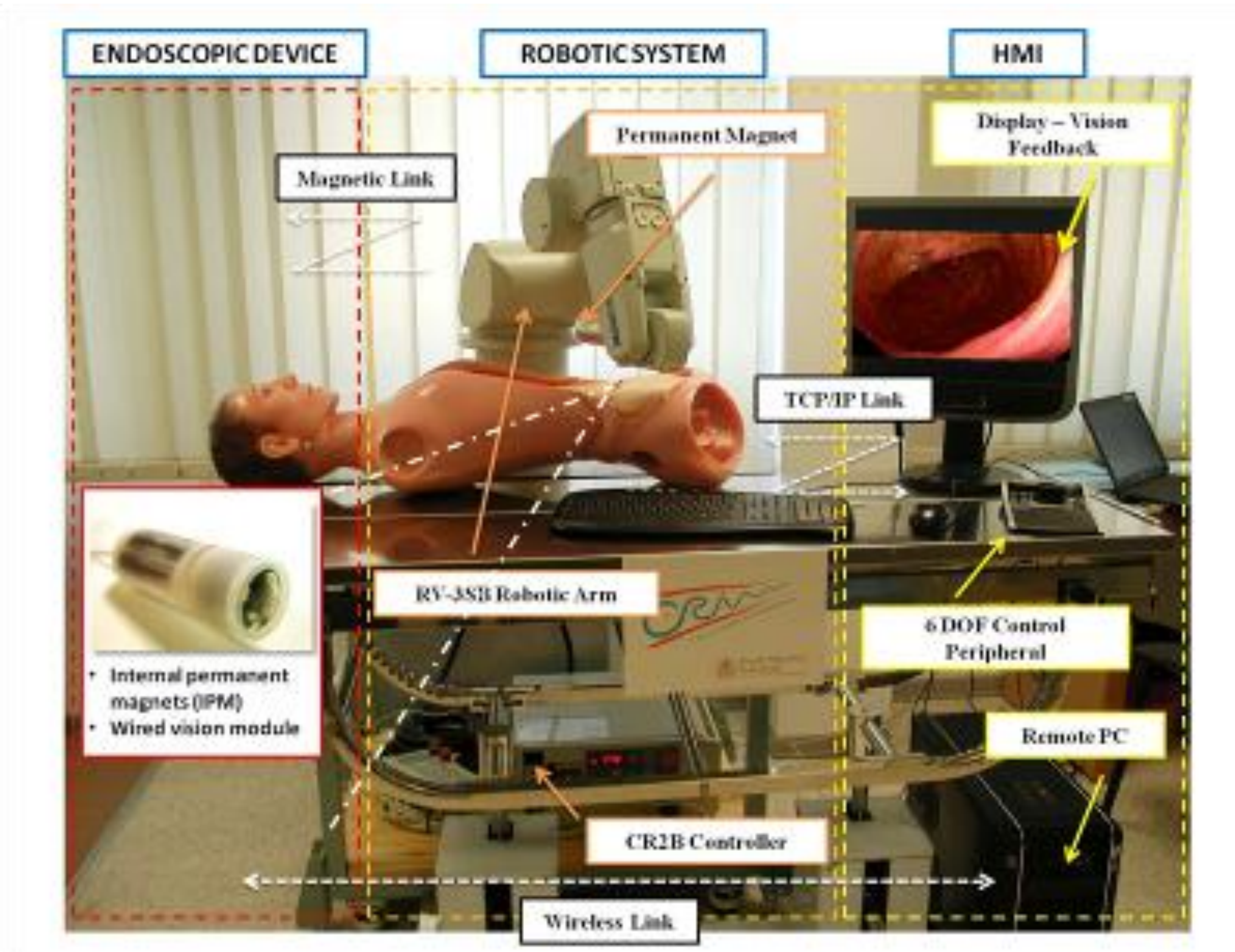
Magnetic locomotion assisted by legged locomotion

No problems of power supply

Internal space for additional modules

Flexibility in fine positioning and efficient rough displacement

Hybrid locomotion strategy:
external magnetic guidance and one internal motorized degree of freedom

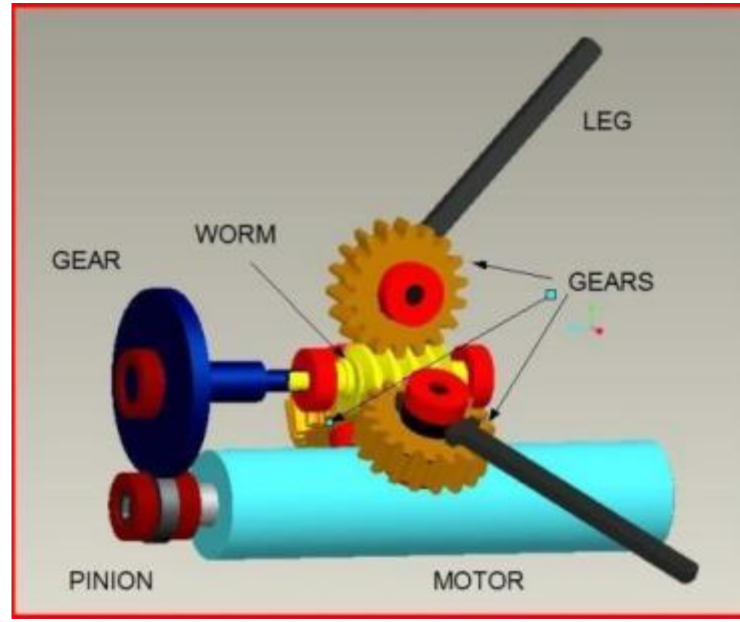


Magnetic capsule in vivo with distended tissue

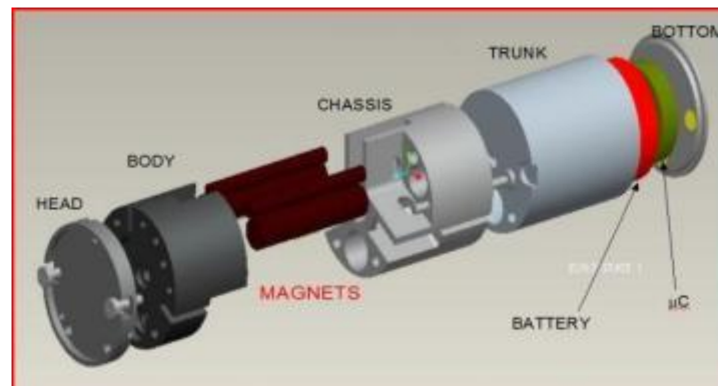
Magnetic capsule in vivo with collapsed tissue

The hybrid approach
– with legs/flaps

- The hybrid capsule is a trade-off solution between external and internal locomotion systems. It should be able to manage collapsed areas of the GI tract exploiting the flaps or legs to modify the external shape of the capsule thus distending the intestine wall.



In vivo test
March 5-09



M. Simi, P. Valdastri, C. Quaglia, A. Menciassi, P. Dario, “*Design, Fabrication and Testing of an Endocapsule with Active Hybrid Locomotion for the Exploration of the Gastrointestinal Tract*”, IEEE Transactions on Mechatronics, 2010, Vol. 15, No.2, pp. 170-180.

Recent activities on the platform for magnetic capsule guidance

Manual control

Target identification reliability

⇩

37%

VS

Robotic control

Target identification reliability

⇩

87%

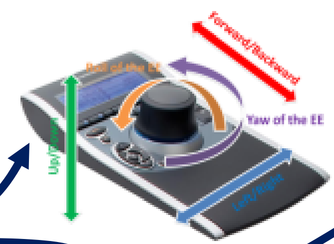
What is the best control methodology for a robotic-aided endoscopic platform? Once the control methodology is chosen, what is the best interface?

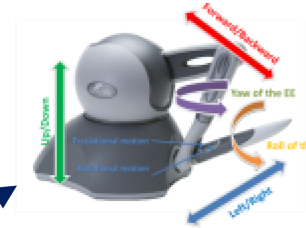
G. Ciuti, R. Donlin, P. Valdastri, A. Arezzo, A. Menciassi, M. Morino, P. Dario, "Robotic Versus Manual Control in Magnetic Steering of an Endoscopic Capsule", Endoscopy, vol. 42, pp. 148–52, 2010.

A comparative evaluation of control methodologies and interfaces for a robotic-aided endoscopic platform

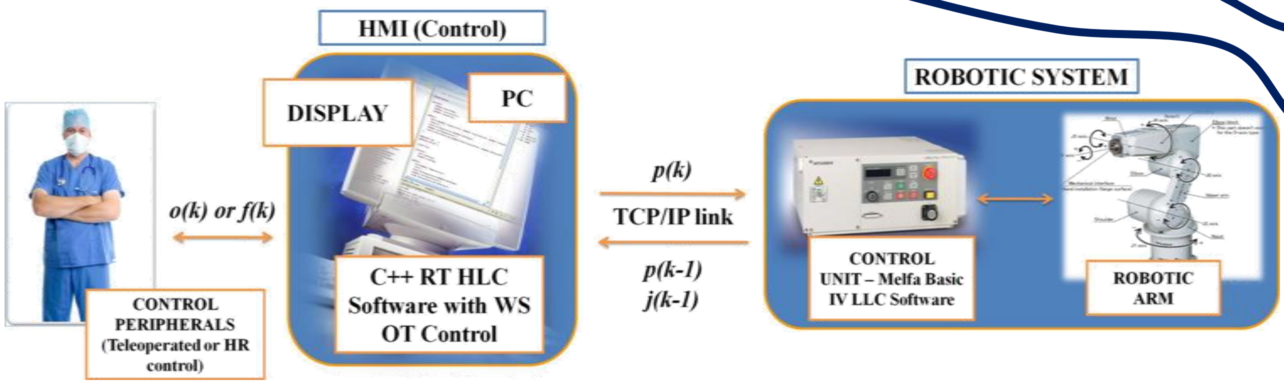
The proposed task consists of the exploration of a segment of *ex-vivo* colon by steering the capsule by the robotic-magnetic approach, with different **control methodologies** and **interfaces**.

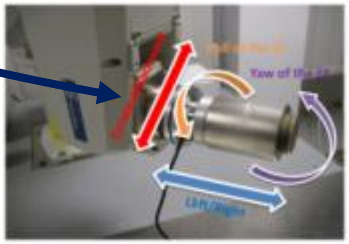
Teleoperated remote control





Human-robot cooperative control



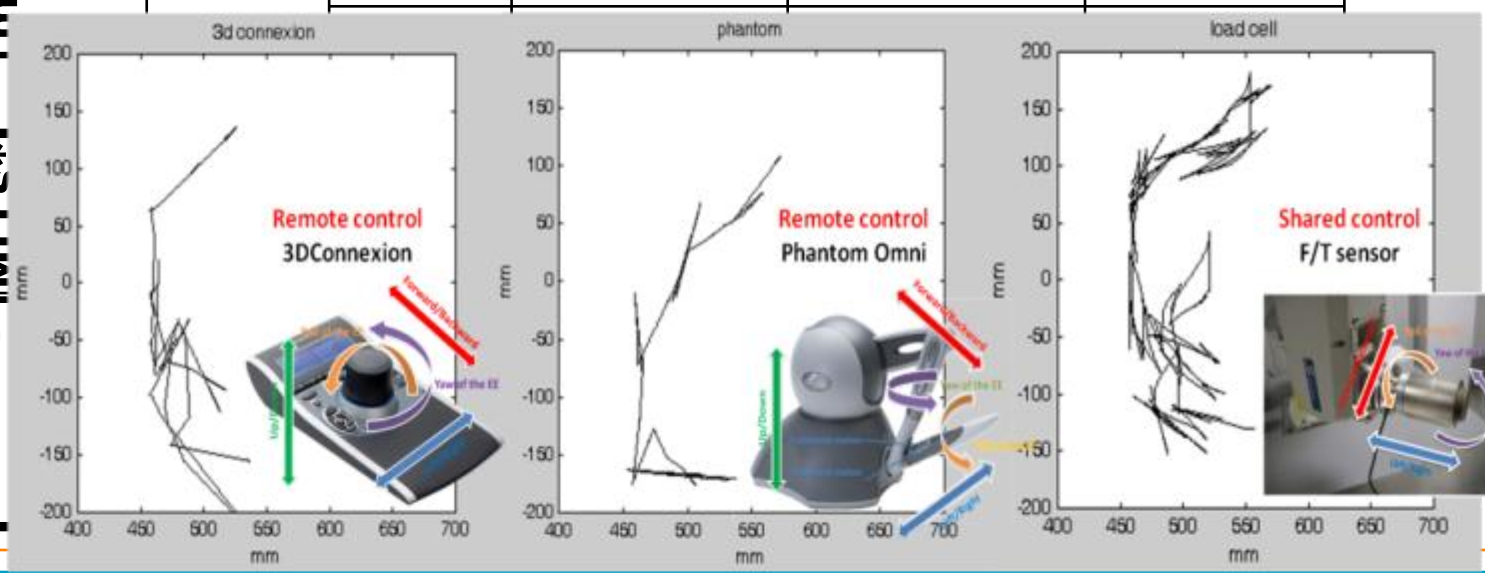


slide31ago

Remote/cooperative control methodologies comparison: results

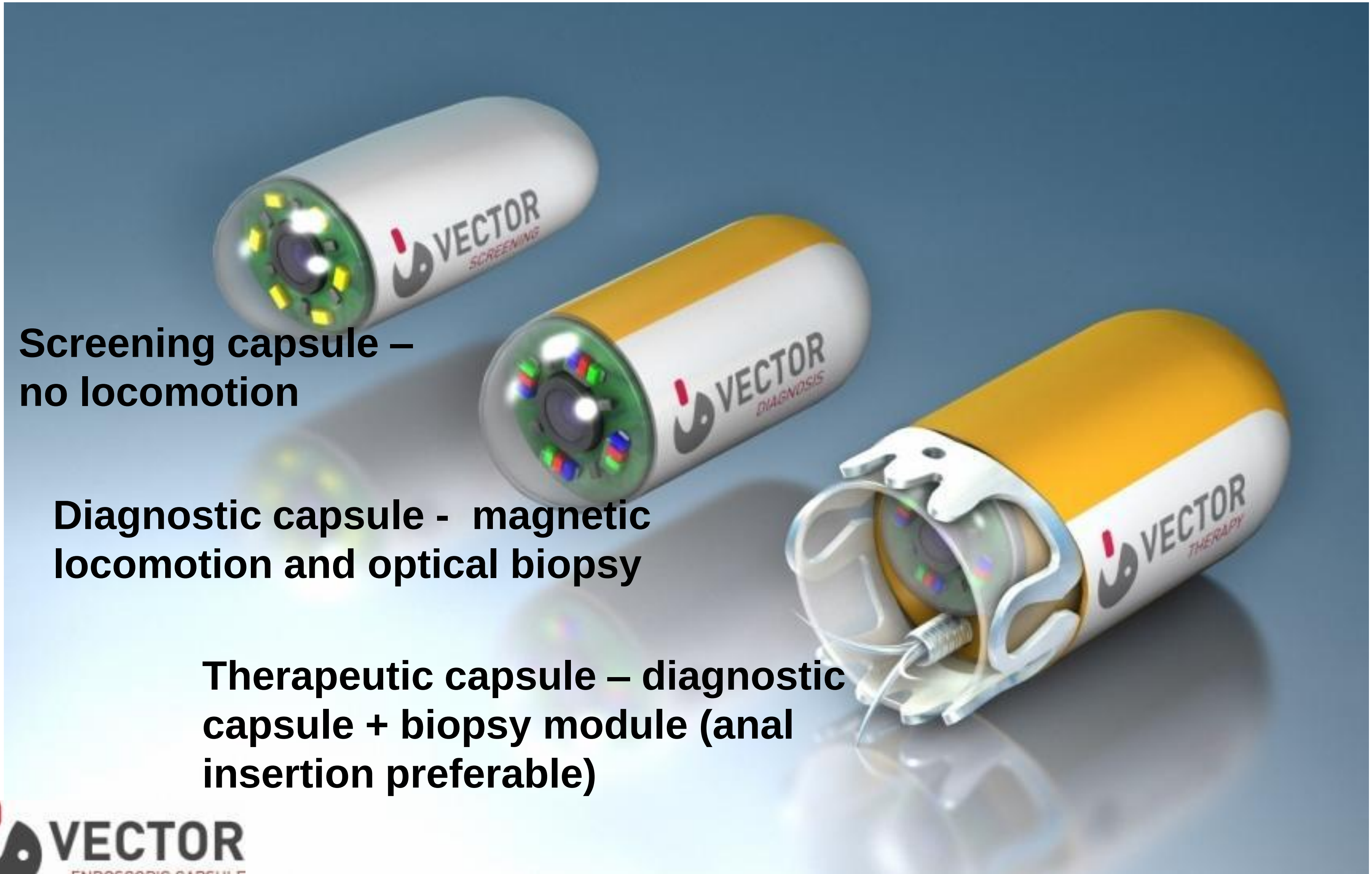
The Phantom Omni haptic device is the best control interface, as regards the smoother motion trajectories *[by Anova test]*

				SSD	Range
				6.2	72.7-92.3
				11.3	55.6-92.3
				10.6	55.6-90.9
				95	157-499
				124	264-707
		ph	575	216	280-1006
Distance [m]	Cooperative		2.6	1.2	1-5.2
		3D	1.3	0.4	0.7-2.0
# MLLs*					
EE velocity					



* Magnetic link losses

The complete set of endoscopic capsules @ VECTOR SSSA/nvn

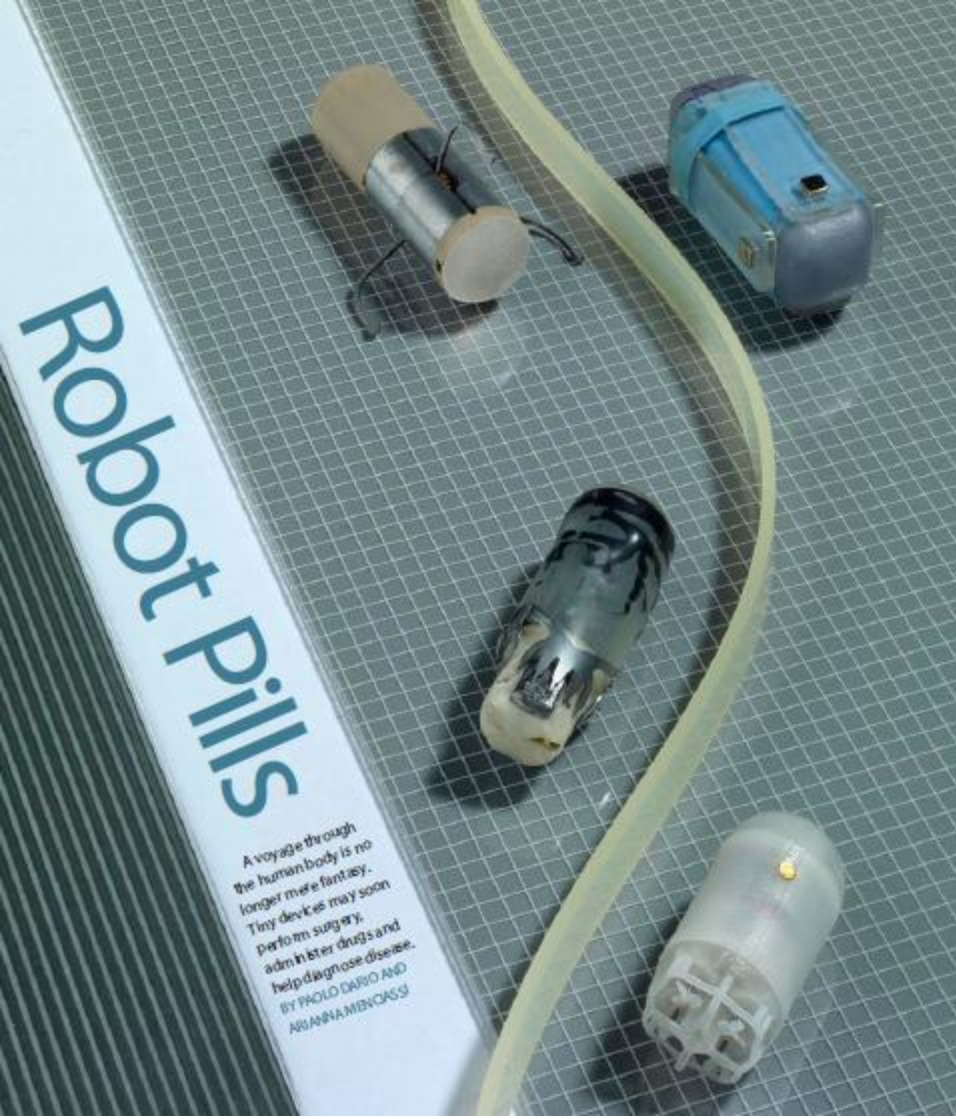


Screening capsule – no locomotion

Diagnostic capsule - magnetic locomotion and optical biopsy

Therapeutic capsule – diagnostic capsule + biopsy module (anal insertion preferable)

VECTOR
ENDOSCOPIC CAPSULE



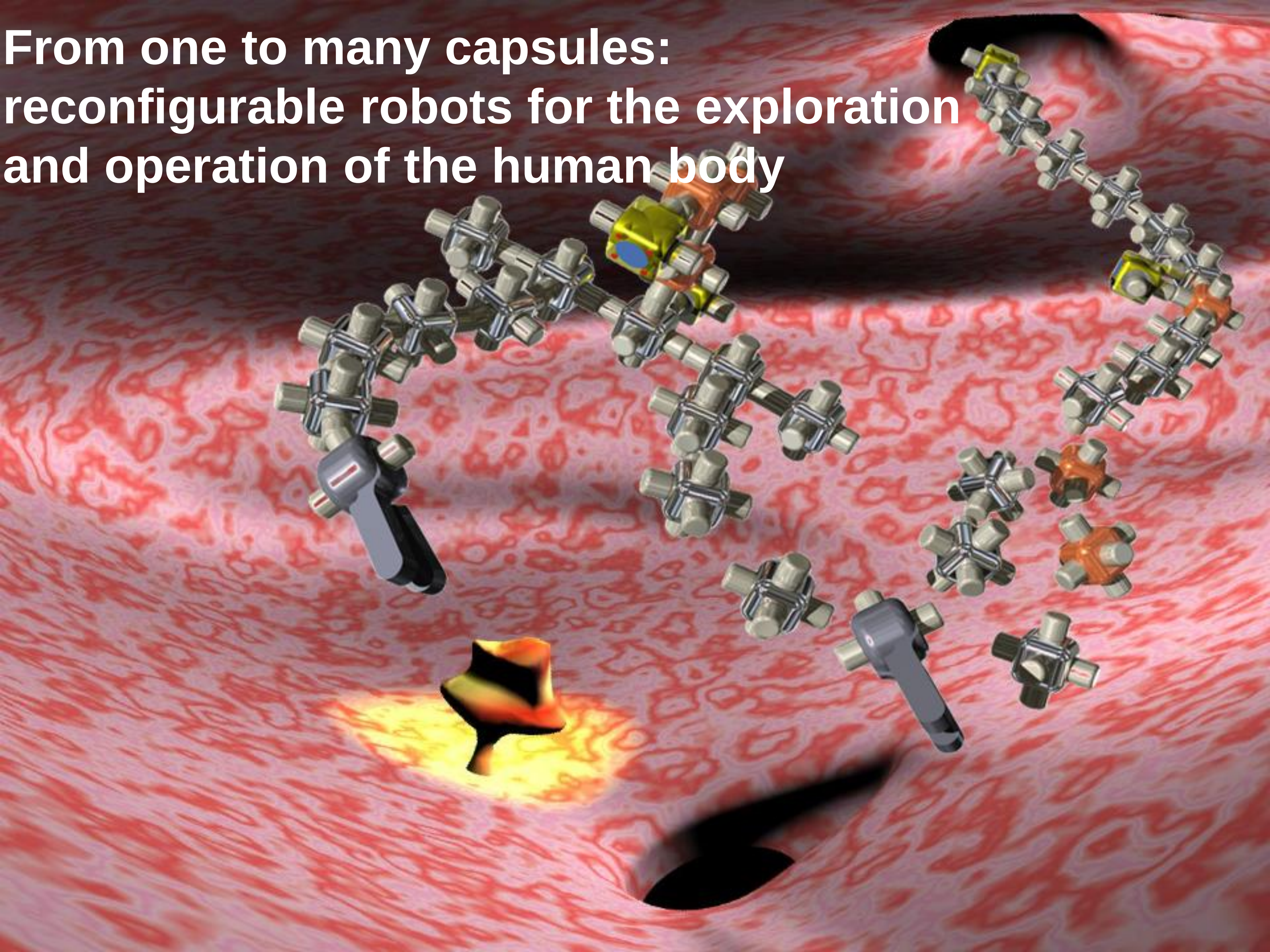
August 2010 issue

A voyage through the human body is no longer mere fantasy.
Tiny devices may soon perform surgery, administer drugs and help diagnose disease.
-By Paolo Dario and Arianna Menciassi

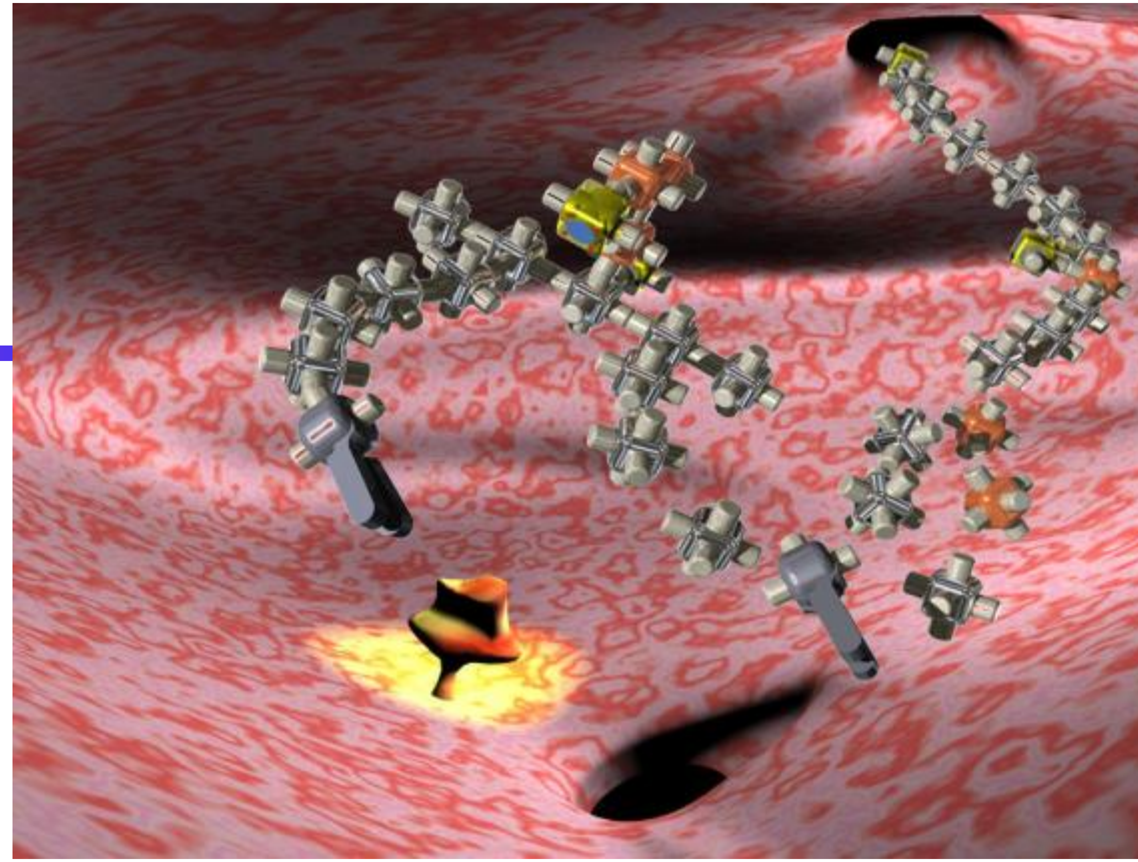
Outline

- The evolution of robotic surgery: state of the art
- From external robots to endoluminal robots

Case 2: reconfigurable surgical robot with single access


From one to many capsules:
reconfigurable robots for the exploration
and operation of the human body

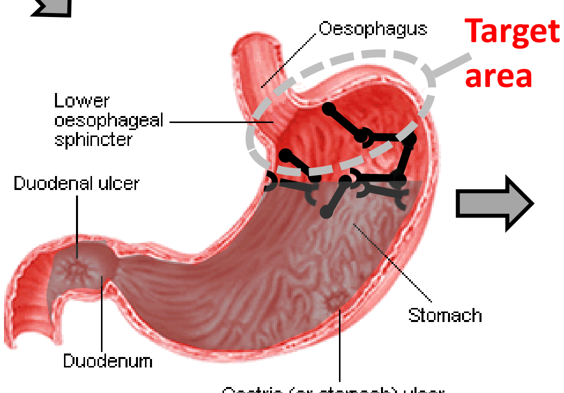
The vision (long term)



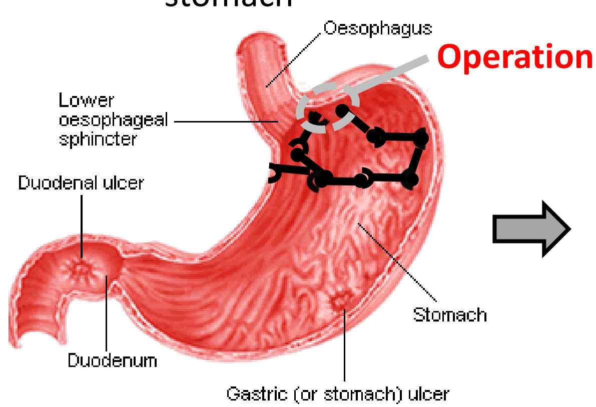
1: Swallowing the capsules

2: Passing through the esophagus

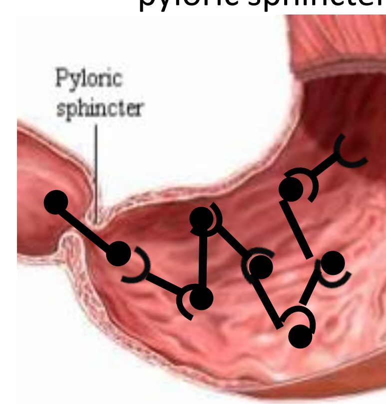
3: Assembly in the stomach



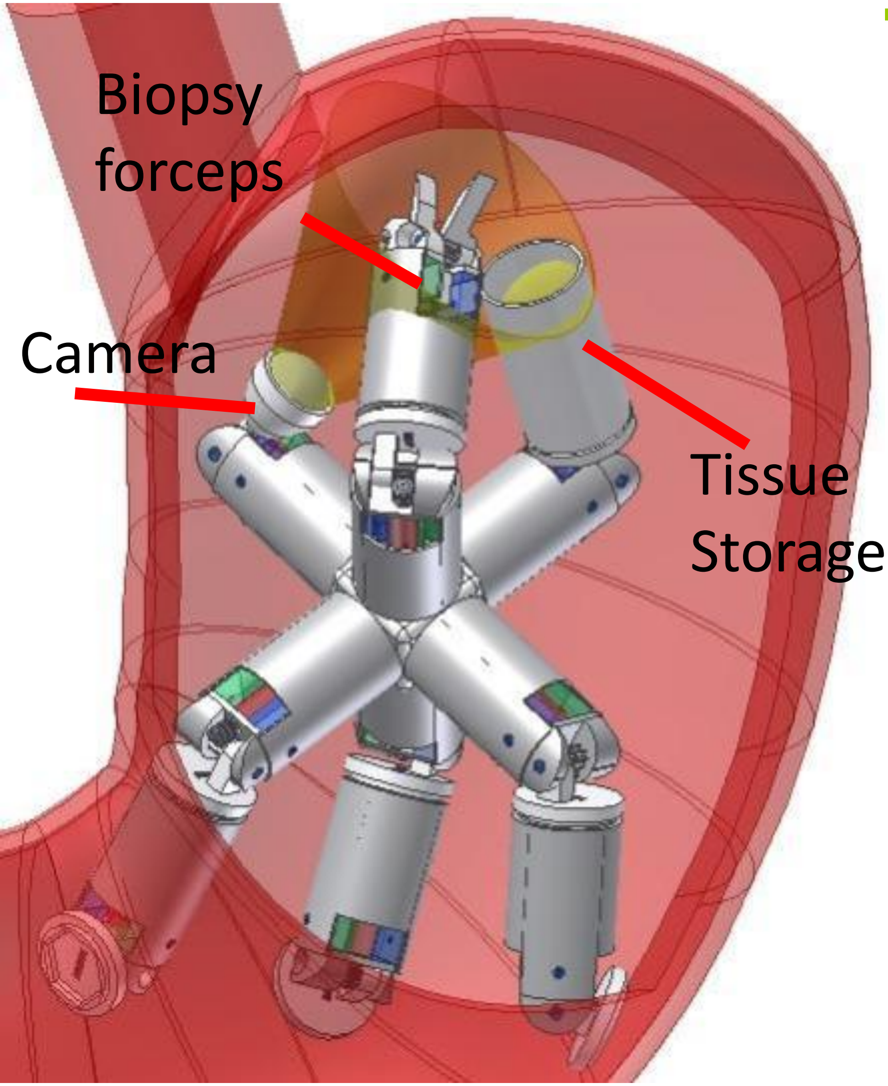
4: Diagnosis/ Intervention in the stomach



5: Reconfiguration for passing the pyloric sphincter



Example of a multi-module robot integrating a grasping tool



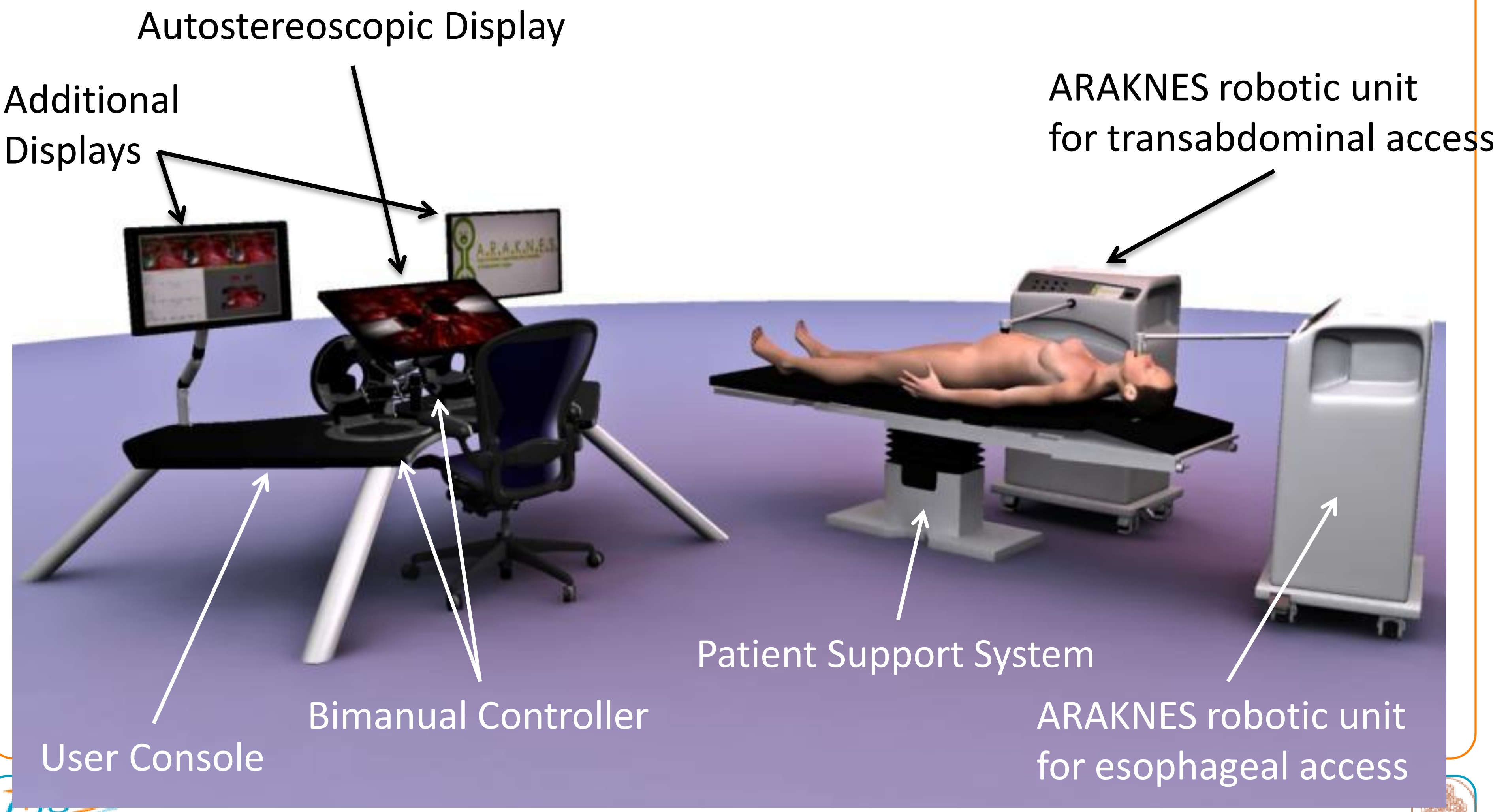
12 Modules

-Camera X1
-Forceps X1
-Storage X1
-Central X1
-Structural X8

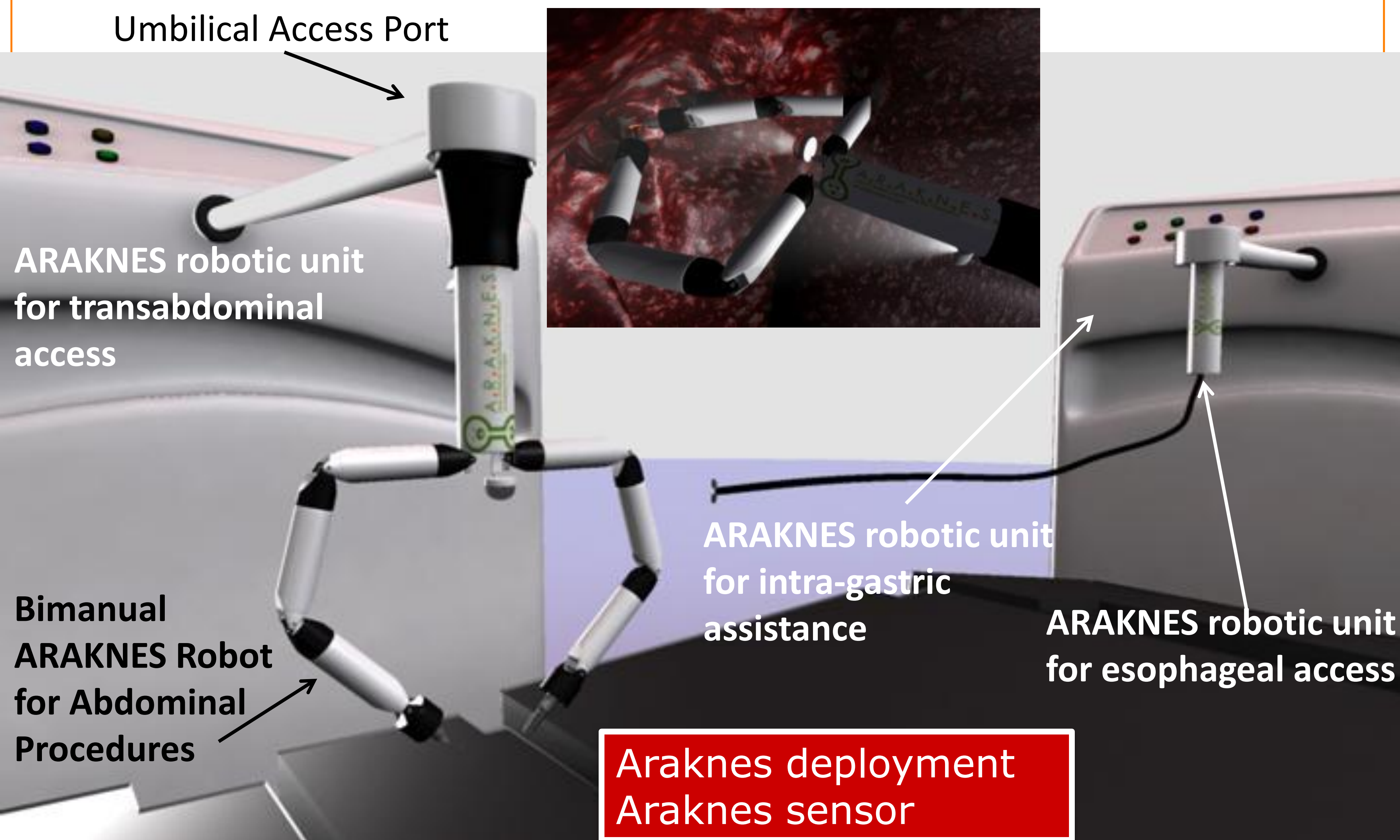
The ARAKNES Project has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement num. 224565.

www.araknes.org

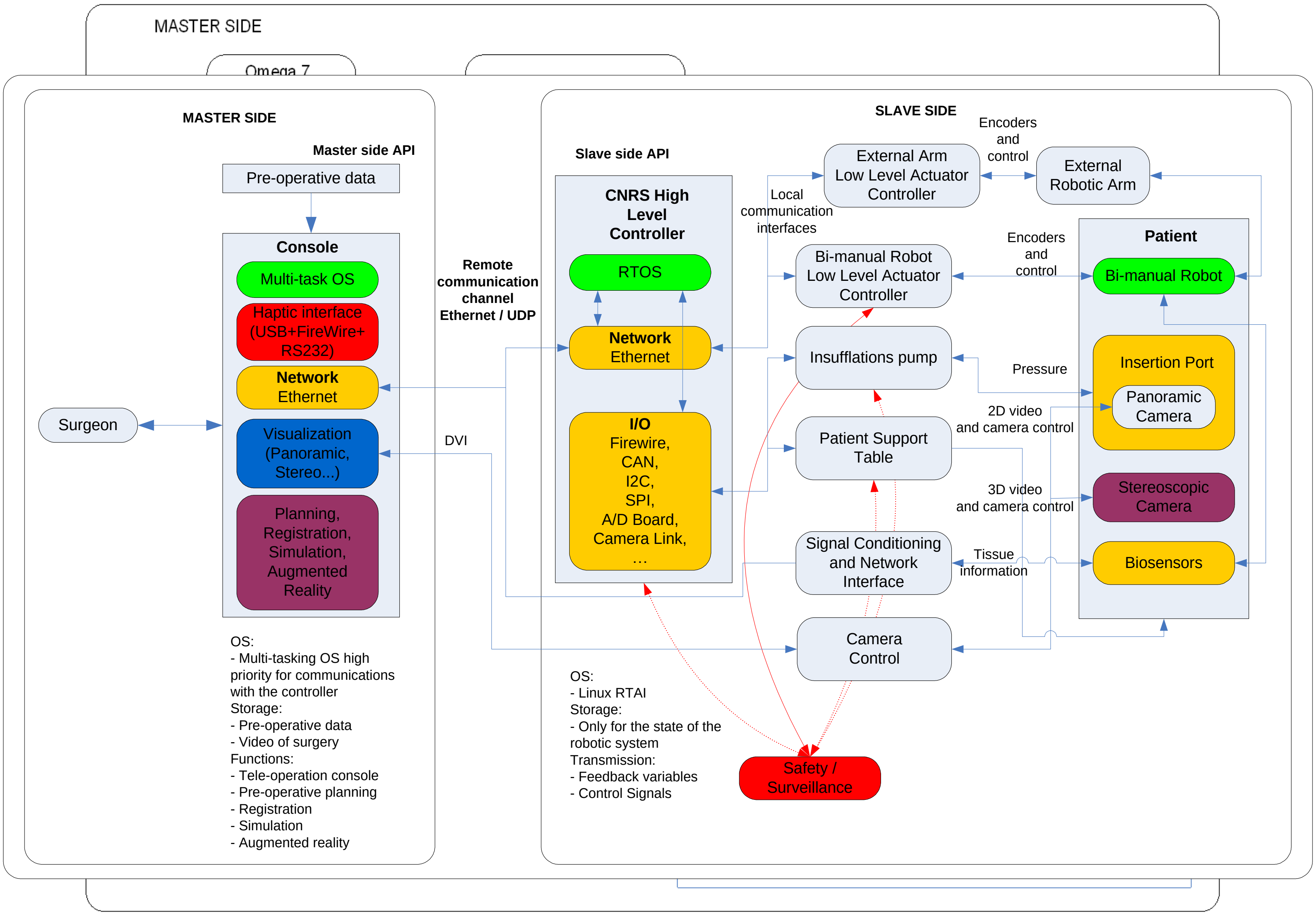
from the “vision” to the patient



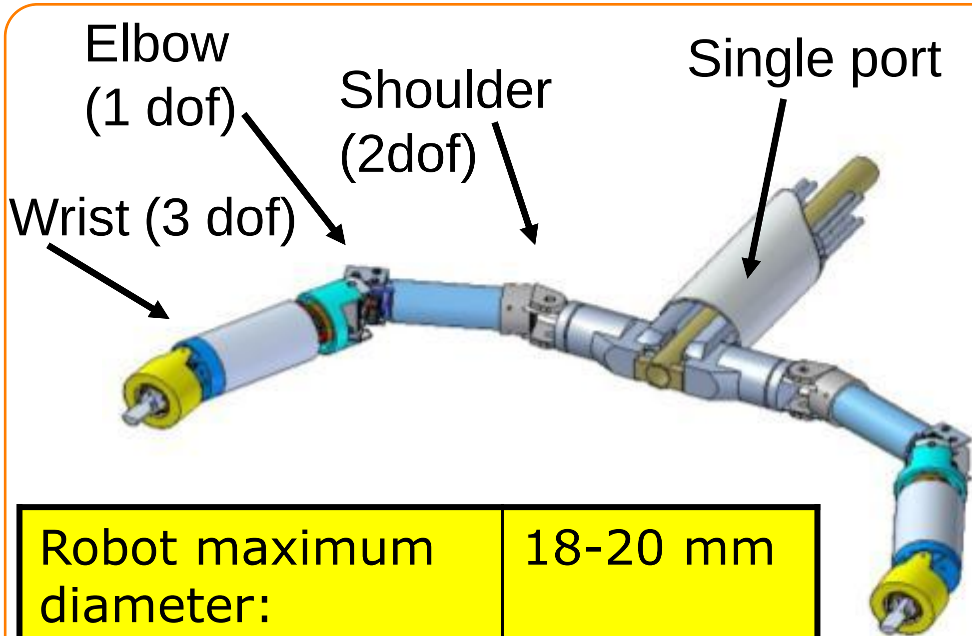
ARAKNES Hybrid Configuration

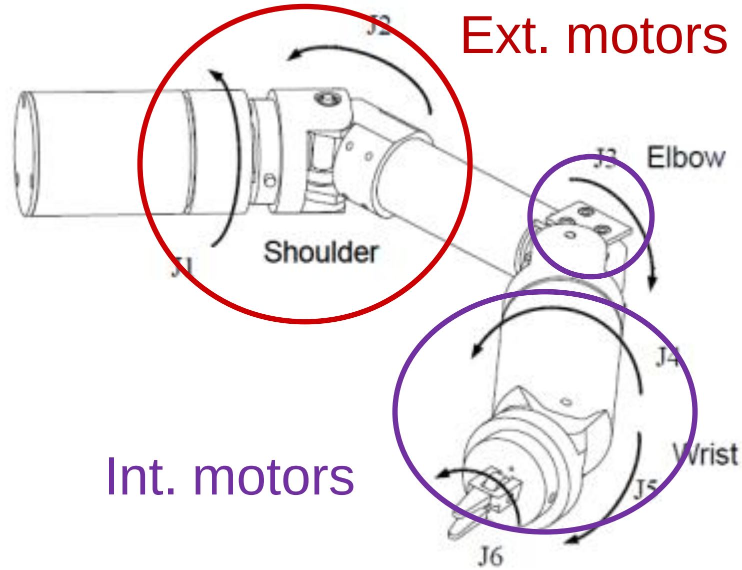


General overview of the ARAKNES Platform and high-level control architecture (by Philippe Poignet , LIRMM UMR 5506 CNRS UM2)



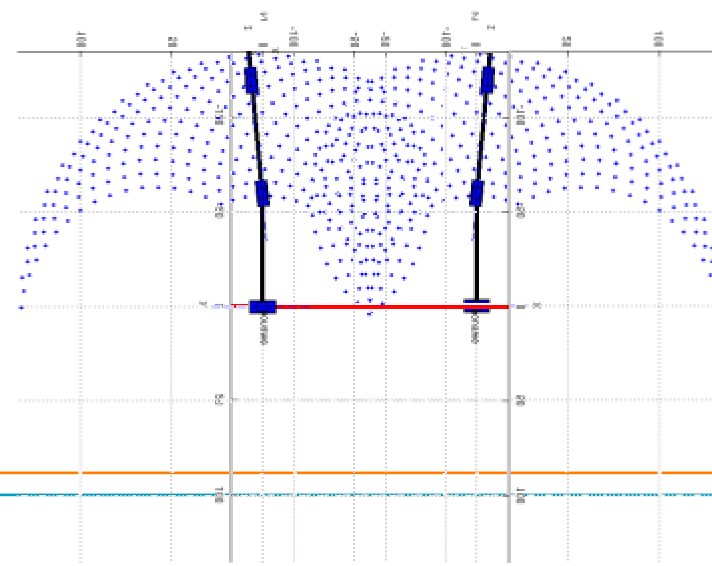
The ARAKNES *mini*-Robotic Arm





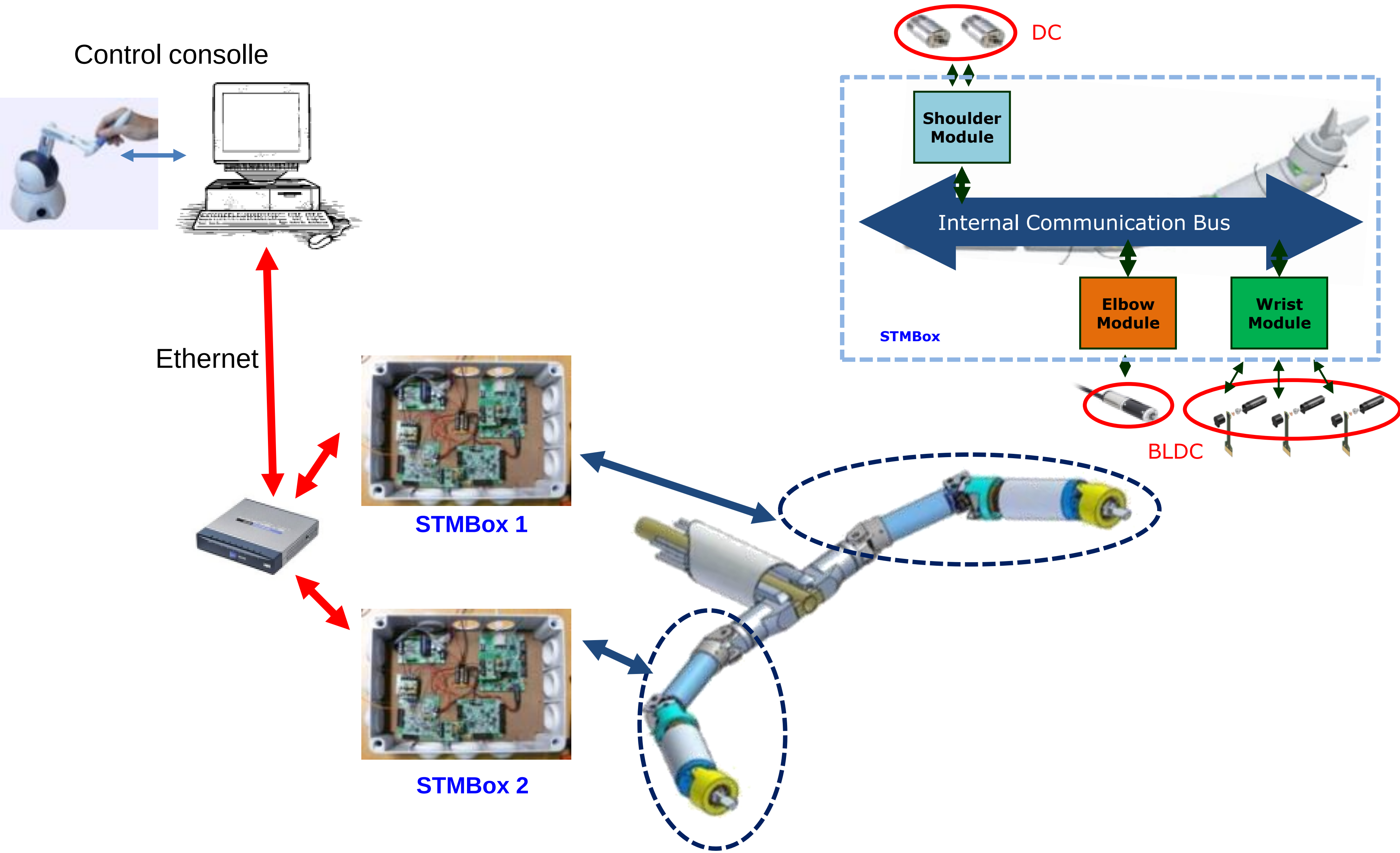
Robot maximum diameter:	18-20 mm
Tip force needed:	5 N
Joint rotational speed needed:	360-540 deg/s
Total lenght:	130 mm

SPRINT_tmech.avi



Bi-manual manipulator control

(in collaboration with STMicroelectronics and CNRS-LIRMM)



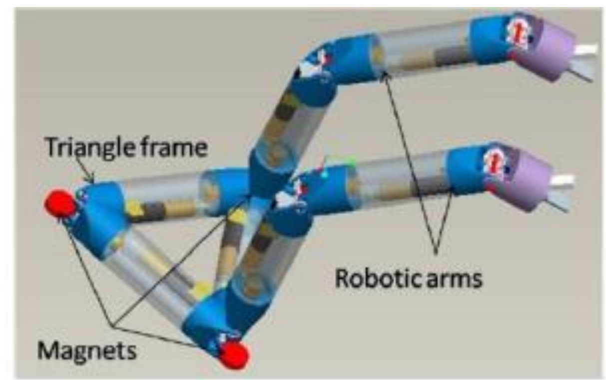
From mini to micro: the top-down approach

Example of miniature platform to be used in Single Port Laparoscopy and NOTES surgery

procedure

+

=

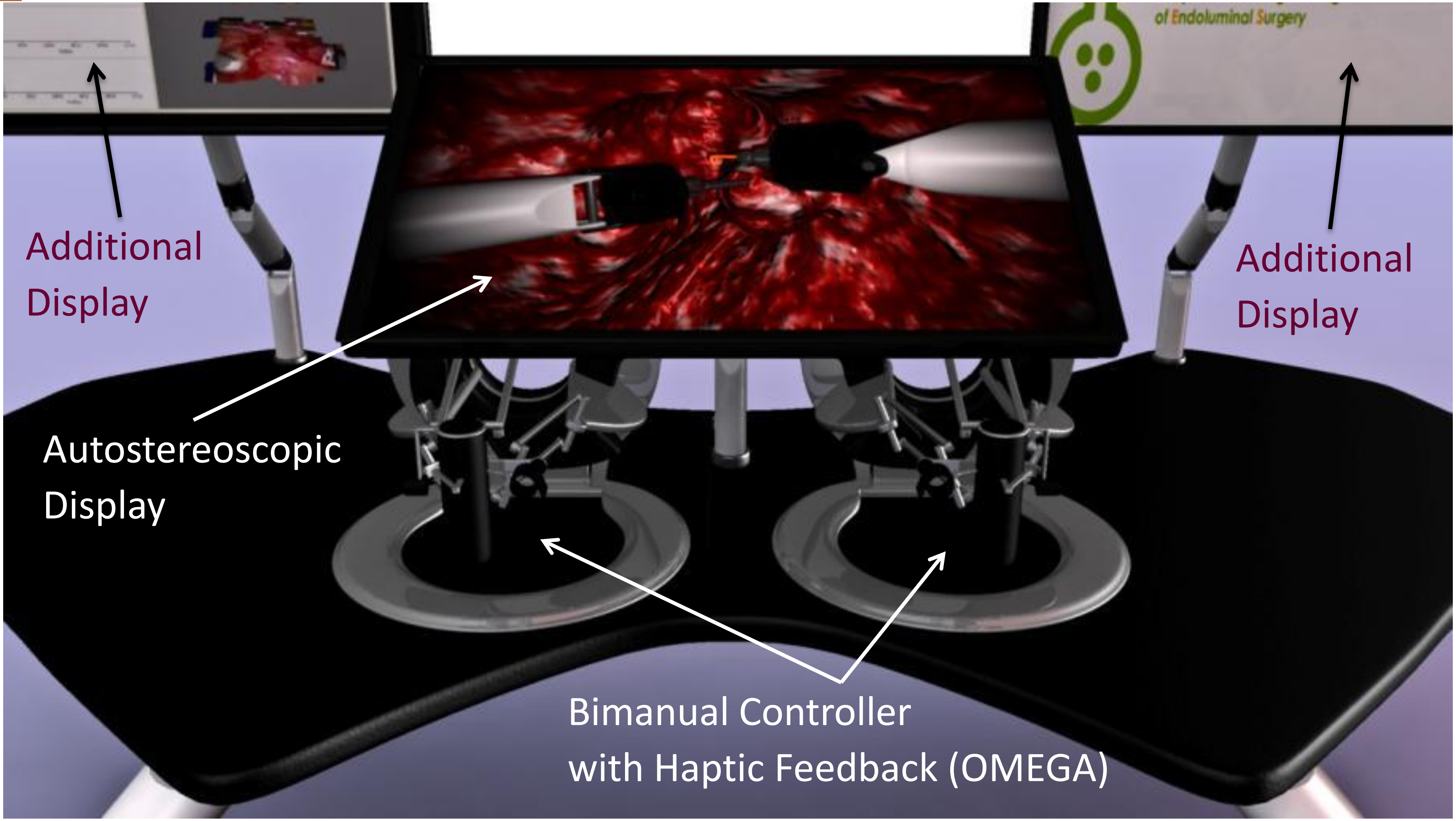


1 robot

Video ICRA2011

2 robots

ARAKNES User Console



Main Features

-Omega based dual haptic interface

- Autostereoscopic display

Outline

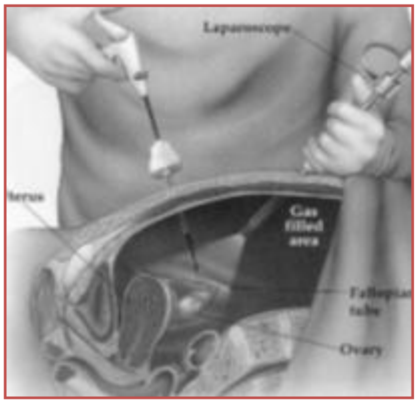
- The evolution of robotic surgery: state of the art
- From external robots to endoluminal robots
- Concluding remarks

Robotics Surgery: Lessons Learned

Problems to be solved for full acceptance of robots in surgery:

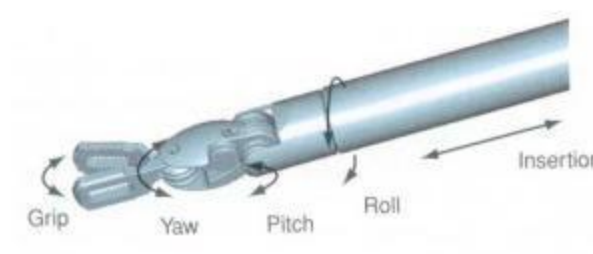
- Real application domains and procedures that benefit: finding the unmet clinical needs among the 6301 currently performed surgical procedures
- Time of intervention
- Time and complexity for set up
- Cost/benefit clearly proved

First generation of robotic technologies for minimally invasive computer-assisted surgery: using "**mechanical**" tools for intervention



Traditional laparoscopy
with abdomen incisions

Robotic driller for
orthopedic surgery



Robotic hand and wrist for
laparoscopic surgery

Second generation of robotic technologies for minimally invasive computer-assisted surgery: using "**non contact**" tools for navigation and intervention

Surgical procedure for "scarless" delivery of tools/particles inside the abdomen

Robotic radiosurgery

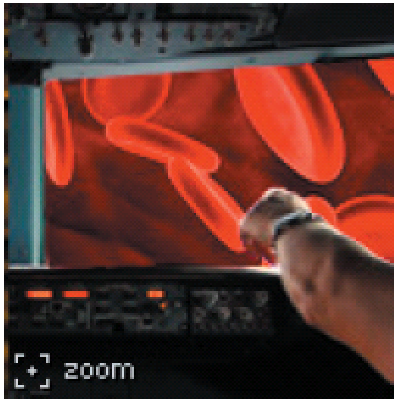
Robotic platform with magnetic guidance for wireless delivery of treatment in the vascular system

ISSUE #29 // JULY-AUGUST 2007

FANTASTIC VOYAGE—FROM FICTION TO REALITY

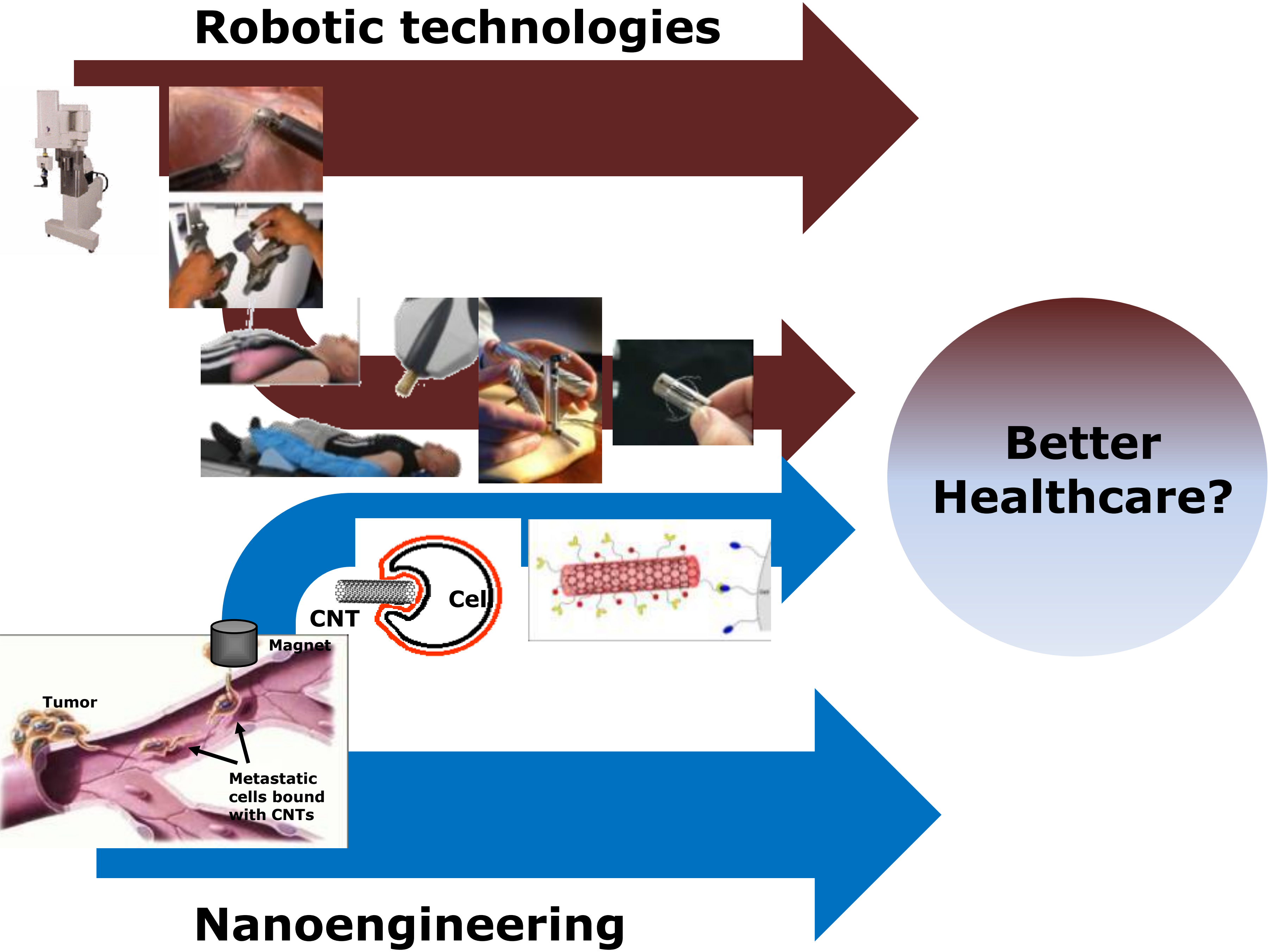
ÉCOLE POLYTECHNIQUE DE MONTRÉAL RESEARCHERS MAKE NEW INROADS FOR CANCER TREATMENT BY USING MRI TO TRACK AND PROPEL DEVICES THROUGH THE BLOODSTREAM.

By Véronique Barker



PROJECT

In the same vein as the 1960s classic movie, Fantastic Voyage, where a crew of scientists are miniaturized and injected into the bloodstream, Sylvain Martel [1], director of the NanoRobotics Laboratory at École Polytechnique de Montréal, has successfully made travel through a living animal's bloodstream possible. "This is really what we are doing, except that we don't send tiny humans of course," he says with a laugh. Instead, Martel is developing tiny robots or nanorobots that can trek through blood vessels. Until recently, the study of nanorobotics [2] has been theoretical, but Martel has demonstrated its potential application with magnetic resonance imaging (MRI) [3].


Robotic technologies
Better Healthcare?
CNT
Cell
Magnet
Tumor
Metastatic cells bound with CNTs
Nanoengineering

Thank you!

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