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Surgical Robotics; A Want or a Need?

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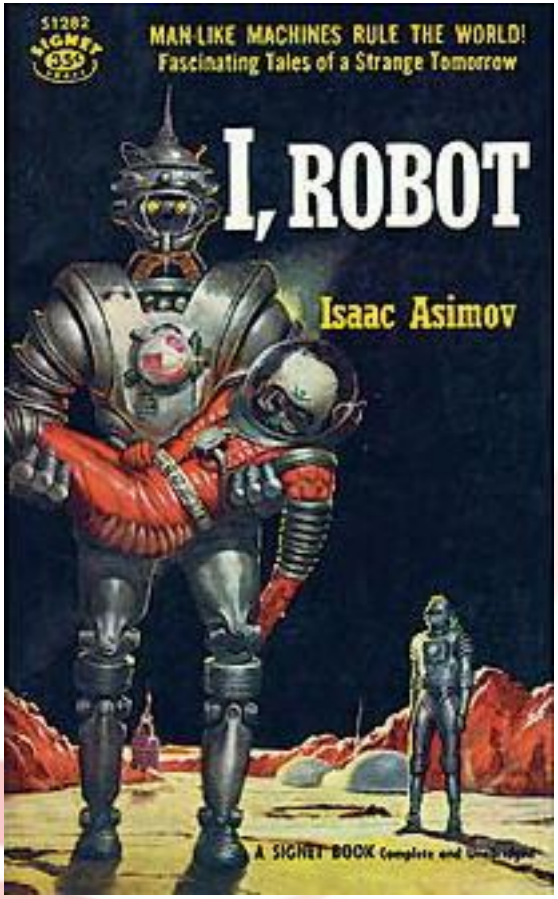
Three Laws of Robotics

Isaac Asimov, 1942

- A robot may not injure a human being or, through inaction, allow a human being to come to harm.
- A robot must obey the orders given to it by human beings, except where such orders would conflict with the First Law.
- A robot must protect its own existence as long as such protection does not conflict with the First or Second Law



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Robotic Technology, Intelligent Systems, Automation

- Perception
  - Sensors, sensory systems, vision (eg. MS Kinect, Wii)
- Cognition
  - Artificial intelligence, decision making, autonomous algorithms (eg. iPhone siri)
- Action
  - Motors, actuators (eg. RC servos)
- Integrated Systems
  - Humanoid robot (eg. NAO), Cyber-sensor network

MS Kinect sensor (USA)

Robotis Dynamix servo (S. Korea)


Aldebaran NAO robot (France)

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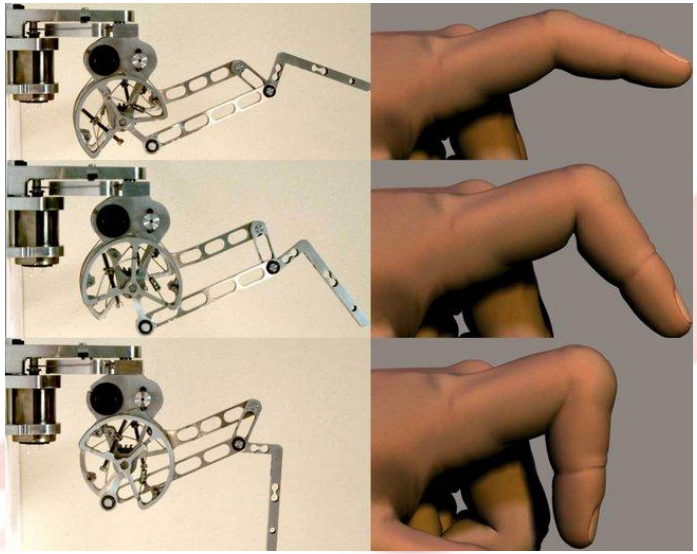
Today's Robots



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Acceptance of Robotics in Society

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Acceptance of Robotics in Society

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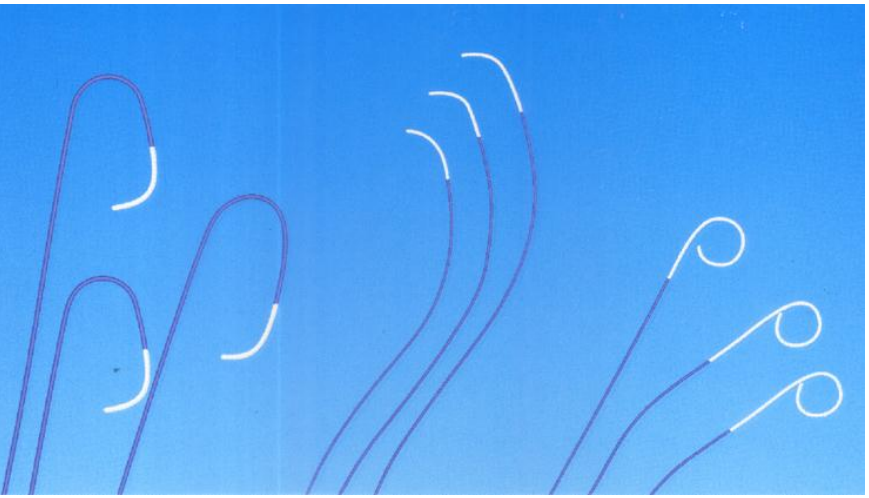
Acceptance of Robotics in Surgery



Surgical Robotics Challenge

The real challenge for the future of robotics in surgery (and perhaps for surgery in general) is

to go **beyond the mere imitation and substitution by a robot of conventional procedures and surgical gestures**,

and rather **to explore completely novel procedures that are possible only by means of robotic/mechatronic tools together with human surgeons for the benefit of the patient.**

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Robotic Colonoscopy

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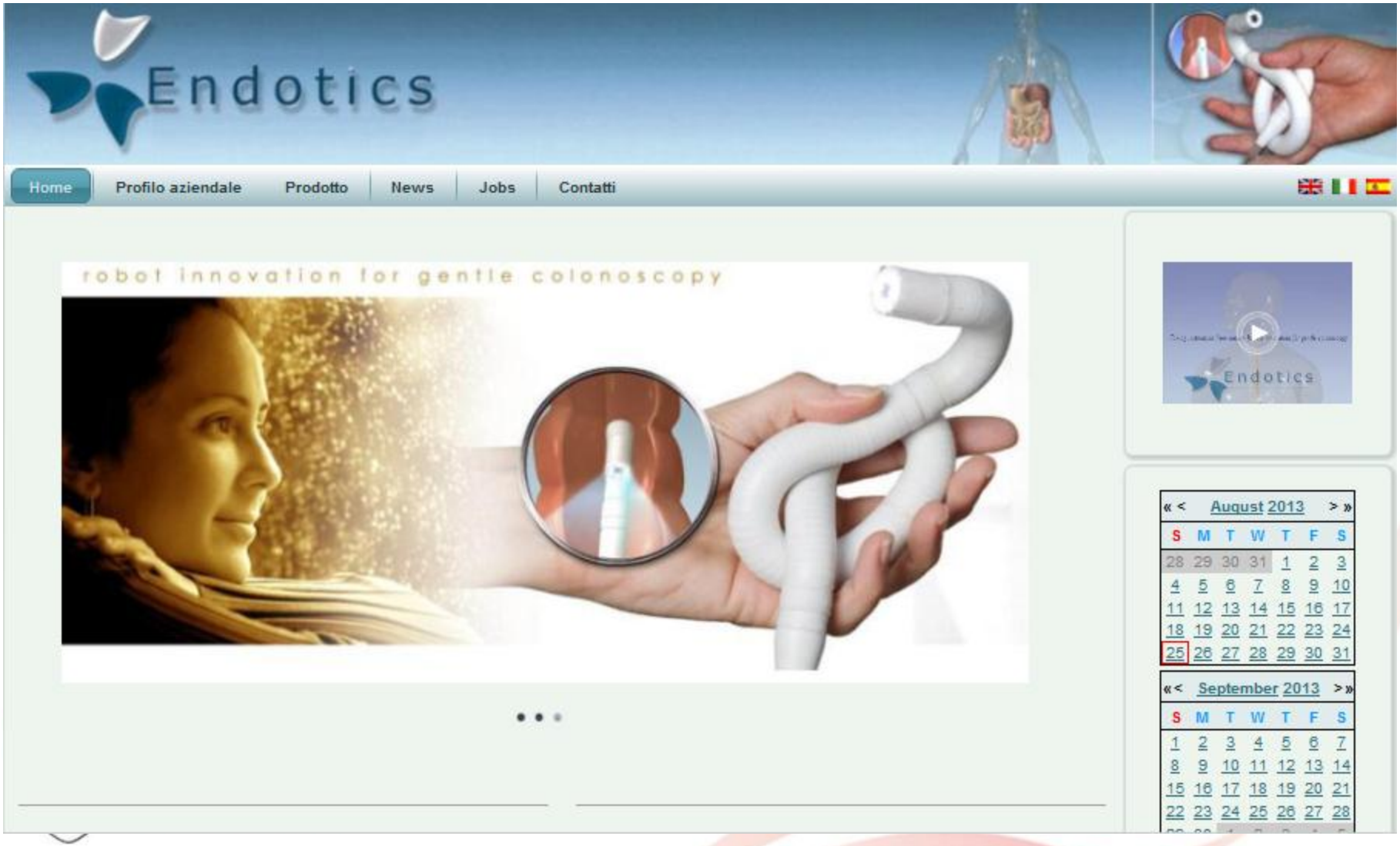
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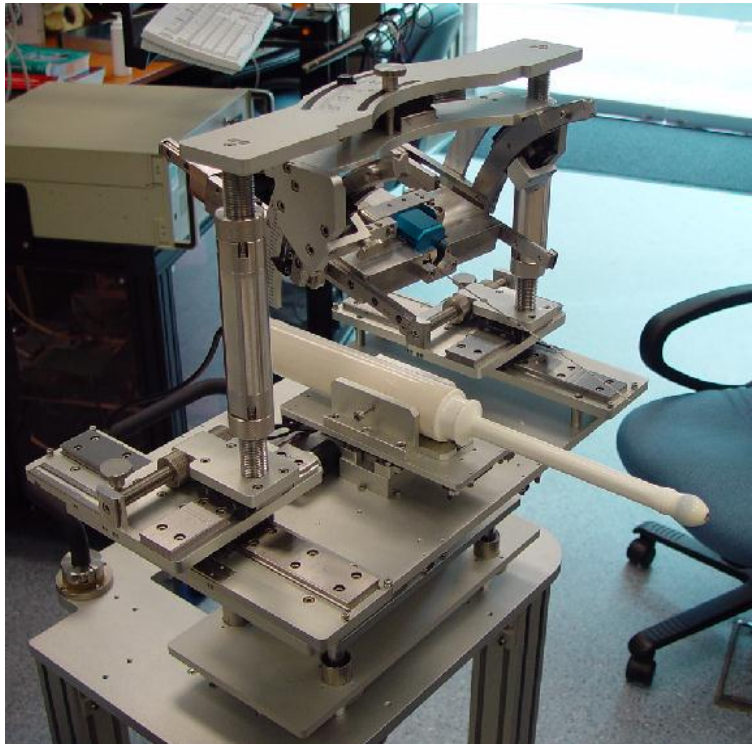
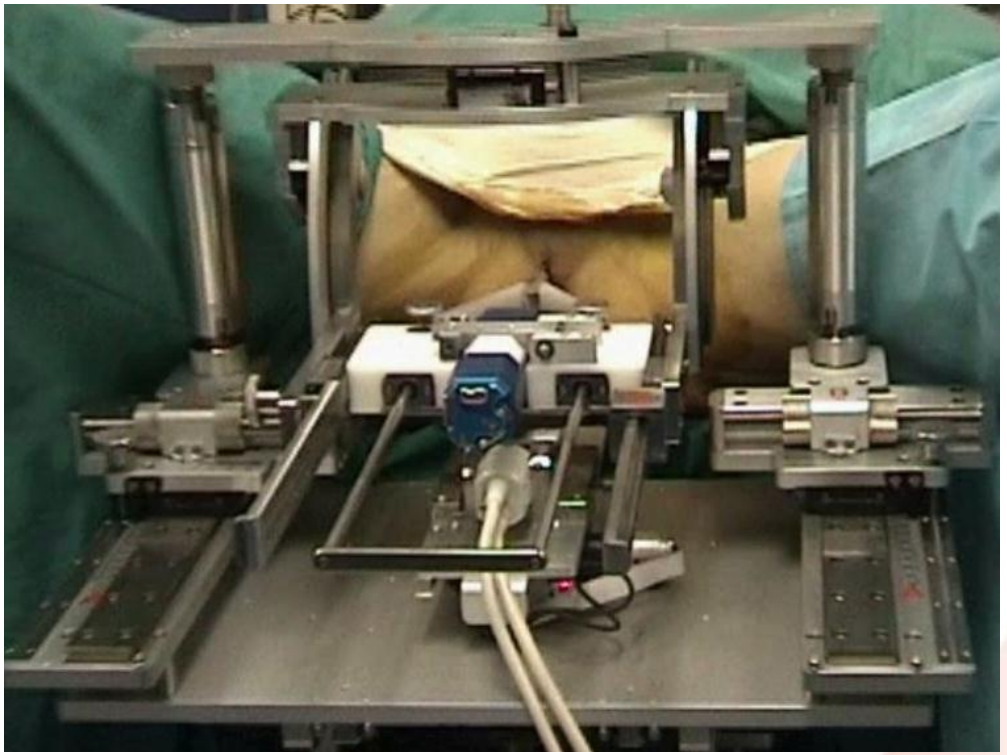
Robotic Prostate Biopsy





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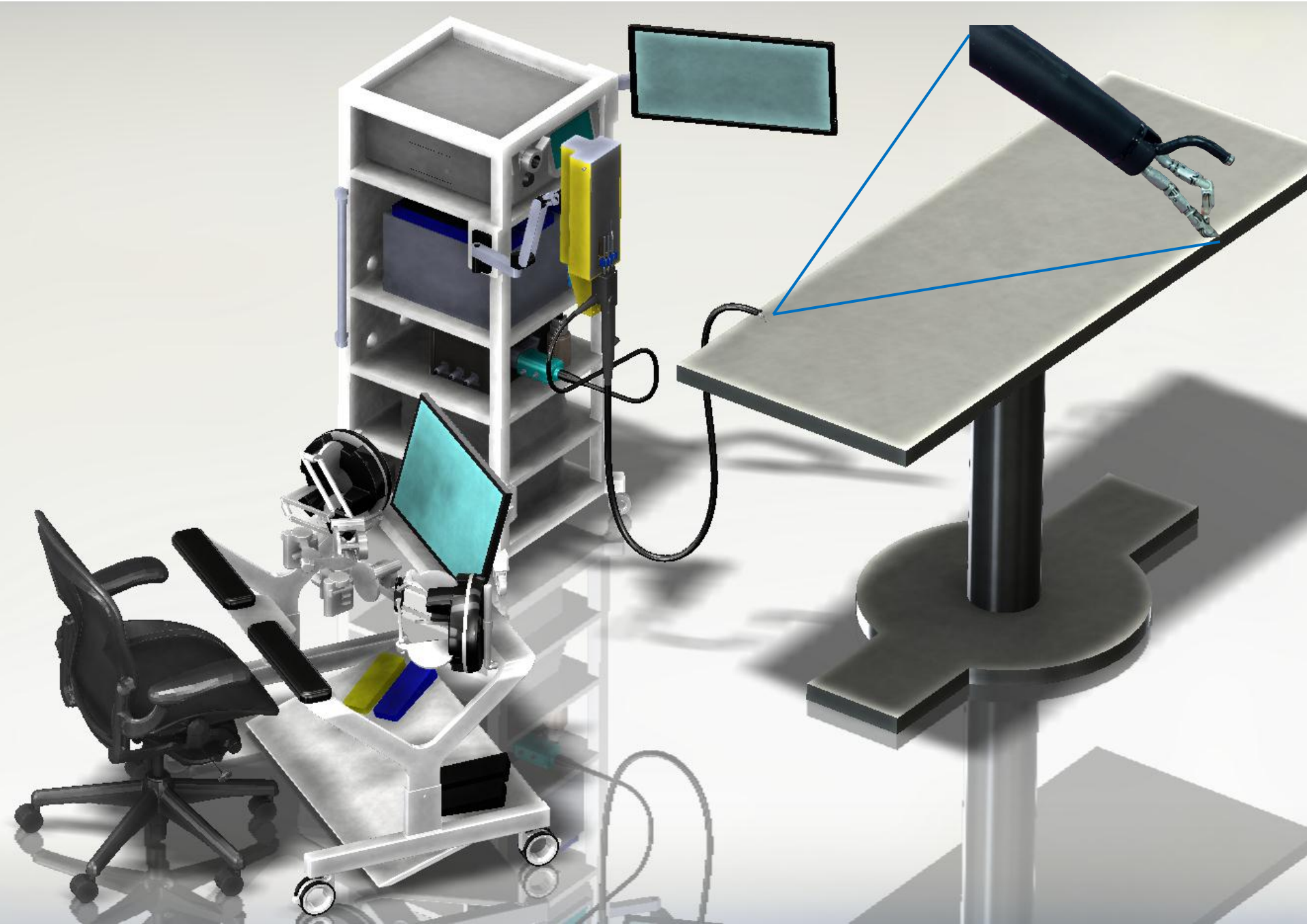

Current commercial systems an overkill?

- Too expensive
- Too complicated and elaborate
- Too bulky
- A lot more could be done with less

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Tremor Compensation

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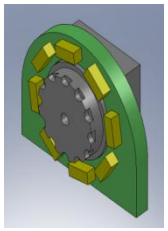
Integration of Capsule Prototype

Main Control Board

Camera

- Model: OV2640
- CMOS sensor
- Resolution: 640x480
- Frame rate: 0.5 f/s
- With compression (JPEG format)



I2C

Image

Microcontroller

- Model: MSP430
- Frequency: 8 MHz
- Voltage: 3 V
- Current: 60 mA

SPI

RF Transceiver

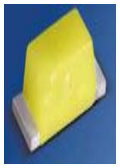
- Model: ZL70101
- Frequency: 433MHz
- Raw data rate: 800kbps
- Effective data rate: 500kbps

Antenna

- Frequency:433MHz
- Bandwidth:20MHz
- Impedance:50ohm
- Dimensions: 12.0 X 4.0 mm

LEDs

- Model: SmartLED 0603
- White Hyper-Bright LED
- Voltage: 3 V
- Dimensions: 1.7 x 0.8 x 0.65 mm



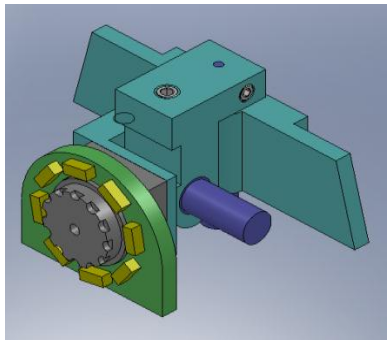
Motor Driver

- Brushless DC Motor driver
- Open loop speed control
- Voltage: 3 V
- Current: <10 mA

3 PWM Signals

Mechanical Actuator

- Faulhaber BLDC Motor
- 2 DOF actuation
- Voltage: 3 V
- Current: 70 mA

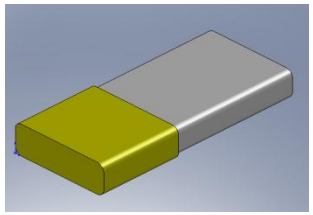


V- (0 V)

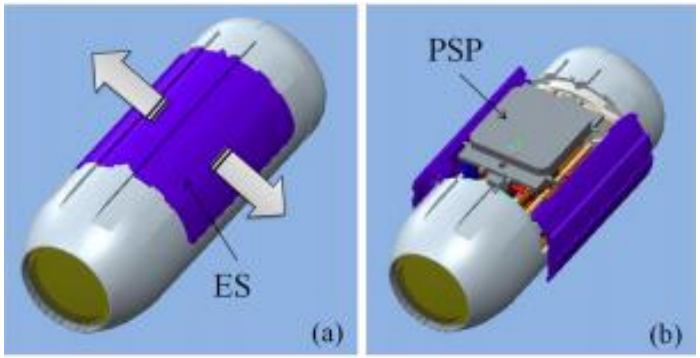
V+ (3.7 V)

Battery

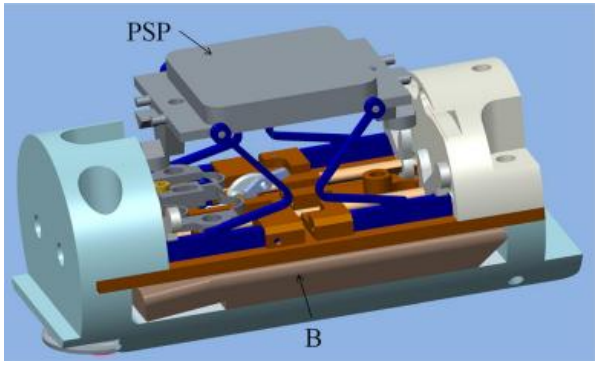
- Polymer Lithium Ion Battery (x2)
- Nominal Voltage: 3.7V
- Nominal Capacity: 100 mAh (0.2C)
- Discharge cut-off Voltage: 2.75 V
- Dimensions (mm): 4 × 15 × 28



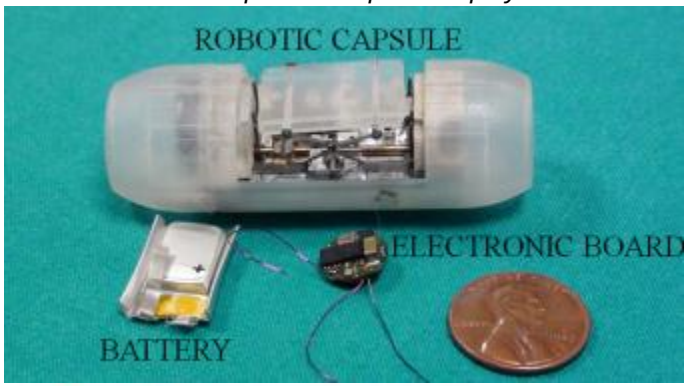
Capsule Platform



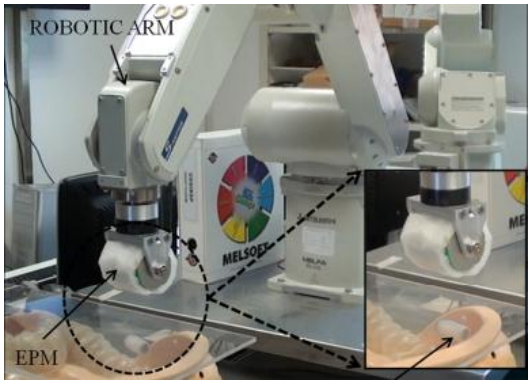
(a) Schematic view of the capsule "closed" configuration adopted during locomotion: ejectable shells (ES) are aligned with capsule surface. (b) Schematic view at patch release: ES are ejected and patch supporting plate (PSP) is displaced for patch deployment.



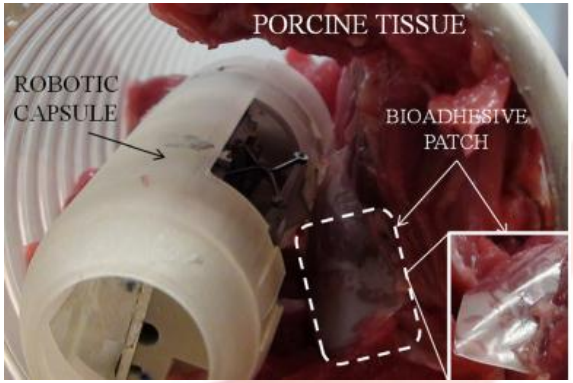
Assembly of the patch release mechanism. On-board battery (B) is also sketched



Main on-board electronic components



Robotic arm moving the permanent magnet (EPM) used for capsule navigation and tissue scraping



Bioadhesive patch release test onto ex vivo porcine GI tissue. After patch deployment, capsule was slightly displaced and patch supporting plate was removed, for ease of visualization.

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Quaglia C, Tognarelli S, Sinibaldi E, et al. Wireless robotic capsule for releasing bioadhesive patches in the gastrointestinal tract. J Med Device 2013;8(1):014503-3

Take Home Thoughts

- Technology is ever advancing
- Some technology is way beyond its time (maybe generation dependent)
- Differentiate the ‘need’ from the ‘want’

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