Image-Guided Medical Robotics

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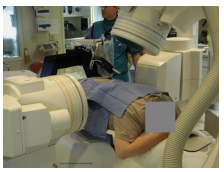

SHEIKH ZAYED INSTITUTE for PEDIATRIC SURGICAL INNOVATION

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Outline

- What is image-guided robotic surgery?
- Where does it fit in OR of the future?
- Image-guided robotics
- MRI-compatible robotics
- Rehabilitation robotics
- Conclusions

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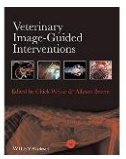
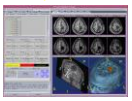
What is image guidance?

- Very broad term
  - Might say any procedure using medical images is image-guided including ultrasound for joint injections, etc.
- The use of medical images to guide an intervention
  - Mostly the domain of interventional radiologists
    - (or interventional cardiologists)
  - Use of imaging in procedures / surgery continues to grow
- Image guidance: commonly used for surgical procedures such as pedicle screw placement or central line insertion
- Image-guided robotic surgery
  - Use of robotic technology coupled with medical image to guide a procedure




Operating Room of the Future: (OR2020)

2004 workshop: presented at SPIE Medical Imaging 2006

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Digital Operating Room

- Robot is one part of the digital infrastructure
- Robot couples "information to action" (R. Taylor, JHU)
- Surgical cockpit is the control center

RAVEN teleoperation with Surgical Cockpit

https://www.youtube.com/watch?v=Wn1IZV398UM

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DaVinci Robot and Beyond

KEY POINTS

- New platforms – current patents impending expiry with entry of Medtronic and Verb.
- Advances – haptics, patient interface, image guidance, flexible robotics with web-connectivity.
- Great anticipation of advances to improve patient care.

	Da Vinci Xi [33]	Senhance [34]	REVO-I (preclinical) [35]
Manufacturer	Intuitive Surgical, (Sunnyvale, USA)	Transenterix (Morrisville, USA)	Meerecompany (Hwaseong, Korea)
Instrument size	8mm	5/10 mm	8/10 mm
Console	Closed	Open 3D HD (polarized glasses)	Open
Haptic feedback	No	Yes	Yes
Surgeon interface	Fingertip	Laparoscopic	Fingertip
Instrument Use	10	Lap – reusable Robo articulating – single	>20
Cart	Single gantry	Separate floor based gantries	Single gantry
Special Features	Camera hopping Table motion Firefly Single Port System	Eye tracking camera movement	Limited articulation

What robot for tomorrow and what improvement can we expect?.
Namdarian, Benjamin; Dasgupta, Prokar

Current Opinion in Urology. 28(2):143-152, March 2018.
DOI: 10.1097/MOU.0000000000000474

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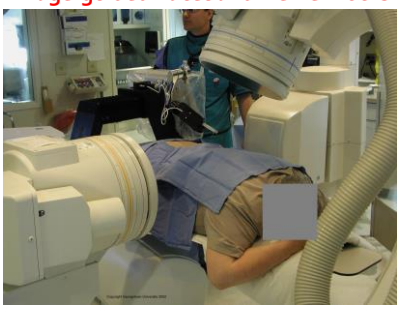
Image-guided Facet and Nerve Blocks



Robotically assisted nerve and facet blocks: a cadaveric study.

Acad Radiol. 2002 Jul;9(7):821-5.

Cleary K, Stoianovici D, Patriciu A, Mazilu D, Lindisch D, Watson V.

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Mazor Robotics

The Current Role of Robotic Technology in Spine Surgery

Srikanth Divi, Sean Pollster, Edwin Ramos,and Michael J. Lee

Oper Tech Orthop 27:275-282C2017 Elsevier Inc

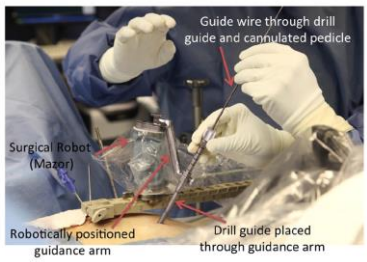

Figure 2 Use of robotic guidance during percutaneous pedicle screw placement.

Which Spine Robot Will Dominate?

Surgical robotic systems took center stage at the North American Spine Society meeting last week. Here's analysts' take on the offerings from Zimmer Biomet, Mazor Robotics, and Globus Medical.

Oct. 2016

https://www.mddionline.com/which-spine-robot-will-dominate

Brainlab: Image-Guided Spine Surgery

- Portable, light-weight design (approx. 11kg)
- Mounted directly to the O.R. table rail
- Fully integrated computer unit with no footprint
- Port for different application-specific modules

https://www.brainlab.com/en/surgery-products/overview-spinal-trauma-products/cirq-robotics/

Globus Medical

"ExcelsiusGPS is the only robotic system that combines surgical navigation and robotic guidance for spinal surgery, which offers significant advantages to spine surgeons."

https://www.odtmag.com/contents/view_breaking-news/2017-10-12/globus-medical-announces-first-spine-surgeries-using-excelsiusgps/

Globus Medical Announces First Spine Surgeries Using ExcelsiusGPS

ExcelsiusGPS supports minimally invasive and open screw placement procedures.

ExcelsiusGPS provides real-time visualization of instrument positioning and screw placement with respect to patient anatomy and closes the loop for the robotic guidance. Image courtesy of Globus Medical.

Mako® Robotic-Arm Assisted Technology

This is Mako, a robotic-arm assisted technology that helps surgeons provide patients with a personalized surgical experience. A 3D model of your hip or knee will be used to pre-plan and assist your surgeon in performing your joint replacement surgery.

Mako Total Hip | Mako Partial Knee | Mako Total Knee

MRI Compatible Robotics

- Access is difficult in closed-bore MRI
- Robot can provide a steady guide for instrumentation
- Can enable in-bore interventions
- Can enable real-time image during interventions

Interventional Radiologist Karun Sharma, MD/PhD, reaching inside scanner to target a ham phantom in biopsy tests on a Siemens 70 cm MRI system

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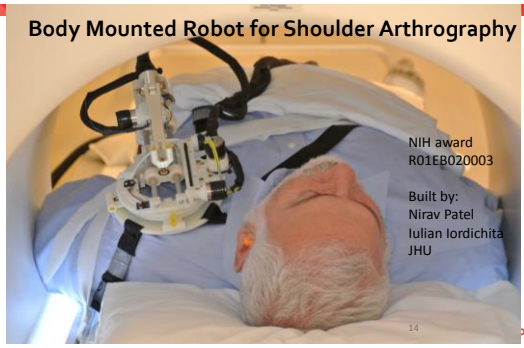
Body Mounted Robot for Shoulder Arthrography



NIH award
R01EB020003

Built by:
Nirav Patel
Iulian Iordichita
JHU

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Table Mounted Robot for Long Bone Biopsy Under MRI

Dan Stoianovici,
Changhan Jun
Sunghwan Lim
Doru Petrisor

Johns Hopkins Urobotics Laboratories

Figure 2A. Robot mounted on table with long bone phantom in middle and imaging coils on both sides

Figure 2B. Coils removed to show phantom, robot, and long thin fiducial in needle guide (cutout in phantom can be seen)

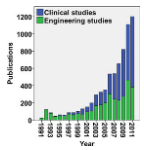
Figure 2C. Robot in scanner isocenter. Robot can be actuated to align needle guide while at isocenter.

Figure 2D. View from right side illustrating robot mount and simulated positioning between legs

Research Challenges

- Access to body
- Imaging
- Instruments
- Human-machine interface
- Prototype systems (added by me)

Surgical Robotics Through a Keyhole: From Today's Translational Barriers to Tomorrow's "Disappearing" Robots



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Summary and Conclusions

- Will there be a surgical robot in your future?
  - The robots are here to stay
  - Activity in the field continues to increase
- Scientists need to work with clinicians to develop these system to improve the precision and lessen the invasive of these procedures
- AAPM is a good venue for these discussions

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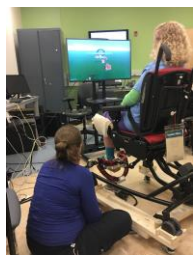
Related Work Rehabilitation Robotics

PedBot Ankle Robot

Hippotherapy Simulator Poster



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