ROBOTICS IN MEDICINE: WHO'S HOLDING THE KNIFE?

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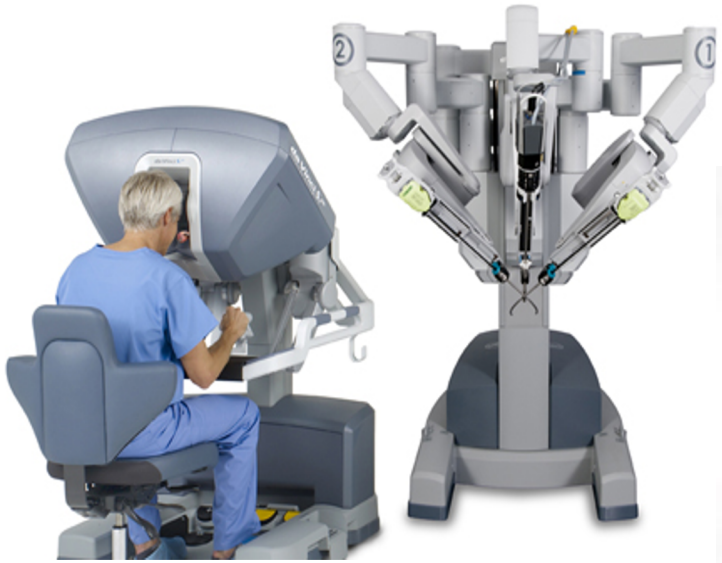
Why Robots?

Table 1. Advantages and disadvantages of humans and autonomous robotic systems

	Human	Robot
Advantages	Good judgement Adaptable and able to improvise Able to use qualitative information Easy to train Easy communication with humans	Good mechanical precision Untiring and stable Can work in hazardous environments Multimodal sensory integration
Disadvantages	Limited mechanical precision Prone to fatigue, tremor, inattention Cannot work in hazardous environments Limited quantitative abilities	No judgement No qualitative abilities Limited in haptic sensation Expensive

Yip, Michael, and Nikhil Das. 2017. "Robot Autonomy for Surgery." *arXiv Preprint*

Surgical Robot Autonomy



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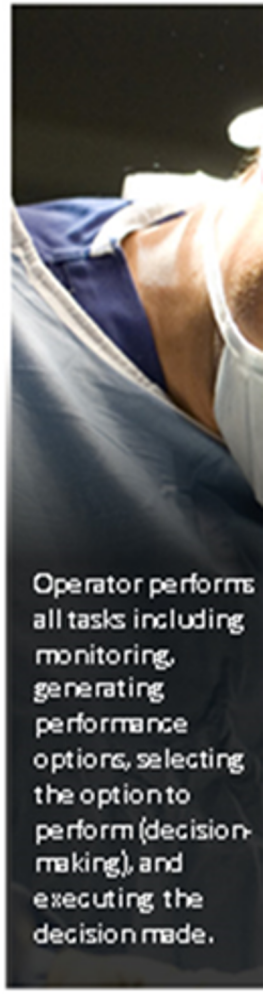


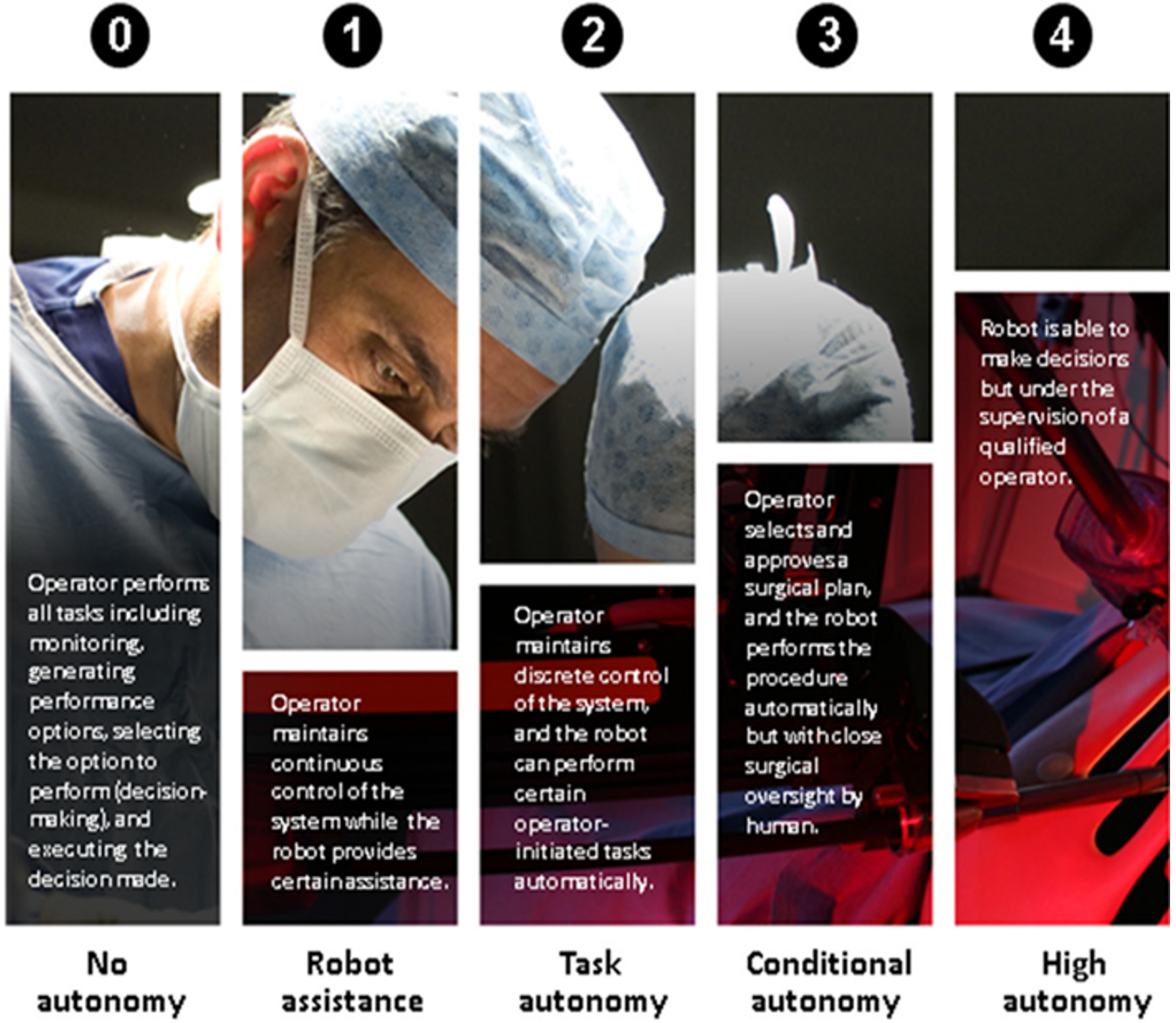
No autonomy

Surgical Robot Autonomy

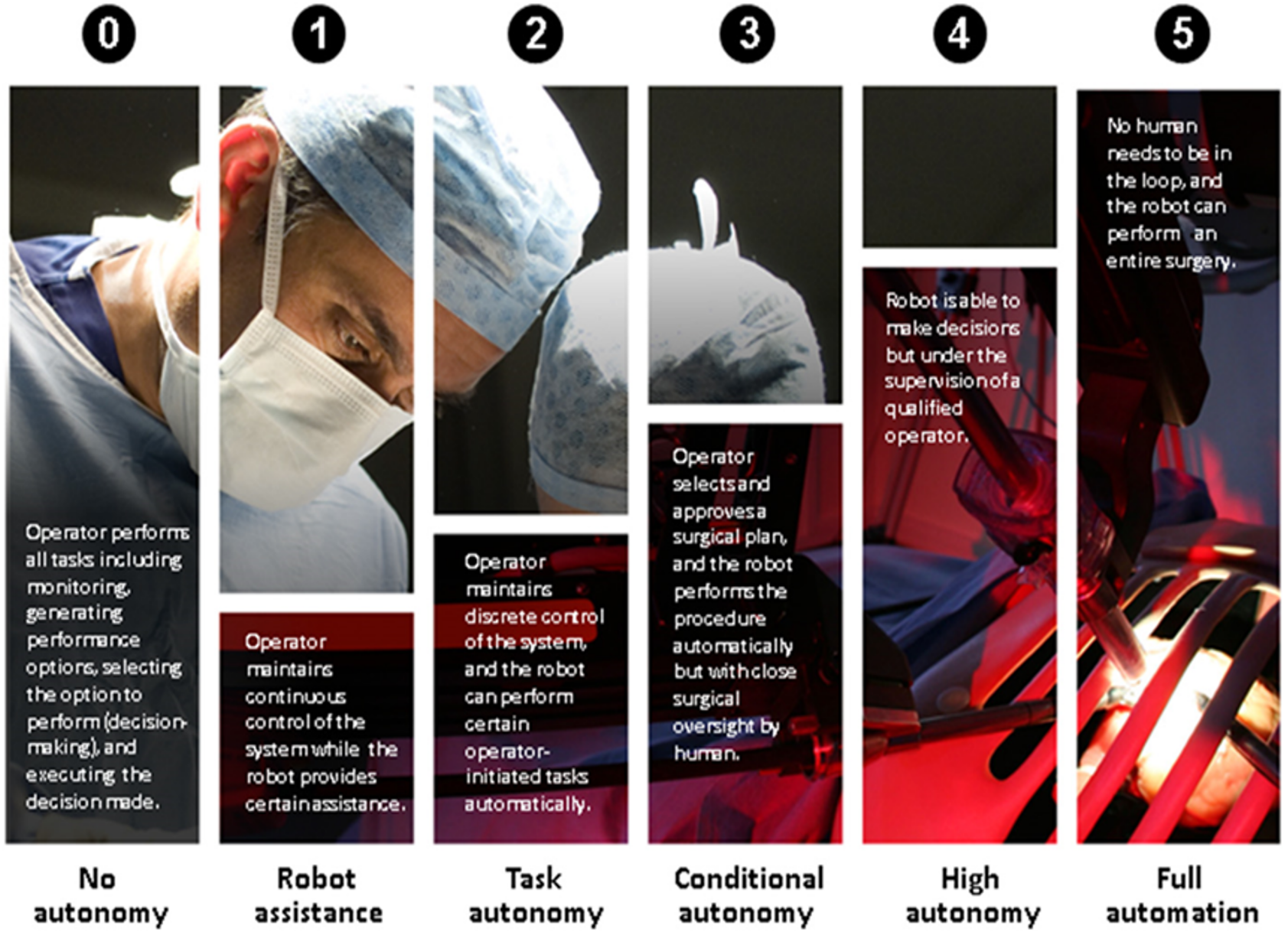
Surgical Robot Autonomy

Surgical Robot Autonomy

Surgical Robot Autonomy



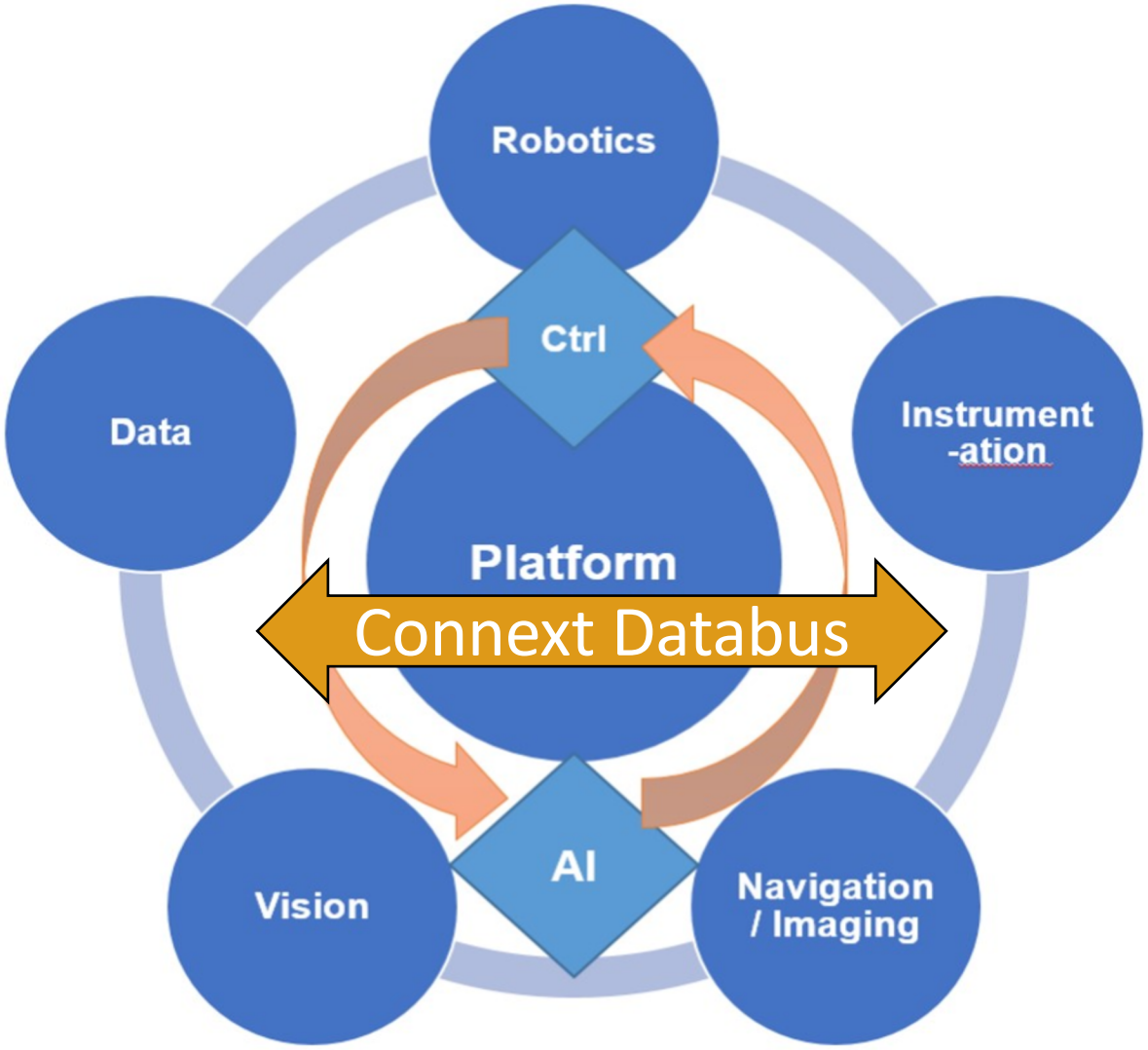
Surgical Robot Autonomy



Medical Robotics

Challenges

- Near instantaneous Response
- Real-world model
- Modular
- Data-centric

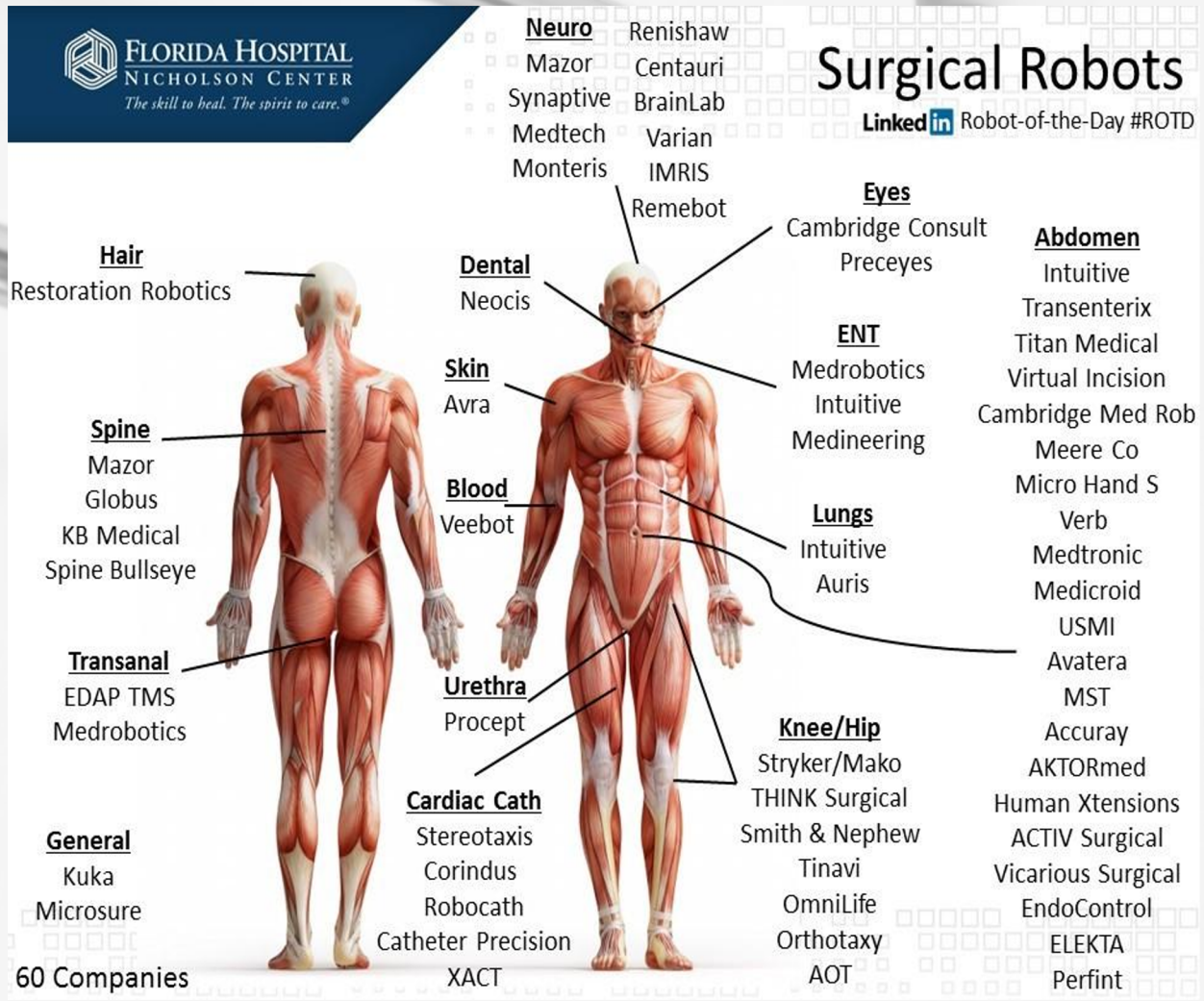


Market Segment Landscape

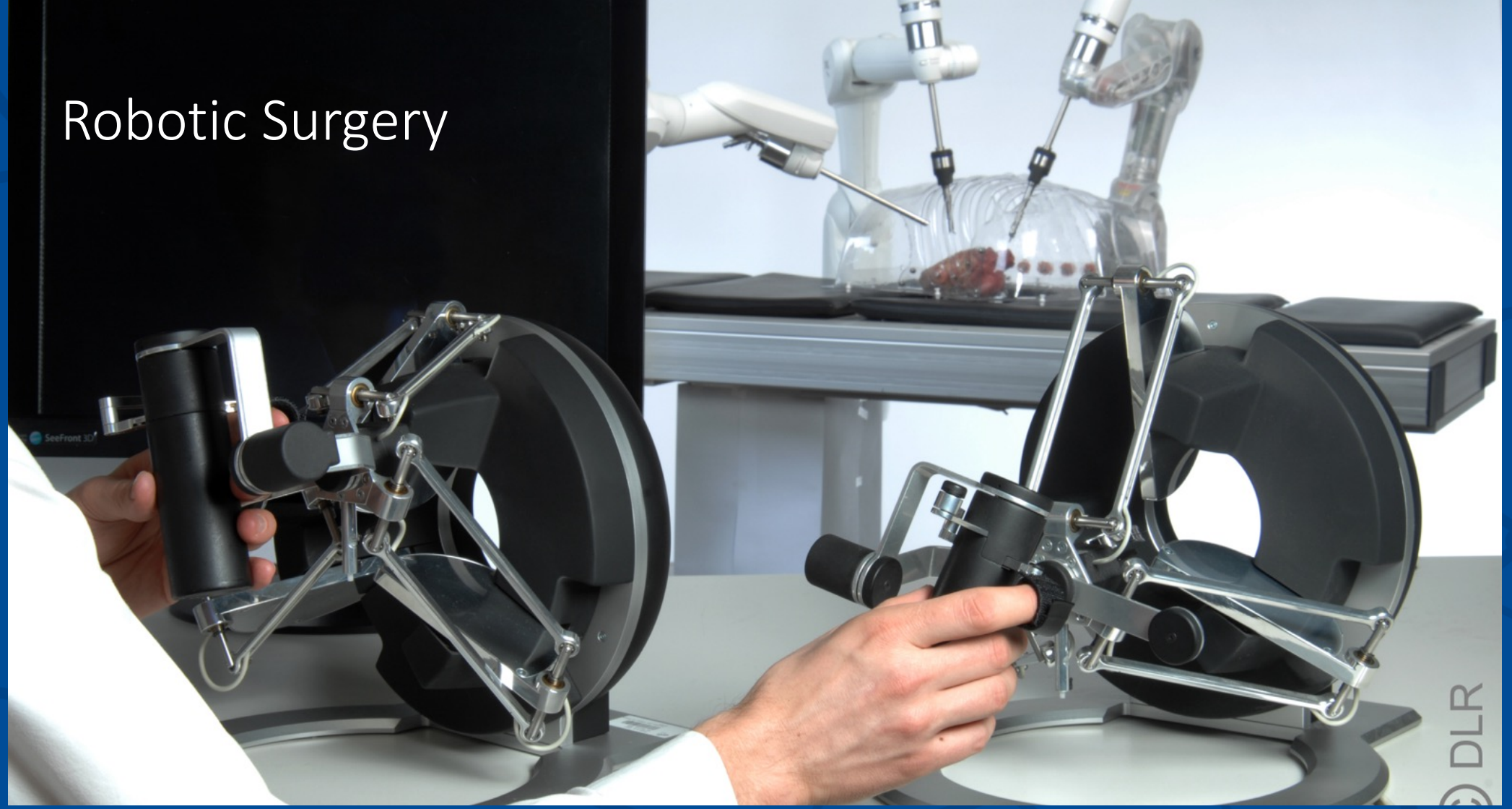
Global Medical Robotics Market		Market Size (US$ billion)		CAGR% (2016 – 2022)
		2016	2022	
Total		**5.38**	**14.56**	**18.1**
Robotic Systems		4.82	12.90	17.8
Surgical Robots	**Total**	**2.90**	**7.73**	**17.8**
	Laparoscopy Surgical Robotic Systems	1.30	3.40	17.3
	Neurosurgical Robotic Catheters	0.69	1.75	16.8
	Orthopedic Robotic Systems	0.49	1.51	20.6
	Steerable Robotic Systems	0.42	1.07	17.1
Rehabilitation Services	**Total**	**1.12**	**2.85**	**16.9**
	Assistive Robots	0.39	0.92	15.3
	Therapeutic Robots	0.32	0.71	14.2
	Orthotics Robots	0.26	0.55	13.7
	Prosthetic Robots	0.11	0.30	17.4
	Exoskeletons	0.04	0.38	47.3
Hospitals and Pharmacies	**Total**	**0.80**	**2.32**	**19.5**
	Telemedicine Robots	0.34	0.91	18.0
	I.V. Robots	0.28	0.89	21.3
	Pharmacy Robots	0.18	0.52	19.1
Instruments and Accessories		0.56	1.66	19.7

Source: Scalar Market Research Analysis

Applications



Robotic Surgery



DLR

The Minimally Invasive Robotic Surgery (MIRS) system at DLR coordinates three robots to perform delicate heart surgery.

RTI enables new medical techniques.

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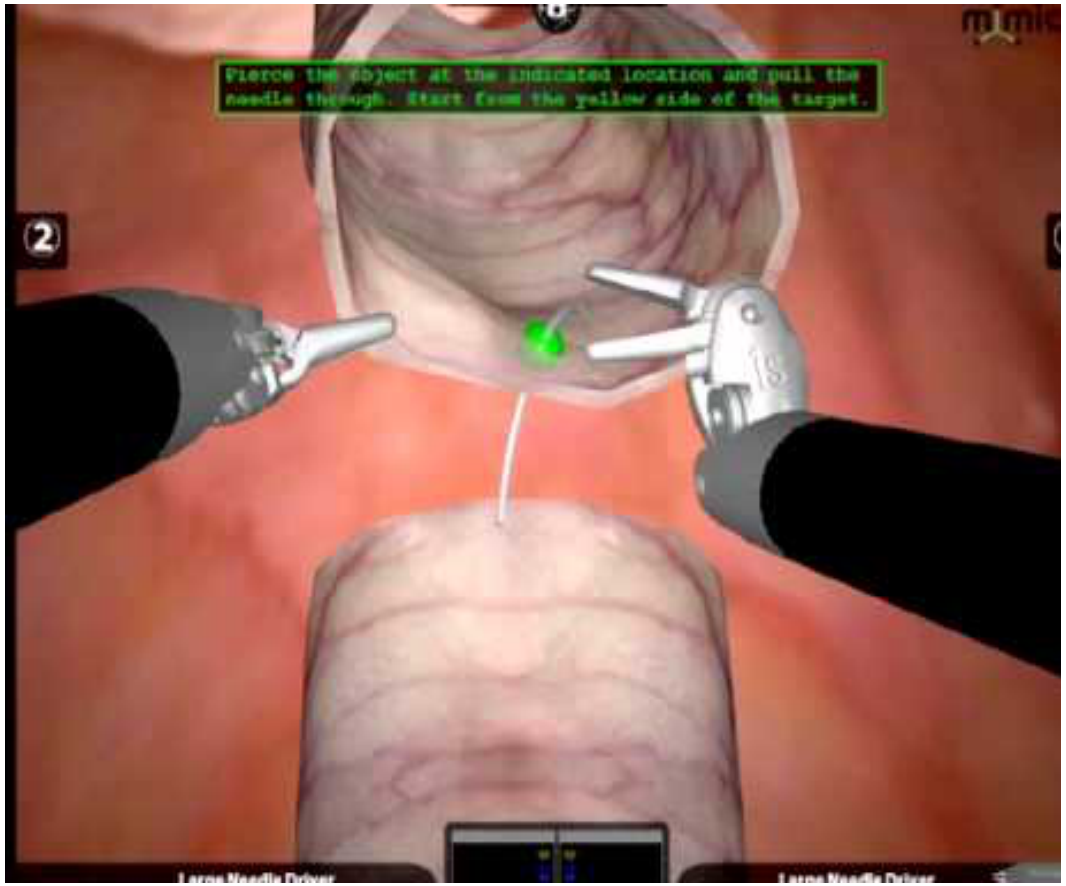
Simulation & Augmented Reality

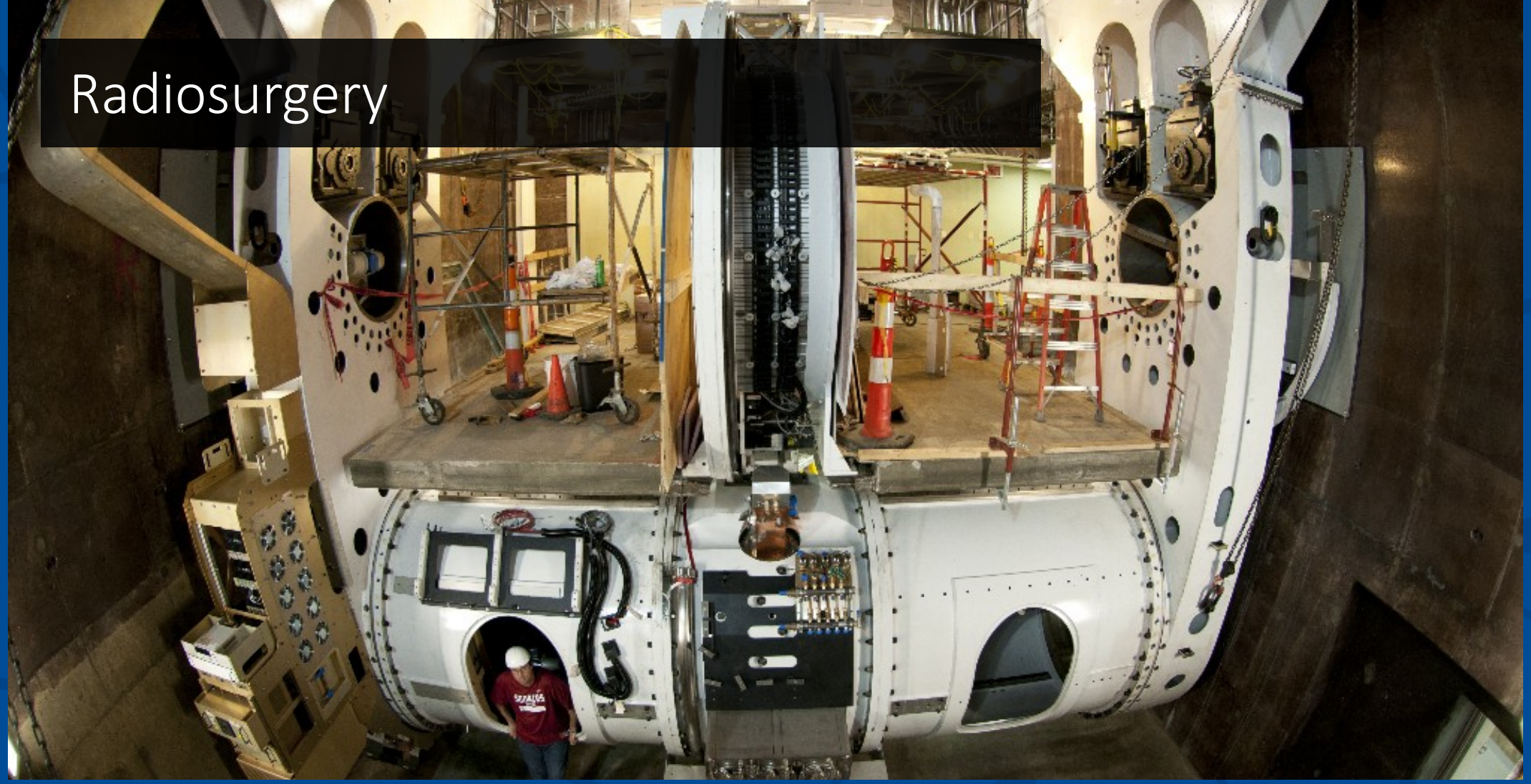
STEINBERG CENTRE FOR
SIMULATION AND INTERACTIVE LEARNING
CENTRE DE SIMULATION ET
D'APPRENTISSAGE INTERACTIF STEINBERG

OSSimTech™

CAE Healthcare



Radiosurgery



MEVION medical systems

Mevion's Proton-Beam Radiation Therapy system zaps tumors with accelerated protons. The treatment must be continuous for 30-40 days; downtime endangers treatment success.

With Connext DDS, Mevion delivers dependable treatment at low cost.

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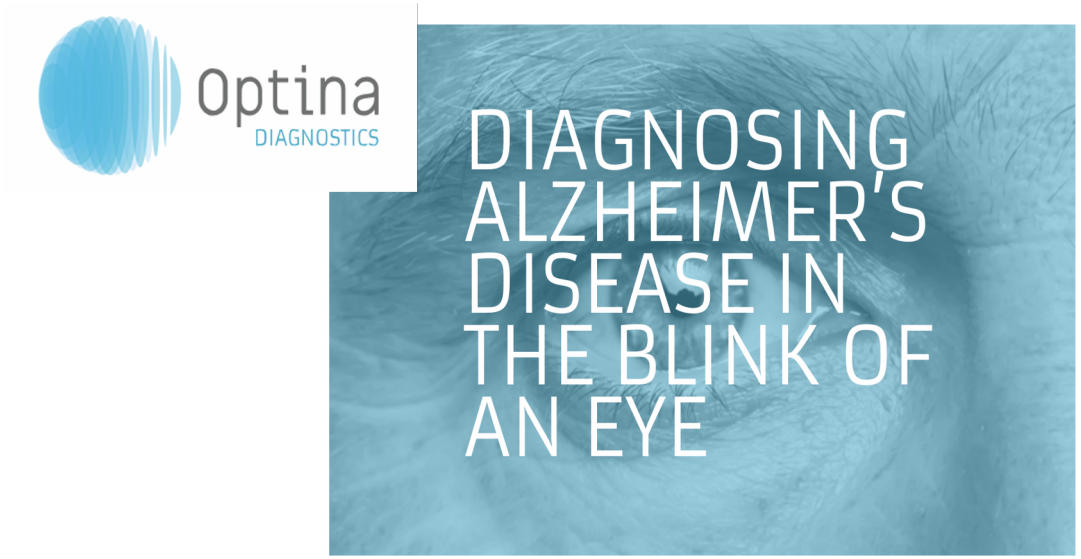
Medical Imaging & AI

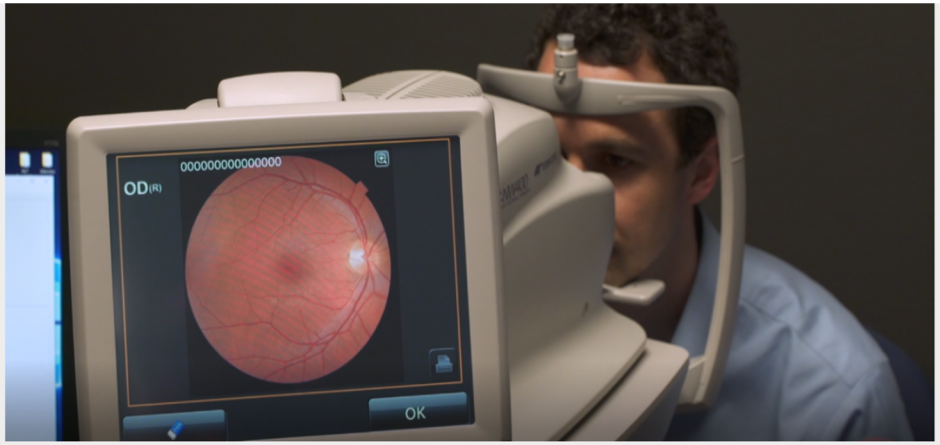
AI supporting clinical decision-making

Initial focus of AI in medical imaging

- Inputs (images) and outputs (classification, segmentation) leverage AI foundations in computer vision
- Imaging data volume & availability
- Less variability in data format
- No patient interaction

Medical Imaging & AI

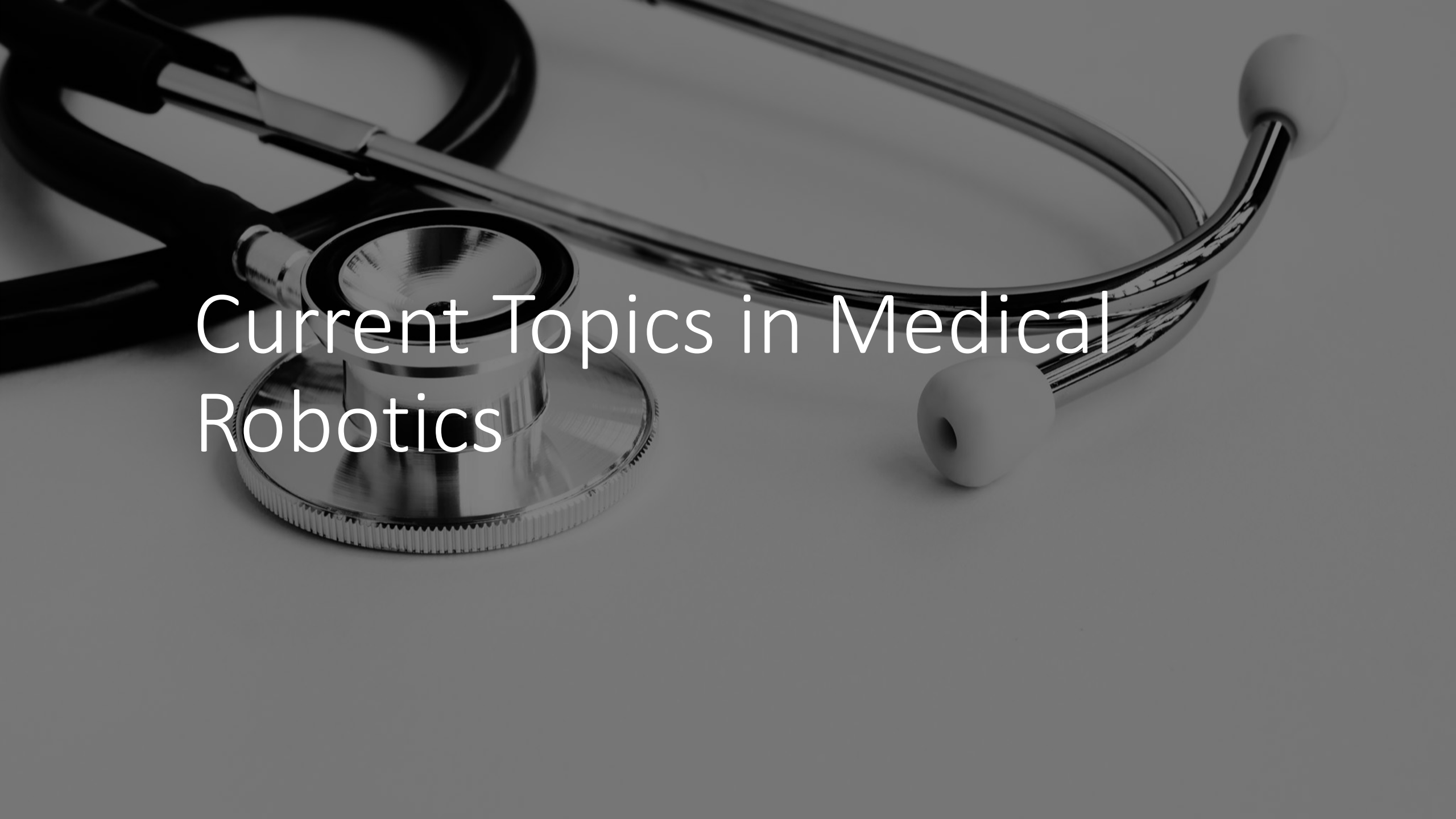




FDA approves AI-powered diagnostic that doesn't need a doctor's help
IDx, April 2018

Ahead:

- Data access, privacy, security
- Black box
- Regulatory approval
- Healthcare & patient acceptance



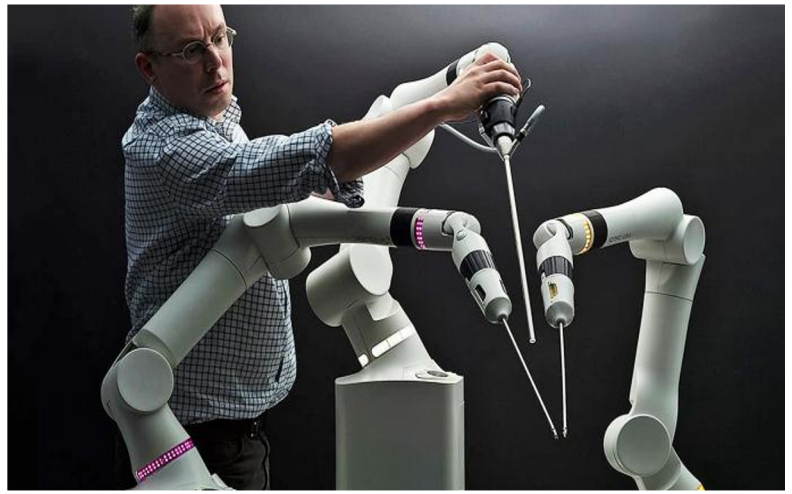
Current Topics in Medical Robotics

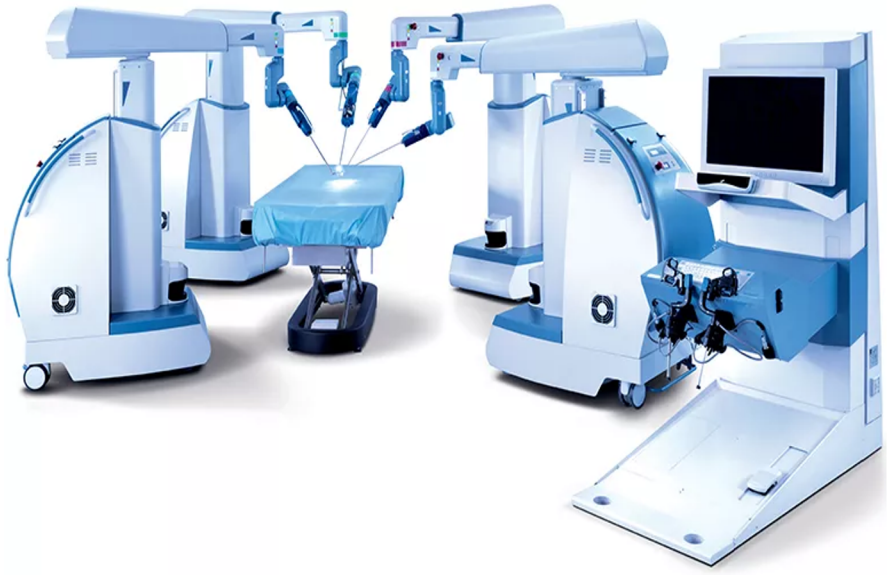
Laparoscopic Robots

Titan Medical Sport Applications:

- Abdominal
- Cardiac
- Urological
- Gynaecology

Intuitive Da Vinci





TransEnterix Senhance

Orthopaedic Robots

Tinavi Phecda

Think Surgical TSolution One

AOT CARLO

Stryker Mako

Globus Excelsius GPS

Medtronic Mazor X

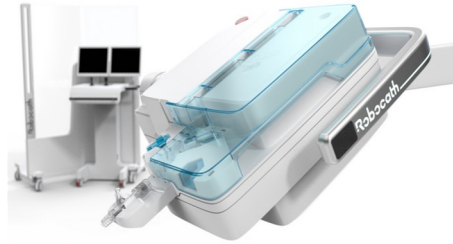
BlueBelt Navio PFS

Zimmer Rosa Spine

Applications:

- Partial & total knee arthroplasty
- Total hip replacement
- Spine procedures: pedicle screw insertion

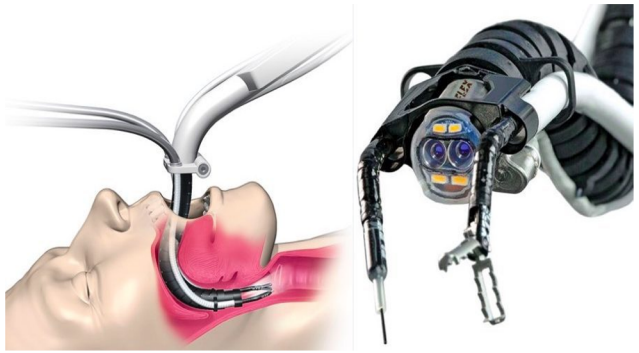
Endoluminal & Endovascular Robots



Robocath R-One

Stereotaxis Epoch

Hansen Magellan

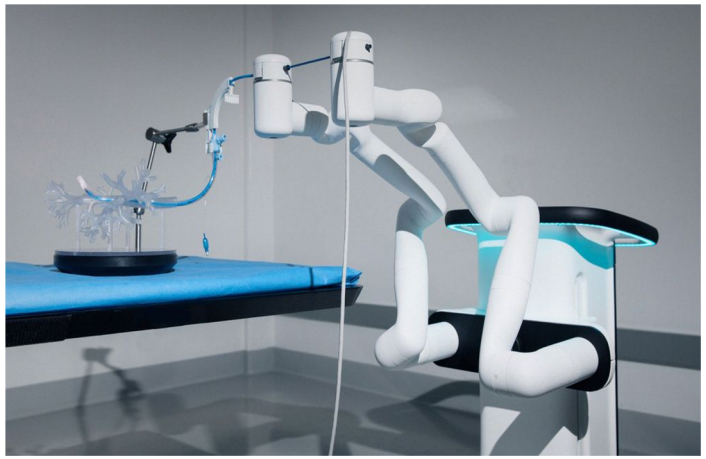


Medrobotics Flex

Applications:

- Bronchoscopy
- Cardiovascular & stroke
- Electrophysiology
- ENT

Medrobotics Flex



Auris Health Monarch

Surgical Robotics Pros & Cons

PROS

- Precision and accuracy in executing surgical plan
- Improved access to intervention site
- Reduces orthopaedic stress on user
- Reduces radiation exposure
- Training & Education: 2nd console, simulation
- Enables telesurgery

CONS

- Limited clinical evidence
- Lack of tactile feedback
- Cost
- Bulk and limited access to patient
- Limited device/implant options
- Limited to subset of procedures
- System setup

Closing

- Number and variety of Medical Robotics applications are exploding
- Good data drives positive patient outcomes
- Developers want to focus their efforts on applications
  - They need a platform that allows them to do that
- RTI Connext DDS:
  - Enables autonomy in the real world
  - Provides super-reliable operation with high-speed control
  - Connects many heterogeneous system together
  - Enables (coming soon) high-fidelity remote WAN operation
- Connext DDS can provide a basis for all types of autonomy

Thank You!