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Tutorial on Medical Robotics

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ICRA 2016 Tutorial on

Medical Robotics

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Stanford University

Nobuhiko Hata
Harvard Medical School

Etienne Burdet
Imperial College London

About this tutorial

- Focus of this tutorial: Design and control of robots and associated technology for medical applications, focusing on surgery, interventional radiology and neurorehabilitation
- We expect that you are in the fields of engineering and computer science; no medical background is necessary.
- Audience: Who are you?

About us

Allison
Mechanical Engineering PhD
Stanford University
Dextrous manipulation
Immersion, Inc. (Haptics)
Professor at Johns Hopkins,
Stanford

Noby
ME & Computer Science PhD
Tokyo University
Brigham and Women's Hospital
+ Harvard Medical School
"Engineer in scrubs"

Etienne
Theoretical physics, PhD in robotics
ETHZ (Switzerland)
Postdoc in Canada/Japan/USA
in neuromechanics
Research in medical robotics &
neuroscience at NUS Singapore
Professor, Imperial College London

Structure of this tutorial

- 8:10-9:00 am
  Lecture 1: Design Considerations for Medical Robots
- 9:00-9:50 am
  Lecture 2: Kinematics and Control of Medical Robots
- 9:50-11:10 am
  Lecture 3: Image-Guided Interventions
- 11:10-12:10 pm
  Lecture 4: Collaborative Robots for Mobility Assistance and Rehabilitation
- 12:10-12:30 pm
  Discussion

Learning Objectives

Lectures 1 & 2 (Allison)

- Define surgery and minimally invasive surgery
- Explain the function and advantages/disadvantages of current commercial robot-assisted surgical systems
- Highlight design features of current and future generations of robotic devices
- Understand the kinematic structures of medical robots
- Identify common types of sensors and actuation technologies used in medical robots
- Identify control strategies used for human-in-the loop medical robots

Lecture 3 (Noby)

- Understand the fundamentals of medical imaging
- Understand the role of medical imaging to guide therapy and diagnosis – Image Guided Therapy
- Learn role of robotics in Image Guided Therapy research and key enabling technologies

Lecture 4 (Etienne)

- Learn the main factors for collaborative robots physically interacting with human movements
- Know how robots can be used to investigate human sensorimotor control
- Understand some aspects of human-robot interaction

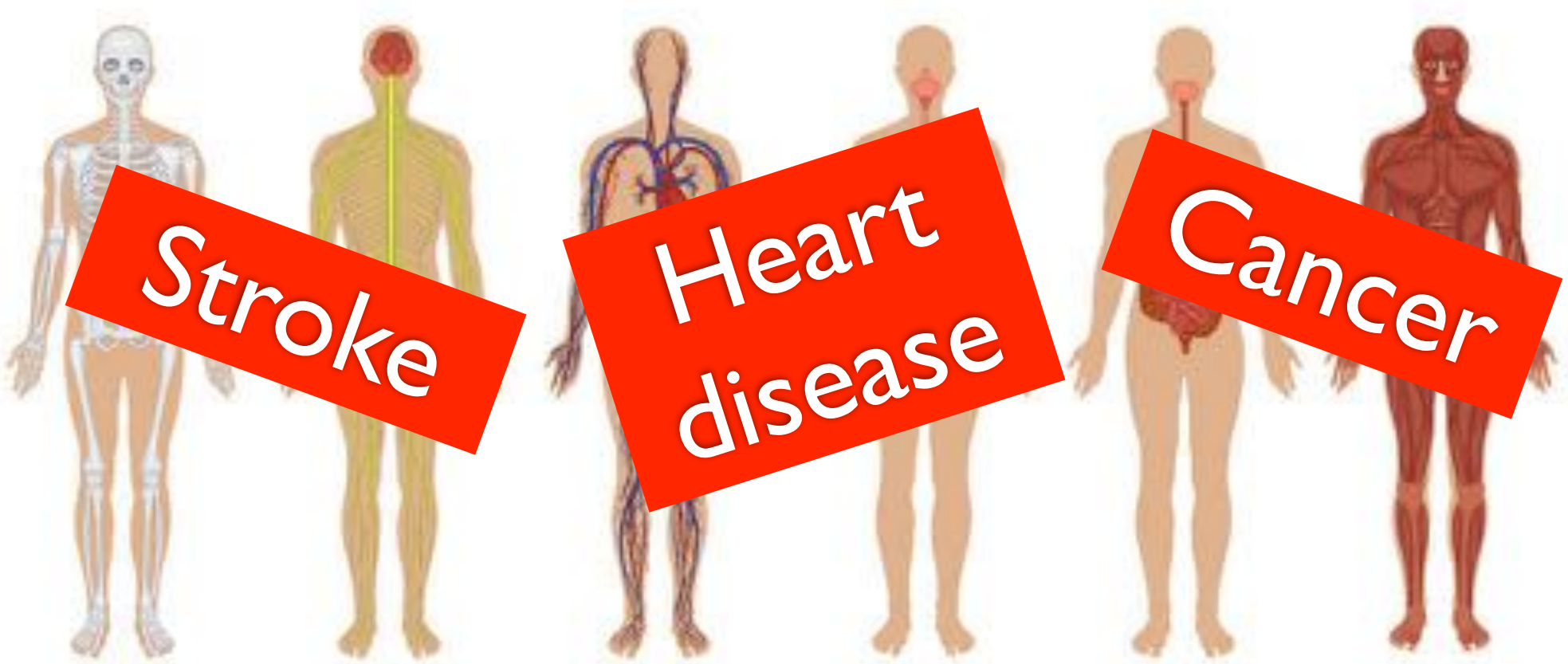
Why use medical robots?

Diseases and disorders

brain/
nervous system

respiratory/
lungs

muscular
system



orthopedic

circulatory

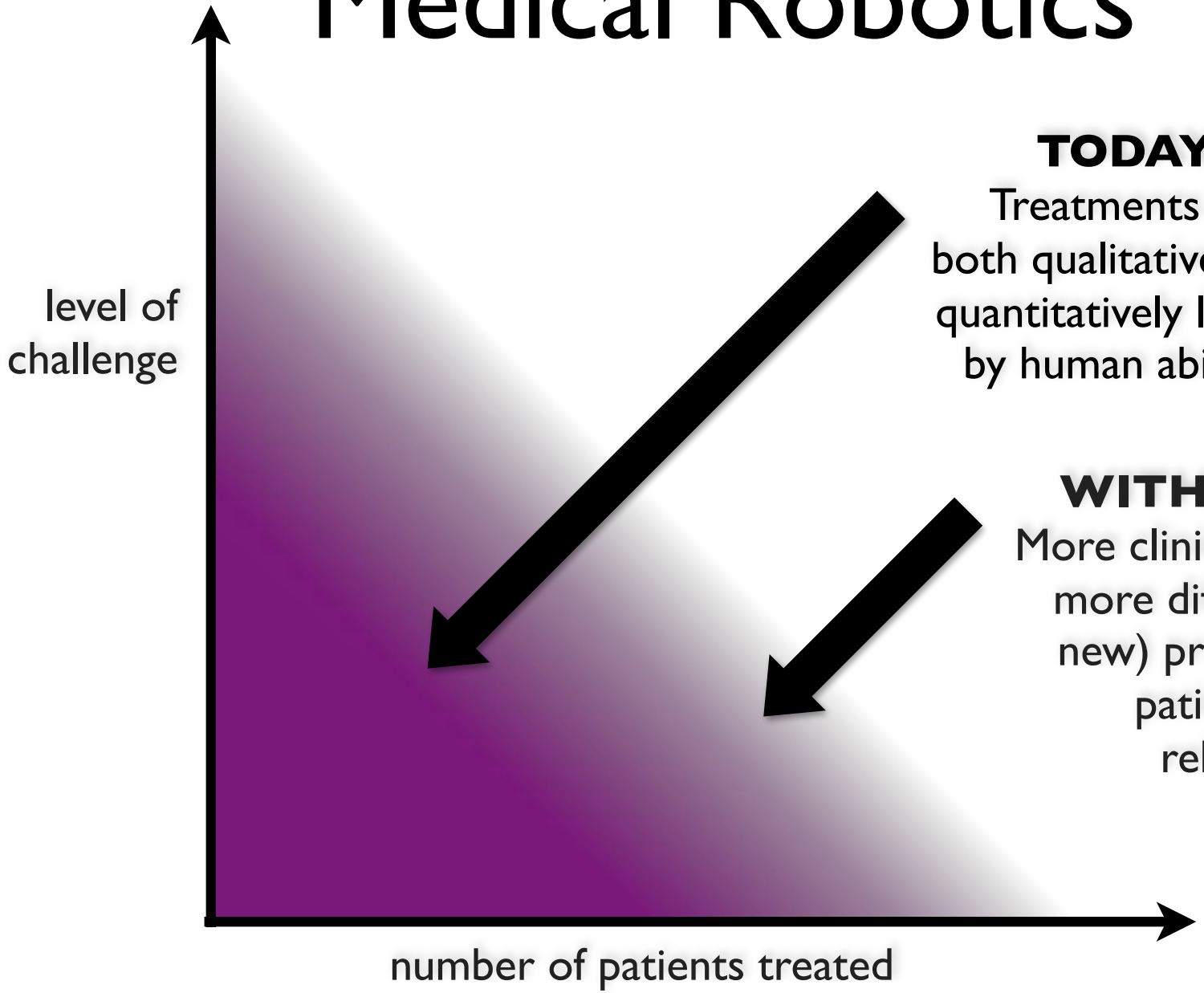
liver, kidney,
gastrointestinal

Robots are...

- Accurate and precise; Untiring
- Smaller or larger than people (as needed for access)
- Remotely operated (as needed)
- Connected to computers, which gives them access to **information**
- Not able to operate autonomously in highly complex, uncertain environments (yet)

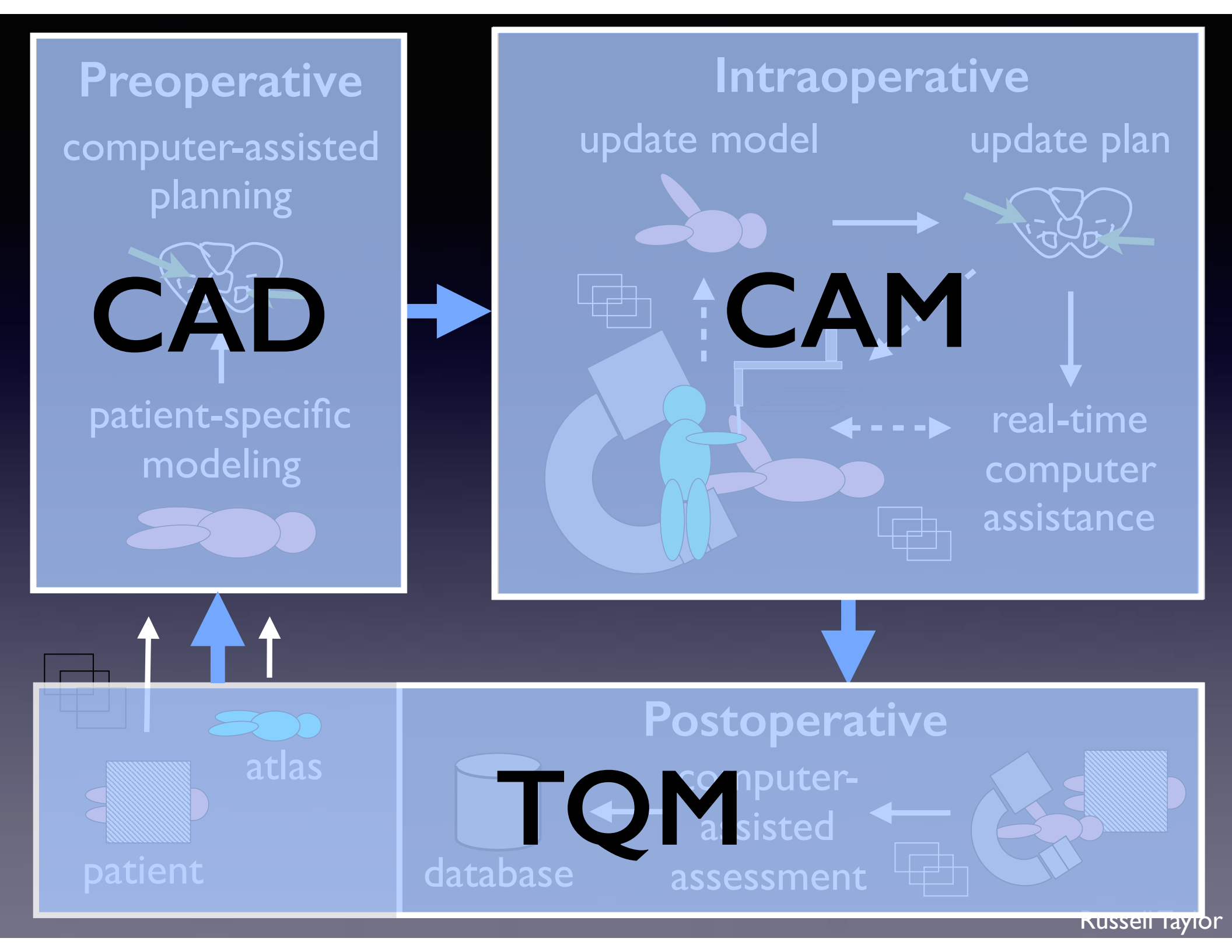
→ **Need for human interaction**

Potential Impact of Medical Robotics



TODAY:
Treatments are both qualitatively and quantitatively limited by human abilities

WITH ROBOTICS:
More clinicians can perform more difficult (and even new) procedures; more patients can be rehabilitated


Preoperative
computer-assisted planning
CAD
patient-specific modeling
Intraoperative
update model
update plan
CAM
real-time computer assistance
atlas
patient
TQM
database
Postoperative
computer-assisted assessment

Key features of robot-assisted interventions

- Quantitative descriptions of patient state
- Use of models to plan intervention
- Design of devices, control, and processes to connect information to action (= robotics)
- Incorporate human input in a natural way

Ultimate goal: Improve health and quality of life

Safety and Reception

Safety of **industrial robots** is ensured by keeping humans out of the workspace.

Medical robots come in contact with both patients and clinicians/caregivers.

Approaches include:

- Low force and speed
- Risk analysis (eliminate single points of failure)
- Fault tolerance (hardware and software)
- Fail safe design (system fails to a safe state)
- Redundant sensing

PUMA Industrial Robot

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