University of Basel
Department of Biomedical Engineering

Project MIRACLE
Medical Robotics and Mechatronics
BIROMED-Lab

# Intuitive control of macro-robots for surgery

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## Motivation

Typically, surgical robots are teleoperated which is not intuitive to surgeons. Different phases of surgery have varied accuracy requirements. Different control interfaces allow robot control at varied accuracies and intuitiveness.

Redundant robot motion in null space control is not intuitive to surgeons when priority-based controllers [1, 2,3] are used.

## Goals

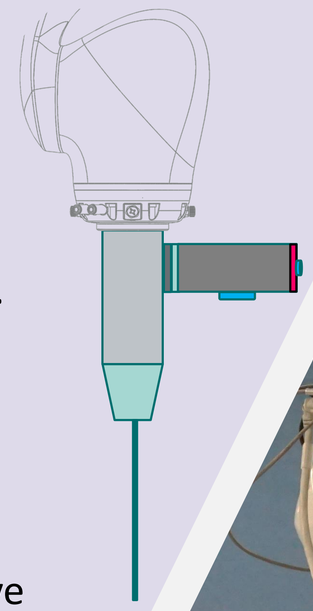
Reduce surgeon's effort and enhance intuitiveness of robot control by:

- Bringing multiple choice of control interfaces to the surgeon.
- Learning surgeon's preferred null space configurations and intelligently controlling the robot to avoid surgeon's workspace.

## Methods

### Hands-on Control

*Fig: An alternative handle design for hands-on robot control*

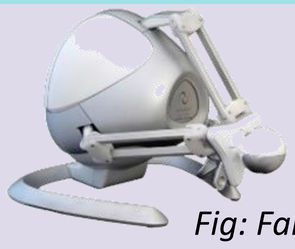


+ Intuitive to the user.
− Low accuracy.

**Research Challenges:**

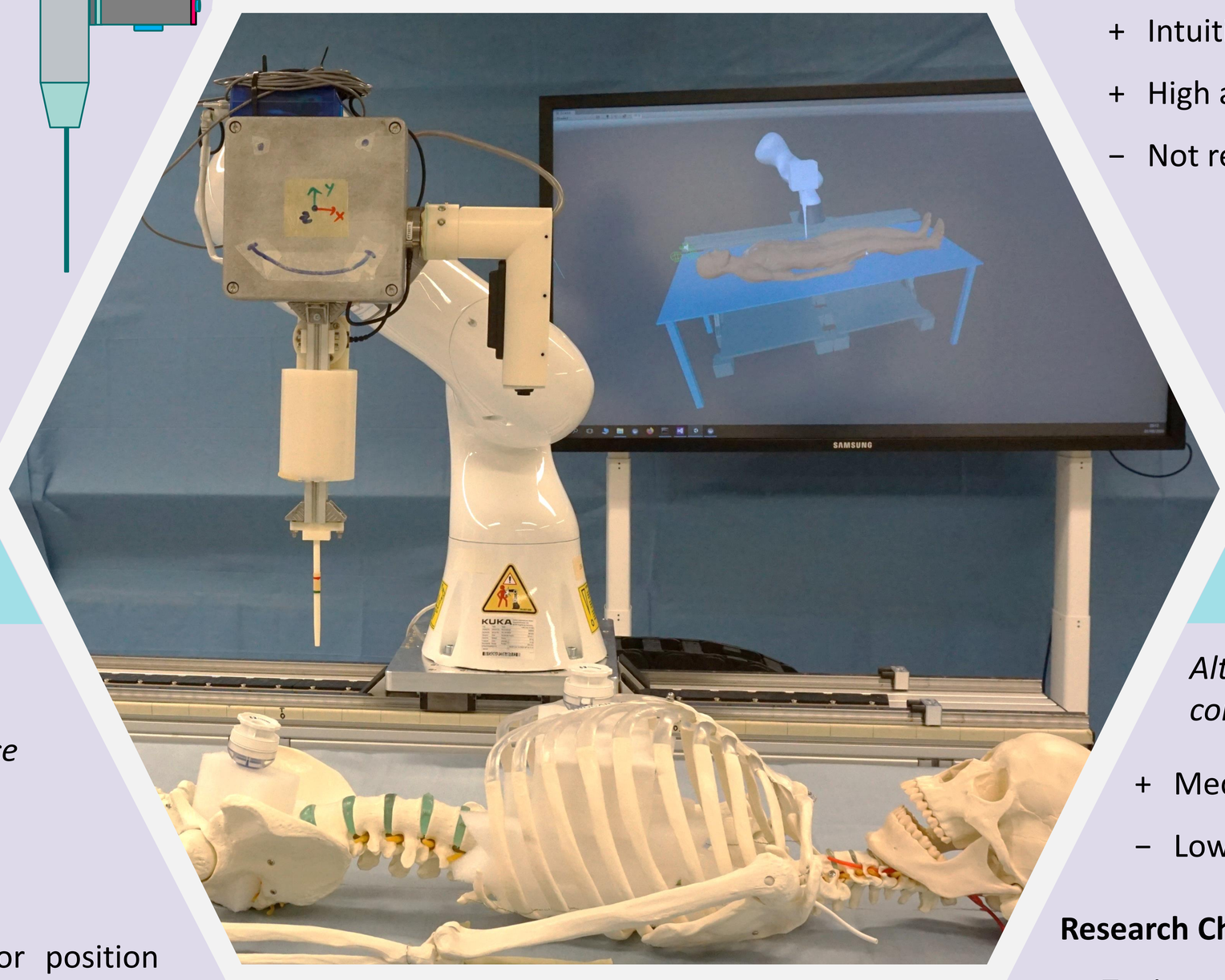
- Investigating intuitive handle designs.
- Choosing admittance control parameters.

### Teleoperation



+ High accuracy.
− Less intuitive.

*Fig: Falcon by Novint Technologies, USA.*




### Virtual reality Based

*Visualize robot motion and plan safe surgical paths.*

*Fig: Vive by HTC, Taiwan*

+ Intuitive to the user.
+ High accuracy.
− Not real-time.

**Research Challenges:**

- Registering the robot and VR spaces.
- Visualizing robot workspace.

### Learned task space control

*Learn surgeons' preferred robot configurations and move the robot in null space away from surgeon.*

**Research Challenges:**

- Dissimilarity metrics for position and orientation.
- Extension to higher degrees-of-freedom robots.

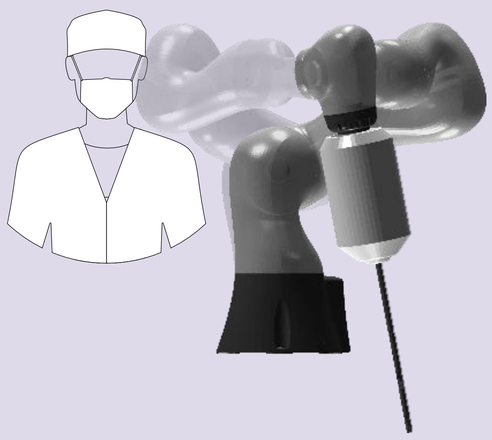


*Fig: Alternative null space robot configuration that is away from the surgeon for a redundant robot.*

### Series Elastic actuation

*Alternative joint design with compliance using springs.*

+ Mechanically ensured safety.
− Lower accuracy.

**Research Challenges:**

- Tuning trade-off between accuracy and compliance.

*Fig: An SEA link that moved along the applied impact. It will return to its goal position (transparent) once the force is removed.*

**References**

[1] H. Moradi and S. Lee, "Joint limit analysis and elbow movement minimization for redundant manipulators using closed form method," in *International Conference on Intelligent Computing*. Springer, 2005, pp. 423–432.
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[3] B. Siciliano, "Kinematic control of redundant robot manipulators: A tutorial," *Journal of intelligent and robotic systems*, vol. 3, n0. 3, pp. 201-212, 1990.

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