

III. Intelligent Augmentation

Virtual Fixtures in Robotic Surgery

- Hawkeye King, Sina Nia Kosari, Fredrik Ryden, Howard Chizeck
- Goals
 - Sensor-based real-time guidance
 - Shared human-machine control
 - Improved safety



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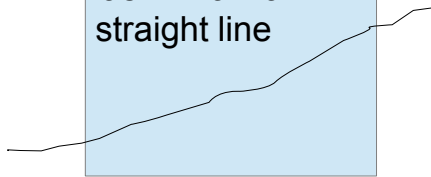
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Virtual Fixture Example



Task: Draw a straight line

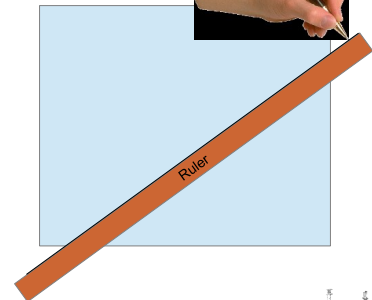


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Fixtures: Ruler



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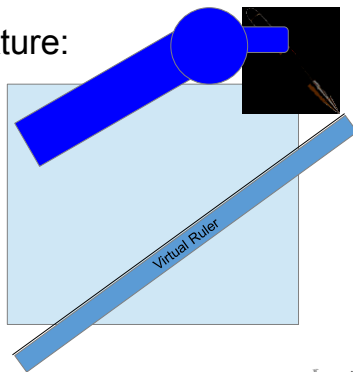
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Virtual Fixture:



Remote operator



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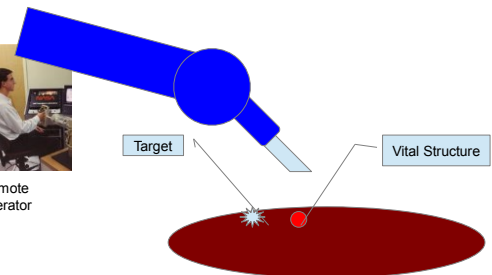
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Surgical guidance:



Remote operator



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3D sensing: Kinect™



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BioRobotics Lab

Kinect IR projection

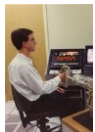
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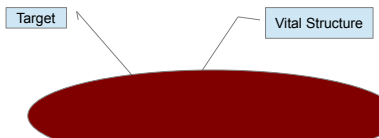


Medical Virtual Fixture:

Sensing based virtual fixture



Remote operator

VF based
On organ shape
And Motion

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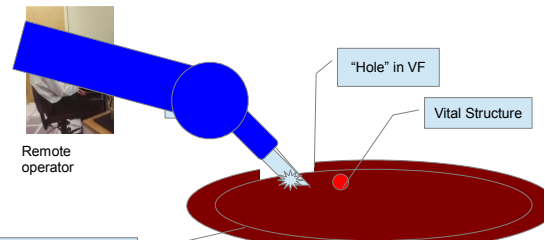


Medical Virtual Fixture:

Sensing based virtual fixture



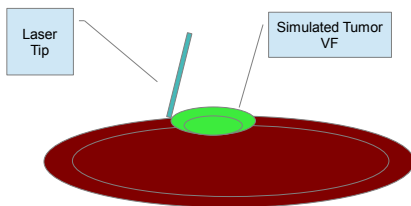
Remote operator

VF based
On organ shape

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Laser Resection Demo:

Real Time VF based
On organ shape
(butcher shop liver)

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Laser Tumor Resection



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Haptics via Kinect



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Haptic Rendering using Kinect

- Haptic Rendering based data from non-contact devices (Kinect)
- Potentially useful in many tele-operation tasks.



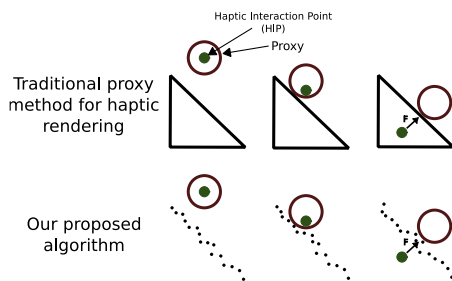
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Comparison with a Traditional Haptic Algorithm



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The Main Challenges

We need an algorithm for moving the proxy in the point cloud environment. The proxy should be constrained by the points as if the points represented surfaces.

We must be able to interact with **time varying** point clouds.



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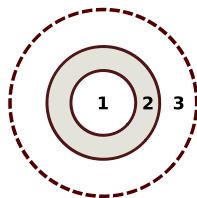
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New Definition of Proxy

Our proxy consists of three regions to detect states of *free motion*, *contact* and *entrenchment*.



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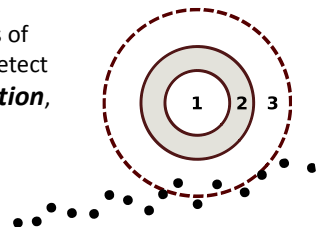
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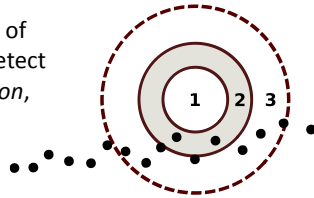
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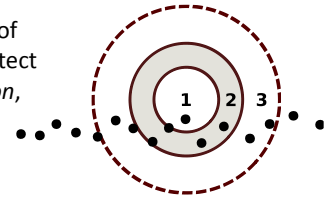
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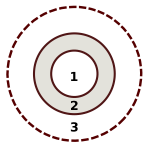
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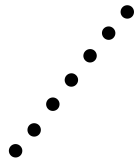


Proxy in Free Motion

Proxy



HIP

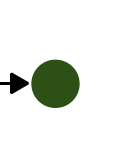
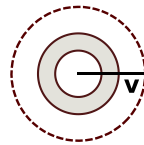


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Proxy in Free Motion

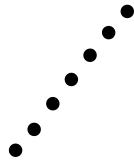


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Proxy in Free Motion

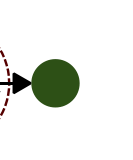
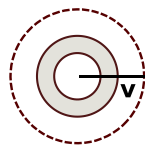


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Proxy in Free Motion

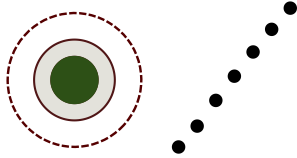


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Proxy in Free Motion

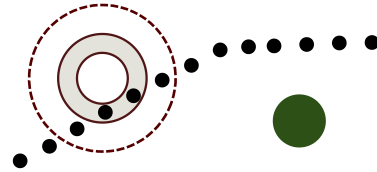


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Proxy in Contact

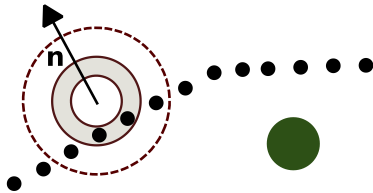


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Proxy in Contact

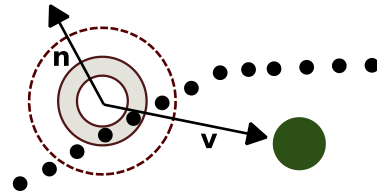


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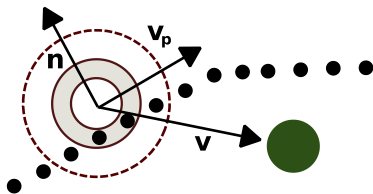


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Proxy in Contact

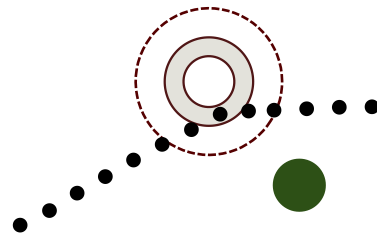


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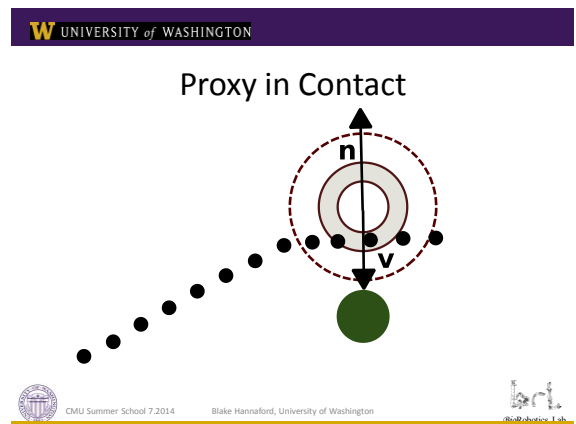
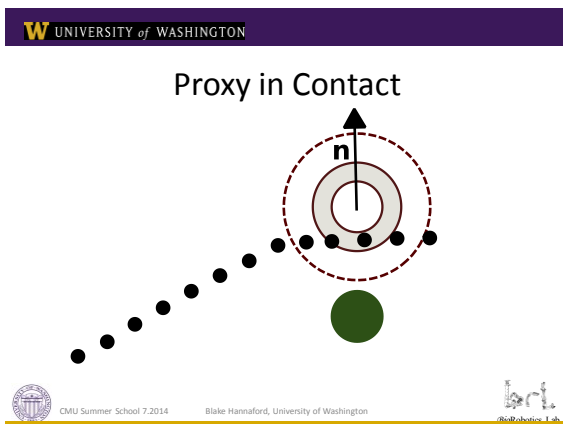
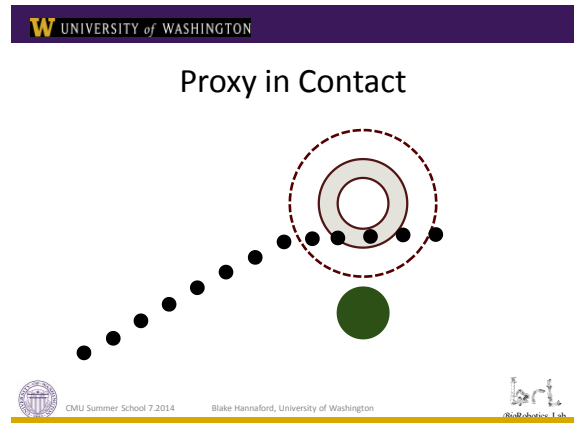
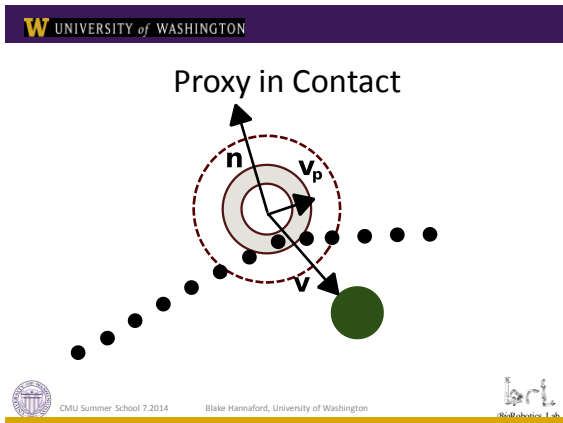
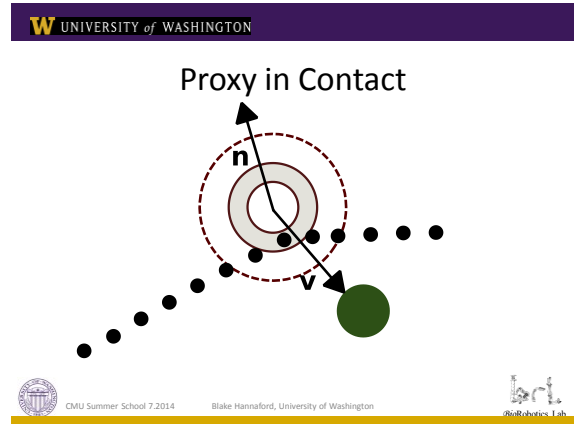
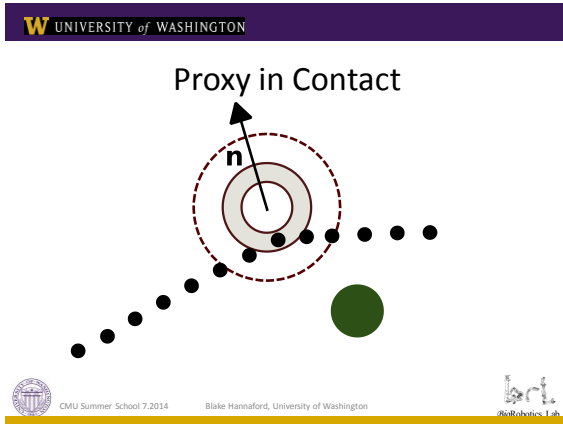
Proxy in Contact



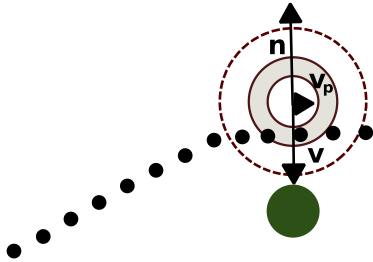
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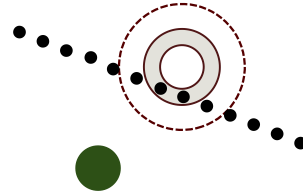


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Entrenched Proxy

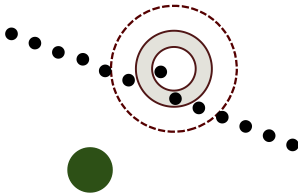


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Entrenched Proxy

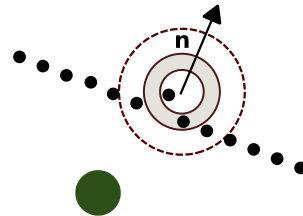


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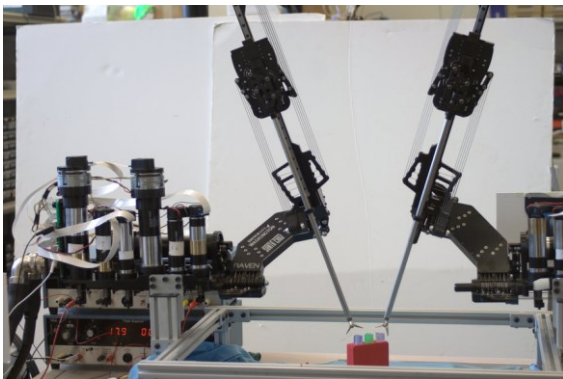


Entrenched Proxy

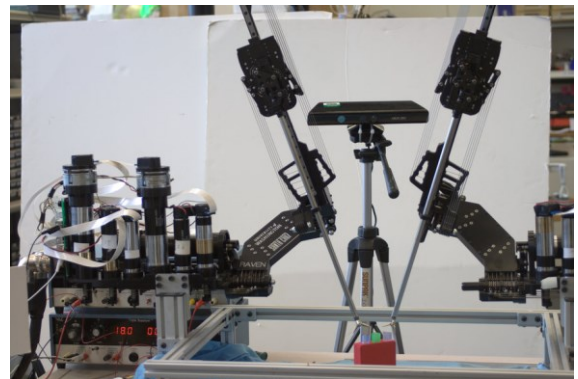


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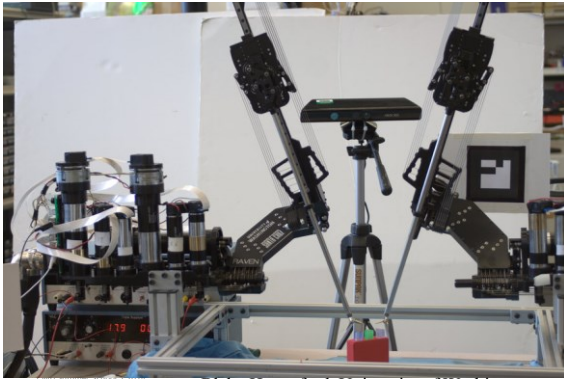
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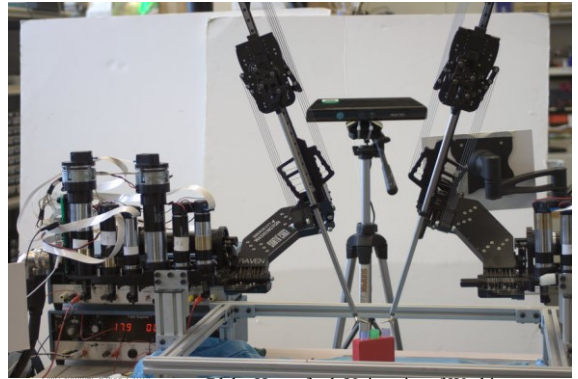
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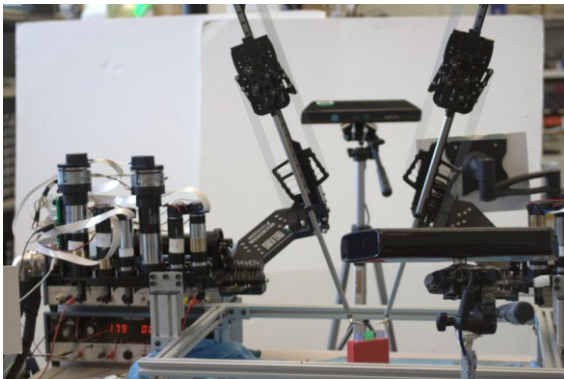
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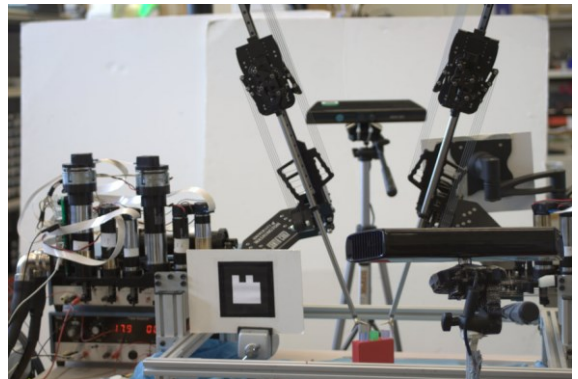
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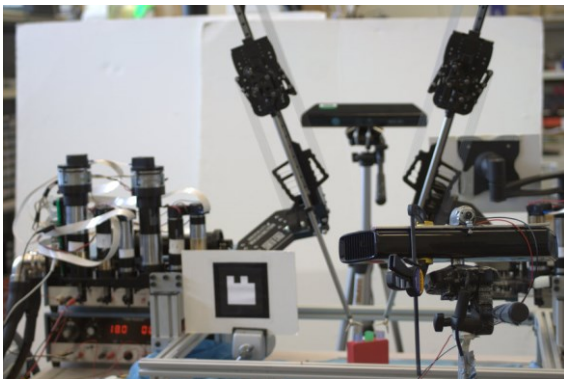
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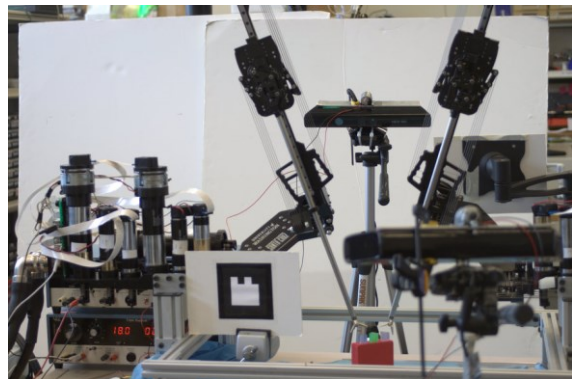
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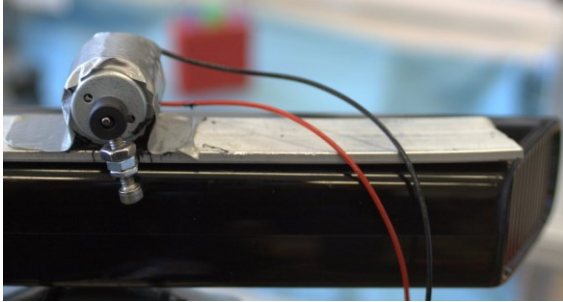
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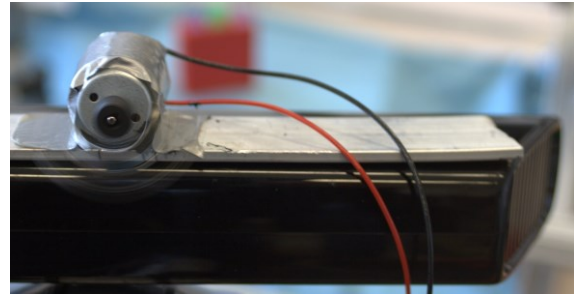


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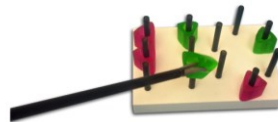
Advanced Virtual Fixtures

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FLS

- Basic curriculum from Society of American Gastrointestinal and Endoscopic Surgeons (SAGES)
- <http://www.flsprogram.org>
- Block Transfer:
- [RPI Video of Block transfer Task](#)



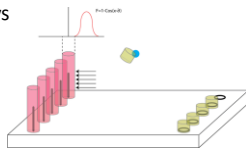
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•“Virtual Fixtures”

–Tactile Perceptual Overlays

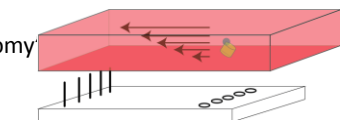


•“Mixed Autonomy

–Automation



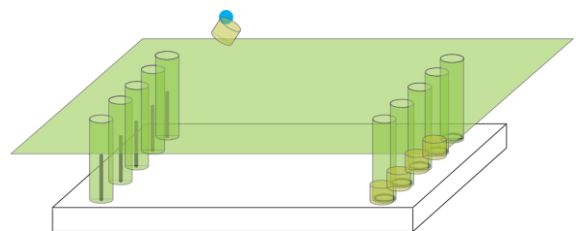
of sub-tasks



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Putting Green VF



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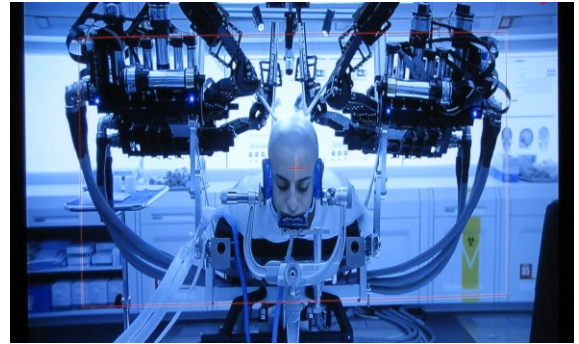


Ender's Game



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