RAVEN II – QUT Training Visit System and Community Intro

Andrew Lewis - Roboticist

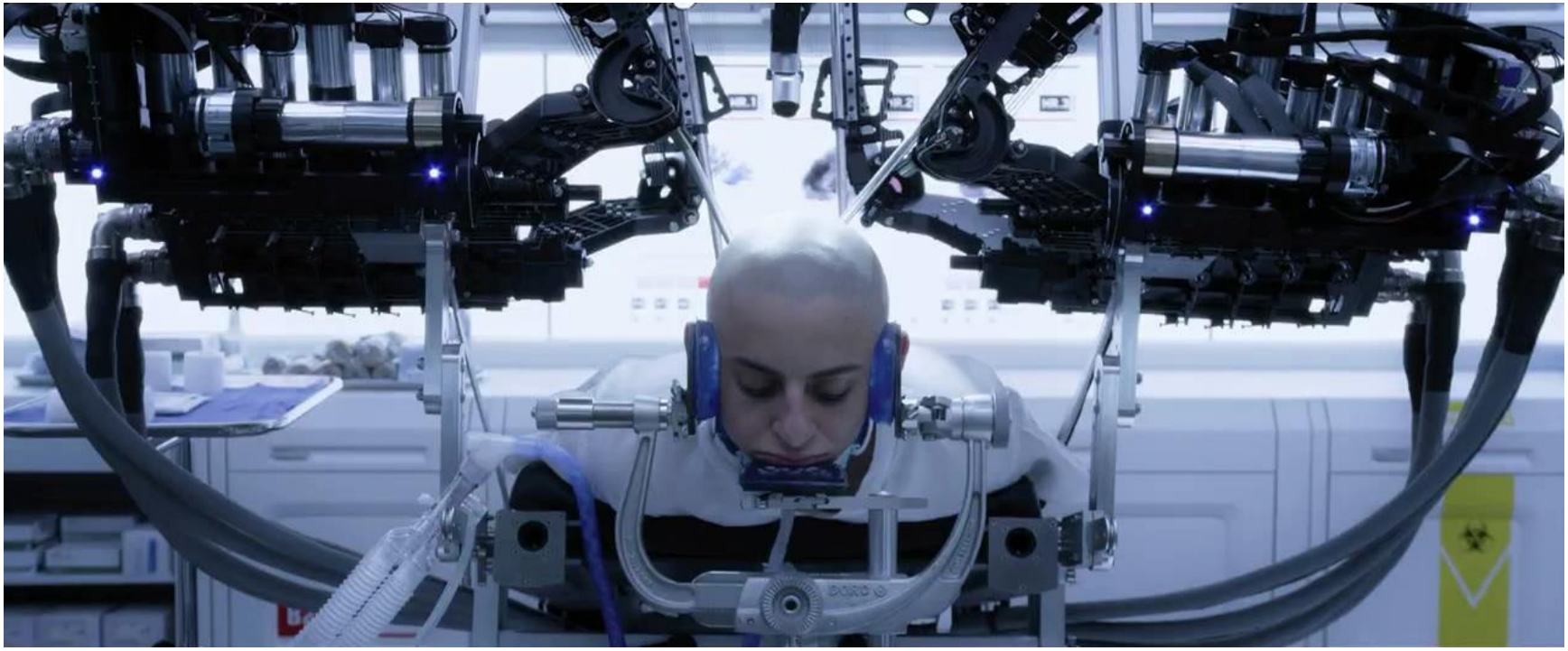
Training Schedule

- Intro Presentation (this)
- Practical practice
  - Important code areas
  - Robot startup
  - Teleoperation practice
- Homework/hackathon
- Maintenance
  - Cable replacement

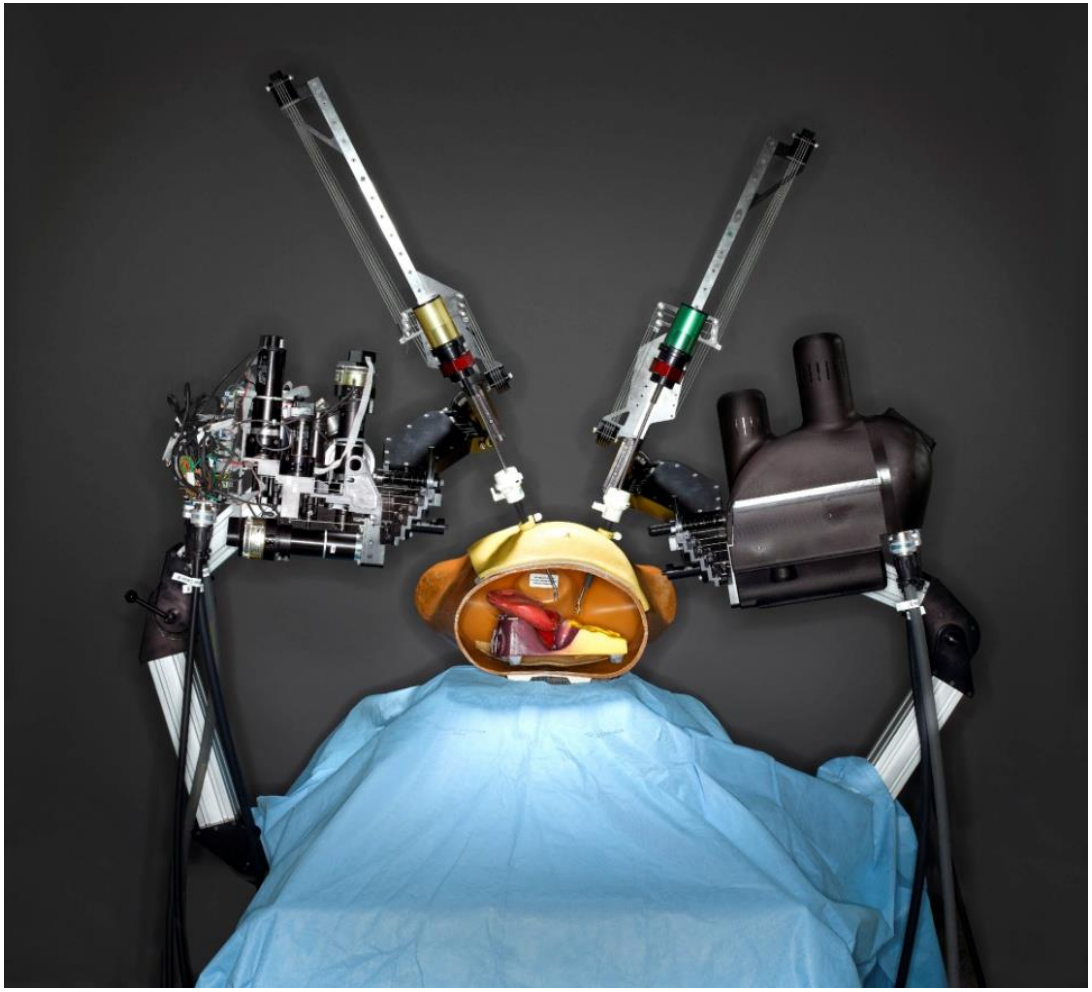
Presentation Topics

- RAVEN History
- The RAVEN II
  - System
  - Community Research
- Applied Dexterity
  - Background
  - Research Interests
- RAVENs Future
- RAVEN resources

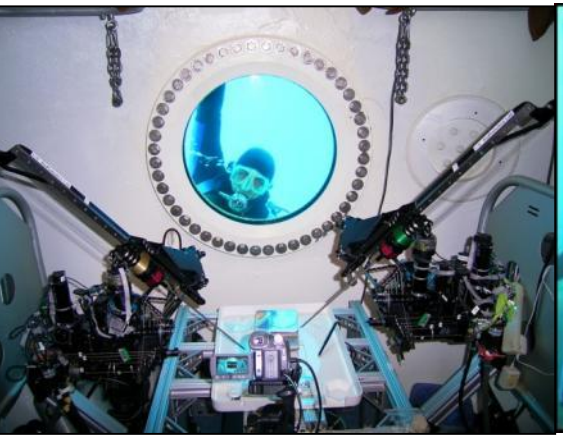
The Future



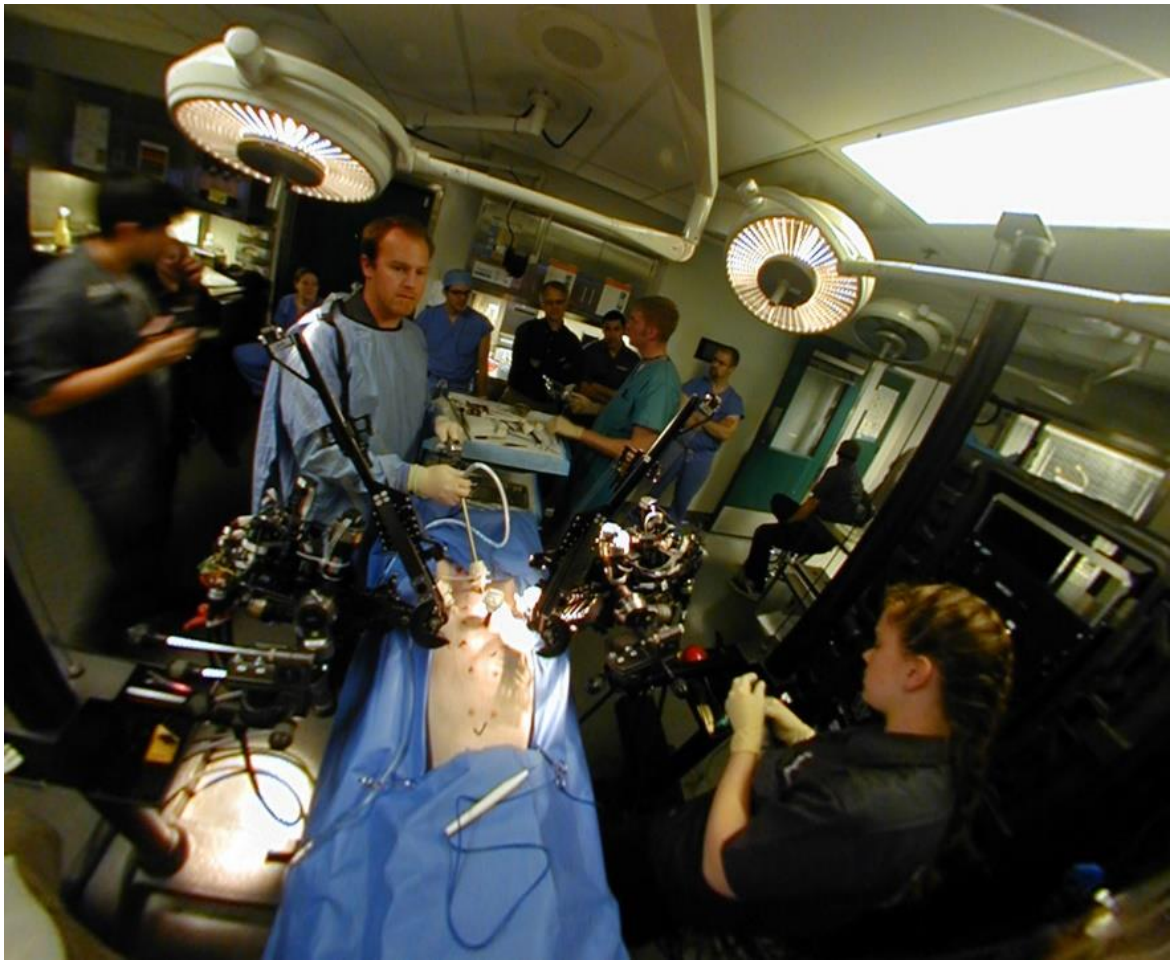
RAVEN I (2005)



Harsh and Remote Environments



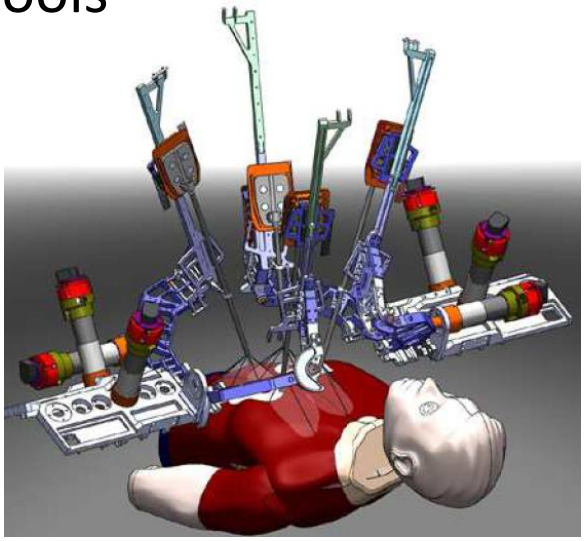
Porcine Cholecystectomy



RAVEN II Upgrades

RAVEN

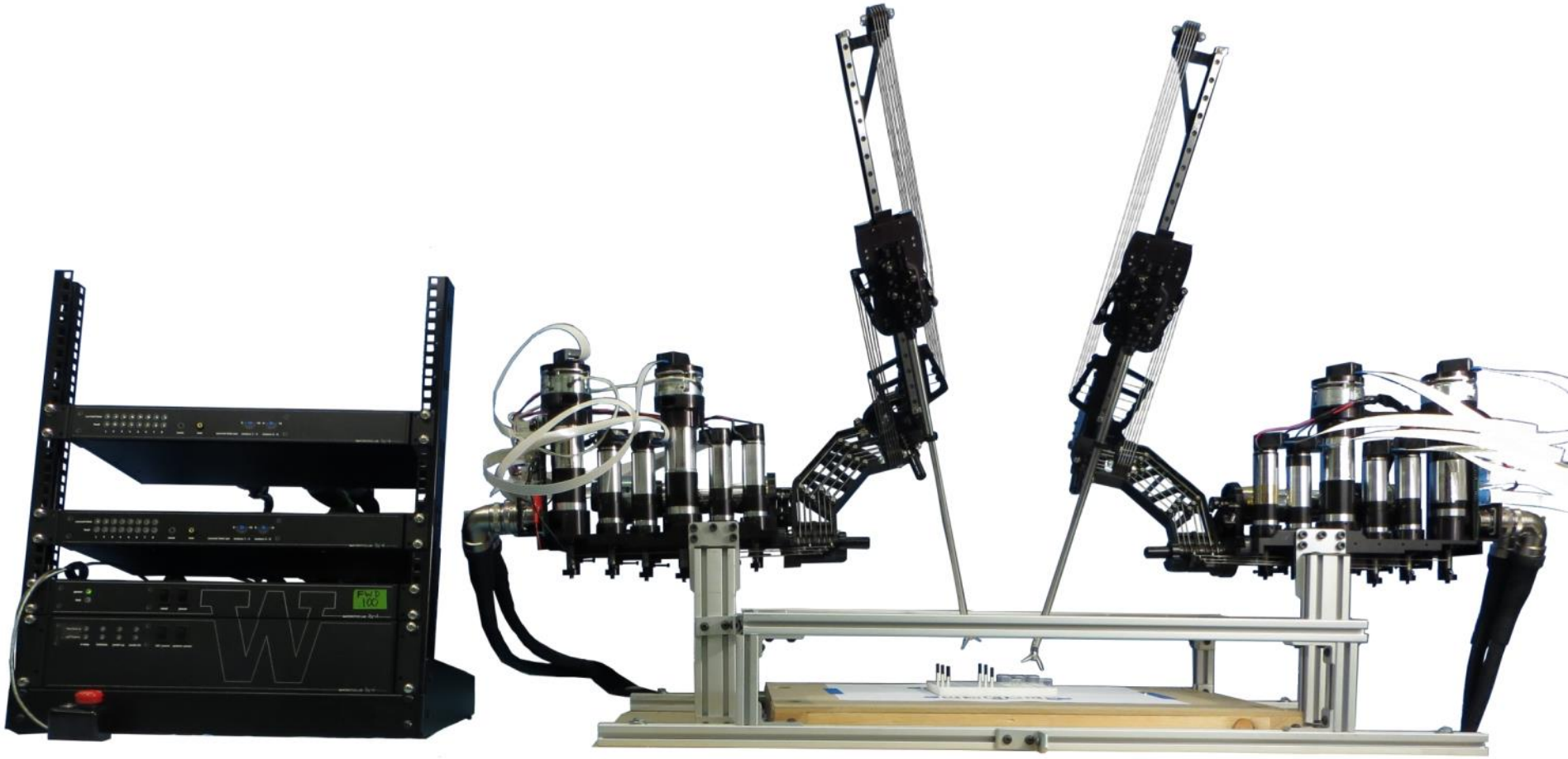
- Link angles and base optimized for 2 arms
- Link mass: 4.6 kg
- 5 DoF tools



RAVEN II

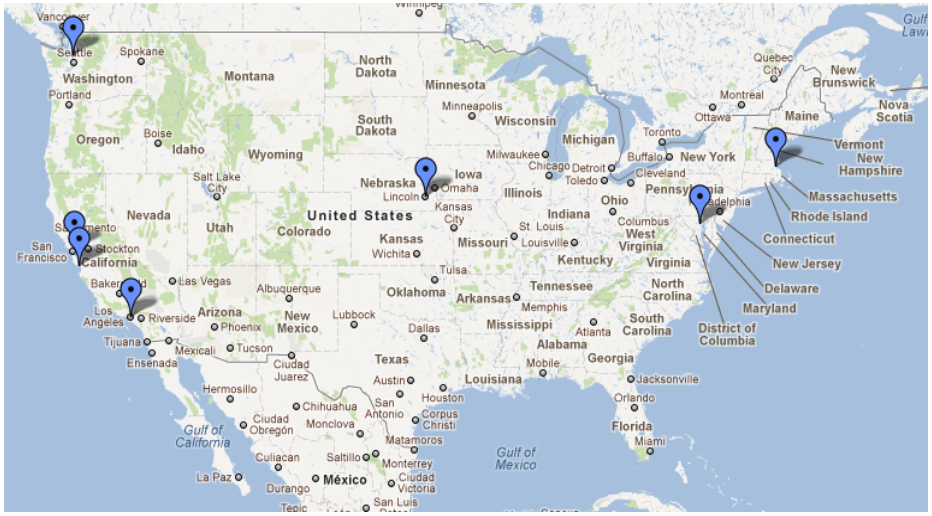
- Link angles and base optimized for 4 arms
- Link mass: 2 kg
- 6 DoF Tools
- Compatible with da Vinci Instruments using Adapter.
- Simplified cable routing
- Electronics improved for reliability, compactness and performance

RAVEN II (2011)

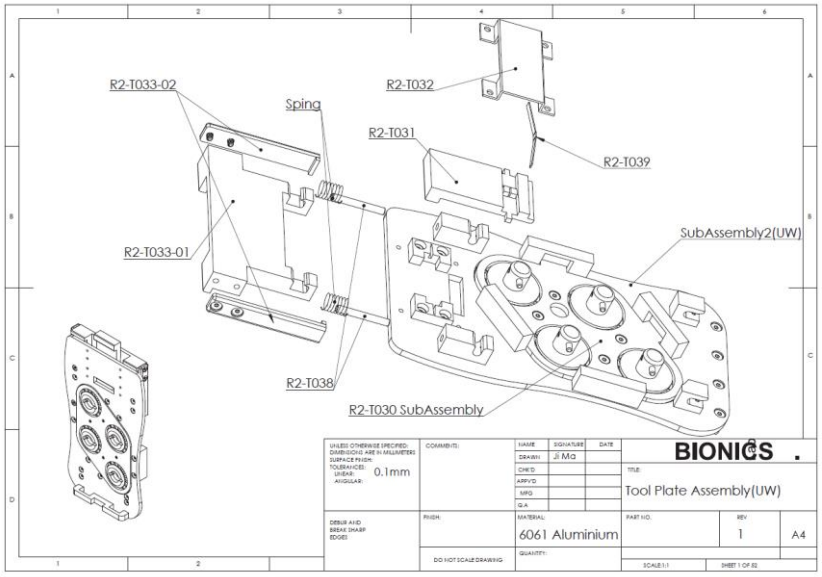


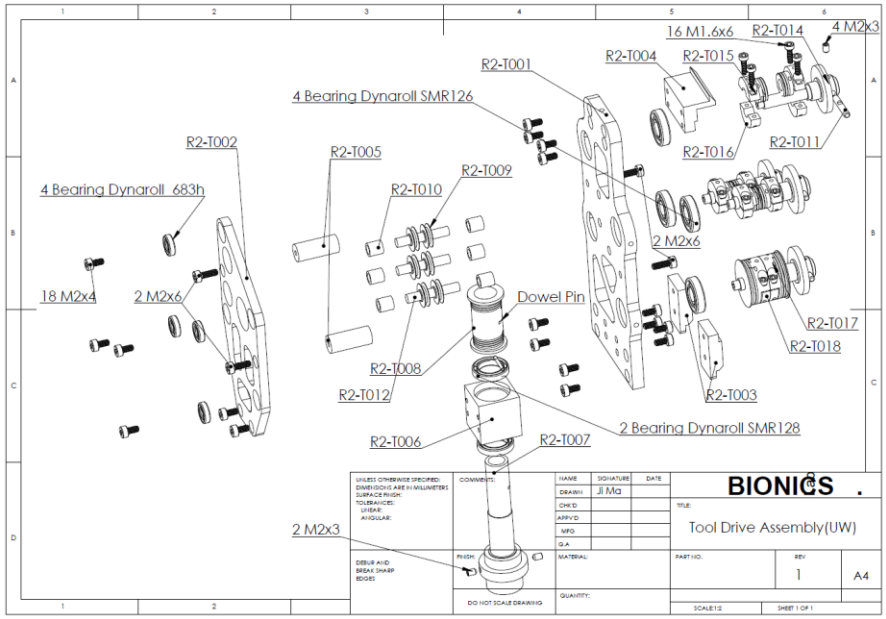
Shared Research Platform

- A common platform
  - Community Support
  - Shared developments
  - Replication and extension of results

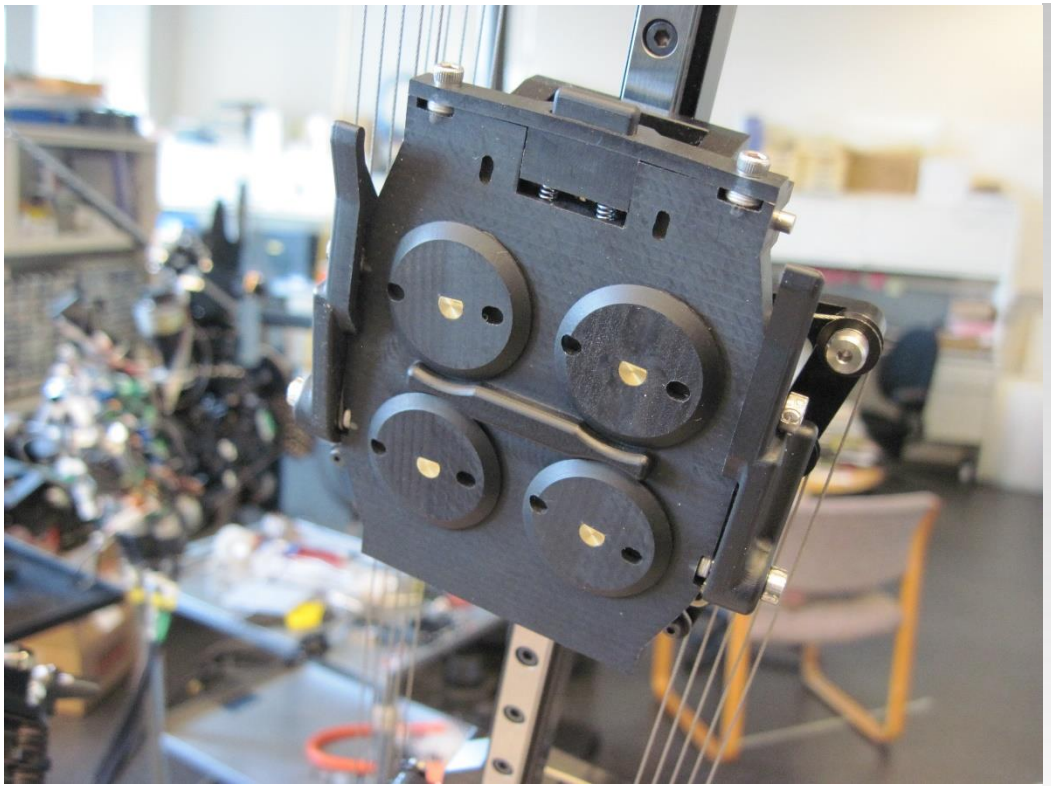


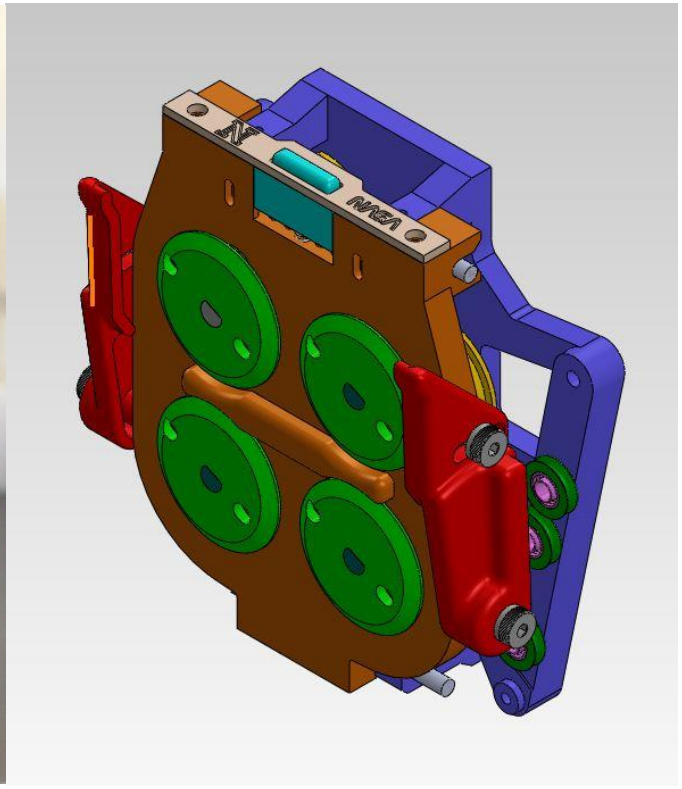
Open Interfaces





dV Si adapter



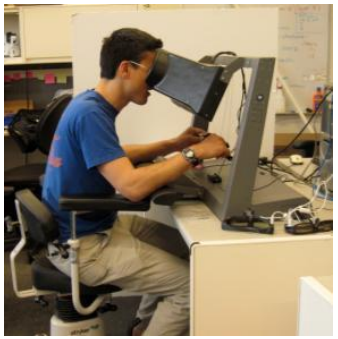
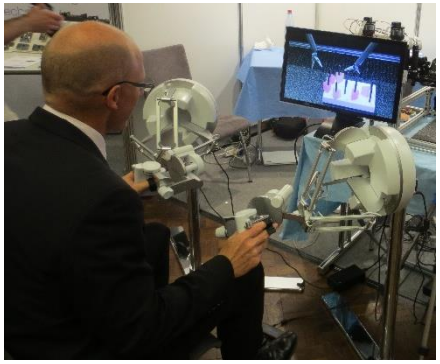


Control Electronics

- Motor controllers with custom USB 2.0 interface board
  - Up to 8 channels analog I/O
  - 8 encoder interfaces
  - Available digital I/O
- Linux control computer with ROS and RT Kernel @ 1000Hz
- 48v Power supply with safety PLC + E-Stop

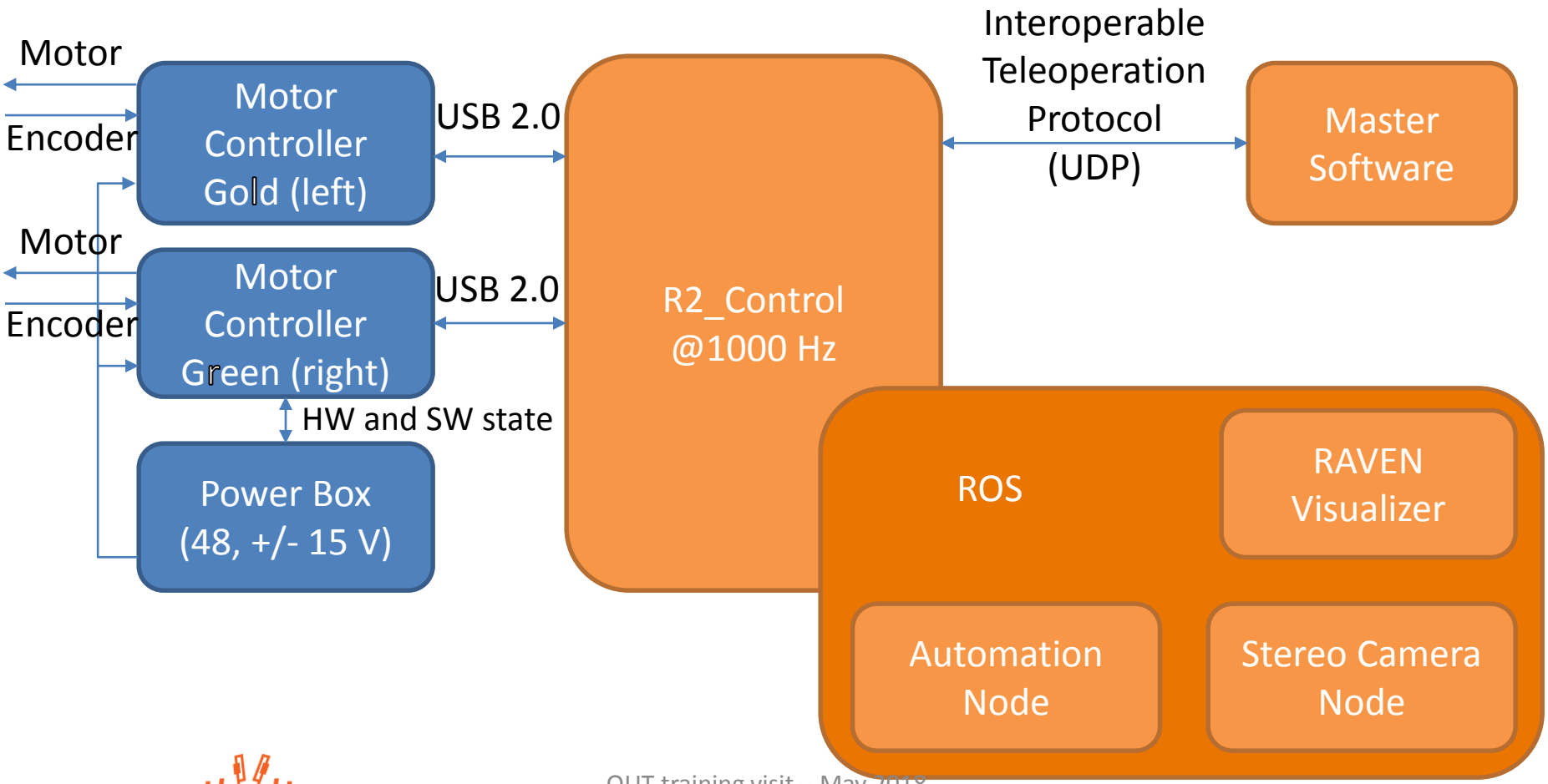
Master Interfaces

- ROS messages
  - Keyboard
  - Autonomous agents
- Interoperable Teleop Protocol (UDP)
  - Plugfest 2009: 28 unique connections
- Human Interface devices
  - Phantom Omni (6 DOF)
  - Force Dimension (7 DoF)
  - Mimic Mantis Duo (7 DOF)
  - Entact W5D (6 DoF)
  - Surgical Cockpit (28 DOF)

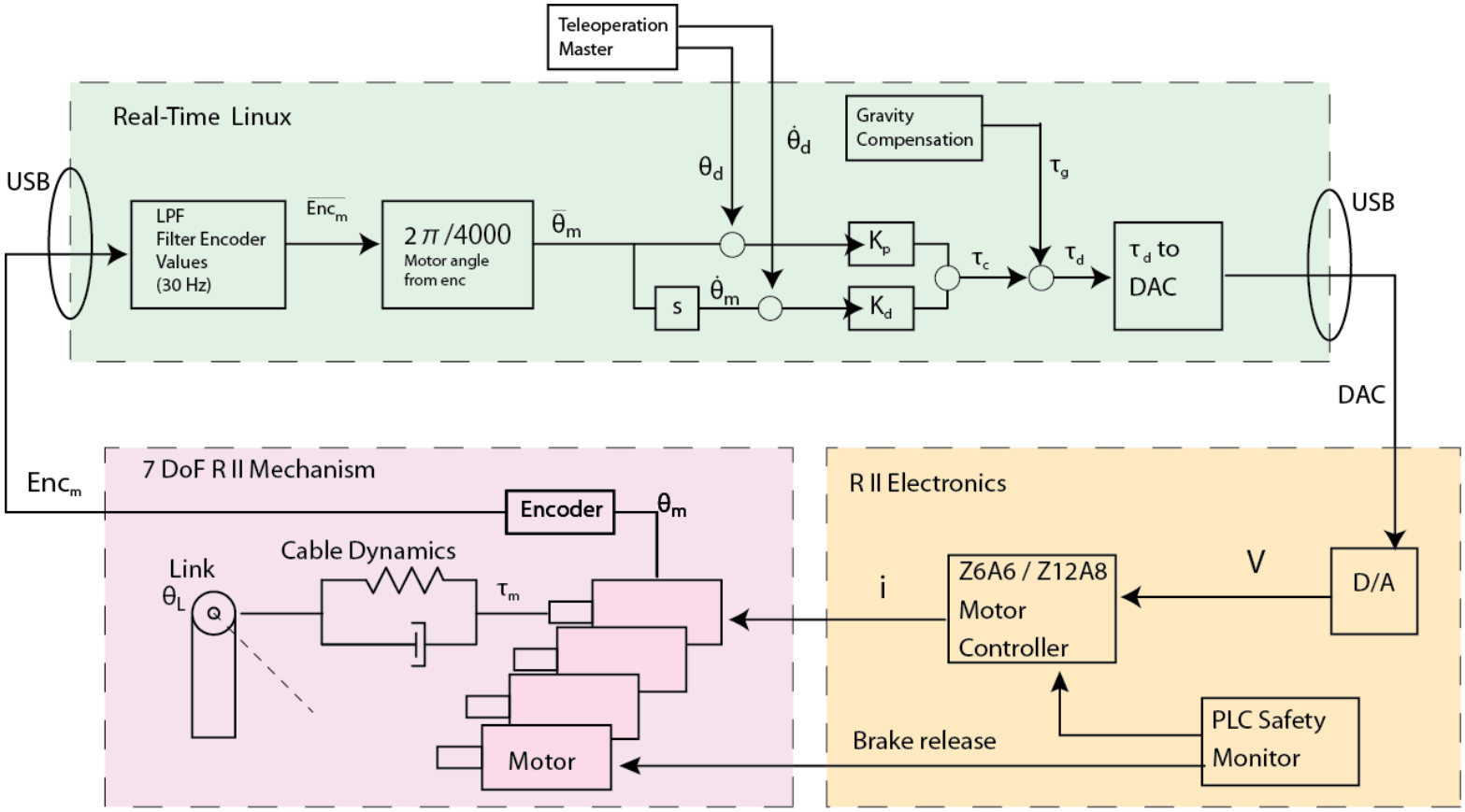





Master Interfaces

Slave Diagram

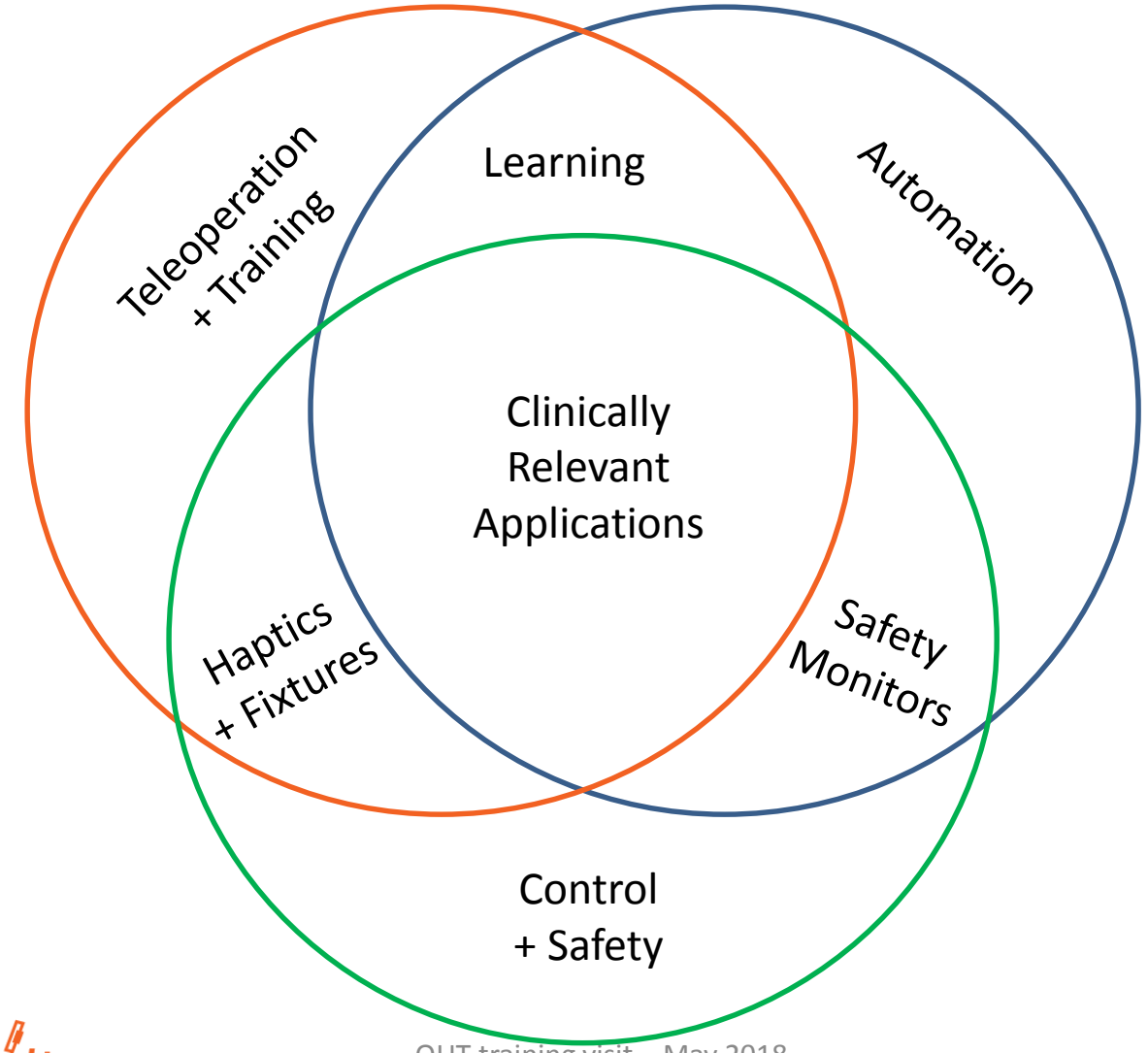


RAVEN II Control



Globally Diverse Research Community

RAVEN Research



RAVEN Research at the UW BRL
Profs Hannaford and Chizeck

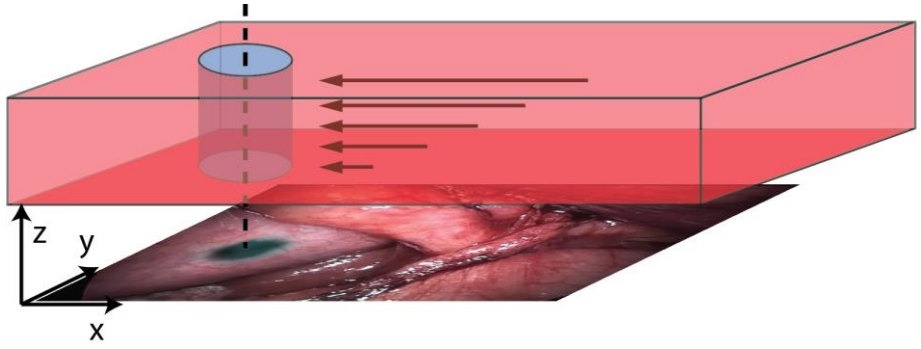
- **Assisted Autonomy**
- Dynamic Model
  - Unscented Kalman Filter
  - Cable Modelling
- **Virtual Fixtures with Point Clouds**
- **Autonomous tumor ablation**
- Surgical Skill Assessment
- Telerobotic security
- Community Support
- Spin-outs

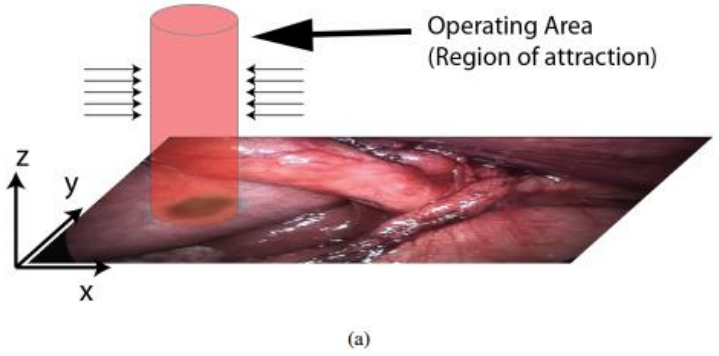
Virtual Fixtures + Tumor Resection

Dr. Sina Nia Kosari (Verb Surgical)

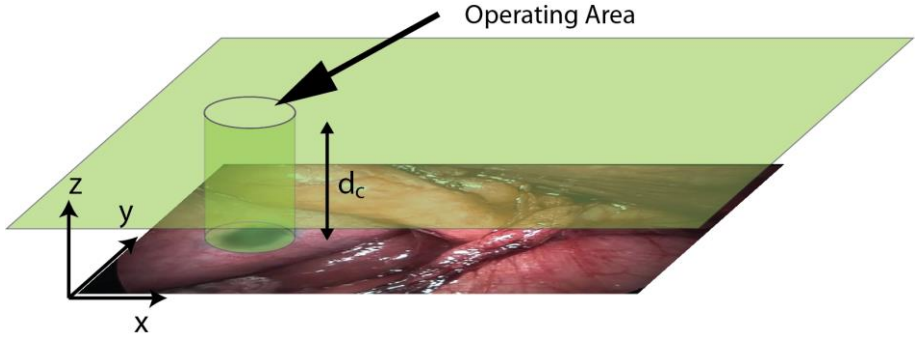
https://www.youtube.com/watch?v=3Kt_vgRmsqs&t=27s

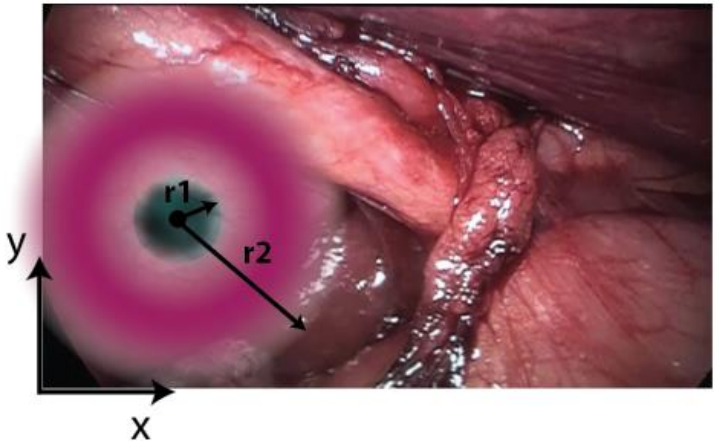
Virtual Fixtures and Assistive Autonmy





(a)



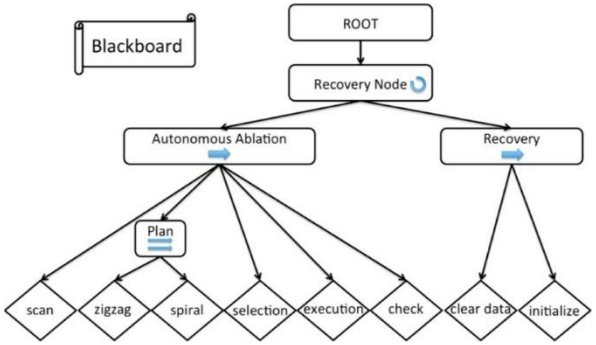


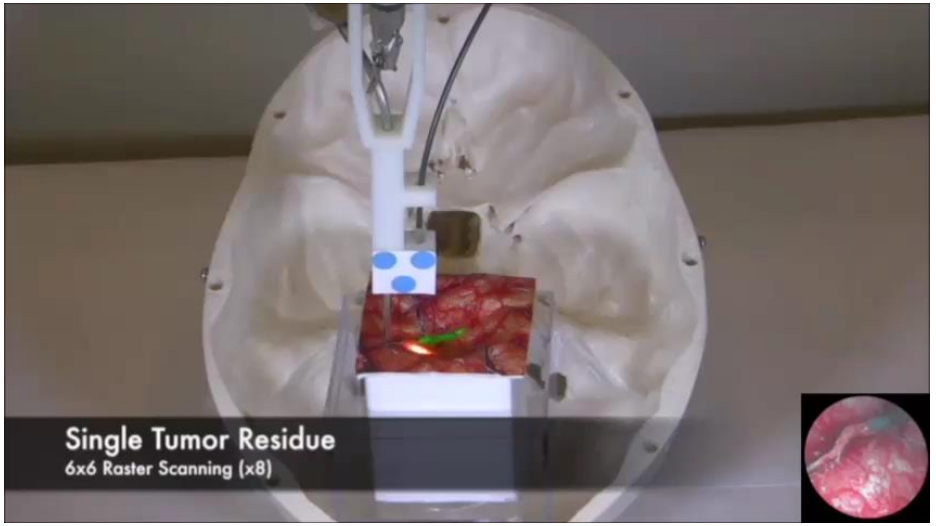
(b)

Dr. H. Hawkeye King (Sail Drone)
IROS 2014

Autonomous Tumor Ablation

- Autonomous Behavior Tree
  - Fiber Optic scanning
  - Cavity reconstruction & segmentation
  - Planning, permission
  - Execution

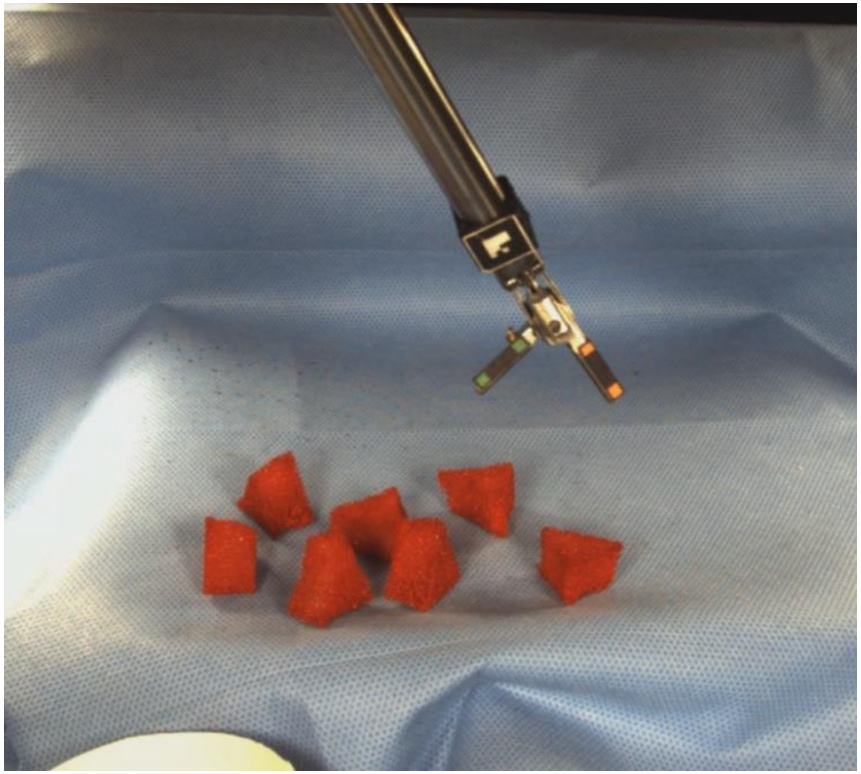


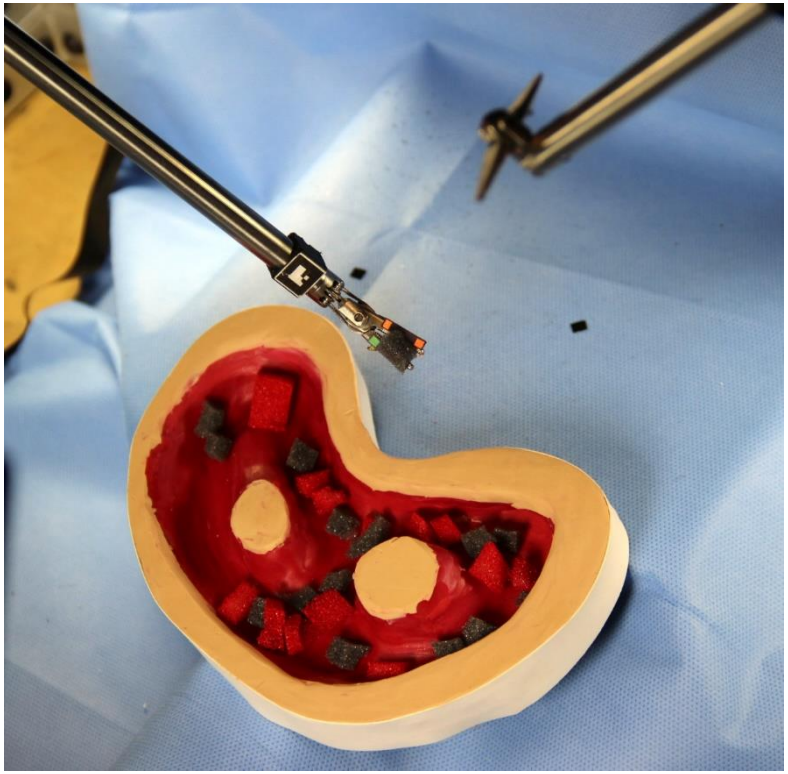


Dr Danying Hu (Magic Leap)
ICRA 2015 -- https://youtu.be/baYfDJ_mZq4

Research at UC Berkeley
Profs Goldberg and Abbeel

- Autonomous Debridement





Kehoe (iRobot) et al., ICRA 2014

Autonomous Debridement

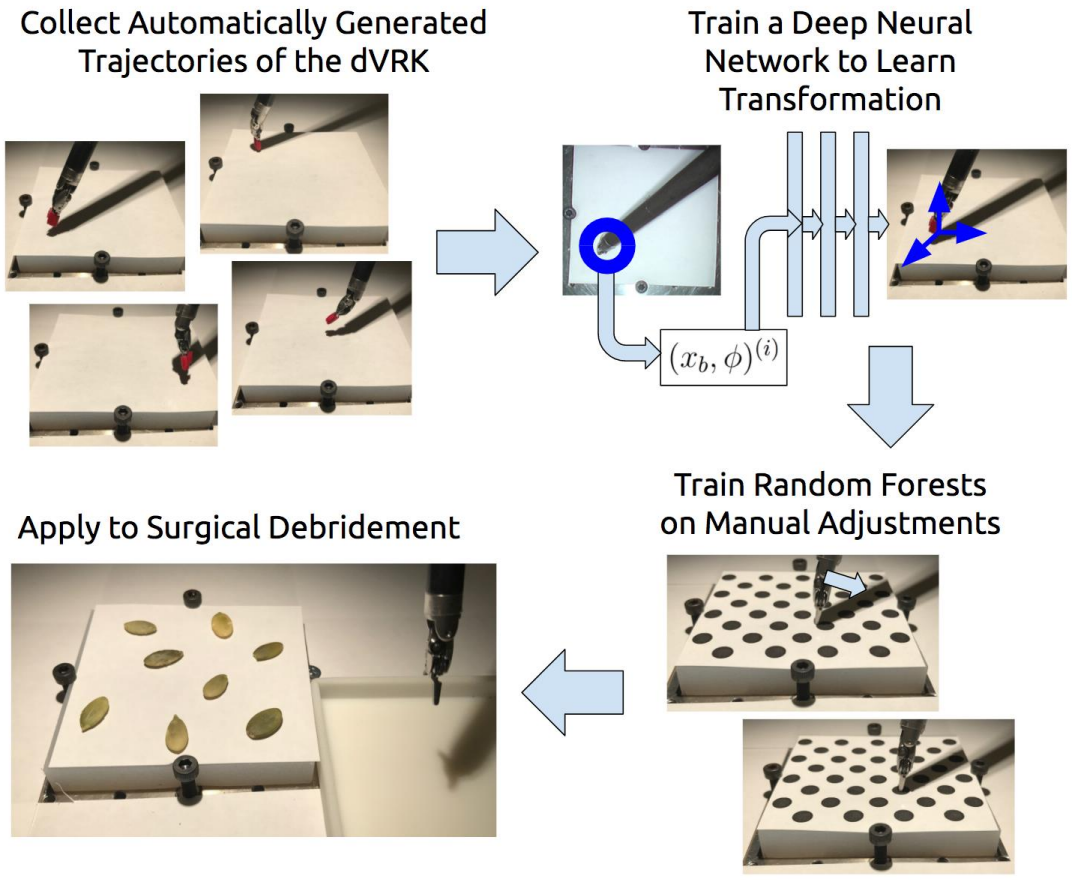
Kehoe et al., ICRA 2014

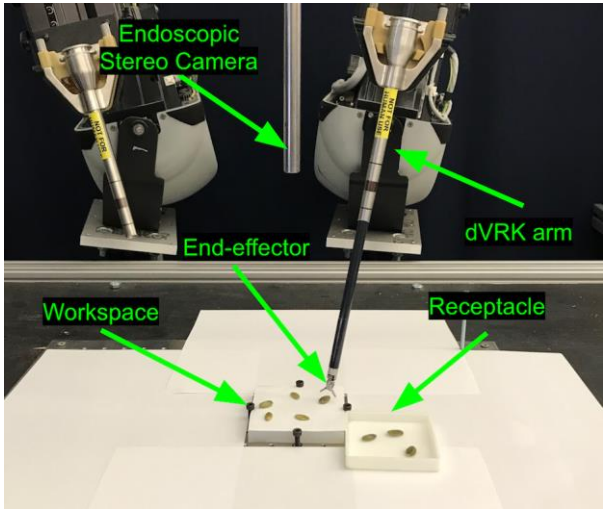
https://www.youtube.com/watch?v=fN55LywhlkU

Autonomous Surgical Subtasks

Murali, Sen, et al., ICRA 2015
https://youtu.be/beVWB6NtAaA

Autonomous Debridement cont'd



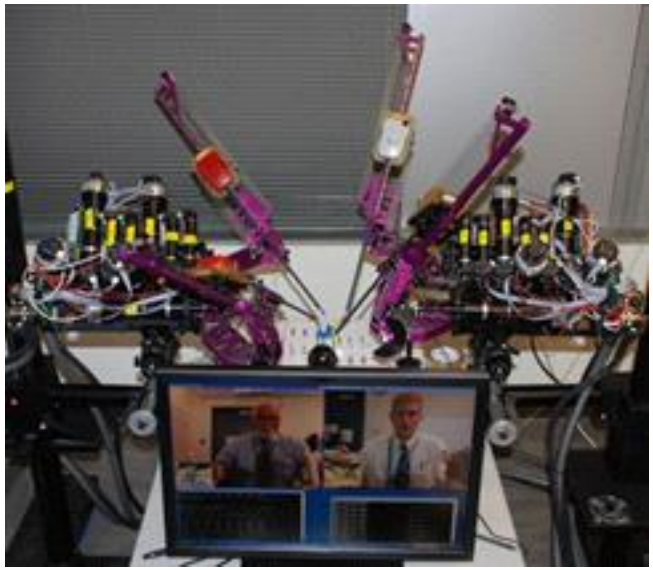


Daniel Seita et al., ICRA 2015

https://sites.google.com/view/calib-icra/

Research at UC Santa Cruz (Now UCLA) Prof Rosen

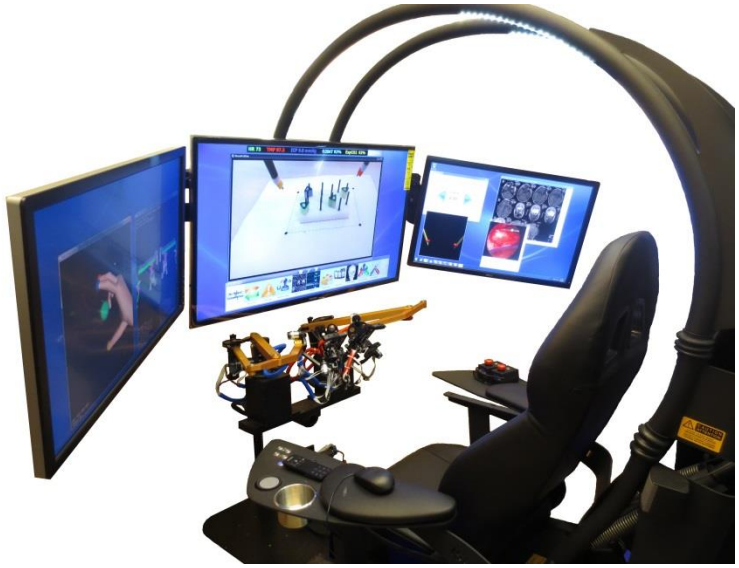
- Autonomous Block Transfer
- Collaborative Telesurgery
- Surgical Cockpit



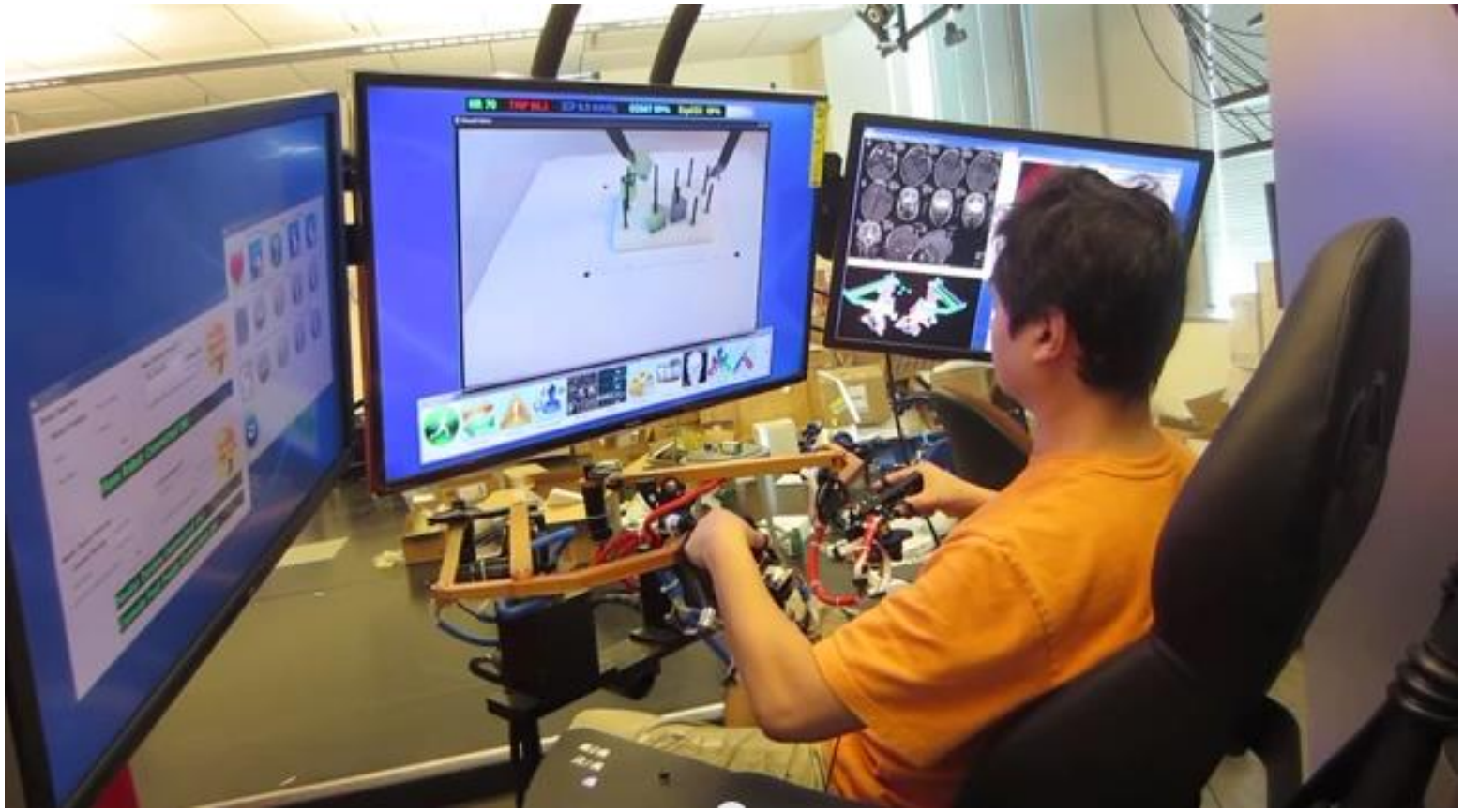
Drs Jacob Rosen and Ji MA

Surgical Cockpit details

- 24 Degrees of Freedom
  - Two 12-DOF hand + finger controls (9 haptic DOFs)
  - Suitable for rendering haptic palpation
  - 4 DOF Haptic foot pedal
- 3D primary monitor and HD peripheral displays



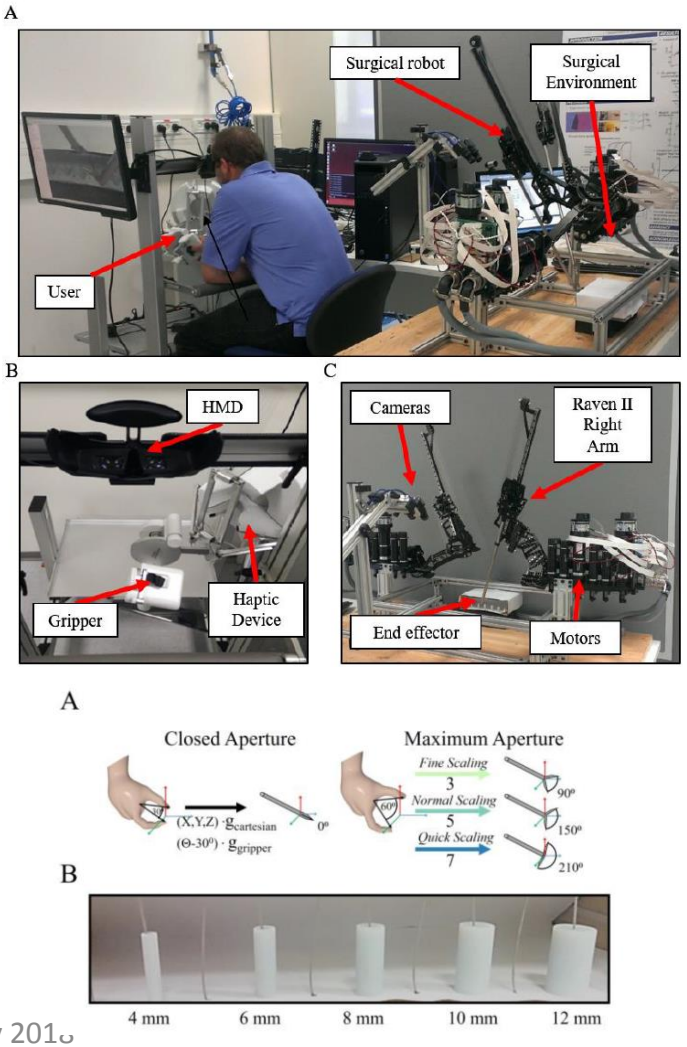
Surgical Cockpit in Action



https://youtu.be/Wn1IZV398UM

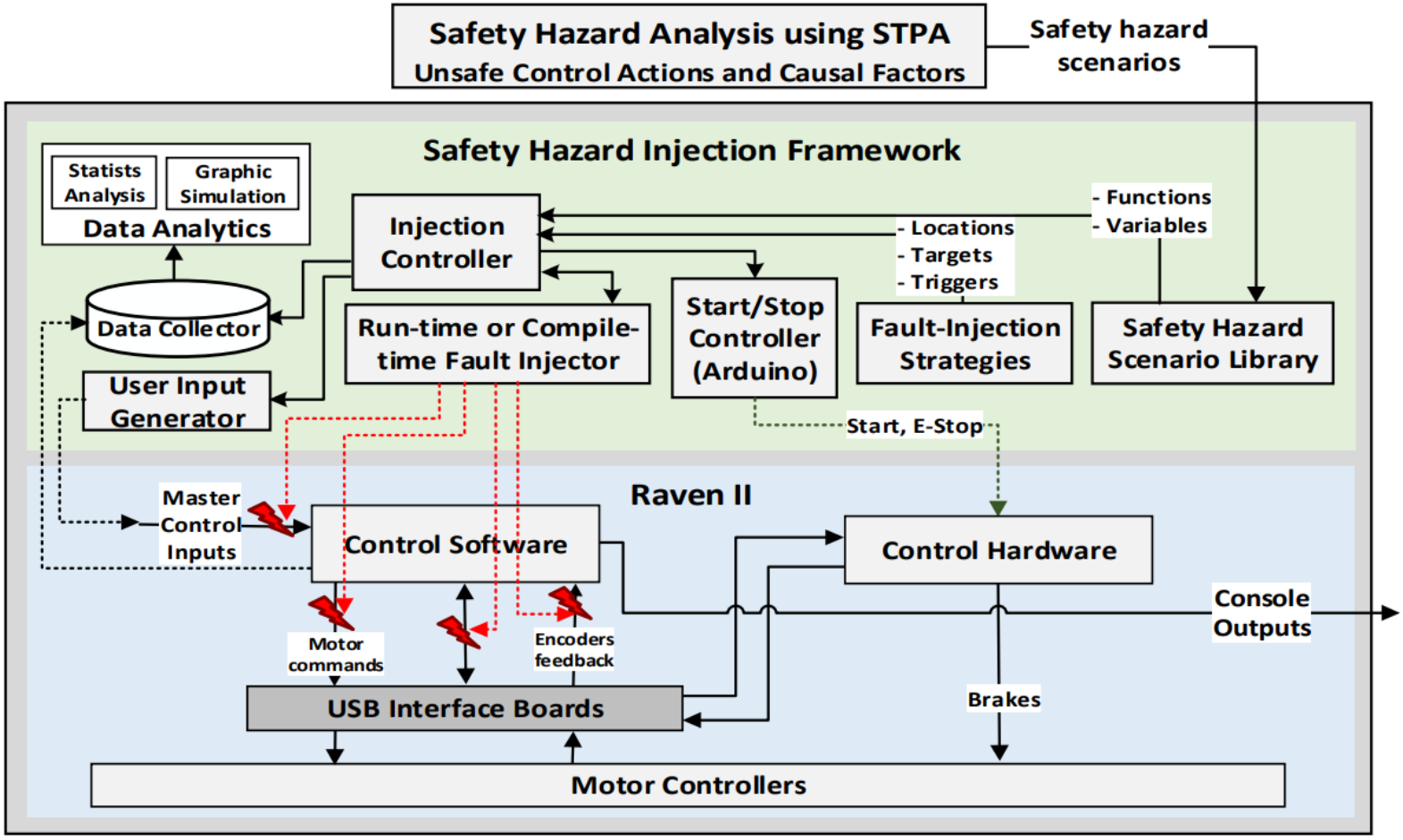
Ben Gurion University
Prof Nisky

- Grasping Pyschophysics
- Human-centered
  - Transparency
    - Natural action
    - Perception
- Transparent except fine scaling



https://arxiv.org/abs/1710.05319

University of Illinois Urbana-Champaign and University of Virginia
Profs Iyer, Kesavadas and Alemzadeh



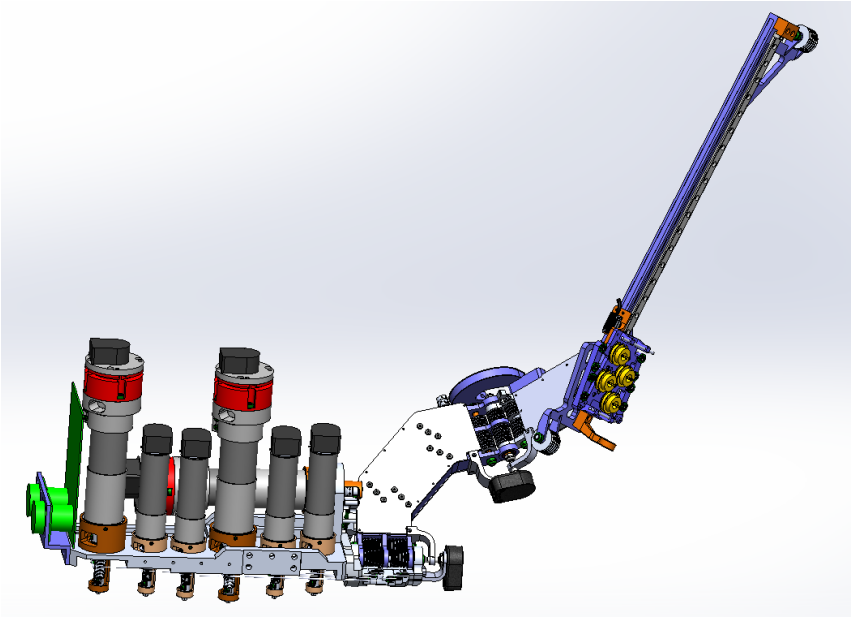
Cool Projects cont'd

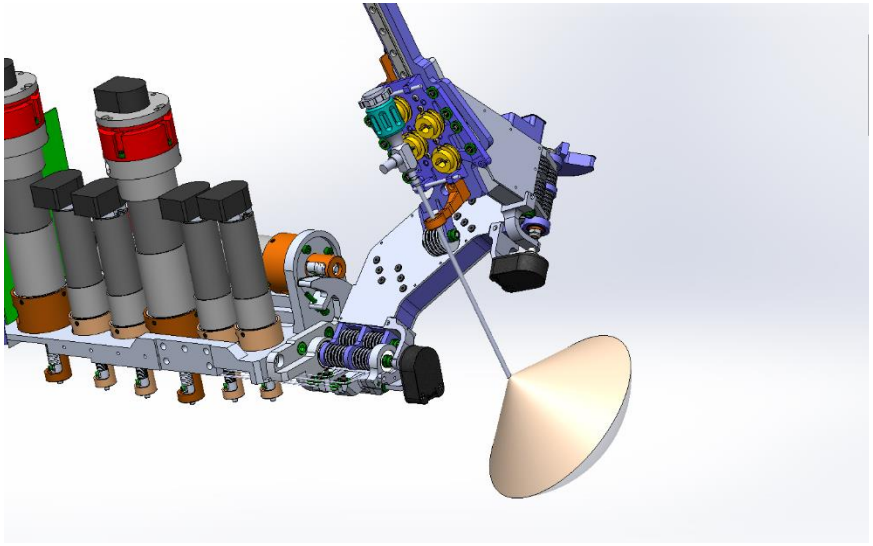
- Stanford (Prof Okamura)
  - Effects of orientation misalignment
- Imperial College London (Prof GZ Yang)
  - Novice training with expert models
  - Human-Robot collaborative framework
- Southern Denmark University (Prof Savarimuthu)
  - Software modernization

Applied Dexterity R&D

- RAVEN improvements
  - Joint encoders & Camera adapter
  - Software updates
- Experiment support
- New products & markets
  - NASA applications!
  - Others!

New RAVEN II Features





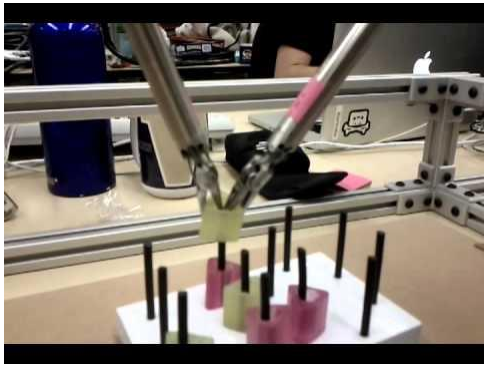
New RAVEN II Hardware

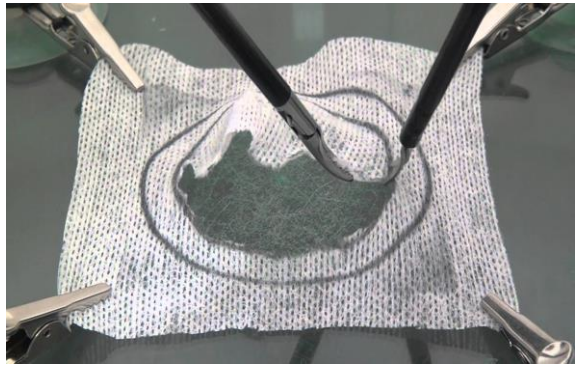
ISS Rodent Dissection

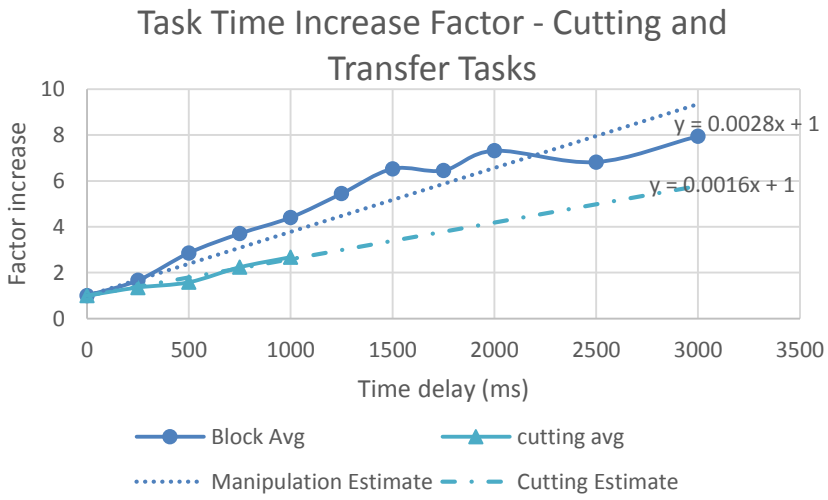
- Mouse dissection used as physiologic and pharma model on ISS
- Asked to perform feasibility studies
  - Time delay ’13
  - CONOP ‘15
  - JSC Demo ’16
- Proposed RAVEN as an ISS resource ‘17
  - Plant pathology
  - Lab work / automation

Extreme Time Delay (prelim)

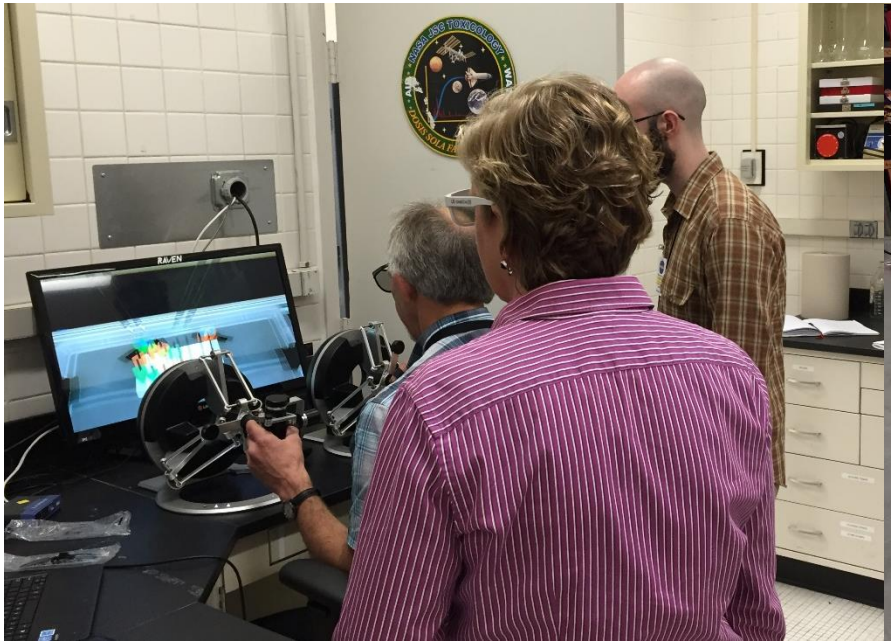
- Characterize time increase of complicated tasks
- Up to 3 seconds(RT)
- FLS block transfer and circle cutting
- 1 subject, 165 trials
- Factor = time(x sec) / time (0 sec)

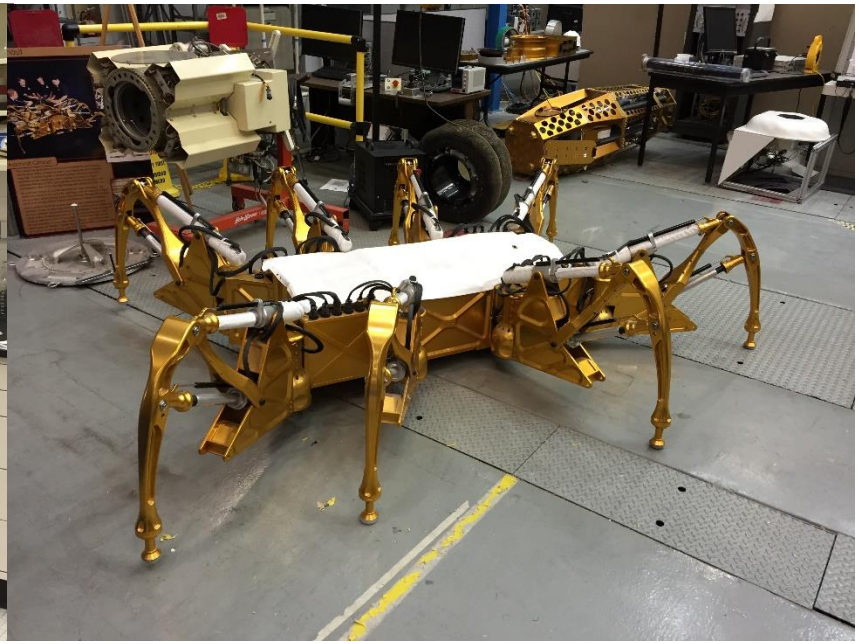






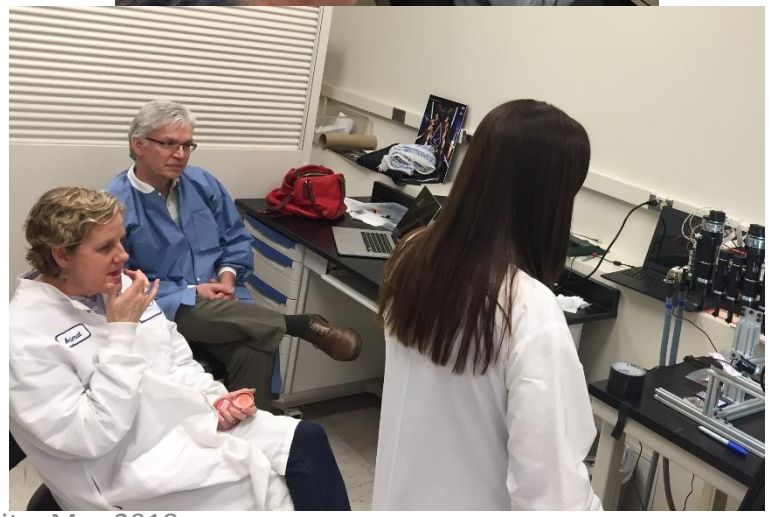
Johnson Space Center Visit





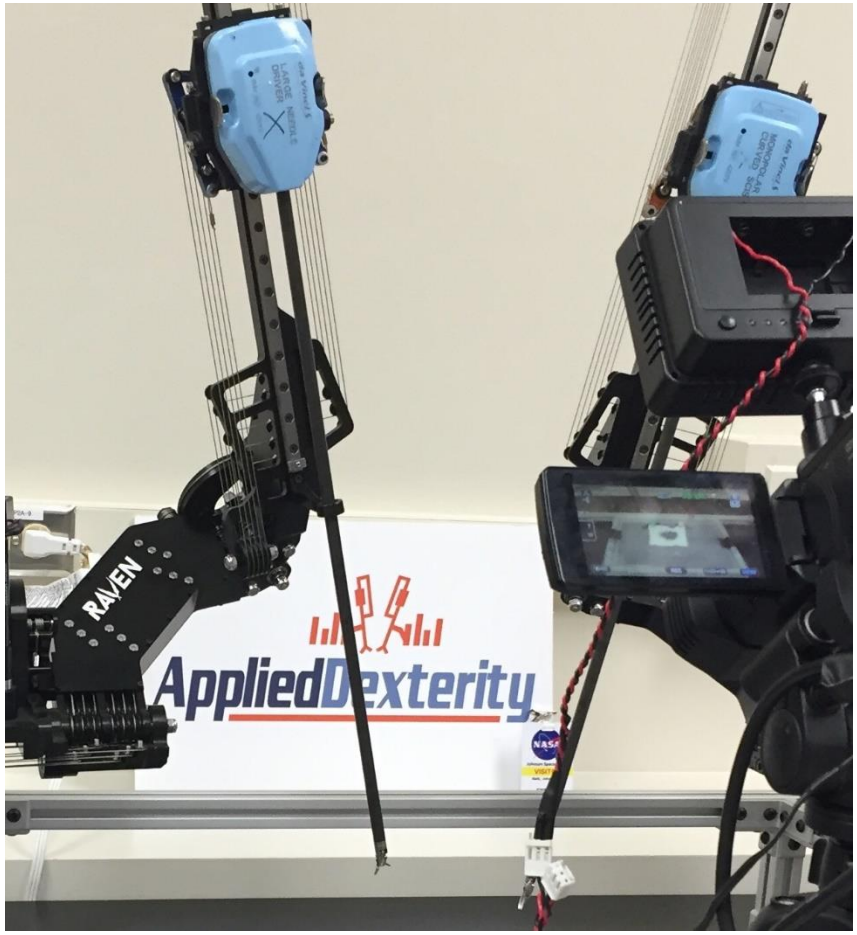
JSC Experiments

- CONOP validation
  1. Opened abdomen
  2. Spleen
  3. Liver
  4. Kidneys
  5. Both hind limbs, skinned and removed
- Feasibility
  1. Eyes
  2. Brain



JSC Results

1. Created a CONOP accounting for engineering issues of:
   - Loss of Signal (LOS)
   - Communications Time Delay.
2. Demonstrated sequential dissections using current RAVEN hardware and simulated time delay.
3. Trained NASA personnel to use RAVEN for rodent research dissection procedures.
4. 10 Astronauts provided feedback
   - Hands on demonstration and group discussion
   - They loved it.



NSF CPS Grant

- Proposed large project to get RAVEN to ISS
- Team of academic and industry experts
- Provide a highly capable robotic platform for Earth and Space
  - Bio, Pharma, Robotic, CPS research
  - Teleoperated or Autonomous

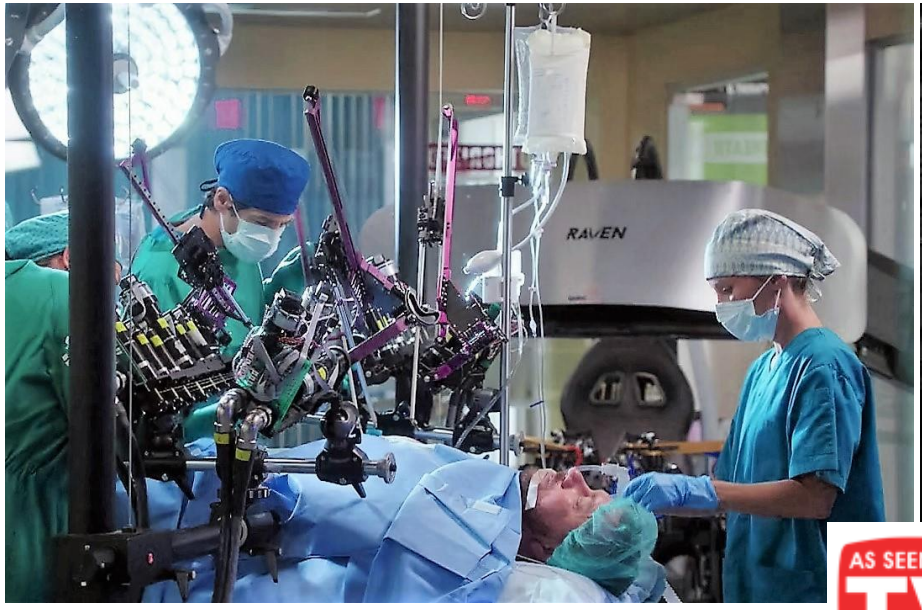
Future Directions for the RAVEN community

- Interoperability with DVRK
  - Improved software management and community integration
- Improved accuracy & control
- Collaborative autonomous agents
- Dynamic simulation
  - Full software simulation available soon – no hardware req'd
  - Gazebo as part of RAVEN/DVRK efforts

Software and Documentation Resources

- Github Repository
- Doxygen Documentation
- Users Guide Doc
- YouTube Tutorial Playlist
- Wiki + forum
- Kinematics Tech Report
- RAVEN PI and Users list – ask for add
- UW BRL RAVEN code group
  - brl_raven_code (at) googlegroups {dot} com
- Andrew at Applied Dexterity

Questions?



AS SEEN ON TV

Thanks for your time!