Customizing Semi-Autonomous Nursing Robots using Human Expertise

IML Intelligent Motion Lab — ILLINOIS

Duke University School of Nursing

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Summary

- Collaborative project between UIUC Engineering (Hauser) and Duke School of Nursing (Shaw) to develop trainable supervisory control interfaces for tele-nursing robots
- Direct applications: nursing in quarantine areas; infectious diseases, immunocompromised patients
- UIUC: fabricating the TRINA 2.0 hardware platform, devising semi-autonomous primitive tasks, and trainable UIs
- Duke: user studies with RNs (experts) customizing the UI for nursing students (novices) in nursing tasks

Prior work

Tele-Robotic Intelligent Nursing Assistant (TRINA)
- Developed with NSF RAPID funding in response to 2014 Ebola outbreak [1]

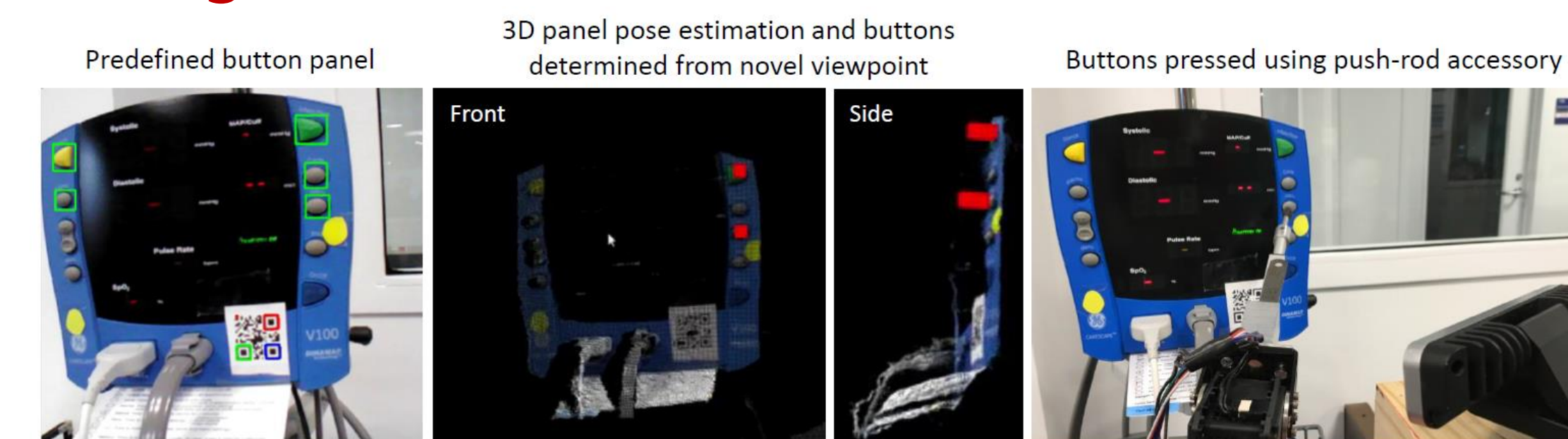*Direct teleoperation:* 19/26 nursing tasks feasible, but 50-200x slower than human nurse

Automated: Personnel Protective Equipment (PPE) donning and doffing via PbD [2]

Project Vision

Primitive tasks

Navigation, picking, placing, button pressing, wiping [3], unscrewing [3], auscultation [4]

Predefined button panel — 3D panel pose estimation and buttons determined from novel viewpoint — Buttons pressed using push-rod accessory
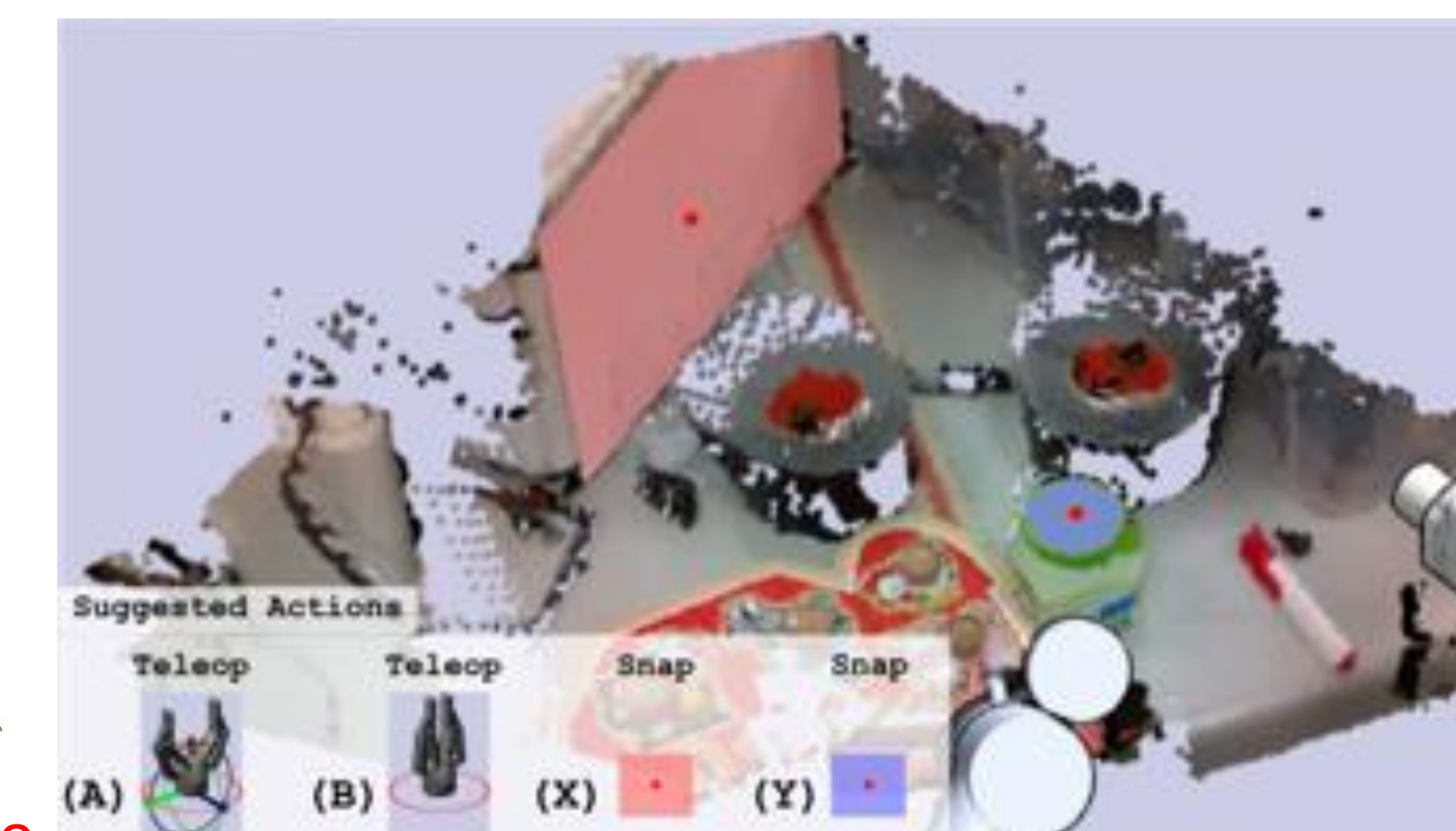
This year: improving pick and place reliability, articulated object manipulation, wiping => Intelligent UI, testing w/ RNs at Duke

Anatomical model / auscultation locations registered to patient scan
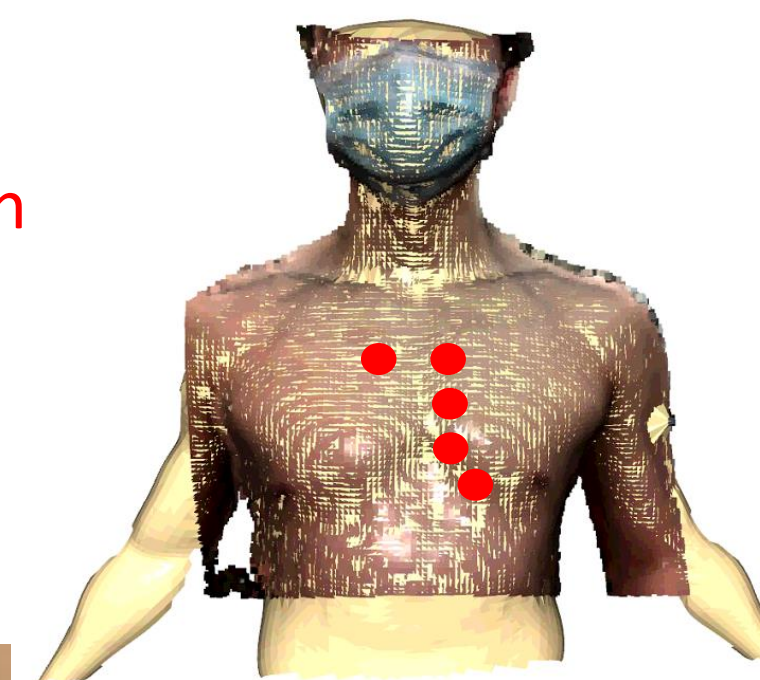
Bayesian optimization to adjust sensing locations to identify high-quality sounds [4]
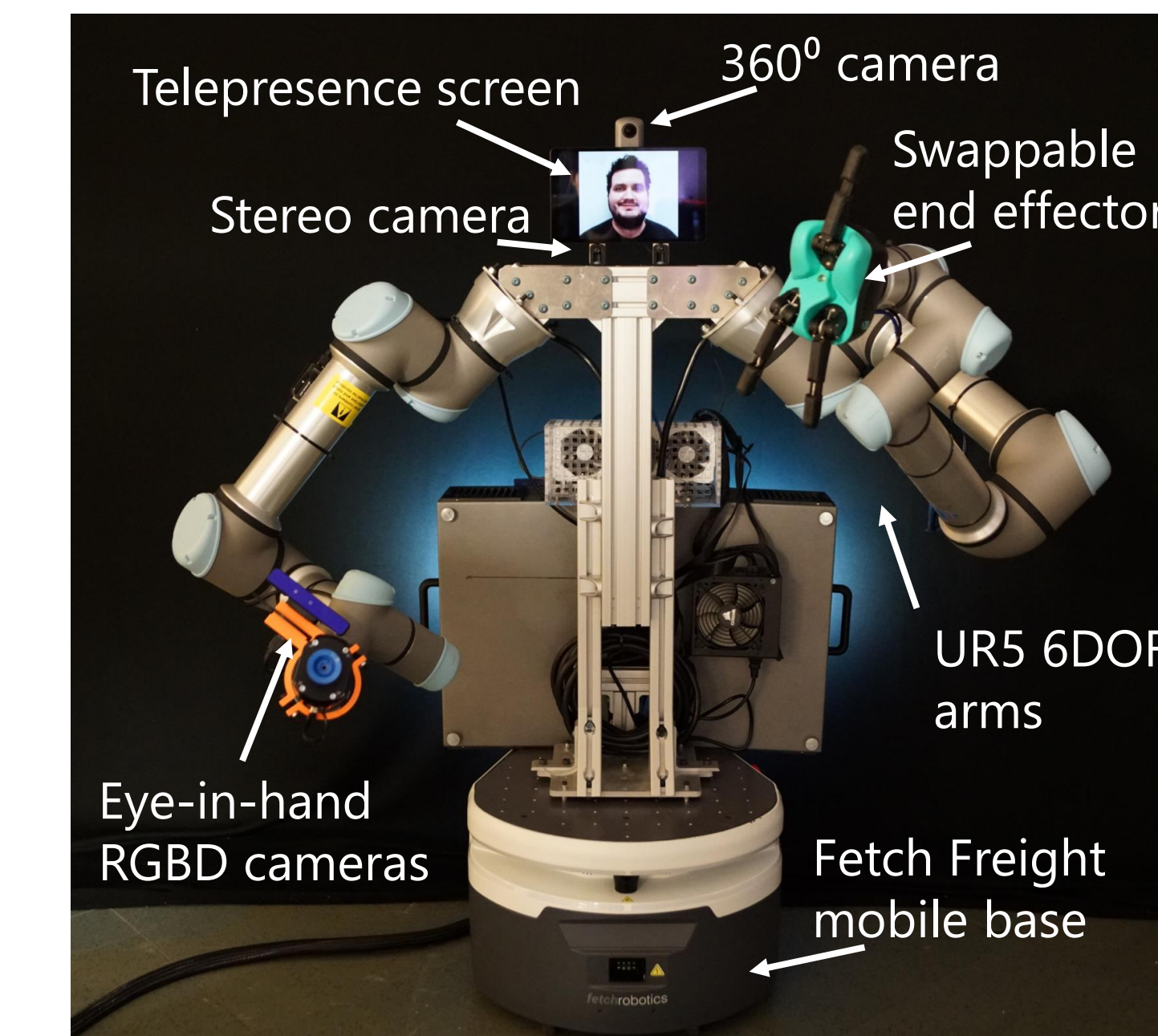
Intelligent UIs: predict k-most likely actions from expert teleoperator demonstrations
Open-world perception: variable action parameter domains
>90% accuracy in erasing, unscrewing, pick and place

Technical Challenges

- Design and fabrication of TRINA 2.0
- Implementation of reliable (95%) autonomous primitives
- Human-interpretable database of objects, locations, poses, motions
- Hierarchical task customization involving conditions, loops
- Contextual, most-likely task inference
- Implementation and testing on mobile GUI

Current progress

Telepresence screen — 360⁰ camera — Stereo camera — Swappable end effectors — Eye-in-hand RGBD cameras — UR5 6DOF arms — Fetch Freight mobile base

TRINA 2.0 complete. Sensors, 2D and 3D SLAM, VR input

2022 thrust
Testing Intelligent UI
Usability refinement
ANA Avatar XPRIZE finals

Synergistic relation with ANA AVATAR XPrize

UIUC TRINA group at XPRIZE Semifinals

References

[1] Z. Li, P. Moran, C. Dong, R. Shaw, and K. Hauser. *Development of a Tele-Nursing Mobile Manipulator for Remote Care-giving in Quarantine Areas*. ICRA, 2017

[2] T. Lu, H. Bader, and K. Hauser. *The Design and Doffing of Personal Protective Equipment for Healthcare Robots*. Military Health Systems Research Symposium (MHSRS), August 2018.

[3] P. Naughton and K. Hauser. *Structured Action Prediction for Teleoperation in Open Worlds,* IEEE RA-L, 2022

[4] Y. Zhu, A. Smith and K. Hauser, Automated Heart and Lung Auscultation in Robotic Physical Examinations, IEEE RA-L, 2022