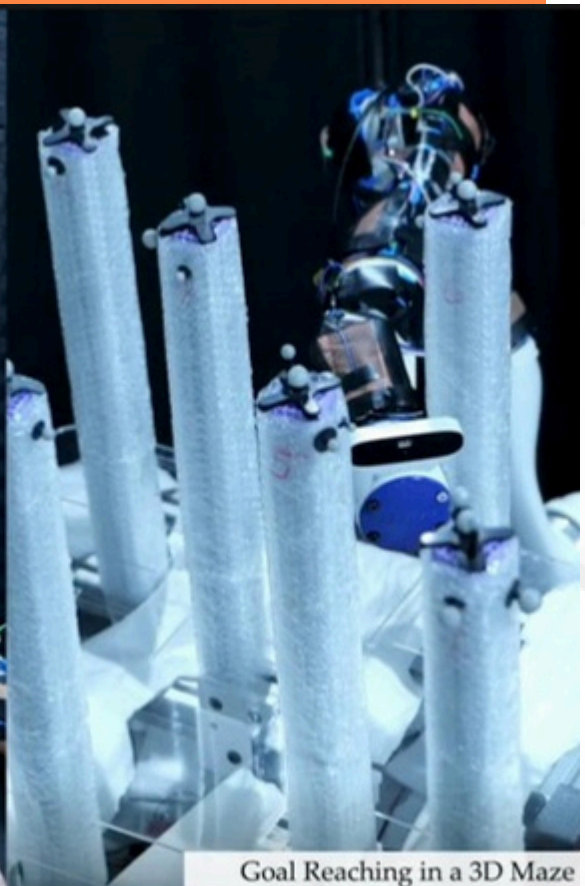




TOWARDS PERSONALIZED PHYSICAL HUMAN-ROBOT INTERACTION CASE STUDIES & APPLICATIONS | KINOVA

Case Studies and Applications



KINOVA

Case Study

How Cornell's EmPRISE Lab used a Kinova Gen3 to build a system that learns contact preferences for safer, more comfortable physical human-robot interaction.

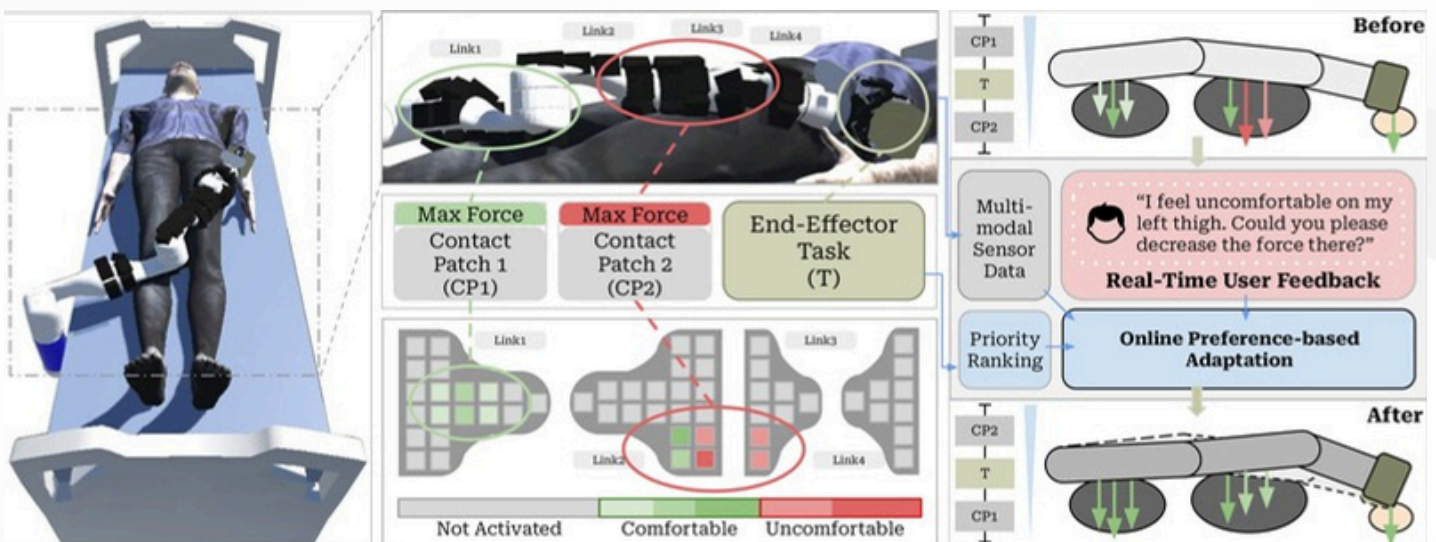
The Challenges

Many caregiving tasks, such as bed bathing, dressing, and transferring require a robot arm to make contact with multiple parts of a person's body, often at the same time. Different body regions have different comfort and safety limits, and what feels acceptable can change from person to person and over time. A single, fixed control strategy cannot satisfy all of these preferences while still completing the task efficiently. We needed a way for a robot to **adapt** online to individual contact preferences, where and how much force to apply during whole-arm physical human-robot interaction, without putting users at risk through trial-and-error exploration.

The Approach

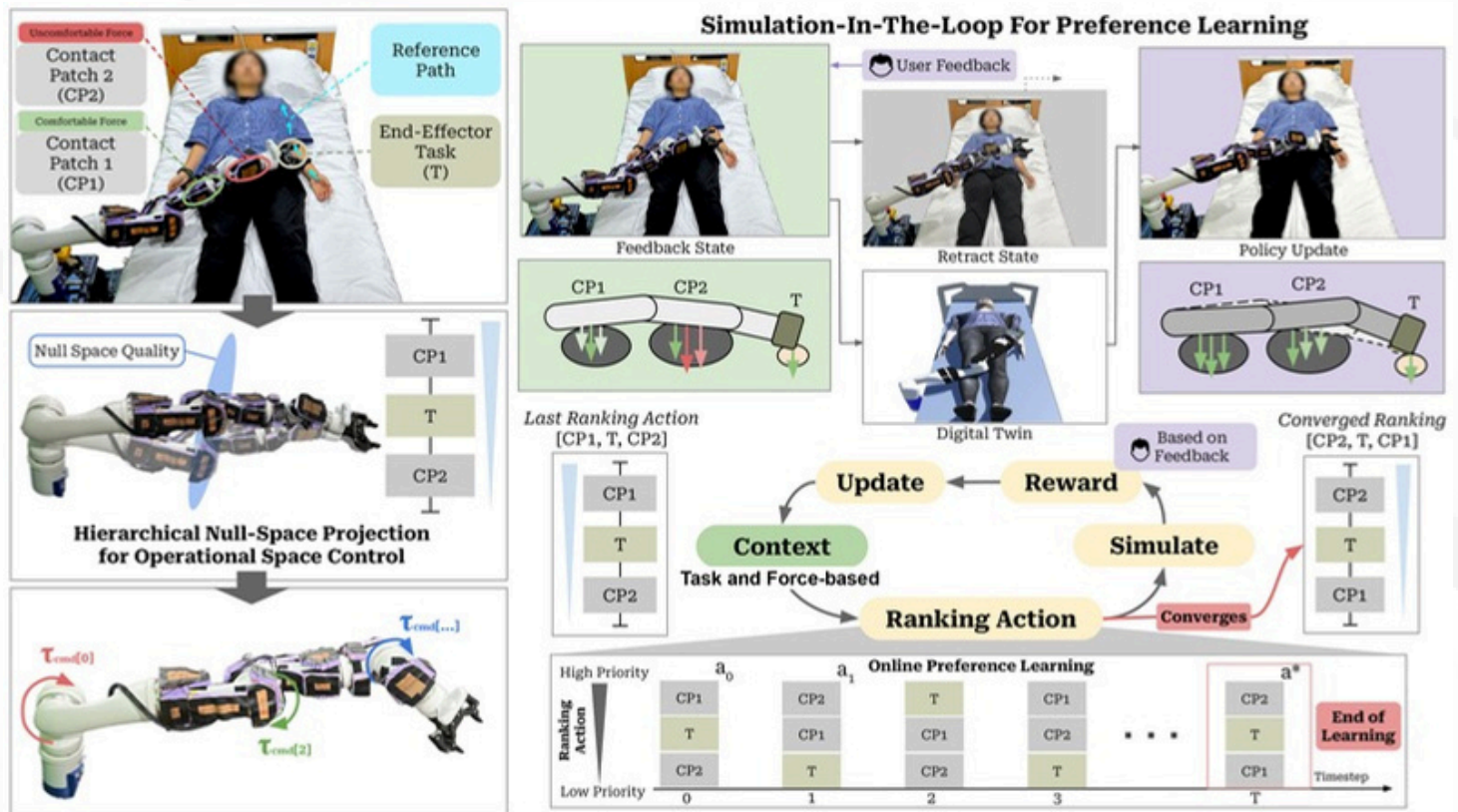
We developed PrioriTouch, a framework that treats contact preference learning as a learning-to-rank problem over control objectives. A high-level reference path (for example, a bed-bathing wipe trajectory) is executed by a **hierarchical operational space controller** (H-OSC) running on the Kinova Gen3 arm. At each time step, PrioriTouch ranks pose-tracking and body-part-specific force-regulation objectives and executes them using a strict null-space based hierarchy, so higher-priority contacts are protected while lower-priority ones use the remaining redundancy.

A novel contextual bandit algorithm, **LinUCB-Rank**, updates this priority ordering from sparse user feedback such as "I feel uncomfortable around my left arm," combined with measured contact forces from distributed tactile skin on the Gen3 arm. To keep learning safe and data-efficient, we use a simulation-in-the-loop digital twin: when feedback is received, the robot briefly retracts, explores alternative priority orderings in simulation, and only then resumes real interaction with an updated policy.



Key objectives

- Enable personalized **whole-arm contact** by adapting to individual contact preferences.
- Minimize the amount of user feedback required to personalize behavior.
- Ensure **safer online learning** by validating new priority policies in a digital twin before deployment.
- Demonstrate that the approach scales from simulation to real-world experiments on the Kinova Gen3 and to user studies in realistic caregiving scenarios.



We have been using Kinova's Gen3 robot arm in our experiments for many years. Because our lab focuses on physical robot caregiving, it is only natural that we rely on one of the most widely adopted assistive robotic arms in the field. Its compact form factor and multiple mounting-interface options allow it to be integrated with a wide range of wheelchair platforms, greatly simplifying our in-the-wild deployments with real users.

- Tapomayukh Bhattacharjee, Assistant Professor, Computer Science

The results

Using PrioriTouch on a Kinova Gen3 arm with distributed tactile sensing, we observed:

- **Fewer force-threshold violations** compared to fixed or heuristic priority baselines, meaning the robot better respected per-body-part comfort limits during whole-arm contact.
- **Improved sample efficiency:** the learning-to-rank approach required fewer feedback signals to discover a good priority ordering, especially as the number of simultaneous contacts increased.
- **Comparable or better task times** while reducing excessive forces, demonstrating that personalization did not require sacrificing task performance.
- In a realistic robot-assisted bed-bathing user study with 8 participants, 7 out of 8 **preferred PrioriTouch** over a heuristic baseline, reporting higher perceived safety, comfort, and overall task performance.





Kinova Gen3 provided us with a reliable and compliant platform to test what whole-arm physical human-robot interaction could look like in real caregiving scenarios. It allowed us to move beyond end-effector-only contact and safely explore how a robot can use its entire arm to interact more comfortably and intelligently with people.

- Rishabh Madan, PhD Candidate, Computer Science

INTERVIEW QUESTIONS

Kinova: Can you give us a brief description of your University / Lab / Company?

Client: EmPRISE Lab is a part of the College of Computing and Information Science at Cornell University. Our mission is to develop robots that enhance the quality of life for people with mobility limitations by assisting with Activities of Daily Living (ADLs). We are a full-stack robotics lab that integrates sensing, perception, planning, learning, and control to achieve intelligent autonomy in unstructured human environments. Our research spans human-robot interaction, robot manipulation, haptic perception, and tactile sensing, with a strong emphasis on not just novel algorithms, but also on building real systems, deploying them in realistic settings, and thoroughly evaluating them with real users.

K: What is your role within the University / Lab / Company?

Client: I am the lead author of this project and a PhD Candidate in Computer Science at Cornell University, where I work at the EmPRISE Lab with Prof. Tapomayukh Bhattacharjee. My research focuses on moving beyond the traditional view of robot manipulation, where almost all contact is restricted to the end-effector and any contact along the rest of the arm is treated as a collision to be avoided. I work on whole-arm physical human-robot interaction, where we intentionally allow and use contacts along the entire arm. I develop methods that leverage tactile sensing, robot learning, and model-based control to enable safer, more comfortable physical interaction between humans and robots.

K: What was the situation you were encountering that required you to seek out a company like Kinova? How did you come to learn about Kinova?

Client: We needed an assistive robot arm that was safe, torque-controlled, and compact enough to be mounted near a bed or wheelchair for future deployments. The arm had to work reliably with external tactile skins and integrate cleanly with our real-time control stack and simulation tools. Kinova arms were already widely used in assistive and rehabilitation robotics. Our lab has had prior experience with Kinova robots across multiple projects, so when we started working on PrioriTouch, the Gen3 was a natural choice for building and evaluating our system.

K: Can you describe your first impressions of the product?

Client: Our first impression of the Kinova Gen3 was that it was very research-friendly. Due to our rich history working with this arm, it was quick to set up, the APIs and ROS integration were straightforward, and it played nicely with our custom tactile skin and external controllers. The arm feels light and compliant, which is exactly what you want when you're making contact with a person's body. Once we integrated our hierarchical controller with our custom compliant controller for Gen3, it delivered smooth, stable torque control, making it much easier to focus on the contact-preference learning problem.

K: What was the impact of this solution on your project?

Client: The reliability and compliance of the Gen3 enabled challenging multi-contact experiments, such as bed bathing, while maintaining comfort thresholds. In practice, this meant we could validate that our learning-to-rank approach not only worked in simulation but also translated into safer, more comfortable interactions with real people, which is the project's core goal.

K: Who would you recommend this product for?

Client: I would recommend the Kinova Gen3 to research labs and companies working on physical human-robot interaction. It's particularly well-suited for projects that require torque control and redundancy. It's also a strong choice for teams building and testing advanced control algorithms, because the platform is reliable and designed for safer interactions.

EmPRISE lab is a part of the [Department of Computer Science](#) in the [Computing and Information Science](#) at [Cornell University](#). His mission is to enable robots to improve the quality of life of people with mobility limitations by assisting them with activities of daily living (ADLs)



Kinova is a global leader in designing and manufacturing robot arm for various applications in the Industrial, Professional, Academic and Medical markets and for Assistive technologies. We have for mission to provide humanity with robots that empower them to achieve the extraordinary everyday.

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