

Human – Robot Skill Transfer for Assembly Task

Case Study



KINOVA



The challenge

Bridging the Gap in Object Manipulation Skills

Equipping robots with human-like object manipulation skills is crucial for improving overall robot performance in manufacturing automation. Although almost every task in big manufacturing companies are automated, complicated and highly dexterous tasks. While robots can learn and acquire skills through trial and error, mastering new skills without guidance is time-consuming and demanding. However, learning from explicit demonstrations by expert technicians may face challenges due to the inherent structural differences between humans and robots.

95%

of the assembly line processes in car manufacturing are still done by hand.

Therefore, robots should focus on understanding the underlying intentions and core dynamic behavior behind human motion. This understanding can then be implemented in their own trial-and-error learning process.

The ACIS lab has embarked on exploring a new approach to human-robot skill transfer and is investigating methods to enable robots to incorporate and leverage these skills in their own practice. By effectively uncovering and applying these principles, robots can enhance their capabilities and bridge the gap between human and robotic manipulation skills.



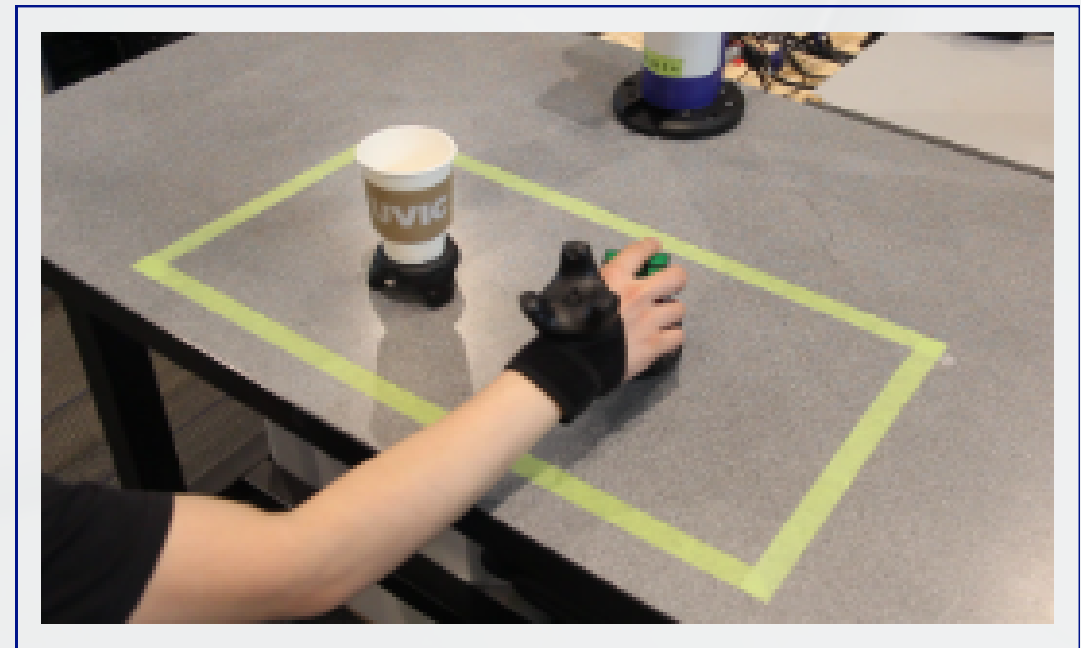
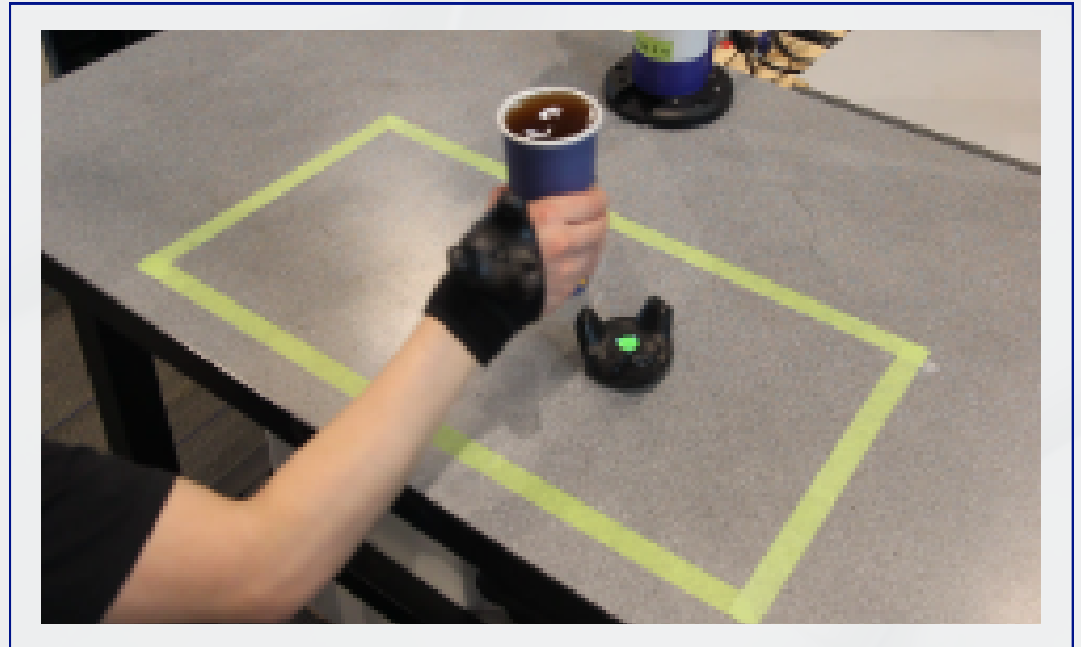
The approach

Revolutionizing Robotic Training: From Human Motion Data to Dynamic System Modeling

First, the research team created multiple human hand motion datasets for different skills using a motion tracker.

Secondly, the research team modelled these motions as a virtual spring-damper dynamic system employing the Dynamic Movement Primitive (DMP) framework. The research team then designed an automated optimization process to choose the dynamic system that best describes human skill.

Finally, the robot was trained to find a policy built upon the dynamic modelling for determining its next movement. This training was based on both the robot's own experiences in simulations and the recorded human motion.





The key objectives

Empowering Robots to autonomously acquire skills from human experts

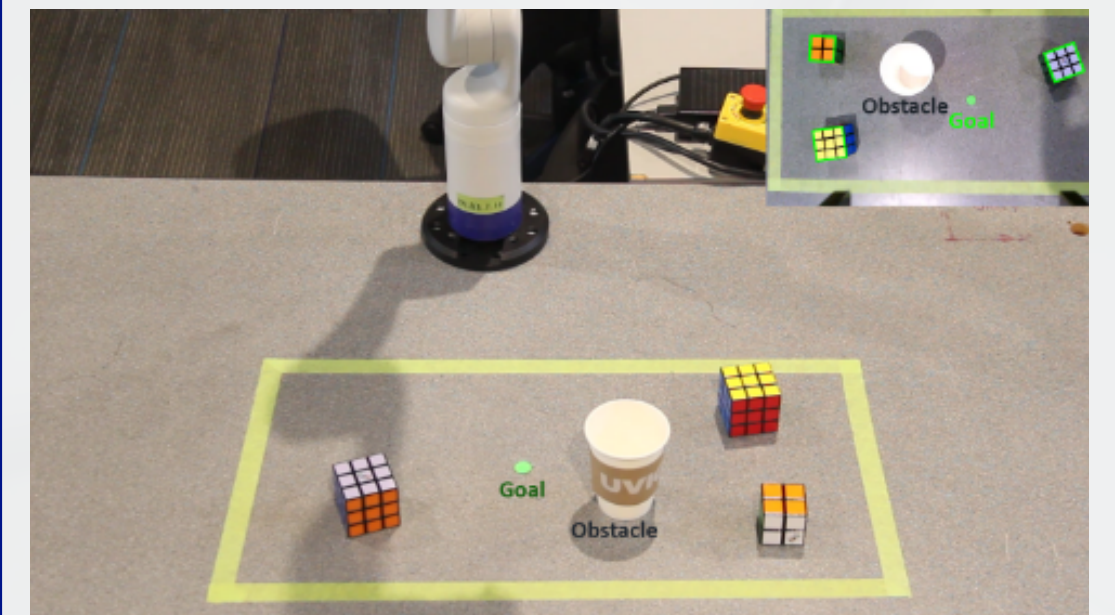
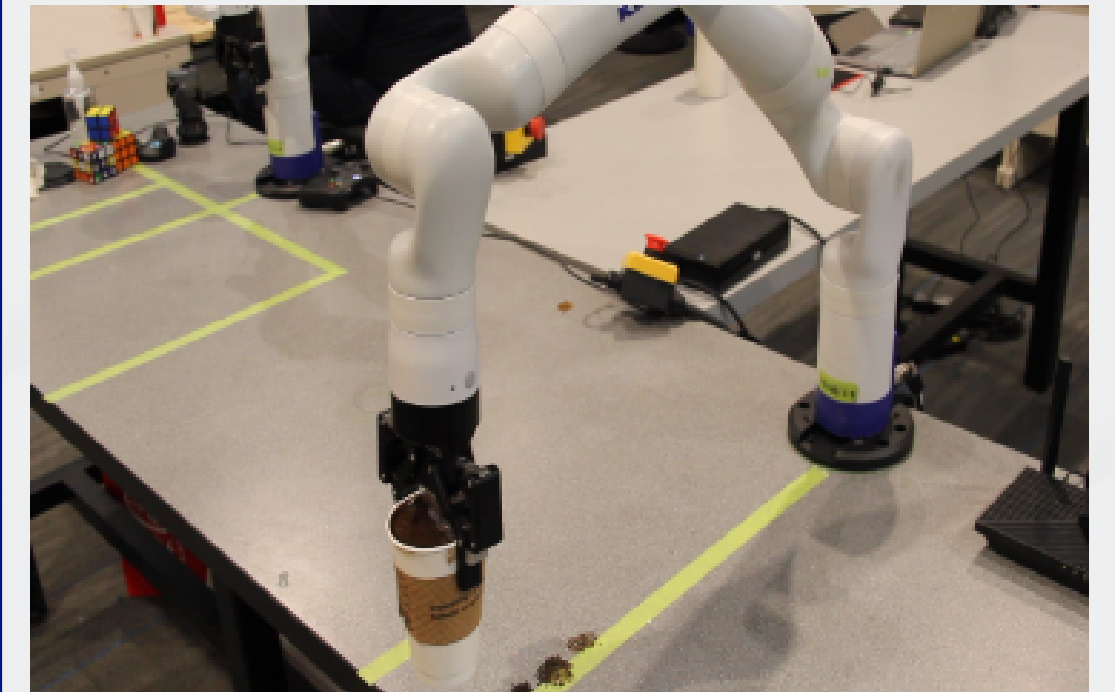
The primary objective of this research project is to equip a robot with a skill acquired from a human expert and enable it to autonomously generate adaptive trajectories without the need for waypoint teaching. The human skill is therefore not the trajectory, but it is extracted in the form of a dynamic model. To illustrate this method's efficiency, the ACIS research team assigned the robot two fundamental tasks:

1

Carrying a cup of coffee to show the robot's ability to learn smooth and jerk-free motion from a human

2

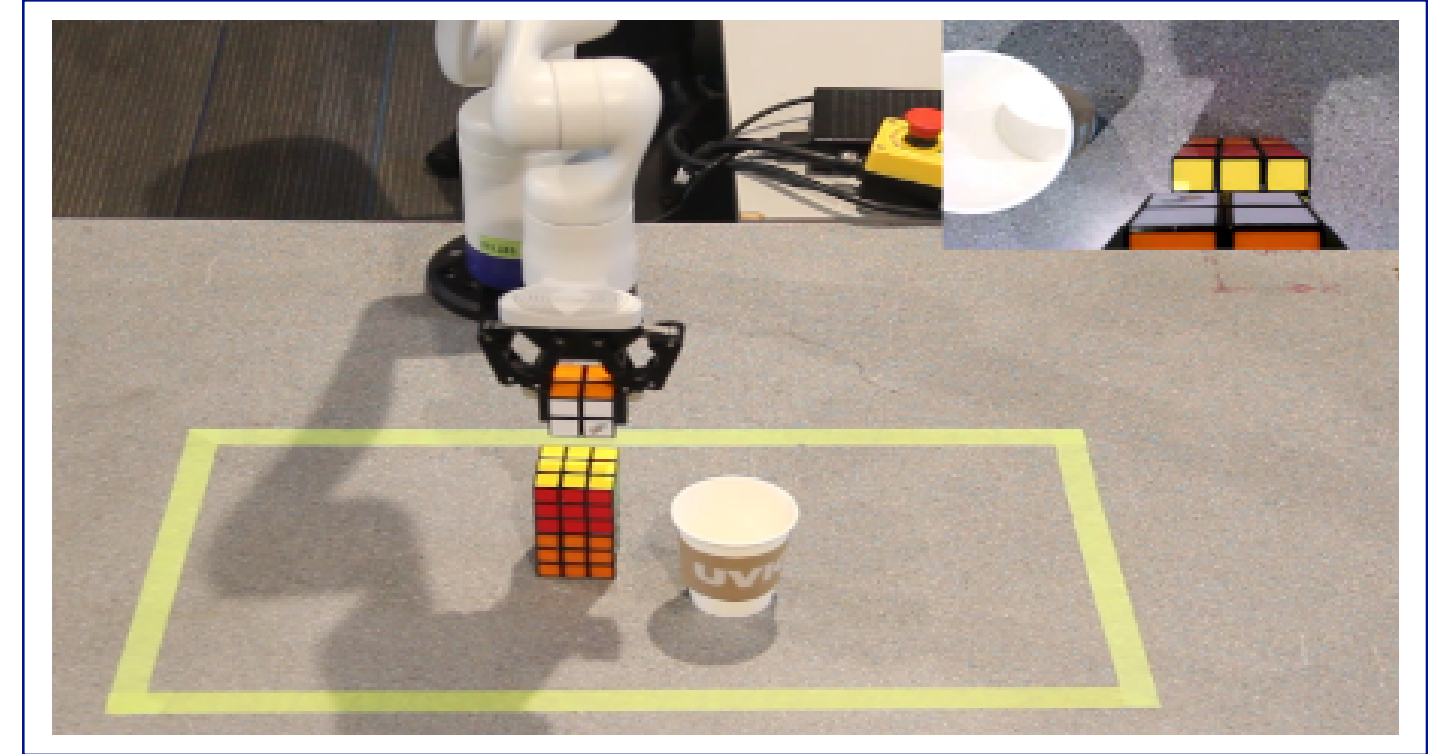
Stacking randomly placed cubes onto a specified target location while avoiding collisions with obstacles to verify the transfer of safe human motion in an assembly task to the robot



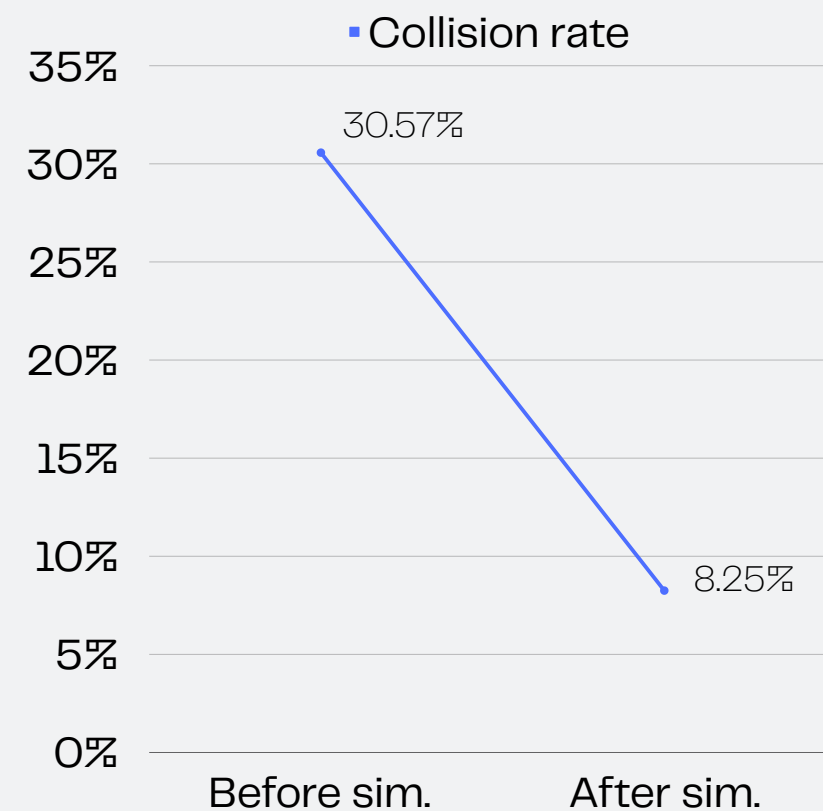
The results

ACIS Lab's Kinova Gen3 Robotics System and Open Dataset

The University of Victoria ACIS research lab constructed their robotic system using the Kinova Gen3 TM, mounted on a workbench. They utilized the VIVE TM motion tracker to record a dataset of 500 human demonstrations, capturing the hand movement positions as well as the positions of obstacles and the goal. This dataset is openly accessible online, allowing other researchers to use it for similar studies.



Click [here](#) to watch the video



After training the robot agent, its performance was evaluated in both simulation and experimental tests, based on success rates. In the simulation study, the robot's collision rate, when using skill transfer, significantly decreased from 30.57% to 8.25%, in comparison to a baseline condition where skill transfer was not used.

In the experimental validation, the success rate reached 13.64%, which is a lot lower than the non-skill-transfer simulation, even in the presence of uncertainties encountered in real-world experiments. Naturally, the success rate can further increase with reward shaping and longer training time.

As next steps in this research project, ACIS lab at University of Victoria is looking at generalizing this approach to more complicated tasks and creating and end-to-end human skill extraction and robot training software.



“We, at the UVic ACIS Lab, are creating the brain of the next generation robots with unparalleled intelligence for complicated tasks in complex environments, and have been lucky to have Kinova as a partner in this. Nowadays, collaboration between humans and robots or among robots projects new frontiers with great promises for intelligent robots, but it also brings new challenges that make our research both interesting and useful.”

- Homayoun Najjaran – Professor, Mechanical Engineering and Electrical and Computer Engineering Departments, University of Victoria



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.

info@kinovarobotics.com

1 855 6 KINOVA



**University
of Victoria**

Homayoun Najjaran founded the Advanced Control and Intelligent Systems (ACIS) Laboratory in 2006. His lab at University of Victoria specializes in theory and applications of control systems, artificial intelligence, robotics, industrial automation, and MEMS.