



# **Robot Skill Acquisition Through Prior-Conditioned Reinforcement Learning**

av

**Quantao Yang**

## **Akademisk avhandling**

Avhandling för teknologi doktorsexamen i Computer Science,  
som kommer att försvaras offentligt  
tisdag den 31 oktober 2023 kl. 09.15,  
Hörsal F, Örebro universitet

Opponent: Prof. Dr. Gerhard Neumann  
Karlsruhe Institute of Technology  
Karlsruhe, Germany

Örebro universitet  
Institutionen för naturvetenskap och teknik  
701 82 ÖREBRO

# Abstract

Quantao Yang (2023): Robot Skill Acquisition through Prior-Conditioned Reinforcement Learning. Örebro Studies in Technology 101.

Advancements in robotics and artificial intelligence have paved the way for autonomous agents to perform complex tasks in various domains. A critical challenge in the field of robotics is enabling robots to acquire and refine skills efficiently, allowing them to adapt and excel in diverse environments. This thesis investigates the questions of how to acquire robot skills through prior-constrained machine learning and adapt these learned skills to novel environments safely and efficiently.

The thesis leverages the synergy between Reinforcement Learning (RL) and prior knowledge to facilitate skill acquisition in robots. It integrates existing task constraints, domain knowledge and contextual information into the learning process, enabling the robot to acquire new skills efficiently. The core idea behind our method is to exploit structured priors derived from both expert demonstrations and domain-specific information which guide the RL process to effectively explore and exploit the state-action space.

The first contribution lies in guaranteeing the execution of safe actions and preventing constraint violations during the exploration phase of RL. By incorporating task-specific constraints, the robot avoids entering into regions of the environment where potential risks or failures may occur. It allows for efficient exploration of the action space while maintaining safety, making it well-suited for scenarios where continuous actions need to adhere to specific constraints. The second contribution addresses the challenge of learning a policy on a real robot to accomplish contact-rich tasks by exploiting a set of pre-collected demonstrations. Specifically, a variable impedance action space is leveraged to enable the system to effectively adapt its interactions during contact-rich manipulation tasks. In the third contribution, the thesis explores the transferability of skills acquired across different tasks and domains, highlighting the framework's potential for building a repository of reusable skills. By comparing the similarity between the target task and the prior tasks, prior knowledge is combined to guide the policy learning process for new tasks. In the fourth contribution of this thesis, we introduce a cycle generative model to transfer acquired skills across different robot platforms by learning from unstructured prior demonstrations. In summary, the thesis introduces a novel paradigm for advancing the field of robotic skill acquisition by synergizing prior knowledge with RL.

Keywords: Reinforcement Learning, Robot Manipulation, Transfer Learning, Safety Constraints, Prior Knowledge Learning

Quantao Yang, School of Science and Technology  
Örebro University, SE-701 82 Örebro, Sweden, [quantao.yang@oru.se](mailto:quantao.yang@oru.se)