DAVID CÁCERES DOMÍNGUEZ received his bachelor's degree in Industrial Electronics and Automation Engineering from Universidad Carlos III de Madrid (UC3M) in 2017, followed by a master's degree in Science and Technology Studies from the Technical University of Munich (TUM) in 2020. Since 2021, he has been a doctoral student in Computer Science at the Centre for Applied Autonomous Sensor Systems (AASS) at Örebro University, in collaboration with Suzuki Garphyttan.

The vision of robots assisting with our daily life tasks hinges on a fundamental challenge: most robot behaviors require programming by experts, creating a barrier for the many. Learning from Demonstration (LfD) is a family of methods with the potential to democratize robot programming by enabling laypeople to teach robots new skills simply by showing them. However, most LfD methods operate as black-box systems, making it difficult for humans to interpret, adapt, or reuse — key factors for human-robot collaboration and understanding.

In this thesis, we build upon Behavior Trees (BTs) — a transparent and manageable robot programming framework, whose reactive, modular design and potential for interoperability make them well-suited for constructing sophisticated robot behaviors. We propose a path toward more intuitive and effective robot learning, articulated through three key contributions:

First, this thesis formalizes core BT properties for robotics and introduces metrics for the systematic evaluation and comparison of learned policies. Building on this foundation, it investigates how different BT structures impact the interpretability of the control policy, identifying design patterns that best align with human intuition and understanding.

Second, this thesis presents a unified control framework that integrates BTs with a high-frequency Stack-of-Tasks (SoT) control strategy, enhancing transparency of BT policies by explicitly revealing the underlying subgoals. This approach allows BT nodes to function as hierarchical, high-frequency control objectives. Moreover, the resulting system achieves rapid reactivity in dynamic environments while supporting the coexistence of heterogeneous controllers and preserving a clean, modular decomposition of complex tasks.

Finally, this thesis introduces an end-to-end, label-free LfD pipeline that simultaneously learns the global BT structure and the underlying actions — modeled as Dynamic Movement Primitives — directly from raw demonstration data. By leveraging vision-language models to automatically extract and annotate state representations, this method eliminates the need for handcrafted action sets, predefined state spaces, and time-consuming manual labeling.

In summary, this thesis provides a comprehensive framework for learning interpretable, modular, and adaptable robot control policies from demonstration, bridging the gap between transparent policy representation and practical, high-frequency robot control, which marks a significant step toward making robot programming more accessible, robust, and understandable for both experts and non-experts.

ISSN 1652-4063
ISBN 978-91-7529-713-2

DAVID CÁCERES DOMÍNGUEZ Learning Interpretable Robot Policies from Demonstration

ÖREBRO UNIVERSITY

Doctoral Dissertation

Learning Interpretable Robot Policies from Demonstration

DAVID CÁCERES DOMÍNGUEZ
Computer Science

2025

Örebro Studies in Technology 110 | ÖREBRO 2025

ÖREBRO UNIVERSITY

DAVID CÁCERES DOMÍNGUEZ Learning Interpretable Robot Policies from Demonstration