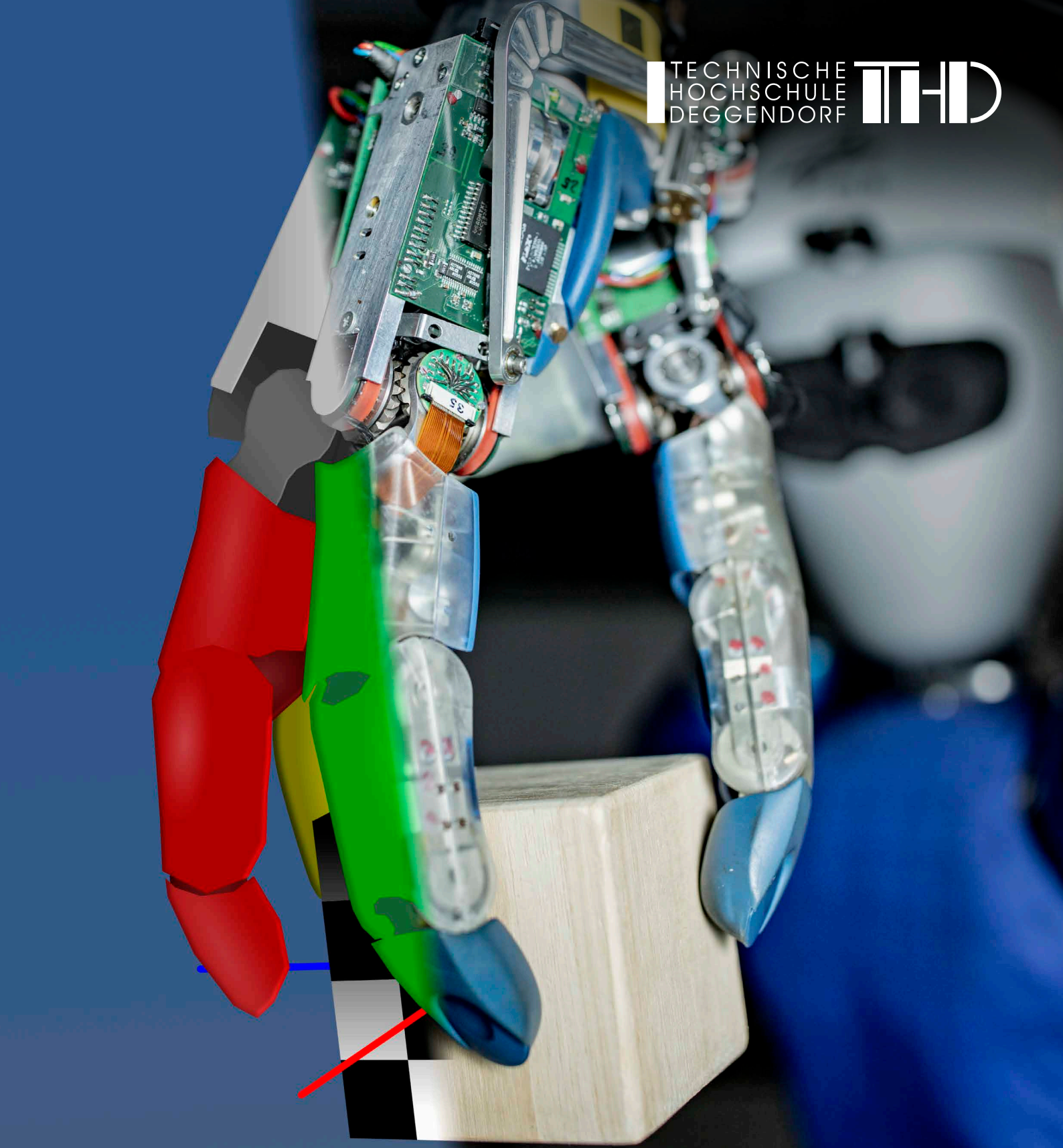

TECHNISCHE HOCHSCHULE DEGGENDORF

LEARNING DEXTROUS MANIPULATION

SENSITIVE AND DEXTROUS LIKE HUMANS: ROBOT LEARNS OBJECT MANIPULATION BY PLAYING IN SIMULATION.

DLR Deutsches Zentrum für Luft- und Raumfahrt e.V.

Weitere Infos

Abstract

Project Title:

Learning Purely Tactile In-Hand Manipulation with a Torque-Controlled Hand

Introduction:

Dexterous in-hand manipulation, e.g., moving and reorienting an object inside the hand, is an important skill humans use all the time in their daily life. But it is also a challenging task demanding complex multi-finger strategies with intricate multi-contacts. The manipulation is especially difficult if the hand is pointing downwards and the object is not resting on a support as this requires permanent force closure to not drop the object. Humans can perform such manipulation tasks with ease, even without looking at the object, using only tactile feedback. However, most robotic systems still heavily rely on precisely calibrated visual tracking systems for executing any kind of fine manipulation, which renders these systems basically useless for real world applications.

The goal of our project is the dexterous in-hand manipulation of objects with an advanced robotic multi-finger hand – the DLR-Hand-II – using only its integrated position and torque sensors. Similar to the human, the task should be learned completely autonomously by using reinforcement learning, where a control strategy is trained by interacting with an environment, only guided by a reward signal encoding the task.

Method:

For learning the neural network controller, we implemented a parallelized version of the Soft Actor Critic deep reinforcement learning algorithm. All training is done in a rigid body simulation of the torque-controlled DLR-Hand-II for which we performed an accurate system identification. In combination with an appropriate domain randomization, this allows for a zero-shot transfer of the controller to the real robotic system (Sim2Real). For realtime execution, we integrated the neural network in the Simulink-based control architecture of DLR's humanoid robot Agile Justin.

Result:

We show for the first time that a purely tactile dexterous in-hand manipulation task with continuous regrasping, requiring permanent force closure, can be learned in simulation and robustly executed on a real robotic hand. The learned controller can robustly rotate a variety of cuboids using only the hand's integrated sensors. dlr-alr.github.io/dlr-tactile-manipulation

Project Participants:

Leon Sievers and **Johannes Pitz:** Since 2020, they are research assistants at the DLR-DIT Joint Research Lab "Autonomous Intelligent Robots" and PhD students at

the TU Munich. They hold a master's degree in Computer Science of the TUM with specialization in deep learning for robotics.

Berthold Bäuml: Since 2020, he is heading the DLR-DITJoint Research Lab and is professor at DIT. He is also with DLR and founder and head of the Autonomous Learning Robots Lab which developed one of the most advanced mobile humanoid robots worldwide.

Project Partners:

DLR (German Aerospace Center) Institute of Robotics, Oberpfaffenhofen
DIT (Deggendorf Institute of Technology), TC Plattling
The MathWorks, Inc., Nattick, USA

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Logos: