



# Grasping Complexity: Design Choices in State-of-the-Art Robotic Hands

Working Student, Master's Thesis

Dexterous robotic hands represent a pinnacle of modern robotics, aiming to replicate the versatility, precision, and adaptability of the human hand. These systems have transformative potential across industries, including manufacturing, healthcare (e.g., prosthetics), and human-robot interaction. However, achieving human-like dexterity remains a significant challenge due to the complex interplay of mechanical design, actuation methods, control systems, and material choices.

Design decisions—such as the number of degrees of freedom (DoF), type of actuators (e.g., motors, pneumatics), sensor integration, and structural materials—profoundly influence a robotic hand's performance, cost, and practical applicability. Existing dexterous hands, such as the Shadow Hand, iCub Hand, and DLR/HIT Hand, showcase diverse approaches to these challenges, yet no single design has emerged as a universal standard. This thesis seeks to systematically investigate how these design choices shape functionality and to compare the strategies employed by state-of-the-art robotic hands.

The motivation for this study stems from the growing demand for robots capable of performing complex tasks in unstructured environments, coupled with the need to balance performance with scalability and affordability. By analyzing existing designs, this work aims to identify trade-offs, highlight innovative solutions, and propose guidelines for future development.

## Methodology:

- i. Define Core Design Elements: Pinpoint critical factors shaping robotic hand dexterity.
- ii. Compare Current Models: Assess key dexterous hands for design and performance trends.
- iii. Test Design Impacts: Simulate how choices affect functionality and trade-offs.
- iv. Extract Insights: Identify strengths, weaknesses, and optimization patterns.
- v. Propose Guidance: Offer a framework for future hand design innovation.

The work is carried out at the German Aerospace Center in Oberpfaffenhofen.

Start: at the earliest possible date.

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Please attach a brief motivation, curriculum vitae and a transcript of records.



Fig. 1: DLR David