Embodied Safety by Robotic Core Elements: Creating Intrinsically Safe Mechanisms by Extracting Principles from the Living Body's Inherent Underactuated Drive Mechanisms

Project manager

(since 2026)

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Leader's institution

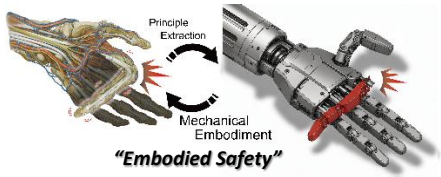
The University of Osaka

R&D institutions

The University of Osaka, The University of Tokyo, Yamaguchi University, Nagaoka University of Technology, New York University

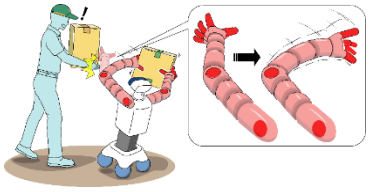
Summary of the project

This research focuses on the hands and arms—the critical points of physical contact that enable AI-powered humanoid robots to work safely in people's everyday living spaces. Our goal is to develop hands and arms that make grasping failures less likely to lead to serious accidents. Going beyond reliance on sensors and stop functions alone, we embed mechanisms inspired by the human body into the robot's core physical structure. These include underactuation, which allows multiple joints to move with fewer actuators, and mechanical coupling that coordinates their motion. By building safety into the mechanism itself, we aim to create limbs that are less likely to exert dangerous forces, even when control systems malfunction or mistakes occur during learning.



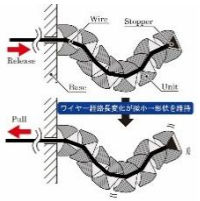
Milestone by 2028

By 2028, we aim to establish and physically demonstrate the foundational mechanisms of a robotic hand with safety built into its core structure. Drawing on underactuated, mechanically coupled motion in the human body, we will use variable-stiffness mechanisms, magnetic springs, and related elements to create initial prototypes of a safety-envelope mechanism designed to make transitions into states that could make serious accidents less likely.

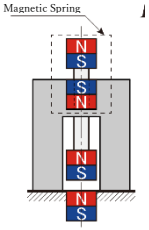


Yield to horizontal forces. Support loads against gravity.
"Embedding Safety into the robot's body"
by Force Tolerance.

To bring these concepts to life in physical prototypes, we will build on and further develop the Tadakuma Laboratory's core technologies shown below: a one-dimensional variable-stiffness mechanism and a magnetic-spring-based magnet mechanism.







Project structure

Our team integrates anatomy, AI, philosophy, and engineering. PI Prof. Ogihara will identify underactuation, reflex principles, and internal input-output relationships within the human anatomy. PI Prof. Obayashi will incorporate insights from safety mechanisms into LLM-based AI control. PI Prof. Koyama will contribute philosophical perspectives on trustworthiness and safety, while PI Prof. Kimura will define engineering safety requirements. PM Tadakuma will coordinate these contributions, enabling each discipline to strengthen the others.



*Certain illustrations in this document were created with the assistance of generative AI.

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