

# **Introduction to Grasping - Mujoco Project Work**

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Final Report

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# Importance of Grasping in Robotics

- Interactions with the environment
- Complexity in designing algorithms for different
  - Object Shapes
  - Sizes
  - Material
- Robotic grasping facilitates tasks for various fields, improving
  - Speed
  - Human Error Reduction
- Potential for Diverse Applications such as
  - Health Care
  - Space Exploration
  - Home Assistance



**Allegro Hand**  
Source: [xelarobotics](http://xelarobotics.com)

# The Grasping Problem

- Complexity in replicating human-like precision and adaptability
- Designing actuation systems for smooth, responsive control
- Handling a variety of objects, dealing with uncertainties
- Advancements unlock broader applications, improve efficiency, and enhance safety



**Source: Sam Chivers**

# Problem Description and Tools

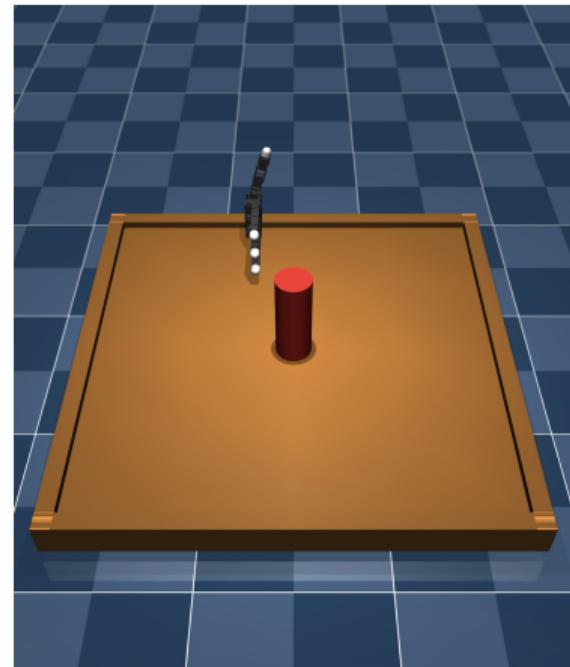
- Allegro Hand and its unique features such as:
  - Dexterity
  - Close Resemblance to the Human Hand
- Test objects were:
  - Cylinder
  - Rectangular Cube

## Approach

- Focused on grasping via fingertip control
- Implementing a precise controller, ensuring accurate contact points, and maneuvering actuator movements.

# Mujoco Scene Setup

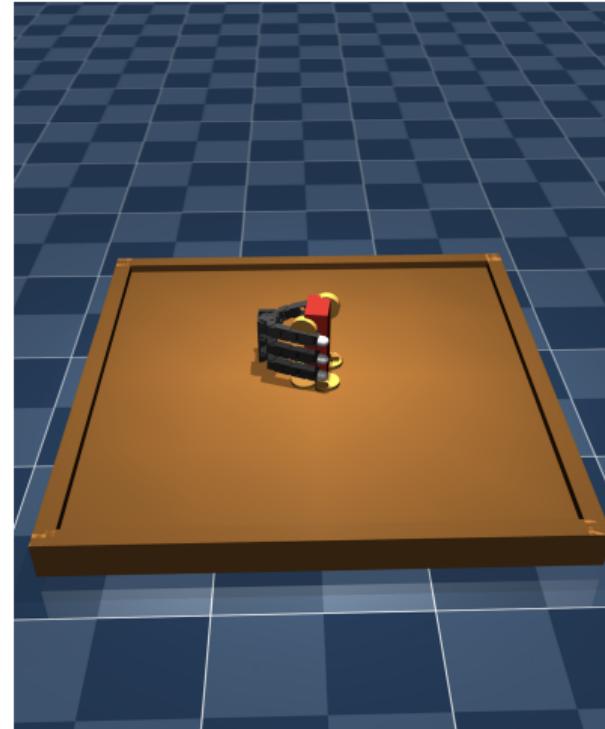
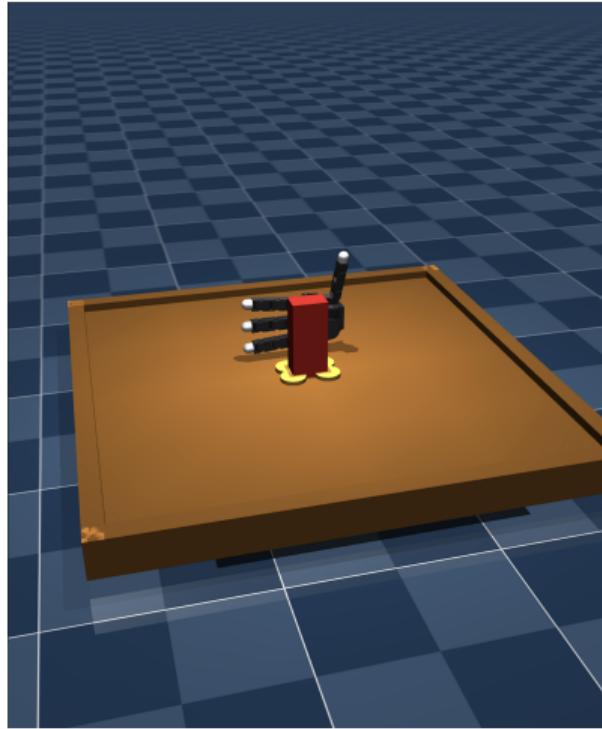
- The Allegro hand, robotic hand with 16 individually controllable joints
- Setup is in a three-dimensional virtual environment that mimics real-world physics
- An object to be grasped by the hand is also located within this environment
  - Cylinder
  - Rectangle Cube
- The main goal of the hand in this scene is to reach out and grasp the object



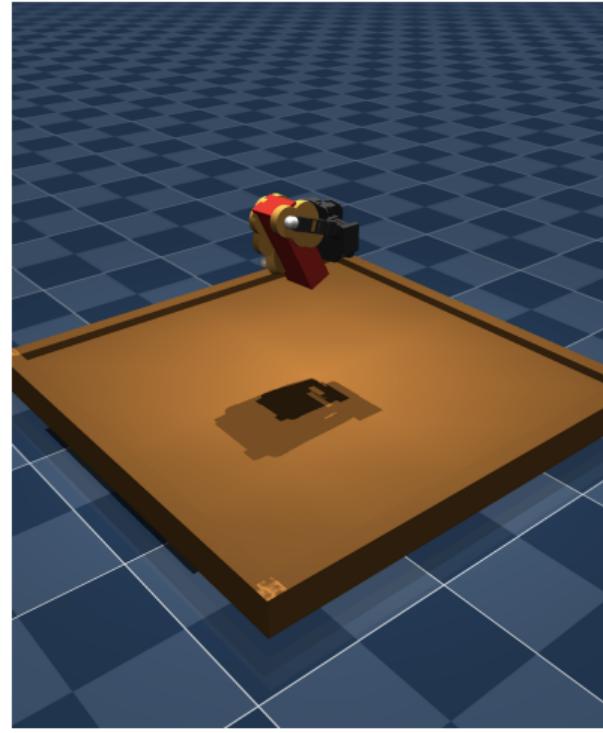
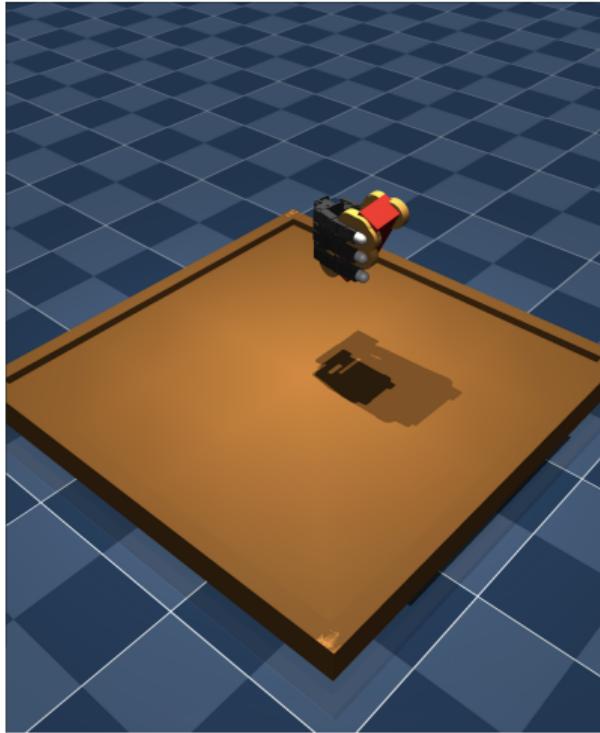
# Controller and Simulation

- The open-hand moves toward the object
- A PID controller directs the movement of the hand, adjusting angles and forces
- Each finger moves separately until close to the target
- When fingers reach their targets, the grasping phase starts
- The final hand position is set
- Jacobian matrices calculate control signals with the target end-effector position
- After grasping, the hand moves to the final position with the grasped object
- Finger and palm positions are regularly updated, and control is recalculated

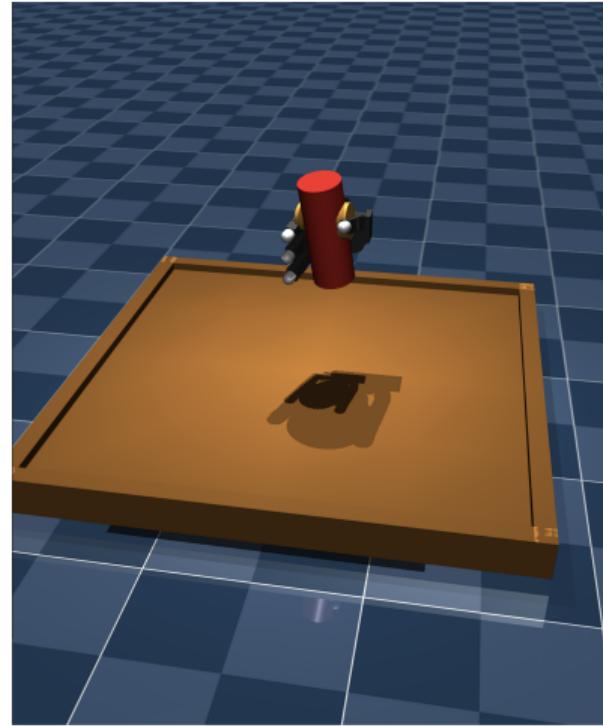
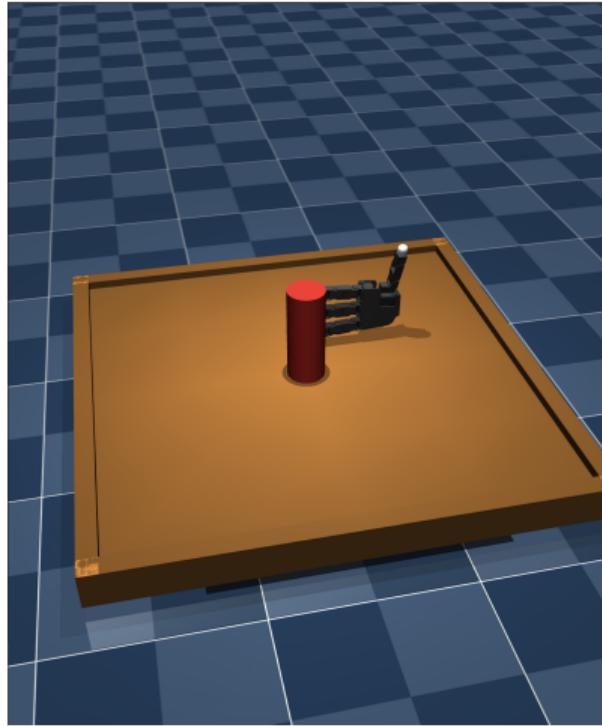
# Results - Cube



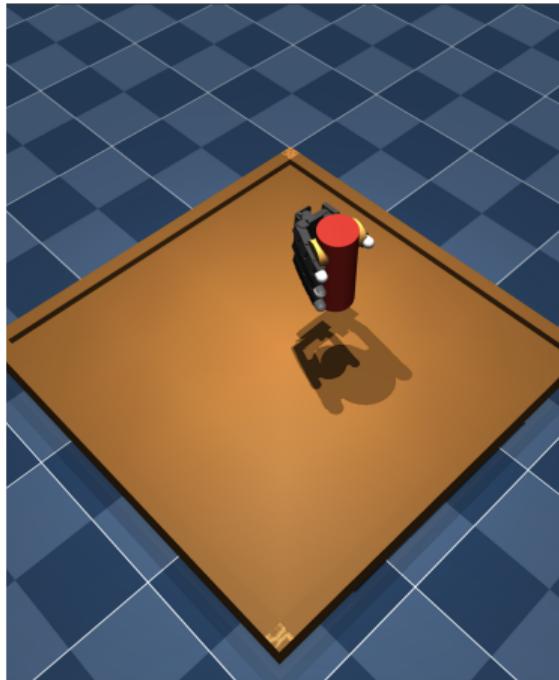
# Results - Cube



# Results - Cylinder



# Results - Cylinder



# Video Recording

**Place Holder for Video Simulation**

## Discussion

- Control strategies show different effectiveness in controlling the Allegro hand
- Applying a PID controller to each joint, not just end-effectors, better performance
- Impedance control might offer benefits such as stability and interaction control
- Grasping remains a challenging task due to complexities in various aspects

### Key Takeaways from this project:

- Hands-on experience with Mujoco, an essential tool in the field of modern robotics
- Practical implementation of controllers, including PID and impedance control
- Delved into the physics behind robotic movement and control
- Engaged with complex tasks in robotic grasping
- Gaining insight into real-world robotics challenges

# Conclusion and Future Work

## Summary and Future Work

- Our work resulted in an implementation of the Allegro Hand using Mujoco
- Despite challenges in grasping tasks, substantial progress was achieved
- Future work will focus on refining control strategies, such as implementing PID controllers at the level of individual joints for more precise control
- Further exploration of impedance control could also enhance the Allegro Hand performance
- The broader goal is to develop more efficient and intuitive robot-hand control methods, bringing us one step closer to realistic human-like robotic manipulation