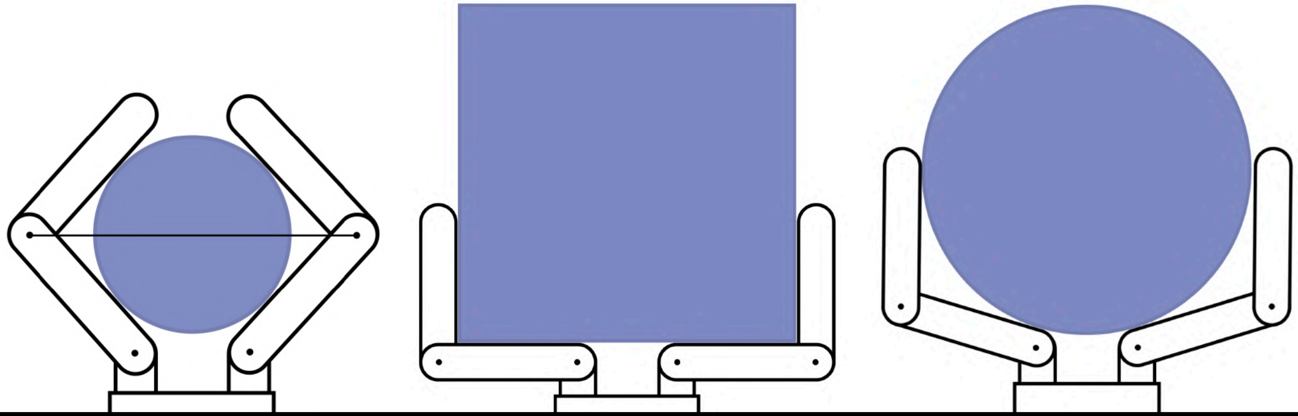
Investigating the Standardization of Work Volume for Robotic Manipulators

Adam Wathieu, Joe Falco



National Institute of Standards and Technology
U.S. Department of Commerce

Intelligent Systems Division

GEORGETOWN UNIVERSITY

Agenda

- Background and objective
- Testbed: the Schunk Dexterous Hand (SDH)
- Work Volume Method 1
- Work Volume Method 2
- Manipulator Work Volume Simulator (WoVoS)
- Continued Work

Background: Performance Metrics and Test Methods for Robotic Hands

- The need to capture the individual competencies and characteristics of robotic hands under a unified framework
- NIST contributions and efforts
- Objective and Use

Finger Strength

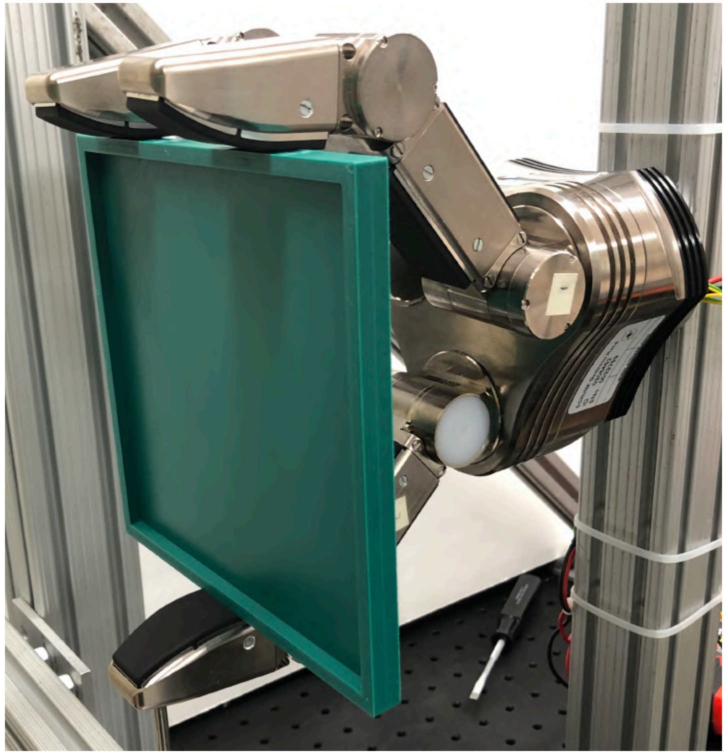
Grasp Strength

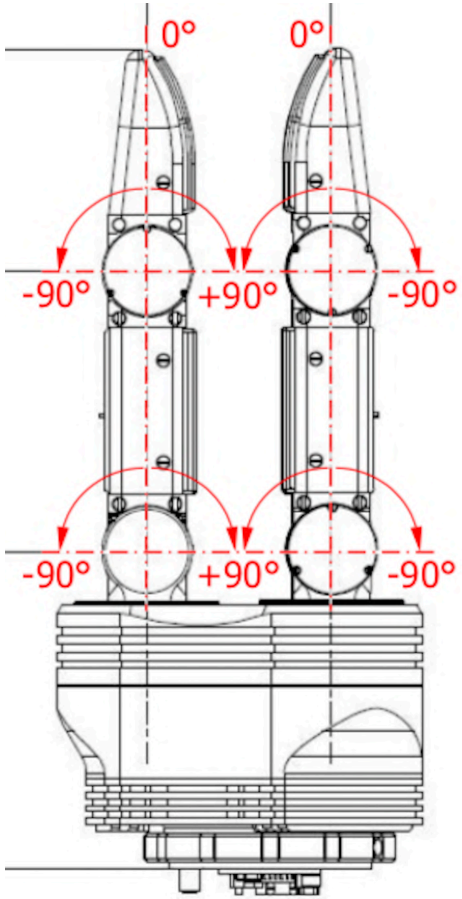
Background: Work Volume

- A multi-faceted measure of the space in which a hand can grasp objects
- Useful for determining and comparing the payload volumes of robotic hands
- Purpose of this research is to investigate how to measure Work Volume under a common method

Testbed: Schunk Dexterous Hand (SDH)

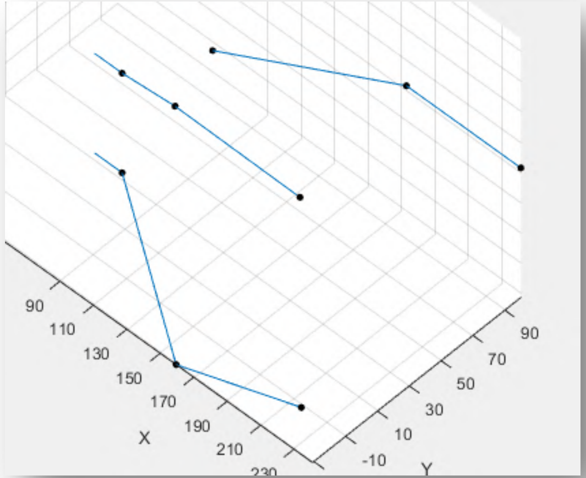
- 3 fingered fully actuated robotic hand

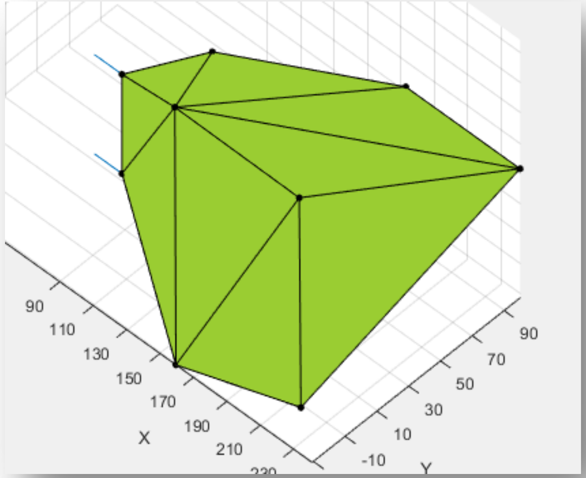


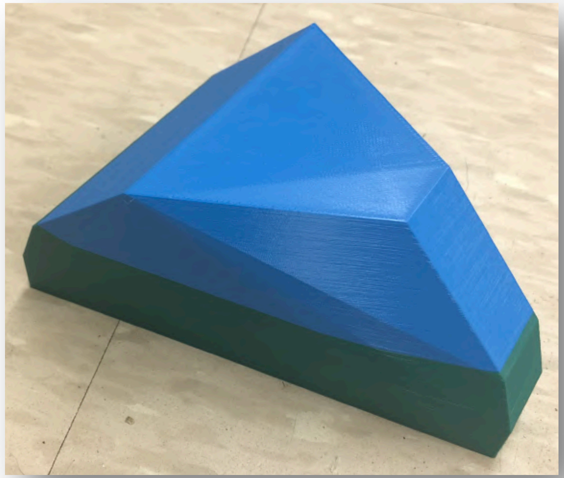


Work Volume, Method 1

- Polyhedron volume given the hand kinematics and joint limits
- Pros: software based, precise
- Cons: polyhedrons, practicality

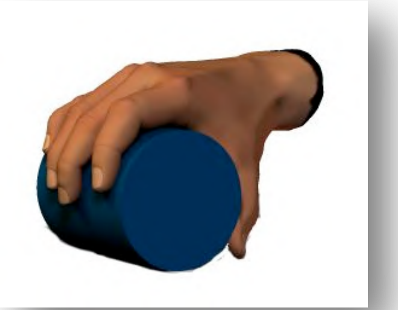


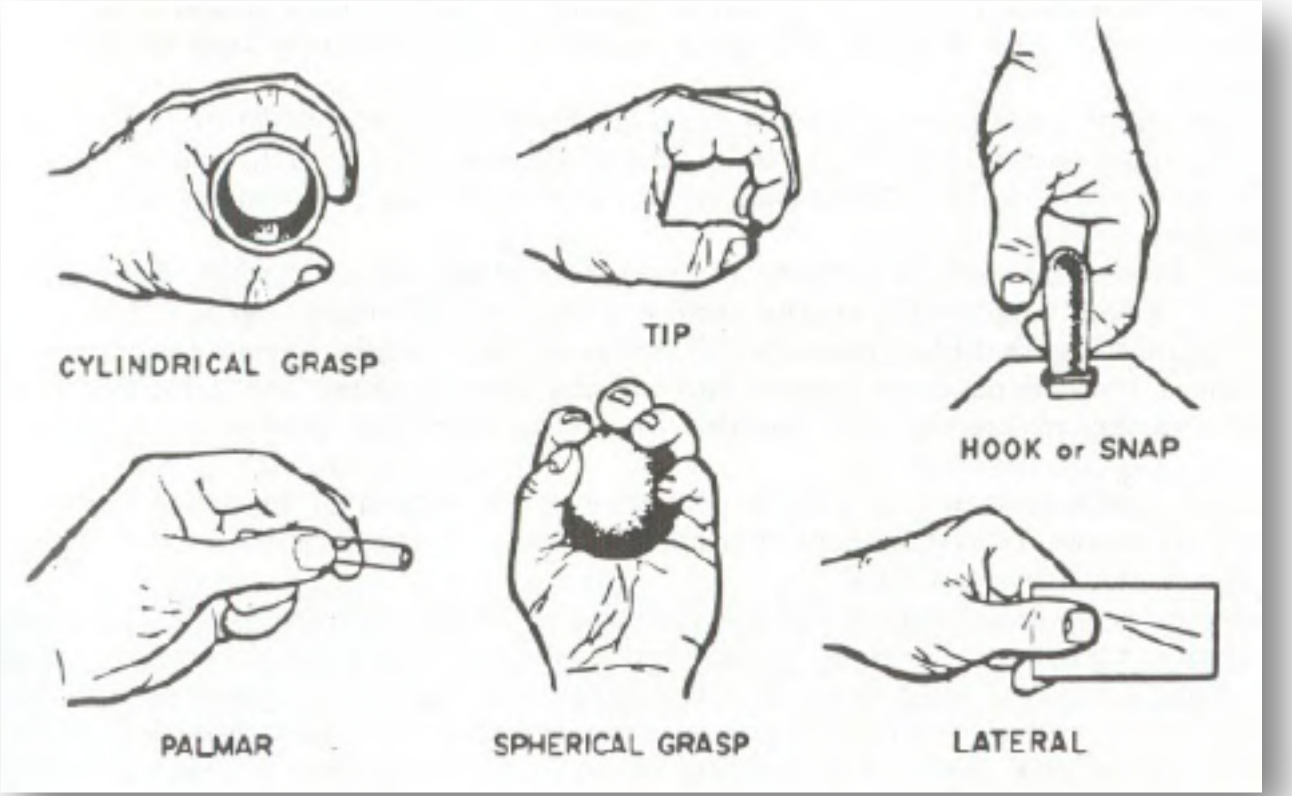




Grasp Taxonomy

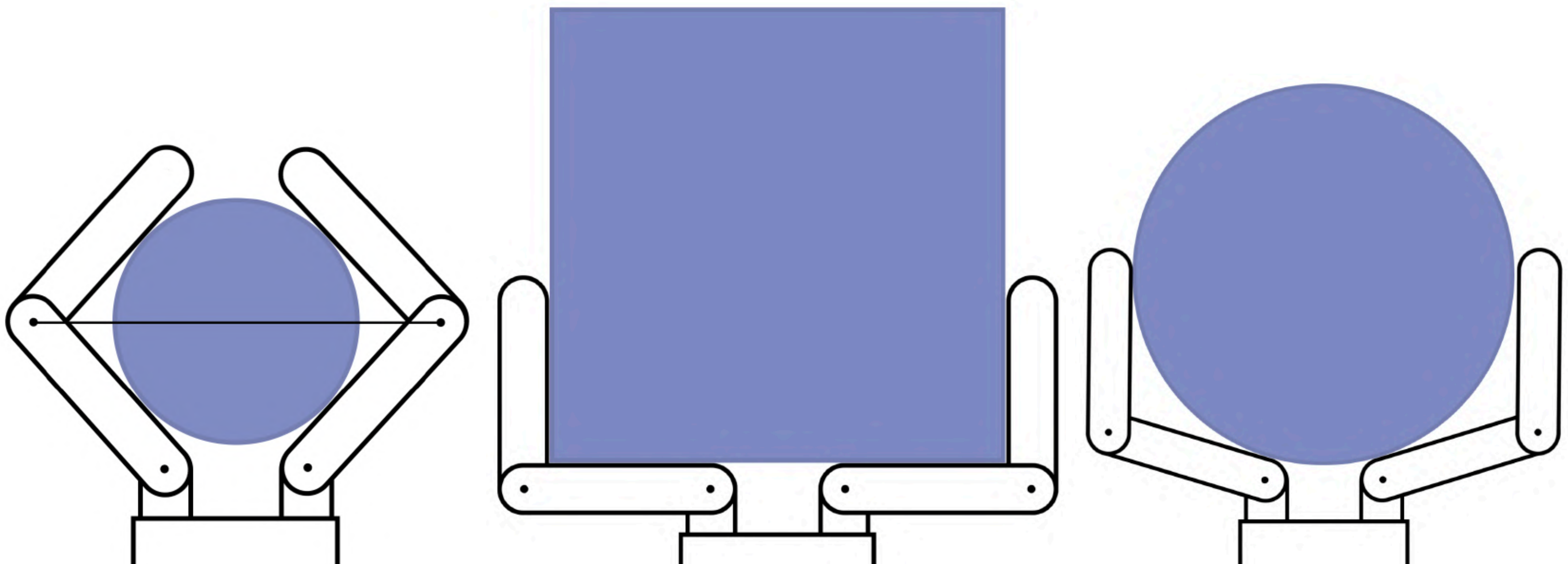
- Considering grasp types
- Volumetric characteristics given a grasp type and associated joint limits





Work Volume, Method 2

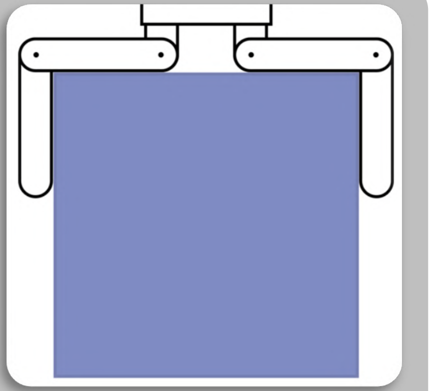
- Maximum dimensions of primitive shaped objects (e.g., square, cylinder, sphere)
- Pros: Intuitive, directly applicable to industry
- Cons: Physical objects necessary, accuracy



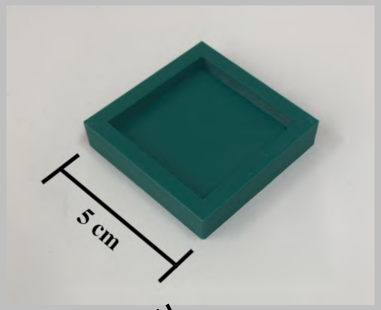
Work Volume, Method 2, Continued

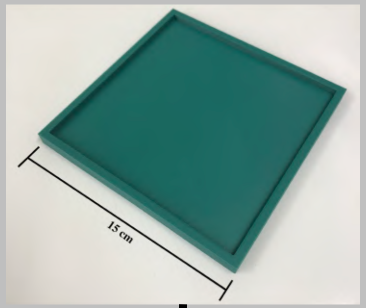
Cube Compatibility

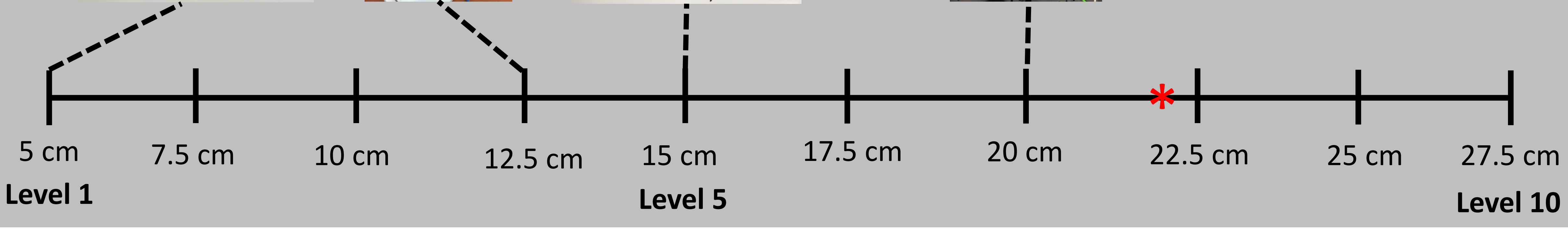
The biggest cube that can be held by a hand such that the last link of two fingers can go over opposite edges of the cube



Levels



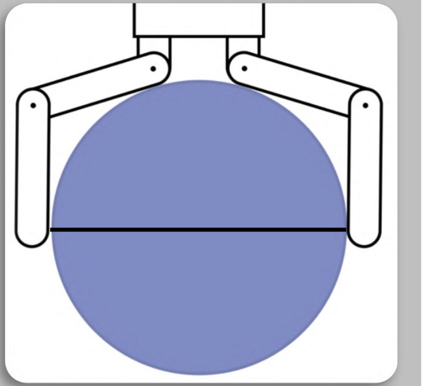




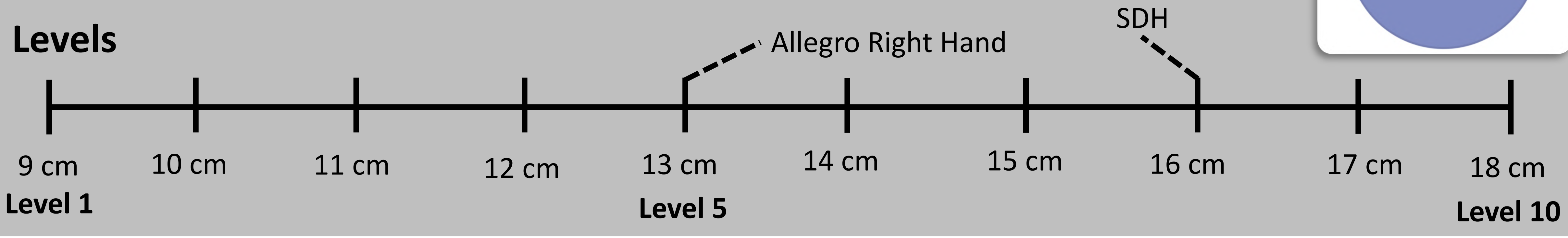
Work Volume, Method 2, Continued

Pinch Compatibility

The biggest sphere or cylinder that can be held by a hand such that the end effector of two fingers reach the diameter of the sphere or cylinder



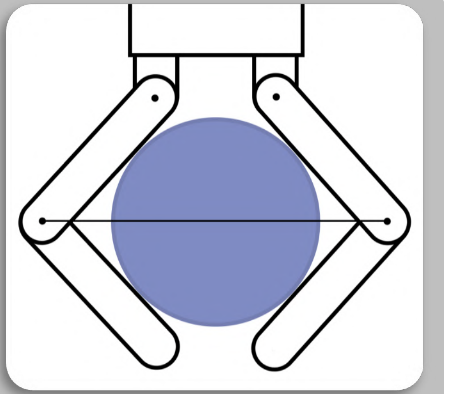
Levels



Work Volume, Method 2, Continued

Wrap Compatibility

The biggest sphere or cylinder that can be held by a hand such that the end effector of two fingers reach over the diameter of the sphere or cylinder



Levels

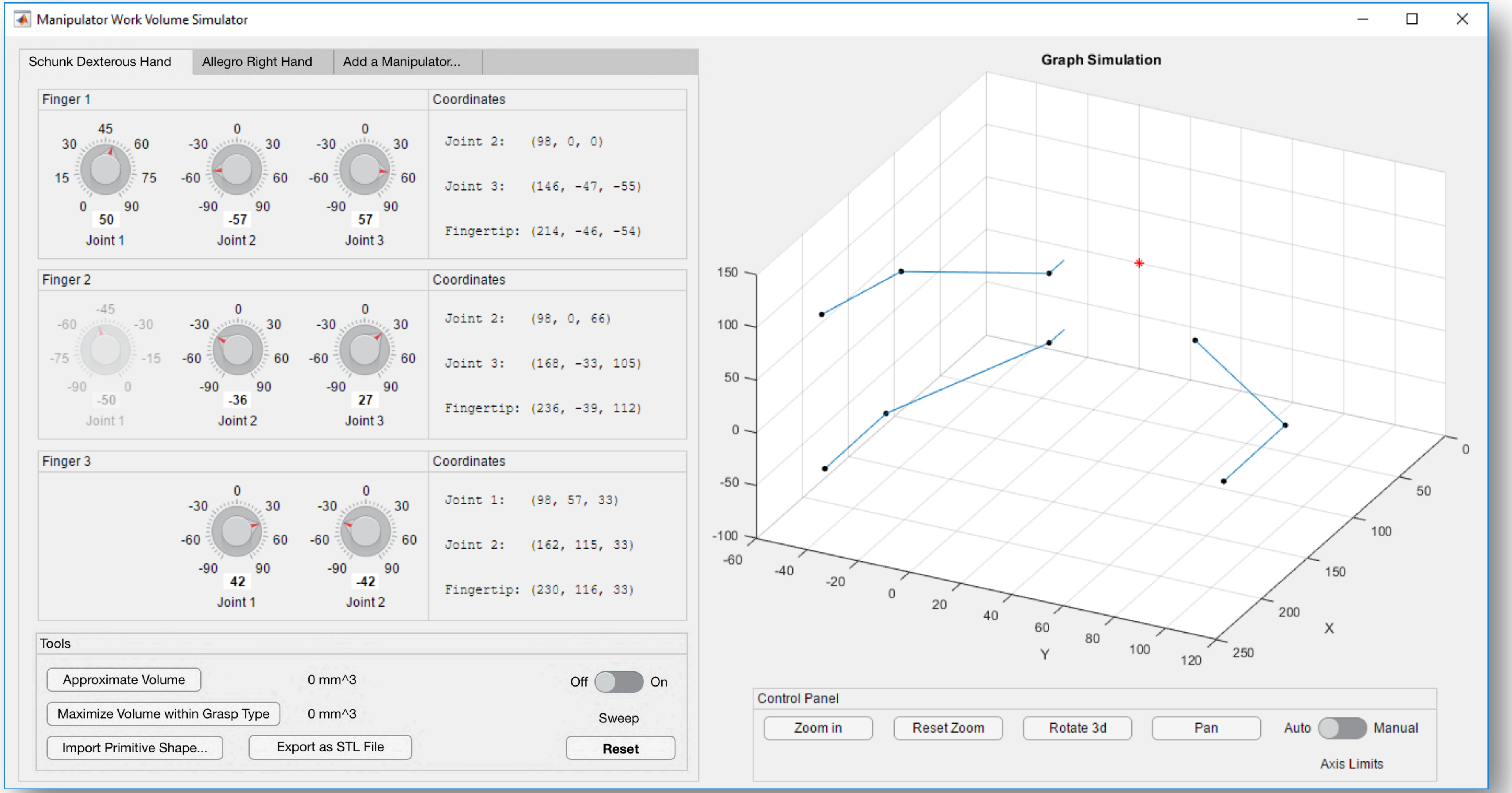
2 cm | 3 cm | 4 cm | 5 cm | 6 cm | 7 cm | 8 cm | 9 cm | 10 cm | 11 cm

Level 1 (2 cm) — **Level 5** (6 cm) — **Level 10** (11 cm)

- Directly applicable to Industry

Manipulator Work Volume Simulator (WoVoS)

- Modular MatLab Application
- Robotics Toolbox
- Forward Kinematics
- Currently supports the SDH



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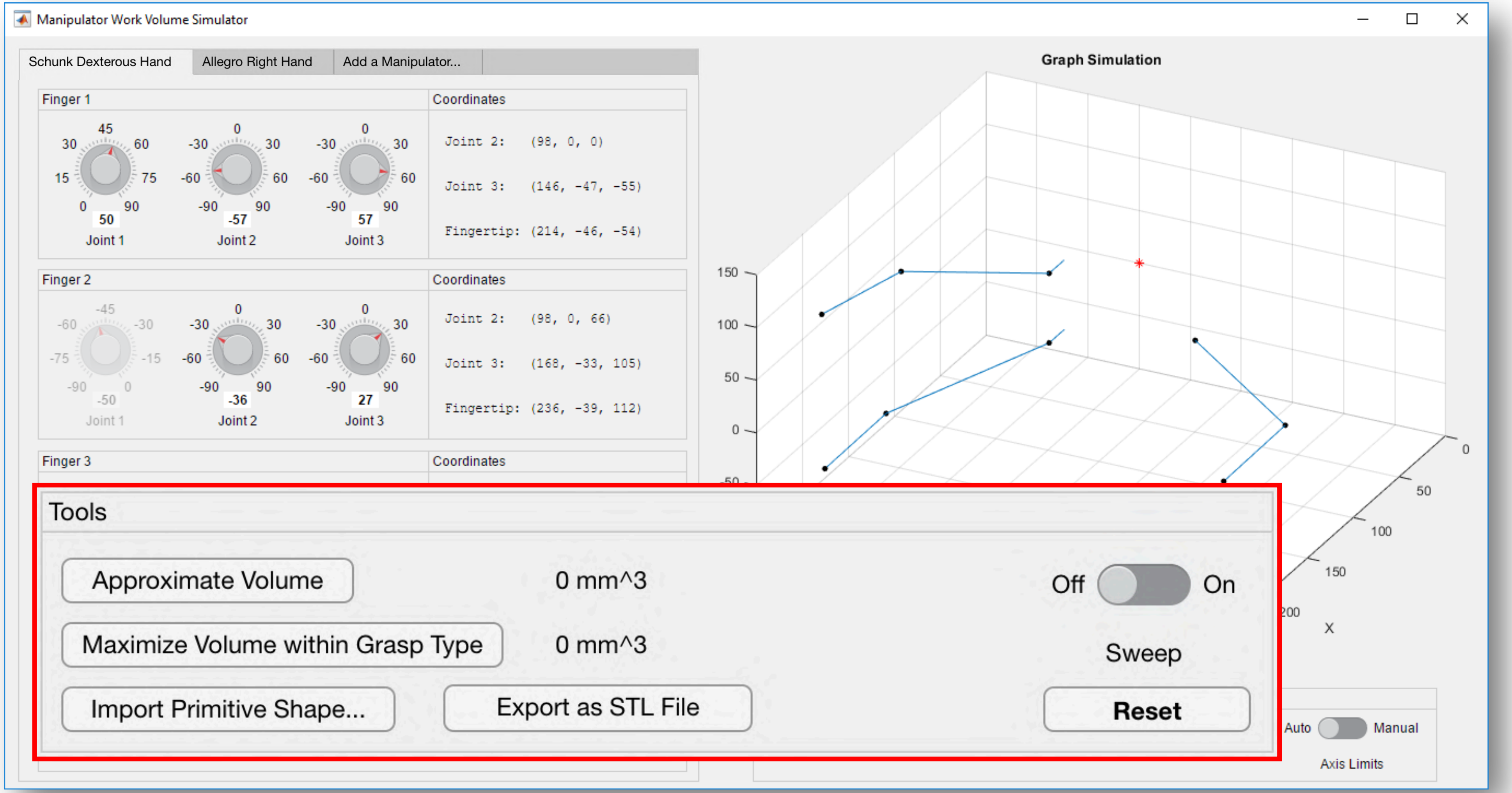
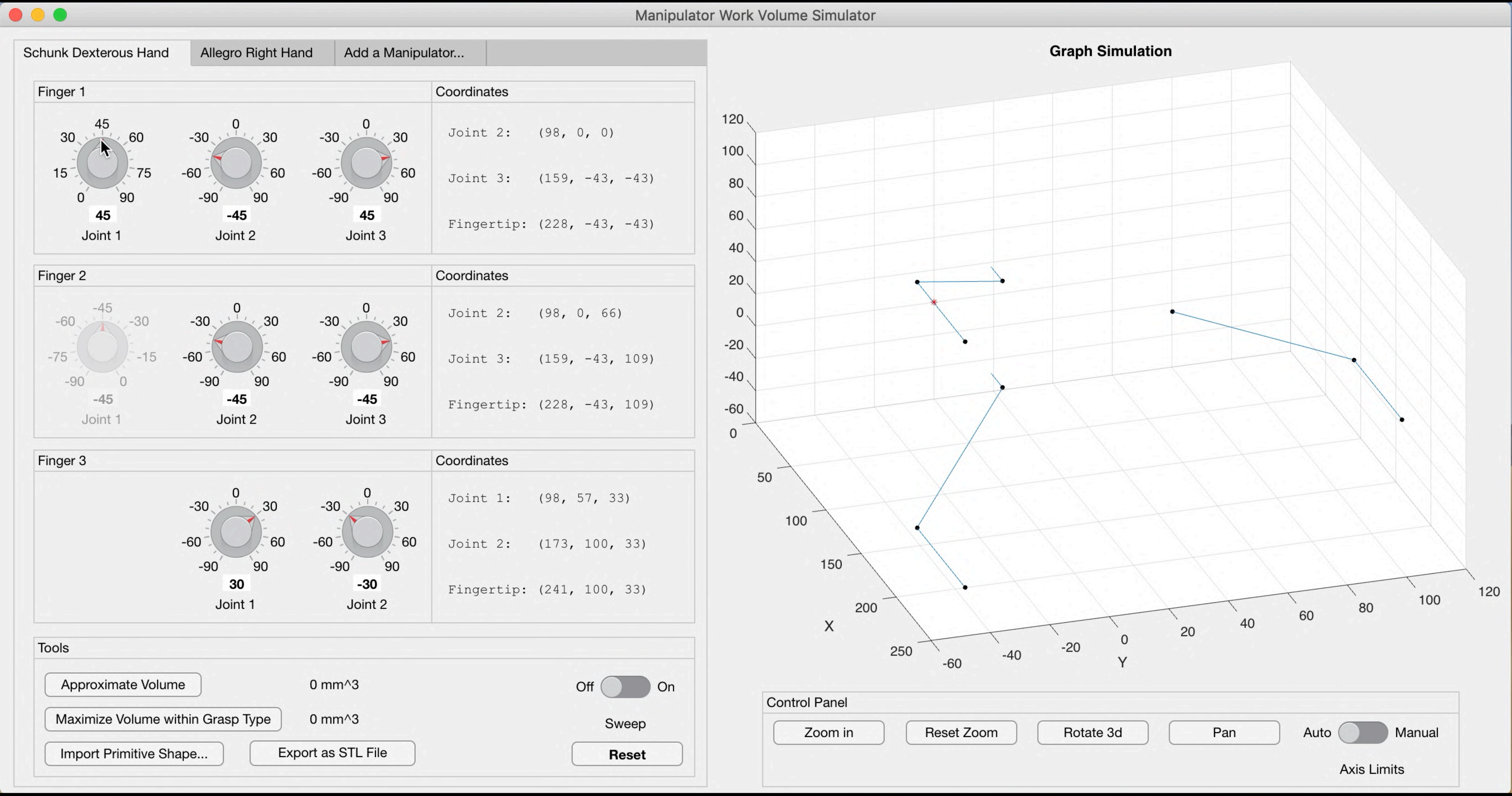
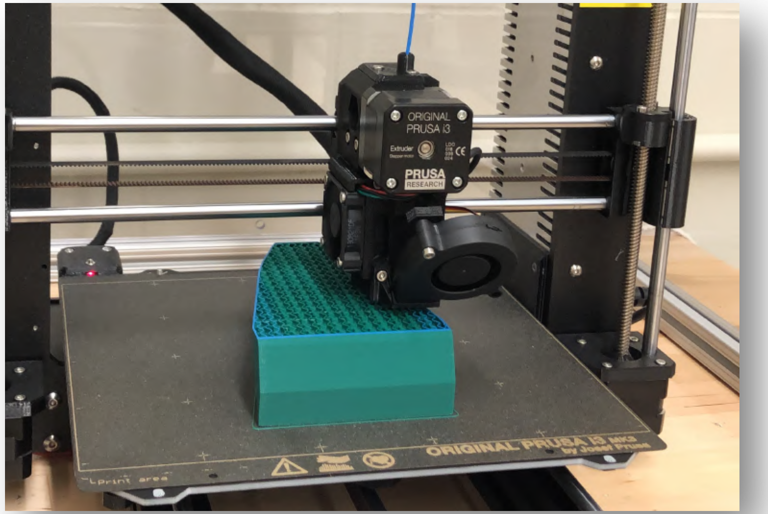
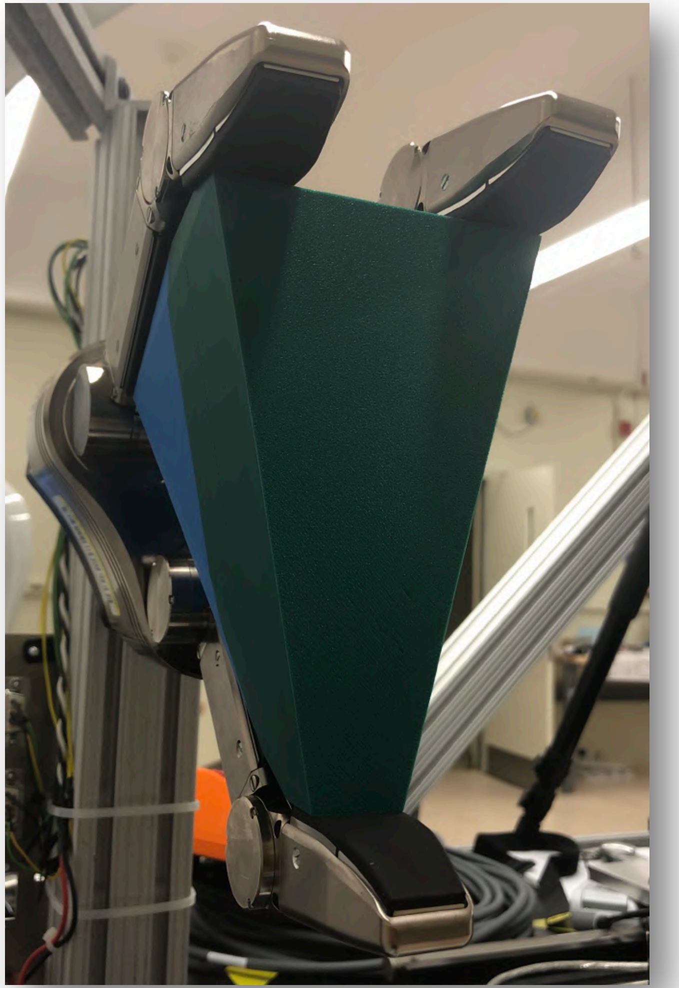


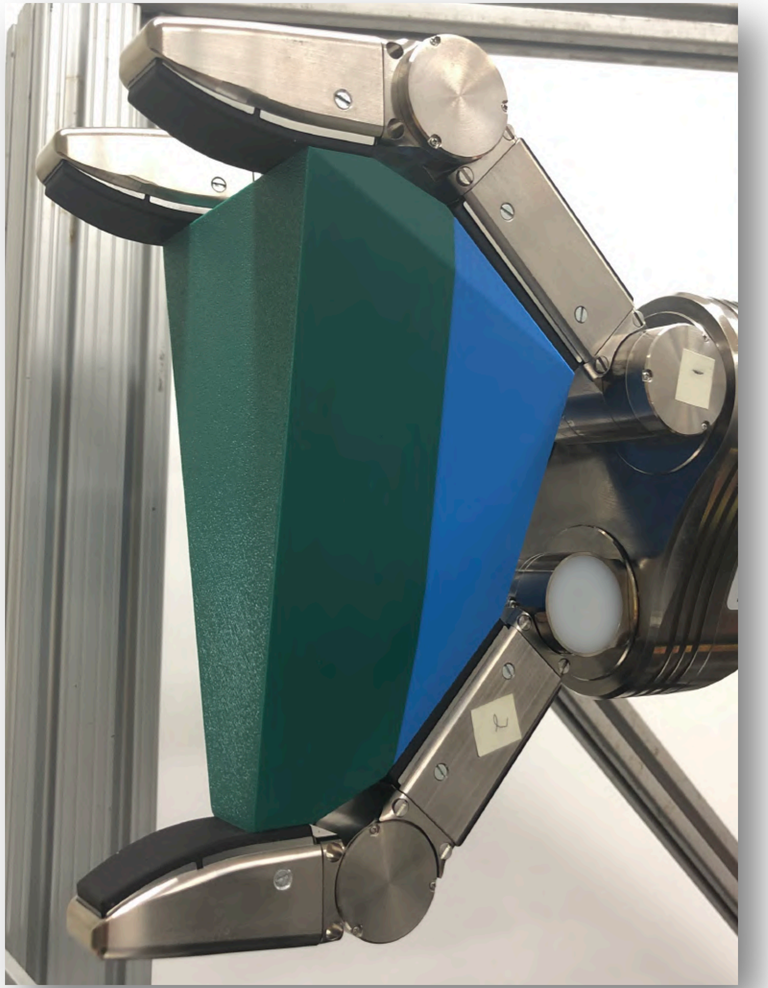

Manipulator Work Volume Simulator
Schunk Dexterous Hand
Allegro Right Hand
Add a Manipulator...
Finger 1
Joint 1
45
Joint 2
-45
Joint 3
45
Coordinates
Joint 2: (98, 0, 0)
Joint 3: (159, -43, -43)
Fingertip: (228, -43, -43)
Finger 2
Joint 1
-45
Joint 2
-45
Joint 3
-45
Coordinates
Joint 2: (98, 0, 66)
Joint 3: (159, -43, 109)
Fingertip: (228, -43, 109)
Finger 3
Joint 1
30
Joint 2
-30
Coordinates
Joint 1: (98, 57, 33)
Joint 2: (173, 100, 33)
Fingertip: (241, 100, 33)
Tools
Approximate Volume
0 mm^3
Maximize Volume within Grasp Type
0 mm^3
Import Primitive Shape...
Export as STL File
Off
On
Sweep
Reset
Graph Simulation
X
Y
Control Panel
Zoom in
Reset Zoom
Rotate 3d
Pan
Auto
Manual
Axis Limits

Results, Continued

- Mathematics are correct and precise
- Functions continue to be implemented







Continued Work

- Using the SDH as a proof of concept
- Method 2 implemented in WoVoS
- Robustness
- Minimum Volume
- Work Volume of a hand and its metrics and test methods continues to be refined by the project team

More Information and Acknowledgements

Kenny Kimble

Omar Aboul-Enein

https://www.nist.gov/programs-projects/measurement-science-manufacturing-robotics

https://www.nist.gov/publications/performance-metrics-and-test-m
ethods-robotic-hands-draft

Repo: https://github.com/adamwathieu-bit/manipulator-work-volume.git