

Executive Summary

At Roboflow, we are designed and delivered an automated end-of-arm tool change system for the Omron TM5-900 robot. The robot has an exchangeable tooling that interacts with the space around it called end effectors. One of these end effectors, the two-finger gripper, contains exchangeable fingers that can be replaced. An operator must carry out tooling changes as there is no automatic process to change either end effectors or fingers. There were two main goals of this project: to create an automatic End Effector Change Process and Finger Change Process for the robot. Deliverables included design and fabrication of the tool stand, design and implementation of the robot program, and a demonstration of the robot's abilities. The deliverables have been met with the complete design, fabrication, and implementation of the two systems.

Background

The client proposed a system where the robot can switch roles throughout the day. Previously, these role transitions were not possible without manual intervention. The robot has 3 End effectors and 11 finger sets that had to be manually changed, increasing time spent doing manual work. Commercial solutions, such as the Atlas FLEX Finger Tooling Kit, use standardized bases, swivel clamps, and interchangeable crossbars to allow rapid finger reconfiguration (Atlas Technologies, 2023). However, these systems are designed to be changed manually. This reliance on human input still introduces downtime and limits true autonomy.

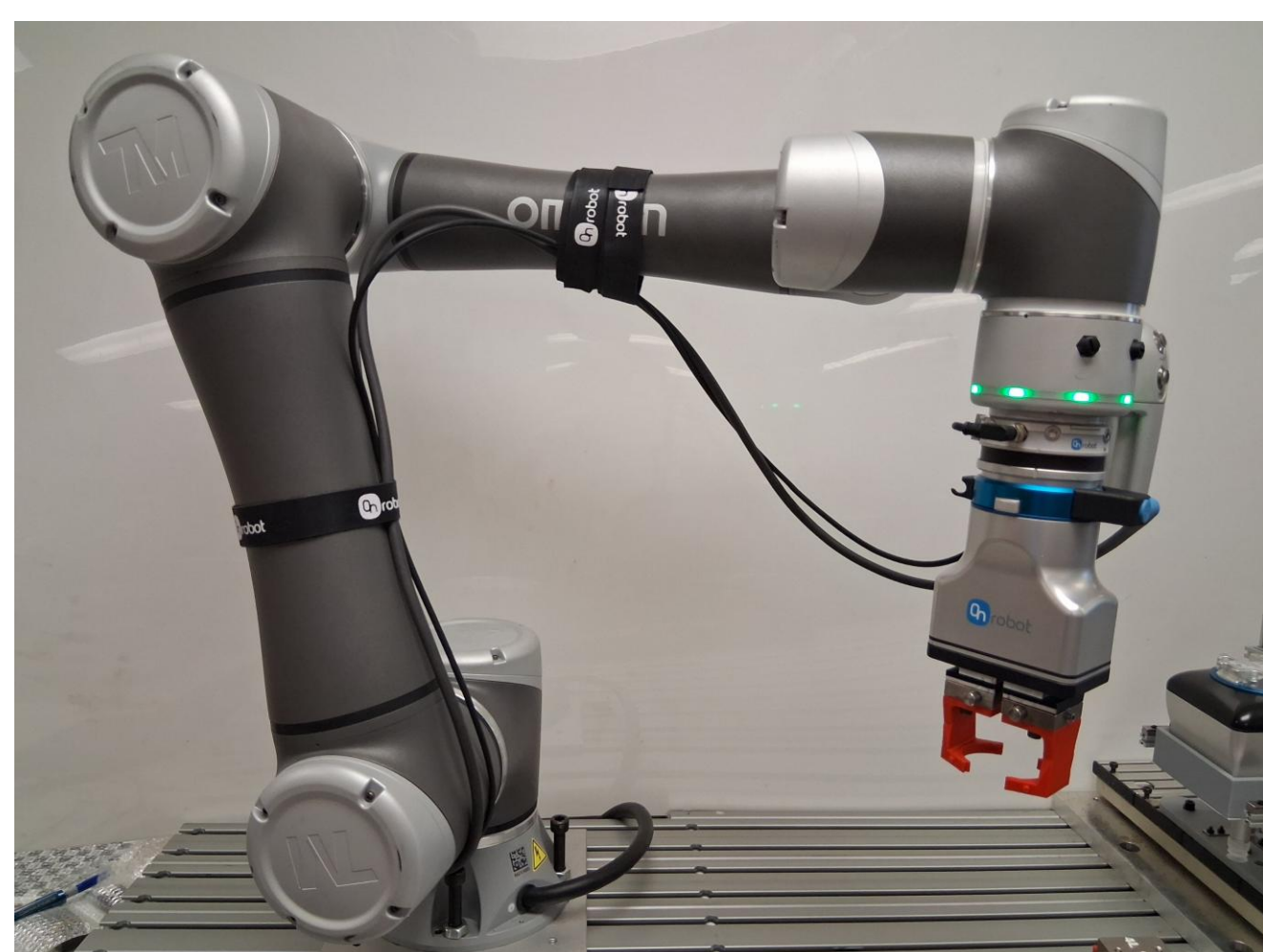


Figure 1. Omron TM5-900

Building on the same principles of modularity, our project takes the next step by automating the changeover process. The Omron TM5-900 cobot was be programmed to dock into custom tool stands and execute both end-effector changes and finger changes without human intervention.

Project Setup

There are two processes, one for changing end effectors and one for changing the finger set equipped on the “two-finger gripper”. These must be automatic, >95% successful, and not damage any equipment during use.

Constraints:

1. Robot itself can't be modified
2. Robot cannot exert a force of >150N (Omron, 35)

Initial analyses – The robot can actuate its own external mechanical releases (~40N) using its own force. This means the robot does not need an external device to release and attach its end effectors.



Figure 2. Robot Equipped with Two Finger Gripper and Three Finger Gripper (left, right)

Process Design Plan

Finger Change Process

The FCP uses force sensing to determine if removal of fingers from the stand is successful. If fingers aren't free after an initial pull, the robot will oscillate and free the fingers from the stand. If the robot can't free the fingers, it will replace fingers and attempt again from the start.

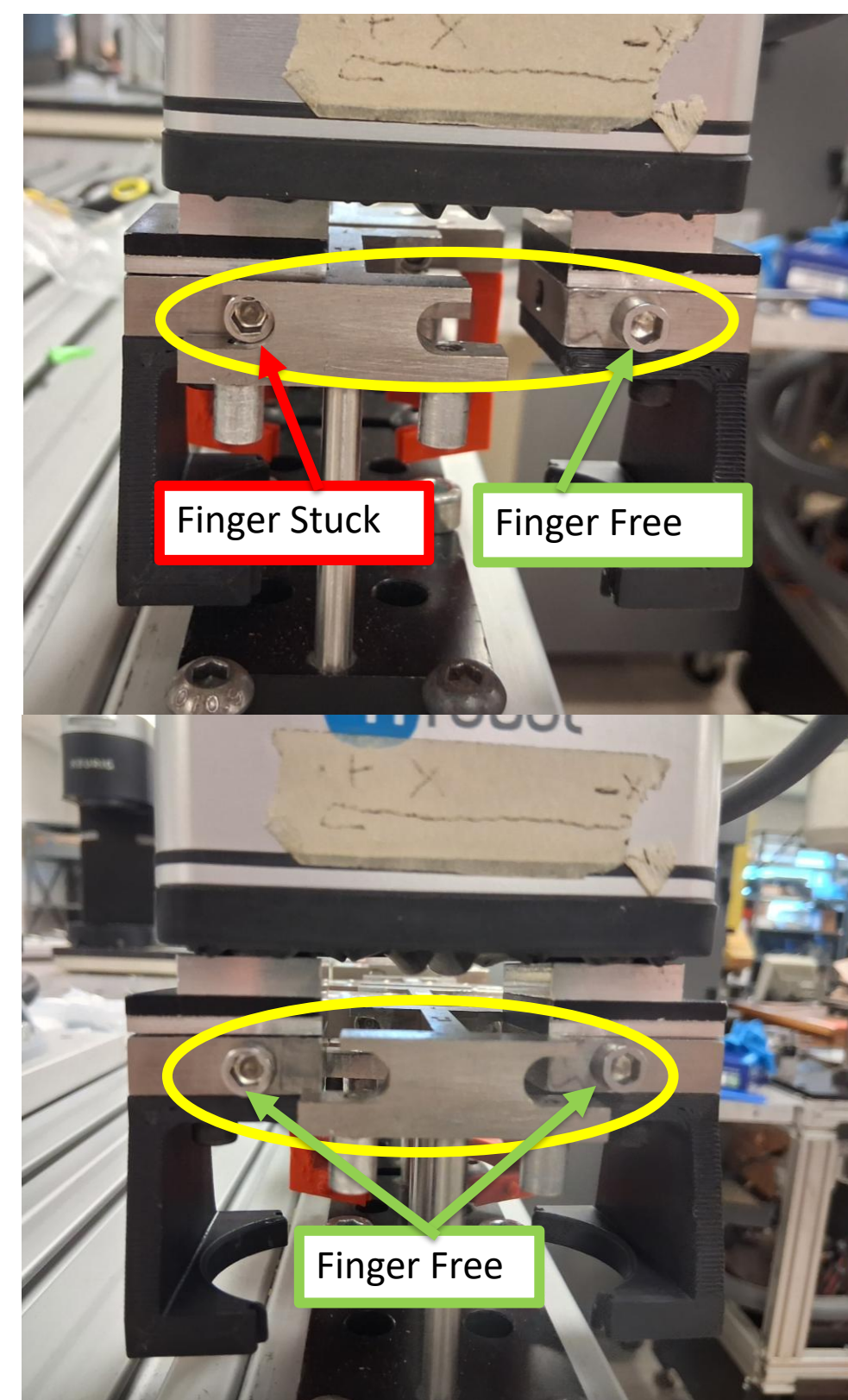


Figure 3. Unsuccessful Finger Change vs. Successful Finger Change (top, bottom)

The FCP is the exact same process for all 11 finger sets. This allows for more flexibility with adding, removing, relocating, or changing stands.

End Effector Change Process

The EECF has a dynamic stand built to allow for mechanical actuation of end effector attachment buttons. The Robot manipulates the end effector against stand to activate the release button.

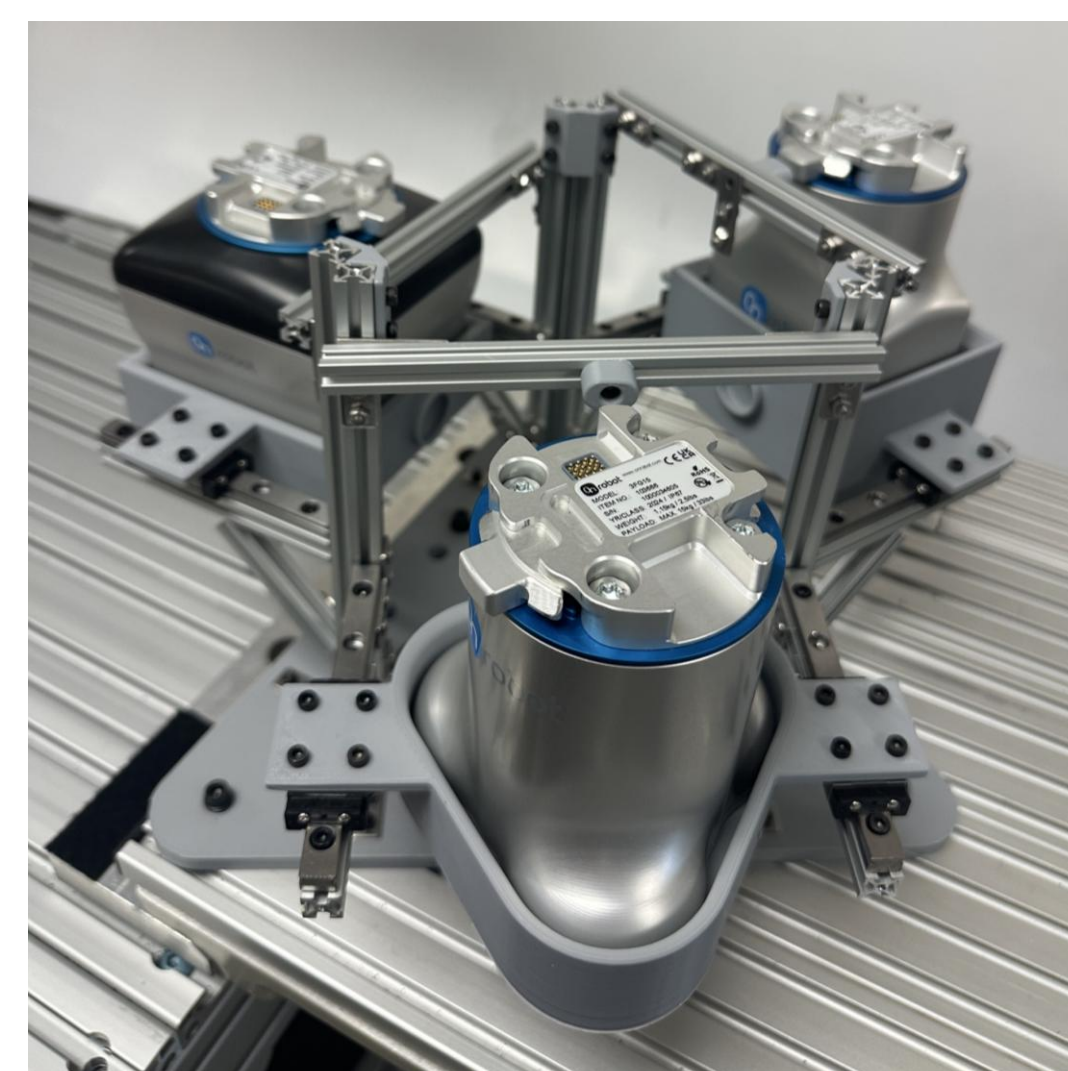


Figure 4. End Effector Change Stand

To remove an end effector, the robot first lowers the end effector into the stand. Then, the robot actuates the release button by pressing itself against stand. Finally, the robot maneuvers its way out of the stand, leaving the end effector behind. To pick up an end effector, it does the entire process in reverse. The EECF is similar to the FCP in that it uses the same process for all the end effectors, allowing for more flexibility with making system wide changes.

Experimental Results

Finger Change Process

Finger Change Process characteristics:

1. Success rate: 98.6% (305/310)
2. Implementation: 10/11 stands
3. Cycle time: ~10 seconds
4. Failure results in retry



Figure 5. The robot after freeing a finger set from its stand

The FCP was able to be implemented on 10 of the 11 finger sets given. When the robot is unable to free a finger set, it replaces the finger set fully in the stand and tries again. No force overloads have been recorded during the process.

End Effector Change Process

Preliminary success has been shown with currently ~10 successful operations for all 3 end effectors.

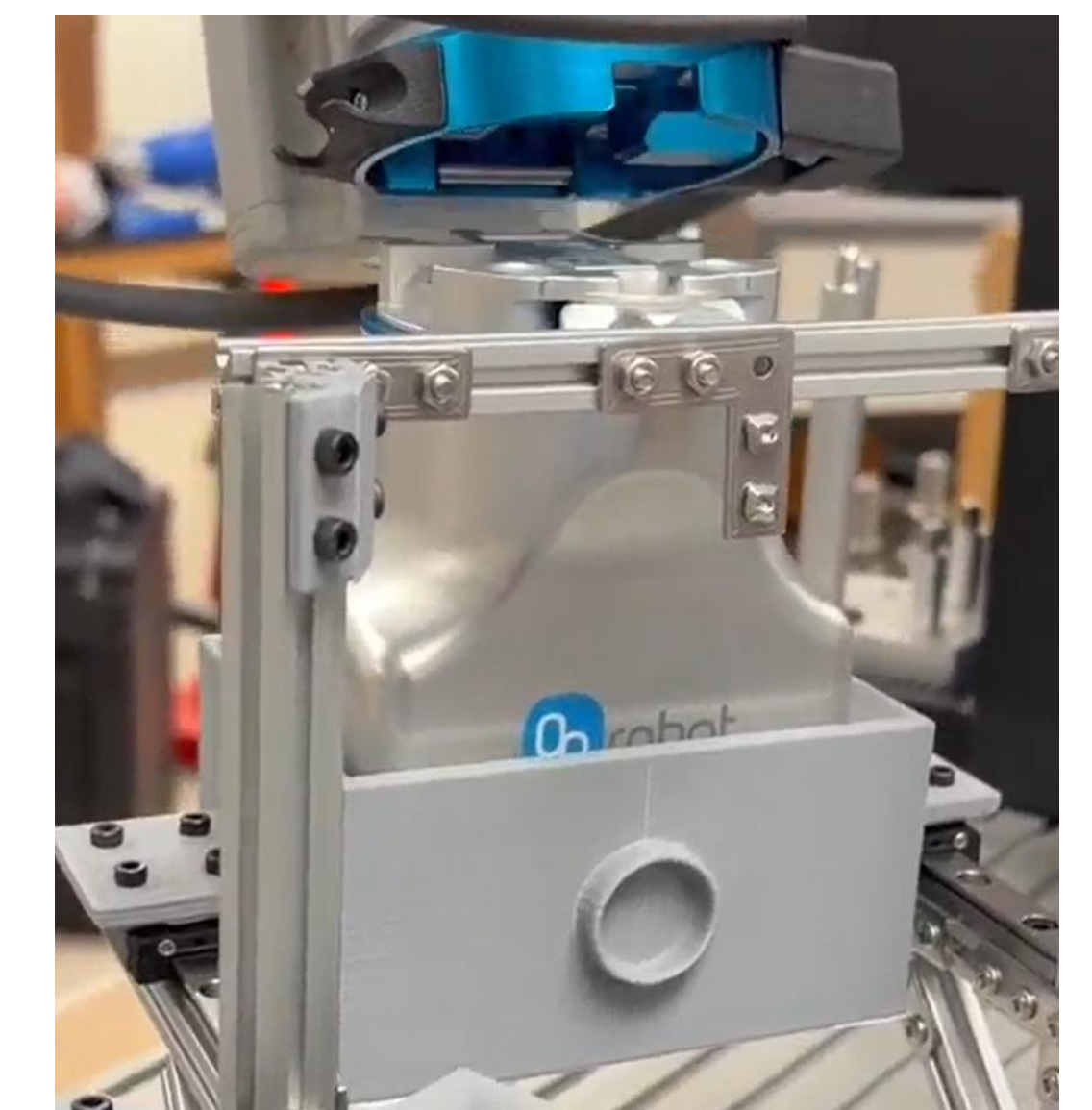


Figure 6. The robot after placing the Two Finger Gripper in its stand

A key thing to note is that the EECF does induce wear on specifically the Two Finger Gripper. Due to friction while inserting the end effector into the stand, one of outward facing rubber seals has visibly worn.

Conclusions

The project was an overall success as most of the desired characteristics were met. Our client, Dr. Huff, has accepted the system and is now looking to integrate it with other projects in his laboratory.

We had general success in using exact same process in all stands. With the FCP, the stands were already provided. The uniformity of the stands depended on their condition. Due to major differences in stand condition for one stand, we were unable to apply the same process to all stands. With the EECF, the stands were designed and created by our team, allowing for the physical stand to be designed with the intent of being used in the process. Being able to design the entire system in the EECF allowed us to easier apply one robot program to multiple different end effectors.

We also had success with using the force sensors for force informed motion. Given that the resolution of the force sensor (<1N) was much smaller than the magnitudes of forces needed to be detected (>20N), we were able to reliably use the force sensor to determine the robot's state. Using this force information, the robot was then able to make changes in its pathway to correct itself or abort the process safely.

References

- “Flex Finger Tooling.” *Atlas Technologies*, Atlas Technologies, 19 Sept. 2023, atlastechnologies.com/flex-finger-tooling.
- “Original Instruction Regular Payload Series Hardware Installation Manual.” *Omron*, Omron, files.omron.eu/downloads/latest/manual/en/i623_tm5_series_installation_manual_en.pdf?v=2. Accessed 7 Apr. 2026.