Team 5 - Gripper

Awab A., Borna M., Param O., Aman D.

EGR 557

Dr. Daniel Aukes

# Developing a Research Question

## Research Question

Can a mechanically-actuated (non-metallic) foldable mechanism be used as a gripper, have as much holding torque as a soft pneumatic gripper?

## Tractability

The design is inspired by the BYU oriceps design [1]. The constraints revolve around the optimization of mechanical components for creating a state of equilibrium. While in this state, a small force in either direction can shift the balance and moment of the system. The goal is to prototype this mechanism with the least cost. Current estimation is that the final product would cost less than $30. To make the project feasible we plan on using widely available materials such as PLA, ABS, PTEG, laminates for the body of the gripper. Mechanical parts such as springs or fasteners may be used to strengthen the joints on the gripper.

The gripper mechanism is constructed of electro-mechanical components that help with the actuation of foldable mechanisms. Since pneumatic actuators utilize pressure differences to create torque, this mechanism needs to incorporate external components to increase the translated torque within its kinematic motion. Components such as springs, silicon parts for creating tension, 3D printed bodies, and laminate links help us substitute pneumatics with torsional mechanisms.

## Novelty

<u>Keywords:</u>

- Forceps
- Origami
- Robot Gripper
- Foldable
- Kirigami
- Medical

<u>Highly Cited Sources:</u>

1. **An Origami-Inspired Monolithic Soft Gripper Based on Geometric Design Method [2]:**
   Soft end-effectors have great potential with many applications due to their capabilities while maintaining simplicity, the speed with fabrication time, and low cost of production. This journal focuses on combining origami with 3D printed soft robotics to develop a gripper that is able to form around the object it intends to grab. Two tests are performed to test the grippers capability and the research demonstrates the gripping capabilities with daily objects.

2. **Oriceps: Origami-Inspired Forceps [3]:**
   This paper talks about the development of a monolithic forcep that can be used for minimally invasive surgery. Current forceps are challenging to manufacture due to their complexity and size and can also be difficult to maintain due to the nature of their use. Hence, there is a use for tools that are inexpensive, scalable, and require less maintenance. The oriceps are created using a single planar sheet of material and a single input force is used to create the clamping motion. The main design objectives that were finalized were mechanical advantage, material suitability, product scalability, and mechanism stiffness. This design can be manufactured at a large scale and be used in applications on the micro and macro scales. Potential future work includes considering smart materials in the design and how they can be applied.

3. **Mechanically Programmed Miniature Origami Grippers [4]:**
   This paper focuses on the development of a new adjustable gripper that uses a single actuator input for one degree of freedom motion. The gripper itself is developed from a laser cut of a laminate fold. This mechanism works based on a transfer function that determines the range of motion of the gripper. The mechanism implements torsional springs to release the grip. Tendons attached to a motor shaft translate the rotary motion to linear motion of the gripper ends. The tension on the tendons, the torsion of the spring, and the dimension of the folds determine the kinematic properties in the mechanism.

4. **A 3D printable Robotic Gripper Based on Thick Panel Origami [5]:**
   This paper focuses on the development of an origami gripper based on the kinematics of thick panel origami. The gripper was designed to make the experimental kinematics more accurate because normal origami gripper motions are not too accurate, so the gripper uses a water bomb origami design in which 4 legs are used to maximize the gripping strength. The thickness of the legs also further reduce the degrees of freedom of the overall gripper and thereby reduce the wear and tear normal origami grippers face due to their high level of degrees

of freedom and complex kinematics. The gripper used four 3d printed TPU legs and was tested on symmetrical and asymmetrical materials, and the experimental results were accurate with analytical results.

## Interesting

The question is important because such a gripper can be used in many different fields and create a greater impact in the field. The question is important now because of the greater dependence on human and robot interaction to achieve common goals. The advancement in technology has allowed humans to enhance their capabilities to achieve different tasks in fields such as medicine and space exploration. Such human-robot interaction was not present 10 years ago, thus, there was no need for a solution to this problem. A delicate yet strong gripper is needed to complete certain tasks with precision. Furthermore, being lightweight and modular, such a gripper should eliminate unnecessary costs and encourage similar actuation methods. For the general public, an inexpensive gripper could be used to generate interest in the masses and used for educational purposes, while ensuring the safety of the users.

## Open-Ended

Yes, the question remains open-ended as it allows researchers to discuss multiple possibilities to achieve the goal. Further research could include methods to make the design stronger, better actuated, and more modular to fit in multiple fields. Provided enough time and resources, better actuation methods and materials can be tested and compared to make the design more lightweight, stronger, and designed for different applications. The research question is structured in a way that allows us to investigate various mechanisms and methods without being limited to certain mechanisms or techniques.

## Modular

Yes, the question is modular because the gripper could be made into one part of a larger project, a lightweight robot arm that is strong while using foldable robotics techniques. There are a wide number of fields in which such devices could be used, for example, space applications could benefit greatly from a lightweight robot arm/gripper that is able to carry heavy-weight objects while being gentle and able to handle delicate or fragile objects.

## Team Fit

Mechanical mechanisms are a common topic of interest among all team members. Some team members are very skilled with mechanical mechanisms, while others have experience with folding mechanisms and origami. We believe that combining the skills with fabrication techniques we gain from the class could lead to a successful project that functions as intended.

## Topic Fit

The question looks to explore origami-inspired mechanisms to actuate a gripper. While the team plans on using springs to aid the gripper, the gripper will be strictly a mechanical mechanism made out of materials and techniques commonly used in foldable robotics, such as laminates, plastics, and 3D printed parts.

## Citations


[1] “Origami inspires tiny medical devices - youtube.” [Online]. Available: https://www.youtube.com/watch?v=L_9BDZ6ZBwk. [Accessed: 07-Feb-2022].

[2] Z. Kan, Y. Zhang, Y. Yang, Y. A. Tse and M. Y. Wang, "An Origami-Inspired Monolithic Soft Gripper Based on Geometric Design Method," *2019 2nd IEEE International Conference on Soft Robotics (RoboSoft),* 2019, pp. 470-476, doi: 10.1109/ROBOSOFT.2019.8722746.

[3] B. J. Edmondson, L. A. Bowen, C. L. Grames, S. P. Magleby, L. L. Howell, and T. C. Bateman, “Oriceps: Origami-inspired forceps,” *Volume 1: Development and Characterization of Multifunctional Materials; Modeling, Simulation and Control of Adaptive Systems; Integrated System Design and Implementation,* 2013.

[4] Orlofsky, C. Liu, S. Kamrava, A. Vaziri and S. M. Felton, "Mechanically Programmed Miniature Origami Grippers," *2020 IEEE International Conference on Robotics and Automation (ICRA)*, 2020, pp. 2872-2878, doi: 10.1109/ICRA40945.2020.9196545.

[5] C. Liu, P. Maiolino, and Z. You, “A 3D-printable robotic gripper based on thick panel origami,” *Frontiers in Robotics and AI*, vol. 8, 2021.