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Portfolio
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JWR

Contents

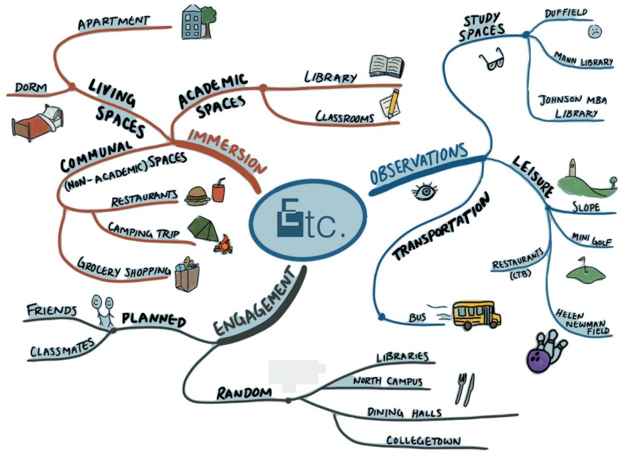
/w **The Terrain Table**—a table to support students

In a class project for Innovative Product Design via Digital Manufacturing, my team and I developed a product meant to improve the lives of university students. We were tasked with **redesigning the student experience** so that they may thrive on campus. This process was broken down into need finding/empathy fieldwork, ideation, brand development, and fabrication/final design. This project melded design thinking methods, systems engineering techniques, and mechanical engineering to arrive at a final optimized product. The project was realized over the course of a semester and was completed in collaboration with Stephanie Young, Dani Weisenfeld, Gabriella Passarelli, Neil Ramasray, Chase Collins, Sabrina Morse, and Ashley Paton.

Final prototype in folded position

/w User research, needfinding, and brainstorming

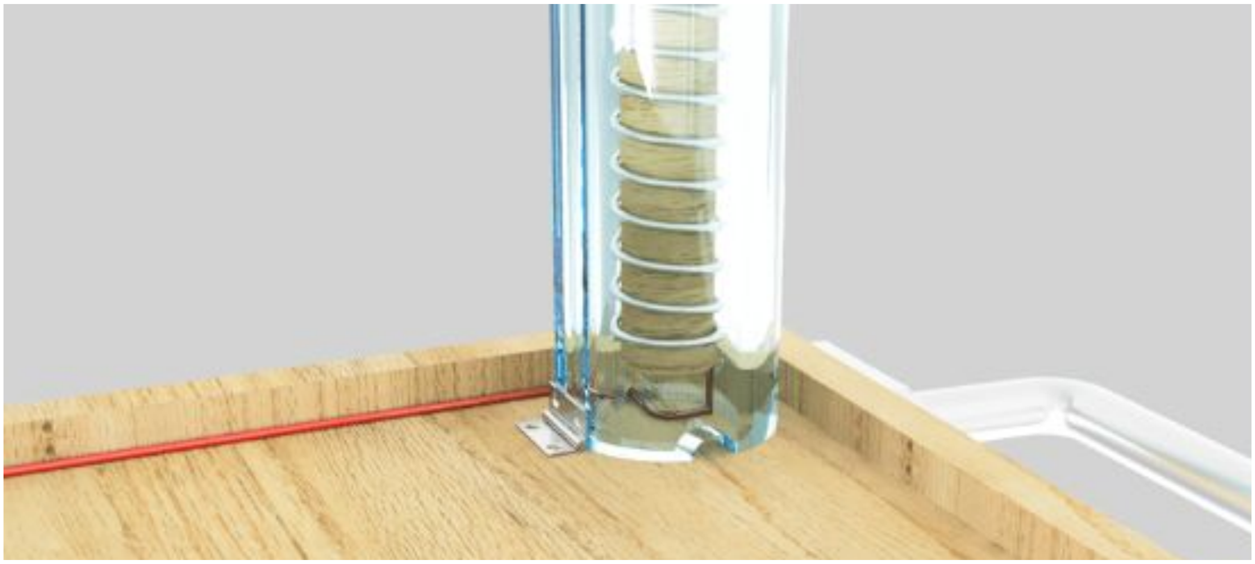
The design process began with **empathy fieldwork**, as all 8 team members attempted to understand the needs and desires of students on the Cornell campus. Fieldwork involved student interviews, observations of common areas, and reflections on our own experiences.



We recognized the value in designing a product which could facilitate **a healthy social life** and enable students to spend more **time outside**. We brainstormed ideas, and I proposed an adjustable table capable of maintaining a level surface on any slope. This table would allow students to meet with friends, complete assignments, or simply have lunch in any outdoor environment. We developed a rough paper prototype to explore the feasibility of the design and better understand the user experience.

Rough prototype (Design 0) in action on a sloped surface

/w Modeling and key mechanisms



Close up of the spring (silver)-string (red) interaction and the outer leg housing geometry

From a mechanical perspective, the final design would feature four auto-leveling legs. Inspired by the mechanisms commonly found in ladders, each leg included a spring-washer system which, when actuated by a string, allowed each leg to slide freely to the ground. The springs maintained an internal washer at a non-perpendicular angle with the axis of the inner leg . By designing for a small clearance between the concentric washer and inner leg, the angled washer imposed a friction force on the leg and locked it in place. Pulling the string realigned the plane of the washer to be perpendicular with the leg, allowing free movement and removing the interference. My contributions to the 3D modeling were focused on the outer leg enclosure (pictured in grey) and the multi-degree of freedom feet.

/w Final prototype, design features, and branding

To contextualize our product development, our team chose the brand name **Et Cetera**, representing the intersection of our different skill sets. Together, we synthesized expertise in design, engineering, and more.

3D printed lattice feet

Features

/a Compliant Lattice Feet
[3D printed, multi-degree of freedom feet enabled compliance with any surface geometry]

/b Folding features
[Concealed hinges at all four legs and along the middle of the table minimize the size and improve portability]

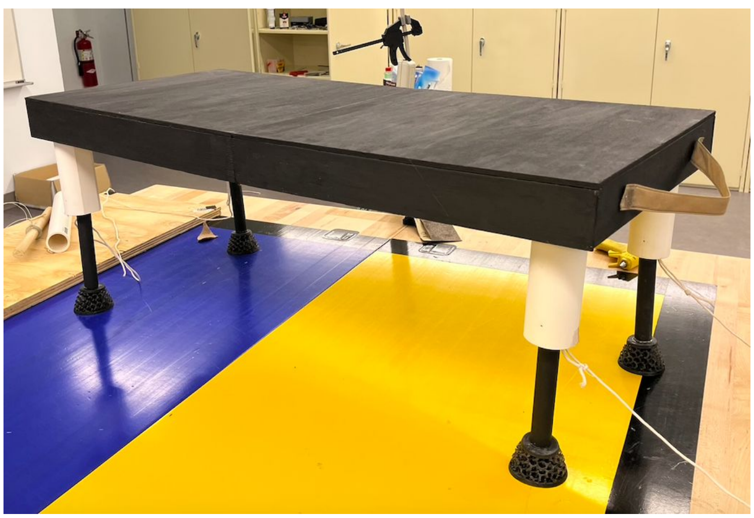
/c Integrated Table Level
[Table level enables visual confirmation of a level surface]

/d Self Leveling Mechanism
[Hidden spring-washer mechanism with tension release allows for automatic leveling at the pull of a string]

Folded view of Terrain Table

The final design was optimized for a seamless user experience. Integrating key features established via a conjoint analysis survey, the product was finalized and presented to the class. While not mentioned for brevity, further work investigated the manufacturing process for such a product, a competitor analysis, and potential legal concerns for product development.

/w Final presentation and physical model



In an end of semester final symposium, Et Cetera presented the **Terrain Table** to the class and select industry professionals.

While not all features of the ideal design were included in the physical model, the design won third place in the competition.

/x Adjustable, accessible hairbrush—**Soulo**

Functional Prototype Features

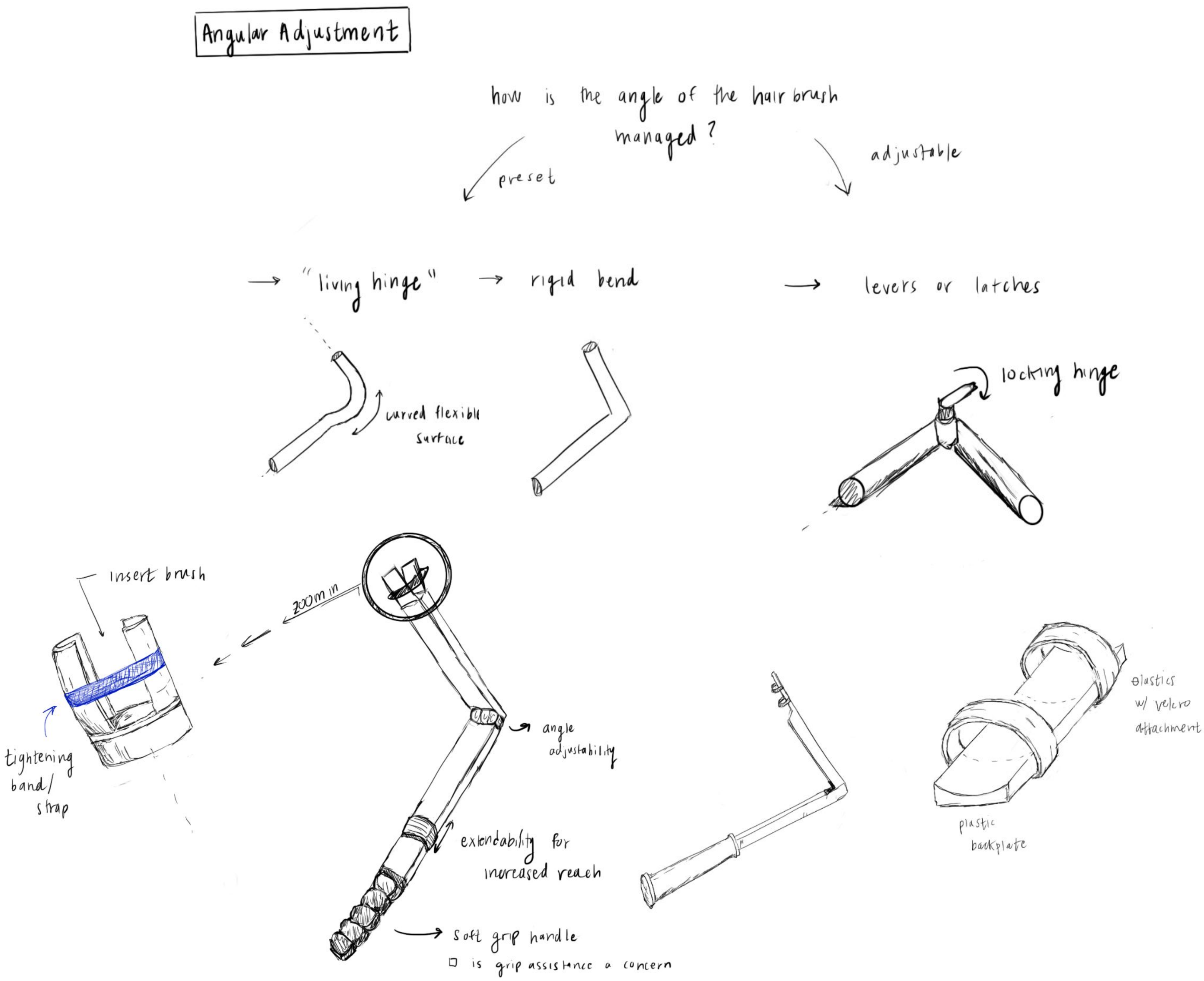
/a Tapered Handle
[Conical handle with ergonomic grip]

/b Angle Adjustability
[Twist locking hinge allows for variable angle position]

/c Brush Attachment
[Detachable brush head may be exchanged for other **Soulo designed brush attachments**]

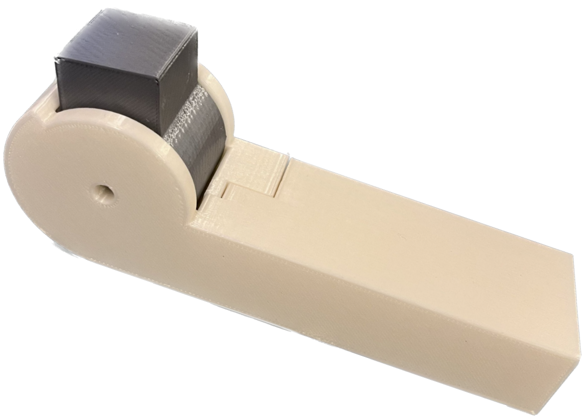
As a mechanical engineering intern with the design and innovation startup **Soulo**, I lead the early development of a new product. I spent months designing and fabricating prototypes of a hinged, adjustable hairbrush intended for users with limited mobility. In collaboration with Everhome, a company dedicated to elderly home care, we developed this hairbrush principally to accommodate the needs of one of their clients who has severely limited hand and shoulder dexterity. Through extensive user research and ideation, we developed an early prototype that could help the client and other users suffering from similar ailments brush their hair independently.

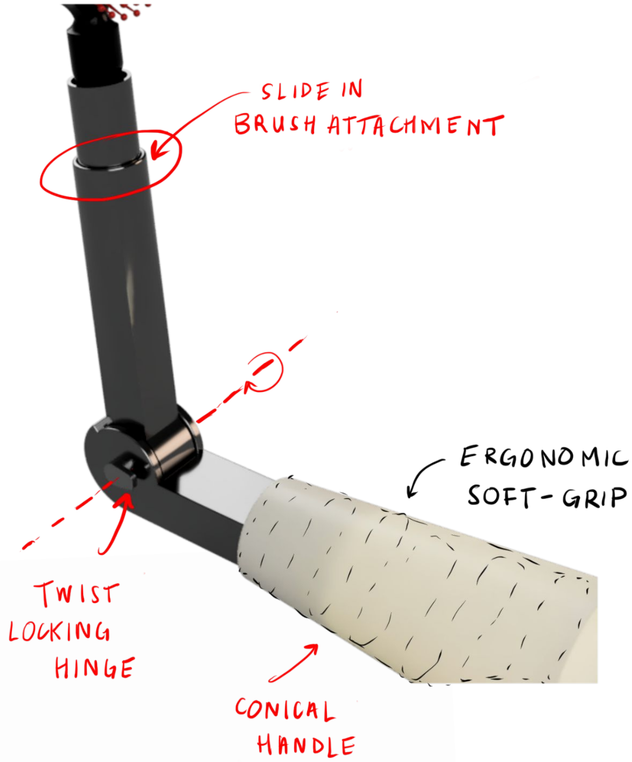
/x Early product development and ideation

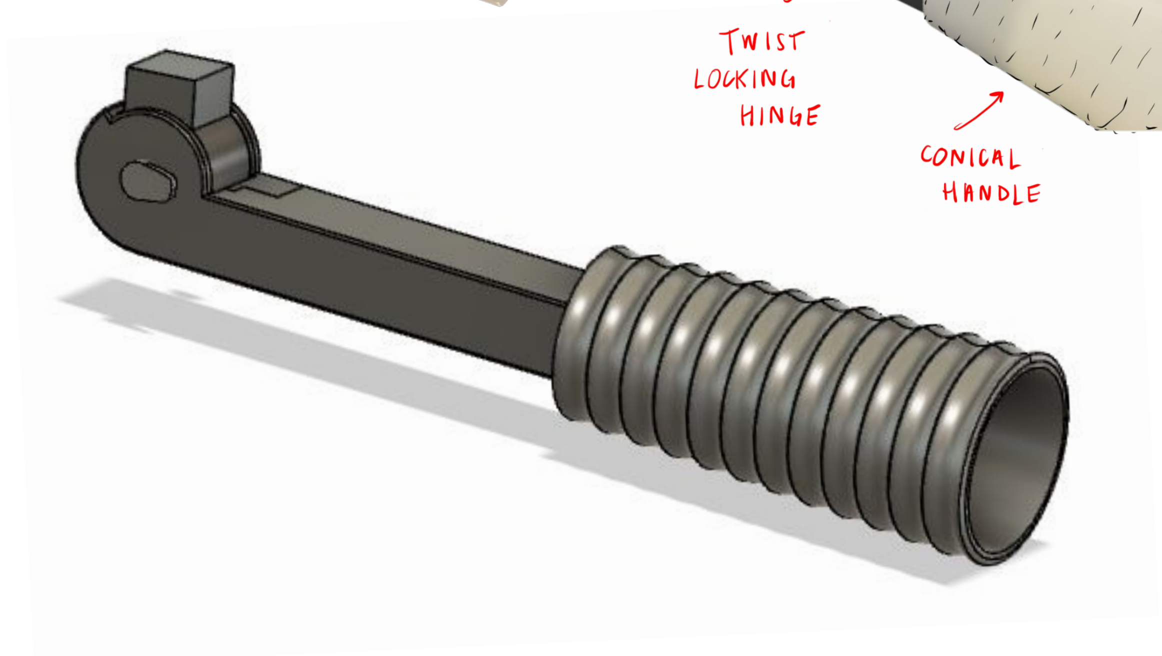


Development focused primarily on two key hairbrush features: angular adjustability and the brush attachment, with priority given to the angularity of the brush. The angularity of the hairbrush, as validated by our client, was essential to effectively brushing the back of the head without extensive arm or shoulder movement. Multiple designs were considered to address this user need, such as flexible 'living hinges', rigid structures, and adjustable locking hinges. A locking hinge design inspired by disc brakes in bicycles was selected due to the simultaneous improved structural rigidity and variable angle adjustability. Collectively, we decided the brush attachment would require more long term development internally to manufacture a set of proprietary brush head inserts for different hair types and styling needs.

/x Presented prototype and future plans

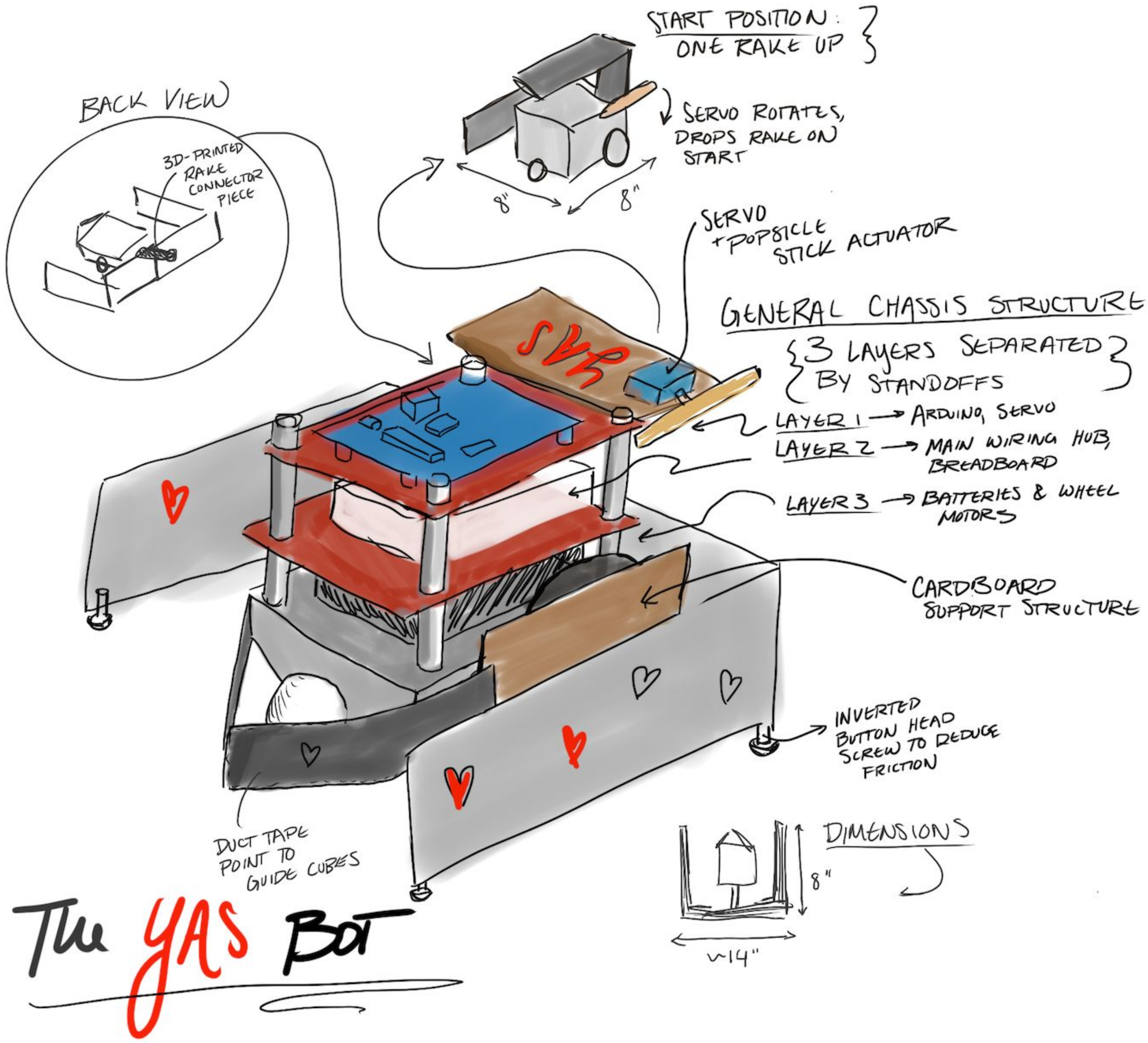






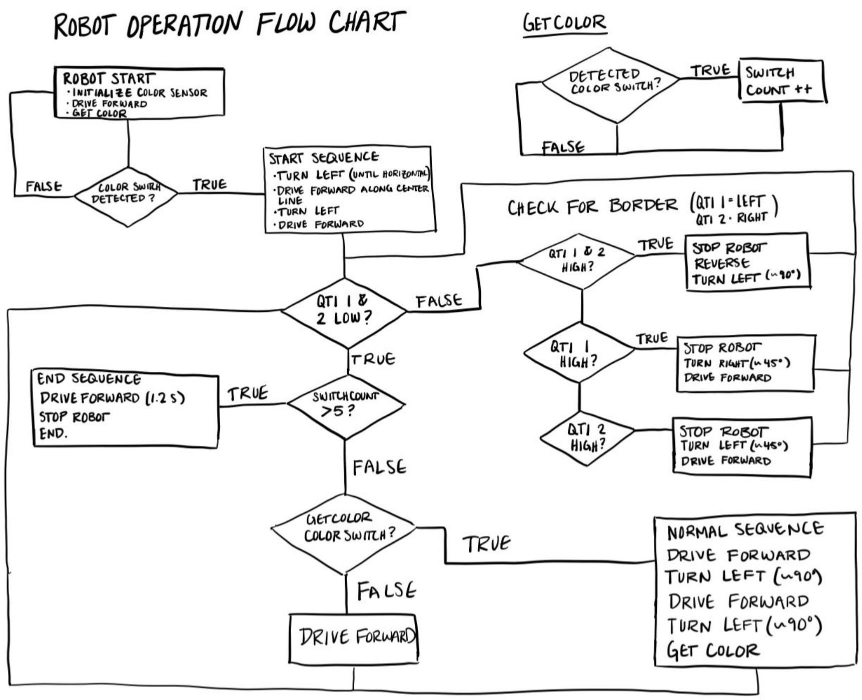
By the end of my internship with **Soulo**, I had developed a variety of successful features to be implemented on the hairbrush. While the actual hair brush attachment and ultimate product styling would be addressed by a collaborating industrial designer (Ivan de Leon), the hinge locking mechanism proved to be a versatile and robust feature which could ensure compatibility with a variety of users. Additionally, the conical, ergonomic grip design was successfully tested and developed using compliant TPU filament for a comfortable, easy-to-grip feel. We plan to submit a provisional patent for the presented design in 2024.

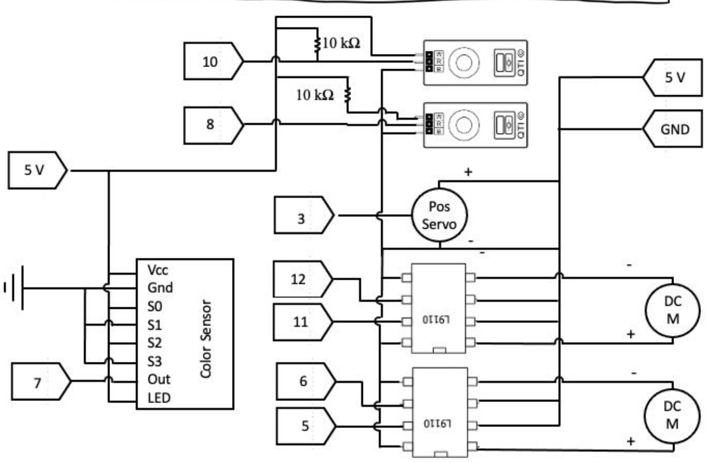
/y An autonomous mobile robot: **Yas-bot**



For a class project in Mechatronics, my team and I were tasked with developing an autonomous mobile robot to compete in the Cube Craze—a competition where robots would compete to gather the most cubes on their side of a game board. This multi-month project challenged our group to develop a sophisticated robot using electronic sensing to efficiently gather cubes. Synthesizing mechanical and electronic design, my group built a robot reliant on color sensing (relevant to the colors of the game board). We developed an algorithm to command the robots motion based on the color sensor feedback, performing preset maneuvers depending on the position of the robot on the board (home, away, or leaving the board). From a mechanical perspective, the robot featured an aluminum rake which was used to gather cubes passively as the robot traversed the board. This rake was deployed from an upright position to comply with the initial robot sizing constraints.

/y Robot algorithm and electronic design

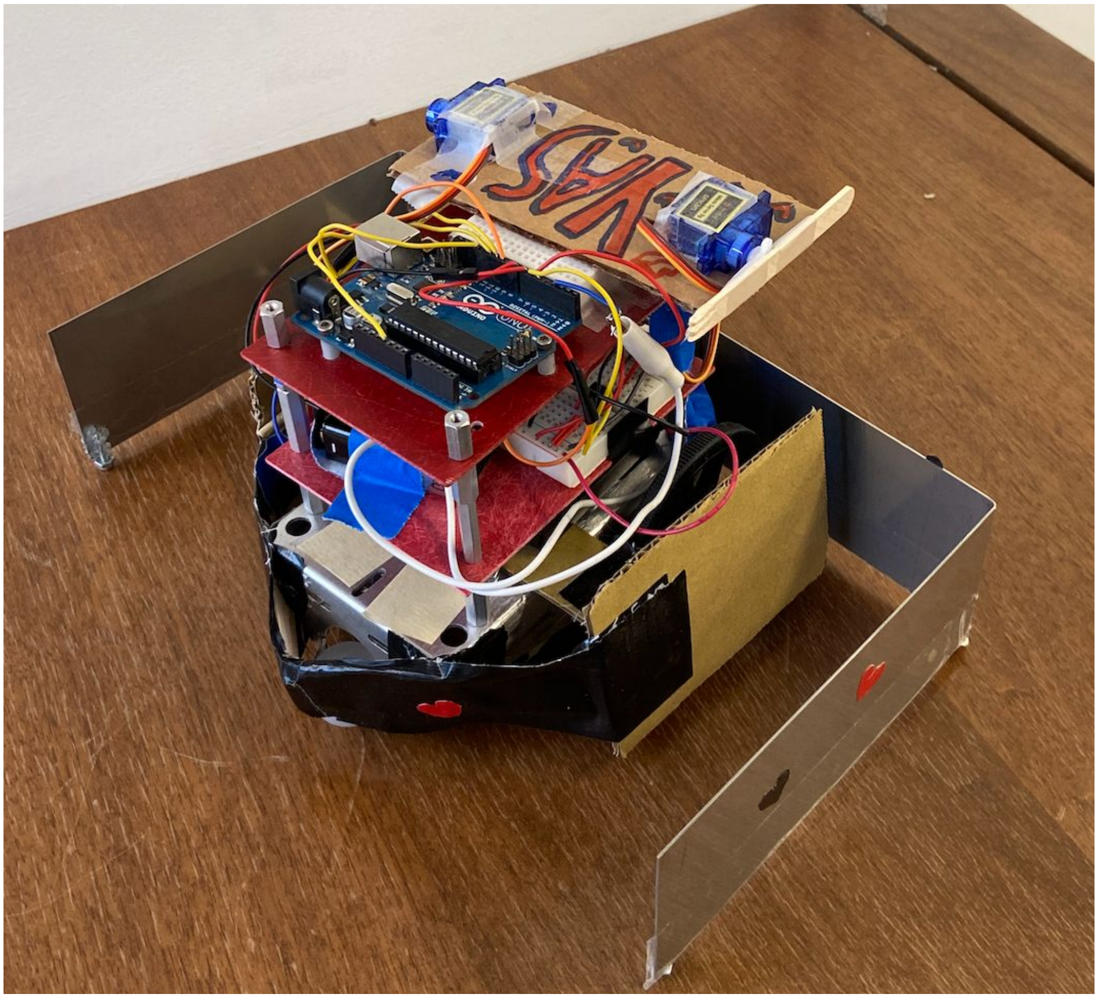




Circuit diagram for the Yas-bot

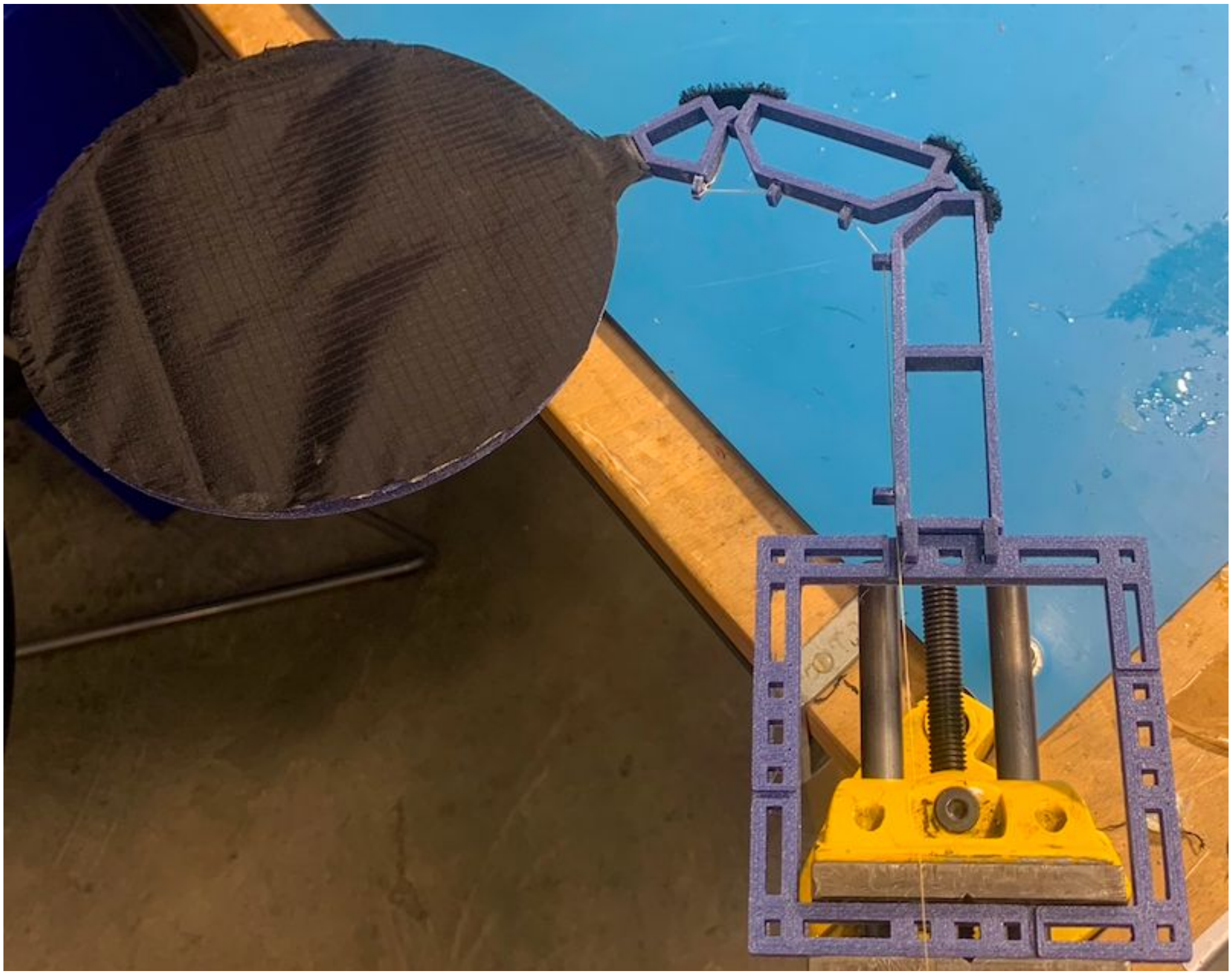
In order to ensure reliable robot maneuvers and avoid unforeseen control sequences, our group chose to rely on color sensing feedback exclusively. This means we did not use distance/sonar sensing to avoid colliding with the competing robot or 'aim' for cubes. My contributions to the project were primarily in the development of this algorithm and its translation into functional C++ code. The algorithm, put simply, directed the robot to perform loops on each side of the game board, using color sensors to detect each time the robot switched sides. By ensuring the robot switched sides an even number of times, we guaranteed the robot and its rake full of cubes finished each match on the home side of the board. Simultaneously, the robot continuously sensed for the black border of the board and would perform a number of movements to stay within the border dependent on feedback from the black color sensors (QTI).

/y Competition performance



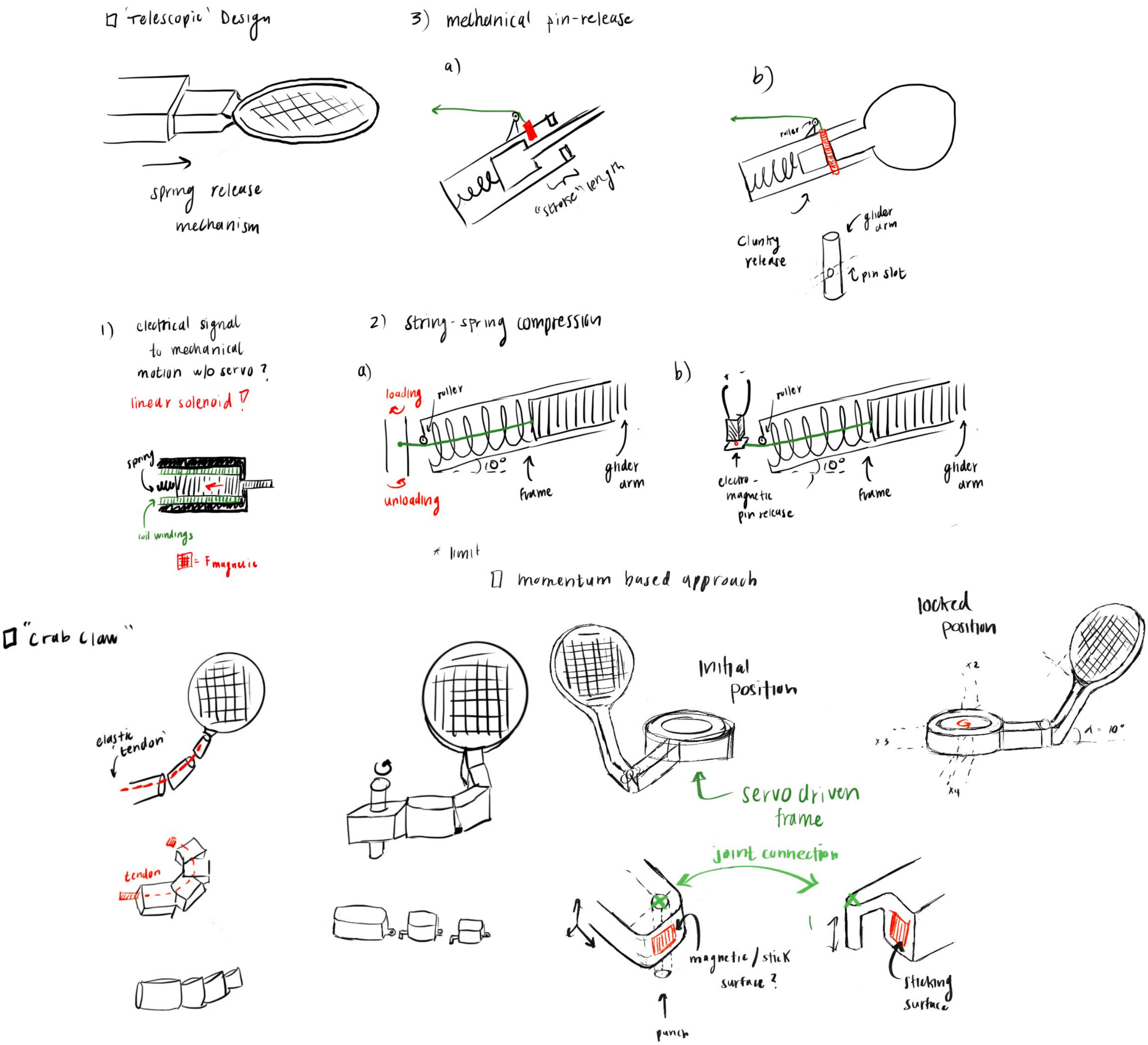
Shown above is the robot's final physical design before the Cube Craze competition. Mechanical features not previously discussed include the inverted button head screws attached to the rake arms to reduce friction, the pointed nose to direct cubes into the rake, and the cardboard wheel-guards to prevent wheel-cube interference. Ultimately, the robot won multiple matches in the Cube Craze before being eliminated. The competing robots' behavior proved to be extremely erratic, and the group's decision to rely on color/black sensing alone was an astute choice.

/z Bio-inspired drone attachment for dual gliding-flying flight behavior

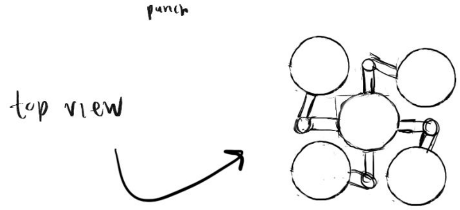


In a summer research experience at Imperial College London under Professor Mirko Kovac and Dr. Pham Huy Nguyen, I co-developed an attachment for a **flying frog inspired drone**. This drone was capable of bi-modal flight behavior, **both flying and gliding**. My task was to develop an attachment to deploy four frog-like glider arms from a contracted position. I spent weeks prototyping different mechanisms to deploy these arms, considering weight, complexity, materials, and reliability as design constraints. The final design was further inspired by the tendons in a crab claw and relied on a string-actuated, elastic contraction mechanism. Shown above is the final design featuring the square retaining frame, one glider arm with three hinged sub-sections, and the attached glider pad sized via preceding computational work.

/z Early design process and ideation



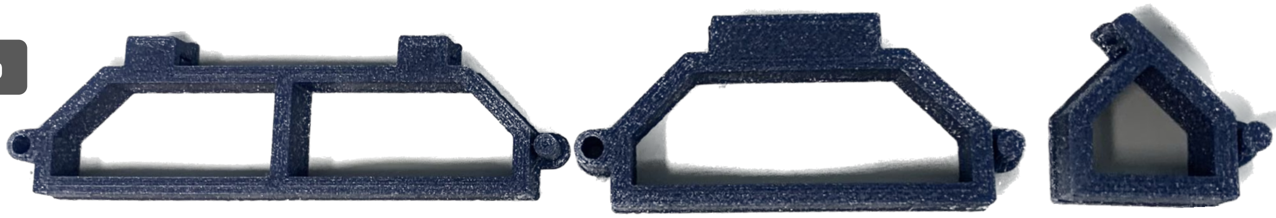
A variety of mechanisms were sketched and explored in the initial design process. The considered designs included a hinged crab claw mechanism, various telescopic arm deployment mechanisms, and hinged momentum-based mechanisms.



/z Early prototyping via FDM 3D printing

/a

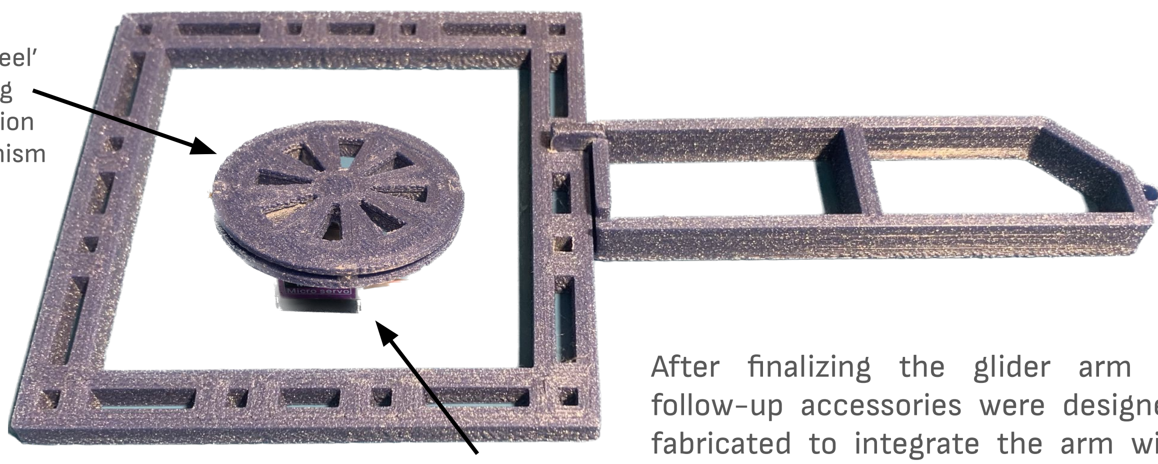
/b



/c

Early prototypes explored the reliability of **/a** a telescopic extension mechanism and **/b** a crab claw inspired mechanism. It was quickly determined that the telescopic mechanism introduced unnecessary complexity, as the tolerancing and tight clearances necessary for smooth operation were challenging to achieve with the available equipment. The crab claw mechanism presented a simple, intuitive, lightweight alternative reliant only on string actuation. Some obstacles to this design's development involved proper tolerancing in the hinge joints between the three sub-arm sections. A poor joint fit is shown between the final two arm sections in **/c**.

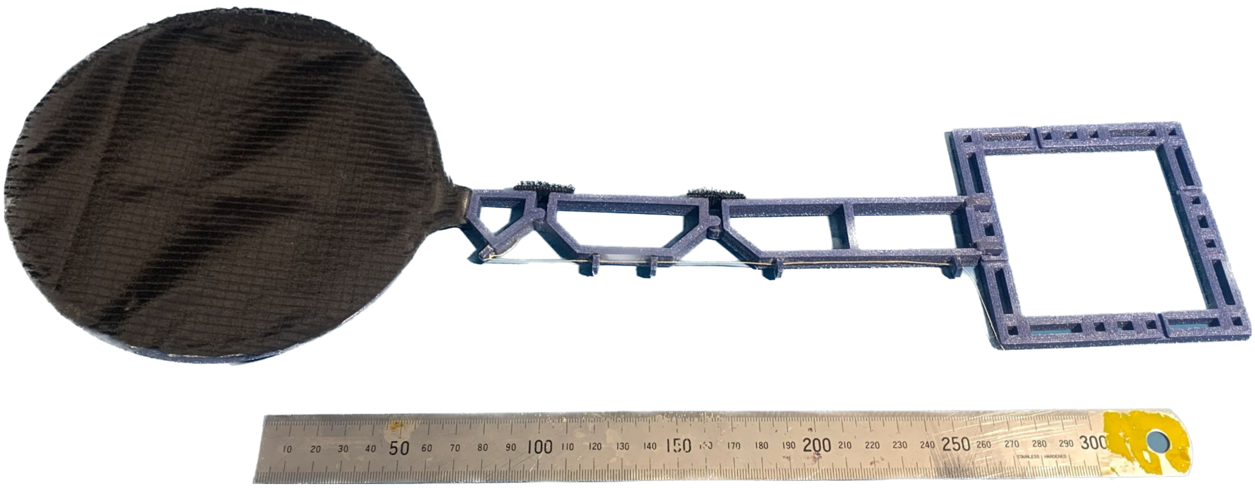
/z Design refinement and accessory development



The development of the crab claw arm involved multiple iterations, varying tolerances between joints, wall thickness, elastic sizing, string pathways, and more. This is is shown above with the three side-by-side glider arms. Key goals of the design process were to balance the competing influences of weight/beam bending effects and structural integrity.

After finalizing the glider arm design, follow-up accessories were designed and fabricated to integrate the arm with the drone body. This included the black glider pad shown at the top, the rectangular retaining frame to connect the four arms, and the 'film-reel' string actuator powered by a central servo motor. All accessories featured weight saving cutouts and involved multiple iterations to refine the functionality. Note that the glider pad sizing and preset dihedral angle (out of plane angle optimized for flight behavior) was determined by previous work in the lab.

/z Final prototype functionality



By the conclusion of the six week International Research Opportunities Program, I had successfully co-developed the presented design for a drone attachment enabling bi-modal flight behavior. The final prototype allowed for a 229 percent extension from the contracted position. While the final product was not tested in flight with an actual drone, the design concept was validated through ground testing. All work was presented at the **Cornell Commitment Virtual Symposium**. I would like to thank Dr. Pham Huy Nguyen, Oscar Peng, and Professor Mirko Kovac for their contributions and support.

[Thank you]

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I like to go surfing.