A Lightweight, Efficient, and Cost-Effective Bionic Fish

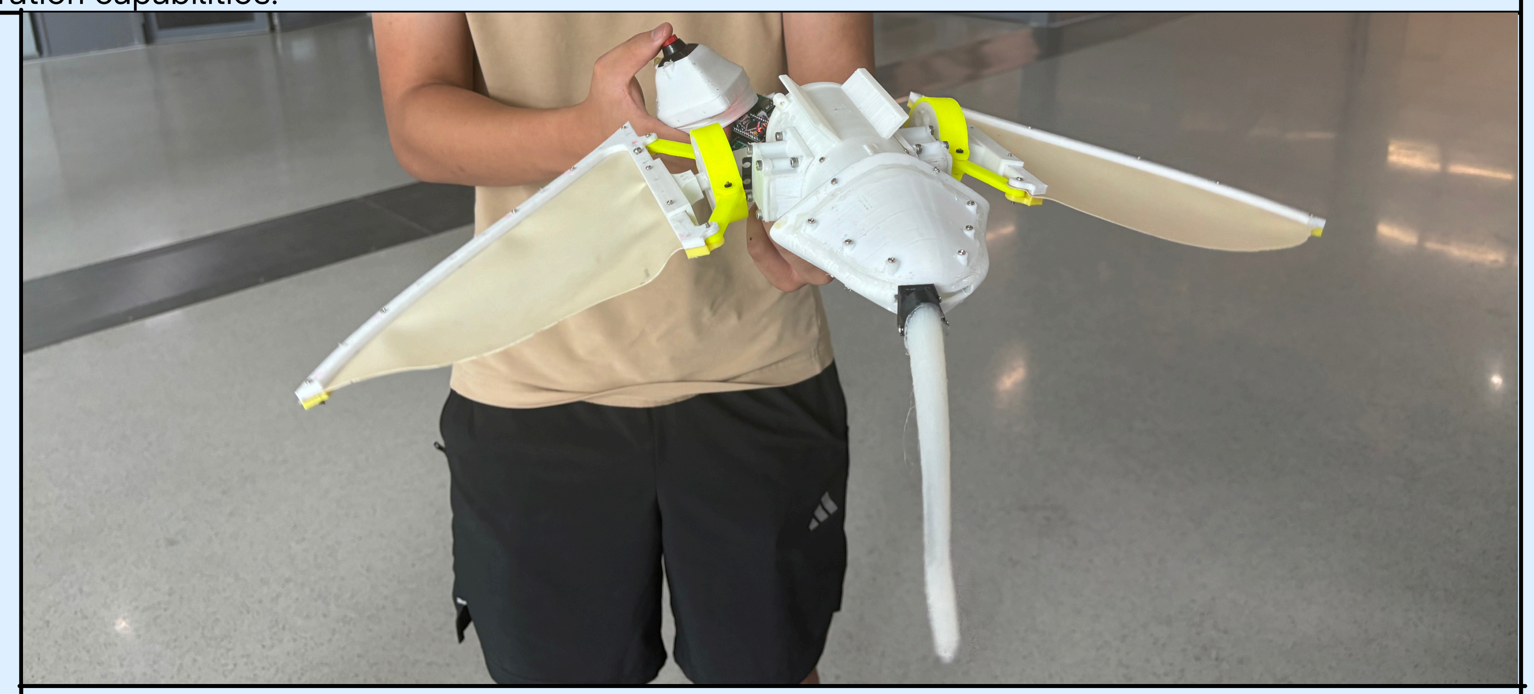
Jada Rue Ryan Zhang Ryan Hu Steven Andrade

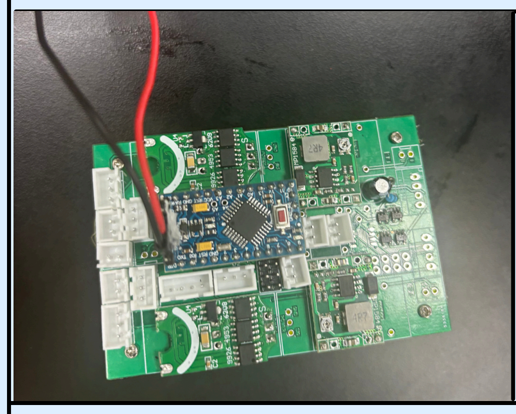
INTRODUCTION

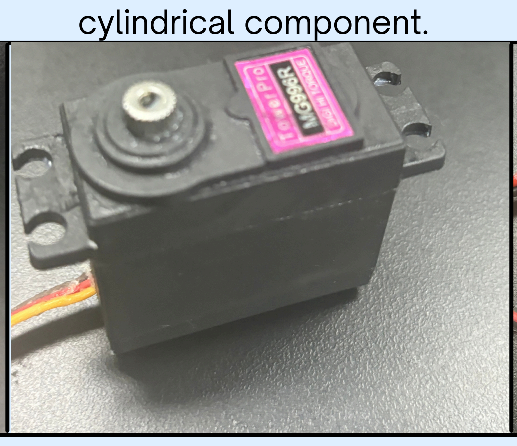
Robotic fish represent a fascinating intersection of biology and technology, designed to mimic real aquatic creatures' graceful movements and efficiency. In the early stages of development, engineers focused primarily on creating mechanical models that could swim underwater with some degree of realism. These early prototypes were often bulky and limited in their capabilities, relying on basic programming and simple mechanical systems. Today, robotic fish are used in various applications, ranging from environmental monitoring to underwater exploration and surveillance. Their ability to navigate complex underwater environments with agility and precision makes them valuable tools for scientific research and industrial purposes. As technology continues to evolve, robotic fish are poised to play an increasingly important role in understanding aquatic ecosystems and enhancing our underwater exploration capabilities.

DESIGN AND DEVELOPMENT

Our design process starts with the wings. We started by shaping and cutting the rubber fabric to fit the shape of the wing. In order to assemble the two parts of the wing together we poked holes in the rubber fabric to allow screws to go through. Then by screwing the plastic wing portion, rubber fabric, white wing portion, together in that order the wing is assembled. With the wing assembled the next task would be to attach the servos to the wings. Fit the servo into the servo case and attach the support for the wing to the gears of the servo and attach the wings to the support with long and short attachments. Fit the servo wires through the plat and then attach the plat to the top of the body. Then add the acrylic cylindrical component to the top of the body. Moving onto the head, we attached a button to the top along with two LEDS. Now to make the tail, we created a mold using silicone gel that was then attached and screwed to the tail holder. Both the design of the tail and the wings were specifically modified to be hydrodynamic. Then the top portion and the bottom portion were screwed together. Our Arduino board was made by attaching an Arduino pro mini to the top. Then super-gluing the Arduino Board to the battery case. We then fit the battery into the battery case. Then attach the wires from the servo to the circuit board along with wires from the battery and the power circuit in the head. Finishing off we attached the fish head to the acrylic cylindrical portion and attached the tail to the bottom of the body. To waterproof our robotic fish we waxed the gears of the servos and superglued its wires. For the head we stuck two molds shaped as cylindrical pyramids in the two holes found in the inside of the head. To further waterproof we superglued all the holes in the body of the fish and cemented the connection between the acrylic cylindrical component and the body. To finish off we hot glued the connection between the tail and the body and again onto the connection between the cylindrical component and the body. Finally, we taped the any loose ends in the connection between the head and the cylindrical component.





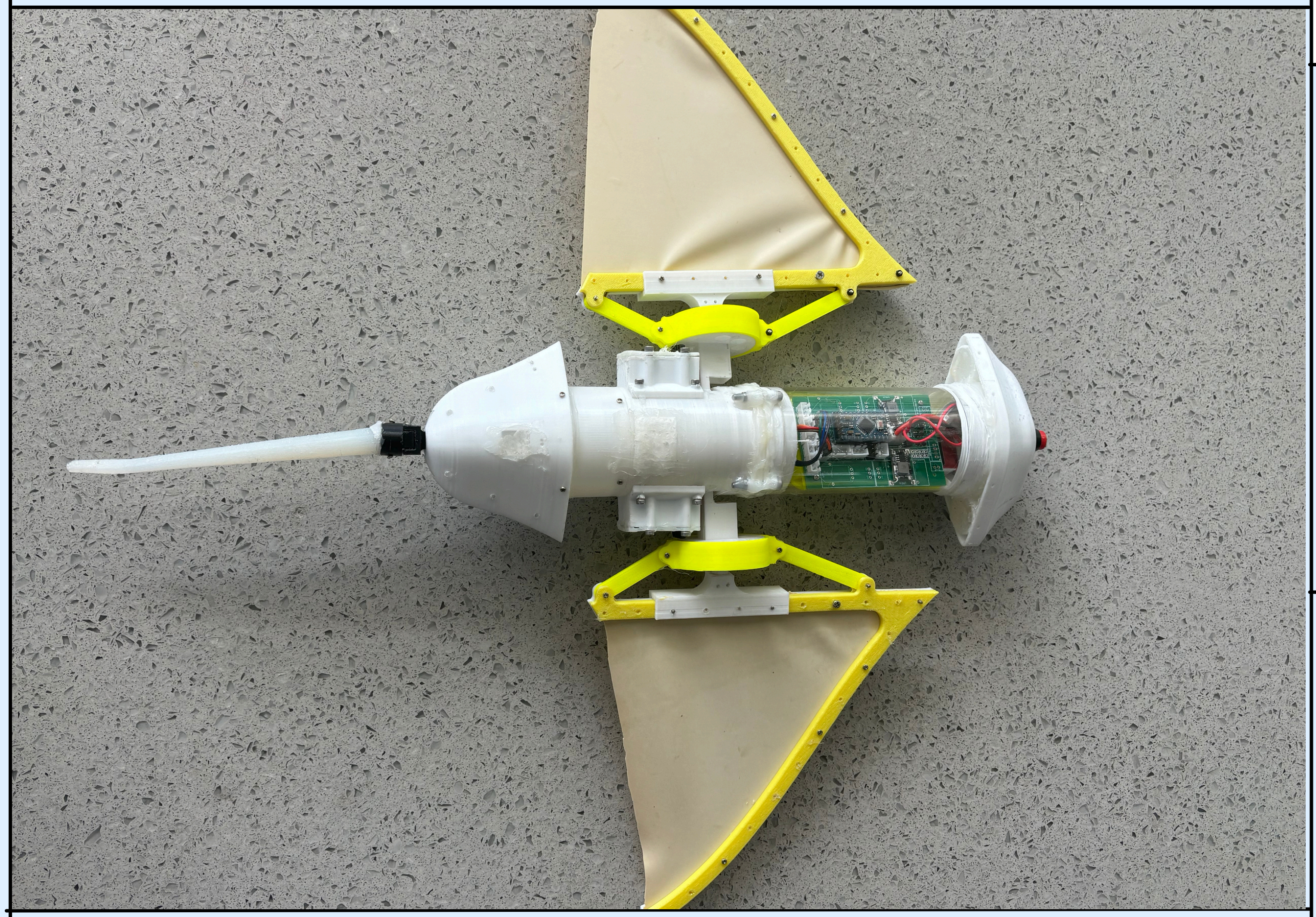


ELECTRONICS

First, we have to modify the code for the Arduino board as we encountered a critical issue with one of the servo. The left wing was unable to move high enough, hence we changed the angle of elevation of the corresponding servo. Then we download the code to the Arduino board through the Arduino Mini. Afterwards, we would connect the Arduino board to the battery for power, the button for activation, and the two servo for the movement.

RESULTS AND LESSONS LEARNED

The robotic fish was able to swim in the water. However, it was drifting to the ______ due to certain flaws in our design. First, silicone tail is not perfectly straight, hence causing the fish to not swim in a straight line. Besides, the two wings might not flap equally as we had difficulty making one of the servo function properly.



CHALLENGES

Various problems were encountered during our design process. The first set of problems were all related to the assembly of the actual robotic fish. We made errors like making the wings backwards and rebuilding the wings due to the servos being placed at the wrong angle. To remedy this problem we learned from our mistakes and powered through. A big obstacle in our assembly process was the breaking down of components. Breaking things like the support for the wing lead to us having to take things apart and re-assemble continuously. To fix this problem we learned to simply be more careful with the pieces and to not force pieces into place and instead use hammers to place a more precise force onto objects. Moreover, there were many times that we had to face the inherent inaccuracies of 3D printing, where the whole for a screw is not big enough, thus we had to drill the whole bigger in order to fit the components.Another big obstacle was the failure of pieces to work. For example, our Arduino mini wasn't working leading to us having to build a new one by soldering on a receiver.

CODE

To achieve the "flapping" motion, we code the two servo motors. There are two for loops, the first controls the upward motion, and the latter controls the downward motion. In the Arduino programming language, the setup function happens at the instant the program is run and the loop function repeats forever.

```
#include "Servo.h" //Servo.h is a library which includes many functions.

Servo servo1,servo2; //create the objects which will call the functions

void setup() {
  servo1.attach(A2); //a servo has three wires, GND,VCC and signal, this line tells the board, the signal wire is connected to A2 pin on the board
  servo2.attach(A3);
}

void loop() {
  for(int i=70;i<110;i=i+1) //make the angle increases from 70 degrees to 110 degrees
  {
    servo1.write(i-40); //make servo1 stop at the angle i
    servo2.write(180-i);//why should servo2 stop at the angle 180-i
    delay(20);
  }
  for(int i=110;i>70;i=i-1) //make the angle decreases from 110 to 70
  {
    servo1.write(i-40); //make servo1 stop at the angle i
    servo2.write(180-i);//why should servo2 stop at the angle 180-i
    delay(20);
  }
}

```

CONCLUSION

In summary, this mechanical engineering project has prompted us to demonstrate both our technical abilities as well as our interpersonal skills. Where we faced critical problems with the robotic fish during several stages, yet we managed to overcome such ordeals by seeking help, improvising, and collaborating. We demonstrated our technical knowledge through modifying the code according to our needs, wiring, and constructing the robot. Throughout the making of the robotic fish, we understand that the integration of ROVs and biomimetic robotic fish into marine research and exploration represents a significant advancement in our ability to understand and protect the ocean. These technologies not only enhance our capacity to explore and exploit underwater environments sustainably but also contribute to critical scientific discoveries that can shape our future. By minimizing environmental impact and expanding the frontiers of exploration, ROVs and robotic fish are indispensable tools for preserving the health of our oceans and advancing human knowledge.

OUR WEBSITE →

REFERENCES

1. Faria, Jolyon J., et al. "A Novel Method for Investigating the Collective Behaviour of Fish: Introducing "Robofish."" Behavioral Ecology and Sociobiology, vol. 64, no. 8, 2010, pp. 1211–1218, www.jstor.org/stable/40792927?searchText=robotic+fish&searchUri=%2Faction%2FdoBasicSearch%3FQuery%3Drobotic%2Bfish%26so%3Drel%26efqs%3DeyJjdHkiOlsiYW05MWNtNWhiQT09Il19&ab_segments=0%2Fbasic_search_gsv2%2Fcontrol&refreqid=fastly-default%3A9a705b6927f9f43f59e2b25de98d422c. Accessed 18 July 2024.
2. Conner-Simons, Adam. "Soft Robotic Fish Swims alongside Real Ones in Coral Reefs." MIT News | Massachusetts Institute of Technology, 21 Mar. 2018, news.mit.edu/2018/soft-robotic-fish-swims-alongside-real-ones-coral-reefs-0321.
3. Research - World's First Biomimetic Submersible to Dive to 2,000 Meters Westlake University ." En.westlake.edu.cn, 19 June 2023, en.westlake.edu.cn/news_events/westlakenews/research/202306/t20230619_34028.html. Accessed 18 July 2024.