Miniature Biomimetic Robot Fish Research

SAG Final Report Spring 2018
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The Project

The miniature, biomimetic robot fish project aims to develop a small, low-cost robot for use as a swarm agent. Swarms of tiny robots have an increasing area of potential applications, including sensing and collecting data over large areas with a distributed network, monitoring fragile ecosystems like coral reefs, and synthetic biology test beds for swarm algorithm research and education. Mimicking the swimming motion of a real fish increases the hydrodynamic performance of a robot, since fish are incredible swimmers, and would allow for longer missions or the mounting of higher power sensors. Last semester, we worked to create an untethered version of the robot by bringing all of the electronics inside of the robot itself. One of the greatest obstacles to forward propulsion we encountered before this was the pull of the tethers connecting the robot to the electronics, restricting its motion. Additionally, having on-board power brings us one step closer to an autonomous platform will enable research in biomimetics and swarming.

This semester, we have continued our progress towards efficiency by reshaping our fish to improve its hydrodynamics, restructuring its fin, and doing comprehensive force studies to investigate the usefulness of our propulsion mechanisms.

The Team

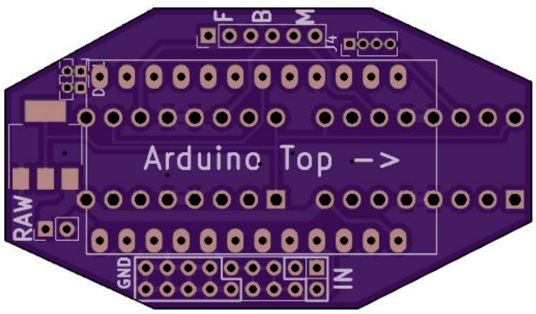
I was able to keep one member of last semester's team, Chris Lee, as well as several other part-time members to create a great group of talented minds.

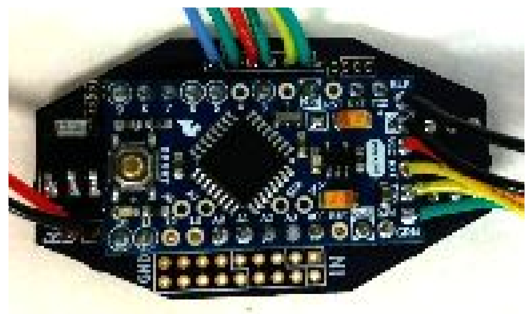
Results

This semester, we mainly tackled optimizing the physical shape of the robot as well as performing comprehensive force evaluations on its joints.

Electronics from Last Time

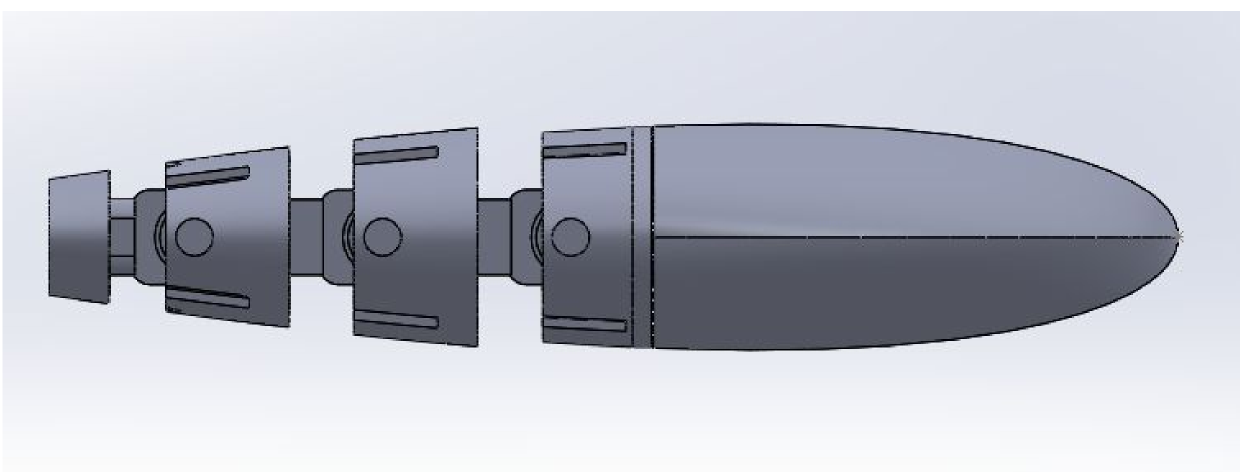
To fit all of the electronics components necessary to control the robot and arrange them in such a way as to make wiring less of a nightmare, the team designed a PCB. The board routed all external connections to H-bridges, angle sensors, and batteries to easily accessible pins and allowed for the setup of master power and ground rails. Additionally, the H-bridge and Arduino in the same segment were able to mesh together without electrical interference, effectively using the limited space. While we want to keep the size of the fish as small as possible, we scaled the original robot's size to accommodate the electronics; this was also an opportunity to improve the parameterization of the CAD files, allowing us to scale the horizontal and vertical dimensions independently.





Shape Optimization

We rebuilt the entire shape of our fish from the ground up to mimic a NACA 0016 airfoil, which closely resembles the shape of real fish. This design creates a dramatic decrease in drag which nearly quadruples the maximum speed that we can swim.

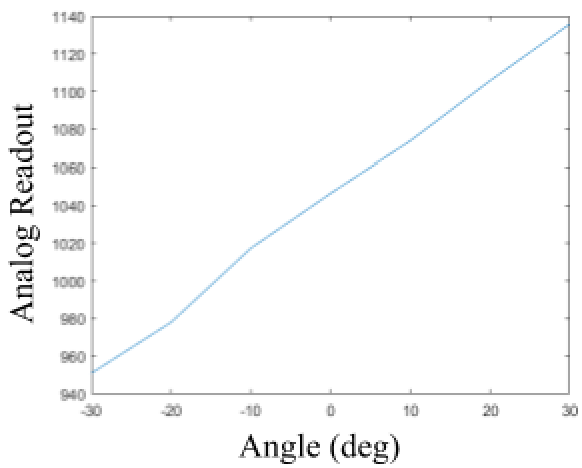


We also redesigned the placement of the joints, shifting them significantly farther back to produce more swimming power and also further reduce drag by allowing a smoother transition between straight and curved.

Force Testing

We created a force testing mechanism that allows us to precisely measure the output of our coils under a range of currents. We are also able to measure how different arm lengths and angles affect power output.

We found that at a maximum power of about 80 Watts, the coils produced a torque of about 15 N cm, while under normal conditions they produced about 7 N cm.



Next Steps

We want to continue to investigate other propulsion options as well as new ways to improve hydrodynamic efficiency. Once we have created a mechanical model that works, we can dive deeper into complex control loops and begin to experiment with advanced underwater maneuvers. Currently, our robot is not powerful enough to do this, but we hope that in the future we can solve both these problems sumultaneously.