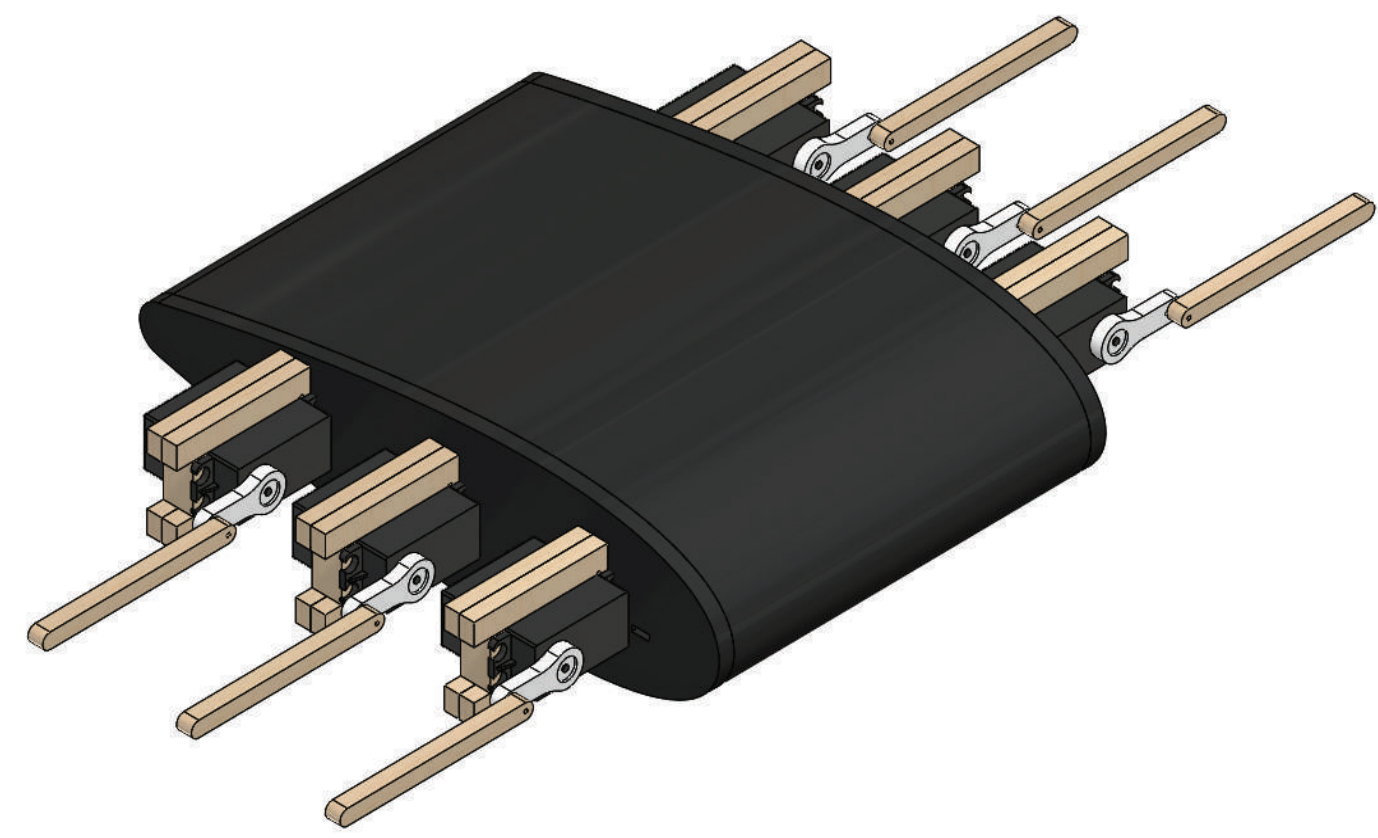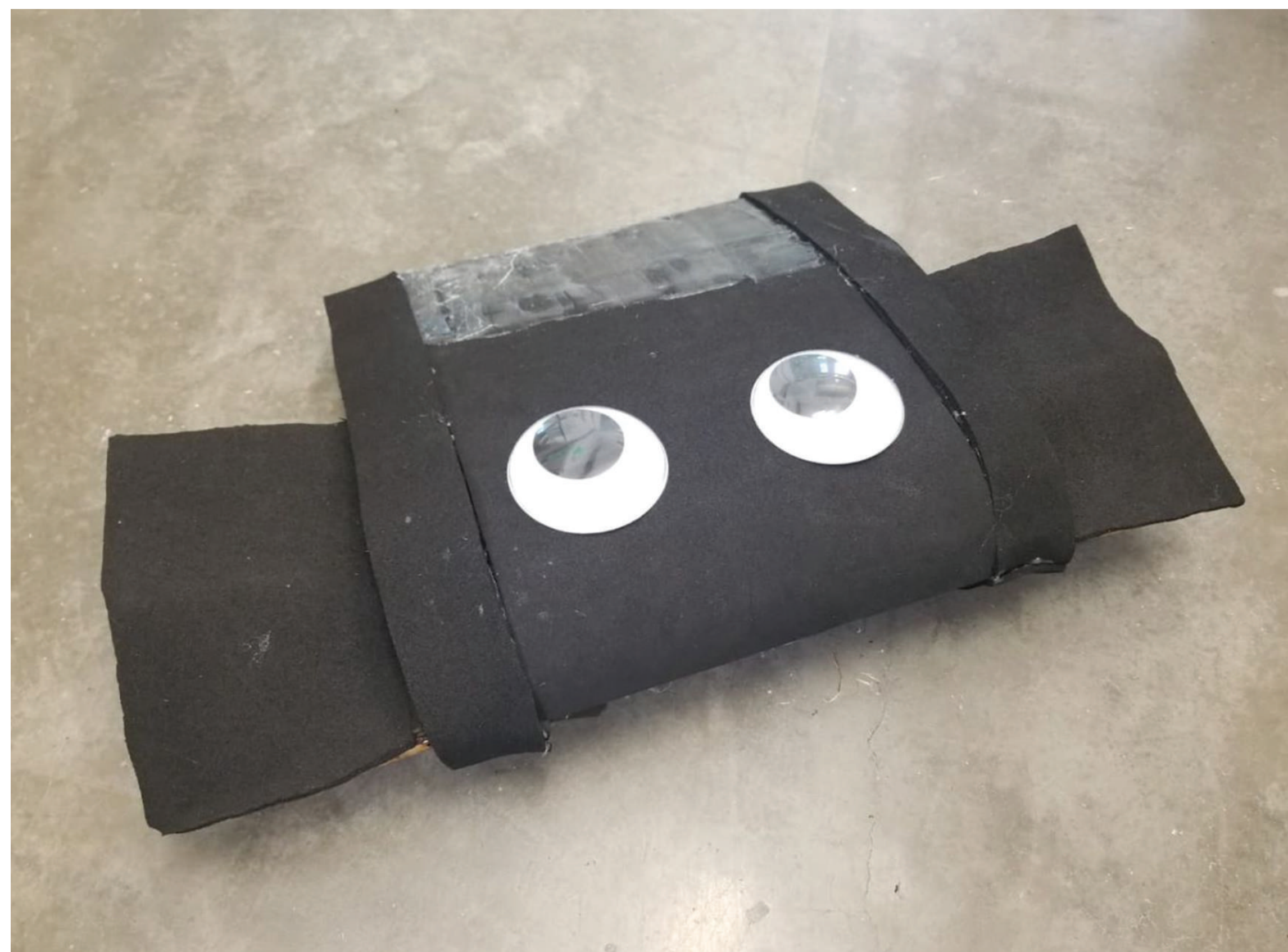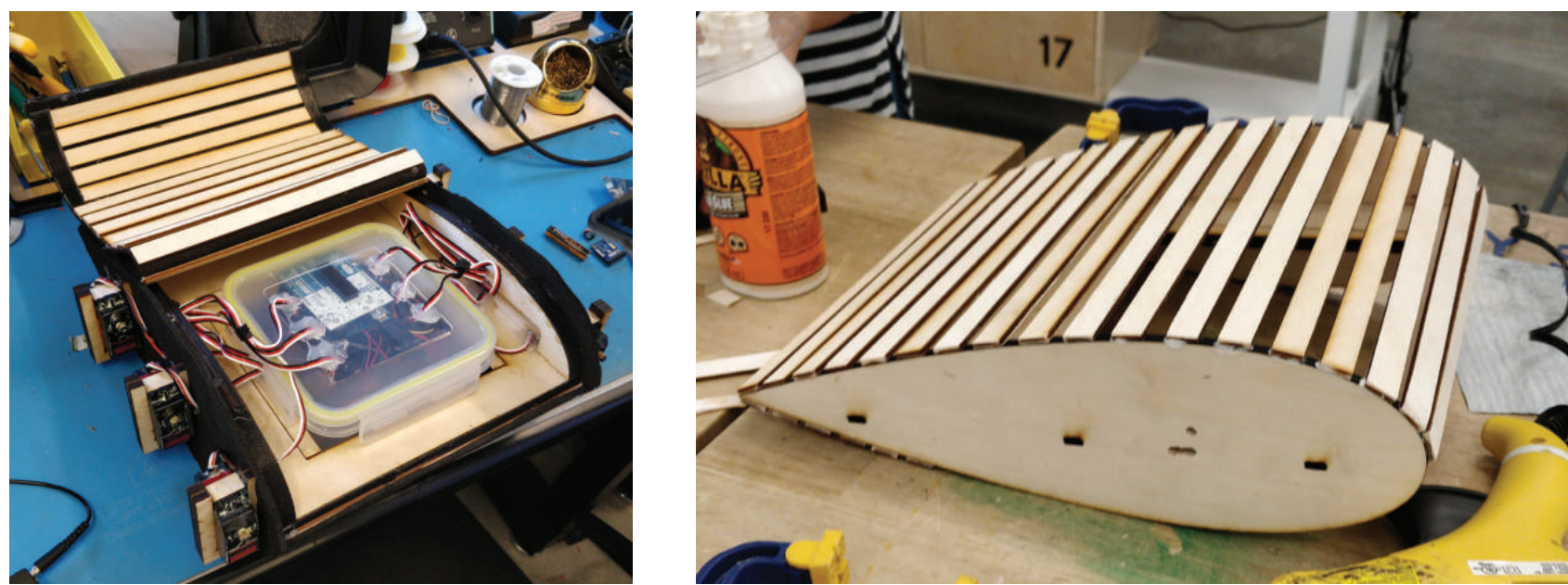# Stingray Emulating Vehicle

Design

- **laser cut** plywood parts
- **neoprene skin** to reduce drag and waterproof wood
- **airfoil-shaped body** (NACA 0020) for hydrodynamic form
- **watertight lunchbox** to house electronics
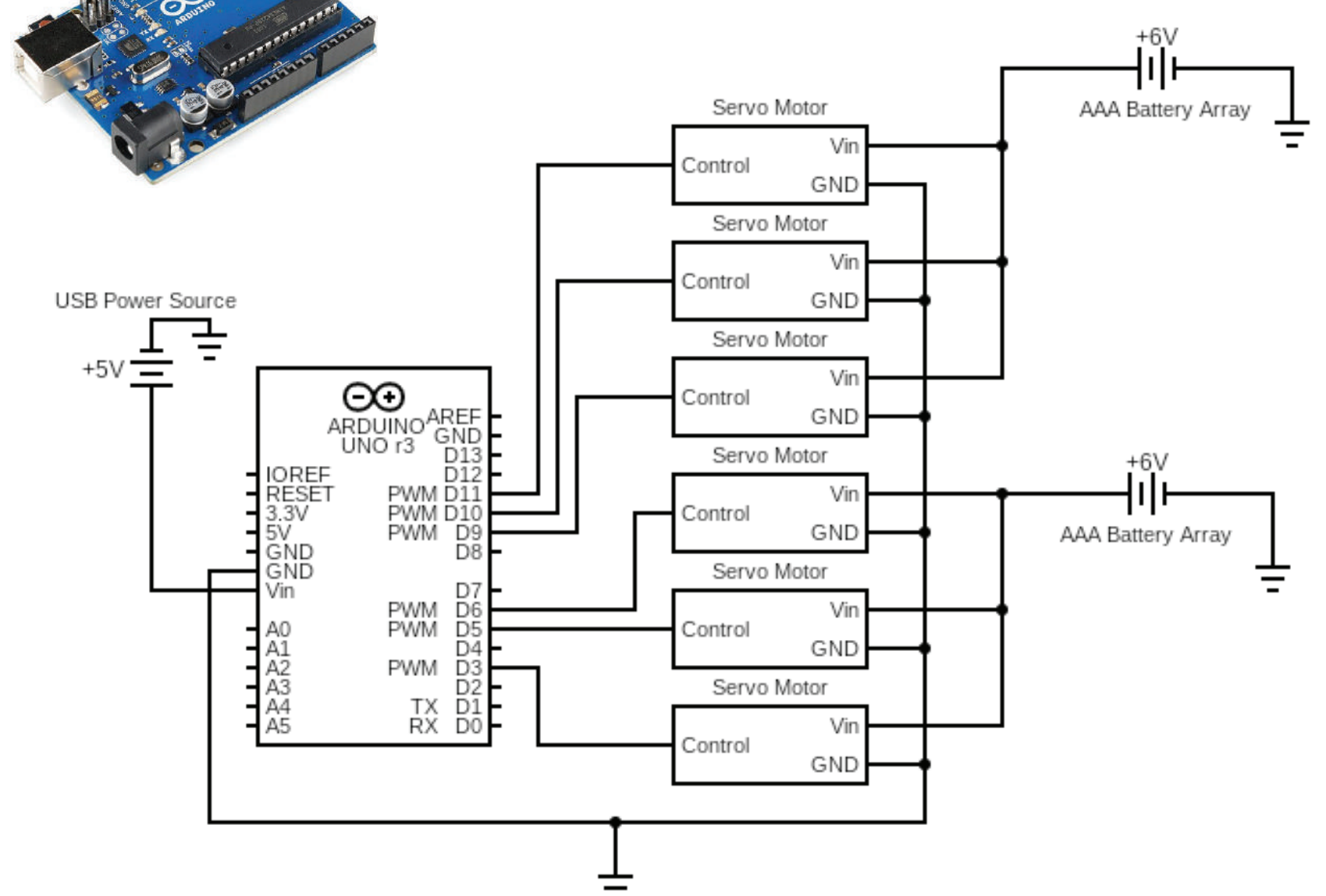- **rice** as weight to submerge robot

StEVe is a stingray-inspired robot that propels through the water by undulating its fins in a sinusoidal motion like a stingtray. She swims near the surface of the water using six waterproofed servos.

Electronics

- 20KG water-resistant servos x6
- Arduino Uno
- Arduino Proto Shield
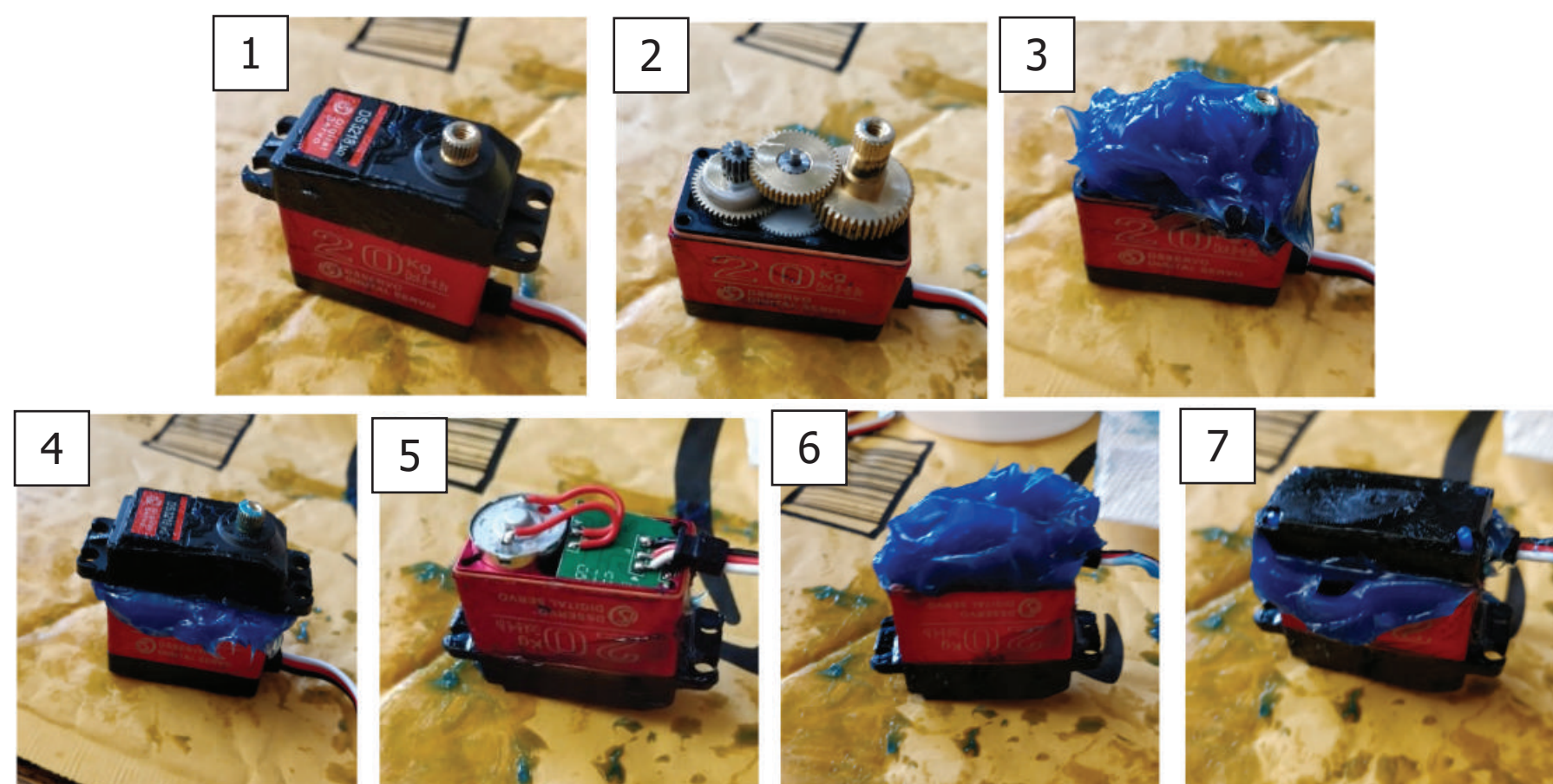- AAA batteries x8
- Rechargeable battery w/ USB

Video

Watch StEVe in action!

bit.ly/STEVE102B

Waterproofing

Waterproof, non-conductive marine grease was used to insulate the servos from water on the inside and outside.

Movement

The undulating motion of the stingray fin is in the form of a backward-traveling wave, which accelerates the water backwards, perpendicular to the fin and parallel to the body. The accelerating fluid creates a reaction force that propels the stingray forward.
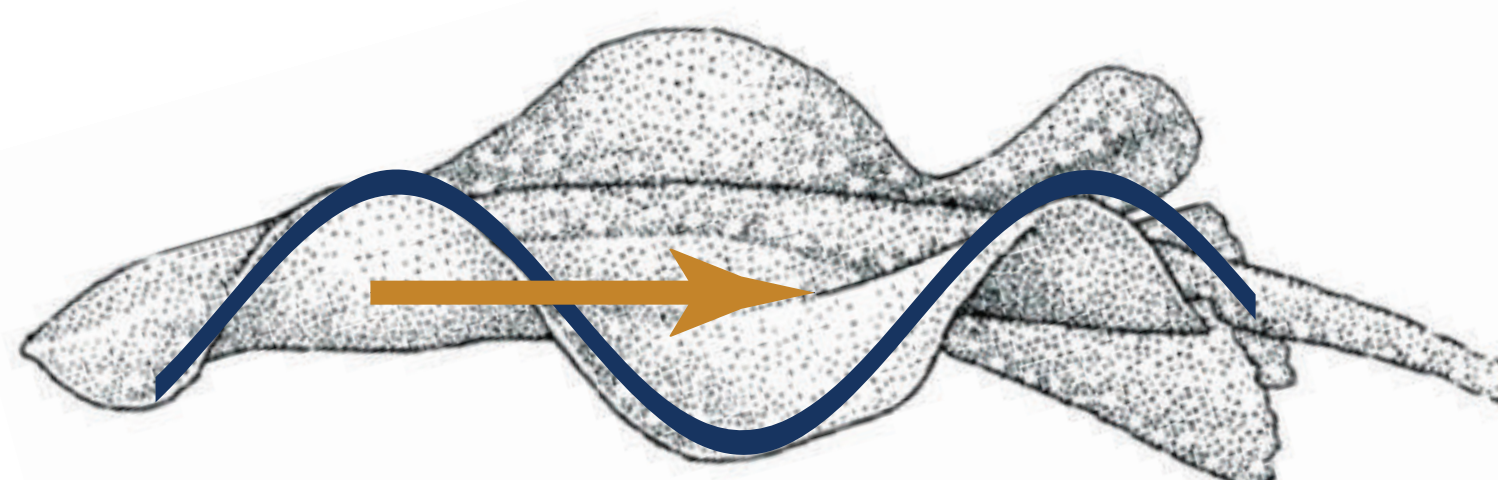

Image source: http://jeb.biologists.org/content/215/18/3231

StEVe's fin motion is modeled after this, allowing her to move forward in water. She achieves turning by decreasing the wave frequency of one of her fins.

Fin Code

To achieve fin undulation, we used the sine wave equation for each servo:

$$y(t) = A sin\left(\frac{-2\pi v}{\lambda}t\right)$$

$$A = r cos(\theta_{max})$$

By tuning the wave velocity v, wavelength λ, and max servo arm angle θ_{max}, we optimized the fin thrust.