Optimizations of 3D-Printable Artificial Muscles for Quiet UUV Propulsion

Proposed Work and Deliverables

- We will build COMSOL simulations of the above basic artificial muscles fiber bundle architecture. Then we will vary geometric scaling and parameters to determine the conditions that maximize output force.
- The proposed optimization is based on the tradeoff between force generation and force transference. Briefly, more cross-section devoted to fibers means more force per unit volume generated, but less transferred through bulk material (functioning as “tendons”) to the outside world. Conversely, more spacing improves transfer (up to a point), but decreases the generated force. We aim to determine the values of the parameters optimizing that tradeoff for maximal delivered force.
- Once the simulations narrow down the goldilocks region, we will produce devices with corresponding geometry, to confirm the results experimentally.
- The deliverables are the optimization plots and best values of the parameters, allowing for efficient engineering towards scale-up and field tests.

Approach/Methodology

- We will import the SolidWorks drawings of the artificial muscle fiber bundle architecture into COMSOL and use it as a basis to build simulations that output transferred force as a function of the geometric parameters, dielectric constant of the bulk material, the electric conductivity of the electrolyte solution filling the channels, and the applied voltage. The simulations will produce a family of phase space plots that will help us narrow down the optimal regions for the parameters in maximizing the output force density.
- Once the parameter values are narrowed down, we will use them in a series of devices. Output force would be measured directly and/or calculated from the measured strain as a function of applied voltage. This will achieve experimental confirmation of the optimal parameter values and complete the proposed optimization.

Significance and Impact

- The survivability of naval assets is strongly affected by their ability to evade, confuse, decoy, or trick the enemy. Hence, quiet propulsion and acoustic translucence are highly desirable in friendly UUVs.
- These might be achievable by electrostatically-driven artificial muscles made of soft low-density materials. Our designs for such are based on 3D-printable microfluidic devices wherein the bulk of the material is a polymer dielectric and the microchannels serve as wiring when filled with electrolyte.
- We are prototyping these devices using FY19 CRUSER funding and propose to further optimize and improve these devices in FY20, in preparation for follow-on full-scale manufacture and thrust tests in field conditions.
- Success would move optimized artificial muscles to full-scale manufacture and field testing.

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FY20 Call for Proposals