NRI: FND: COLLAB: A Foundational Approach to Muscle Actuators that Lowers Barriers to Muscle-Powered Robotics Research

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SUMMARY

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Fig. 1: Do we need to be experts in material sciences, control, and design to use artificial muscles*? Shown here are (a) dielectric, (b) TCP/SCP, (c) soft fluidic (d) piezoelectric (e) muscle wires.*

What problem are we addressing (Fig. 1)? Despite the decades of materials research in discovering new muscles and improving existing muscles, their transition into more widespread use in robot systems and machines to date has been limited. We need to address some open problems:

1. How do you select or even compare muscle actuators for a specific application?
2. How does one approach modeling and control and does it necessarily have to differ for each chosen actuator?
3. How can we compare our actuators against other researchers' efforts without replicating and unrealistically burdening ourselves?

What are our project objectives?

1. Data-driven (model-free) selection and design of muscle-actuated biomimetic motions
2. A generalized modeling and control common across robot muscles groups
3. A robot muscle toolkit for accessible muscle-powered robot design and benchmarking

Some Key Approaches

Novel Definitions

Describing a *performance space {P}*: A set of quantitive metrics defining the reachable outputs of all muscles, such as strain, stress, twist, contraction length, heat, etc.

Describing a *configuration space {C}*: a set of quantitative parameters that define muscles in general: resting length, thickness, width, bundle configuration, material

Populate *joint space (Fig. 2)* to visualize the span of muscle groups (experimental, from published papers, from community outreach) over possible configurations and output performance. This data comes from experiments, from scouring published papers, and from community outreach and involvement.

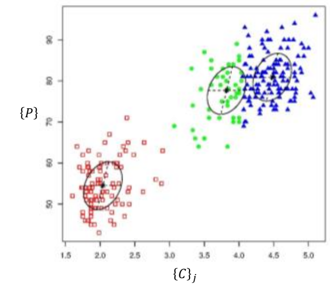

Fig. 2: Joint space*; given sufficient samples defines a topology of possible actuators for selection.*

Generalized modeling and control definitions follow naturally then from this definition:

$$p = F(c_1 \dots c_n, l_1 \dots l_m)$$

where $c \sim C$ configuations and $l \sim L$ inputs, and $p \in P$ output performance, and a variety of optimization or gradient descent methods could be used to find new solutions (Fig. 3).

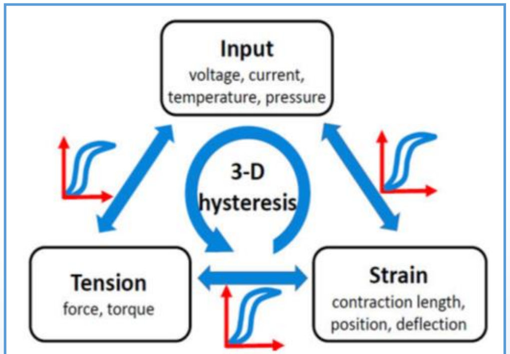

Fig. 3: A potential model of F *in which it can be muscle and configuration agnostic.*

A Planned Robot Muscles Toolkit

Much like success of soft robotics toolkit, this online, interactive toolkit will have

(a) Spaces{P,C} graphs available online

(b) Data Visualization program for graphs

(c) The modeling and control strategies (F)

(d) CAD files for simple fab setups

(e) a set of simple actuators, bill of materials, and step-by-step instructions

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