Rotary "One-To-Many" (OTM) Novel Actuator

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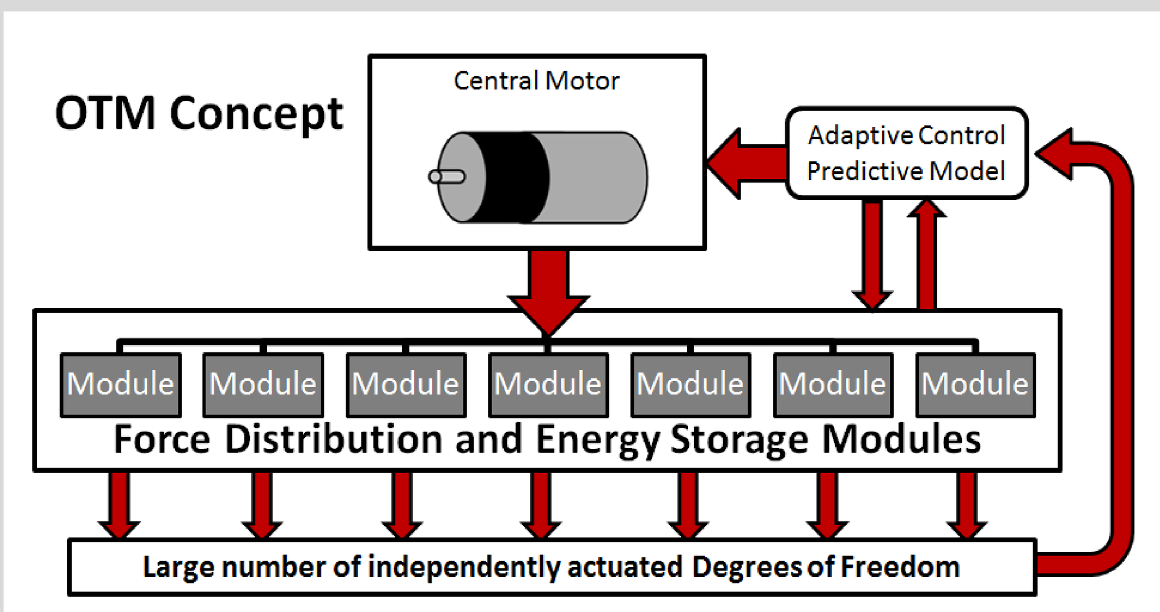
Abstract

The Rotary One-to-Many Project is aimed at designing and realizing an innovative novel actuator capable of emulating human muscle dexterity. This technology utilizes the "One-to-Many" (OTM) concept, which allows a single artificial actuator to store energy in the form of elastic potential energy and drive multiple independently actuated and controlled degrees of freedom (DoF). This technology may prove critical for systems with many DoF like soft-robotics Exomusculature as well as many others. The feasibility of the concept was initially proven using the Linear OTM system, after which, the Rotary OTM system was designed, prototyped, and successfully tested.

Applications for a Rotary OTM

- Could be utilized to operate any cable driven device.
- When coupled with an Exomusculature, Rotary OTM would be a portable, lightweight, energy-efficient, and cost-effective rehabilitation robotic device.
- Number of DoF could adjusted to appropriate number of muscle fibers needed in specific Exomusculature system.

Rotary OTM



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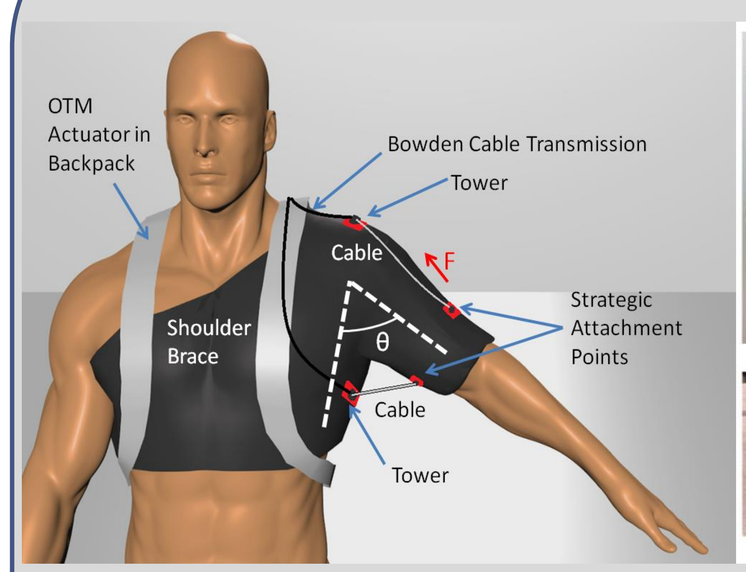
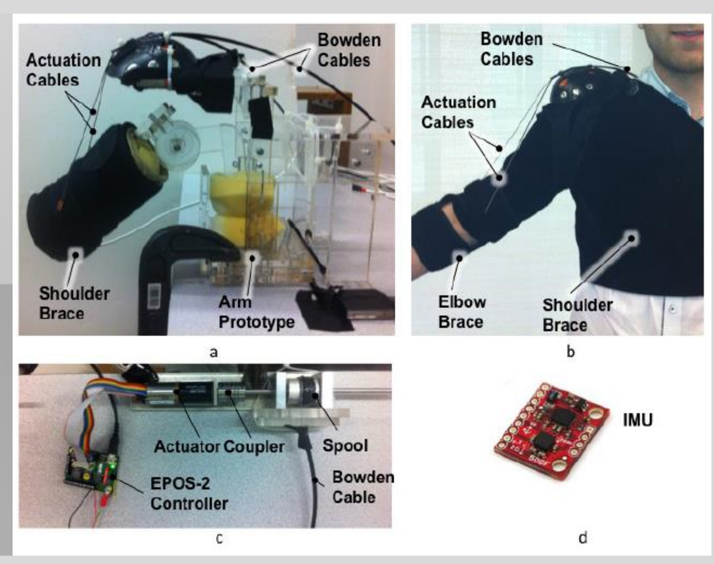
Soft Robotics Exomusculature



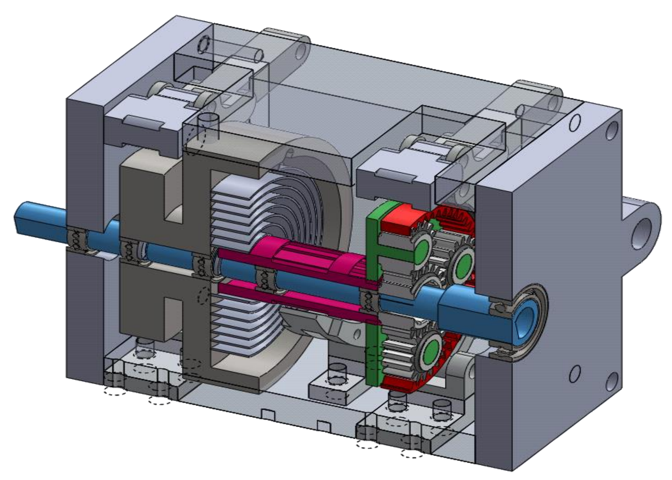
Soft Robotics Exomusculature



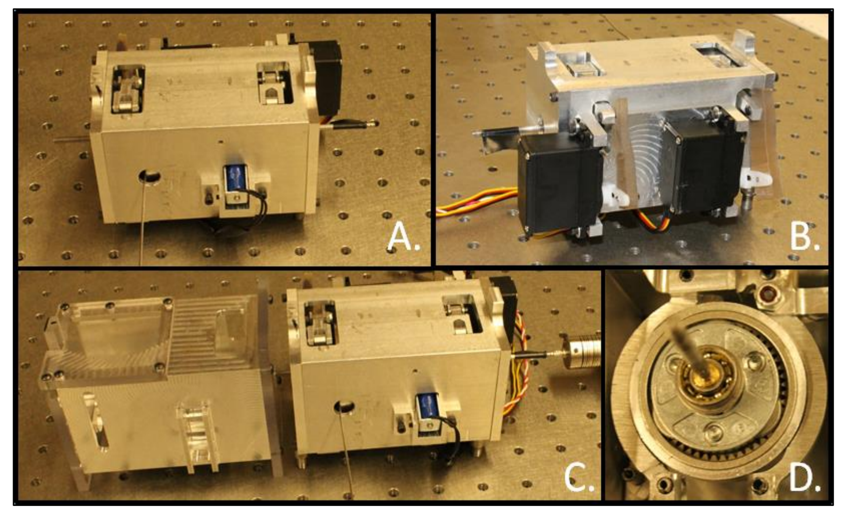
Shoulder brace actuation, transmission, sensing and control package

Final Mechanical Design

- Input shaft runs the length of each module.
  - Shaft connects to either electric actuator/other module.
- Module stores energy in for of elastic potential energy.
- Release pulls Bowden cable into module around drum producing linear actuation.
- Main actuator is never directly connected to load.
- Each module is independent from rest of system.
- Internal Mechanisms controlled with servos and solenoids.
- Power output is augmented.



Final CAD Model – Section View

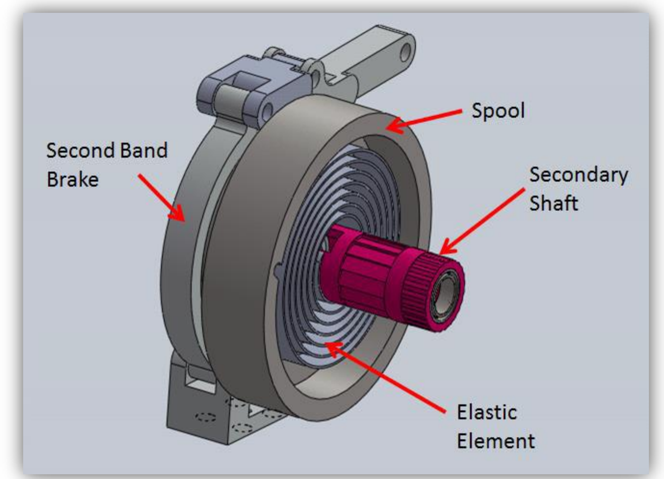


Physical Prototype - *A) Front View, B) Rear View, C) Two modules in series , D) Planetary gear set used in clutch 1.*

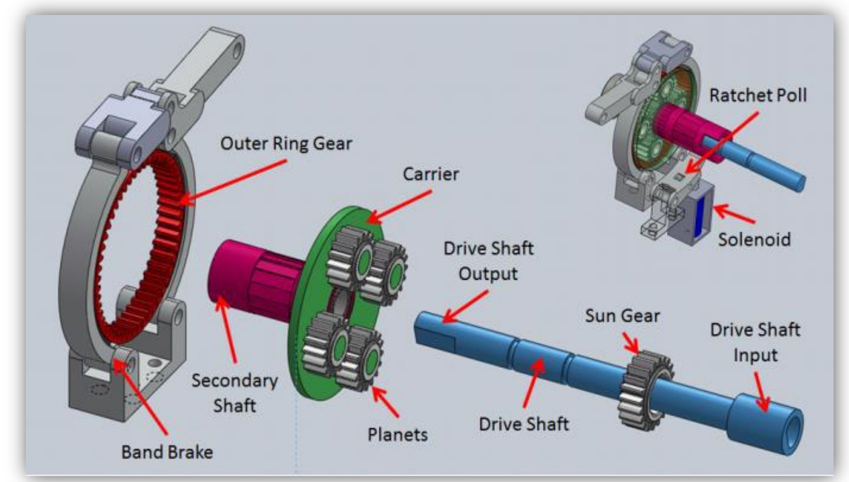
Critical Components

Two critical components that comprise system (shown below):

- Planetary Transmission Component
  - Allows module to engage/disengage input shaft rotating at a constant velocity.
  - State of component controlled by first band brake.
- Energy Storage Component
  - Elastic element stores energy in rotary fashion.
  - State of component controlled by second band brake.

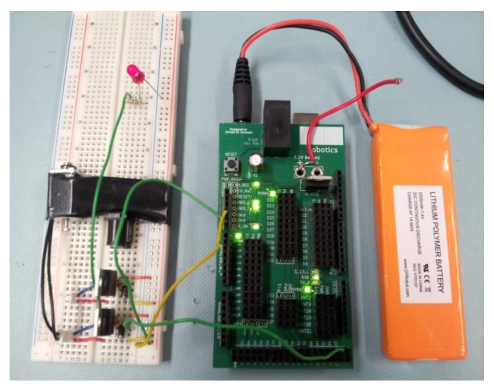


Energy Storage Component

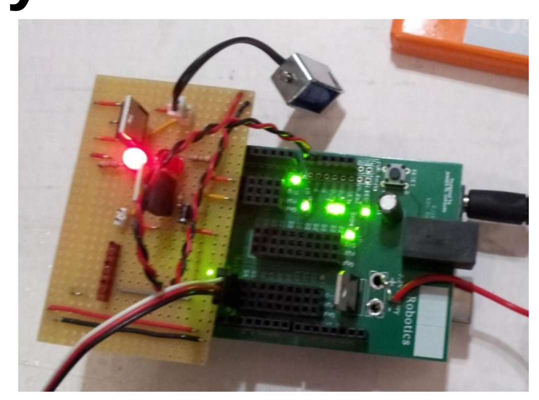


Planetary Transmission Component

Control System



Controller with Breadboard Shield



Controller with Finalized Custom Shield

- System controlled by single-microprocessor designed around Atmel AVR Chip.
- Microcontroller with customized shield to provide interface for servos and solenoids that operate internal mechanisms.

Conclusion

A single motor operating at optimal motor conditions can actuate n DoF with power amplification. Hence, the system can be a portable, lightweight, cost-effective, and energy-efficient, alternative to traditional actuators.

Results

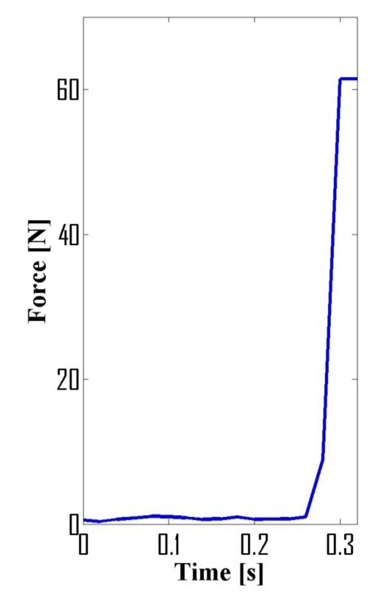


Figure 1: Force vs. Time

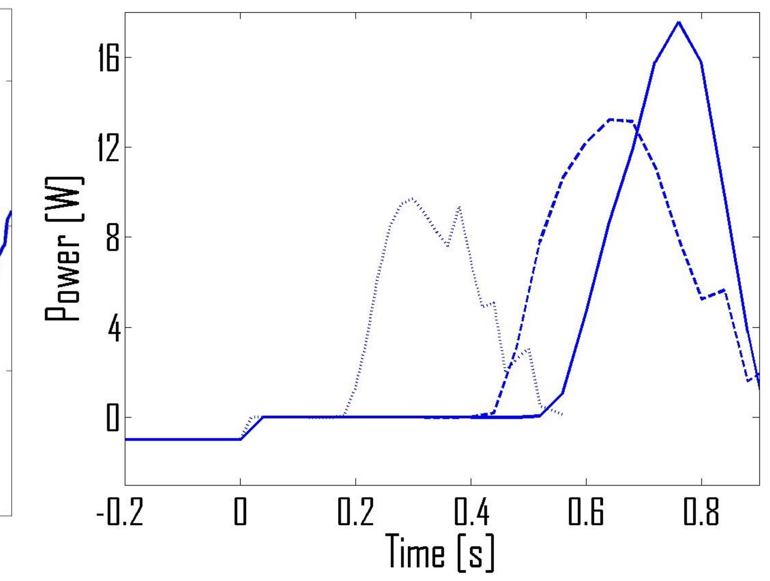


Figure 2: Power vs. Time

Fig.1 - Left: sudden release of energy; Right: slow controlled release of energy; Results: graph shows force output can be controlled with respect to time.

Fig 2 - Three trials; Lines represent total energy output of system; All three runs have same initial power. Differences between trials illustrate controlled power outputs .

Recommendations

- Optimize design: reduce size, weight, cost to manufacture.
- Fully develop soft robotic exomusculature.
- Develop higher-level control architecture using non-invasive electromyography techniques.

Acknowledgments

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