CAREER: Bio-inspired Multi-joint Design and Control for Efficient and Lightweight Wearable Robots

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Problem Statement

Powered exoskeletons promise to improve our productivity, health, and independence by augmenting, preserving, and restoring our ability to move. However, existing powered exoskeletons are heavy and inefficient, which largely prevents them from being used in real life.

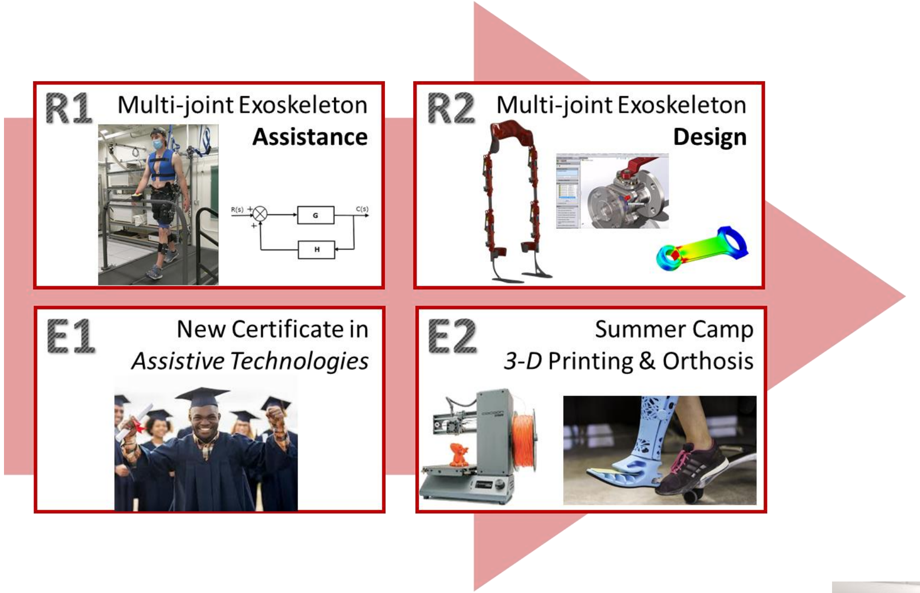
Central Hypothesis

Optimizing the dynamic exchange of energy between multiple joints will result in superior powered exoskeletons—in terms of size, weight, and performance—compared to considering each actuated joint separately.

Solution Statement

Develop energy-conserving mechanisms and control algorithms inspired by human ambulation..

- **Optimal control of multi-joint assistance**
- **Design of multi-joint powered exoskeletons.**



https://belab.mech.utah.edu/sonomyography/

UTAH COMPOSITE HIP EXO

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Exoskeleton	Actuator Weight [kg]	Battery Weight [kg]	Total Weight [kg]	Measured During Ambulation: Average Peak Torque [Nm]	Measured During Ambulation: Actuator Torque Density [Nm/kg]	Measured During Ambulation: Exoskeleton Torque Density [Nm/kg]
Utah	**0.567**	**0.204**	**2.7**	**41.9**	**73.9**	**15.52**
Harvard* [21]	1.337	1.011	5.0	38.1	28.5	7.62
CUNY [4]	0.777	--	3.4	20	25.7	5.88
Samsung [9]	--	--	2.8	10.9	--	3.89
NCSU^{+}[16][17]	1.5	--	9.2	34.3	22.9	3.73
ASU [18]	1.135	--	2.95	9	7.9	3.05
SSSA^{o} [20]	1.2	--	4.2	10	8.3	2.38
Honda [8]	--	0.200	2.8	6	--	2.14
Georgia Tech [14]	1.5	1.04	7	14.1	9.4	2.01
Panasonic$^{\#}$ [22]	0.58	--	9.3	10	17.2	1.08

M.K. Ishmael, D. A. Archangeli, and T. Lenzi, *"A Powered Hip Exoskeleton with High Torque Density for Walking, Running, and Stair Ascent"*, IEEE/ASME Transactions on Mechatronics, 2022 10.1109/TMECH.2022.3159506

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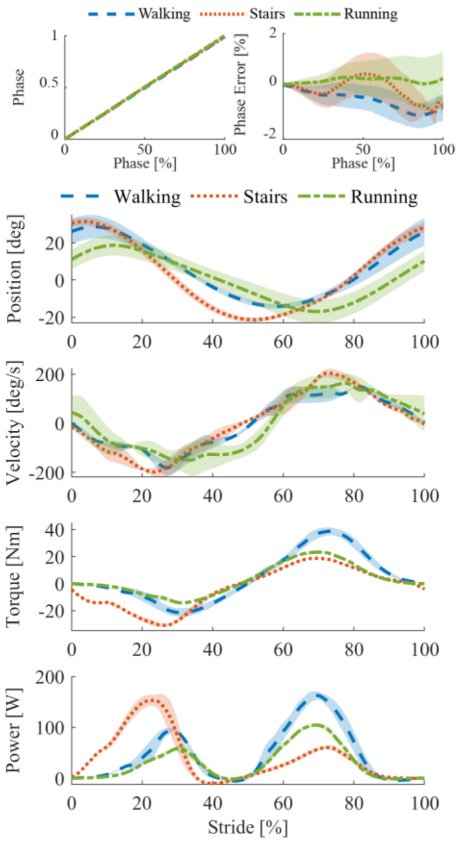

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Powered hip exoskeleton improves walking economy in individuals with above-knee amputation

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