Stanford

Biomechatronics Laboratory

CMMI 1734449: NRI: INT: Individualized Co Robotics

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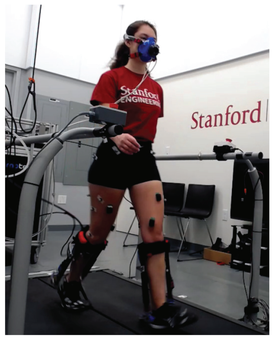
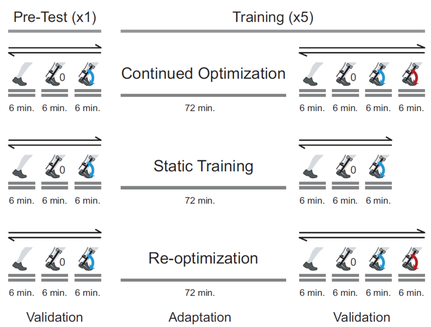
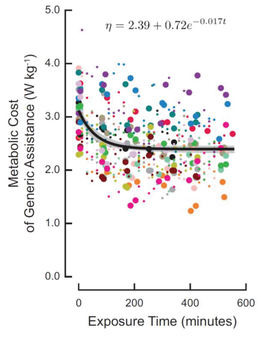
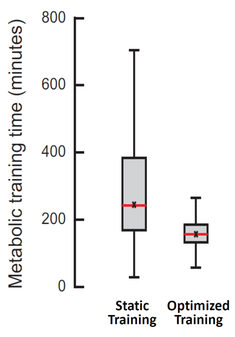
Results: Learning to use Ankle Exoskeletons

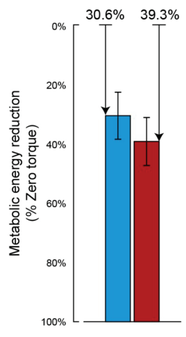
- Becoming expert takes longer than most experiments (hrs)
- Variations in exoskeleton activity speed human learning
- Optimized exoskeletons deliver large benefits to experts
- Large open-source dataset on human-exo adaptation











Motivations: Exoskeletons to Improve Mobility

Need: Aging and disability make walking slower and more effortful.
Potential solution: Ankle exoskeletons to aid walking.

Challenge: We don't know what exoskeletons should do to help.
Solution: Human-in-the-loop optimization of exo assistance.

Challenge: We don't know how humans should use exoskeletons.
Solution: Train expert users and study their responses.

Challenge: We don't know how to train users.
Solution: Try multiple methods: variation training, static exposure.

Challenge: We don't know what can be improved, or by how much.
Solution: Try to optimize multiple outcomes: energy use, speed.

Implications: Large Improvements Possible

With sufficient training and optimized exo.assistance, healthy young people can use 40% less effort and can walk 40% faster. The next project should test these techniques among older adults.

Other Impacts: People, Outreach, and Translation

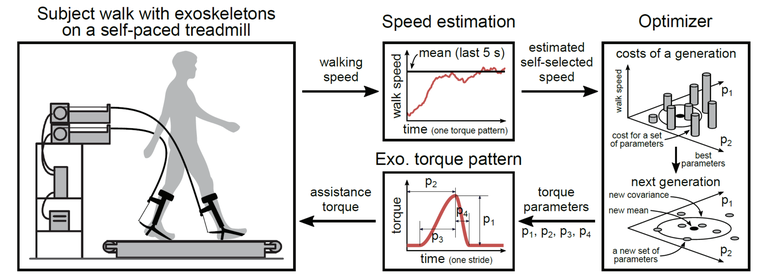
People: Ten PhD students and Postdocs trained, three now faculty.

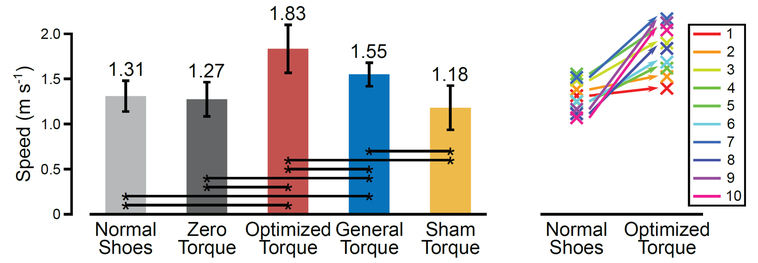
Outreach: NeurIPS competition, open-source design course tool.

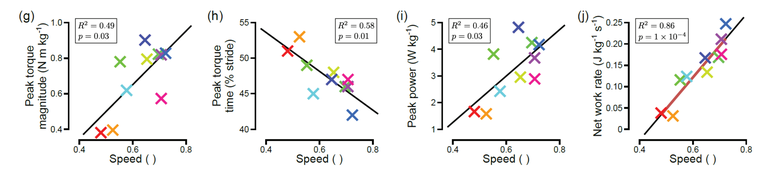
Translation: Worked to aid two spin-off companies.

Results: Maximizing Walking Speed

- Large improvements in speed are possible (up to 90%).
- Without regulation, user energy cost can also increase.
- Open-source tool for self-pacing instrumented treadmills.







Outreach & Translation:

NEURAL INFORMATION PROCESSING SYSTEMS

HUMOTECH

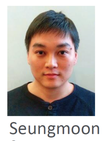
P3D: THE STANFORD PERSONAL 3D PRINTER PROGRAM

ESTAT ACTUATION

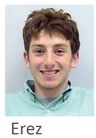
PhD Students & Postdocs:


Ge Lv


Katie Poggensee


Seungmoon Song


Sasha Voloshina


Erez Krimsky


Cara Welker


Vince Chiu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Michael Raitor


Sabrina Abram

Collaborators:


Allison Okamura


Emma Brunskill


Friedl De Groot


Max Donelan

Other Results:

New optimization algorithms: Lv, Xing et al., *in Proc. ACC*
Optimizing prosthesis function: Welker et al., *RSOS*
Prosthesis teleoperation: Welker et al., *TBME*
Navigating uneven terrain: Chiu et al., *RSOS*
Stroke asymmetry: Nguyen et al., *JNER*
Addressing balance: Tan, Raitor et al., *ICRA*
Efficient untethered devices: Krimsky et al., *ICRA*
Exploration in motor learning: Abram et al., *submitted*
Expert vs. novice biomechanics: Poggensee et al., *in preparation*
Exoskeletons for amputees: Voloshina et al., *in preparation*
Predictive simulations: Afschrift et al., *in preparation*