Towards optimal gait assistance

Human-in-the-loop optimization & Neuromechanical simulation

NRI PI meeting

Feb 28, 2020

Seungmoon Song

PIs: Chris Atkeson and Steve Collins

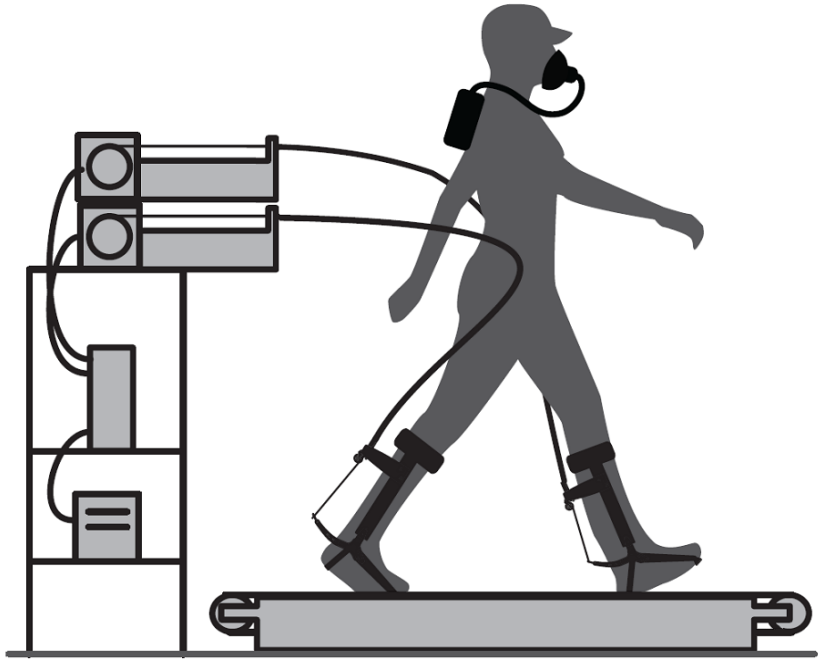
http://biomechatronics.stanford.edu/

smsong@stanford.edu

http://seungmoon.com

CMMI-1734449: NIR: INT: Individualized Co-Robotics

Objective: Improve normal walking

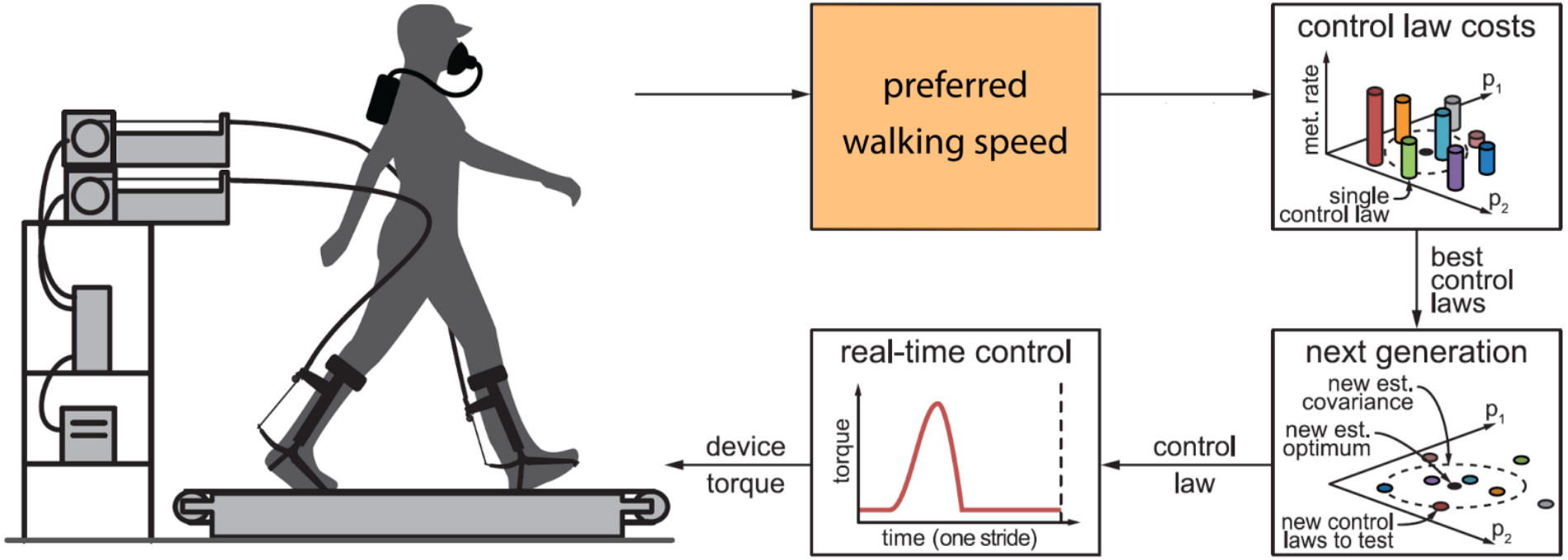


To get to target location:

- Safely
- With minimum effort
- In a minimum time

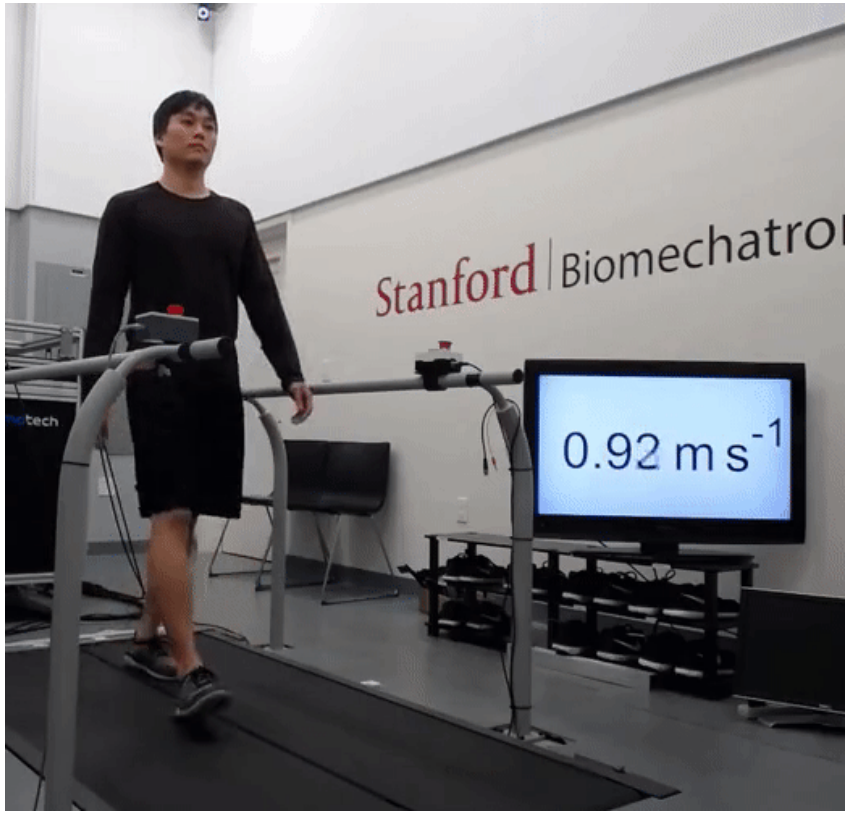
Can ankle assistance increase preferred walking speed?

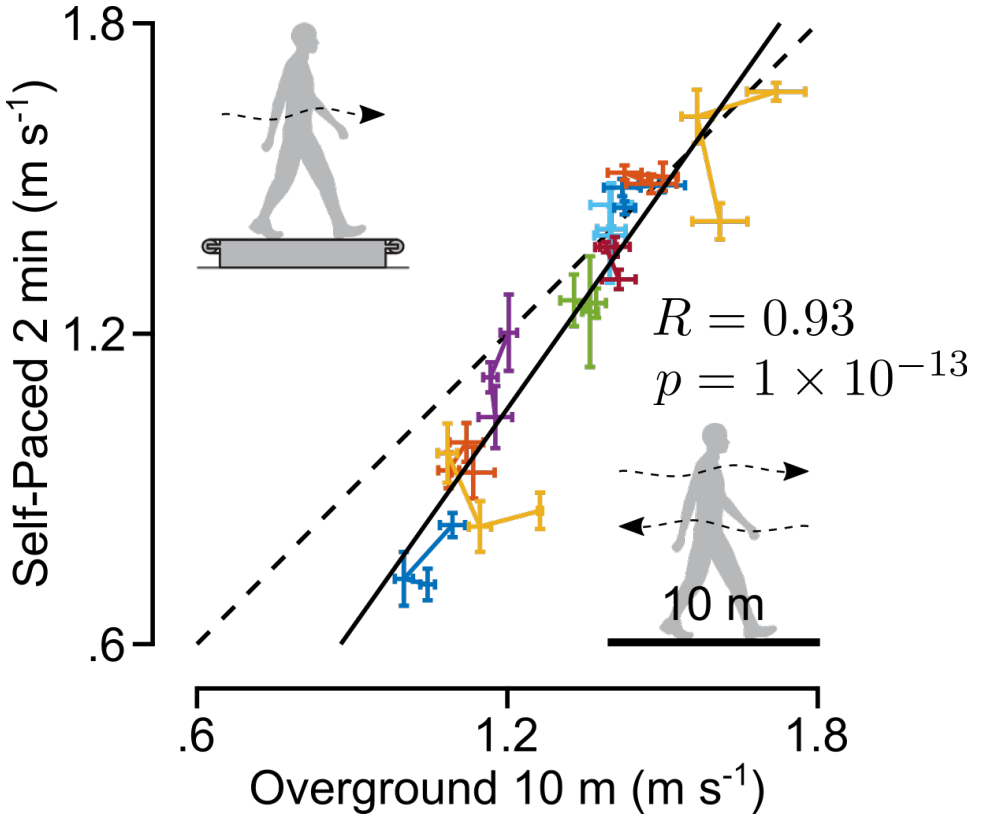
Method: Human-in-the-loop optimization



[Zhang et al., *Science*, 2017]

Measure preferred walking speed:
"Comfortable speed" on self-paced treadmill



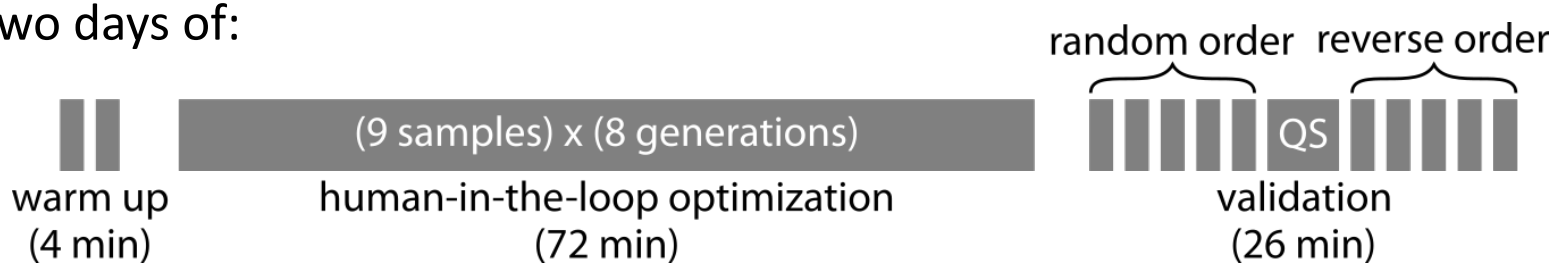


Self-pacing code: https://github.com/smsong/self-paced-treadmill

[Song, Choi & Collins, Using force data to self-pace an instrumented treadmill and measure self-selected walking speed, *submitted*]

Experiment: HILO for faster walking speed (N=10)

Two days of:

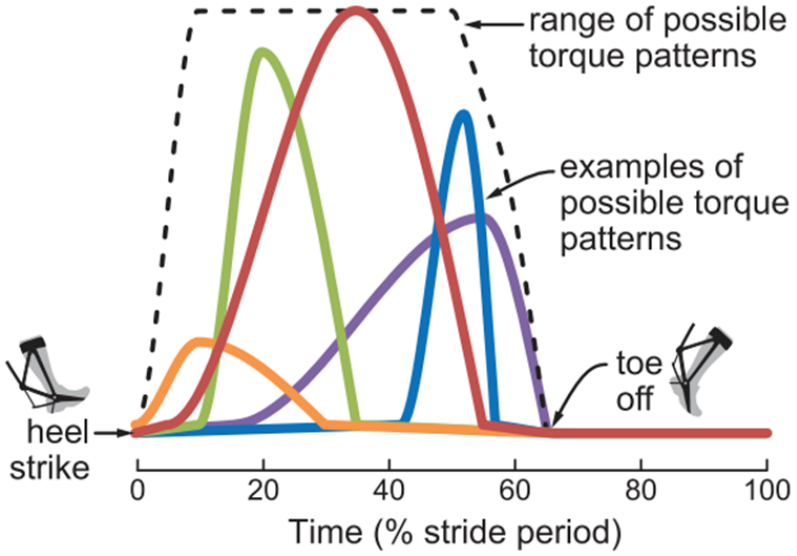


Instruction: “walk at a comfortable speed”

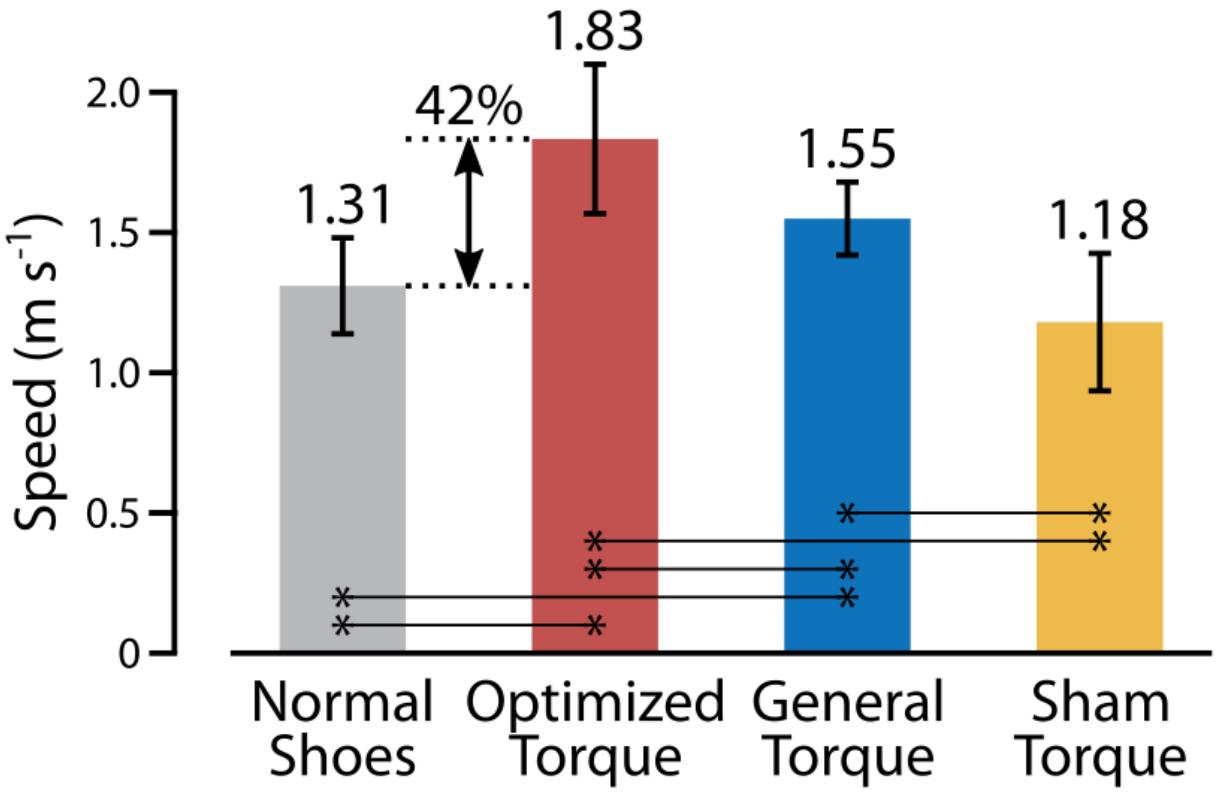
Optimize: Four torque parameters

Validation:

- Normal shoes
- Zero torque
- Optimized torque
- General torque
- Sham torque

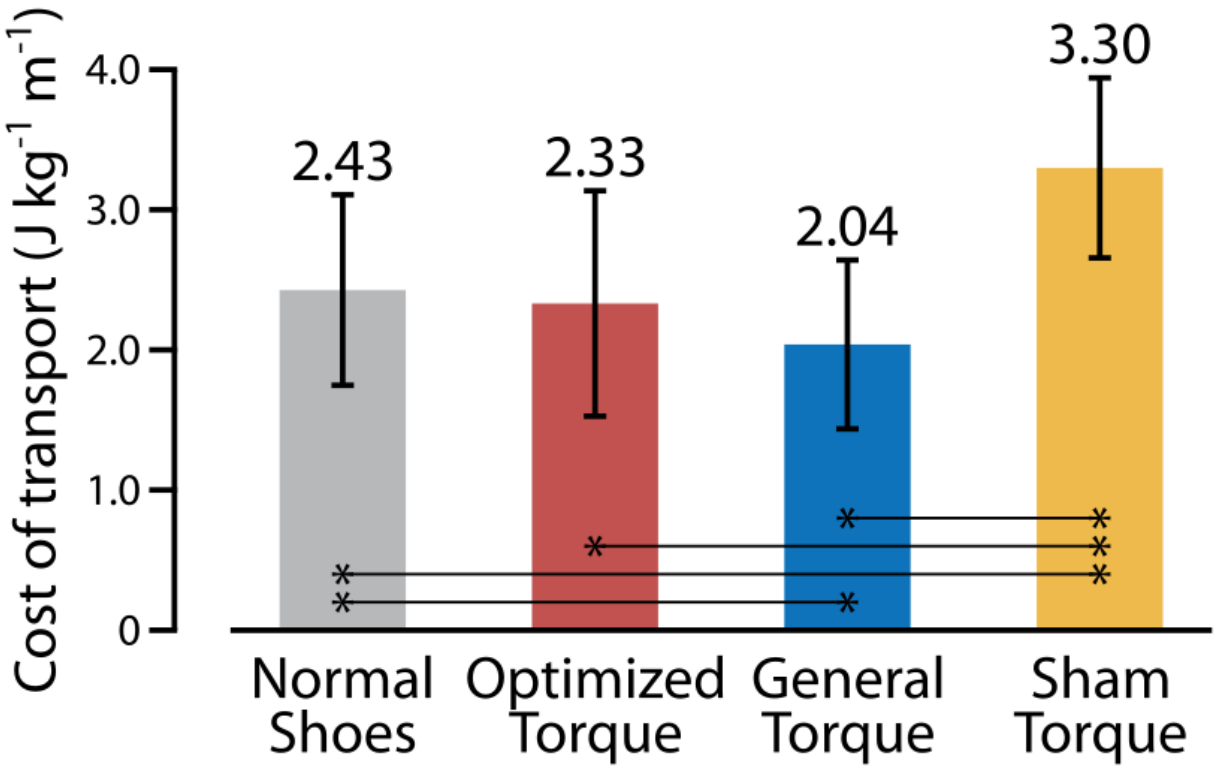


Main result: Walking speed



Self-selected walking speed increased by 42% (6 ~ 91%)

Quality of walking: Cost of transport



Change in COT varied across subjects (-31 ~ +78%)

Fast walking can be induced in different ways

Normal walking

Speed: 1.2 m s^{-1}

Optimized torque

Speed: +82%, COT: -20%

Optimized torque

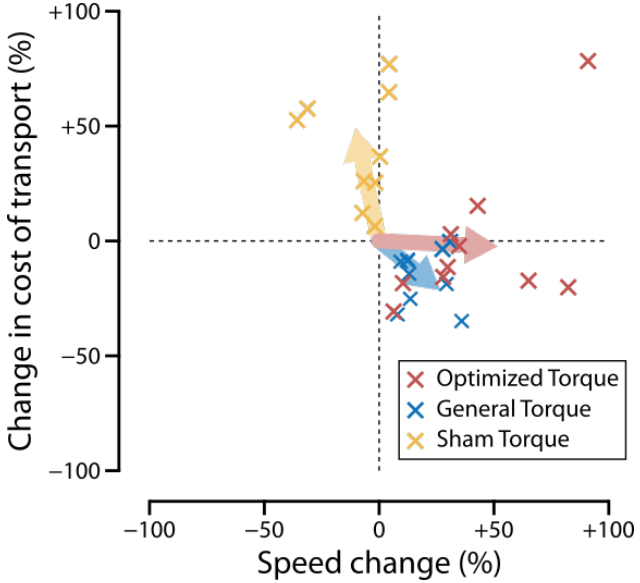
Speed: +91%, COT: +78%

Implications

Ankle assistance can increase self-selected walking speed

Only focusing on speed in HILO may result in *bad* assistance

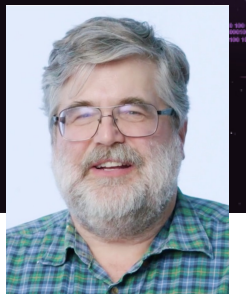
- **Multi-objective HILO**
- **HILO with domain knowledge**
  - Expert guided training
  - Smart exploration space
  - …



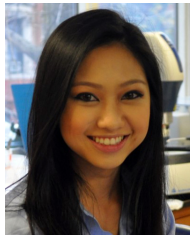
smsong@stanford.edu
http://seungmoon.com
http://biomechatronics.stanford.edu/

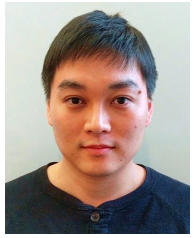
CMMI-1734449: NIR: INT: Individualized Co-Robotics

Individualized Co-Robotics for Gait Assistance




Exoskeleton assistance for impaired gait


Thu Nguyen


Seungmoon Song

Chris Atkeson

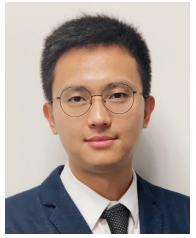
Steven Collins

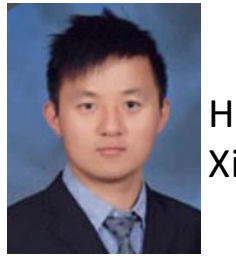
Motor learning during walking in exoskeletons


Katherine Poggensee

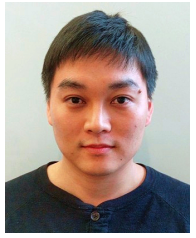

Sabrina Abram

Task-invariant learning framework for exoskeletons


Ge Lv


Haosen Xing

Predictive neuromechanical gait simulation


Seungmoon Song

CMMI-1734449: NIR: INT: Individualized Co-Robotics