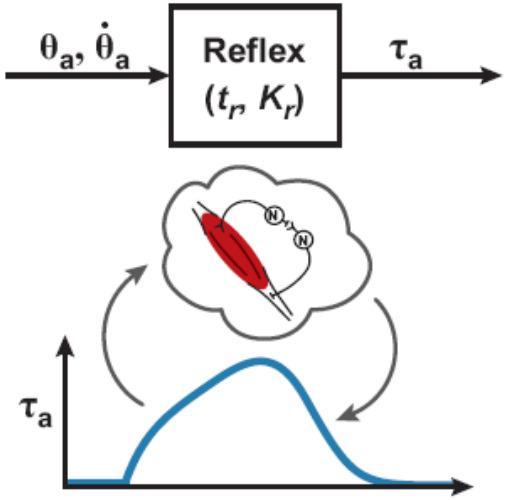
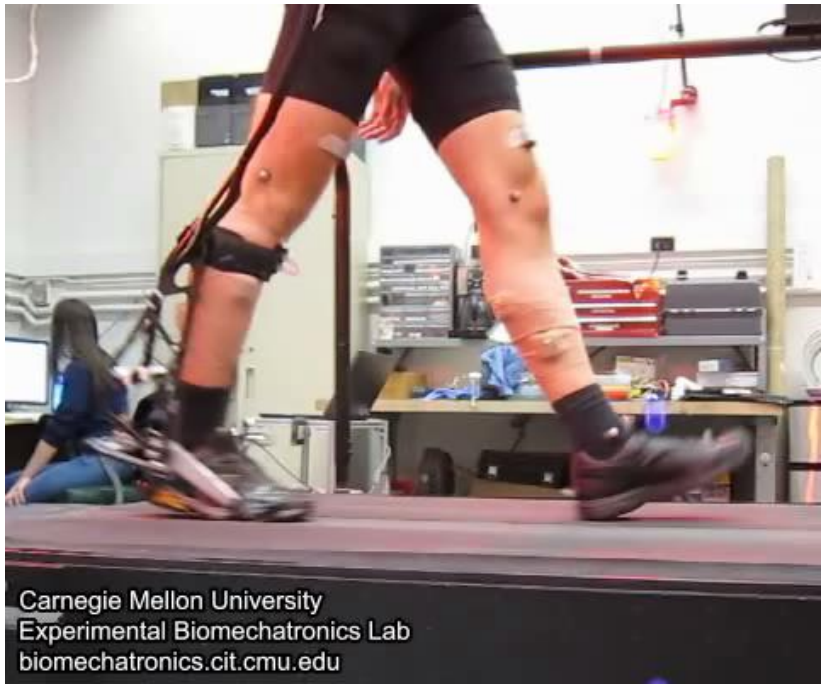
NSF National Robotics Initiative:

Rapid exploration of robotic ankle exoskeleton control strategies





PI: Steve Collins

Carnegie Mellon University

Experimental Biomechatronics Laboratory

Project Overview

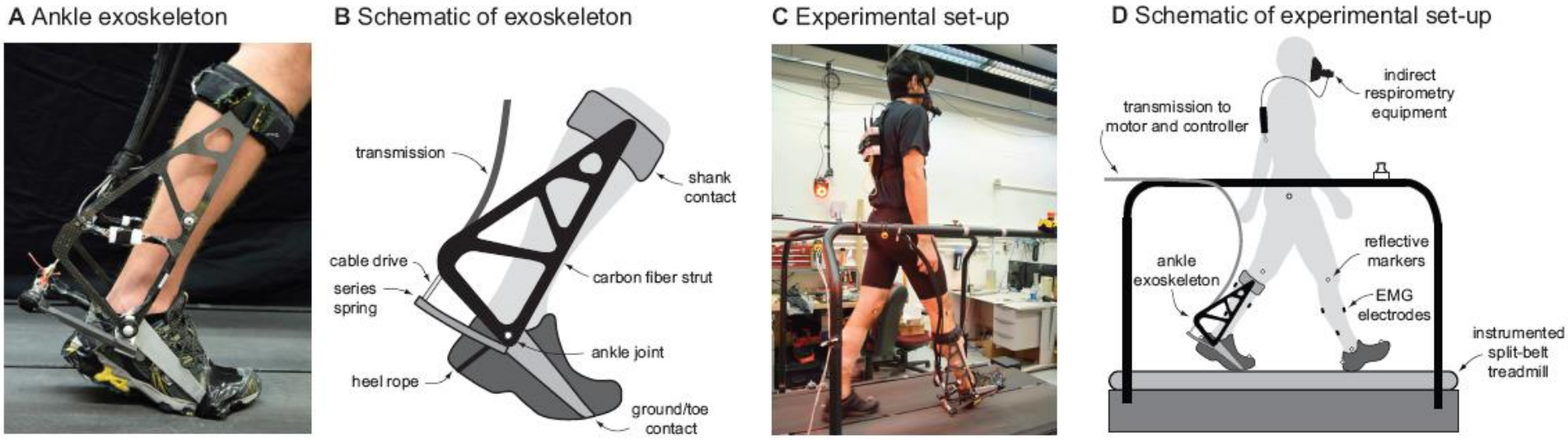
Missing keys for exoskeleton design:

- Tools for rapid, systematic exploration
- Neuromechanics models of performance

Our approach:

- Universal ankle-foot exoskeleton emulator
- Measures from muscle fascicle to whole body

Universal ankle-exoskeleton emulator

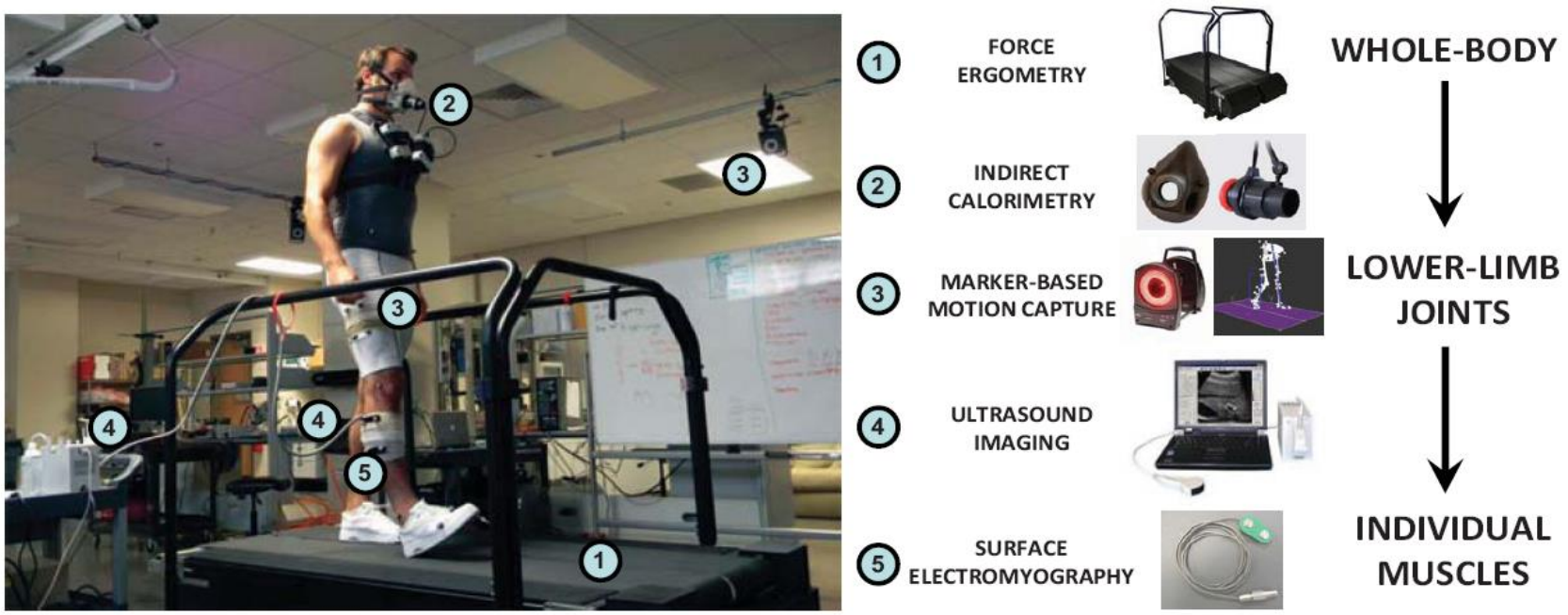


Trades autonomy for *exceptional* versatility.

From idea to experiment in hours, not years.

Steve Collins · Carnegie Mellon University · biomechatronics.cit.cmu.edu · stevecollins@cmu.edu

Multi-scale locomotion physiology toolset

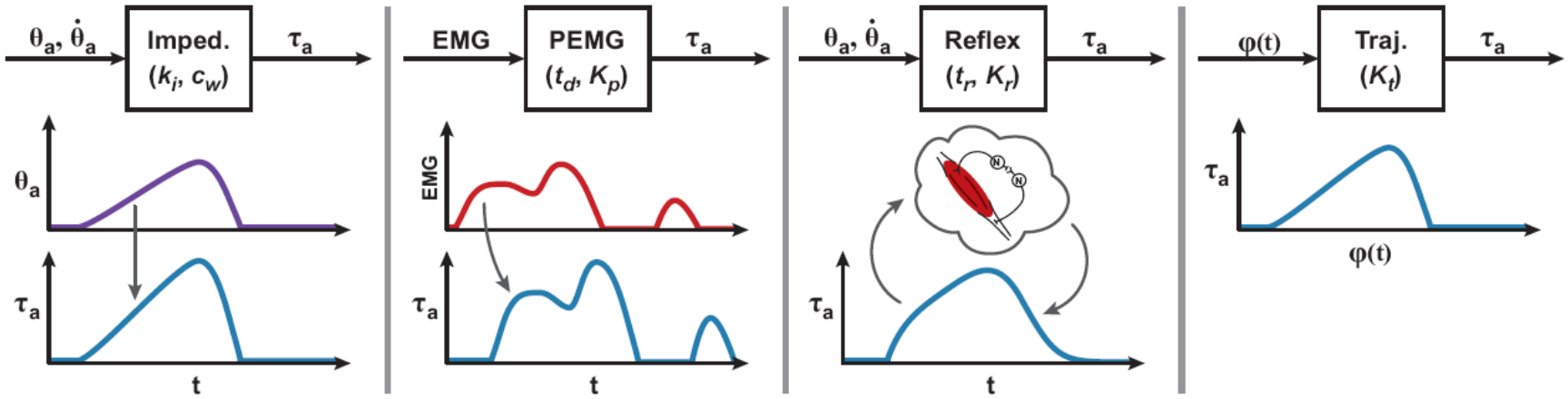


From whole-body dynamics and chemistry…

… to individual muscle mechanics and activation

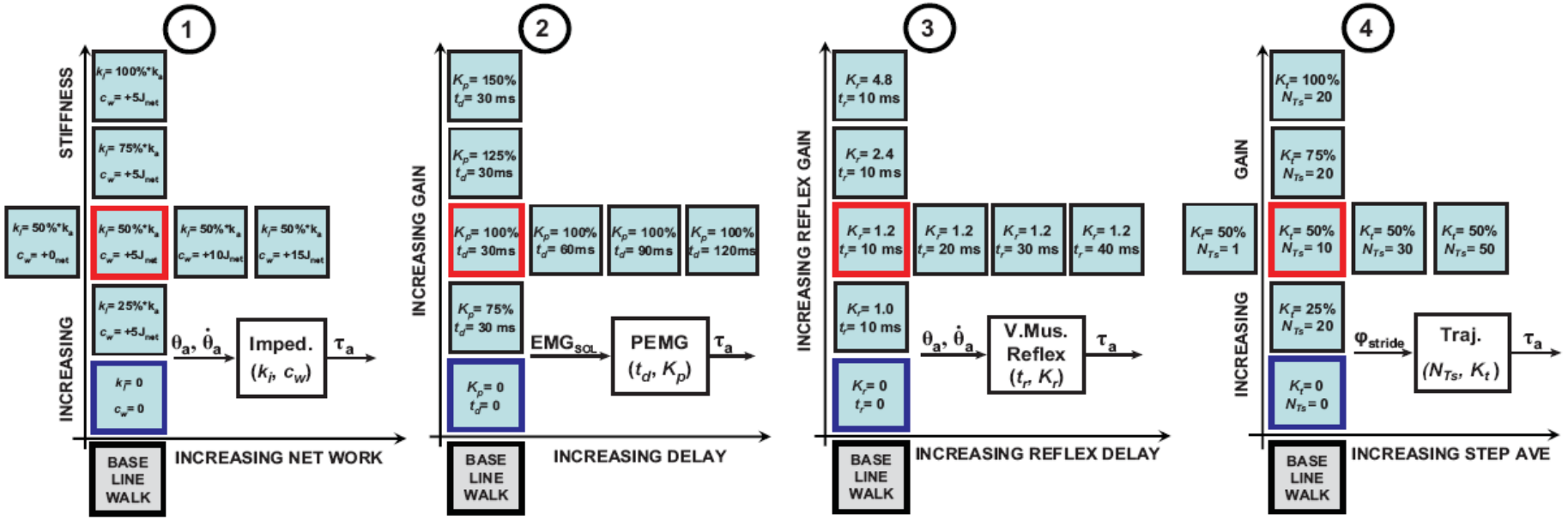
Steve Collins · Carnegie Mellon University · biomechatronics.cit.cmu.edu · stevecollins@cmu.edu

Assistance strategies worth exploring



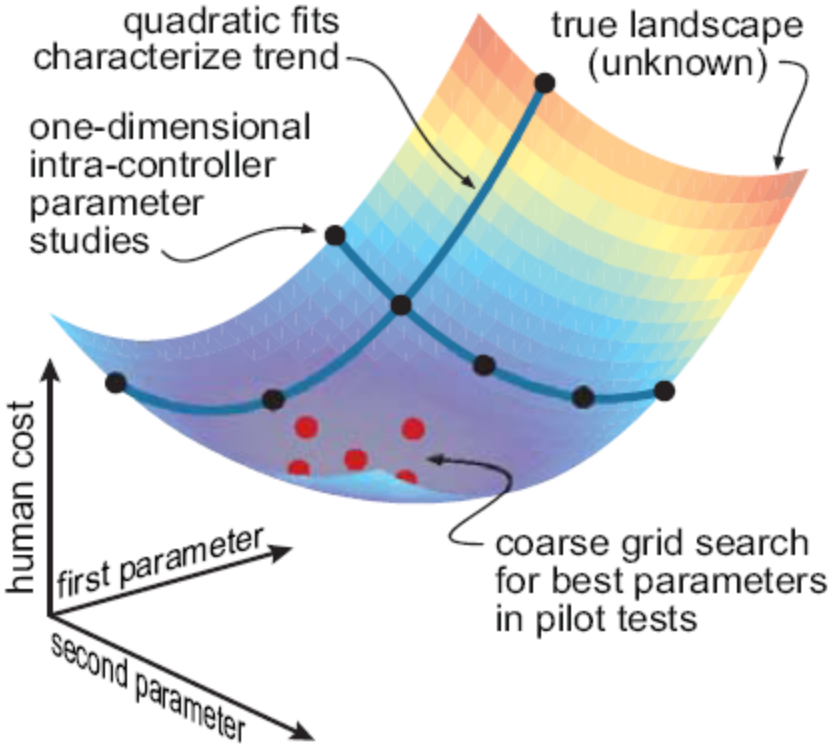
1. Impedance: springs and (negative) dampers
2. Proportional EMG: muscle amplifier
3. Reflex-like: virtual muscles and neurons
4. Trajectory-based: on the clock

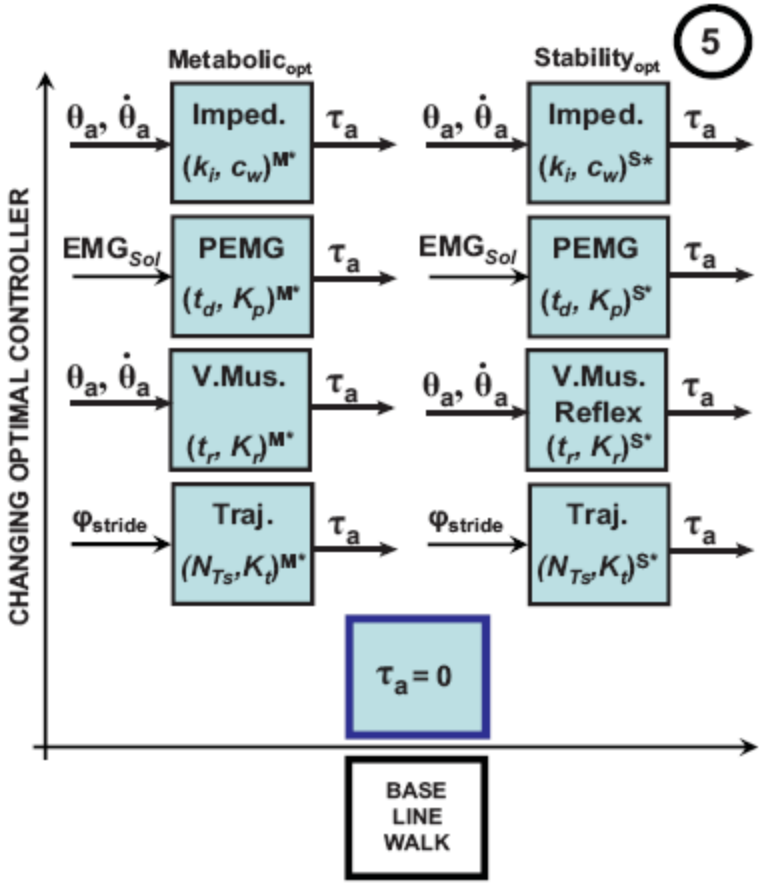
Intra-controller experiments



Systematic exploration along key parameters

Inter-controller experiments





Comparison of each approach at its best

Milestones: Ahead of Schedule

Completed:

- Embodiment of all high-level controllers[1]
- Parameter sweep on impedance control[2]
- Platform improvements and duplication[3]

In progress:

- Proportional EMG sweep (Q2, 2015)
- Online optimization (Q4, 2014)
- Expansion to knee (Q4, 2014)

1. Jackson and Collins (2014) In review: *Journal of Experimental Biology*
2. Zhang and Collins (2014) In review: *International Journal of Robotics Research*
3. Witte and Collins (2015) In preparation for *International Conference on Robotics and Automation*

Steve Collins · Carnegie Mellon University · biomechatronics.cit.cmu.edu · stevecollins@cmu.edu