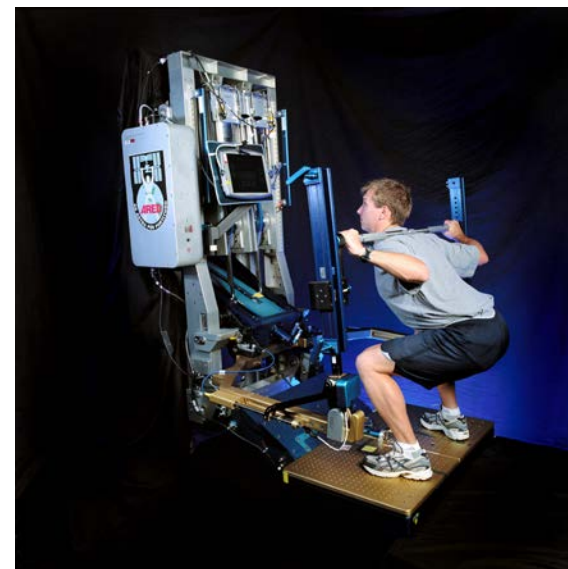# CPS Synergy: Cyber-Enabled Repetitive Motions in Rehabilitation
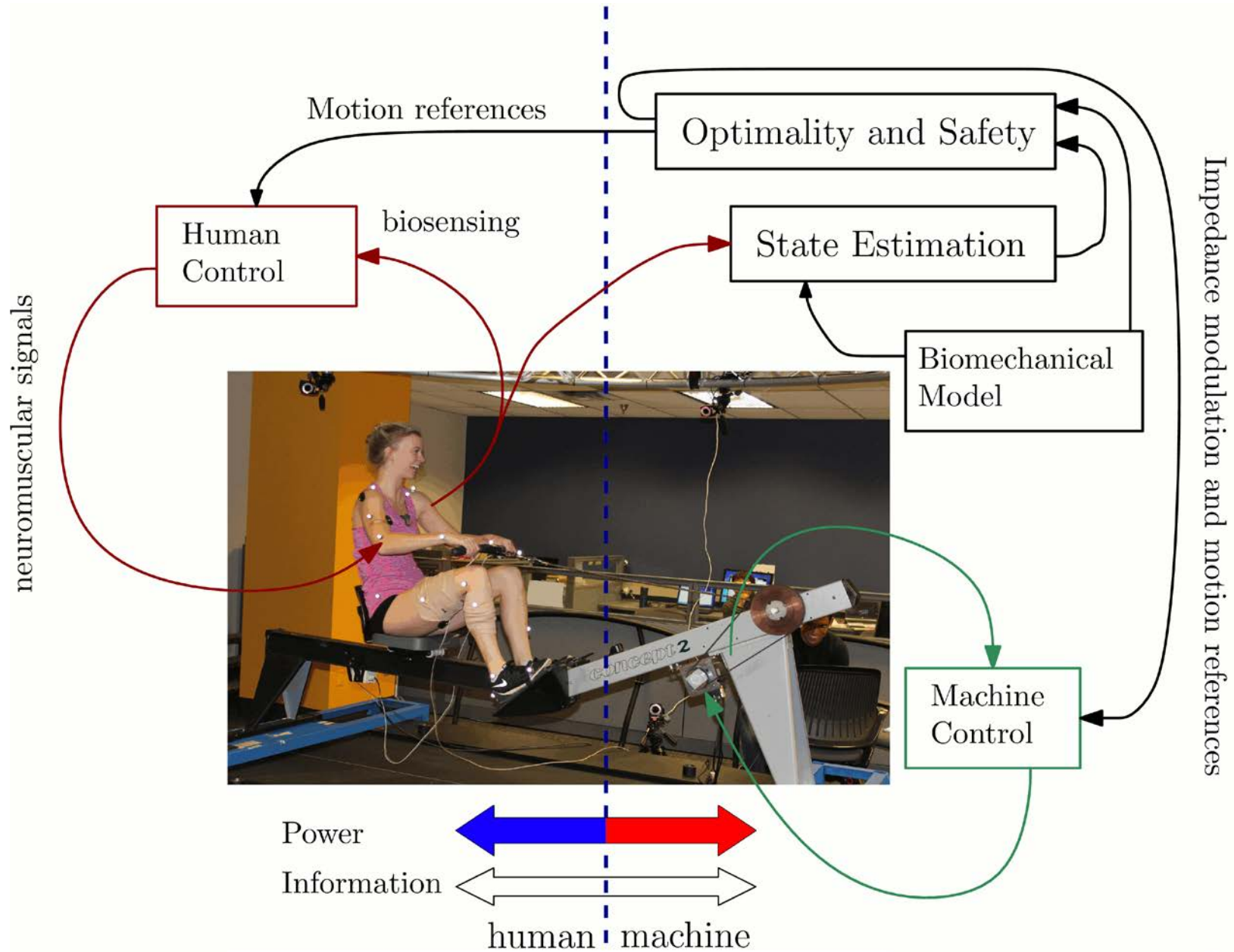
Hanz Richter (PI), Mech Eng

Ton van den Bogert, Mech Eng

Ken Sparks, Human Performance

Dan Simon, Electr. Eng and Comp. Sci.

Cleveland State University
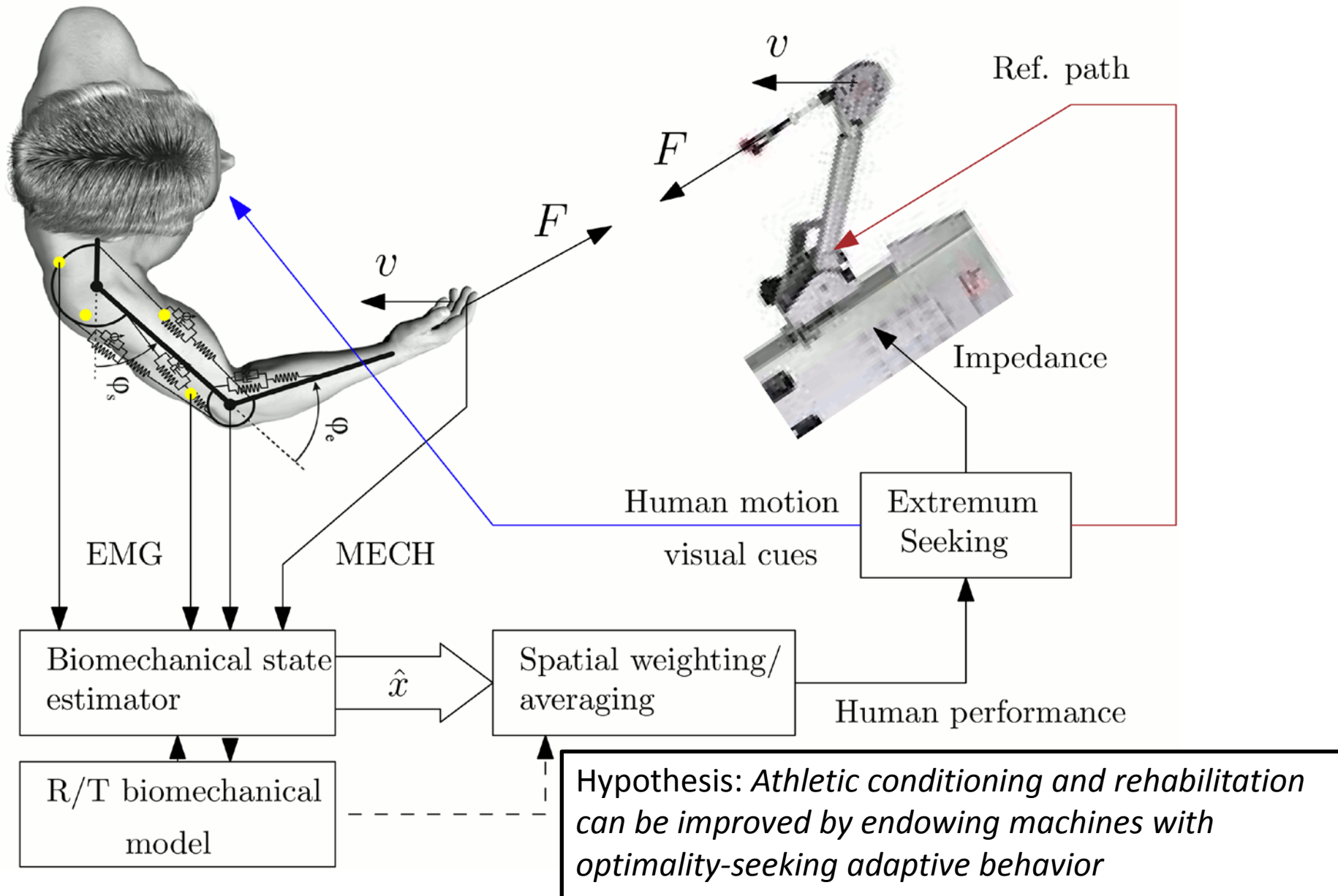
h.richter@csuohio.edu

CPS# 1544702

Our research applies to exercise machines for microgravity.
Source: NASA ISS ARED machine

Cyber-physical human exercise

Estimating and maximizing performance

Hypothesis: *Athletic conditioning and rehabilitation can be improved by endowing machines with optimality-seeking adaptive behavior*

Core disciplines and findings

State Estimation (Dan Simon)

Kalman Filter/Nonlinear observers for biomechanical state / muscle activation estimation from EMG

Human performance science (Ken Sparks)

Characterization of metabolic expenditure relative to eccentric loading

Biomechanics (Ton van den Bogert)

Real-time musculo-skeletal model. Predictive simulation of human movement

Control / Optimization (Hanz Richter)

Robust impedance control for maximal performance. Modeling of human control