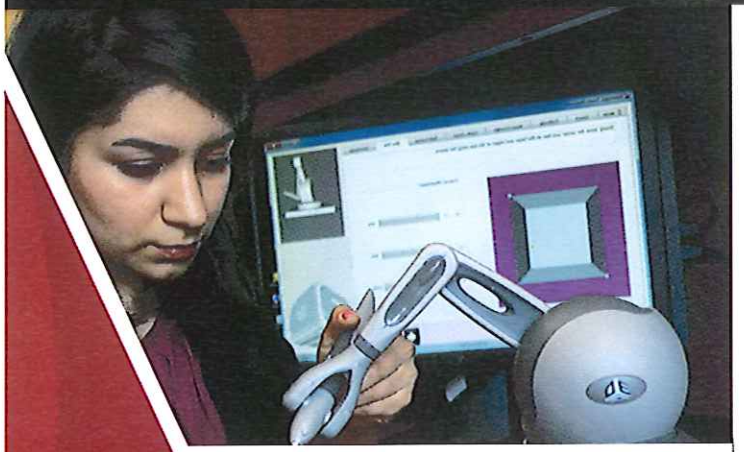


Research

Clinical Prosthetics

Education

Biomedical Research

Jon Sensinger

Electrical and Computer Engineering

Institute of Biomedical Engineering

University of New Brunswick, Canada

IBME: a New Brunswick Gem

- Founded in 1965 by Bob Scott to address clinical needs with scientific expertise
- Internationally recognized as a leader in prosthesis research and clinical care

IBME: Clinical care for NB and beyond

- We provide clinical upper-limb prosthetic care for New Brunswick and difficult cases across Atlantic Canada

- We are fortunate to provide services to NB children due solely to the support of philanthropic groups such as War Amps

International research with a local impact

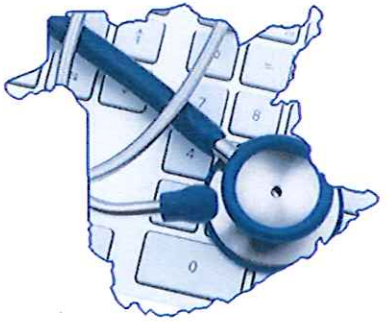
- Our research formed the foundation of international advanced prosthesis control
- Frequently sought in international teams and media
- Research impacts our local clinical care, both in the prosthetics clinic and at the Stan Cassidy Rehabilitation Centre

Looking forward while keeping our roots

- Our scientific advances are fueled by our unique blend of research and clinical care
- Branching out to broader clinical populations (stroke, MS, spinal cord injury)
- Developing new technologies (robotic exoskeletons, outcome measure tool-kits)
- Provincial funding agencies are allowing us to achieve clinical & local commercial impact

Global impact, regional benefit

- Health Technologies is poised to become the next booming industry
  - Chronic disease
  - Healthy aging
- NB has the innovation ecosystem, loyalty, education, and clinical population for success
  - NB Innovation Research Chair in Medical Devices and Technologies
  - Created technology that resulted in first ever commercialization of 'smart' prosthesis controller
  - E5E: IBME spin-off
  - Close relationships with **local** industry (T4G, Excel Manufacturing, SmartSkin, etc…)



TECHNOLOGY MANAGEMENT & ENTREPRENEURSHIP

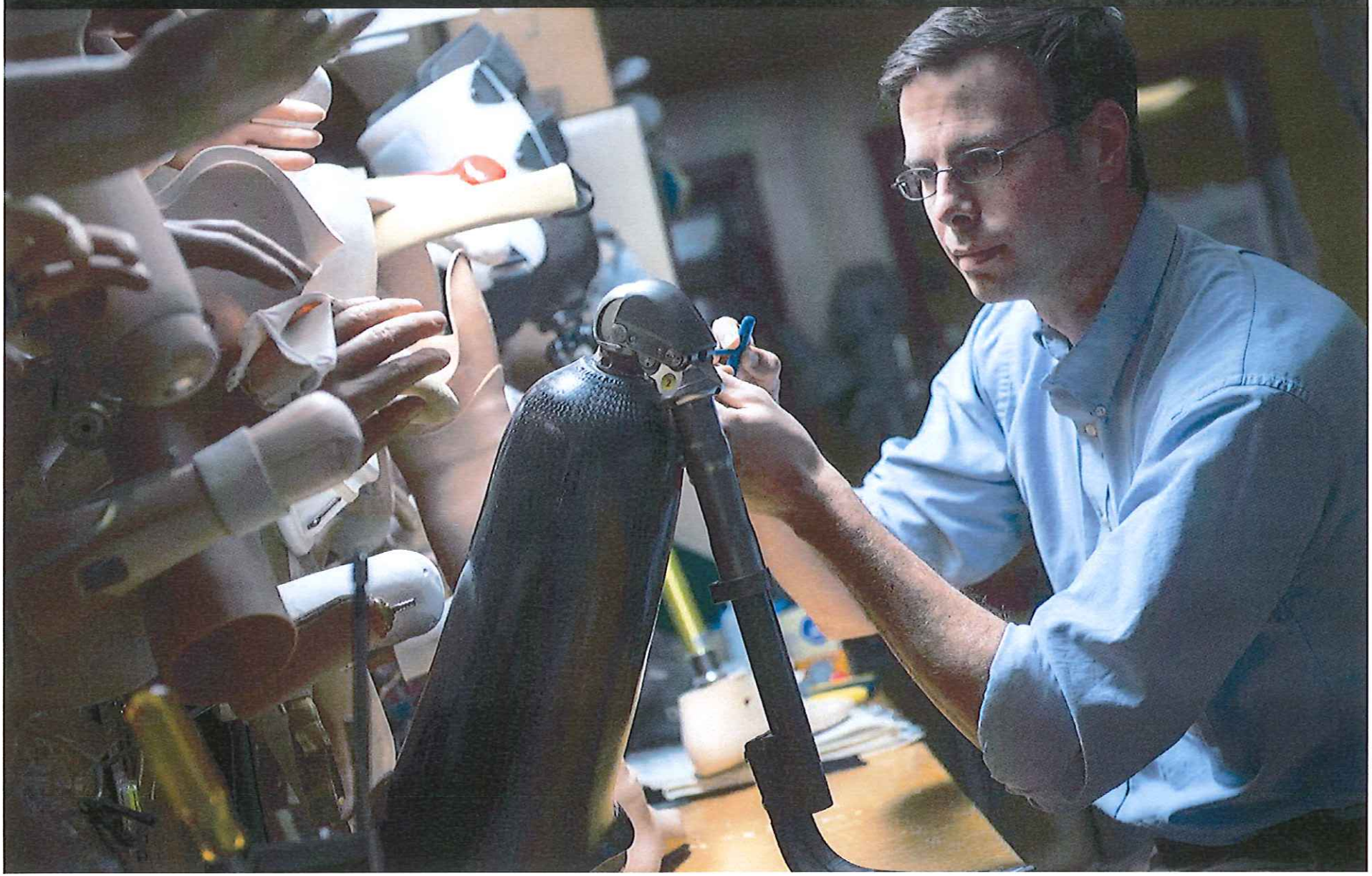
New Brunswick Nouveau Brunswick CANADA

New Brunswick Health Research Foundation

FINBIF INNOVATION

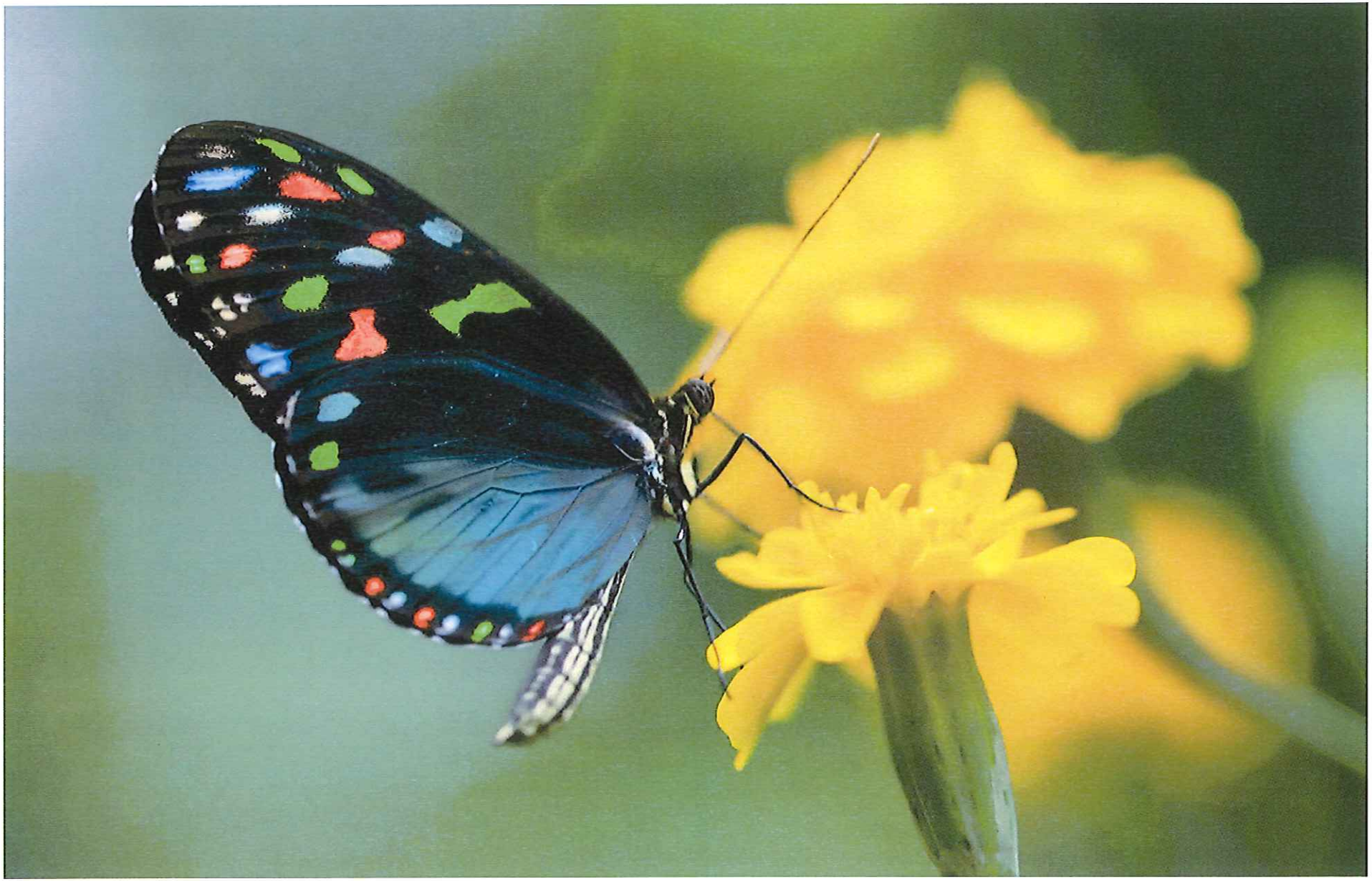
invest NB

What is biomedical research?

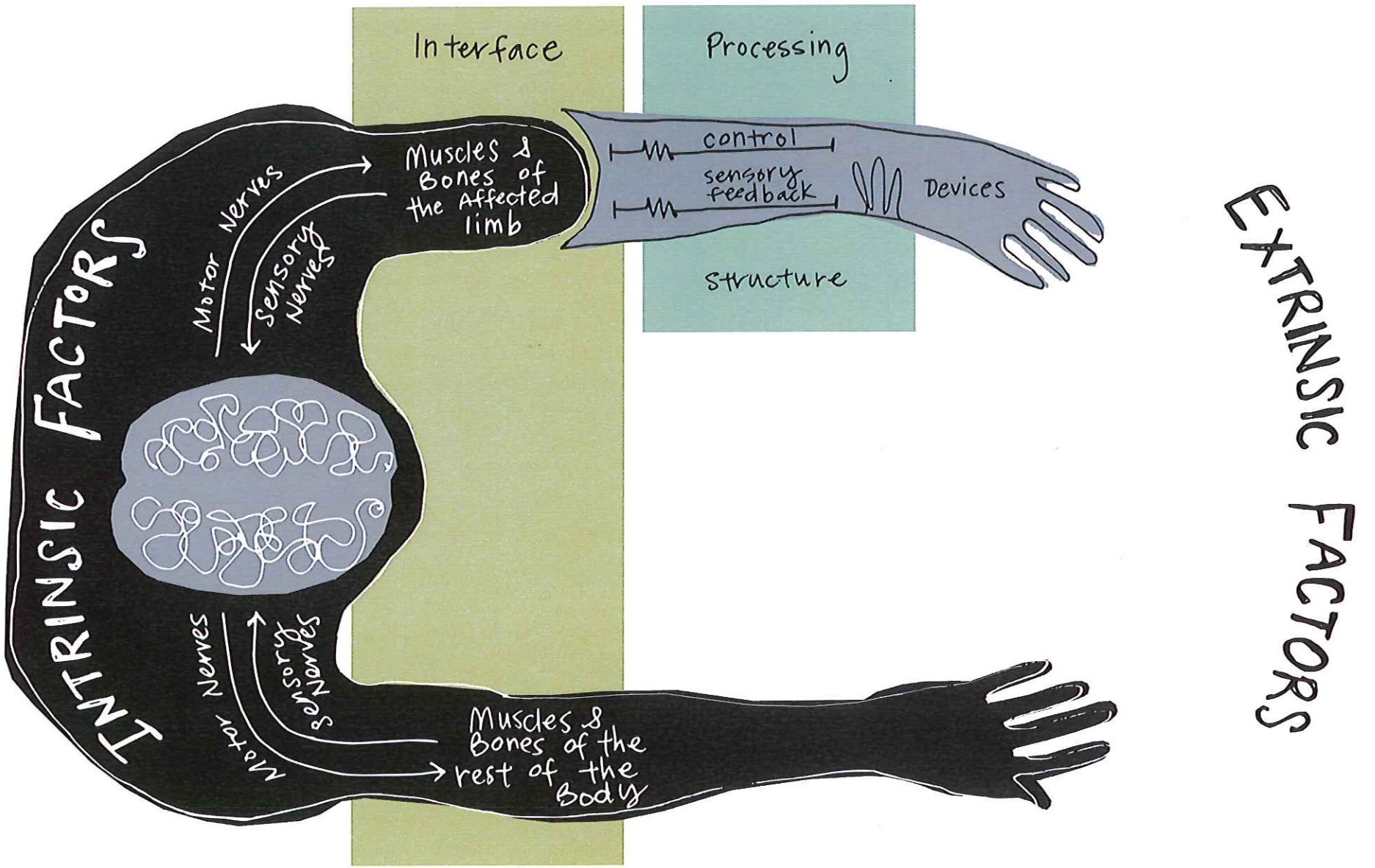


What research is

Biomimicry: *what* vs. *why*



Prosthesis control is complex



Simple, accurate models

Why are causal models important?

- Things are complicated
- Subjects are few
- Can tap larger knowledge base on able-bodied control theory
- Predictions are often counter-intuitive (but accurate!)

Simple, accurate models

Simple, accurate models

[Useful scientific frameworks] include the relevant data, do so with a certain sort of simplicity, and prove fruitful in areas beyond the immediate concern. ~ N.T. Wright

$$\dot{x} = Ax + Bu$$
$$P = A'PA + Q$$
$$K = \frac{P}{Q + R}$$
$$\dot{x} = \dot{x} + K(\hat{x} - x')$$
$$P = P(I - K)$$

Simple, accurate models

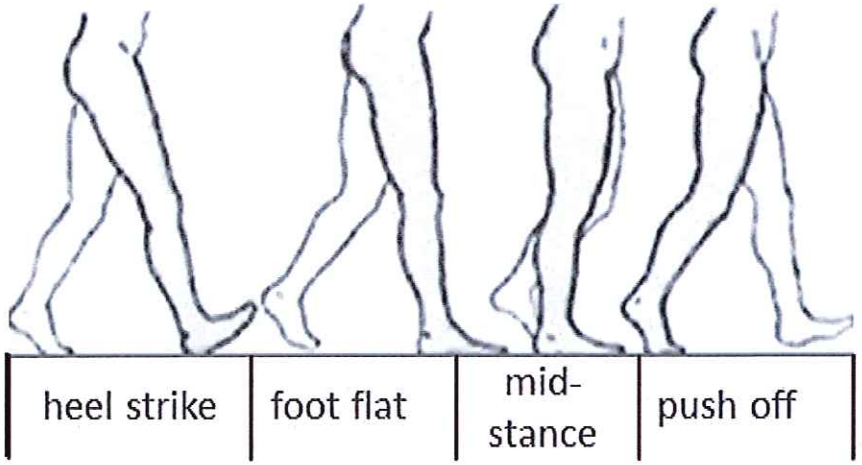
Enable us to:

- Developing quantifiable outcome measures
- Improve control through augmenting feedback
- Better understand human-robot interaction

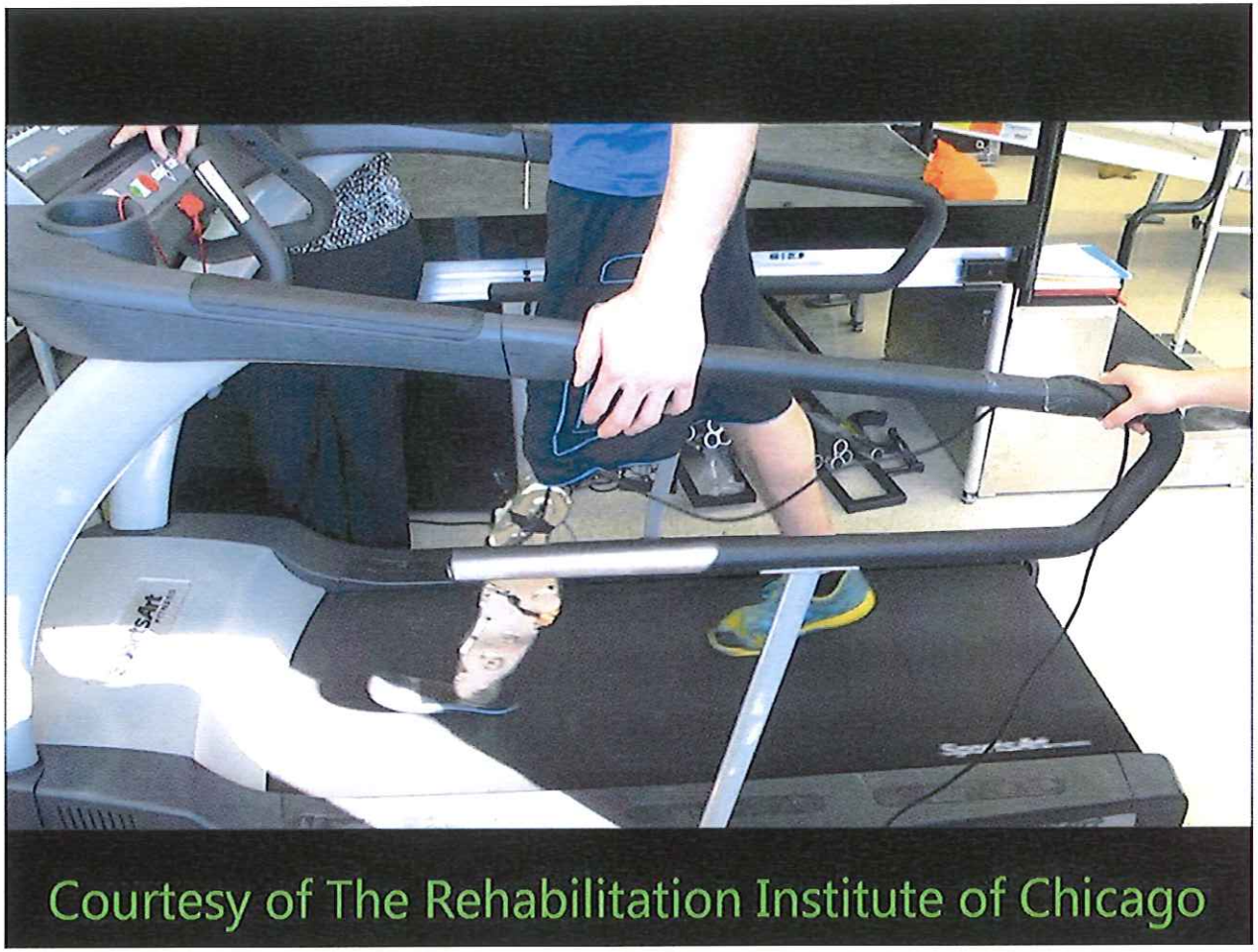
Amputee Locomotion

- Inefficient, slow, unstable walking
- Control challenges in new powered legs:

different control model
for every joint and phase



Nonlinear models to control legs



Bobby Gregg

Tommaso Lenzi

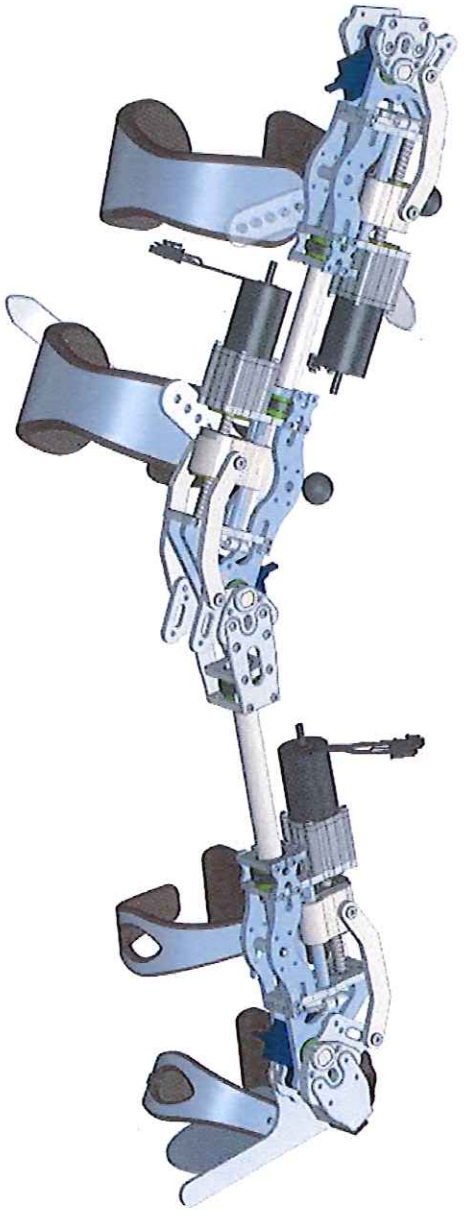
Lenzi, Sensinger et al. (2014), IEEE Robotics & Automation Mag
Gregg, Sensinger et al (2014), IEEE Trans Robotics
Gregg & Sensinger (2014), IEEE Trans Control Systems Technology
Patents pending

Application to Exoskeletons

Rehab exoskeletons move slowly and unnaturally to guarantee safety

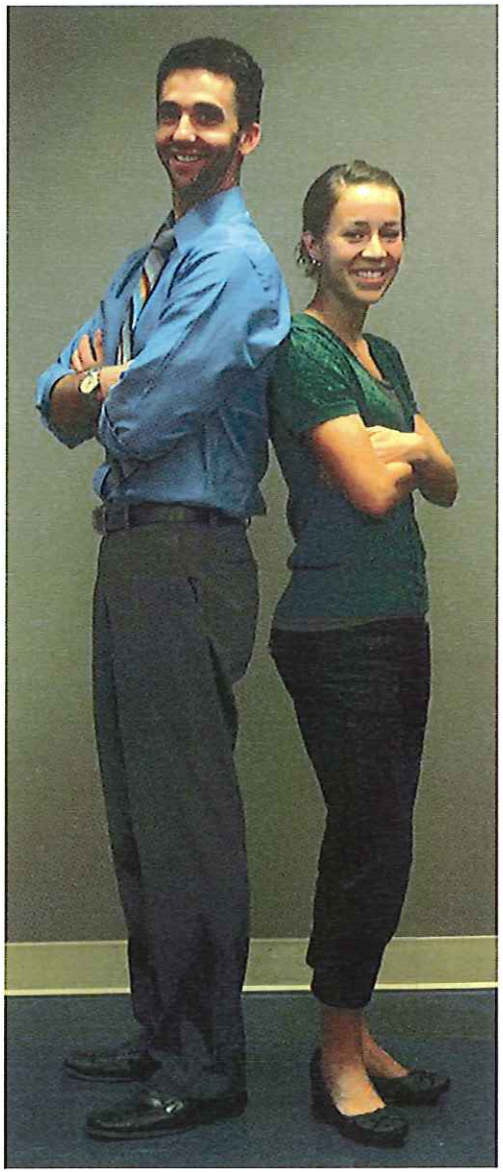
Using a new virtual constraint, we have developed a controller that ensures robust stability, yet enables, fast, natural gait.

We are applying it to our UNB hip-knee-ankle exoskeleton



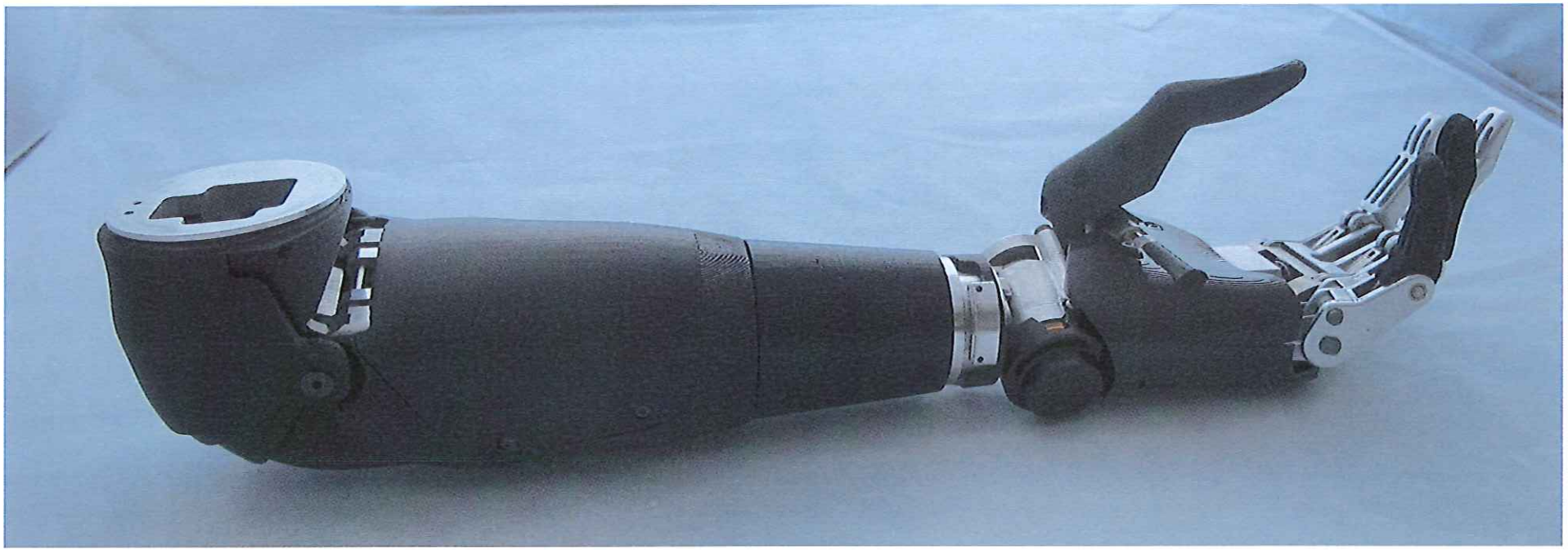
New Brunswick Health Research Foundation
Fondation de la recherche en santé du Nouveau-Brunswick
NBIF

Inventor's dilemma

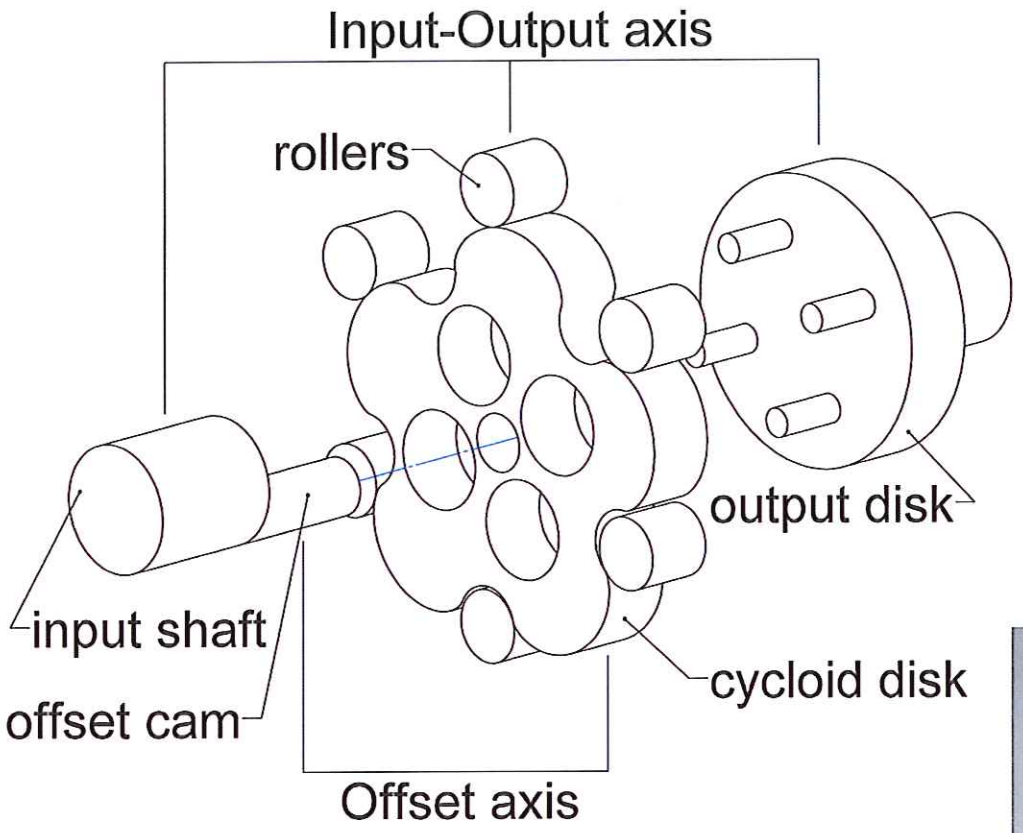


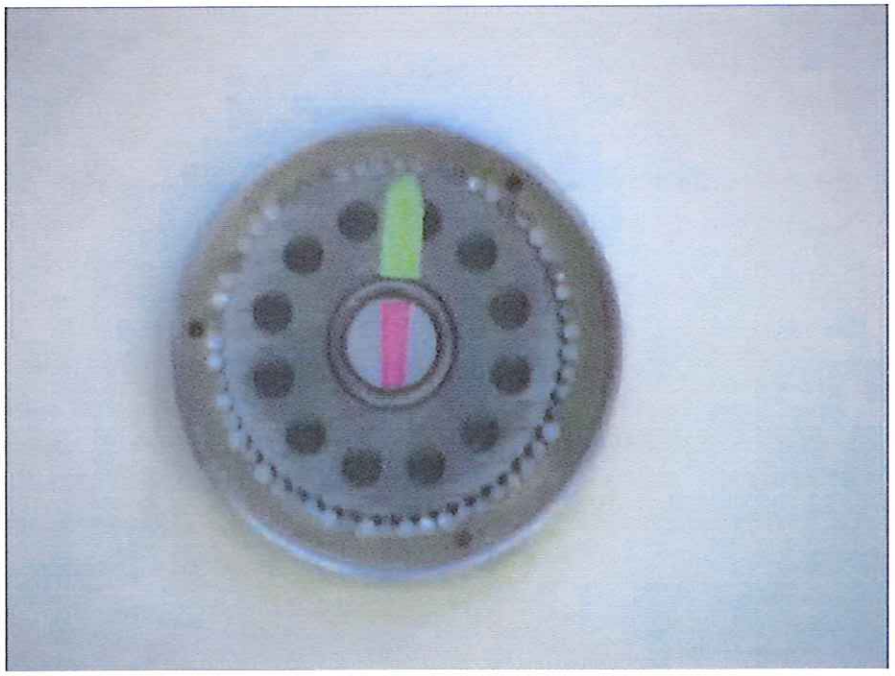
RIC arm

As small and light
as a 25th percentile female



Compact, rugged technology: Cycloids

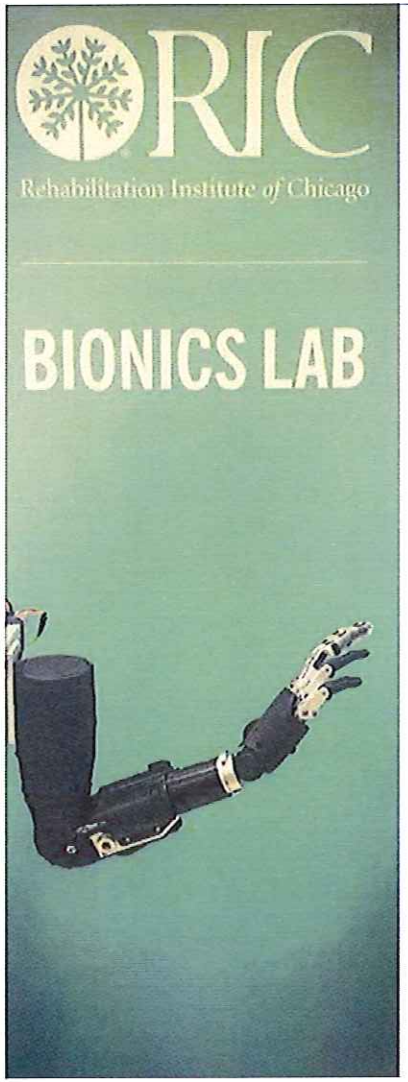




Sensinger (2010). Journal of Mechanical Design
Sensinger (2013). Journal of Mechanical Design

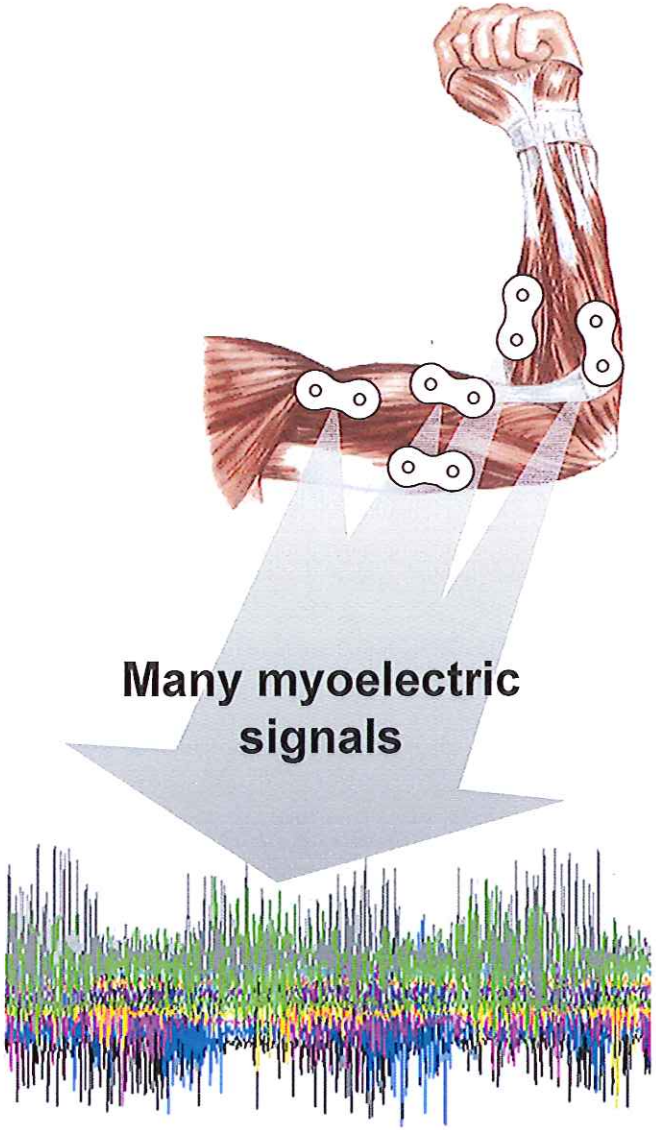
RIC arm

Lenzi, Lipsey, and Sensinger (2016). IEEE Transactions on Mechatronics

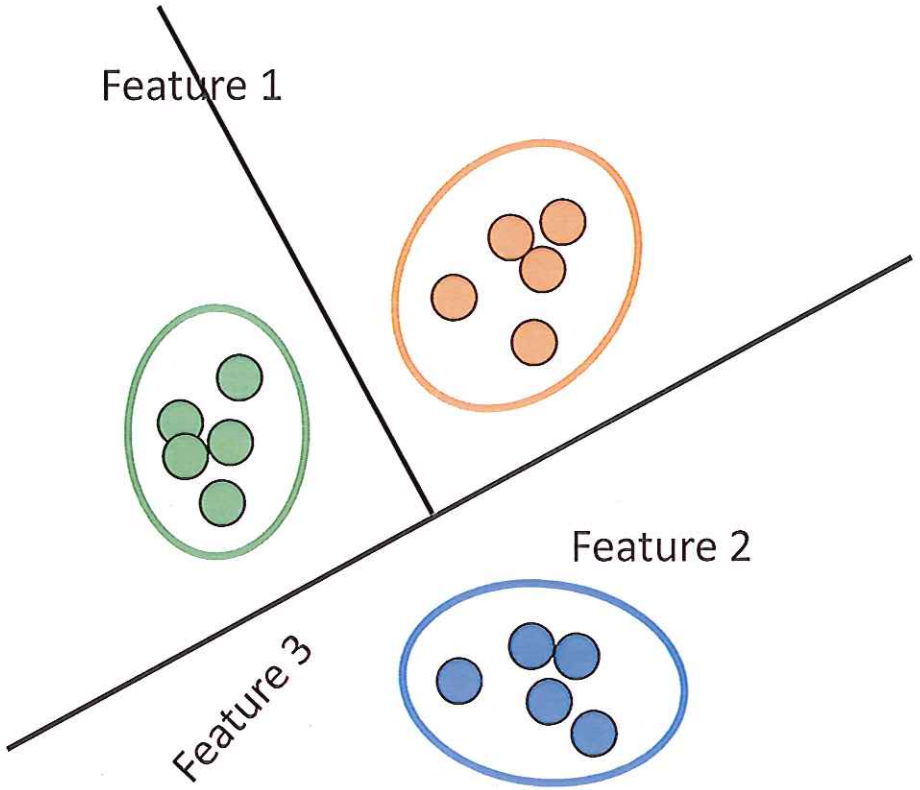


Clothespin Test

Control



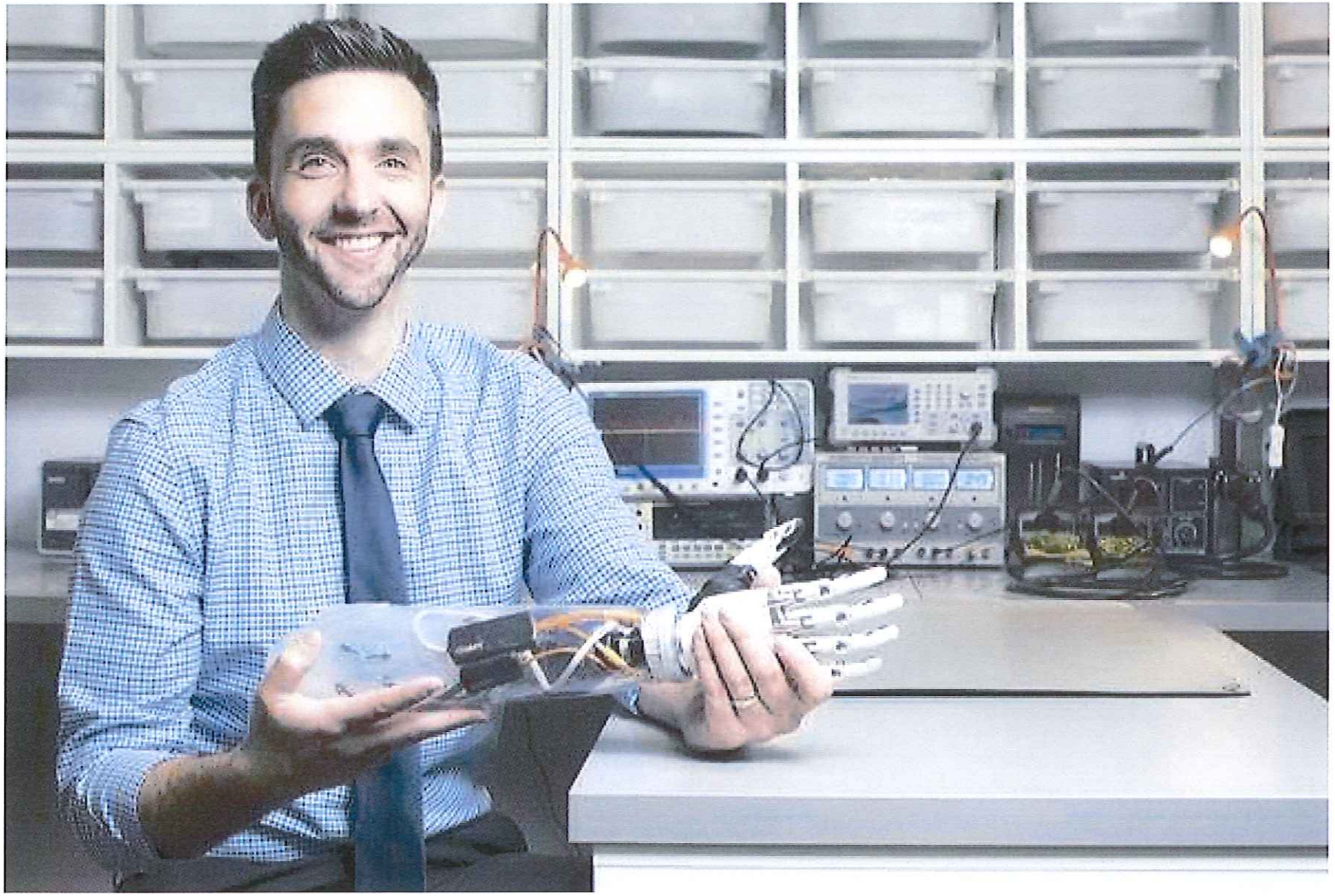
Requirement 1: Repeatability



Requirement 2: Separability

Control

Coapt: First commercialization of prosthetic pattern recognition



Summary

- Amazing time to be in the field
  - Transfer of engineering gadgets, control theory, psychophysical and experimental paradigms to end-users
- Great applications for exoskeletons, rehabilitation robots, and med-tech for an aging society

Our Staff and Faculty

Support

This work was funded by:

- New Brunswick Health Research Foundation
- New Brunswick Innovation Foundation
- Natural Science and Engineering Research Council
- Mitacs Globalink
- USA National Institutes of Health
- USA National Science Foundation
- USA DARPA
- USA NIDRR
- USA CDMRP

Our Students & Post-doctoral Fellows


Support

This work was funded by:

- New Brunswick Health Research Foundation
- New Brunswick Innovation Foundation
- Natural Science and Engineering Research Council
- Mitacs Globalink
- USA National Institutes of Health
- USA National Science Foundation
- USA DARPA
- USA NIDRR
- USA CDMRP