

# Eric Rombokas

Department of Veterans Affairs  
Center for Limb Loss and MoBility (CLiMB)  
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## Education and Employment:

Affiliate Assistant Professor Depts. of Mechanical and Electrical Engineering University of Washington	2014 - Present
Research Health Scientist (Principal Investigator) Center for Limb Loss and MoBility (CLiMB) Veterans Affairs Rehabilitation R&D	2013 - Present
Postdoctoral Researcher University of Washington Advisor: Dr. Tom Daniel	Oct 2012 - Oct 2013
Ph.D. in Electrical Engineering University Of Washington Advisor: Dr. Yoky Matsuoka Dissertation: "Dynamic Manipulation for Tendon-Driven Hands"	2012
Software Engineer NAVSEA NUWC Keyport SONAR and Tracking	2002 - 2005
Master of Electrical Engineering Rice University	2002
Bachelor of Electrical Engineering Rice University	2001

## Research Interests:

**Dynamic control of robots:** Control in uncertain environments and nonlinear robotic hardware is still impossible, but we are beginning to crack the hard problems. I am interested in using reinforcement and unsupervised learning as a means for achieving model-predictive control without an oracle of system dynamics. I believe that neuroscience provides clues for overcoming the curse of dimensionality and mismatch between models and reality that comes with embodiment in the real world. It also provides clues about the combined nature of sensation and action, and can lead us to a new understanding of active sensing.

**Neural control of movement:** Leveraging our understanding of biological

movement control to improve the control of synthetic systems. Animal movement control reveals the deeply intertwined role of movement and sensation, but the details remain mysterious. Of particular interest is the role and self-organization of cerebellar and cortical internal models for movement, and how they are formed and adapted according to experience. Implementation of computational methods from the neural control of movement on biomechanically relevant hardware does more than improve robotic control - it can help us to answer the difficult questions of neuroscience.

**Sensory Substitution and Body Ownership:** We are developing a variety of technologies that can alter or replace multimodal sensory experiences. A simple example of this is a sensorized prosthetic foot that measures important forces and delivers tactile cues to the residual limb of the user. We are also examining how vision, proprioception, and haptic sensation are fused by the brain to create a unified experience of self situated in the body. We use virtual reality to probe how the feeling of body ownership can be extended to virtual avatars.

#### **Activities and Awards:**

Reviewer: ASME Journal of Mechanisms and Robotics  
IEEE Multi-Conference on Systems and Control  
IEEE Transactions on Human-Machine Systems  
NSF Grant Review Panel 2015  
IEEE Conference on Decision and Control  
PLOS ONE  
IEEE Transactions on Automatic Control  
IEEE Transactions on Mechatronics  
Journal Of NeuroEngineering and Rehabilitation  
IEEE Transactions on Biomedical Engineering  
IEEE International Conference on Robotics and Automation  
IEEE/RSJ International Conference on Intelligent Robots and Systems  
The American Controls Conference  
IEEE Transactions on Autonomous Mental Development  
Journal of the Franklin Institute  
Robotica  
Attention, Perception, & Psychophysics  
International Conference on Intelligent Robots and Systems  
Biomedical Engineering Online

Meetings: Northwest Biomechanics Symposium  
2015 Co-Chair  
<http://depts.washington.edu/nwbs/2015/>

Administrative:

VA Puget Sound Space Committee – Alternate Member  
2013-present  
Seattle Institute for Biomedical and Clinical Research –  
Member 2014-present

Grants and funding:

Current:

“Optimizing the virtual body: Bishop’s Hand”

Sponsored research agreement with Oculus Research

Role: PI

Support: \$289K

“Interdisciplinary Center for Analysis of Motion and Performance in  
Humans and Machines”

University of Washington Strategic Research Initiatives Program 2016

Role: Co-PI

Support: \$100K

“Sensory Feedback for Lower Extremity Protheses Incorporating  
Targeted Muscle Reinnervation (TMR)”

Department of Defense, Defense Medical Research and Development  
Program, Clinical and Rehabilitative Medicine Research Program,  
Neuromusculoskeletal Injuries Research Award 01/2015

W81XWH-15-1-0417, MR140172

Role: PI

Support: \$1.5M, Role: Initiating PI (2.4 person months donated)

Pending:

“Comparing Surgical Treatments for Hallux Rigidus using a  
Biomechanically and Anatomically Realistic Foot Model”

Department of Veteran Affairs “Merit Review” RX-17-001, 06/12/2017

Role: Co-PI

Support: \$824K

“Limb Motion Prediction for Prosthetic Control”

DoD DMRDP CDMRP Accelerating Innovation in Military Medicine  
Research Award, W81XWH-17-DMRDP-AIMM

Role: PI

Support: \$430K

Complete:

“Acquisition of a Objet500 Connex3 3D Printer”

Department of Veteran Affairs “Sheep” Equipment Grant, 02/2015

Role: Co-Investigator  
Support: \$274K

"Instrumented Task Board with Adjustable Dynamics" (\$4000)  
Center for Sensorimotor Neural Engineering (CSNE) Seed Grant,  
Winter 2012  
Role: PI  
Support: \$4k

Northwest Biomechanics Symposium  
2015 Co-chair  
<http://depts.washington.edu/nwbs/2015/>

Founding member: Student Leadership Committee  
Center for Sensorimotor Neural Engineering (CSNE). 2011-2012.

"Eyes in the sky:" Controlling an aerial robot using body movement.  
Center for Sensorimotor Neural Engineering Tech Sandbox Showcase

Invited talks:

Center for Sensorimotor Neural Engineering Fall Seminar, October 12 2017  
"Targeted Reinnervation: Sensory Effects"

Shen Lan Group, Seattle WA, April 3, 2016 "Bodies, Brains, and Machines"

UW Institute of Neuroscience, Seattle WA, May 13 2015 "Sensory  
augmentation for targeted reinnervation in the lower limb"

Kavli Foundation / CSNE Seminar, Seattle WA, Dec 2013 "Multi-Modal  
Human-Computer Interaction for Interfaces, Rehabilitation, and Myometric  
Authentication"

CSNE Industrial Affiliates Board Meeting, Seattle WA, Sep 2013 "Multi-modal  
Human-Computer Interaction"

Pacific Science Center Festival of the Fountains, Seattle WA, July 2013 "Mind  
Control: Brain, Body, and Machine"

University of Washington Dept. of Mechanical Engineering Colloquium, Seattle  
WA, May 2013 "Control of Movement: Clues from Biology"

Office of Naval Research (ONR) MURI Program review, Washington DC, May  
2013 "Principles of Sensing and Control in Insect Flight and Biologically  
Inspired Robotic Flight Platforms"

VA Center of Excellence for Limb Loss Prevention and Prosthetic Engineering,  
Seattle WA, March 2013 "Neural Control Principles and Reinforcement"

Learning for Biomechanically Accurate Robotic Manipulation"

University of Washington Medicine 2013 Mini-Medical School, Seattle WA,  
March 2013 "Living in an Artificial World: Where Silicon Meets the Neuron"

San Diego State University, San Diego CA, March 2013 "Movement Control  
and Sensation: From Biorobotics to Robot-Assisted Biology"

Microsoft Research, Seattle, Seattle WA, Jan 2013 "Interfacing With The  
World: The Sensor, the Motor, and the Sensorimotor"

3rd NSF-JST Joint Workshop On The Development of Model-based Assistive  
Robotics Technologies for Medicine and Rehabilitation, San Francisco CA,  
January 2013 "The Sensory, The Motor, and the Sensorimotor: From  
Biorobotics to Robot-Assisted Biology"

4th NSF-JST Joint Workshop On The Development of Model-based Assistive  
Robotics Technologies for Medicine and Rehabilitation, San Francisco CA,  
March 2012 "Manipulation and Contact for Tendon-Driven Hand Robotics"

University of Wisconsin, Madison AISEM Series 2012, Madison WI, February  
2012 "Incredible Machines: Body, Brain, and Robot"

Center for Sensorimotor Neural Engineering Research Colloquium, Seattle  
WA, April 2011 "Neural Control of Movement as a Model for Robotic  
Manipulation Control"

University of Washington Computer Science Department CS4HS: Computer  
Science for High School Workshop 2009. "Educational Robots and  
Braitenberg's Vehicles" (Instruction of a one-day workshop for high school  
educators)

Internships: Intel Research, Seattle  
Advisor: Ali Rahimi  
Object recognition and computer vision

University of Washington  
Advisor: Rajesh Rao  
Brain-computer interface and Electroencephalography

AT&T Labs  
Advisor: Rich Cox & Group  
Frequency reassignment and modulation filtering

University of Washington  
Advisor: Maya Gupta  
Machine learning for protein folding prediction

Enercorp, LLC. Casablanca, Morocco  
Technical Consultant

### Peer-Reviewed Journal Publications:

Palve L and **Rombokas E** "Design and characterization of stimulus intensity for a novel cam-follower vibrotactile actuator" ( In review )

Caballero D and **Rombokas E** "Sensitivity to conflict between visual touch and tactile touch" ( In review )

Johnson L, Lew M, Johnson I, Richburg C, Aubin P, and **Rombokas E** "Lattice Structures for 3D-Printing Biomechanically Accurate Soft Tissue" ( In review)

**Rombokas E**, Malhotra M, Theodorou E, Todorov E, and Matsuoka Y. "Reinforcement learning and synergistic control of the ACT hand." IEEE Transactions on Mechatronics Vol. 18 Issue 2, pp. 569-577 2013

**Rombokas E**, Stepp C E, Chang C, Malhotra M, and Matsuoka Y. "Vibrotactile Sensory Substitution for Electromyographic Control of Object Manipulation." IEEE Transactions on Biomedical Engineering, Vol. 60 Issue 8, pp. 2226-2232, 2013

### Peer-Reviewed Conference Publications:

Sie A , Boe, D, and **Rombokas E** " Design and Evaluation of a Wearable Haptic Feedback System for Lower Limb Prostheses during Stair Descent" ( In review )

Rai V and **Rombokas E** "Localization for lower limb prosthesis control" ( In review )

Sie A, Realmuto J, and **Rombokas E**. "Design of a Lower Limb Prosthesis Haptic Feedback System for Stair Descent." Design of Medical Devices 2017

Rai V, and **Rombokas E**. "Visual Localization for Prosthetic Lower Limb Control." Meeting of the American Academy of Orthotists and Prosthetists (AAOP) 2017

Williams G, **Rombokas E**, and Daniel TL. "GPU based Path Integral Control with Learned Dynamics." Neural Information Processing Systems (NIPS) 2014

Hinson BT, **Rombokas E**, Dyhr JP, Daniel TL, Morgansen KA. "Sensing From Control: Airframe Deformation for Simultaneous Actuation and State Estimation." IEEE Conference on Decision and Control 2013, Venice, Italy.

**Rombokas E**, Malhotra M, Theodorou E, Todorov E, and Matsuoka Y. "Tendon-Driven Variable Impedance Control Using Reinforcement Learning." Robotics: Science and Systems (RSS) 2012, Sidney, Australia.

Chung M\*, **Rombokas E\***, An Q, Matsuoka Y, and Bilmes J. "Continuous Vocalization Control of a Full-Scale Assistive Robot." IEEE RAS and EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob) 2012, Roma, Italy.

\* equal contribution

**Rombokas E**, Brook P, Smith J R, and Matsuoka Y. "A Simple Grasp Planner Using Orthogonal Approach Angles." IEEE RAS and EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob) 2012, Roma, Italy.

Tejeiro C, Stepp CE, Malhotra M, **Rombokas E**, and Matsuoka Y. "Comparison of remote Pressure and Vibrotactile Feedback for Prosthetic Hand Control." IEEE RAS and EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob) 2012, Roma, Italy.

**Rombokas E**, Theodorou E, Malhotra M, Todorov E, and Matsuoka Y. "Tendon-driven control of biomechanical and robotic systems: A path-integral reinforcement learning approach." IEEE International Conference on Robotics and Automation 2012, St. Paul, USA.

Malhotra M, **Rombokas E**, Theodorou E, Todorov E, and Matsuoka Y. "Reduced dimensionality control for the ACT hand." IEEE International Conference on Robotics and Automation 2012, St. Paul, USA.

**Rombokas E**, Malhotra M, and Matsuoka Y. "Task-specific dynamics for robotic hand control." IEEE EMBS Conference on Neural Engineering 2011, Cancun, Mexico.

**Rombokas E**, Malhotra M, and Matsuoka Y. "Task-specific demonstration and practiced synergies for writing with the ACT hand." IEEE International Conference on Robotics and Automation 2011, Shanghai, China.

#### **Conference Abstracts:**

Rokhmanova N and **Rombokas E** "Haptic Feedback During Stair Descent" American Society of Biomechanics 2018

#### **Papers in Preparation:**

Preechayasomboon P and **Rombokas E** "A dual-modality conductance and pressure sensor integrated with a conductive elastomeric soft actuator"

Preechayasomboon P, Mukherjee G, and **Rombokas E** "Biosensor and movement correlates of body ownership in an active, stimulating movement task"