

# Stephen A. Mascaro

## Curriculum Vitae

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### Education

**MASSACHUSETTS INSTITUTE OF TECHNOLOGY** Cambridge, MA

- **Ph.D.** in Mechanical Engineering, February 2002. Thesis: Design and Analysis of Fingernail Sensors for Measurement of Fingertip Touch Force and Finger Posture. Major in System Dynamics and Control.
- **M.S.** in Mechanical Engineering, February 1997. Thesis: Force Guided Docking Control of an Omnidirectional Holonomic Vehicle and its Application to Wheelchairs.

**CLARKSON UNIVERSITY** Potsdam, NY

B.S. in Mechanical Engineering, May 1995. Emphasis on design and mechanics.

**HOUGHTON COLLEGE** Houghton, NY

B.A. in Physics, May 1995. Pre-engineering 3-2 program. Minor in Mathematics.

### Awards/Honors

- Finalist for Best Conference Paper Award, IEEE International Conference on Robotics and Automation, 2003.
- Best Conference Paper Award, IEEE International Conference on Robotics and Automation, 1999.
- Goddard Award for Best Research Contribution, NASA Academy, 1995.

### Appointments

1/05-Present Assistant Professor, Mechanical Engineering, University of Utah  
8/03-12/04 Assistant Professor, Mechanical Engineering, North Dakota State U.  
1/02-7/03 Postdoctoral Associate, Mechanical Engineering, MIT  
9/05-1/02 Graduate Research Assistant, Mechanical Engineering, MIT  
6/05-8/05 Research Assistant, Goddard Space Flight Center, NASA

**Research** **UNIVERSITY OF UTAH** Salt Lake City, UT  
Continuing research on biologically inspired mechatronics and human-machine systems, focusing primarily on the concept of *wet robotics*, where robots and machines are imbued with networks of artificial blood vessels and fluid circulation. Such wet machines will be capable of new methods of actuation, sensing, temperature regulation, and growth/self-repair. Also continuing research on development of fingernail sensors and finger models, as well as collaborating on a new method of imaging fingernail using a camera system.

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## MIT Department of Mechanical Engineering

Cambridge, MA

Supervisor: Professor H. Harry Asada

- Researched novel idea of new high-speed modular wet Shape Memory Alloy actuator arrays, where SMA wires are embedded in a network of artificial blood vessels using a scalable architecture. *Spring 2002 – Summer 2003.*
- Designed a new type of sensor that detects fingertip touch force and finger posture by measuring the pattern of coloration or blood volume beneath the human fingernail. Analyzed two-dimensional spatial array of data from multiple experimental subjects in order to characterize relationship between finger actions and sensor response. Biomechanical and hemodynamic modeling and simulation of the human fingertip was also performed in order to understand the mechanism of fingernail color change. Results of the data analysis and model simulation were used to define design principles and create methods for sensor calibration. The sensor was applied as a novel device for human-machine interaction, including a wearable computer mouse. *Summer 1997 - Fall 2001.*
- Designed an omnidirectional ball-wheeled robotic vehicle for application to a transformable wheelchair system. Designed unique force-sensor arrangements and geometries, as well as control algorithms that allowed the robotic wheelchair to autonomously navigate and compliantly dock with stationary fixtures. *Fall 1995 – Spring 1997.*

## GODDARD SPACE FLIGHT CENTER, NASA

Greenbelt, MD

Research Assistant, NASA Academy Program. Modeled and designed a 10 Kelvin miniature radiative cooler for a space telescope. ***Winner of the Goddard Award for best research contribution.*** *Summer 1995.*

## CLARKSON UNIVERSITY

Potsdam, NY

Undergraduate Research Assistant, Department of Mechanical and Aeronautical Engineering. Analyzed stress-strain relationships and crack growth in fatigued nickel specimens. *Summer 1994.*

## Teaching

### UNIVERSITY OF UTAH

Salt Lake City, UT

Instructor for ME EN 5210/6210 State Space Controls. *Spring 2006/07.*

Instructor for ME EN 5200/6200 Advanced Controls. *Fall 2005/06.*

### NORTH DAKOTA STATE UNIVERSITY

Fargo, ND

Instructor for ME 412 Engineering Measurements. *Spring 2004/Fall 2004.*

Instructor for ME 213 Modeling for Engineers. *Fall 2003/04.*

### MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Cambridge, MA

Laboratory Instructor for 2.671 Measurement and Instrumentation (undergraduate level) in conjunction with Professor I. Hunter. *Spring 2002.*

Teaching Assistant for 2.151 Advanced System Dynamics and Control (graduate level) under Professor H. H. Asada. *Spring 2000.*

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## Journal Publications

- Mascaro, S. and Asada, H., 2006. "The Common Patterns Of Blood Perfusion In The Fingernail Bed Subject To Fingertip Touch Force And Finger Posture," *Haptics-e: The Electronic Journal of Haptics Research*, vol. 4, no. 3, pp. 1-6.
- Mascaro, S. and Asada, H., 2004. "Measurement of Finger Posture and Three-Axis Fingertip Touch Force Using Fingernail Sensors," *IEEE Transactions on Robotics and Automation*, vol. 20, no. 1, pp. 26-35.
- Mascaro, S. and Asada, H., 2001. "Photoplethysmograph Fingernail Sensors for Measuring Finger Forces without Haptic Obstruction," *IEEE Transactions on Robotics and Automation*, vol. 17, no. 5, pp. 698-708.

## Refereed Conference Proceedings

- Sun, Y., Hollerbach, H. and Mascaro, S., "Finger Force Direction Recognition by Principal Component Analysis of Fingernail Coloration Pattern," Accepted for *Proc. of the 15<sup>th</sup> Int. Symp. on Haptic Interfaces for Virtual Environment and Teleoperator Systems*, March 22-24, 2007.
- Sun, Y., Hollerbach, H. and Mascaro, S., "EigenNail for Finger Force Direction Recognition," Accepted for *Proc. of the IEEE International Conference on Robotics and Automation*, April 10-14, 2007.
- Flemming, L., and Mascaro, S. "Control of a Scalable Matrix Vasoconstriction Device for Wet Actuator Arrays," Accepted for *Proc. of the IEEE International Conference on Robotics and Automation*, April 10-14, 2007.
- Ertel, J., and Mascaro, S., "Thermomechanical Modeling of a Wet Shape Memory Alloy Actuator," Accepted for publication in *ASME IMECE Dynamic Systems and Control Division*, Nov. 5-10, 2006.
- Sun, Y., Hollerbach, H. and Mascaro, S., 2006. "Dynamic Features and Prediction Model for Imaging Fingernail to Measure Finger Forces," *Proc. of IEEE International Conference on Robotics and Automation*, pp. 2813-2818.
- Sun, Y., Hollerbach, H. and Mascaro, S., 2006. "Measuring Fingertip Forces by Imaging the Fingernail," *Proc. of 14th Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems*, pp. 125-131.
- Flemming, L. and Mascaro, S., 2005. "Wet SMA Muscle Array with Matrix Vasoconstrictive Control," *Proc. of ASME Dynamic Systems and Control Division*, vol. 74, no. 2, pp. 1751-1758.
- Flemming, L. and Mascaro, S., 2005. "Control of Scalable Wet SMA Actuator Arrays," *Proc. of IEEE International Conference on Robotics and Automation*, pp. 1350-1355.
- Cho, K.-J., Roy, B.; Mascaro, S., and Asada, H.H., 2004. "A Vast DOF Robotic Car Seat Using SMA Actuators with a Matrix Drive System," *Proc. IEEE International Conference on Robotics and Automation*, vol. 4, pp. 3647-3652.
- Mascaro, S. and Asada, H., 2003. "Vast DOF Wet Shape Memory Alloy Actuators Using Matrix Manifold and Valve System," *Proc. ASME Dynamic Systems and Control Division*, vol. 72, no. 1, pp. 577-582.

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- Mascaro, S., Cho, K., and Asada, H., 2003. "Design and Control of Vast DOF Wet SMA Array Actuators," *Proc. IEEE/RSJ International Conference on Intelligent Robots and Systems*, vol. 2, pp. 1992-1997.
- Mascaro, S. and Asada, H., 2003. "Wet Shape Memory Alloy Actuators for Active Vasculated Robotic Flesh," *Proc. IEEE International Conference on Robotics and Automation*, vol. 1, pp. 282-287. **Finalist for the Best Conference Paper Award.**
- Mascaro, S. and Asada, H., 2002. "Filter Design and Calibration for Fingernail Sensors to Measure Fingertip Forces and Finger Posture," *Proc. IEEE International Conference on Robotics and Automation*, vol. 2, pp. 1642-1648.
- Mascaro, S. and Asada, H., 2002. "Understanding of Fingernail-Bone Interaction and Fingertip Hemodynamics for Fingernail Sensor Design," *Proc. 10<sup>th</sup> Int. Symp. on Haptic Interfaces for Virtual Environment and Teleoperator Systems*, pp. 106 -113.
- Mascaro, S. and Asada, H., 2001. "Finger Posture and Shear Force Measurement using Fingernail Sensors: Initial Experimentation," *Proc. IEEE Int. Conf. Robotics and Automation*, vol. 2, pp. 1857-1862.
- Mascaro, S. and Asada, H., 2000. "Fingernail Sensors for Measurement of Fingertip Touch Force and Finger Posture," *Proc. ASME Dynamic Systems and Control Division*, vol. 69-2, pp. 1249-1250.
- Mascaro, S. and Asada, H., 2000. "Fingernail Touch Sensors: Spatially Distributed Measurement and Hemodynamic Modeling," *Proc. IEEE Int. Conf. Robotics and Automation*, vol. 4, pp. 3422-3427.
- Mascaro, S. and Asada, H., 1999. "Distributed Photo-Plethysmograph Fingernail Sensors: Finger Force Measurement Without Haptic Obstruction," *Proc. ASME Dynamic Systems and Control Division*, vol. 67, pp. 73-80.
- Mascaro, S., Chang, K.-W. and Asada, H., 1999. "Photo-Plethysmograph Nail Sensors for Measuring Finger Forces Without Haptic Obstruction," *Proc. IEEE Int. Conf. Robotics and Automation*, vol. 2, pp. 962-967. **Winner of the Best Conference Paper Award.**
- Mascaro, S. and Asada, H., 1999. "Virtual Switch Human-Machine Interface Using Fingernail Touch Sensors," *Proc. IEEE Int. Conf. Robotics and Automation*, vol. 4, pp. 2533-2538.
- Mascaro, S., Chang, K.-W., and Asada, H., 1998. "Finger Touch Sensors Using Instrumented Nails and Their Application To Human-Robot Interactive Control," *Proc. ASME Dynamic Systems and Control Division*, vol. 64, pp. 91-96.
- Mascaro, S., Chang, K.-W., and Asada, H., 1998. "Instrumented Fingernails: a Haptically Unobstructive Method for Touch Force Input," *Proc. SPIE Telemanipulator and Telepresence Technologies V*, vol. 3524, pp. 170-178.
- Mascaro, S. and Asada, H., 1998. "Hand-in-Glove Human-Machine Interface and Interactive Control: Task Process Modeling Using Dual Petri Nets," *Proc. IEEE Int. Conf. Robotics and Automation*, vol. 2, pp. 1289-1295.
- Mascaro, S. and Asada, H., 1998. "Docking Control of Holonomic Omnidirectional Vehicles with Applications to a Hybrid Wheelchair/Bed System," *Proc. IEEE Int. Conf. Robotics and Automation*, vol. 1, pp. 399-405.
- Mascaro, S., and Asada, H., 1997. "A Hybrid Bed/Chair System for Bedridden Patients - Elimination of Transfer Between a Bed and Wheelchair," *Proc. ASME Dynamic Systems and Control Division*, vol. 61, pp. 393-400.

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- Mascaro, S., Spano, J. and Asada, H., 1997. “A Reconfigurable Holonomic Omnidirectional Mobile Bed with Unified Seating (RHOMBUS) for Bedridden Patients,” *Proc. IEEE Int. Conf. Robotics and Automation*, vol. 2, pp. 1277-1282.

## Patents

- Sun, Y., Hollerbach, J., and Mascaro, S. “Device And Method Of Detecting A Force Applied To A Finger,” US Provisional Application No. 60/787,996, Filed March 31, 2006.
- Asada, H.H. and Mascaro, S., 2002. “Fingernail Sensors for Measuring Finger Forces and Finger Posture,” US Patent 6,388,247, Issued May 14, 2002.
- Asada, H.H., Mascaro, S., and Chang, K.-W., 2001. “Finger Touch Sensors and Virtual Switch Panels,” US Patent 6,236,037, Issued May 22, 2001.
- Asada, H.H., Mascaro, S., and Spano, J., 2000. “Human Transport System with Dead Reckoning Facilitating Docking,” US Patent 6,135,228, Issued October 24, 2000.

## Society Memberships

- American Society of Mechanical Engineers
- Institute of Electrical and Electronics Engineers
- IEEE Robotics and Automation Society
- *Pi Tau Sigma* National Mechanical Engineering Honor Society.

## Service Activities

- Technical Committee Participant: ASME Dynamic Systems and Control, Robotics Panel.
- Reviewer: IEEE Transactions on Robotics and Automation, IEEE Transactions on Mechatronics, IEEE International Conference on Robotics and Automation, IEEE Haptics Symposium, ASME International Mechanical Engineering Congress and Exposition, Optical Engineering (SPIE), International Journal of Robotics and Automation (IASTED).

## Grants Awarded

- “Measuring Finger Forces by Imaging the Fingernail.” NIH Exploratory/Developmental (R21) Bioengineering Research Grants (EBRG), PA-03-058. John Hollerbach, PI, Stephen Mascaro Co-PI. 07/12/06 - 06/30/08, \$392,677.