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# Nicholas A. Patronik, Ph.D.

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## OBJECTIVE

A position in industry that explores robotics research for medical applications; with a focus on mechanical design, robotic control, user interfacing, and clinical testing

## EDUCATION

### **Ph.D. Robotics**, May 2008

Carnegie Mellon University, The Robotics Institute, Pittsburgh, PA

*Thesis:* A Miniature Mobile Robot for Precise and Stable Access to the Beating Heart

*Advisor:* Prof. Cameron Riviere

*Committee:* Dr. Marco Zenati, Prof. Metin Sitti, Prof. Russell Taylor

### **M.S. Robotics**, May 2004

Carnegie Mellon University, The Robotics Institute, Pittsburgh, PA

*Thesis:* Development and Testing of a Mobile Robot for Cardiac Intervention

*Advisor:* Prof. Cameron N. Riviere

### **B.S. Biomedical Engineering**, May 2000

Boston University, Department of Biomedical Engineering, Boston, MA

Graduated summa cum laude

*Thesis:* Evaluation of a Sensory Substitution System for Eliciting Postural Responses

*Advisor:* Prof. Lars Oddsson

## RESEARCH EXPERIENCE

### **Graduate Research Assistant (Doctoral program)**, May 2004 - May 2008

Carnegie Mellon University, The Robotics Institute, Pittsburgh, PA

Medical Instrumentation Laboratory

- Advised by Prof. Cameron Riviere
- Research focused on the design, control, user interface, and testing of a heart-mounted mobile robot (HeartLander) for navigation and positioning on the beating heart for minimally invasive cardiac therapy
- Developed a control system for path planning, trajectory generation, and navigation to targets located around the entire surface of the beating heart with an accuracy of 1 mm
- Designed delivery mechanisms for the administration of several cardiac therapies from HeartLander, including: regenerative material injection, lead placement, and ablation
- Demonstrated all system components using closed-chest beating-heart porcine models

## RESEARCH EXPERIENCE (CONT'D)

### **Graduate Research Assistant (Masters program),** Aug 2002 - May 2004

Carnegie Mellon University, The Robotics Institute, Pittsburgh, PA  
Medical Instrumentation Laboratory

- Advised by Prof. Cameron Riviere
- Research focused on the initial development of a mobile robot to provide minimally invasive access to the beating heart (HeartLander) from a concept to a working prototype
- Analyzed physiological constraints to determine design parameters
- Designed and constructed a wire-driven continuum-type mobile robot to provide enhanced minimally invasive access to the surface of the beating heart for cardiac therapy
- Demonstrated successful testing of prehension and locomotion designs using open-chest, beating-heart porcine models

### **Research Assistant,** May 2003 - Sept 2003

Ecole Polytechnique Federal de Lausanne, Institut de Production et Robotique, Lausanne, Switzerland  
Virtual Reality and Active Interfaces (VRAI) Group

- Advised by Prof. Terry Fong
- Research focused on haptic devices for needle biopsy training and assistance
- Redesigned a quick-release needle grasper for a passive, 6-DOF haptic device for needle biopsy

### **Research Assistant,** Jan 2001 - Aug 2002

Massachusetts Eye and Ear Infirmary, Department of Otolaryngology, Boston, MA  
Jenks Vestibular Diagnostic Laboratory

- Advised by Prof. Conrad Wall, III
- Research focused on the development of techniques to assess and treat gait ataxia (incoordination) resulting from vestibular (inner ear) pathologies
- Coordinated a gait perturbation experiment with vestibulopathic subjects using a computer-controlled, programmable displacement platform and an optical tracking system
- Performed data analysis to determine how the recovery strategies of vestibulopathic subjects differed from healthy subjects

### **Undergraduate Research Assistant – Senior thesis research,** Sept 1998 - May 1999

Boston University, The NeuroMuscular Research Center, Boston, MA  
Injury Analysis and Prevention Laboratory

- Advised by Prof. Lars Oddsson
- Project lasted one year and required formal proposal, formal report, and oral presentation
- Research focused on motor control mechanisms related to balance and the effects of sensory substitution for the completion of mandatory senior thesis
- Constructed a pressure-based sensory substitution system for peripheral neuropathy
- Designed and conducted human experiments to analyze the postural behavior of subjects via stabilogram diffusion and electromyography to determine the effect of sensory substitution

### **Undergraduate Research Assistant,** Sept 1998 - May 1999

Boston University, Department of Biomedical Engineering, Boston, MA  
Respiratory Systems Analysis Laboratory

- Supervised by Prof. Kenneth Lutchen
- Research focused on the mechanics of the lungs during ventilation
- Performed data analysis of lung mechanics and ventilation

## INDUSTRIAL EXPERIENCE

### **Project Engineer**, Oct 2000 - Jan 2001

Boston Scientific Corporation, Natick, MA  
Microvvasive Endoscopy Group

- Evaluated a prototype full-thickness resection device and its limitations to determine significant improvements to be implemented in the first major revision of the device
- Designed two experimental prototypes of the improved mechanical component of the device using solid modeling software Pro/ENGINEER, and validated the designs in bench testing

### **Engineering Intern**, June 1999 - Sept 1999, July 2000 - Oct 2000

Boston Scientific Corporation, Natick, MA  
Microvvasive Endoscopy Group

- Researched and purchased vision system and control components for prototype robotic medical device
- Conducted in vivo animal studies with medical device to evaluate performance
- Designed mechanical layout for second revision of medical device using Pro/ENGINEER and conducted in vivo animal studies to evaluate performance following revisions

### **Lab Technician**, June 1998 - Sept 1998

Sylvania Lighting International, Canton, MA

- Built, tested, and repaired ballast circuits for fluorescent lighting

## TEACHING EXPERIENCE

### **Teaching Assistant**, Aug 2004 - Dec 2004

Carnegie Mellon University, The Robotics Institute, Pittsburgh, PA  
Mathematical Fundamentals for Robotics

- Graduate-level course covering the mathematical concepts often encountered in the study of robotics
- Prepared and delivered lecture
- Graded assignments
- Held office hours to assist students with assignments and general course material

### **Ph.D. Thesis Research Committee Member**, Aug 2005 - May 2008

Carnegie Mellon University, The Robotics Institute, Pittsburgh, PA

- Samuel Clanton, 2006 - 2008
- David Choi, 2006 - 2008

### **Undergraduate Mentor**, Aug 2003 - May 2008

Carnegie Mellon University, The Robotics Institute, Pittsburgh, PA

- Peter Allen (1 publication), Harsha Tumala (1 publication), Faezeh Razjouyan (1 publication), Chee Kiat Ng (1<sup>st</sup> place in undergraduate honors thesis competition), Ye Gang

## PUBLICATIONS

### **Refereed Journal Publications**

- [1] **N. A. Patronik**, T. Ota, M. A. Zenati, and C. N. Riviere, "Synchronization of stepping with heartbeat and respiration for locomotion on the beating heart," *International Journal of Medical Robotics and Computer Assisted Surgery (IJMRCAS)*, 2008. (In preparation).

## PUBLICATIONS (CONT'D)

- [2] **N. A. Patronik**, T. Ota, M. A. Zenati, and C. N. Riviere, "A miniature mobile robot for precise and stable access to the beating heart," *IEEE Transactions on Robotics*, 2008. (Submitted for review).
- [3] T. Ota, **N. A. Patronik**, C. N. Riviere, and M. A. Zenati, "Minimally invasive epicardial injections using a novel semi-autonomous robotic device," *Circulation*, 2008. (In press).
- [4] T. Ota, **N. A. Patronik**, C. N. Riviere, and M. A. Zenati, "Percutaneous subxiphoid access to the epicardium using a miniature crawling robotic device," *Innovations: Technology & Techniques in Cardiothoracic & Vascular Surgery*, vol. 1, pp. 227-231, 2006.
- [5] **N.A. Patronik**, M.A. Zenati, C.N. Riviere, "Preliminary evaluation of a mobile robotic device for navigation and intervention on the beating heart," *Computer Aided Surgery*, vol.10, pp. 225-232, 2005.
- [6] C. N. Riviere, **N. A. Patronik**, and M. A. Zenati, "Prototype epicardial crawling device for intrapericardial intervention on the beating heart," *Heart Surgical Forum*, vol. 7, pp. E639-643, 2004.
- [7] C. Wall, 3rd, L. I. Oddsson, **N. A. Patronik**, K. Sienko, and E. Kentala, "Recovery trajectories of vestibulopathic subjects after perturbations during locomotion," *Journal of Vestibular Research*, vol. 12, pp. 239-253, 2002.

## Refereed Conference Proceedings

- [1] **N. A. Patronik**, T. Ota, M. A. Zenati, and C. N. Riviere, "Accurate positioning for intervention on the beating heart using a crawling robot," in *Proceedings of the 2nd IEEE International Conference on Biomedical Robotics and Biomechatronics (BioRob)*, 2008. (In press).
- [2] P. D. Allen, **N. A. Patronik**, M. A. Zenati, and C. N. Riviere, "A mobile robot driven by miniature onboard motors for cardiac intervention," in *Proceedings of the 34th Annual Northeast Bioengineering Conference*, 2008, pp. 9-10.
- [3] **N. A. Patronik**, T. Ota, M. A. Zenati, and C. N. Riviere, "Improved traction for a mobile robot traveling on the heart," in *Proceedings of the 28th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*. vol. 1, 2006, pp. 339-342.
- [4] F. Razjouyan, **N. A. Patronik**, M. A. Zenati, and C. N. Riviere, "Enhancing the locomotion of an in vivo robot for cardiac surgery," in *Proceedings of the 32nd IEEE Annual Northeast Bioengineering Conference*, 2006, pp. 97-98.
- [5] H. Tummala, **N. A. Patronik**, and C. N. Riviere, "The design of a mobile robot to record torques generated by cardiac motion," in *ASME Summer Bioengineering Conference*, 2006.
- [6] **N. A. Patronik**, M. A. Zenati, and C. N. Riviere, "A miniature cable-driven robot for crawling on the heart," in *Proceedings of the 27th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*. vol. 6, 2005, pp. 5771-5774.
- [7] **N. A. Patronik**, C. N. Riviere, S. El Qarra, and M. A. Zenati, "The HeartLander: a novel epicardial crawling robot for myocardial injections," in *Proceedings of the 19th International Congress of Computer Assisted Radiology and Surgery*. vol. 1281C: Elsevier, 2005, pp. 735-739.
- [8] **N. A. Patronik**, M. A. Zenati, and C. N. Riviere, "Crawling on the heart: a mobile robotic device for minimally invasive cardiac interventions," in *Proceedings of the 7th International Medical Image Computing and Computer Aided Intervention Conference (MICCAI)*. vol. 3217: Lecture Notes Computer Science, 2004, pp. 9-16.
- [9] **N. A. Patronik**, M. A. Zenati, and C. N. Riviere, "Development of a tethered epicardial crawler for minimally invasive cardiac therapies," in *Proceedings of the 30th IEEE Annual Northeast Bioengineering Conference*, 2004, pp. 239-240.

## PUBLICATIONS (CONT'D)

### Conference Abstracts

- [1] T. Ota, **N. A. Patronik**, C. N. Riviere, and M. A. Zenati, "Minimally invasive epicardial injection using a miniature crawling robotic device through a subxiphoid approach," in *Proceedings of the American Heart Association Scientific Sessions*, 2007.
- [2] T. Ota, **N. A. Patronik**, D. Schwartzman, C. N. Riviere, and M. A. Zenati, "Subxiphoid epicardial pacing lead implantation using a miniature crawling robotic device," in *The Journal of Surgical Research*. vol. 137, 2007, pp. 242-243.
- [3] T. Ota, **N. A. Patronik**, C. N. Riviere, and M. A. Zenati, "Epicardial injection using a miniature crawling robotic device through a subxiphoid approach," in *Proceedings of the 10th Annual Meeting of the International Society of Minimally Invasive Cardiothoracic Surgery (ISMICS)*, 2007, pp. 173-174.
- [4] T. Ota, **N. A. Patronik**, C. N. Riviere, and M. A. Zenati, "Percutaneous subxiphoid access to the epicardium using a miniature crawling robotic device," in *Proceedings of the 9th Annual Meeting of the International Society of Minimally Invasive Cardiothoracic Surgery (ISMICS)*, 2006, pp. 204-205.
- [5] C. N. Riviere, **N. A. Patronik**, S. El Qarra, and M. A. Zenati, "Epicardial crawling device for myocardial injections," in *Proceedings of the 8th Annual Meeting of the International Society of Minimally Invasive Cardiothoracic Surgery (ISMICS)*, 2005, p. 170.

### Technical Reports

- [1] **N. A. Patronik**, "A Miniature Mobile Robot for Precise and Stable Access to the Beating Heart," Doctoral thesis, technical report CMU-RI-TR-08-13, The Robotics Institute, Carnegie Mellon University, May, 2008.
- [2] **N. A. Patronik**, "Development and Preliminary Testing of a Mobile Robot for Cardiac Intervention," Masters thesis, technical report CMU-RI-TR-05-08, The Robotics Institute, Carnegie Mellon University, February, 2005.

### Patents

- [1] C. N. Riviere, **N. A. Patronik**, M. A. Zenati, G. D. Stetten, "Robot for minimally invasive interventions," US and International Patents Pending, submitted November 5, 2004.
- [2] S. K. Sharma, D. I. Freed, **N. A. Patronik**, J. M. Wendlandt, "Full thickness resectioning device," US Patent 6,685,079, issued to SciMed Life Systems, submitted May 24, 2002, issued February 3, 2004.

## AWARDS AND SCHOLARSHIPS

- NASA Graduate Student Researchers Program (GSRP) Fellowship, 2006 - 2008
- CMU Robotics Institute Fellowship, 2004 - 2008
- 1<sup>st</sup> Place Mini Presentation at 10<sup>th</sup> Annual Meeting of the International Society of Minimally Invasive Cardiothoracic Surgery (ISMICS), 2007
- 3<sup>rd</sup> Place Poster Presentation at IEEE 30<sup>th</sup> Annual Northeast Bioengineering Conference, 2004
- 3<sup>rd</sup> Place Oral Presentation at 15<sup>th</sup> Annual Boston University Biomedical Engineering Senior Project Conference, 2000
- BU University Scholarship, 1996 - 2000
- Biomedical Engineering Honor Society, 1998 - 2000
- BU Engineering Dean's List, 1996 - 2000

## COURSEWORK

### Graduate

Kinematics, Dynamics, and Control  
Advanced Topics in Kinematics  
Fundamentals of AI for Robotics  
Micro/Nano-Robotics  
Computer Vision  
Mobile Robot Programming  
Surgery for Engineers (Johns Hopkins)  
Sensing and Sensors  
Entrepreneurial Thought and Action  
Machine Learning  
Mathematical Fundamentals for Robotics  
Strategic Uses of Information Technology

### Undergraduate

Electric Circuit Theory  
Vector Mechanics  
Electronics  
Engineering Design I & II  
Logic Design  
Solid Biomechanics  
Digital Signal Processing  
Fluid Mechanics  
Linear Signals and Systems  
Intro to Medical Imaging  
Linear Control Systems  
Biomedical Instrumentation

## SKILLS

- Pro/ENGINEER
- MATLAB
- SolidWorks
- C++
- HTML and CSS

## PROFESSIONAL SERVICE

- Reviewer, Computer Aided Surgery, 2008
- Reviewer, Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2007, 2008
- Reviewer, IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2008
- Reviewer, International Medical Image Computing and Computer Aided Intervention Conference (MICCAI), 2007
- Reviewer, IEEE International Conference on Robotics and Automation (ICRA), 2007