

Umashankar Nagarajan

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RESEARCH INTERESTS

Robotics, Dynamics and Control, Motion Planning, Integrated Planning and Control, Human-Robot Physical Interaction, Mobile Robots, Legged Robots, Exoskeletons, Balancing Robots, Underactuated Systems

EDUCATION

Carnegie Mellon University

Pittsburgh, PA, USA

The Robotics Institute, School of Computer Science

DOCTOR OF PHILOSOPHY IN ROBOTICS

August 2012

Thesis: Fast and Graceful Balancing Mobile Robots

Advisor: Prof. Ralph Hollis

MASTER OF SCIENCE IN ROBOTICS

December 2008

Birla Institute of Technology and Science

Pilani, India

BACHELOR OF ENGINEERING (HONS.) IN MECHANICAL

December 2006

Thesis: Simulation Analysis of Rider Effect on Bicycle Stabilization

Advisor: Mr. H. D. Sharma

RESEARCH EXPERIENCE

Honda Research Institute USA, Inc.

Mountain View, CA, USA

RESEARCHER

November 2013 – Present

- o Developing control algorithms for exoskeleton devices that assist humans to balance better and avoid falls

SUMMER RESEARCH INTERN

May – August, 2009

- o Developed control and planning algorithms that use foot placement and inertia shaping strategies to cause a humanoid robot to fall in a safe direction, when its fall is inevitable

Disney Research

Pittsburgh, PA, USA

Walt Disney Imagineering Research & Development, Inc.

POSTDOCTORAL ASSOCIATE

August 2012 – October 2013

- o Developed algorithms to automatically generate task-specific simplified models for humanoid robots
- o Developed universal balancing controllers for bipedal robots in dynamic, unstable environments

Carnegie Mellon University

Pittsburgh, PA, USA

The Robotics Institute, School of Computer Science

GRADUATE STUDENT RESEARCHER

August 2009 – July 2012

- o Developed planning and control algorithms for the ballbot, a human-sized robot that balances on a ball
- o Developed shape trajectory planners that use dynamic constraint equations to plan motions for the arm and body angles of the ballbot in order to achieve the desired ball motion
- o Developed an integrated planning and control framework that allows the ballbot to plan in the space of motion policies to achieve navigation tasks while ensuring overall graceful motion

RESEARCH ENGINEER

January – May, 2009

- o Developed control software and graphical user interface for the ballbot

- GRADUATE STUDENT RESEARCHER August 2007 – December 2008
- o Developed robust balancing controllers for the ballbot to handle disturbances like kicks, shoves and collisions
 - o Explored a variety of human-robot physical interaction tasks with the ballbot

Central Electronics Engineering Research Institute Pilani, India

- PROJECT ASSISTANT February – May, 2007
- o Developed an intelligent system design procedure using fuzzy logic that generates percepts from sensory information and generates actions from these percepts for pre-determined tasks

- SUMMER RESEARCH INTERN June – July, 2006
- o Developed adaptive neuro-fuzzy controllers for stabilization of an autonomous bicycle model

Birla Institute of Technology and Science Pilani, India

- UNDERGRADUATE RESEARCHER June 2004 – December 2006
- o Modeled an autonomous bicycle and analyzed its inherent stability with and without a rigid rider
 - o Developed a variety of fuzzy logic controllers for stabilization of the autonomous bicycle model

TEACHING AND MENTORING EXPERIENCE

Carnegie Mellon University Pittsburgh, PA, USA
The Robotics Institute, School of Computer Science

- VISITING INSTRUCTOR
- Co-taught with Prof. Christopher Atkeson, while independently taught kinematics, dynamics and control
- o Humanoids (16-264) January – May, 2013

- TEACHING ASSISTANT
- Prepared and graded assignments, held office hours and presented lectures
- o Introduction to Feedback Control Systems (16-299) January – May, 2010

- MENTOR
- Guided and supervised research and software development
- o Byungjun Kim (MS Mechanical Engineering) August 2009 – May 2011
 - o Jun Xion Leong (BS Physics) May – July, 2008
 - o Jared Goerner (BS Electrical and Computer Engineering) January – May, 2008

Birla Institute of Technology and Science Pilani, India
Department of Mechanical Engineering

- PROFESSIONAL ASSISTANT
- Prepared course presentations, graded assignments and tutored undergraduate students
- o Control Systems (AAOC-C321) August 2005 – December 2006
 - o Advanced Mechanics of Solids and Kinematics (ME-C392) August – December, 2006

PATENTS

- [1] **Umashankar Nagarajan** and Katsu Yamane, “Universal Balancing Controller for Robust Lateral Stabilization of Bipedal Robots in Dynamic, Unstable Environments”, *Disney Enterprises, Inc.*, Application No. 14/171208, Filed on February 23, 2014 (Pending).
- [2] **Umashankar Nagarajan** and Katsu Yamane, “Automatic Task-specific Model Reduction for Robots”, *Disney Enterprises, Inc.*, Application No. 14/037183, Filed on September 25, 2013 (Pending).
- [3] Ambarish Goswami, **Umashankar Nagarajan** and Yoshiaki Sakagami, “Humanoid Fall Direction Change Among Multiple Objects”, *Honda Motor Co., Ltd.*, U.S. Patent No. 8369991, Issued on February 05, 2013.

PUBLICATIONS¹

Refereed Journal Articles

- [1] **Umashankar Nagarajan** and Katsu Yamane, “Environment Information is Not Essential for Balancing in Dynamic, Unstable Environments”, *IEEE Transactions on Robotics (T-RO)*, 2014 (To Appear in Volume 30, Issue 5).
- [2] **Umashankar Nagarajan**, George Kantor and Ralph Hollis, “The Ballbot: An Omnidirectional Balancing Mobile Robot”, *International Journal of Robotics Research (IJRR)*, Volume 33, Issue 6, pp. 917 – 930, May 2014.
- [3] Ambarish Goswami, Seung-kook Yun, **Umashankar Nagarajan**, Sung-Hee Lee, KangKang Yin and Shivaram Kalyanakrishnan, “Direction-Changing Fall Control in Humanoid Robots: Theory and Experiments”, *Autonomous Robots (AURO)*, Volume 36, Issue 3, pp. 199 – 223, March 2014.
- [4] **Umashankar Nagarajan** and Ralph Hollis, “Shape Space Planner for Shape-Accelerated Balancing Mobile Robots”, *International Journal of Robotics Research (IJRR)*, Volume 32, Issue 11, pp. 1323 – 1341, September 2013.
- [5] **Umashankar Nagarajan**, George Kantor and Ralph Hollis, “Integrated Motion Planning and Control for Graceful Balancing Mobile Robots”, *Special Issue: Motion Planning for Physical Robots, International Journal of Robotics Research (IJRR)*, Volume 32, Issue 9 – 10, pp. 1005 – 1029, August/September 2013.

Refereed Conference Papers

- [1] **Umashankar Nagarajan** and Katsu Yamane, “Universal Balancing Controller for Robust Lateral Stabilization of Bipedal Robots in Dynamic, Unstable Environments”, *IEEE International Conference on Robotics and Automation (ICRA)*, pp. 6698 – 6705, May 2014.
- [2] **Umashankar Nagarajan** and Katsu Yamane, “Automatic Task-specific Model Reduction for Humanoid Robots”, *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pp. 2578 – 2585, November 2013.
- [3] **Umashankar Nagarajan**, George Kantor and Ralph Hollis, “Integrated Planning and Control for Graceful Navigation of Shape-Accelerated Underactuated Balancing Mobile Robots”, *Proceedings of the IEEE International Conference on Robotics and Automation (ICRA)*, pp. 136 – 141, May 2012.
- [4] **Umashankar Nagarajan**, Byungjun Kim and Ralph Hollis, “Planning in High-dimensional Shape Space for a Single-wheeled Balancing Mobile Robot with Arms”, *Proceedings of the IEEE International Conference on Robotics and Automation (ICRA)*, pp. 130 – 135, May 2012.
- [5] **Umashankar Nagarajan**, George Kantor and Ralph Hollis, “Hybrid Control for Navigation of Shape-Accelerated Underactuated Balancing Systems”, *Proceedings of the 49th IEEE Conference on Decision and Control (CDC)*, pp. 3566 – 3571, December 2010.
- [6] **Umashankar Nagarajan**, “Dynamic Constraint-based Optimal Shape Trajectory Planner for Shape-Accelerated Underactuated Balancing Systems”, *Proceedings of Robotics: Science and Systems (RSS)*, June 2010.
- [7] **Umashankar Nagarajan** and Ambarish Goswami, “Generalized Direction Changing Fall Control of Humanoid Robots among Multiple Objects”, *Proceedings of the IEEE International Conference on Robotics and Automation (ICRA)*, pp. 3316 – 3322, May 2010.
- [8] **Umashankar Nagarajan**, George Kantor and Ralph Hollis, “Trajectory Planning and Control of a Dynamically Stable Single Spherical Wheeled Mobile Robot”, *Proceedings of the IEEE International Conference on Robotics and Automation (ICRA)*, pp. 3743 – 3748, May 2009.
- [9] **Umashankar Nagarajan**, Anish Mampetta, George Kantor and Ralph Hollis, “State-Transition, Balancing, Station Keeping and Yaw Control for a Dynamically Stable Single Spherical Wheel Mobile Robot”, *Proceedings of the IEEE International Conference on Robotics and Automation (ICRA)*, pp. 998 – 1003, May 2009.
- [10] **Umashankar Nagarajan**, George Kantor and Ralph Hollis, “Human-Robot Physical Interaction with Dynamically Stable Mobile Robots”, *Proceedings of the ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, pp. 281 – 282, March 2009.

¹ All publications can be found at: <http://www.umashankarnagarajan.com/publications.html>. The citation counts can be found at: http://scholar.google.com/citations?user=v7Z5O_wAAAAJ.

- [11] **Umashankar N** and Himanshu Dutt Sharma, "Adaptive Neuro – Fuzzy Controller for Stabilizing Autonomous Bicycle", *Proceedings of the IEEE International Conference on Robotics and Biomimetics (ROBIO)*, pp. 1652 – 1657, December 2006.
- [12] Himanshu Dutt Sharma and **Umashankar N**, "A Model Approach for Perception based Intelligent Design", *Proceedings of the IEEE International Conference on Robotics and Biomimetics (ROBIO)*, pp. 660 – 665, December 2006.
- [13] Himanshu Dutt Sharma and **Umashankar N**, "A Robotic Model (ROBI) of Autonomous Bicycle System", *Proceedings of the International Conference on Computational Intelligence for Modeling, Control and Automation (CIMCA)*, p. 107, November 2006.
- [14] **Umashankar N** and Karthik V N, "Multi-criteria Intelligent Dispatching Control of Automated Guided Vehicles in FMS", *Proceedings of IEEE International Conference on Cybernetics and Intelligent Systems (CIS)*, pp. 422 – 427, June 2006.
- [15] Himanshu Dutt Sharma and **Umashankar N**, "Fuzzy Controller Design for an Autonomous Bicycle System", *Proceedings of the IEEE International Conference on Engineering of Intelligent Systems (ICEIS)*, pp. 498 – 503, April 2006.
- [16] Himanshu Dutt Sharma and **Umashankar N**, "Stabilization of Autonomous Bicycle using Fuzzy Controller with Maximum Allowable Lean Constraint", *Proceedings of the 3rd International Conference on Computational Intelligence, Robotics and Autonomous Systems (CIRAS)*, December 2005.
- [17] Himanshu Dutt Sharma, Sameer M. Kale and **Umashankar N**, "Simulation Model for Studying Inherent Stability Characteristics of Autonomous Bicycle", *Proceedings of the IEEE International Conference on Mechatronics and Automation (ICMA)*, pp. 193 – 198, July 2005.

Theses

- [1] "Fast and Graceful Balancing Mobile Robots", *PhD Thesis (CMU-RI-TR-12-16)*, The Robotics Institute, Carnegie Mellon University, Pittsburgh, PA, USA, 2012.
- [2] "Simulation Analysis of Rider Effect on Bicycle Stabilization", *Undergraduate Thesis*, Birla Institute of Technology and Science, Pilani, India, 2006.

INVITED TALKS

- [1] "Fast and Graceful Balancing Personal Robots", *Dynamic Robotics Laboratory, School of Mechanical, Industrial and Manufacturing Engineering, Oregon State University, Corvallis, OR, USA*, June 2012.
- [2] "Fast and Graceful Balancing Personal Robots", *Neato Robotics, Pittsburgh, PA, USA*, April 2012.
- [3] "Control, Planning and Interaction with Dynamically Stable Single Spherical Wheeled Mobile Robot", *Department of Theoretical and Applied Mechanics, Cornell University, Ithaca, NY, USA*, March 2009.

MEDIA AND PRESS

- o UK's Gadget Show, January 2010
- o Video exhibit of the ballbot in RoboWorld, Carnegie Science Center, Pittsburgh, PA, USA.

HONORS AND PROFESSIONAL ACTIVITIES

HONORS

- o Graduate Fellowship, Carnegie Mellon University, Pittsburgh, PA, USA 2008 – 2012
- o Merit-cum-Need Scholarship, Birla Institute of Technology and Science, Pilani, India 2003 – 2006

MEMBERSHIP

- o IEEE RAS Technical Committee on Algorithms for Planning and Control of Robot Motion 2013 – Present
- o IEEE Robotics and Automation Society 2012 – Present
- o IEEE Member 2007 – Present

REVIEWER

- o IEEE Transactions on Robotics 2013
- o Mechatronics (Elsevier Journal) 2013
- o International Journal of Advanced Robotic Systems 2013
- o IEEE International Conference on Robotics and Automation 2010 – 2014
- o IEEE/RSJ International Conference on Intelligent Robotics and Systems 2010 – 2014
- o IEEE Conference on Decision and Control 2011
- o IEEE International Conference on Advanced Intelligent Mechatronics 2009

COMPUTER SKILLS

Languages: C and C++

Software: MATLAB, SIMULINK, Mathematica, Pro/Engineer, and Altium Designer (Protel)

Operating Systems: Microsoft Windows, UNIX, Linux and QNX

REFERENCES

Available upon request