

Umashankar Nagarajan

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RESEARCH INTERESTS

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

EDUCATION

The Robotics Institute, Carnegie Mellon University

DOCTOR OF PHILOSOPHY IN ROBOTICS
Advisor: Ralph Hollis

Pittsburgh, PA, USA

June 2012 (Expected)
CGPA: 3.75/4.0

MASTER OF SCIENCE IN ROBOTICS
Advisor: Ralph Hollis

December 2008
CGPA: 3.83/4.0

Birla Institute of Technology and Science

BACHELOR OF ENGINEERING (HONS.) IN MECHANICAL
Advisor: Himanshu Dutt Sharma

Pilani, India

December 2006
CGPA: 9.17/10.0

RESEARCH EXPERIENCE

The Robotics Institute, Carnegie Mellon University

GRADUATE STUDENT RESEARCHER

Pittsburgh, PA, USA

August 2009 – Present

- Developed planning and control algorithms for the ballbot, a human-sized robot that balances on a ball
- 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
- 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

- Developed control software and graphical user interface for the ballbot, which enables the user to wirelessly monitor the robot's operation, issue commands to the robot and teleoperate it

GRADUATE STUDENT RESEARCHER

August 2007 – December 2008

- Developed control algorithms that enable the ballbot to balance reliably, be robust to disturbances including kicks, shoves and collisions with objects
- Explored a variety of human-robot physical interaction tasks with the ballbot

Honda Research Institute USA, Inc.

Mountain View, CA, USA

SUMMER RESEARCH INTERN

June – August, 2009

- Developed control and planning algorithms that use foot placement and inertia shaping strategies to cause safe fall of a humanoid robot without causing damage to its surrounding objects, when the robot fall is inevitable

Central Electronics Engineering Research Institute

Pilani, India

PROJECT ASSISTANT

February – May, 2007

- 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

- Designed, trained and simulated multiple 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

- Modeled an autonomous bicycle system and analyzed its stability characteristics and the relationship between lean and steer
- Analyzed the effect of the presence of a rigid rider on stabilization of the autonomous bicycle model
- Developed a variety of fuzzy logic controllers for stabilization of the autonomous bicycle model

TEACHING AND MENTORING EXPERIENCE

The Robotics Institute, Carnegie Mellon University

Pittsburgh, PA, USA

TEACHING ASSISTANT

Prepared and graded assignments, held office hours and presented lectures

- Introduction to Feedback Control Systems (16-299)

January – May, 2010

MENTOR

Guided and supervised research and software development

- Byungjun Kim (MS Mechanical Engineering)
- Jun Xion Leong (BS Physics)
- Jared Goerner (BS Electrical and Computer Engineering)

August 2009 – May 2011

May – July, 2008

January – May, 2008

Birla Institute of Technology and Science

Pilani, India

PROFESSIONAL ASSISTANT

Prepared course presentations, graded assignments and tutored undergraduate students

- Control Systems (AAOC-C321)
- Advanced Mechanics of Solids and Kinematics (ME-C392)

August 2005 – December 2006

August – December, 2006

SEMINAR TALKS

- **Umashankar Nagarajan**, “Control, Planning and Interaction with Dynamically Stable Single Spherical Wheeled Mobile Robot (Ballbot)”, *Department of Theoretical and Applied Mechanics, Cornell University, Ithaca, NY, USA*, March 2009.
- **Umashankar Nagarajan**, “Trajectory Planning and Control of an Underactuated Dynamically Stable Single Spherical Wheeled Mobile Robot”, *Center for the Foundations of Robotics, Carnegie Mellon University, Pittsburgh, PA, USA*, October 2008.

PATENTS

- Ambarish Goswami, **Umashankar Nagarajan** and Yoshiaki Sakagami, “Humanoid Fall Direction Change Among Multiple Objects”, *Honda Motor Co., Ltd. (Patent Pending)*, June 2010.

JOURNAL ARTICLES

- **Umashankar Nagarajan** and Ralph Hollis, “Shape Space Planner for Shape-Accelerated Balancing Mobile Robots”, *IEEE Transactions on Robotics (Under Review)*, 2011.
- **Umashankar Nagarajan**, George Kantor and Ralph Hollis, “The Ballbot: An Omnidirectional Balancing Mobile Robot”, *IEEE Transactions on Robotics (Under Review)*, 2011.
- 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”, *International Journal of Robotics Research (Under Review)*, 2011.

REFEREED CONFERENCE PAPERS

- **Umashankar Nagarajan**, George Kantor and Ralph Hollis, “Integrated Planning and Control for Graceful Navigation of Shape-Accelerated Underactuated Balancing Mobile Robots”, *Accepted for publication at the IEEE International Conference on Robotics and Automation (ICRA)*, May 2012.
- **Umashankar Nagarajan**, Byungjun Kim and Ralph Hollis, “Planning in High-dimensional Shape Space for a Single-wheeled Balancing Mobile Robot with Arms”, *Accepted for publication at the IEEE International Conference on Robotics and Automation (ICRA)*, May 2012.
- **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.
- **Umashankar Nagarajan**, “Dynamic Constraint-based Optimal Shape Trajectory Planner for Shape-Accelerated Underactuated Balancing Systems”, *Proceedings of Robotics: Science and Systems (RSS)*, June 2010.
- **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.
- **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.
- **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.
- **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.
- **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.
- 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.
- 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, December 2006.
- **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.
- 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.
- 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.
- 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.

TECHNICAL REPORTS

- **Umashankar N**, “Simulation Analysis of Rider Effect on Bicycle Stabilization”, *Undergraduate Thesis*, Birla Institute of Technology and Science, Pilani, December 2006.

The listed publications are available at: <http://www.cs.cmu.edu/~unagaraj/publications.html>.

The robot videos are available at: <http://www.cs.cmu.edu/~unagaraj/videos.html>.

COMPUTER SKILLS

Languages: C and C++

Softwares: MATLAB, SIMULINK, Mathematica, Pro/Engineer, Altium Designer (Protel) and Open Dynamics Engine

Operating Systems: Microsoft Windows, UNIX, Linux and QNX

HONORS AND ACTIVITIES

- Reviewer for the IEEE International Conference on Robotics and Automation (ICRA), 2010 – 2012
- Reviewer for the IEEE/RSJ International Conference on Intelligent Robotics and Systems (IROS), 2008, 2010 – 2011
- Reviewer for the IEEE International Conference on Advanced Intelligent Mechatronics (AIM), 2009
- Recipient of the Robotics Graduate Fellowship, 2008 – Present
- IEEE Graduate Student Member, 2007 – Present
- Recipient of BITS Pilani Merit-cum-Need Scholarship, 2003 – 2006

MEDIA COVERAGE

- Appeared with the ballbot in UK's Gadget Show, January 2010
- Appeared in the video exhibit of the ballbot in RoboWorld, a permanent robotics exhibition at Carnegie Science Center in Pittsburgh, 2009

REFERENCES

- **Ralph Hollis**
Research Professor, The Robotics Institute, CMU
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Phone: (412) 268-8264
- **Howie Choset**
Professor, The Robotics Institute, CMU
Email: choset@cs.cmu.edu
Phone: (412) 268-2495
- **George Kantor**
Systems Scientist, The Robotics Institute, CMU
Email: kantor@ri.cmu.edu
Phone: (412) 268-7084
- **Ambarish Goswami**
Principal Scientist, Honda Research Institute USA
Email: agoswami@honda-ri.com
Phone: (650) 314-0432