

Curriculum Vitae: Surya P. N. Singh

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Research Interests

I am interested in the agile control of robot motion. This encompasses both analysis (biomechanics, inverse control) and synthesis (integrated motion planning and optimal control).

Education

- Ph.D.**, Stanford University (School of Engineering) April 2006
Mechanical Engineering
Dissertation: *Self-contained Field Analysis of Dynamic Legged Locomotion*
- M.S.**, Carnegie Mellon University (School of Computer Science) December 2001
Robotics
Thesis: *ARMS: Autonomous Robots for Military Systems*
(published as CMU Technical Report: CMU-RI-01-16)
- B.S.**, The University of Tennessee May 2000
Mechanical Engineering and Economics (minor) – *summa cum laude*

Academic Experience

- University of Sydney** (Australian Centre for Field Robotics) 2008-Present
Research Fellow
Studying optimal control and planning methods so as to leverage analytic models along with probabilistic system identification for agile system performance. This has been applied to the driving system of the first fielded autonomous (blast-hole) drill rig (now in routine commercial operation).
- University of Western Australia** (School of Mechanical Engineering) 2006-2007
Visiting Lecturer & Fulbright Scholar
Field teleoperation and improved “display”/“sensing” tools for humanitarian landmine clearance operations.
- Stanford University** (Mechanical Engineering Design Division) 2002-2006
Research Associate (Robotics Locomotion Laboratory) and Teaching Assistant
Studied in-field sensing and estimation of agile locomotion, particularly galloping, leading to the first hybrid estimator for legged robots with integrated systems identification and online center of mass estimation. Used for motion synthesis on KOLT (robot) and analysis (of galloping dogs outdoors).

Honors and Awards

- U. Sydney AMME Teaching Commendation March 2010
- UWA Individual Teaching Award nomination December 2007
- Fulbright Scholar (to Australia) 2006-2007
- NSF EAPSI Summer Scholar (to the Tokyo Institute of Technology) June-August 2005
- JSPS Invited Scholar (to the Tokyo Institute of Technology) May-August 2004
- National Defense Science and Engineering Graduate (NDSEG) Fellowship 2001-2004
- Tau Beta Pi Fellowship (General Electric #1) 2001
- Barry Goldwater Scholar 1998-2000

Publications

Journal:

1. **S. Singh**, R. Fitch, and S. Williams, “A Research-Driven Approach to Undergraduate Robotics Education,” *Computers in Education Journal*, **20(4)**, Oct-Dec 2010.
2. J. Ma, A. Wittek, **S. Singh**, G. Joldes, T. Washio, K. Chinzei, and K. Miller “Evaluation of accuracy of non-linear finite element computations for surgical simulation: study using brain phantom,” *Computer Methods in Biomechanics and Biomedical Engineering*, **13(6)**:783–794, December 2010.

3. K. Waldron, J. Estremera, P. Csonka, and **S. Singh**, “Analyzing Bounding and Galloping Using Simple Models,” *Journal of Mechanisms and Robotics*, **1**:011002:1–11, February, 2009.
4. M. Matsuoka, A. Chen, **S. Singh**, *et al.*, “Autonomous Helicopter Tracking and Localization Using a Self-Locating Camera Array,” *International Journal of Robotics Research*, **26(2)**:205–215, 2007.
5. J. G. Nichol, **S. Singh**, K. J. Waldron, L. R. Palmer, and D. E. Orin. “System Design of a Quadrupedal Galloping Machine,” *International Journal of Robotics Research*, **23(10-11)**:1013–1027, 2004.

Conference (Refereed):

6. K. Waldron and S. Singh, “Resolving the Paradox of Asymmetry in the gallop gait,” (to be presented at the IFToMM 2011 World Congress, June 2011).
7. K. Seiler, **S. Singh**, H. Durrant-Whyte, “Using Lie Group Symmetries for Fast Corrective Motion Planning,” Proc. of the Ninth International Workshop on the Algorithmic Foundations of Robotics, Dec. 2010.
8. B. Douillard, **S. Singh**, *et al.*, “A Pipeline for the Segmentation and Classification of 3D Point Clouds,” Proc. of the at International Symposium on Experimental Robotics, Dec. 2010.
9. S. Singh and K. Axelrod, “Coordinated Steering for an Uncalibrated Pan-Tilt-Zoom Camera Array,” Proc. of the Australian Conference on Robotics and Automation (ACRA), Dec. 2010.
10. N. Kirchner, A. Alempijevic, S. Singh, *et al.*, “RobotAssist - a Platform for Human Robot Interaction Research,” Proc. of the Australian Conference on Robotics and Automation (ACRA), Dec. 2010.
11. M. Freese, **S. Singh**, F. Ozaki, N. Matsuhira, “V-REP: A Versatile 3D Robot Simulator,” Proc. of the Second Int. Conf. on Simulation, Modeling and Programming for Autonomous Robots (SIMPAN), Nov. 2010.
12. G. Maeda, **S. Singh**, H. Durrant-Whyte, “Feedback Motion Planning Approach for Nonlinear Control using Gain Scheduled RRTs,” Proc. of the International Conference on Intelligent Robots and Systems, Oct. 2010.
13. B. Douillard, **S. Singh**, *et al.*, “Elevation Maps: 3D Surface Models for Segmentation,” Proc. of the International Conference on Intelligent Robots and Systems, Oct. 2010.
14. X. Fan, **S. Singh**, F. Oppolzer, *et al.*, “Integrated Planning and Control of Large Tracked Vehicles in Open Terrain,” Proc. of the International Conference on Robotics and Automation (ICRA), May 2010.
15. **S. Singh** and K. Waldron, “Generalized Dog Motion Measurements to Support a Simple Model of Rotary Galloping Locomotion,” Proceedings of the 12th International Conference on Climbing and Walking Robots, (to be published by World Scientific).
16. M. Freese, **S. Singh**, W. Singhose, E. Fukushima, and S. Hirose, “Terrain Modeling and Following Using a Compliant Manipulator for Humanitarian Demining Applications,” Proceedings of the 7th International Conference on Field And Service Robotics, (to be published as Springer Tracts in Advanced Robotics series).
17. **S. Singh**, “A Traceable Inertial Calibration Procedure Suited for MEMS Sensing,” Proceedings of the RSS 2009 Workshop on Performance Evaluation and Benchmarking for Next Intelligent Robots and Systems.
18. **S. Singh**, S. Trujillo, and K. Waldron, “A Screw Representation for Aiding State Estimation with Application to Dynamic Quadrupedal Locomotion,” ROMANSY 2008.
19. **S. Singh**, “Comparison of Field Quadruped Motion Tracking”, *Biorobotics Workshop at 2008 International Conference on Robotics and Automation*, May 2008.
20. **S. Singh** and K. Waldron, “Robotic Harness for the Field Assessment of Galloping Gaits,” *Proceedings of the 2007 International Conference on Intelligent Robots and Systems (IROS)*, October 2007, 4247-4252.
21. K. Waldron, J. Estremera, P. Csonka, **S. Singh**, “Thinking About Bounding and Galloping Using Simple Models,” *Proceedings of the 10th Int. Conference on Climbing and Walking Robots (CLAWAR)*, July 2007.
22. **S. Singh** and K. Waldron, “A Hybrid Motion Model for Dynamic Quadrupedal Locomotion,” *Proceedings of the 2007 International Conference on Robotics and Automation (ICRA)*, April 2007, 4337-4342.
23. **S. Singh**, M. Freese, J. Trevelyan, “Contributions on a Design Direction for Future Humanitarian Demining Robots,” *Proceedings of the 2007 ICRA*, Workshop on Robotics in Challenging and Hazardous Environments, April 2007.
24. **S. Singh**, P. Csonka, and K. Waldron, “Optical Flow Aided Motion Estimation for Legged Locomotion,” *Proc. of the 2006 International Conference on Intelligent Robots and Systems (IROS)*, October 2006, 1738–1743.
25. M. Freese, **S. Singh**, E. Fukushima, and S. Hirose, “Bias-Tolerant Terrain Following Method for a Field Deployed Manipulator,” *Proceedings of the 2006 ICRA*, May 2006, 175-180.
26. **S. Singh** and K. Waldron, “Attitude Estimation for Dynamic Legged Locomotion Using Range and Inertial Sensors,” *Proceedings of the 2005 ICRA*, April 2005, 3935–3940.
27. ———, “Design and Evaluation of an Integrated Planar Localization Method for Desktop Robotics,” *Proceedings of the 2004 ICRA*, April 2004, 1109–1114.
28. ———, “Towards High-Fidelity On-Board Attitude Estimation via a Hybrid Optical and Inertial Approach,” In *Experimental Robotics IX*, **21**, M. H. Ang and O. Khatib (Eds.), 2006, 589–598.

29. **S. Singh** and S. Thayer, "Development of an Immunology-Based Multi-Robot Coordination Algorithm for Exploration & Mapping," *Proceedings of the 2002 IROS*, October 2002, 2735–2739.
30. ———, "Kilobot Search and Rescue Using an Immunologically Inspired Approach," *Distributed Autonomous Robotic Systems (DARS)*, **5**, 2002, 300-305.
31. ———, "A Foundation for Kilorobotic Exploration." *Proceedings of the Congress on Evolutionary Computation (CEC 2002)*, May 2002, 1033-1038.
32. ———, "Immunology Directed Methods for Distributed Robotics: A Novel, Immunity-Based Architecture for Robust Control & Coordination," *Proceedings of SPIE: Mobile Robots XVI*, **4573**, Nov. 2001, 44-55.
33. **S. Singh**, and C. Riviere, "Physiological Tremor Amplitude During Vitreoretinal Microsurgery," *Proceedings of the 28th Annual Northeast Bioengineering Conference*, April, 2002, 171-172.
34. **S. Singh** and S. Everett, "Sensor, Model, and Variable Velocity Telerobotic Assistance in Surgical and Biomedical Environments," Tennessee Conference on Biomedical Engineering, April 1999.

Patents (Provisional)

1. **2009904465** – A system and method for autonomous navigation of a tracked or skid-steer vehicle
2. **2009901949** – Method and System for Regulating Movement of an Autonomous Entity Between Zones
3. **2009901933** – Control System for Autonomous Operation
4. **2009901656** – Drill Hole Planning
5. **US 60/565,667** – Non-mechanical Method and Device for Simultaneously Sensing Planar Position

Professional Qualifications

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|--------------------------------------------------------------------|---------------|
| 1. Graduate Certificate in Higher Education (University of Sydney) | October 2009 |
| 2. Research Higher Degree Supervision (University of Sydney) | June 2009 |
| 3. Rio-Tinto: Lockholder and PIO | February 2009 |
| 4. Engineer in Training in Mechanical Engineering (NCEES) | June 2000 |

Grants and Research Awards

1. "Bodies in Space," Chief Investigator (with Drs. Dullin and Sinclair)
ARC Linkage Projects 2010 - Round 2, \$210k
2. "Optimal Methods for Miniature Navigation from Multiple Inertial Measurements and Gait-tuned Estimation Software with Biomedical and Robotic Applications," Principal Investigator,
ARC/UWA Research Grants Scheme 2008, \$8k
3. Mechatronics Course Support for "System Configuration & Simulation for Supervised Teleoperation of Automated Ship Loading" project, Principal Investigator, **Rio Tinto Iron Ore**, \$6k
4. Robotic and Autonomous Mines, Improvised Explosive Devices And Counter-Measures, Co-investigator (with Prof. J. Trevelyan), **Defence Systems Analysis Division (DSTO)**, \$50k
5. Mechatronics Infrastructure Support Grant, Principal Investigator,
UWA Teaching and Learning Committee Award, \$8k

Teaching Experience

University of Sydney

- **Introduction to Mechatronics (MTRX 1701)** **2008, 2009, 2010**
Evaluations: University of Sydney Unit of Study Evaluation (USE): **Overall: 3.96/5, Relevance: 4.43/5**
USYD AMME Teaching Committee Commendation
- **Experimental Robotics (MTRX 4700 -- with Drs. Fitch and Williams)** **2009, 2010**

University of Western Australia

- **Mechatronics Design (MCTX 3420)** **2008**
Evaluations: UWA Students' Unit Reflective Feedback (SURF): **Overall: 3.4/4**,
UWA SPOT: **Course Overall: 4.11/5, Instructor: 4.47/5**,
UWA Individual Teaching Award nomination.
- **Mechanisms and Multibody Systems (MECH3422 – with Prof. K. Miller)** **2008**

Stanford University

- **Stress, Strain, and Strength (ME 80 – Teaching assistant under A/Prof. B. Pruitt)** **2004, 2005**
- **Introduction to Sensors (ME 220 – Teaching assistant under Prof. T. Kenny)** **2002, 2004**

Students Supervised

Doctoral:

Mr. Guilherme Maeda, U. Sydney, (expected 2012)
Mr. Konstantin Seiler, U. Sydney, (expected 2012)
Ms. Joanne Mikl, U. Sydney, (expected 2013)

Masters:

Mr. Hadrien Vrba, U. Sydney, 2010
Coordinated Motion Control of a Robotic Excavator
Mr. Jiajie Ma, UWA, 2009 (co-supervised with Dr. Adam Wittek)
Experimental Validation of Viscoelastic Constitutive Models by X-Ray Feature Tracking

Undergraduate Honors:

Mr. Sri Puthi, U. Sydney, (expected 2010)
Mr. Kit Axelrod, U. Sydney, (expected 2010)
Pan-Tilt-Zoom Camera Array Calibration and Tracking
Mr. Alexander Kurukulasuriya, U. Sydney, 2009 (1st honors)
Material Classification by Acoustic Method
Mr. William Liu, U. Sydney, 2009
Spectral Analysis on Household Materials
Mr. Shayne Pitting, U. Sydney, 2009
Office Automation Diagnosis
Mr. Sandy Taylor, U. Sydney, 2009 (1st honors)
Applied Vehicle Route Optimisation
Mr. Ankur Patel, UWA, 2008 (2nd honors)
Relief Valves: A Methodology for Optimisation of Maintenance, using modified Risk Based Analysis

Collaborators

Alen Alempijevic (UTS, Mechatronics)	Damien O'Meara (NWSIS)
Alan Bowling (U. Texas, Mechanical Engineering)	Florian Oppolzer (Rio Tinto)
Bertrand Douillard (U. Sydney, AMME)	Marcus Pandy (U. Melbourne, ME)
Hugh Durrant-Whyte (NICTA)	Fabio Ramos (U. Sydney, SIT/AMME)
Darren Dutto (CalPoly Pomona, Kinesiology)	Peter Sinclair (U. Sydney, Human Movement)
Robert Fitch (U. Sydney, AMME)	Russ Tedrake (MIT, CSAIL)
David Lloyd (UWA, Human Movement)	Kenneth Waldron (Stanford, ME)
Karol Miller (UWA, Mechanical Engineering)	Adam Wittek (UWA, ME)

Outreach and Academic Service

Outreach and Invited Lectures:

1. Robotics Education in Remote Schools Pilot (at Rottneest Island School, Western Australia)
2. Murdoch College Invited Seminar – “Robotics & Design: Today & Tomorrow”
3. Fulbright Seminar – “Robotics for the Everyday from the Everyday”

Press Coverage:

1. Robotics Panelist for ABC TV's, *New Inventors* (to air ~ Feb 2011).
2. Profiled in E. Klarreich, “Artificial Immune Systems,” *Nature*, **415**:468-470, 2002.

Peer Review:

1. International Journal of Robotics Research
2. Mechanism and Machine Theory
3. IEEE Transactions on Robotics
4. Journal of Field Robotics
5. International Conference on Intelligent Robots and Systems (IROS)
6. International Conference on Robotics and Automation (ICRA)
7. International Symposium on Robotic Research (ISER)
8. Robotica
9. Robotics: Science and Systems

Workshops Organized:

1. Organizer and Chair, **Biorobotics: Research Advances, Standards, & Education** Workshop, ICRA 2008.
2. Organizer, **RAS Chapter and Student Leaders meeting**, ICRA 2008.

Administrative Committees:

1. **Student Activities Chair for IEEE-RAS** (2005-2007) – Advocated for and coordinated increased student participation through the RAS, especially with student chapters. Member of its administrative committee. Highlights include an open [Robotics Jobs Wiki](#) and Chapter & Students leaders workshop (ICRA 2008).
2. **UWA Mechatronics Education Committee** (2006-2007) – Interdepartmental group responsible for Mechatronics education and practice. Lead the draft of a *Survey of Mechatronics Coursework in Australia*.

Governance:

1. **Sustainability Officer**, Engineers Australia (2009-2010)
2. **Mechanical Engineering Design Division Student Representative** (2003-2004)
3. **Stanford Committee on Research** (2002-2005)
4. **Graduate Student Council** (2002-2004)

Professional Society Membership

1. Robotics and Automation Society (RAS)
2. Engineers Australia
3. IEEE
4. ASME
5. Tau Beta Pi

Citizenship

U.S. and Australian citizenship holder

References

1. Prof. Adam Wittek
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2. Prof. Stefan Williams
e-mail: stefanw@acfr.usyd.edu.au
phone: +61 (2) 2 9351-4023
address: Australian Centre for Field Robotics (ACFR), J07
The University of Sydney NSW 2006, AUSTRALIA
3. Prof. Kenneth J. Waldron
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phone: +1 (650) 736-1412
address: Terman Eng. Cntr. 551, Mechanical Engineering
Stanford University
Stanford, CA 94305-4021

Current and Past Research Summary Descriptions

Control and Operations Research

As part of the Rio Tinto Centre for Mine Automation program at the Australian Centre for Field Robotics, this work is looking at predictive and systematic hierarchical control architectures with application to open pit and underground mining. Current research is investigating methods and stability criteria for (1) planning and logistics (scheduling) in the presence of uncertainty and (2) methods for adapting control based on dynamic parameter estimation. Related applications, outside of mining, include non-destructive monitoring and human motion tracking.

Smart Demining Manipulation Research

The core problem is a >100:1 false positive rate. This work has used parameter estimation to (1) improve the robustness of input shaping methods and (2) to vary the orientations of a metal detector attached to a robot manipulator for improved background rejection. Done in collaboration with researchers at Tokyo Tech., this has produced a stereo vision terrain map filtering method with minimal feature degradation, allowing the sensor body to be placed closer to the terrain. Project work also includes documenting the design factors associated with developing technologies for remote communities and in explaining the issues involved with humanitarian landmine clearance.

Artificial Quadruped Project

Design and development of efficient localization algorithms for legged locomotion systems on uncharacterized terrains using a dynamic switched hybrid model. This work was done as part of the KOLT project, which developed the first robotic locomotion platform for full galloping gaits. Research involved experimental design, hardware specification, mechanical isolation, algorithms, and software implementation of these methods to provide final estimates up to 400 Hz. Efforts are considering biomechanical applications such as horse locomotion.

Immunology-derived Distributed Autonomous Robotics Architecture (IDARA)

A mobile robot architecture for the coordination of distributed autonomous robot teams comprised of very-large populations (i.e., over a thousand). Bio-inspired by immune system constructs, IDARA is an iterative refinement approach with responses based on each unit's capability to timely address the perceived need(s). While an optimal solution is an order-NP hard problem (i.e., like the multiple traveling salesman problem), the results of this methods was a rapid, order-N, locally-optimal coordination solution.