

Sachin Chitta

Post Doctoral Associate

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Research Interests

Dynamic modeling, simulation, design, control and motion planning for robotic systems including modular robots, walking robots, mobile robots and unconventional locomotion systems.

Education

University of Pennsylvania, Philadelphia, PA. (GPA: 4.0/4.0)
Ph.D. in Mechanical Engineering and Applied Mechanics, May 2005.
M.S. in Mechanical Engineering and Applied Mechanics, December 2000.
Advisor: Dr. Vijay Kumar
Thesis: “Dynamics and Control of a Class of Modular Locomotion Systems”

Indian Institute of Technology, Bombay, India (GPA: 8.47/10.0)
Bachelor of Technology in Mechanical Engineering, July 1999.
Senior Design Thesis: “Computer Control of an Electrohydraulic Servomechanism”

Research Experience

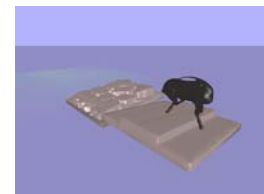
**Department of Mechanical Engineering and Applied Mechanics,
University of Pennsylvania, Philadelphia, PA**

Postdoctoral Associate, May 2005 – Present

- **Learning for Locomotion (<http://www.grasp.upenn.edu/LearningLocomotion>)**
PIs: Dr. Dan Lee, Dr. Vijay Kumar, Dr. George Pappas and Dr. Dan Koditschek

Theoretical Contribution

- Leading a team to design new controllers for quadruped walking over extremely rough terrain (a few orders of difficulty higher than the current state of the art).
- Developed robust statically stable walk and planning method to move over rough terrain. Can handle terrain features close to size of the experimental prototype robot itself.
- Learning implemented to recognize good foothold placement points based on terrain features including height of obstacles, local flatness of terrain around candidate points and normal to terrain.



Experimental Contribution

- Implemented statically stable gait for motion over known rough terrain on experimental platform robot (about the size of a small dog) using a motion capture system.

- **CKBot – Homogeneous Modular Robotic System (<http://www.grasp.upenn.edu/superbot>)**
PI: Dr. Mark Yim

Theoretical Contribution

- Developed graph isomorphism based algorithm for automated recognition of the configuration of a modular robotic system.
- Developed and implemented shape changing algorithm for speed control of a dynamic rolling robot composed of multiple homogeneous modules.

Experimental Contribution

- Led a team to implement the design, modeling, simulation and control of a highly mobile modular robot for planetary exploration. The robot consists of multiple modules with a single rotary degree of freedom, multiple ports for communication using a global CAN bus, onboard controllers, power supply and sensors.
- Designed controller for next generation of individual modules with a global CAN bus, local serial communication, servo control, IR range sensing and accelerometers.
- Conducted extensive experiments with different types of configuration for different tasks including locomotion like a rolling wheel, snake like motion, digging, walking and unique two and three module gaits.

General Robotics, Automation, Sensing, and Perception (GRASP) Laboratory,
University of Pennsylvania, Philadelphia, PA

Graduate Research Assistant, Fall 1999 – May 2005

- **Modular Locomotion Systems (PhD Thesis Work)**

Theoretical Contribution

- Developed algorithms to analyze the dynamics, generate gaits and carry out motion planning for locomotion systems with multiple locomotion modules subject to constraints. Constraints include holonomic constraints that arise from slip-free ground contact of the legs and nonholonomic constraints due to presence of powered and passive wheels.
- Generated gaits and simulated motion of different kinds of modular locomotion systems including a hybrid wheel-legged robot, a novel planar Rollerblading robot (with passive wheels as locomotion modules) and a single-input robot called the RoboTrikke.

Experimental Contribution

- Supervised and participated in design and construction of a Rollerblading robot consisting of a central platform mounted on omnidirectional wheels and two 3 degree of freedom legs with a pair of passive rollerblade wheels mounted on the ends.
- Implemented and validated gaits on the prototype Rollerblading robot including a novel non-anthropomorphic rotary gait.
- Implemented closed-loop control using visual feedback for a novel single input undulatory robot called the RoboTrikke.

Developmental work

- Designed control software and interface for the robot in C# and MATLAB using a mini SSC II Servo Control Board.
- Developed the Rollerblade robot model in ProE prior to fabrication.
- Implemented software modules in C# for visual feedback and communication between a static camera and robot control system.



- **RoboCup – Robot Soccer World Cup (Legged League)**

Led the University of Pennsylvania **Upennalizers** Robot Soccer Team to 3rd place in Team Competition and 2nd place in Technical Challenge competition among 16 international teams at RoboCup 2001 in Seattle, Wa. Participated in RoboCup 2000, Melbourne, Australia and RoboCup 2002, Japan.

Theoretical Contribution

- Designed *omnidirectional walking gaits* for SONY's four legged robots. Design of gaits allowed fast transitions.
- Designed statically stable gaits and algorithm for determining *right phasing* of legs based on desired direction of motion.

Experimental and Developmental Work

- **Walking** – Implemented walking and kicking gaits on SONY's four legged robots.
- **Software architecture** – designed hierarchical software architecture for control of a team of soccer playing robots. Implementation included virtual sensor and actuator modules, modular description of tasks, *task tables* that allowed easy specification of higher level control strategies.
- **Strategy** – Designed and implemented behavioral modes for robot soccer including attack, defend and goalie modes.
- **Vision** – Designed and implemented algorithms for blob detection, pose estimation of objects on the soccer field, visual servoing for tracking the ball.
- **Localization** – Implemented Kalman filter based localization to determine self-pose on the field using odometry information and fiducial markers on the field.
- **Multi-Robot Cooperation** – Implemented strategies for team cooperation using sound and wireless based communication. Cooperation included sensor fusion using data from multiple robots to determine location of the ball, role assignment reflecting different types of behavior (attack, defend, goalie), role switching.

Advisory experience

- Advised undergraduate students in senior design and summer research projects (as part of the SUNFEST program www.ee.upenn.edu/~sunfest) for implementing walking gaits, control algorithms, potential-field based path planning and obstacle avoidance methods for the RoboCup project.

Robotics Laboratory, Indian Institute of Technology, Bombay, India.

Research Assistant, Summer 1999

Designed, constructed and conducted experiments, wrote lab manuals, chose and purchased equipment for a new undergraduate lab in Mechatronics and Control for senior undergraduate students.

Robotics Division, BARC, India.

Summer Intern, Summer 1998

Designed several novel mechanisms for a robot to inspect narrow pipes in a power plant subject to severe size constraints.

Teaching Experience

Department of Mechanical Engineering, University of Pennsylvania, Philadelphia.

- **Advanced Topics in Robotics** (Spring 2006, Spring 2007) (Co-Instructor) - Developed curriculum and taught a class in advanced concepts in kinematics to graduate students.
- **Robotics** (Spring 2001 and Spring 2004) – Developed course plan (Spring 2004) and taught classes in Robotics. Developed, implemented and conducted new laboratory exercises (Spring 2001) to explain concepts in Robotics, Kinematics and Control as part of laboratory portion of the course.
- **Nonlinear Control Theory** (Spring 2002) – Assisted graduate students with concepts in nonlinear control theory.
- **Advanced Engineering Mathematics** (Fall 2000) – Assisted graduate students with concepts in Linear Algebra and Vector analysis.

Publications

JOURNAL PAPERS/ BOOK CHAPTERS/ TECHNICAL REPORTS

- **Sachin Chitta** and Vijay Kumar, “Biking Without Pedaling”, in preparation for the ASME Journal of Mechanical Design.
- **Sachin Chitta**, Frederik Heger, and Vijay Kumar, “Design, Analysis, Simulation and Experimental Results for a Rollerblading Robot”, in preparation for the International Journal of Robotics Research.
- **Sachin Chitta**, Peng Cheng, and Vijay Kumar, “RoboTrikke: A novel undulatory locomotion system”, in preparation for the International Journal of Robotics Research.
- Michael Park, **Sachin Chitta**, Alex Teichman and Mark Yim, “Automatic Configuration Recognition Methods in Modular Robots”, under review for the International Journal of Robotics Research.
- Jimmy Sastra, **Sachin Chitta** and Mark Yim, “Dynamic Rolling for a Modular Loop Robot”, under review for the International Journal of Robotics Research.
- **Sachin Chitta**, William Sacks, Jim Ostrowski, Aweek Das, and P. K. Mishra, “The University of Pennsylvania RoboCup Legged Soccer Team”, in A. Birk, S. Coradeschi, S. Tadokoro (Editors), Lecture Notes in Computer Science 2377: RoboCup 2001: Robot Soccer World Cup V, Springer Verlag, 2001.
- Jim P. Ostrowski, Ken A. McIsaac, Aweek Das, **Sachin Chitta**, and Julie Neiling, “The University of Pennsylvania RoboCup Legged Soccer Team”, in P. Stone, T. Balch, G. Kraetzschmar (Editors), Lecture Notes in Computer Science 2019: RoboCup 2000: Robot Soccer World Cup V, Springer Verlag, 2000.
- **Sachin Chitta** and J. Ostrowski, “Technical Report MS-CIS-01-08: Enumeration and motion planning for modular mobile robots”, Technical Report, Department of Computer and Information Science, University of Pennsylvania.

REFEREED CONFERENCE PAPERS

- **Sachin Chitta**, Paul Vernaza and Daniel Lee, “Proprioceptive Localization for a Quadrupedal Robot on Known Terrain”, accepted to the *2007 IEEE International Conference on Robotics and Automation, Rome, Italy*.

- **Sachin Chitta**, Mustafa Karabas, Kevin Galloway and Vijay Kumar, “RoboTrikke: Design, Modeling and Experimentation with a Robotic Trikke”, in *Proceedings of the 2006 ASME Design Engineering Technical Conference, Philadelphia, Pennsylvania, 2006*.
- Jimmy Sastra, **Sachin Chitta** and Mark Yim, “Dynamic Rolling for a Modular Loop Robot”, in *Proceedings of the International Symposium on Experimental Robotics, Rio Di Janerio, Brazil, 2006*.
- **Sachin Chitta** and Vijay Kumar, “Biking without pedaling”, in *Proceedings of the Fifth ASME International Conference on Multibody Systems, Nonlinear Dynamics and Control, Long Beach, California, 2005*.
- **Sachin Chitta**, Peng Cheng, Emilio Frazzoli and Vijay Kumar, “RoboTrikke: A Novel Undulatory Locomotion System”, in *Proceedings of the 2005 International Conference on Robotics and Automation, Barcelona, Spain, 2005*.
- **Sachin Chitta**, Frederik Heger and Vijay Kumar, “Design, Analysis, Simulation and Experimental Results for a Rollerblading Robot”, in *Proceedings of the 2004 ASME Design Engineering Technical Conference, Salt Lake City, Utah, 2004*.
- **Sachin Chitta**, Frederik Heger and Vijay Kumar, “Design and Gait Control of a Rollerblading Robot”, in *Proceedings of the 2004 IEEE International Conference on Robotics and Automation, New Orleans, 2004*.
- **Sachin Chitta** and Vijay Kumar, “Dynamics and generation of gaits for a planar Rollerblader”, in *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems, Las Vegas, 2003*.
- **Sachin Chitta** and James P. Ostrowski, “Motion Planning for Heterogeneous Modular Mobile Systems”, in *Proceedings of the 2002 IEEE International Conference on Robotics and Automation, Washington D.C., 2002*.
- **Sachin Chitta** and James P. Ostrowski, “New Insights into Quasi-Static and Dynamic Omnidirectional Quadruped Walking”, in *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems, Maui, Hawaii, 2001*.

Software Skills

- **Modeling/Simulation** – extensive experience with MATLAB, Mathematica, Maple.
- **Programming** – C#, C/C++, Aperiods (Real time operating system for SONY robots).
- **CAD** - ProEngineer, AUTOCAD.

Hardware Skills

- Embedded system programming and interfacing using the PIC18 series microcontroller.
- Sensor integration – accelerometers, IR range sensors.
- RoboticsBus – CAN based communications protocol for autonomous systems.

Awards

- Winner of 2nd prize in **Yantriki 97**, the annual robot building competition of the Department of Mechanical Engineering, IIT Bombay. The competition involved building a robot to compete with other robots in plucking and collecting beads from a tree-like structure.
- Awarded 1st prize in 2004 for the article “**3D Modeling in Archaeology**” and 3rd prize in Best Non-Technical Article category by Engineering College Magazines Associated for the article “**There’s a Snake in the Grasp Lab!**”.

Other Information

- Treasurer, Mechanical Engineering Graduate Student Association, 2000-2001.
- Writer for the **Pennsylvania Triangle**, the student publication of the School of Engineering and Applied Sciences at the University of Pennsylvania. 1999- Present.

References

Available on request.