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Personal Statement

My research into human-like robotic walking began in the Fall of 2008 when I started my doctoral studies at Texas A&M University as the first student member of AMBER Lab under Prof. Aaron Ames. In the time since then, I have studied various aspects of human and robotic walking, constantly searching for the next step toward a more complete and unified understanding of dynamic locomotion. I have investigated different pieces of the puzzle, ranging from formal mathematical models representing humanoid robots and walking gaits to experimental implementation on robotic platforms. I see the accelerating development of humanoid robots as a long-term trend which will precipitate a new revolution in robotics, inevitably leading to a society where human–robot interactions are complex and commonplace and prostheses fully reproduce the form and function of their biological counterparts. Contemporary robots already demonstrate impressive efficiency in a wide range of manipulation tasks making them practically useful in myriad industrial applications, but the scarcity and immaturity of results on bipedal walking in particular yet act as a barrier, preventing humanoid robots from manifesting their utility in serving higher-visibility functions. I believe that the key to achieving breakthrough progress toward human–robot collaboration and thus toward many important related aspects of robotics lies in achieving robust and human-like walking and I have thus sought to focus my research accordingly.

Education

Ph.D.	Mechanical Engineering	Texas A&M University	May 2015
M.S.	Mechanical Engineering	Texas A&M University	May 2011
B.S.	Electrical Engineering	California Institute of Technology	Jun. 2007

Awards

IROS 2011 Student Travel Award, IEEE/RSJ International Conference on Intelligent Robots and Systems (2011), to travel and present research results at IROS'11 in San Francisco, CA on Sept. 27, 2011.

Graduate Student Council Travel Award, Texas A&M University (2011), to travel and present research results at the 18th IFAC World Congress in Milan, Italy on Aug. 31, 2011.

Outstanding Student Research, Robots@TAMU 2011, Texas A&M University (2011), for superior achievement in conducting and publishing robotics research.

National Science Foundation Graduate Research Fellowship, Texas A&M University (2010–13), for the study of hybrid systems, bipedal locomotion, and prosthetics.

Summer Undergraduate Research Fellowship, California Institute of Technology (2005), for analysis of data collected by Mars Global Surveyor.

Research Interests

≫ Bipedal locomotion, Human motion, humanoid robotics, prosthetics, biomimetic design

≫ Hybrid systems, Lyapunov stability, Poincaré analysis, energy shaping, Langrangian modeling

≫ Dynamical systems, nonlinear control, quadratic programming, geometric reduction

Professional Societies

≫ Member, American Society of Mechanical Engineers (ASME)

≫ Member, Institute of Electrical and Electronics Engineers (IEEE)

Research Experience

Graduate Student Researcher Texas A&M University. Advisor: Prof. Aaron Ames. Jan. 2014–Dec. 2014

As part of my studies, I have also investigated energy shaping which aims to alter the stability properties of periodic orbits based on an understanding of energy flow. So far this has produced theoretical results applicable to a large range of mechanical systems; numerical simulations have shown that the method, also known in the literature total energy shaping, can improve robustness with respect to perturbations in initial conditions. The initial exposition has been accepted for publication [C9] and additional results have been submitted [J5] and as part of my Ph.D. dissertation [T2].

Graduate Student Researcher NASA Johnson Space Center. PI: Nicolas Radford. Jun. 2013–Jan. 2014

Worked on-site with the Valkyrie humanoid robot as a member of the DARPA Robotics Challenge team at NASA Johnson Space Center. This challenge involved building a humanoid robot and controlling it to achieve a variety of tasks. My work focused on locomotion including control design, implementation, and testing. In addition, I implemented a novel online system identification program which has been submitted as [C8]. I also contributed to system integration, sensor interfacing and filtering as well as operating the robot. This robot was featured in IEEE Spectrum, `http://youtu.be/IE-YBaYjbqY`.

NSF Graduate Research Fellow Texas A&M University. Advisor: Prof. Aaron Ames. Jun. 2010–May 2013

The primary goal of this work was to achieve human-like walking on robots using formal methods in hybrid control systems. This project began with some ideas on how to achieve three-dimensional robotic walking in a manner which decouples the control design problem, using a novel approach to geometric reduction, into sagittal and coronal plane dynamics, facilitating migration to three dimensions for controllers designed on a planar biped. The initial control design for the planar biped combined extant methods with novel local control strategies to achieve multi-phase walking for a biped with feet [C1,C2,C3,T1,J3].

After studying reduction, this project took a new direction as collaborations began with Prof. Ruzena Bajcsy at the University of California at Berkeley which led to a series of motion capture experiments in which human subjects were recorded. These experiments were analyzed for patterns and the results were used obtain human-like walking on a robot in simulation [C4]. After achieving multi-phase walking, the project took a step back to look at applications of the human-inspired framework to simpler models [C6,J2] as well as prosthetics [C5], eventually combining human-inspired control with reduction as a manner of achieving three-dimensional, human-like walking [C6,J1,J4].

The human-inspired control methods have been used to realize walking on various bipedal robots including AMBER 1, AMBER 2, and NAO. Some of the hardware for the AMBER series of robots was provided by National Instruments and the project has involved low-level work to implement field-oriented control on the motors using FPGA/DSP technology along with other common considerations such as interface design and embedded systems programming. These robots have proved instrumental as test beds and have been used to validate some of the above work.

Graduate Student Researcher Texas A&M University. Advisor: Prof. Aaron Ames. Sep. 2008–Jun. 2010

See **NSF Graduate Research Fellow** above.

Summer Undergraduate Research Fellow NASA Jet Propulsion Laboratory. Advisor: Dr. Anton Ivanov. Jun. 2005–Sep. 2005

Working at the NASA Jet Propulsion Laboratory, this project involved creating a database for storing data from the Mars Global Surveyor mission, including data collected using such tools as the Mars Orbital Laser Altimeter (MOLA) and the Mars Orbital Camera (MOC). The key focus of this project was to design a database schema to take advantage of geospatial indexing which allows for a manner of indexing much more practical than simple time stamps. After implementing this, interfaces were created for web queries and with ArcGIS which allowed users to obtain data for specific regions of Mars in a reasonable time frame, achieving a tenfold increase in query speed.

Student Advising

Undergraduate Students (2008) Mentored undergraduate student (Rigoberto Lopez) in original research for the NSF sponsored LSAMP program.

Teaching Experience

Teaching Assistantships *Design of Nonlinear Control Systems* (MEEN 655). Graduate level course, Texas A&M University, Spring 2014. Responsibilities included mentoring students, writing solution sets for homework and exams, and covering lectures when instructor was unavailable. Created and maintained a course wiki for students to share materials and experimented with online office hours using group video chat. Course description: "To enable students to design controllers for nonlinear and uncertain systems; and apply their designs to mechanical systems."

Guest Lectures *Engineering Dynamics* (MEEN 613). Graduate level course, Texas A&M University, Fall 2012. Course description: "Three dimensional study of dynamics of particles and rigid bodies and application to engineering problems; introduction to Lagrange equations of motion and Hamilton's principle."

Design of Nonlinear Control Systems (MEEN 655). Graduate level course, Texas A&M University, Spring 2011. Course description: "To enable students to design controllers for nonlinear and uncertain systems; and apply their designs to mechanical systems."

Professional Experience

Conference Reviewer
- ≫ American Control Conference
- ≫ IEEE Conference on Decision and Control
- ≫ IEEE International Conference on Robotics and Automation
- ≫ IEEE–RAS International Conference on Humanoid Robots
- ≫ IEEE/RSJ International Conference on Intelligent Robots and Systems
- ≫ International Conference on Hybrid Systems: Computation and Control
- ≫ IFAC World Congress

Journal Reviewer
- ≫ IEEE/ASME Transactions on Mechatronics
- ≫ IEEE Transactions on Robotics
- ≫ IEEE Transactions on Automatic Control
- ≫ IFMBE Medical and Biomedical Engineering and Computing
- ≫ Robotica

Presentations

Presentations

[P1] R. W. Sinnet, "Realizing Human-Like Locomotion on Bipedal Robots and Prostheses," *Dual Conference in Innovation'14 and Automation'14*, Gilruth Center, NASA–JSC, Houston, TX, keynote presentation.

Publications

Theses

[T2] R. W. Sinnet, "Energy Shaping of Mechanical Systems via Control Lyapunov Functions with Applications to Bipedal Locomotion," Ph.D. dissertation, Texas A&M University, May 2015.

[T1] R. W. Sinnet, "Hybrid Geometric Feedback Control of Three-Dimensional Bipedal Robotic Walkers with Knees and Feet," Master's thesis, Texas A&M University, May 2011.

Journal Papers

[J5] R. W. Sinnet and A. D. Ames, "A Lyapunov approach to energy shaping in non-conservative hybrid systems," submitted to *Automatica*.

[J4] M. J. Powell, R. W. Sinnet, and A. D. Ames, "3D Human-Inspired Robotic Walking: Optimization, Speed Regulation and Implementation," submitted to *IEEE Transactions on Robotics*.

[J3] J. W. Grizzle, C. Chevallereau, R. W. Sinnet, and A. D. Ames, "Models, feedback control, and open problems of 3D bipedal robotic walking," survey article in *Automatica*, Vol. 50, No. 8, pp. 1955–88, 2014.

[J2] R. W. Sinnet, S. Jiang, and A. D. Ames, "A human-inspired framework for bipedal robotic walking design," in *International Journal of Biomechatronics and Biomedical Robotics*, Vol. 3, No. 1, pp. 20–41, 2014.

[J1] R. W. Sinnet and A. D. Ames, "Bio-Inspired Feedback Control of Three-Dimensional Humanlike Bipedal Robots," in *Journal of Robotics and Mechatronics*, Special Issue on Focused areas and future trends in bio-inspired robots, Vol. 24, No. 4, pp. 595–601, 2012.

Book Chapters

[B1] A. D. Ames, R. W. Sinnet, and E. D. B. Wendel, "Three-Dimensional Kneed Bipedal Walking: A Hybrid Geometric approach," in *12th ACM International Conference on Hybrid Systems: Computation and Control (HSCC 2011)*, pp. 16–30, San Francisco, CA, Apr. 2009.

Conference Papers

[C9] R. W. Sinnet and A. D. Ames, "Energy Shaping of Hybrid Systems via Control Lyapunov Functions," accepted for presentation at *2015 American Control Conference (ACC 2015)*.

[C8] S. Kolathaya, B. J. Morris, R. W. Sinnet, and A. D. Ames, "System Identification and Control through Efficient SVA–Based Regressor Computation," submitted to *2015 International Conference on Robotics and Automation (ICRA 2015)*.

[C7] R. W. Sinnet and A. D. Ames, "Extending Two-Dimensional Human-Inspired Bipedal Robotic Walking to Three Dimensions through Geometric Reduction," in *2012 American Control Conference (ACC 2012)*, pp. 4831–6, Montreal, Canada, Jun. 2012.

[C6] R. W. Sinnet, M. J. Powell, S. Jiang, and A. D. Ames, "Compass Gait Revisited: A Human Data Perspective with Extensions to Three Dimensions," in *50th IEEE Conference on Decision and Control (CDC 2011)*, pp. 682–9, Orlando, FL, Dec. 2011.

[C5] R. W. Sinnet, H. Zhao, and A. D. Ames, "Simulating Prosthetic Devices with Human-Inspired Hybrid Control," in *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2011)*, pp. 1723–30, San Francisco, CA, Sep. 2011.

[C4] R. W. Sinnet, M. J. Powell, R. P. Shah, and A. D. Ames, "A Human-Inspired Hybrid Control Approach to Bipedal Robotic Walking," in *18th IFAC World Congress (IFAC 2011)*, pp. 6904–11, Milan, Italy, Aug. 2011.

[C3] J. W. Grizzle, C. Chevallereau, A. D. Ames, and R. W. Sinnet, " 3D Bipedal Robotic Walking: Models, Feedback Control, and Open Problems," plenary paper in *8th IFAC Symposium on Nonlinear Control Systems (NOLCOS 2010)*, pp. 505–32, Bologna, Italy, Sep. 2010.

[C2] R. W. Sinnet and A. D. Ames, "3D Bipedal Walking with Knees and Feet: A Hybrid Geometric Approach," in *Joint 48th IEEE Conference on Decision and Control and 28th Chinese Control Conference (CDC/CCC 2009)*, pp. 3208–13, Shanghai, China, Dec. 2009.

[C1] R. W. Sinnet and A. D. Ames, "2D Bipedal Walking with Knees and Feet: A Hybrid Control Approach," in *Joint 48th IEEE Conference on Decision and Control and 28th Chinese Control Conference (CDC/CCC 2009)*, pp. 3200-7, Shanghai, China, Dec. 2009.

Posters

[P2] R. W. Sinnet, M. J. Powell, S. Jiang, H. Zhao, R. P. Shah, and A. D. Ames, "Closing the Loop on Bipedal Walking: Modeling Humans and Robots as Hybrid Systems," in *Robots@TAMU 2011*, Texas A&M University, College Station, TX, Apr. 2011.

[P1] R. W. Sinnet and A. D. Ames, "A Hybrid Approach to Three-Dimensional Bipedal Robotic Walking," in *Dynamic Walking 2010*, Massachusetts Institute of Technology, Cambridge, MA, Jun. 2010.