

Jerry E. Pratt

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Institute for Human and Machine Cognition
40 South Alcaniz Street
Pensacola, FL 32502

Professional Interest:

To understand, produce, and control systems that exhibit interesting dynamical interactions, including various electro-mechanical devices, legged robots, and biological systems. Specific areas of research interests include:

- Bipedal and Quadrupedal Walking and Running Robots
- Bipedal Walking: Modeling, Simulation, Control
- Powered Prosthetics, Exoskeletons
- Advanced Control Systems
- Artificial Life, Natural Computation

Education

- Massachusetts Institute of Technology
 - Ph.D. Electrical Engineering and Computer Science. 2000
 - M.Eng. Electrical Engineering and Computer Science 1995
 - B.S. Mechanical Engineering 1994
 - B.S. Electrical Engineering and Computer Science 1994

Experience

- Research Scientist. (April 2002 – Present). Institute for Human and Machine Cognition. Researching bipedal walking and running control, robotics, and exoskeletons. Leading a team of approximately 20 people engaged in projects on humanoid robot design and control, running robots, advanced human-machine interfaces, and exoskeletons.
- President and CEO, Yobotics, Inc. (January 2000 – April 2002.). Co-founder of robotics startup company specializing in powered prosthetics, biomimetic robots, muscle-like actuators, simulation software, and robotic consulting. Generated over \$500,000 in revenue.
- Research Assistant (June 1994 – June 2000), Prof. Gill Pratt, Department of Electrical Engineering and Computer Science, M.I.T. Designed, constructed, and controlled various bipedal walking robots. Developed advanced control techniques for robotic systems.
- Undergraduate Research Assistant (May 1993 – June 1994), Prof. Chris Atkeson, Department of Brain and Cognitive Science, M.I.T. Designed and built vision and support systems for autonomous helicopter research.
- Mechanical Engineer (June 1992 – August 1992), Timken Research, Canton OH. Designed and built a system for detecting the initiation and propagation of spalls on rolling contact fatigue steel samples.
- Undergraduate Research Assistant (May 1991 – January 1992), Prof. David Tennenhouse, Department of Electrical Engineering and Computer Science, M.I.T. Designed, built, and tested interfaces for connecting DEC 5000 and SUN Workstations to a high-speed network switch concurrently under design.

Funded Research Grant Proposals

- PI: “FastRunner: High Speed, Efficient, Dynamically Stable Bipedal Robot”, DARPA Maximum Manipulation and Mobility, 2011-.
- PI on Subcontract for Atlas Robot. Boston Dynamics lead, DARPA Maximum Manipulation and Mobility, 2011-.
- PI: Robonaut Walking Algorithm Development, NASA Johnson Space Center, 2010-
- PI: “Humanoid Disturbance Recovery while Walking with Limited Available Footholds”, DARPA Information Processing Technology Office, 2009-2010.
- Co-PI: “Effective Learning Through State and Action Transformations Based on the Fundamentals of Quadrupedal Locomotion”, DARPA Learning Locomotion Program, 2005-2009.
- Co-PI: “Robots for Transportation Security”, ONR, 2005
- Co-author: “Quadrupedal Robot that can Walk, Trot, Gallop, and Jump”, ARMY/TARDEC SBIR, Phase I and II. 2003-2004.
- PI: “Naval Automation and Information Management Technology”, ONR, 2002-2004.
- Contributing author: “Visually Guided Running and Scrambling Robots for Tactical Urban Environments”, DARPA/TTO BAA 98-08, 1998-2000.

Selected Projects

1. M2V2 Humanoid Robot. (2006-Present). Developing a 12 degree of freedom lower body humanoid robot. Developing control algorithms for walking and push recovery. Key algorithm designer and Principal Investigator.
2. FastRunner: High Speed, Efficient, Dynamically Stable Bipedal Robot. (2011-Present) Principal Investigator.
3. LittleDog. (2005-2009). Walking algorithms for rough terrain. Key algorithm designer and Principal Investigator.
4. Power-autonomous Legged robot for Urban Terrain Operations (PLUTO). (2003-2006). Developed control algorithms for gas powered monopedal and quadrupedal robots.
5. Performance Improving Self-Contained Exoskeleton for Swimming (PISCES). (2003-2005). Principal Investigator.
6. RoboWalker (2001-2002). Co-designed, and developed control algorithms for a powered lower body orthotic device that enhances one’s strength and endurance during walking.
7. Agile Robot Arm. (2000-2001). Electronics and Software engineer for a seven degree of freedom force-controllable robot arm.
8. Yobotics! Simulation Construction Set. (2000-2002): Project Manager and chief engineer on the development of a software package for simulating robots.
9. M2 (1998-2000): Co-designed, simulated, and performed control studies for a 3D, seven link, twelve degree of freedom bipedal walking robot.
10. Spring Flamingo (1996-2000): Designed, constructed, and controlled a seven link, six degree of freedom planar bipedal walking robot that can walk quickly (1.2 m/s) and can walk over rolling terrain. Demonstrated the benefits of exploiting natural dynamics in the control of bipedal robots.

11. Spring Turkey (1994-1996): Masters Thesis Project. Co-designed and controlled a five link, four degree of freedom planar bipedal walking robot. Developed a motion control tool called Virtual Model Control that helps simplify the control of walking robots.
12. Reinforcement Learning (1999): Area Exam. “Elephants Don’t Play Backgammon, Either”. Demonstrated that Reinforcement Learning is equivalent to brute force search of Traditional AI plus stochastic dynamics. Implemented various Reinforcement Learning algorithms on a Pong Game.
13. Artificial Life Simulations (1998): Implemented various simulations of Diffusion Limited Aggregation, Cell Differentiation, and an Artificial Ecosystem.
14. Genetic Algorithms and Central Pattern Generators (1997): Implemented a Genetic Algorithm for tuning the parameters of a Central Pattern Generator that controlled a simulated multi-link “Recti-Blob” robot. Integrated the Genetic Algorithm code into the Leg Lab’s Creature Library dynamic simulation package.
15. Video Production and Editing (1994-2002): Scripted, produced, and edited various Lab and company distribution videos.
16. Web Pages (1994-2002): Designed, constructed and maintain the M.I.T Leg Laboratory web page: www.ai.mit.edu/projects/leglab/, and Yobotics web page: www.yobotics.com/
17. Whizzy Vision (1994): Undergrad Thesis Project. Designed and built a general-purpose robotic control and vision system which included a color blob tracker and frame grabber. Could track a model helicopter at 30Hz with a precision of 1cm over 10 meters.
18. Knock Out Keyless Door Lock (1990): Invented, designed, and built a keyless door lock that recognizes a programmable sequence of knocks. Won Grand prize in the 1990 Design a Duracell Device Scholarship Competition.

Skills

- Control Theory: Robust, Adaptive, Multi-Variable, Non-Linear, Linear, Signal Processing, Neural Networks.
- Project Management, Proposal Writing.
- Reinforcement Learning, Artificial Intelligence, Genetic Algorithms, Neural Oscillators.
- Machine Design: SolidWorks, ProEngineer.
- Programming: Java, C, LISP, Assembly, Matlab, Maple, Latex, HTML.
- Circuit Design and Layout: SPICE, OrCAD.
- Project Planning, Budgeting, Scheduling, and Documentation.
- Writing, Teaching, Communicating to the Public.
- Machining, Woodworking, Quick Prototyping.
- Video Production, Digital and Analog.

Teaching Experience

- University of West Florida, Course “Bipedal Walking Robots”
- M.I.T. Course 6.894, “Legged Locomotion in Robots and Animals”
 - Lecturer: Fall 1999
 - Lecturer: Spring 1996

Students Supervised or Member of PhD Committee

- Tomas De Boer, Delft University, PhD Committee, 2012.
- Twan Koolen, Delft University, 2009-2010.

- John Carff, University of West Florida, 2003-2005.
- Chris Eagle, University of West Florida, 2004.
- Jim Warrenfeltz, summer internship, 2002, “Genetic Algorithm Development for Tuning Legged Robots”
- Ann Torres, B.S. Mech. Eng. 1996, “Virtual Model Control of a Hexapod Walking Robot”
- Mike Wittig, B.S. Mech Eng. 1996, “The Design and Construction of a Modular Force Control Actuator”

Selected Publications

- Twan Koolen, Tomas De Boer, John Rebula, Ambarish Goswami, and Jerry E. Pratt, Capturability-Based Analysis and Control of Legged Locomotion. Part 1: Theory and Application to Three Simple Gait Models, to appear in *International Journal of Robotics Research*, 2012.
- Jerry Pratt, Twan Koolen, Tomas De Boer, John Rebula, Sebastien Cotton, John Carff, Matthew Johnson, and Peter Neuhaus, Capturability-Based Analysis and Control of Legged Locomotion, Part 2: Application to M2V2, a Lower-Body Humanoid, to appear in *International Journal of Robotics Research*, 2012.
- Sebastien Cotton, Ionut Olaru, Matthew Bellman, Tim van der Ven, Johnny Godowski, and Jerry Pratt, FastRunner: A Fast, Efficient and Robust Bipedal Robot, Concept and Planar Simulation, to appear in *Proceedings of the 2012 IEEE International Conference on Robotics and Automation (ICRA 2012)*, St. Paul, Minnesota.
- Peter D. Neuhaus, Jerryll H. Noorden, Travis J. Craig, Tecalote Torres, Justin Kirschbaum, Jerry E. Pratt, Design and Evaluation of Mina a Robotic Orthosis for Paraplegics, *Proceedings of the 2011 International Conference on Rehabilitation Robotics (ICORR 2011)*, Zurich, Switzerland.
- Peter D. Neuhaus, Jerry E. Pratt, and Matthew J. Johnson, Comprehensive summary of the Institute for Human and Machine Cognition's experience with LittleDog, *The International Journal Of Robotics Research*, vol. 30, no. 2, pp. 216-235, February 2011.
- Jerry E. Pratt, Peter Neuhaus, Matthew Johnson, John Carff, Ben Krupp, Towards Humanoid Robots for Operations in Complex Urban Environments, *Proceedings of the 2010 SPIE*.
- John Carff, Matthew Johnson, Eman M. El-Sheikh, and Jerry E. Pratt, 2009, Human-Robot Team Navigation in Visually Complex Environments, *Proceedings of the 2009 IEEE International Conference on Intelligent Robots and Systems (IROS '09)*, St. Louis, MO.
- Hian Kai Kwa, Jerryll H. Noorden, Matthew Missel, Travis Craig, Jerry E. Pratt, Peter D. Neuhaus, Development of the IHMC Mobility Assist Exoskeleton, *Proceedings of the 2009 IEEE International Conference on Robotics and Automation, (ICRA '09)*, Kobe, Japan.
- Jerry Pratt, Ben Krupp, Design of a bipedal walking robot, *Proceedings of the 2008 SPIE*, Volume 6962, 69621F
- John Rebula, Fabian Canas, Jerry Pratt, Ambarish Goswami, Learning Capture Points for Humanoid Push Recovery, *Proceedings of the 2007 IEEE-RAS International Conference on Humanoid Robots*, November 29-December 1, 2006, Pittsburgh, Pennsylvania.

- John Rebula, Peter Neuhaus, Brian Bonnländer, Matthew Johnson, Jerry Pratt, A Controller for the LittleDog Quadruped Walking on Rough Terrain, *Proceedings of the 2007 IEEE International Conference on Robotics and Automation, (ICRA '07)*, Rome, Italy, pp. 1467-1473.
- Jerry Pratt, Sergey Drakunov, 2007. Derivation and Application of a Conserved Orbital Energy for the Inverted Pendulum Bipedal Walking Model. *Proceedings of the 2007 IEEE International Conference on Robotics and Automation (ICRA '07)*, Rome, Italy, pp. 4653-4660. (Please note that there is a typo. The $x_{\dot{0}}$ in the RHS of Equations 48 and 51 should be squared. Thanks to Martin Andrews for pointing out this error.)
- Jerry Pratt, John Carff, Sergey Drakunov, and Ambarish Goswami, 2006. Capture Point: A Step toward Humanoid Push Recovery. *Proceedings of the 2006 IEEE-RAS International Conference on Humanoid Robots*, December 4-6, 2006, Genoa, Italy, pp. 200-207.
- Jerry E. Pratt and Russ Tedrake, 2006. Velocity Based Stability Margins for Fast Bipedal Walking, Presented at the First Ruperto Carola Symposium in the International Science Forum of the University of Heidelberg entitled "Fast Motions in Biomechanics and Robots", September 7-9, 2005, Heidelberg Germany.
- Benjamin T. Krupp, Jerry E. Pratt, A power autonomous monopedal robot, *Proceedings of the 2006 SPIE*, Volume 6201, 620112
- Fredrik Rehnmark, Robert O. Ambrose, S. Michael Goza, Lucien Junkin, Peter D. Neuhaus, Jerry E. Pratt, *Centaur: a mobile dexterous humanoid for surface operations*, SPIE Defense and Security Symposium, Orlando, FL, March 28 – April 1, 2005.
- Jerry E. Pratt, Benjamin T. Krupp, Christopher J. Morse, and Steven H. Collins, 2004. *The RoboKnee: An Exoskeleton for Enhancing Strength and Endurance During Walking*. Proceedings of the 2004 IEEE International Conference on Robotics and Automation (ICRA '04), New Orleans, LA, 2430-2435.
- Peter D. Neuhaus, Michael O'Sullivan, David Eaton, John Carff, and Jerry E. Pratt, 2004. *Concept Designs for Underwater Swimming Exoskeletons*. Proceedings of the 2004 IEEE International Conference on Robotics and Automation (ICRA '04), New Orleans, LA, 4893-4898.
- D. J. Paluska and J. E. Pratt, 2003. Bipedal Walking Robots in *Biomimetic Robotics*, Brezeal, C. and Yoseph Bar-Cohen, Ed., SPIE Press, 228-252.
- Jerry Pratt, Ben Krupp, and Chris Morse, 2002. Series elastic actuators for high fidelity force control. *Industrial Robot Journal*, Vol. 29, No. 3, pp. 234-241
- Jerry Pratt. 2002. Bipedal Walking Robots: Advancing the Science through Killer Applications, Replication and Validation, Standards and Common Platforms, and Competition. Proceedings of the 2002 FIRA Robot World Congress, Seoul, Korea, May 26-29, 2002. pp. 111-114.
- Jerry E. Pratt, Chee-Meng Chew, Ann Torres, Peter Dilworth, Gill Pratt, 2001. *An Intuitive Approach for Bipedal Locomotion*. International Journal of Robotics Research, 20:(2), 129-143.
- Jerry E. Pratt, 2000. Exploiting Inherent Robustness and Natural Dynamics in the Control of Bipedal Walking Robots. PhD. Thesis, MIT Computer Science. June 2000.
- Chee-Meng Chew, Jerry E. Pratt, Gill A. Pratt. 1999. *Blind Walking of a Planar Bipedal Robot on Sloped Terrain*. Proceedings of IEEE International Conference on Robotics and Automation (ICRA '99), Detroit, Michigan.

- Jerry E. Pratt, Gill A. Pratt. 1999. *Exploiting Natural Dynamics in the Control of a 3D Bipedal Walking Simulation*. Proceedings of the International Conference on Climbing and Walking Robots (CLAWAR99), Portsmouth, UK, September 1999
- David W. Robinson, Jerry E. Pratt, Daniel J. Paluska, Gill A. Pratt. 1999. *Series Elastic Actuator Development for a Biomimetic Walking Robot*. IEEE/ASME International Conference on Advanced Intelligent Mechatronics, Sept. 19-22, 1999. Atlanta, GA.
- Jerry E. Pratt, Gill A. Pratt. 1998. *Intuitive Control of a Planar Bipedal Walking Robot*. Proceedings of the IEEE International Conference on Robotics and Automation (ICRA '98), Leuven, Belgium 1998.
- Jerry E. Pratt, Peter C. Dilworth, Gill A. Pratt. 1997. *Virtual Model Control of a Bipedal Walking Robot*. Proceedings of the IEEE International Conference on Robotics and Automations (ICRA '97), Albuquerque, NM. 1997.
- Jerry E. Pratt, Ann L. Torres, Peter C. Dilworth, Gill A. Pratt. 1996. *Virtual Actuator Control*. Proceedings of the IEEE International Conference on Intelligent Robots and Systems (IROS '96), Osaka, Japan.
- Gill A. Pratt, Matt M. Williamson, Peter C. Dilworth, Jerry E. Pratt, Karsten Ulland, Anne Wright 1995. *Stiffness Isn't Everything*. Proceedings of ISER '95, Stanford CA.

Invited Talks and Workshops, Program Committees

- General Organizer, Dynamic Walking Conference 2012, to be at IHMC in May 2012.
- Jerry Pratt, 2012, *Capturability-Based Analysis and Control of Bipedal Walking and Balance*, First UAE Conference on Rehabilitation, Khalifa University, March, 2012.
- Program Committee, 3rd International Symposium on Adaptive Motion in Animals and Machines (AMAM 2005).
- Workshop: "Introducing the HUROSOT Simulation League Competition". 2002 FIRA Robot World Congress. Seoul, Korea, May 2002.
- Jerry Pratt, 2002, *Bipedal Walking Robots: Advancing the Science through Killer Applications, Replication and Validation, Standards and Common Platforms, and Competitions*, Proceedings of the 2002 FIRA Robot World Congress, pp. 111-114. Seoul, Korea, May 2002.
- Jerry E. Pratt, Gill A. Pratt. 1998. *Exploiting Natural Dynamics in the Control of a Planar Bipedal Walking Robot*. Proceedings of the Thirty-Sixth Annual Allerton Conference on Communication, Control, and Computing, Monticello, IL, September 1998.
- International Advisory Committee: International Conference on Climbing and Walking Robots (CLAWAR 99).

Journal and Grant Reviews

- Swiss National Science Foundation.
- National Institute for Disability and Rehabilitation Research (NIDRR), Dept. of Education.
- International Journal of Robotics Research.
- IEEE Transaction on Robotics and Automation.
- IEEE International Conference on Robotics and Automation.
- IEEE/ASME Transactions on Mechatronics.

- IEEE Transactions on Control Systems Technology.

Community Service

- Cofounding the “Pensacola Mess Hall”, a place for curious minds to mess about with Math, Engineering, Science, and Stuff. Pilot museum scheduled to open summer of 2012.
- Assisting in the development and execution of the IHMC “Science Saturday’s” informal science education program.
- Scientific American Frontiers “Ask The Scientists”
- Reply to dozens of emails per year from grade school and high school students who inquire about robots and engineering.

Patents

- US7949430B2: Determination of Foot Placement for Humanoid Push Recovery.
- US7798264B2: Reconfigurable Balancing Robot and Method for Dynamically Transitioning Between Statically Stable Mode and Dynamically Balanced Mode.
- US7090200B2: Actuator.