

Huihua Zhao | Curriculum Vitae

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Research Expertise

• Nonlinear optimization • Trajectory planning and path following for racing autonomous motorcycle • Model Predictive Control • Dynamical modeling and analysis of bipedal/humanoid robotic systems • Nonlinear control design of bipedal/humanoid/prosthetic robots • Embedded system software development using MATLAB, C++ and ROS • Rich robotic system integration and hands-on implementation experiences (sensing, motion control, PCB design and mechatronic system design) with more than 10 robots

Education

Ph.D. in Mechanical Engineering (Robotics)	Georgia Institute of Technology (GaTech), USA	2016.09
M.S. in Mechanical Engineering (Robotics)	Texas A & M University (TAMU), USA	2015.03
B.S. in Mechanical Engineering (Automation)	Univ. of Sci. & Tech. of China (USTC), China	2010.07

Research Experience

Planning through Contact in Dexterous Manipulation (TRI).....

Senior Research Scientist: *motion planning, reinforcement learning, perception* 2020.05–present

- Injecting model based heuristics into machine learning to achieve robust and dynamics dexterous hand manipulation.

Sim2Real of a Home-Service Robot (TRI).....

Senior Research Scientist: *modeling and simulation of dynamics and sensors, geometry rendering* 2019.05–2020.05

- Developed a fully functional simulation environment for the TRI home service robot, including dynamics simulation, sensor (force, vision) simulation and camera rendering;

Motion Planning and Control Research on Fully Autonomous Vehicle (TRI).....

Research Scientist: *model predictive control, trajectory optimization, reachability analysis* 2018.04–present

- Led the trajectory optimization team for fully autonomous driving research at Toyota Research Institute;
- Liaison of the reachability research with the Stanford University;
- Realized a Model Predictive Control for path tracking. It is currently running on the testing fleet on public road.

Autonomous Racing Motorcycle (SRI|Robotics).....

Project Leader: *algorithm development (path following control), trajectory optimization* 2016.12–2018.04

- Led the control group (two software engineers and one robotics engineer) of the Motobot project for high performance autonomous racing motorcycle;
- Implemented a nonlinear controller and realized stable multi-contact humanoid walking on the ground.

3D Humanoid Bipedal Locomotion with Durus (SRI|Robotics).....

Project Leader: *algorithm design, software development, 3D modeling and simulation.* 2016.9–2016.12

- Led the group with achieving stable dynamic walking on a humanoid robot DURUS;
- Implemented nonlinear controller and realized stable multi-contact humanoid walking on the ground.

3D Compliant Low-Limb Prosthesis Modeling and Control for AMPRO3.....

Project Leader: *complaint lower-limb prosthesis modeling, serial elastic actuator modeling and control, PCB board design, CANOpen communication, embedded system developing* 2015.6–2016.9

- Co-designed the 3D transfemoral prosthetic device: AMPRO3 coupled with series elastic actuators (SEA) and complaint parts;
- Modeled the compliant 3D prosthetic locomotion for control design and gait generation using Matlab and Mathematica;
- Developed embedded control system in Beagle Bone Board for the 3D prosthesis using C++ and ROS;
- Implemented nonlinear controllers in real-time on the prosthetic device AMPRO3 experimentally.

Robotic Inspired Prosthetic Device Design and Control for AMPRO1&2.....

Project Leader: *prostheses design and modeling, nonlinear optimization, control Lyapunov function, quadratic program, Machine Learning, embedded system developing* 2013.6–2015.6

- Co-designed and built the 2D transfemoral prosthetic device: AMPRO1 and AMPRO2 using SolidWorks and Eagle;
- Designed nonlinear prosthetic controllers in simulation using Matlab;
- Achieved stable walking and stair climbing on prostheses AMPRO1 & 2 with both an unimpaired subject and an amputee;
- Realized natural and smooth prosthetic motion transitions using Machine Learning.

Endurance Competition with DURUS at DARPA Robot Challenge Finals 2015.....

Simulation Expert: 3D humanoid robot modeling, nonlinear optimization 2015.6.5–2015.6.6

- Realized energy efficient, human-like multi-contact gaits on the humanoid robot DURUS;
- Contributed to the SRI-AMBER team in winning the endurance test at the DRC final.

Human-Inspired Multi-Contact Locomotion with AMBER2.....

Project Leader: dynamical system modeling, nonlinear control design and hardware implementation 2013.5–2014.2

- Designed the controller to achieve multi-contact feature of human locomotion on bipedal walking robot;
- Proposed a theory to prove the stability of the generated multi-contact controller;
- Realized the multi-contact walking on the physical bipedal robot AMBER2 experimentally using LabView and C++.

Motion Primitives Studies from Human Locomotion Experiments.....

Project Leader: data processing, bipedal modeling, nonlinear optimization and control design 2011.8–2013.5

- Implemented and automated a novel algorithm to process camera-captured human locomotion data with improved efficiency;
- Achieved formally stable (with theoretical proofs) human-like robotic locomotion for various motion types: standing, walking, stair ascending, descending and running;
- Realized motion-transitions between various motion types using novel optimization problems.

Teaching Experience

Guest Lecturer for Robotics 6407 (GaTech) 2016.1-2016.5

- Coordinated and delivered graduate lectures with professor
- Set and evaluated homeworks and exams

CETL's Faculty Development Workshop (GaTech) 2015.11-2015.11

- Participated discussion forums with faculty colleagues to learn teaching skills
- Understood teaching challenges and learned practical teaching techniques

Academia Tutor for Calculus 101 & 102 (TAMU) 2011.1-2015.5

- Prepared and delivered Q&A sessions
- Tutored students with homeworks one-to-one

Teaching Assistant for MEEN 363 & 364 (TAMU) 2010.9-2011.5

- Prepared and delivered undergraduate lectures and tutorials
- Graded and evaluated homeworks, design projects and exams

Honor and Award

Best Medical Robotics Paper Award Finalist of ICRA 2017

Best Paper Award Finalist of ACC 2017

Graduate Conference Fund Award 2015

Best Paper Award Finalist of ICCPS 2014 2014

Graduate Student Scholarship of TAMU 2010

Outstanding Graduate of USTC 2010

Outstanding Student Scholarship of USTC 2007-2009

Professional Experience

Journal Reviewer: Mechatronics, Journal of Intelligent and Robotic System, Journal of Control, Automation and Systems, IEEE Transactions on Robotics, IEEE Transactions on Mechatronics

Conference Reviewer: ACC, ICRA, IROS, HSCC, CDC, MMAR, MSC, CCTA

Conference Presentations: ACC, ICRA, IROS, CDC, ICCPS, ICORR, DSC

Conference Live-Demonstrations: 5th Anniversary Robotics Caucus Meeting of NRI, DC 2016; Dynamic walking on Durus at the DRC Finals 2015; Demo on DSC Conference 2014; Demo on National Instrument Week 2011

Publications

Thesis

Huihua Zhao. "From Bipedal Locomotion to Prosthetic Walking: A Hybrid System and Nonlinear Control Approach". Ph.D. dissertation, Georgia Institute of Technology, 2016

Huihua Zhao. "Human-Inspired Motion Primitives and Transitions for Bipedal Robotic Locomotion in Diverse Terrain". Master thesis, Texas A& M University, 2015

Journal Papers

- A.Hsu, **H. Zhao**, M. Gaudreault, A. W. Foy, R. Pelrine, "Magnetic Milli-Robot Swarm Platform: A Safety Barrier Certificate Enabled, Low-Cost Test Bed", IEEE Robotics and Automation Letters, 5(2) 2913-2920, 2020
- V. Azimi, T. Shu, **H. Zhao**, A. D. Ames and D. Simon. "Model-Based Adaptive Control of Transfemoral Prostheses: Theory, Simulation, and Experiments". IEEE Transaction on Systems, Man, and Cybernetics: Systems, 1-18, 2019
- H. Zhao**, A. Hereid, W. Ma, and A. D. Ames. "Multi-contact bipedal robotic locomotion". Robotica, 1-35, 2017
- H. Zhao**, J. Horn, J. Reher, V. Paredes, and A. D. Ames. "First steps toward translating robotic walking to prostheses: a nonlinear optimization based control approach". Autonomous: Special Issue on Assistive and Rehabilitation Robotics, 1-18, 2016
- H. Zhao**, J. Horn, J. Reher, V. Paredes, and A. D. Ames. "Multi-contact locomotion on transfemoral prostheses via hybrid system models and optimization-based control". Automation Science and Engineering, IEEE Transactions on, 502-513, 2016
- H. Zhao**, M. Powell, and A. D. Ames. "Human-inspired motion primitives and transitions for bipedal robotic locomotion in diverse terrain". Optimal Control Applications and Methods, 35:730–755, 2013

Conference Papers

- H. Zhao**, E. Ambrose and A. D. Ames "Preliminary Results on Energy Efficient 3D Prosthetic Walking with a Powered Compliant Transfemoral Prosthesis". In Robotics and Automation, IEEE International Conference on, 2017. **Best Medical Robotics Paper Finalist of ICRA**
- V. Azimi, T. Shu, **H. Zhao**, E. Ambrose, A. D. Ames and D. Simon. "Robust Control of a Powered Transfemoral Prosthesis Device with Experimental Verification". In American Control Conference, 2017. **Best Paper Award Finalist of ACC**
- H. Zhao**, A. Hereid, E. Ambrose and A. Ames "3D Multi-Contact Gait Design for Prostheses: Hybrid System Models, Virtual Constraints and Two-Step Direct Collocation". In Intelligent Robots and Systems, IEEE International Conference on, 2016
- H. Zhao**, J. Horn, J. Reher, V. Paredes, and A. D. Ames. "A hybrid systems and optimization-based control approach to realizing multi-contact locomotion on transfemoral prostheses". In Decision and Control (CDC), IEEE International Conference on, 2015
- H. Zhao**, J. Reher, J. Horn, V. Paredes, and A. D. Ames. "Realization of stair ascent and motion transitions on prostheses utilizing optimization-based control and intent recognition". In Rehabilitation Robotics (ICORR), IEEE International Conference on, 2015
- H. Zhao**, J. Reher, J. Horn, V. Paredes, and A. D. Ames. "Realization of nonlinear real-time optimization based controllers on self-contained transfemoral prosthesis". In Cyber Physics System, International Conference on, 2015
- H. Zhao** and A. D Ames. "Quadratic program based control of fully-actuated transfemoral prosthesis for flat-ground and up-slope locomotion". In IEEE, American Control Conference, 2014. **Best Session Paper Award of ACC**
- H. Zhao**, S. Kolathaya, and A. D. Ames. "Quadratic programming and impedance control for transfemoral prosthesis". In Robotics and Automation, International Conference on, 2014
- H. Zhao**, W. Ma, M. B. Zeagler, and A. D. Ames. "Human-inspired multi-contact locomotion with amber2". In Cyber Physics System, ACM/IEEE, International Conference on, 2014. **Best Paper Award Finalist of ICCPS**
- Wen-Loong Ma, **H. Zhao**, Shishir Kolathaya, and A. D. Ames. "Human-inspired walking via unified pd and impedance control". In International Conference on Robotic and Automation. IEEE, 2014
- N. Aghasadeghi, **H. Zhao**, L. J. Hargrove, A. D. Ames, E. J. Perreault, and T. Bretl. "Learning impedance controller parameters for lower-limb prostheses". In Intelligent Robots and Systems, IEEE, 2013
- H. Zhao**, S. Kolathaya, and A. D. Ames. "Bipedal robotic running with partial hybrid zero dynamics and human-inspired optimization". In Intelligent Robots and Systems, International Conference on, 2012
- Matthew J Powell, **H. Zhao**, and A. D Ames. "Motion primitives for human-inspired bipedal robotic locomotion: walking and stair climbing". In Robotics and Automation, IEEE International Conference on, 2012
- S. Jiang, S. Partrick, **H. Zhao**, and A. D. Ames. "Outputs of human walking for bipedal robotic controller design". In IEEE, 2012 American Control Conference, 2012
- R. W. Sinnet, **H. Zhao**, and A. D. Ames. "Simulating prosthetic devices with human- inspired hybrid control". In Intelligent Robots and Systems, International Conference on. IEEE, 2011