Huihua Zhao | Curriculum Vitae

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Research Interests

• Dynamical modeling of robotic systems • Nonlinear control design of hybrid systems • Optimal trajectory design with nonlinear optimization problems • Direct collocation optimization for robotic trajectory design • Prosthetic system design, modeling and control • Embedded system developing • Hardware implementation of bipedal robots and prosthetic devices.

Education

Ph.D. in Mechanical Engineering	Georgia Institute of Technology - Atlanta, USA	GPA[3.6/4.0], 2016.08
M.S. in Mechanical Engineering	Texas A & M University - College Station, USA	GPA[4.0/4.0], 2015.05
B.S. in Mechanical Engineering	University of Science&Technology of China, China	GPA[3.5/4.0], 2010.07

Awards

Graduate Conference Fund Award	**2015**
Best Paper Award Finalist of ICCPS 2014	**2014**
Best Session Paper Award of ACC 2014	**2014**
Excellent Tutor Award at Academy Success Center	**2011-2014**
Graduate Student Scholarship of TAMU	**2010**
Outstanding Graduate of USTC	**2010**
Outstanding Student Scholarship of USTC	**2007-2009**
Excellent Leader as the League Branch Secretary	**2008**

Research Experience

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–current*

- 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;
- Designed nonlinear controllers for series elastic actuators using Matlab;
- 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;
- Modeled the prosthetic walking as a hybrid bipedal system using Matlab and Mathematica;
- Designed nonlinear prosthetic controllers in simulation using Matlab;
- Developed embedded control system in Beagle Bone Board using C++ and ROS;
- 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*

- Modeled the 2D multi-contact locomotion as a hybrid system using Matlab and Mathematica;
- 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 Lecture 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

Professional Experience

Journal Reviewer: Mechatronics, Journal of Intelligent and Robotic System, Journal of Control, Automation and Systems, Journal of Optics and Precision Engineering
Conference Reviewer: ACC, ICRA, IROS, HSCC, CDC, MMAR, MSC
Conference Presentations: ACC, ICRA, IROS, CDC, ICCPS, ICORR, DSC
Conference Live-Demonstrations: Dynamic walking on Durus at the DRC Finals 2015; Demo on DSC Conference 2014; Demo on NASA dual conference keynote lunch speech 2014; Demo on National Instrument Week 2011

Skills

Proficient with: MATLAB, Mathematica, C/C++, Git, Linux, LaTeX
Experienced in: ROS, SolidWorks, Eagle, Python
Basic knowledge of: AutoCAD, LabView, Perl
Expertise: Dynamic system modeling, nonlinear control and optimization, control Lyapunov functions, machine learning, embedded system development, implementation experience with CANOpen, motor control and sensors

Professional Societies

Member, American Society of Mechanical Engineers (ASME)
Member, Institute of Electrical and Electronics Engineers (IEEE)

Publications

Thesis

Huihua Zhao. "From Bipedal Locomotion to Prosthetic Walking: A Hybrid System and Nonlinear Control Approach". Ph.D. dissertation, in progress, 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

Posters

H. Zhao, J. Reher, J. Horn, V. Paredes, and A. D. Ames. "Demonstration of locomotion with the powered prosthesis AMPRO utilizing online optimization-based control". 18th International Conference on Hybrid Systems: Computation and Control, Seattle, 2015

J. Horn, J. Reher, **H. Zhao**, V. Paredes, and A. D. Ames. "Translating Robotic Locomotion to Powered Transfemoral Prosthesis". ASME 2014 Dynamic Systems and Control (DSC) Conference, San Antonio, 2014

Journal Papers

H. Zhao, A. Hereid, W. Ma, and A. D. Ames. "Multi-contact bipedal robotic locomotion". Robotica, 1-35, 2015

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, in press, 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, in press, 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, A. Hereid, E. Ambrose and A. Ames "3D Multi-Contact Gait Design for Prostheses: Hybrid System Models, Virtual Constraints and Two-Step Direct Collocation". Submitted to Decision and Control (CDC), IEEE International Conference on, 2016

V. Paredes , W. Hong, S. Patrick, **H. Zhao**, A. Ames and P. Hur. "Upslope Walking with Transfemoral Prosthesis using Optimization based Spline Generation". Submitted to Decision and Control (CDC), 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, International Conference on, 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