Huihua Zhao | Curriculum Vitae

Mechanical Engineering | Georgia Institute of Technology
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Qualifications

• Trajectory design and optimization • Adaptive control for autonomous systems • Dynamical modeling and analysis of robotic systems • Motion control of robotic systems • Embedded system software development using MATLAB (7 years), C++ (4 years) and ROS (2 years) • Machine learning for intention recognition • PCB design with Eagle • Rich robotic hardware implementation experiences (including sensing, motor control and mechatronic system integration) with 8 robots • Skilled scientific writer with 18 peer-reviewed publications • Conference presentation experience and excellent communication skills • Leadership experience in multiple projects

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

Skills

Proficient with: C/C++, MATLAB, Linux, Mathematica, Git, LaTeX
Experienced in: ROS, Python, Machine learning, IPOPT, CANOpen, IMUs, SolidWorks, Eagle
Basic knowledge of: AutoCAD, LabView, Perl

Relevant Courses

MEEN651: Control System Design
MEEN655: Design of Nonlinear Control System
MEEN612: Mechanical of Robot Manipulation
MEEN689: Special Topic in Model-Based Design
ECEN609: Adaptive Control
ECEN605: Optimal Control
MEEN652: Multi Control System Design
MATH666: Geometric Control

Research Experience

1) **3-Dimensional Prosthetic Walking Design and Implementation with AMPRO 3**
Project Leader: 3D humanoid robot modeling, trajectory optimization, motion control and sensing *2016.2–current*
Skills learned: 3D asymmetric humanoid robot modeling; Trajectory optimization using IPOPT; hardware implementation including motion control and sensing.

- Enhanced the prosthetic gait design method by considering a compliant, asymmetric 3D amputee-prosthesis model, which is solved via a 2-Step direct collocation optimization using IPOPT.
- Co-designed a 3D prosthetic device with complaint ankle roll degree for better comfortability and energy consumption;
- Achieved stable compliant prosthetic walking outdoors, featured in PBS.

2) **Translating Robotic Locomotion to Prostheses Walking (AMBER 1&2 and AMPRO 1&2)**
Project Leader: dynamical system modeling, optimization and control, hardware implementation *2014.5–2015.6*
Skills learned: Embedded system programming with C++ and ROS; Robotic modeling and analysis; Trajectory optimization and motion control; PCB board design; CANOpen implementation; Hardware experience.

- Reduced parameter hand-tuning time significantly for prosthetic control (from 4 hours to 10 minutes) by designing a novel, decentralized nonlinear optimization-based prosthetic controller;
- Verified prosthetic controllers on a physical robot AMBER1 to prove out the controllers prior to human testing;
- Co-designed and built three compact self-contained powered transfemoral prosthetic devices: AMPRO1, 2, & 3;
- Decreased energy requirement ($5W$/step) and improved tracking performance (10%) by implementing nonlinear controllers which achieve stable human-like multi-contact prosthetic walking on the prostheses (with both healthy subject and amputee);

3) **Endurance Competition with DURUS at DARPA Robot Challenge Finals 2015**
Simulation Expert: 3D humanoid robot modeling, motion control and optimization *2015.6.5–2015.6.6*
Skills learned: 3D robotic dynamical modeling using Mathematica and MATLAB; Nonlinear trajectory optimization using IPOPT; hardware implementation with the robot DURUS.

- 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.

4) **Automatic Intent Recognition for Prosthetic Walking with Machine Learning**
Project Leader: data collection with IMUs, neural network implementation *2015.3–2015.5*
Skills learned: machine learning, SVM, neural network.
- Collected various type of human locomotion data using IMUs for neural network model training;
- Implemented neural network machine learning technique to achieve automatic and natural prosthetic motion transitions.

5) **Human-Inspired Multi-Contact Locomotion with AMBER2**
Project Leader: dynamical system modeling, nonlinear control design and hardware implementation *2013.5–2014.2*
Skills learned: Embedded system programming with LabView, AutoCAD design with SolidWorks; Nonlinear control and optimization design with MATLAB and Mathematica; Hardware implementation
- Formulated a theory to formally guarantee stability of a multi-domain optimization problems for achieving stable human-like multi-contact (with heel/toe lift and contact behaviors) robotic walking;
- Realized human-like multi-contact robotic locomotion experimentally on AMBER2, which was featured on Canada Discovery Channel and multiple news sites (Engadget, Gizmag);

6) **Motion Primitives Studies from Human Locomotion Experiments**
Project Leader: data processing, bipedal modeling, nonlinear optimization and control design *2011.8–2013.5*
Skills learned: Processing motion capture data with MATLAB; Modeling bipedal robots using Mathematica; Nonlinear trajectory optimization and control design for various motion types using MATLAB;
- 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.

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

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

Awards

• Graduate Travel Award 2015 • 2014 ICCPS Best Paper Award Finalist • 2014 ACC Best Session Paper Award • 2011–2014 Academy Success Center Excellent Tutor Award • 2010 TAMU Graduate Student Scholarship • 2010 USTC Outstanding Graduate • 2007–2009 USTC Outstanding Student Scholarship

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

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