HAO ZHANG

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Department of Computer Science
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Research Interests

Long-term collaborative autonomy, human-robot/swarm teaming, distributed collaborative mapping, multisensory perception, robot learning and adaptation, long-term autonomy, artificial intelligence (AI), machine learning (ML), augmented reality (AR) and mixed reality (MR), and robot-assisted inspection, repair, & reconnaissance in novel, open, and hazardous & adversarial scenarios.

Education

Ph.D., Computer Science University of Tennessee (UTK) · Knoxville, TN · August 2014

Advisor: Dr. Lynne E. Parker, Assistant Director of Artificial Intelligence at the White House Office of Science and Technology Policy (OSTP)

M.S., Electrical Engineering Chinese Academy of Sciences (CAS) · China · May 2009

B.S., Electrical Engineering University of Sci. and Tech. of China (USTC) · China · May 2006

Professional Experience

Colorado School of Mines August 2014 – Present

Assistant Professor, Department of Computer Science, Golden, CO (2014–Present).

Founder and Director, Human-Centered Robotics (HCRobotics) Laboratory.

Founder and Director of PROGRESS (*Program for Robotics Outreach on Gender and Racial Equity in School and Society*).

University of Tennessee Knoxville August 2009 – July 2014

Research Assistant, Distributed Intelligence Laboratory, Dept. of Electrical Engineering and Computer Science, Knoxville, TN (2009–2014).

Chinese Academy of Science May 2006 – August 2009

Research Assistant, Shanghai Institute of Microsystem and Information Technology, Shanghai, China (2006–2009).

Honors and Awards

First Place, Newmont Innovation Challenge, 2018.

Best Paper Finalist, Robotics: Science and Systems (RSS), 2016.

Finalist of RSJ/KROS Distinguished Interdisciplinary Research Award, IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN), 2015.

Finalist and Travel Award, Amazon (Robotic) Picking Challenge, 2015

Chancellor's Honors Award for Extraordinary Professional Promise, UTK, 2013

Best Paper Award, International Conference on Web-Age Information Management (WAIM), 2013

Graduate Student Senate Travel Award, UTK, 2011, 2013

IEEE Student Travel Award, IEEE/RJS Int'l Conf. Intelligent Robots and Systems (IROS), 2011

EECS Excellent Academic Scholarship, UTK, 2009–2011

Distinguished Graduate Award, CAS, 2009

Outstanding Thesis and Graduate Award, USTC, 2006

Publications

Refereed Conference Papers

1. Kai Liu, Hua Wang, Feiping Nie and Hao Zhang, "Learning Multi-Instance Enriched Image Representation via Non-Greedy Simultaneous ℓ_1-Norm Minimization and Maximization", in *IEEE Conference on Computer Vision and Pattern Recognition* (CVPR), 2018.
2. Sriram Siva and Hao Zhang, "Omnidirectional Multisensory Perception Fusion for Long-Term Place Recognition", in *IEEE International Conference on Robotics and Automation* (ICRA), 2018.
3. Fei Han, Hua Wang, and Hao Zhang, "Learning of Integrated Holism-Landmark Representations for Long-Term Loop Closure Detection", in *AAAI Conference on Artificial Intelligence* (AAAI), 2018.
4. Fei Han, Xue Yang, Yu Zhang, and Hao Zhang, "Sequence-Based Multimodal Apprenticeship Learning for Robot Perception And Decision Making", in *IEEE International Conference on Robotics and Automation* (ICRA), 2017.
5. Fei Han, Xue Yang, Christopher Reardon, Yu Zhang, Hao Zhang, "Simultaneous Feature and Body-Part Learning for Real-Time Robot Awareness of Human Behaviors", in *IEEE International Conference on Robotics and Automation* (ICRA), 2017.
6. Fei Han, Christopher M. Reardon, Lynne Parker, Hao Zhang, "Minimum Uncertainty Latent Variable Models for Robot Recognition Of Sequential Human Activities", in *IEEE International Conference on Robotics and Automation* (ICRA), 2017.
7. Fei Han, Jiayi Liu, William Hoff, and Hao Zhang, "Poster: Planning-based Workflow Modeling for AR-enabled Automated Task Guidance," in *IEEE International Symposium on Mixed and Augmented Reality* (ISMAR), 2017
8. Christopher Reardon, Fei Han, Hao Zhang, and Jonathan Fink, "Optimizing Autonomous Surveillance Route Solutions from Minimal Human-Robot Interaction," in *IEEE International Symposium on Safety, Security, and Rescue Robotics* (SSRR), 2017
9. William Hoff and Hao Zhang, "Poster: Learning Object and State Models for AR Task Guidance", in *International Symposium on Mixed and Augmented Reality* (ISMAR), 2016.
10. Chi Zhang, Hao Zhang, Rui Guo, and Lynne E. Parker, "A Unified Representation for Robot Learning of Action Labels and Motion Trajectories from Internet 3D Human Skeletal Data", in *IEEE International Symposium on Robot and Human Interactive Communication* (RO-MAN), 2016.
11. Hao Zhang, Fei Han, and Hua Wang, "Robust Multimodal Sequence-Based Loop Closure Detection via Structured Sparsity", in *Robotics: Science and Systems* (RSS), 2016. Best Paper Finalist.
12. Xue Yang, Fei Han, and Hao Zhang, "Enforcing Template Representability and Temporal Consistency for Adaptive Sparse Tracking", in *International Joint Conference on Artificial Intelligence* (IJCAI), 2016.
13. Hao Zhang, Christopher Reardon, Fei Han, and Lynne E. Parker, "SRAC: Self-Reflective Risk-Aware Artificial Cognitive Models for Robot Response to Human Activities", in *IEEE International Conference on Robotics and Automation* (ICRA), 2016.
14. Hua Wang, Cheng Deng, Hao Zhang, Xinbo Gao, and Heng Huang, "Drosophila Gene Expression Pattern Annotations via Multi-Instance Biological Relevance Learning", in *AAAI Conference on Artificial Intelligence* (AAAI), 2016.
15. Chi Zhang, Hao Zhang and Lynne E. Parker, "Feature Space Decomposition for Effective Robot Adaptation", in *IEEE/RSJ International Conference on Intelligent Robots and Systems* (IROS), 2015.
16. Christopher Reardon, Hao Zhang, Rachel Wright, and Lynne E. Parker, "Response Prompting for Intelligent Robot Instruction of Students with Intellectual Disabilities", in *IEEE International Symposium on Robot and Human Interactive Communication* (RO-MAN), 2015. Finalist of RSJ/KROS Distinguished Interdisciplinary Research Award.
17. Hao Zhang and Lynne E. Parker, "Bio-Inspired Predictive Orientation Decomposition of Skeleton Trajectories for Real-Time Human Activity Prediction", in *IEEE International Conference on Robotics and Automation* (ICRA), 2015.

18. Hao Zhang, Christopher Reardon, Chi Zhang, and Lynne E. Parker, "Adaptive Human-Centered Representation for Activity Recognition of Multiple Individuals from 3D Point Cloud Sequences", in *IEEE International Conference on Robotics and Automation* (ICRA), 2015.
19. Hao Zhang, Wenjun Zhou, Christopher Reardon, and Lynne E. Parker, "Simplex-Based 3D Spatio-Temporal Feature Description for Action Recognition", in *IEEE Conference on Computer Vision and Pattern Recognition* (CVPR), 2014.
20. Hao Zhang, Wenjun Zhou, and Lynne E. Parker, "Fuzzy Segmentation and Recognition of Continuous Human Activities", in *IEEE International Conference on Robotics and Automation* (ICRA), 2014.
21. Hao Zhang, Scott C. Lenaghan, Michelle H. Connolly, and Lynne E. Parker, "Zebrafish Larva Locomotor Activity Analysis Using Machine Learning Techniques", in *IEEE International Conference on Machine Learning and Applications* (ICMLA), 2013.
22. Richard Edwards, Hao Zhang, and Lynne E. Parker, "Approximate l-Fold Cross-Validation with Least Squares SvM and Kernel Ridge Regression", in *IEEE International Conference Machine Learning and Applications* (ICMLA), 2013.
23. Wenjun Zhou and Hao Zhang, "Correlation Range Query", in *International Conference on Web-Age Information Management* (WAIM), 2013. Best Paper Award.
24. Hao Zhang, Richard Edwards, and Lynne E. Parker, "Regularized Probabilistic Latent Semantic Analysis with Continuous Observations", in *IEEE International Conference on Machine Learning and Applications* (ICMLA), 2012.
25. Hao Zhang, Haihang You, Bilel Hadri, and Mark Fahey, "HPC Usage Behavior Analysis And Performance Estimation with Machine Learning Techniques", in *International Conference on Parallel and Distributed Processing Techniques and Applications* (PDPTA), 2012.
26. Hao Zhang, and Lynne E. Parker, "4-Dimensional Local Spatio-Temporal Features for Human Activity Recognition", in *IEEE/RSJ International Conference on Intelligent Robots and Systems* (IROS), 2011.
27. Hao Zhang, Wen Yu, and Xiaowei Sun, "A Novel Method For Background Suppression in Millimeter-Wave Traffic Radar Sensor", in *IEEE International Conference on Intelligent Transportation Systems* (ITSC), 2008.
28. Hao Zhang, Wen Yu, and Xiaowei Sun, "Adaptive Traffic Lane Detection Based on Normalized Power Accumulation", in *IEEE International Conference on Intelligent Transportation Systems* (ITSC), 2008.

Journal Papers

1. Christopher Reardon, Hao Zhang, Rachel Wright, and Lynne Parker, "Towards Teaching Students with Intellectual Disabilities Using Intelligent Robot Instructors", *IEEE Robotics & Automation Magazine* (RAM), accepted, 2018.
2. Christopher Reardon, Hao Zhang, and Jonathan Fink, "Shaping of Shared Autonomous Solutions with Minimal Interaction", *Frontiers in Neurorobotics*, accepted, 2018.
3. Fei Han, Saad Elbeleidy, Hua Wang, Cang Ye, and Hao Zhang, "Learning of Holism-Landmark Graph Embedding for Place Recognition in Long-Term Autonomy", *IEEE Robotics and Automation Letters* (RA-L), accepted, 2018.
4. Fei Han, Hua Wang, Guoquan Huang, and Hao Zhang, "Sequence-Based Sparse Optimization Methods for Long-Term Loop Closure Detection in Visual SLAM", invited paper, *Autonomous Robots* (AuRo), in press, 2018.
5. Brian Reily, Fei Han, Lynne E. Parker, and Hao Zhang, "Skeleton-Based Bio-Inspired Human Activity Prediction for Real-Time Human-Robot Interaction", *Autonomous Robots* (AuRo), vol.42, no.6, pp 1281-1298, 2018.
6. Fei Han, Xue Yang, Yiming Deng, Mark Rentschler, Dejun Yang, and Hao Zhang, "SRAL: Shared Representative Appearance Learning for Long-Term Visual Place Recognition", *IEEE Robotics and Automation Letters* (RA-L), vol.26, no.3, pp.1172-1179, 2017.
7. Brian Reily, Hao Zhang, and William Hoff, "Real-Time Gymnast Detection and Performance Analysis with a Portable 3D Camera", *Computer Vision and Image Understanding* (CVIU), vol.159, pp.154-163, 2017.

8. Fei Han, Brian Reily, William Hoff, and Hao Zhang, "Space-Time Representation of People Based on 3D Skeletal Data: A Review", *Computer Vision and Image Understanding* (CVIU), vol.158, pp.85-105, 2017.
9. Hao Zhang and Lynne E. Parker, "CoDe4D: Color-Depth Local Spatio-Temporal Features for Human Activity Recognition from RGB-D Videos", *IEEE Transactions on Circuits and Systems for Video Technology* (TCSVT), vol.26, no.3, pp.541-555, 2016.
10. Hao Zhang, Wenjun Zhou, and Lynne E. Parker, "Fuzzy Temporal Segmentation and Probabilistic Recognition Of Continuous Human Daily Activities", *IEEE Transactions on Human-Machine Systems* (THMS), vol.45, no.5, pp.598-611, Oct. 2015.
11. Wenjun Zhou and Hao Zhang, "Correlation Range Query for Effective Recommendations", *World Wide Web*, open access, Nov. 2014.
12. Hao Zhang, Christopher Reardon, and Lynne E. Parker, "Real-Time Multiple Human Perception with Color-Depth Cameras on a Mobile Robot", *IEEE Transactions on Cybernetics* (TCYB, previously known as *IEEE Transactions on Systems, Man, and Cybernetics, Part B: Cybernetics*), vol. 43, no. 5, pp. 1429–1441, Oct. 2013.
13. Scott C. Lenaghan, Yuanyuan Li, Hao Zhang, Jason N. Burris, C. Neal Stewart, Lynne E. Parker, and Mingjun Zhang, "Monitoring the Environmental Impact of TiO_2 Nanoparticles Using a Plant-Based Sensor Network", *IEEE Transactions on Nanotechnology*, vol.12, no.2, pp.182–89, Mar. 2013.
14. Hao Zhang, Wen Yu, and Xiaowei Sun, "Background Power Spectrum Recognition in Applications of Millimeter Wave Flow Detection Radar", *Journal of Infrared and Millimeter Waves*, vol. 27, no. 6, 2008 (in Chinese).

Workshop Papers

1. Sriram Siva and Hao Zhang, "Metacognitive Reasoning of Perceptual Inconsistency for Illusion Detection", *Workshops on Adversarial Robotics* at RSS, 2018.
2. Sriram Siva and Hao Zhang, "Robot Adaptation to Environment Changes in Long-Term Autonomy", *Workshops on Robot Teammates Operating in Dynamic, Unstructured Environments* (RT-DUNE) at ICRA, 2018.
3. Fei Han and Hao Zhang, "Team Intent Understanding through Latent Representation Learning for Underground Search and Rescue", *Workshops on Robot Teammates Operating in Dynamic, Unstructured Environments* (RT-DUNE) at ICRA, 2018.
4. Sriram Siva, Brian Reily, Hao Zhang, "Fast Deployment of Multi-Robot Autonomy in Underground Environments", *IEEE International Conference on Robotics and Automation* (ICRA), Abstract-Only Poster, 2018.
5. Sriram Siva, Peng Gao, Yiming Deng, Hao Zhang, "Multisensory Internal Pipe Threat Prediction Using Inline Inspection Robots", *IEEE International Conference on Robotics and Automation* (ICRA), Abstract-Only Poster, 2018.
6. Fei Han, Christopher Reardon, Cang Ye, and Hao Zhang, "Robot Understanding of Human Intents in Gesture-based Interaction," in Workshop of *IEEE/RSJ International Conference on Intelligent Robots and Systems* (IROS), 2017.
7. Fei Han, Xue Yang, Yiming Deng, Mark Rentschler, Dejun Yang, and Hao Zhang, "Life-Long Place Recognition by Shared Representative Appearance Learning", in *Workshops in conjunction with Robotics: Science and Systems* (RSS), 2016.
8. Ahmed A. Ambarak, John Steele, and Hao Zhang, "CORE: A Dataset of Critical Objects for Response to Emergency", in *IEEE International Symposium on Safety, Security, and Rescue Robotics* (SSRR), Late Breaking Reports, 2015.
9. Chi Zhang, Hao Zhang, and Lynne E. Parker, "Feature Space Decomposition for Autonomous Robot Adaptation in Programming by Demonstration", in *Workshop on Compliant and Versatile Robot Control in Human Environments: Bridging the Gap between Learning and Control* at ICRA, 2015.
10. Haihang You and Hao Zhang, "Comprehensive Workload Analysis and Modeling of a Petascale Supercomputer", in *Workshop on Job Scheduling Strategies for Parallel Processing* (JSSPP), 2012.

Patents

1. Wen Yu, Hao Zhang, and Daigen Xu, “Automatic Recognition Method of Road Driveway Based on Millimeter Wave Traffic Radar”, CN Patent No. 101349754, 2011.
2. Wen Yu, Xiaowei Sun, and Hao Zhang, “Method for Recognizing and Restraining Highway Background Based on Millimeter Wave Traffic Radar”, CN Patent No. 101325007, 2011.

Invited Talks

1. “Robot Adaptation in Long-Term Autonomy”, University of Technology Sydney (UTS), 5/18, Sydney, Australia.
2. “Long-term Collaborative Autonomy”, U.S. Air Force Academy (USAFA), 4/18, Colorado Springs, CO.
3. “Robot Learning for Long-term Collaborative Autonomy”, George Mason University, 1/18, Fairfax, VA.
4. “Robot Learning for Long-term Collaborative Autonomy”, U.S. Army Research Laboratory (ARL), 1/18, Adelphi, MD.
5. “Demonstration of Smart Robots for Abandoned Underground Mine Investigation”, at *Symposium on Design and Construction Issues at Hazardous Waste Sites*, organized by *Environmental Protection Agency* (EPA) & *Society of American Military Engineers* 10/17, Denver, CO.
6. “Towards Natural Collaboration in Peer-to-Peer Human-Robot Teams”, University of Colorado Colorado Springs, 11/15, Colorado Springs, CO.
7. “Data-Driven Fault Detection via Sparse Multisensory Learning”, AIAA Annual Technical Symposium, 10/2016, Golden, CO.

Funding

1. “Low-variance Deep Graph Learning for Predictive Pipeline Assessment with Interacting Threats”, PI, $300,000, awarded by Department of Transportation (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA), 2018-2020.
2. “AI-Enabled Robots for Automated Nondestructive Evaluation and Repair of Power Plant Boilers”, PI, $400,000, awarded by Department of Energy (DOE), 2018-2021.
3. “Prediction of Human Emotional and Cognitive States by Machine Agents to Promote Shared Situational Awareness”, PI, $74,943, awarded by United States Air Force Academy (USAFA), 2018-2019.
4. “Robot Perception Research Support Fund”, PI, $70,000, awarded by Toyota InfoTechnology Center USA Inc., 2018.
5. “CRI: II-New: Infrastructure for Robust Interactive Underground Robots”, Co-PI, $451,102, awarded by National Science Foundation (NSF), 2018-2021.
6. “Internet of Robotic Things for Occupant Sensing and Building Heating/Cooling Energy Use Optimization”, Co-PI, $42,231, awarded by Colorado Energy Research Collaboratory (CERC), 2018.
7. “Multisensory Fusion for Distributed Multi-agent Localization”, PI, $118,634, awarded by Metcalf Archaeological Consultants, Inc., 2017-2018.
8. “Educational Robots for CS-ME Teaching Lab”, Co-PI, $57,640, awarded by Colorado School of Mines, 2017-2018.
9. “Enabling and Securing Robotic Team Situational Awareness”, Co-PI, $459,867, awarded by Army Research Office (ARO), 2017-2019.
10. “Registration and Tracking of a Handheld Device”, PI, $126,396, awarded by Metcalf Archaeological Consultants, Inc., 2017.
11. “Gift for PROGRESS (Program for Robotics Outreach on Gender and Racial Equity in School and Society”, PI, $2,500, 2017.
12. “Automated Maintenance Guide”, Co-PI, $30,000 with $50,000 equipment, awarded by DAQRI, 2016.
13. “Acquisition of Intelligent Robots to Support Courses of Algorithmic Foundations of Robotics”, PI, $31,221.4, awarded by Colorado School of Mines, 2015-2016.
14. “The Geobot”, Co-PI, $106,024, awarded by Colorado School of Mines, 2014-2015.

Student Advising and Postdoctoral Mentoring

(does not include course-only M.S.)

Postdoctoral Fellow

1. Xue Yang, 2016 (joined Google)

Ph.D. Students

1. Jiayi Liu, 2018 (expected, co-advised, with Prof. William Hoff as the advisor)
2. Brian Reily, 2020 (expected)
3. Sriram Siva, 2021 (expected)
4. Peng Gao, 2022 (expected)
5. Alexandra Joseph, 2023 (expected)
6. Fei Han, PhD, 2015-2018, dissertation title: *Representation Learning for Long-term Collaborative Autonomy* (joined Amazon Lab126 as an Applied Scientist)

M.S. Thesis Students

1. Zachary Nahman, M.S. Thesis, 2019 (expected)
2. Ziling Zhang Zhang, M.S. Thesis, 2020 (expected)
3. Brian Reily, M.S. Thesis, 2016 (co-advised, with Prof. William Hoff as the advisor), *Human Activity Recognition and Gymnastics Analysis through Depth Imagery*

M.S. Project Students

1. Saichand Bandarupalli, M.S. Project, 2018, *Deep Learning for Human Detection*
2. Matthew Bailey, M.S. Project, 2017, *Omni-Thermal Imager Design*
3. William Kelly, M.S. Project, 2017, *Robot Grasp Learning*
4. Tyler Lyons, M.S. Project, 2016, *Multi-Human Detection*
5. Nathan Huff, M.S. Project, 2015, *Robot Grasping and Picking* (joined LGS Innovations)

Undergraduate Research Students

Savannah Paul (2017-current), Gazi Mahbub Morshed (2018-current), Carl Schader (2018-current), Huan Wang (2017), Erica A. Holswade (2017), Marie Hetherington (2017), William Kelly (2016), Quentin Corich (2016), Niles Hacking (2016), Jean Farmer (2016), Kenneth Kooy (2015), Christopher Rice (2015)

Teaching Experience

Instructor Colorado School of Mines, 2014 – Present

CSCI473: Human-Centered Robotics, Fall 2014 (16 students), Fall 2015 (11 students), Spring 2017 (14 students), Spring 2018 (15 students)

CSCI573: Human-Centered Robotics, Fall 2014 (13 students), Fall 2015 (16 students), Spring 2017 (11 students), Spring 2018 (25 students)

CSCI442: Operating Systems, Fall 2016 (59 students), Spring 2017 (54 students), Fall 2017 (80 students), Fall 2018 (78 students)

CSCI598A: Robot Intelligence, Spring 2015 (16 students)

Faculty Advisor of Senior Design and Field Session Colorado School of Mines, 2014 – Present

Professional Activities

Professional Services

Organizing Committee:

- *Co-Chair of Junior Researcher Events* on Organizing Committee, IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2015.

Editorial Board:

- *Review Editor* on Editorial Board, Frontiers in Robotics and AI (Section: Robotic Control Systems)
- *Senior Program Committee*, AAAI Conference on Artificial Intelligence (AAAI), 2018.
- *Program Committee*, International Joint Conference on Artificial Intelligence (IJCAI), 2018-current.
- *Program Committee*, AAAI Conference on Artificial Intelligence (AAAI), 2015-2016, 2019.
- *Program Committee Member*,Robotics Science and Systems (RSS), 2016.
- *Associate Editor* on Conference Editorial Board, IEEE International Conference on Robotics and Automation (ICRA), 2015-2017.
- *Associate Editor* on Conference Editorial Board, IEEE-RAS International Conference on Humanoid Robots (Humanoids), 2015-current.
- *Associate Editor* on Conference Editorial Board, IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2015, 2017.

Program Committee Member, Int'l Conf. Intelligent Data Engineering and Automated Learning (IDEAL), 2013.

Grant Review Panel:

- National Science Foundation (NSF), 2015, 2018
- Department of Defense (DOD), 2017, 2018

Paper Reviews

Book Chapters
Computer Vision and Machine Learning with RGB-D Sensors

Journals
IEEE Transactions on Robotics (TRO)
IEEE Robotics and Automation Letters (RA-L)
IEEE Transactions on Automation Science and Engineering (TASE)
IEEE Transactions on Mechatronics (TMECH)
IEEE Robotics & Automation Magazine (RAM)
IEEE Transactions on Cybernetics (TCyb)
IEEE Transactions on Human-Machine Systems (THMS)
IEEE Transactions on Image Processing (TIP)
IEEE Transactions on Circuits and Systems for Video Technology (TCSVT)
International Journal of Social Robotics (SORO)
Springer Journal of Intelligent and Robotic Systems (JIRS)
Elsevier Neurocomputing

Conferences
IEEE International Conference on Robotics and Automation (ICRA)
ACM/IEEE International Conference on Human-Robot Interaction (HRI)
AAAI Conference on Artificial Intelligence (AAAI)
International Joint Conference on Artificial Intelligence (IJCAI)
IEEE International Conference on Data Mining (ICDM)
IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
IEEE International Conference on Humanoid Robots (Humanoids)

Professional Affiliations

IEEE, ACM, AAAI, IEEE Robotics & Automation Society, IEEE Young Professionals