MATTHEW PAN

Curriculum Vitae

Contact Information

Matthew Keith Xi-Jie Pan
Assistant Professor
Electrical and Computer Engineering
Queen's University

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Citizenship

Canadian

Research Overview

I build interactive experiences using robots that detect, interpret, and react to human behaviours. My projects focus on providing social and physical assistance or augmentation to people during human-robot interactions in both real and virtual environments. Examples of my work towards this aim include animatronic mutual gaze behavior, human-robot handover of objects, and a robotic system for introducing dynamic object interactions in virtual reality. My research draws from the areas of robotics, virtual and augmented reality, machine learning, computer vision, human psychomotor behaviour, and cognitive science.

Key Words: Human-robot interaction, collaborative robotics, machine learning, virtual reality, augmented reality, mixed reality, nonverbal behaviour, intent recognition, sensors and actuators, haptics

Education

University of British Columbia, Vancouver, BC, CANADA

Ph.D. Mechanical Engineering **2018**
Advisor: Elizabeth A. Croft
Thesis: *Towards Enabling Human-Robot Handovers: Exploring Nonverbal Cues for Fluent Human-Robot Handovers*

M.A.Sc. Mechanical Engineering **2012**
Advisors: Elizabeth A. Croft, Karon E. MacLean
Thesis: *An Exploration of a Haptic Affect Loop Through Use Cases*

University of Waterloo, Waterloo, Ontario CANADA

B.A.Sc. Mechatronics Engineering w/ Biomechanics Option **2009**
Honours: With Distinction

Research Positions

Queen's University, Electrical and Computer Engineering, Kingston, Ontario CANADA

Assistant Professor **2021-Current**

- Researching physical and social human-robot interaction, VR/AR, and machine learning

UBTECH, Pasadena, California USA

Senior Human-Robot Interaction Consultant **2021**

- Developed human behavior detection methods for healthcare robotics

Disney Research, Los Angeles, California USA

Postdoctoral Associate **2018-2020**
PI: Günter Niemeyer

- Designed and implemented a realistic and interactive social gaze system for Audio-Animatronic® figures
- Defined novel machine learning algorithms to re-target motion-captured kinematics to robot manipulators and animatronics
- Completely designed and implemented a fast human-robot handover system designed to test impacts of interaction delays

Lab Associate **2016-2017**
PIs: Günter Niemeyer, Lanny Smoot

- Developed an interface to allow catching of real ballistic objects while immersed in virtual reality
- Prototyped and studied physical human-robot interactions to augment virtual reality experiences and virtual agent interactions
- Explored the design space for human-robot collaboration and how parameters affect the social perception of robots and efficiency of interaction

University of British Columbia, Vancouver, British Columbia CANADA

PhD Research Assistant **2012-2016, 2017-2018**
PI: Elizabeth A. Croft
Affiliation: Collaborative Advanced Robotics and Intelligent Systems Laboratory

- Studied the use of collaborative and assistive robotics in the context of manufacturing processes in collaboration with General Motors, McGill University, and Université Laval
- Researched how robot non-verbal cues affect characteristics and performance of human-robot handovers
- Developed machine learning processes to perform automatic recognition of handover intent
- Designed and validated a system for programming robot trajectories in augmented reality for complex manufacturing tasks
- Used conductive nylon thread actuators to develop novel, low-cost, high-performance actuator technology to design, build, and control robotic grippers for robust grasping

MASc Research Assistant **2009-2012**
PIs: Prof. Elizabeth A. Croft, Prof. Karon E. MacLean
Affiliations: Collaborative Advanced Robotics and Intelligent Systems Laboratory, Sensory Perception and Interaction Research Group

- Designed and explored applications of low-cost haptic devices for notification

- Studied a human-computer interaction control loop involving the monitoring of physiological activity and haptic feedback for enhancing user self-awareness

University of Western Ontario, London, Ontario CANADA

Honours Research **2008-2009**
PIs: Terry M. Peters, Rajni D. Patel
Affiliations: Virtual Augmentation and Simulation for Surgery and Therapy Lab
Canadian Surgical Technologies and Advanced Robotics

- Completely designed, fabricated and tested a low-cost, modular 5-DOF laparoscopic robot, including 3D image visualization integration for image-guided surgery

Research Assistant **2008**
PIs: Jim Johnson, Louis Ferreira
Affiliations: The Hand and Upper Limb Bioengineering Research Lab
Lawson Health Research Institute

- Developed software to perform real-time tracking and 3D visualization of patient osseous anatomy, orthopaedic implants and surgical instruments
- Performed instrumentation and testing of cadarveric limbs to study upper limb joint movement and kinematics resulting from implants

Awards & Honors

The University of British Columbia

Mechanical Engineering Academic Achievement Award	**2018**
Best Paper Award, ACM/IEEE Int. Conf. on HRI	**2014**
Motion Metrics/ICICS Graduate Scholarship	**2013**
Mechanical Engineering Department Scholar	**2012**
NSERC Doctoral Postgraduate Scholarship	**2012**
UBC Four Year Doctoral Fellowship	**2012**
Faculty of Applied Science Graduate Support Initiative Award	**2012**
Mechanical Engineering Student Leadership Award	**2011**
UBC Killam Graduate Student Teaching Assistant Award	**2011**
Faculty of Applied Science Graduate Entrance Scholarship	**2009**

The University of Waterloo

Faculty of Engineering Entrance Scholarship	**2004**
Alexander Rutherford Scholarship	**2004**

Patents & Publications

Patents

P5 **Pan, M.K.X.J.**, Shao, D. Xiu, Z., Tan, H. (2021). US Patent Pending - "Human Abnormal Behavior Response Method and Mobility Aid Robot Using the Same"

P4 Christensen, D., Wieland, A., Smoot, L., Ayala, A., Smithwick, Q., McIntosh, K., Kennedy, J., **Pan, M.K.X.J.**, Niemeyer, G., Zamora, D.C., Choi S. (2020). U.S. Patent Pending - "Eye contact sensing and control for robotic characters."

P3 Niemeyer, G., Smoot, L., Chawda, V., **Pan, M.K.X.J.** , Knoop, E., Knoop, E., Bächer, M. (2019). U.S. Patent US10362299B1 - "System for introducing physical experiences into virtual reality (VR) worlds. [2nd Publication]"

P2 Niemeyer, G., Smoot, L., Chawda, V., **Pan, M.K.X.J.** (2019). U.S. Patent US10362299 - "System for introducing physical experiences into virtual reality (VR) worlds."

P1 Niemeyer, G., **Pan, M.K.X.J.** (2018). U.S. Patent US10139899 - "Hypercatching in virtual reality (VR) system."

Refereed Journal Articles

J3 Chan, W.P., **Pan, M.K.X.J.**, Croft, E.A., Inaba, M., "An affordance and distance minimization based method for computing object orientations for robot human handovers." International Journal of Social Robotics (SORO), 2018.

J2 **Pan, M.K.X.J.**, Skjervøy, V., Chan, W.P., Inaba, M., Croft, E.A., "Automated detection of handovers using kinematic features." International Journal of Robotics Research (IJRR), February 2017.

J1 **Pan, M.K.X.J.**, McGrenere, J., Croft, E. A., MacLean, K.E., "Exploring the Role of Haptic Feedback in an Implicit HCI-Based Bookmarking Application." IEEE Transactions on Haptics, February 2014.

Refereed Conference Papers

C15 **Pan, M.K.X.J.**, Choi, S., Kennedy, J., McIntosh, K., Campos Zamora, D., Niemeyer, G., Kim, J., Wieland, A., Christensen, D., 'Realistic and Interactive Robot Gaze" In Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS'20), October 2020.

C14 Choi, S., **Pan, M.K.X.J.**, Kim, J., "Nonparametric Motion Retargeting for Humanoid Robots on Shared Latent Space" In Proceedings of Robotics: Science and Systems (RSS'20), May 2020.

C13 **Pan, M.K.X.J.**, Knoop, E., Bächer, M., Niemeyer, G., "Fast Handovers with a Robot Character: Small Sensorimotor Delays Improve Perceived Qualities" In Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS'19), November 2019.

C12 Chan, W.P., Quintero, C.P., **Pan, M.K.X.J.**, Sakr, M., Van der Loos, H.F.M., Croft, E.A., "A Multimodal System using Augmented Reality, Gestures, and Tactile Feedback for Robot Trajectory Programming and Execution." In Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS'18), September 2018.

C11 **Pan, M.K.X.J.**, Croft, E.A., Niemeyer, G., "Exploration of Geometry and Forces Occurring within Human-to-Robot Handovers." In Proceedings of the IEEE Haptics Symposium (HAPTICS'18), San Francisco, CA, March 2018.

C10 **Pan, M.K.X.J.**, Croft, E.A., Niemeyer, G., "Evaluating Social Perception of Human-to-Robot Handovers Using the Robot Social Attributes Scale (RoSAS)." In Proceedings of the ACM/IEEE International Conference on Human-Robot Interaction (HRI'18), Chicago, IL, March 2018.

C9 **Pan, M.K.X.J.**, Niemeyer, G., "Catching a Real Ball in Virtual Reality." In Proceedings of the IEEE Conference on Virtual Reality (IEEE VR 2017), Los Angeles, CA, March 2017.

C8 Chan, W.P., **Pan, M.K.X.J.**, Croft, E.A., Inaba, M., "Characterization of Handover Orientations Used by Humans for Efficient Robot to Human Handovers." In Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS'15), September 2015.

C7 Hart, J.W., Sheikholeslami, S., **Pan, M.K.X.J.**, Chan, W.P., Croft, E.A., "Predictions of Human Task Performance and Handover Trajectories for Human-Robot Interaction." In Proceedings of the ACM IEEE International Conference on Human-Robot Interaction (HRI'15), Portland, OR, March 2015.

C6 Zheng, M., Moon, A., Gleeson, B., Troniak, D., **Pan, M.K.X.J.**, Blumer, B.A., Croft, E.A., Meng, M.Q.H., "Human Behavioural Responses to Robot Head Gaze during Human-Robot Handovers." In Proceedings of the IEEE International Conference on Robotics and Biomimetics (ROBIO'14), December 2014.

C5 Moon, A., Troniak, D.M., Gleeson, B., **Pan, M.K.X.J.**, Zheng, M., Blumer, B.A., MacLean, K.E., Croft, E.A., "Meet Me where I'm Gazing: How Shared Attention Gaze Affects Human-Robot Handover Timing." In Proceedings of the ACM/IEEE International Conference on Human-Robot Interaction (HRI'14), March 2014.

C4 MacLean, K.E., Yohanan, S., Sefidgar, Y., **Pan, M.K.X.J.**, Croft, E.A., McGrenere, J., "Emotional Communication and Implicit Control through Touch." In Proceedings of the IEEE Haptics Symposium (HAPTICS'12), Vancouver, BC, Canada, March 2011.

C3 **Pan, M.K.X.J.**, Chang, J.S., Himmetoglu, G.H., Moon, A., Hazelton, T.W., MacLean, K.E., and Croft, E.A., "Now, Where Was I? Physiologically Triggered Bookmarks for Audio Books." In Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI'11), Vancouver, Canada, May 2011.

C2 **Pan, M.K.X.J.**, Chang, J.S., Himmetoglu, G.H., Moon, A., Hazelton, T.W., MacLean, K.E., Croft, E.A., "Galvanic skin response-derived bookmarking of an audio stream." In Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI'11). ACM, Vancouver, BC, Canada, May 2011.

C1 **Pan, M.K.X.J.**, Baumann, M.A., Hazelton, T.W., MacLean, K.E., Croft, E.A., "Expressive Wearable Haptic Devices." In Proceedings of the IEEE Haptics Symposium (HAPTICS'10), Waltham, MA, USA, March 2010.

Refereed Workshop Papers

W4 Chan, W.P., Quintero, C., **Pan, M.K.X.J.**, Sakr, M., Van der Loos, M., Croft, E.A., "A Multimodal System using Augmented Reality, Gestures, and Tactile Feedback for Robot Trajectory Programming and Execution" IEEE International Conference on Robotics and Automation (ICRA'18), Workshop on Robotics in Virtual Reality, Brisbane Australia, May 2018.

W3 **Pan, M.K.X.J.**, Croft, E.A., Niemeyer, G., "Validation of the Robot Social Attributes Scale (RoSAS) for Human-Robot Interaction through a Human-to-Robot Handover Use Case"IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS'17), Human-Robot Interaction in Collaborative Manufacturing Environments Workshop, Vancouver, BC, Canada, March 2018.

W2 Hart, J., Gleeson, B., **Pan, M.K.X.J.**, Moon, A., MacLean, K.E., Croft, E.A., "Gesture, Gaze, Touch, and Hesitation: Timing Cues for Collaborative Work." ACM/IEEE International Conference on Human-Robot Interaction (HRI'14), Timing Workshop, March 2014.

W1 Karuei, I., Hazelton, T. W., MacLean, K. E., Baumann, M., and **Pan, M.K.X.J.**, "Presenting a Biometrically-Driven Haptic Interaction Loop." ACM Conference on Human Factors in Computing Systems (CHI'10), Workshop on Whole Body Interaction. Atlanta, GA, April 2010.

Other Contributions

O2 **Pan, M.K.X.J.**, Yip, M., Pardasani, U., Peters, T., and Patel, R. (2009). "Robotic Laparoscopy: Design of an Image-Guided Tool for Teleoperated Minimally Invasive Surgery." Robarts Imaging, Canadian Surgical Technologies and Advanced Robotics at the London Health Sciences Centre.

O1 **Pan, M.K.X.J.**, (2008). "MotionStation3D - Development and Deployment of a Tool for 3D Image-Guided Installation of Orthopedic Implants." University of Western Ontario.

Talks

Invited Talks

Queen's University	**2021**
UBTECH North America Research & Development Center, Seminar	**2020**
IROS Workshop on Shared Autonomy	**2017**
Walt Disney Technology Symposium	**2017**
Disney Research Los Angeles, Tech Talk	**2016**
Universitié Laval, General Motors Plugfest	**2012, 2013**

Campus Talks

Ingenuity Labs, Queen's University	**2021**
Walt Disney Imagineering, Software Soiree	**2019**
University of British Columbia, Dept. Seminar Series	**2013, 2014**

Teaching

Queen's University, Kingston, Ontario CANADA

Lecturer (Undergraduate)

MREN 178: Data Structures and Algorithms **2022**

California Institute of Technology, Pasadena, California USA

Teaching Assistantship (Undergraduate)

ME/CS/EE 134: Robotic Systems **2020**

University of British Columbia, Vancouver, British Columbia CANADA

Certification

Instructional Skills Workshop (ISW) Certification **2015**

Curriculum Developer (Undergraduate)

APSC 100: Introduction to Engineering **2015**

Teaching Assistantships (Undergraduate)

MECH 223: Mechanical Design	**2011-2015**
MECH 221: Electrical Circuits	**2010-2014**
MECH 224: Community Service Learning	**2010-2014**

Selected Industry Experience

BeneFACT Consulting Group, Toronto, ON CANADA

Mechanical and Mechatronics Engineering Grant Writer **2010-2014**

- Authored 60+ grant applications for the Government of Canada's Scientific Research and Experimental Development (SR&ED) program

Agilabs Software, Calgary, AB CANADA

Senior R&D Operations Specialist **2007**

- Developed codebase for creating redundant server systems with high-availability load balancing capabilities deployed for mission critical financial transactions

Tyco Safety Products - Digital Security Controls, Toronto, ON CANADA

Manufacturing Engineering Support **2006**

- Optimized printed circuit board manufacturing operations under a lean manufacturing initiative

Nortel Networks, Calgary, AB CANADA

Quality Engineering Developer **2005**

- Developed code and metrics for autonomous monitoring and reporting of manufacturing production quality of business telephony product lines

MechWave Engineering Ltd., Calgary, AB CANADA

Mechanical Engineering Design Assistant **2005**

- Created CAD drawings for HVAC, plumbing, and fire protection systems in building construction projects

Selected Service & Outreach

Conference and Journal Refereeing

ACM Trans. on Human Robot Interaction	**2021**
IEEE Int. Conf. on Robotics and Automation (ICRA)	**2020**
Autonomous Robots (AURO)	**2020**
IEEE-RAS Int. Conf. on Humanoid Robots (Humanoids)	**2020**
IEEE Robotics and Automation Letters (RA-L)	**2020**
ACM/IEEE Int. Conf. on Human-Robot Interaction (HRI)	**2020**
Royal Society Open Science	**2019**
Conf. on Graphics, Visualization & HCI (GI)	**2019**
ACM User Interface Software and Technology Symp. (UIST)	**2018**
IEEE Symp. Robot and Human Interactive Comm. (RO-MAN)	**2016**
IEEE/RSJ Int. Conf. on Intelligent Robots and Systems (IROS)	**2016**
Int. Journal of Robotics Research (IJRR)	**2016**
Int. Journal of Soft Robotics (SORO)	**2013**
IEEE Haptics Symp. (HAPTICS)	**2012**
ACM Conf. on Human Factors in Computing Systems (CHI)	**2012**

Conference Organization

Session Chair, IEEE/RSJ Int. Conf. on Intelligent Robots and Systems (IROS) **2020**

Local Arrangements Organizer, IEEE/RSJ Int. Conf. on Intelligent Robots and Systems (IROS) **2016**

Other Service

Judge, Greater Vancouver Regional Science Fair **2012-2015**

Executive, Mechanical Engineering Graduate Association, The University of British Columbia **2009-2012**

Consultant/Judge, International Autonomous Robot Racing Challenge, The University of British Columbia **2011-2012**

Senior Care Volunteer, Yaletown House Society, Vancouver **2010**

Executive, IEEE Engineering in Medicine and Biology Society, Kitchener-Waterloo Chapter **2006**

Selected Media Coverage

Watch This Disney Robot Make the Most Convincing Eye Contact Ever
Popular Mechanics **2021**

Disney Research Makes Robotic Gaze Interaction Eerily Lifelike
IEEE Spectrum **2020**

Disney Made a Skinless Robot That Can Realistically Stare Directly Into Your Soul
Gizmodo **2020**

This robot arm slows down to avoid the uncanny valley
TechCrunch **2019**

Robot posture and movement style affects how humans interact with them
TechCrunch **2018**

Disney Research Pioneers New Frontiers Using Virtual Reality
Psychology Today **2017**

Watch this guy catch a real ball in VR
The Verge **2017**

Disney shows how you catch a real ball in VR
Engadget **2017**

The key to better – and safer – robots is teaching them about human interaction
National Post **2013**

Working with robots: Our friends electric
The Economist **2013**