

Long Wang, Ph.D.

CONTACT INFORMATION

Department of Mechanical Engineering

Columbia University

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EDUCATION

- **Doctor of Philosophy** 2018
Mechanical Engineering, Vanderbilt University
Areas of specialization: Modeling and Control of Continuum Robots, Telemanipulation, Calibration
- **Master of Science** 2012
Mechanical Engineering, Columbia University
Areas of specialization: Underactuated Robotic Hand
- **Bachelor of Science** 2010
Mechanical Engineering, Tsinghua University
Areas of specialization: Robotics, Manufacturing, Machine Design

ACADEMIC APPOINTMENTS

- **Postdoctoral Research Scientist** 2018 Fall - present
Department of Mechanical Engineering Columbia University
- **Graduate Research Assistant** 2013 - 2018 Summer
Department of Mechanical Engineering Vanderbilt University
- **Teaching Assistant (graduate class)** 2015 Spring, 2017 Spring
Department of Mechanical Engineering Vanderbilt University
- **Teaching Assistant (undergraduate class)** 2012 - 2013
Department of Mechanical Engineering Vanderbilt University
- **Graduate Research Assistant** 2010 - 2012
Department of Mechanical Engineering Columbia University
- **Undergraduate Research Assistant** 2008 - 2010
Department of Mechanical Engineering Tsinghua University, China

PUBLICATION AND SCHOLARSHIP

JOURNAL PUBLICATIONS

- J.1 Chen, T., **Wang, L.**, Haas-Heger, M., and Ciocarlie, M., "Tendon-driven Underactuated Hand Design via Optimization of Mechanically Realizable Manifolds in Posture and Torque Spaces", *submitted to IEEE Transactions on Robotics, under review*, 2019.
- J.2 **Wang, L.**, Del Giudice, and Simaan, N., "Simplified Kinematics of Continuum Robot Equilibrium Modulation via Moment Coupling Effects and Model Calibration", *ASME Journal of Mechanisms and Robotics, in press*, 2019.
- J.3 **Wang, L.** and Simaan, N., "Geometric Calibration of Continuum Robots: Joint Space and Equilibrium Shape Deviations", *IEEE Transactions on Robotics*, Vol. 35, No. 2, pp. 387-402, 2019.
- J.4 **Wang, L.**, Chen, Z., Chalasani, P., Yasin, R. M., Kazanzides, P., Taylor, R. H. and Simaan, N. "Force-Controlled Exploration for Updating Virtual Fixture Geometry In Model-Mediated Telemanipulation," *ASME Journal of Mechanisms and Robotics*, Vol. 9, No. 2, pp. 021010, 2017.
- J.5 Garbin, N., **Wang, L.**, Chandler, J. H., Obstein, K. L., Simaan, N., and Valdastrri, P., "Dual-Continuum Design Approach for Intuitive and Low-Cost Upper Gastrointestinal Endoscopy", *IEEE Transactions on Biomedical Engineering, in press*, 2018.
- J.6 Roy, R., **Wang, L.**, Simaan, N., "Modeling and Estimation of Friction, Extension, and Coupling Effects in Multisegment Continuum Robots," *IEEE Transactions on Mechatronics*, Vol. 22, No. 2, pp. 990-920, 2017.
- J.7 Chalasani, P., **Wang, L.**, Yasin, R. M., Simaan, N., and Taylor, R.H., "Preliminary Evaluation of an Online Estimation Method for Organ Geometry and Tissue Stiffness", *IEEE Robotics and Automation Letters*, vol. 3, no. 3, pp. 1816-1823, 2018.
- J.8 Simaan, N., Yasin, R. M. and **Wang, L.** , "Medical Technologies and Challenges of Minimally Invasive Intervention and Diagnostics in Confined Spaces", *Annual Review of Control, Robotics, and Autonomous Systems*, Vol. 1, No. 1, 2018.
- J.9 Ayvali, E., Ansari, A., **Wang, L.**, Simaan, N., Choset, H., "Utility-Guided Palpation for Locating Tissue Abnormalities", *IEEE Robotics and Automation Letters*, Vol. 2, No. 2, pp. 864-871, 2017.
- J.10 Groom, K., **Wang, L.**, Simaan, N., Netterville, J., "Robot- Assisted Trans-nasal Laryngoplasty in Cadaveric Models: Quantifying Forces and Identifying Challenges", *The Laryngoscope*, Vol. 125, No. 5, pp. 166-168, 2015.
- J.11 Simaan, N., Bajo, A., Rieter, A., **Wang, L.** , Allen, P., Fowler, D. "Lessons Learned Using the Insertable Robotic Effector Platform (IREP) for Single Port Access Surgery", *Journal on Robotic Surgery*, Vol. 7, pp. 235-240, 2013.

CONFERENCE PUBLICATIONS

- C.1 Garbin, N., **Wang, L.**, Chandler, J. H., Obstein, K. L., Simaan, N., and Valdastrri, P., "A Disposable Continuum Endoscope Using Piston-driven Parallel Bellow Actuator", IEEE International Symposium on Medical Robotics (ISMR), Atlanta, GA, 2018, (*best student paper*).
- C.2 Yasin, R. M., **Wang, L.**, Abah, C. and Simaan, N., "Using Continuum Robots for Force-controlled Semi-autonomous

- Organ Exploration and Registration", IEEE International Symposium on Medical Robotics (ISMR), Atlanta, GA, 2018, (*finalist for best student paper*).
- C.3 Salman, H., Ayvali, E., Srivatsan, R. A., Ma, Y., Zevallos, N., Yasin, R.M., **Wang, L.**, Simaan, N., and Choset, H., "Trajectory-Optimized Sensing for Active Search of Tissue Abnormalities in Robotic Surgery", IEEE International Conference on Robotics & Automation (ICRA'), 2018.
- C.4 Garbin, N., **Wang, L.**, Sohn, D., Obstein, K. L., Simaan, N., and Valdastrì, P., "An Intuitive Disposable Endoscope with Intrinsic Pneumatic Actuation", 29th Conference of the international Society for Medical Innovation and Technology (iSMIT), University of Torino, Italy, 2017.
- C.5 Del Giudice, G., **Wang, L.**, Shen, J., Joos, K. and Simaan, N., "Continuum Robots for Multi-Scale Motion: Micro-Scale Motion Through Equilibrium Modulation", IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS'), pp. 2537 - 2542, Vancouver, Canada, 2017.
- C.6 Srivatsan, R.A., **Wang, L.**, Ayvali, E., Simaan, N., Choset, H., "Simultaneous Registration and Stiffness mapping of a Flexible Environment using Stiffness and Geometric Prior," Proceedings of the Hamlyn Symposium of Medical Robotics, London, U.K., 2016.
- C.7 **Wang, L.**, Chen, Z., Chalasani, P., Pile, J., Kazanzides, P., Taylor, R.H., Simaan, N., "Updating Virtual Fixtures From Exploration Data in Force-Controlled Model-Based Telemanipulation," Proceedings of ASME International Design Engineering Technical Conference (IDETC'2016), Charlotte, NC., 2016.
- C.8 Roy, R., **Wang, L.**, Simaan, N., "Investigation of effects of dynamics on intrinsic wrench sensing in continuum robots" IEEE International Conference on Robotics & Automation (ICRA')¹, pp. 2052 - 2059, Stockholm, Sweden, 2016. (*finalist for best medical robotics paper*).
- C.9 Chalasani, P., **Wang, L.**, Roy, R., Simaan, N., Taylor, R.H., Kobilarov, M., "Concurrent Nonparametric Estimation of Organ Geometry and Tissue Stiffness Using Continuous Adaptive Palpation", IEEE International Conference on Robotics & Automation (ICRA'), pp. 4164 - 4171, Stockholm, Sweden, 2016.
- C.10 Srivatsan, A., Ayvali, E., **Wang, L.**, Roy, R., Simaan, N., Choset, H., "Complementary Model Update: A Method for Simultaneous Registration and Stiffness Mapping in Flexible Environments", IEEE International Conference on Robotics & Automation (ICRA'), pp. 924 - 930, Stockholm, Sweden, 2016.
- C.11 Ayvali, E., Srivatsan, A., **Wang, L.**, Roy, R., Simaan, N., Choset, H., "Using Bayesian Optimization to Guide Probing of a Flexible Environment for Simultaneous Registration and Stiffness Mapping", IEEE International Conference on Robotics & Automation (ICRA'), pp. 931 - 936, Stockholm, Sweden, 2016.
- C.12 **Wang, L.** and Simaan, N., "Investigation of Error Propagation in Multi-backbone Continuum Robots", proceedings of the 14th IFToMM (International Federation for the Promotion of Mechanism and Machine Science) Symposium on Advances in Robot Kinematics (ARK2014), Lenarčič, J. and Khatib, O. (Eds.), pp. 385-394, Ljubljana Slovenia, June 29-July 3, 2014.
- C.13 Bajo, A., Goldman, R. E., **Wang, L.**, Fowler, D. and Simaan, N., "Integration and Preliminary Evaluation of an In-

¹Although in some areas conference papers are considered non-peer reviewed publications, in my field all conference papers are peer reviewed. For example, ICRA is the largest robotics conference organized by IEEE society. The acceptance rate for ICRA was 40.25% in 2012, 38.5% in 2013, 48% in 2014, 41% in 2015, 35.1% in 2016.

sertable Robotic Effectors Platform for Single Port Access Surgery", 2012 IEEE International Conference on Robotics and Automation, St. Paul, MI USA, pp. 3381-3387, 2012. (*finalist for best medical robotics paper*).

- C.14 **Wang, L.**, Del Preto, J., Bhattacharyya, S., Weisz, J., and Allen, P. K., "A highly-underactuated robotic hand with force and joint angle sensors". IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS'), pp. 1380-1385, San Francisco, CA, USA, 2011.
- C.15 Zhang, W., **Wang, L.**, Hao, L., et al (2010). An indirect style linkage under-actuated humanoid robot hand. 2nd International Asia Conference on Informatics in Control, Automation and Robotics (CAR), pp. 421-424, Wuhan, China, 2010.
- C.16 **Wang, L.**, Zhang, W., Ye, Y., et al (2009). The indirect style under-actuated robotic finger with tendon-slider mechanisms. IEEE International Conference on Robotics and Biomimetics (ROBIO'), pp. 1790-1795, Guilin, China, 2009.

SUMMARY OF RESEARCH, TEACHING AND SERVICE

PUBLICATION AND SCHOLARSHIP

- 10 independent journal contributions published at high quality journals in my field
- 1 journal manuscripts under review
- 16 peer reviewed conference publications published in the most selective peer-reviewed venues for robotics including IEEE International Conference for Robotics and Automation and IEEE/RSJ International Conference on Intelligent Robots and Systems
- 296 citations, h-index 8, i10-index 8 according to Google Scholar

TEACHING AND MENTORING

- Teaching assistant for an advanced graduate class twice
- Grader for a graduate class
- Teaching assistant for an undergraduate class
- 3 undergraduate students and 1 high school student mentored

PROFESSIONAL SERVICE ACTIVITIES

- 29 manuscripts reviewed for high impact journals in robotics
- 11 manuscripts reviewed for major conferences in robotics
- 1 workshop co-organized, 3 invited seminar talks
- Student Member, IEEE. Student Member, ASME.
- Helped to organize and co-taught 2 winter courses for high school students.

AWARDS AND HONORS

- Finalist award for best poster in workshop on High Accuracy Mobile Manipulation in Challenging Environments in IEEE International Conference on Robotics & Automation, 2019
- Best student paper in IEEE International Symposium on Medical Robotics (ISMR), 2018.
- Finalist award for best medical robotics paper in IEEE International Conference on Robotics & Automation, 2016
- Finalist award for best medical robotics paper in IEEE International Conference on Robotics & Automation, 2012

TEACHING, MENTORING AND SERVICE

JOURNAL REVIEWS

I have provided in total 29 journal manuscript reviews for the following list of journals:

- IEEE Transactions on Robotics (T-RO)
- IEEE/ASME Transactions on Mechatronics (T-Mech)
- ASME Journal of Mechanisms and Robotics (JMR)
- IEEE Transactions on Biomedical Engineering (TBME)
- Mechatronics (Elsevier)
- Robotica
- Autonomous Robots (Springer)
- Advanced Robotics
- IEEE Robotics and Automation Letters (RA-L)
- Frontiers Robotics and AI

CONFERENCE REVIEWS

In addition to the journal reviews, I have also provided 7 reviews to annual conferences in my field:

- International Conference on Robotics and Automation (ICRA)
- International Conference on Intelligent Robots and Systems (IROS)
- RSI International Conference on Robotics and Mechatronics (ICRoM)

OUTREACH EVENTS AND DISSEMINATIONS

Workshop at the ASME Dynamic Systems and Control Conference

My advisor Dr. Simaan and I offered a workshop titled "Continuum Robots for Surgery: Modeling, Control, and Applications"² at the ASME Dynamic Systems and Control Conference, Tysons Corner, Virginia, 2017. This 4-hour workshop that was targeted towards graduate students interested in pursuing research in the area of continuum robot modeling, control

²<http://nri-csa.vuse.vanderbilt.edu/joomla/index.php/workshop-in-dscc-2017-continuum-robots-for-surgery-modeling-control-and-applications>

and applications. The workshop covered surgical applications, kinematic and static modeling, sensing, and control of these robots.

Winterim class at Harpeth Hall high school

My advisor Dr. Simaan, my colleagues in ARMA and I have been involved in outreach activities aimed at helping high school students to identify areas of interest related to science, technology and mathematics. I helped organize and co-taught³ a winter break 3-week high school class for Harpeth Hall 9th and 10th grade students. This class was offered twice, (January 4, 2016-January 22, 2016) and (January 3, 2017-January 20, 2017). The class covered introduction to robotics, medical robotics and hands-on design and programming of simple robots using Arduino. The following web page⁴ provides the code, design and slides for this class.

NSF funded project website

Since I joined ARMA Lab in 2012, I have been helping to maintain the lab website to disseminate the research findings to the general public. I have also created an organization on github⁵ for the lab to contribute some of our software development to the research community. In 2013, I joined an NSF funded project, titled "NRI Large: Collaborative Research: Complementary Situational Awareness for Human-Robot Partnerships". Since then, I have created a website⁶ to share the research outcomes from this project. In addition, I have also published a blog article on the school website to introduce our work to general public audience⁷.

PROFESSIONAL MEMBERSHIPS

- *Student Member*, Institute of Electrical and Electronic Engineers (IEEE) - Robotics and Automation Society
- *Student Member*, American Society of Mechanical Engineers (ASME)

COURSES AS TEACHING ASSISTANT

- **ME391** "Robot Manipulators" is a *graduate* course, taught by my Ph.D. advisor Dr. Nabil Simaan at *Vanderbilt University*. It provides students with background on robot modeling control while focusing on theoretical aspects of robotics including redundancy resolution, screw theory, parallel robots, interaction control, calibration and visual servoing.

I was a TA for this class during *Spring 2015* and *Spring 2017*. Besides grading, holding office hours and contributing to homework solutions, I also composed new homework questions, helped organize lecture notes, and covered lectures occasionally for Dr. Simaan when he was travelling. The student term projects were theoretically challenging and implementationally involving, which required both Dr. Simaan and I to engage in long individual discussions with students in class to provide both theoretical and hands-on consultations. I also developed robotic demonstrations on a PUMA robot for class education purposes.

³My advisor Nabil Simaan, my colleagues (Rashid Yasin, Nima Sarli) and I jointly taught this series of lectures.

⁴<http://nri-csa.vuse.vanderbilt.edu/joomla/index.php/harpethhall-winterim>

⁵<https://github.com/vu-arma-dev>

⁶nri-csa.vuse.vanderbilt.edu/joomla

⁷<https://my.vanderbilt.edu/universityfundingprograms/2017/03/arma-lab-giving-surgeons-a-sense-of-touch/>

- **ME234** "Systems Dynamics" is an *undergraduate* course, taught by Dr. Kenneth D. Frampton at *Vanderbilt University*. It covers energy-based modeling of dynamic mechanical, electrical, thermal, and fluid systems to formulate linear state equations, including system stability, time domain response, and frequency domain techniques. I served as a TA⁸ for this class during *Fall 2013*. Besides grading homework, I also prepared the lab setup with my TA colleagues and led lab sessions in turns.
- **E4058** "Mechatronics and Embedded Micro Systems" is a *graduate* course, taught by Dr. Fred Stolfi at *Columbia University*. It teaches mechatronics as the application of electronics and microcomputers to control mechanical systems. The lab systems explored in class include on/off systems, solenoids, stepper motors, DC motors, thermal systems and magnetic levitation. Students in class are asked to use analog and digital electronics and various sensors for control and to program microcomputers in **Assembly** and **C**. I served as a grader⁹ for this class during *Fall 2011*. Besides grading homework, I also led lab sessions each week, during which I explained the goals and provided assistance during labs.

UNDERGRADUATE / HIGH SCHOOL MENTORING

I have co-advised the following undergraduate / high school students with Dr. Nabil Simaan. Most of these students are mechanical engineering students, participating in Research Experience for Undergraduates (REU) or on a volunteer basis.

- **Hannah Moore**, fall 2017 to spring 2018
Senior at Harpeth Hall High School. Currently an undergrad at Belmont University.
- **Garrison Johnston**, summer 2016, NSF REU supplement for grant #IIS-1327566
*Undergraduate student at Rensselaer Polytechnic Institute, class of 2018.
Currently a Ph.D. student at Vanderbilt University.*
- **Seonghoon Noh**, summer 2016, Vanderbilt Undergraduate Summer Research Program
*Undergraduate student at Vanderbilt University, class of 2018.
Currently a Ph.D. student at Yale University.*
- **Seonghoon Noh**, spring 2016
- **Garrison Johnston**, summer 2015, NSF REU supplement for grant #IIS-1327566
- **Ellie Fitzpatrick**, summer 2015
Junior at Harpeth Hall High School. Currently an undergrad at Case Western Reserve University.
- **Ellie Fitzpatrick**, winter 2015
- **Changyuan Zhang**, summer 2014, NSF REU supplement for grant #IIS-1327566
Undergraduate student at Vanderbilt University, class of 2016.

⁸I am one of the 4 TAs for this class.

⁹I was supported as a grader but the job description was equivalent to a TA