Wenda Xu, PHD Candidate

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Short Bio

Ph.D. candidate in Robotics and Mechatronics at Virginia Tech, with expertise and experience in robotic system development, motion planning, kinematics and dynamics, precision mechanical/mechanism design, design synthesis, design optimization, machine learning, and applied control systems design. My doctoral research focus is on system development of medical robotic exoskeleton gloves. I also developed and applied a data-driven dynamic model prediction approach for force predictive control, developed a vision system to provide perception for manipulation using machine learning techniques, and implemented reinforcement learning methods for motion planning. With solid knowledge in both Mechanical Engineering and Computer Science, I have a successful track record with producing innovative and interdisciplinary approaches to engineering system development from concept to completion.

Key Skills

- ✓ Mechatronics Design
- ✓ Robotic System Integration
- ✓ Deep Learning
- ✓ Human Machine Interfaces (HMI)
- ✓ Kinematics and Dynamics
- ✓ Robotic Manipulation
- ✓ Reinforcement Learning
- ✓ Data Analysis
- ✓ Control Systems
- ✓ Machine Learning
- ✓ Motion Planning
- ✓ Real-time Systems

Software and Coding Skills

Design Software: SolidWorks, NX
Robotics Software: ROS, PyTorch, Mujoco, MoveIt!, TensorFlow, Linux, Simscape
Programming/Coding skills: Python, C++, Java, MATLAB /Simulink

Education

2023 **Ph.D.** **Mechanical Engineering** (GPA 4.0/4.0) ***Virginia Tech***, VA
Dissertation: Design and Development of a Medical Robotic Exoskeleton Glove System

2023 **M.Sc.** **Computer Science** (GPA 3.7/4.0) ***Georgia Institute of Technology***, GA
Major: Computational Perception and Robotics

2018 **M.Sc.** **Mechanical Engineering** (GPA 3.8/4.0) ***Columbia University***, NY
Major: Robotics

2016 **B.Sc.** **Mechanical Engineering** (GPA 3.84/4.0) ***Hunan University***, China

Professional Work Experience

ASML Holding, Semiconductor Company *San Jose, CA*
Systems Engineer *Feb.2019 — Aug.2019*

- Full prototype E-beam Inspection System integration and testing.
- Diagnosed electro optical issues, enabling the development of precise inspection system.

- Optimized wafer stage motion control utilizing interferometry and vibration analysis to improve the accuracy and reliability of the inspection system.

Research Experience

Virginia Tech, Robotics and Mechatronics Lab (Directed by Prof. Pinhas Ben-Tzvi) *Blacksburg, VA*

Research Assistant (Focused on robotic exoskeleton gloves) *2019 - Present*

Keywords: *Kinematics, Dynamics, Motion Planning, Control, Reinforcement Learning, Simscape, Python, C++*

- Designed two generations of robotic glove exoskeletons for people who suffer from hand disabilities.
- Derived kinematic and dynamic models for exoskeleton gloves, resulting in mechanism optimization and finger motion control.
- Developed a material recognition algorithm by combining transfer learning and conditional random field techniques using PyTorch, resulting in a highly accurate and reliable system.
- Developed an algorithm for object weight estimation and localization, contributing to developing precise and efficient grasping strategies.
- Proposed a data-driven dynamic model prediction and force predictive control algorithm, improving the precision of grasp force prediction (~80%) and adaptability of robotic systems.
- Built a simulation environment in Simscape and Mujoco, and implemented intelligent exoskeleton glove manipulation and motion planning using deep reinforcement learning techniques, contributing to developing autonomous robotic glove systems.

The following video shows some of the experimental results showing the fully integrated robotic glove prototype I was involved in developing from concept to completion.

Video: ***https://youtu.be/5inX3800Thc***

Columbia University, ROAR Lab (Directed by Prof. Sunil Agrawal) *New York, NY*

Research Assistant (Focus on a robotic walker for the disabled) *May.2018 — Dec.2018*

Keywords: *SLAM, Deep Learning, Control Systems, Obstacle Avoidance, Python*

- Utilized OpenCV and Deep Learning to design a vision system for tracking pelvis position over time, resulting in improved accuracy and reliability of robotic systems.
- Detected obstacles using Lidar technology and built a current map with closed-loop detection, enabling the development of precise and efficient obstacle avoidance control systems.

Columbia University, ROAM Lab (Directed by Prof. Matei Ciocarlie) *New York, NY*

Research Assistant (Focus on fingertip tactile sensing) *Jan.2018 — Sep.2018*

Keywords: *Path Planning, ROS, Machine Learning, MATLAB*

- Developed a prototype of exoskeleton fingertips based on tactile sensors, built the Unified Robotics Description Format (URDF) configuration for the indenter machine, and path planning in ROS, contributing to developing a precise testing platform.
- Utilized MATLAB to collect and preprocess data, enabling accurate analysis and interpretation of results, and contributed to training the finger by utilizing machine learning techniques.

Additional Project Related Experiences

Intelligent Robot Arm for Control Panel *Jan.2018 — April.2018*

Keywords: *Deep Learning, ROS, Manipulation, Motion Planning, C++*

- Utilized Deep Learning to detect and classify different switches and key points to accurately determine the position of switches in 3D space resulting in an accurate and efficient manipulation systems.
- Implemented motion planning and Cartesian control in ROS.

Video: ***https://youtu.be/xc-jcEjHS-c***

UAV Control Based on Reinforcement Learning *Oct. 2018 — Dec.2018*

Keywords: *Reinforcement Learning, ROS, Path Planning*

- Setup different environments in **ROS** for diversified simulation.
- Implemented **DDPG algorithms** for goal searching path planning to control the UAV in unknown environments.

Video: https://youtu.be/jTPKImfue84

Video Stabilization *Mar. 2021 — May. 2021*

Keywords: *Computer Vision*

- Combined the **optical flow** method with pyramidal Lucas Kanade method to calculate the original camera path from sequential frames, which improved accuracy and efficiency of tracking.
- Introduced saliency constraints, considered dynamic model, and replaced the camera path with a feature path, resulting in a more efficient and stable video.

Video: https://youtu.be/kthqLPRIn9g

Self-Supervised Magnetic Resonance Imaging Reconstruction *Mar. 2021 — May. 2021*

Keywords: *Deep Learning, MRI*

- Preprocessed data on k-space single-coil knee data to focus on specific areas, and undersampled the k-space data into two disjointed sets using a Gaussian distribution to ensure data consistency.
- Defined the loss function by combining the l1-norm and l2-norm between the network output and the reconstructed image after inverse Fourier transform with undersampled data.
- Trained and optimized the ResNet-based CNN model to improve model performance.

Patents

Xu, W., Ben-Tzvi, P., Refour, E., Sebastian, B., Pradhan, S., Guo, Y., “Robotic Exoskeleton Glove System”, U.S. Patent Application No. 16/888,993, Filed June 1, 2020. (to be issued).

Peer-Reviewed Journal Publications

[1] Xu, W., Guo, Y., Bravo, C., Ben-Tzvi, P., "Design, Control, and Experimental Evaluation of a Novel Robotic Glove System for Patients with Brachial Plexus Injuries", *IEEE Transactions on Robotics*, vol. 39, no. 2, pp. 1637-1652, April 2023. Transferred to *proceedings of the 2023 IEEE International Conference on Robotics and Automation (ICRA), May 29 - June 2, 2023, London, UK.*
https://ieeexplore.ieee.org/abstract/document/9962324

[2] Xu, W., Guo, Y., Pradhan, S., Bravo, C.J., Ben-Tzvi, P., “Data Driven Calibration and Control for Compact Lightweight Series Elastic Actuators for Robotic Exoskeleton Gloves”, *IEEE Sensors Journal*, Vol. 21, Issue 19, pp. 21120-21130, October 2021.
*** Selected as a featured article in Volume 21, Issue 19**
https://www.sciencedirect.com/science/article/abs/pii/S0957415822000058

[3] Guo, Y., **Xu, W.,** Pradhan, S., Bravo, C.J., Ben-Tzvi, P., “Personalized Voice Activated Grasping System for a Robotic Exoskeleton Glove”, *Mechatronics Journal*, Vol. 83, pp. 102745:1-12, May 2022. https://www.sciencedirect.com/science/article/pii/S0957415822000058

[4] Xu, W., Guo, Y., Ben-Tzvi, P., “Vision Based Human Machine Interface for a Rehabilitation Robotic Exoskeleton Glove” *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, Under review,

December 2022.

Peer-Reviewed Conference Proceedings

[1] **Xu, W.**, Liu, Y., Ben-Tzvi, P., " Development of a Novel Low-profile Robotic Exoskeleton Glove for Patients with Brachial Plexus Injuries", *Proceedings of the 2022 IEEE International Conference on Intelligent Robots and Systems (IROS 2022)*, Kyoto, Japan, Oct. 23-27, 2022.
https://ieeexplore.ieee.org/document/9981124

[2] **Xu, W.**, Guo, Y., Bravo, C., Ben-Tzvi, P., "Development and Experimental Evaluation of a Novel Portable Haptic Robotic Exoskeleton Glove System for Patients with Brachial Plexus Injuries", *Proceedings of the 2022 IEEE International Conference on Intelligent Robots and Systems (IROS 2022)*, Kyoto, Japan, Oct. 23-27, 2022.
https://ieeexplore.ieee.org/abstract/document/9981468

[3] **Xu, W.**, Liu, Y., Bravo, C., Ben-Tzvi, P., "Design, Analysis, and Prototyping of a Novel Single DOF Index Finger Exoskeleton Mechanism", *Proceedings of the 2022 ASME IDETC/CIE, 46th Mechanisms & Robotics Conference*, St. Louis, MO, Aug. 16-19, 2022.
https://doi.org/10.1115/DETC2022-89625

[4] Guo, Y., **Xu, W.**, Pradhan, S., Bravo, C.J., Ben-Tzvi, P., "Integrated and Configurable Voice Activation and Speaker Verification System for a Robotic Exoskeleton Glove." *Proceedings of the ASME 2020 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference. Volume 10: 44th Mechanisms and Robotics Conference (MR)*. August 17–19, 2020.
https://doi.org/10.1115/DETC2020-22365

[5] **Xu, W.**, Pradhan, S., Guo, Y., Bravo, C.J., Ben-Tzvi, P., "A Novel Design of a Robotic Glove System for Patients With Brachial Plexus Injuries." *Proceedings of the ASME 2020 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference. Volume 10: 44th Mechanisms and Robotics Conference (MR)*. August 17–19, 2020.
https://doi.org/10.1115/DETC2020-22348

[6] **Xu, W.**, Guo, Y., Bravo, C., Ben-Tzvi, P., "Robotic Exoskeleton Glove System Design and Simulation for Patients with Brachial Plexus Injuries", *Proceedings of the 2023 ASME IDETC/CIE, 47th Mechanisms & Robotics Conference*, Boston, MA, August 20-23, 2023.

[7] **Xu, W.**, Guo, Y., Bravo, C., Ben-Tzvi, P., "Voice-based Human Machine Interface for Rehabilitation Exoskeleton Robotic Glove with Speaker Verification Feature Using One-shot Learning", *Proceedings of the 2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS2023)*, Detroit, Michigan, October 1-5, 2023.