Keshav Bimbraw

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EDUCATION

Worcester Polytechnic Institute Worcester, MA
Ph. D. Candidate in Robotics Engineering (Medical FUSION Lab) Aug '20 – Dec '24 (tentative)
Concentration – Ultrasound Image Processing, Medical Robotics & Human-Machine Interfacing *4.00/4.00 GPA*

Georgia Institute of Technology Atlanta, GA
M. S. with Robotics Focus (Music Technology, Computer Software & Media Applications) Aug '17 – May '19
Concentration – Human Augmentation, Medical Robotics & Robotic Musicianship *3.56/4.00 GPA*

Thapar University Patiala, India
B. E. in Mechatronics Engineering (Research Intern - IIT Delhi, Jan – Jul '16) July '13 – June '17
Concentration – Robotics & Mechatronics *4.00/4.00 GPA (8.34 CGPA)*

EXPERIENCE

OnPoint Surgical Concord, MA
Software Engineer, Machine Learning Oct '24 – now
- Working as a machine learning software engineer in the surgical robotics space.

Mitsubishi Electric Research Laboratories Cambridge, MA
Research Intern (Connectivity and Information Processing Group, Mentor: Toshiaki Koike-Akino) June '24 – Aug '24
- Worked on exciting research directions focusing on using Generative AI and Vision Language Models (VLMs) such as GPT-4o as intelligent agents for signal processing and predictive analysis. Paper accepted to NeurIPS 2024 AIM-FM workshop.
- Analyzed ultrasound image classification performance of large vision language models and improved it using retrieval augmented generation (RAG) and few-shot in context learning (ICL). Developed a demonstration for LVLM driven robot control.

Worcester Polytechnic Institute (WPI) Worcester, MA
PhD Candidate (Medical FUSION Lab, Adviser: Haichong K. Zhang) March '20 – Oct '24
- Funded by Amazon Robotics GBTI for the 2023-2024 academic year to use ultrasound to estimate finger forces to improve a haptic feedback system. Demonstrated ultrasound based continuous force estimation with an error of 5% (IEEE IUS '23). Paper. Video.
- Developed a pipeline for simultaneously estimating finger forces and hand gestures from a single ultrasound image using a two-stage Convolution Neural Network (CNN) based pipeline (NEMS '24).
- Worked on using incremental learning, 3D CNN based video classification and fine tuning approaches to improve ultrasound based gesture recognition towards inter-session generalizability (2 papers accepted to IEEE IUS '24).
- Developed an innovative mirror-based ultrasound system for gesture classification, utilizing CNNs and Vision Transformers (ViT), and achieving a gesture classification accuracy of 93% (SPIE Medical Imaging '24). Paper.
- Developed a data-driven hand gesture recognition pipeline for VR interfacing (Meta Quest Pro) using ultrasound data and CNNs, achieving online accuracy of 92% for 4 gestures, and a low pipeline latency of 59.48 ms. Paper. Video.
- Developed a deep learning based pipeline to predict finger angles & hand configurations from forearm ultrasound images. Achieved an error of 7.35º for finger joint angle prediction (IEEE ICRA '22). Paper. Video. Extended version published in IEEE T-MRB.
- Conceptualized a novel augmented reality based lung ultrasound scanning guidance system (MICCAI ASMUS '20). Paper. Video.
- Established the real-time ultrasound data acquisition software framework for a tele-operative low-cost lung ultrasound robot. Paper.
- Designing an ultrasound based American Sign Language classification system using machine learning. Poster presented at ICRA '22.
- Mentoring and assisting undergraduate teams with their major qualifying projects and independent research studies.

Mitsubishi Electric Research Laboratories Cambridge, MA
Research Intern (Connectivity and Information Processing Group, Mentor: Toshiaki Koike-Akino) May '23 – Aug '23
- Designed pipelines for multi-modal biosignal data acquisition and human-machine interaction in AR/VR/XR applications.
- Incorporated adversarial regularization to bolster hand gesture classification performance in the context of domain adaptation.
- Leveraged random channel ablation to optimize the performance across multiple biosignal modalities for hand gesture classification.
- Demonstrated that we can make multi-modal biosignal based gesture classification robust to missing channel data (IEEE EMBC '24).

Nokia Bell Labs New Providence, NJ
Augmented Human Sensing Intern/Co-Op (Data & Devices Group, Mentor: Mingde Zheng) June '22 – Dec '22
- Designed low-latency biosignal based pipelines (sEMG, IMU) to estimate bodily motion for Human-Machine Interaction. Video.
- Submitted and presented a paper (IEEE SII 2023) and multiple invention reports. Offered a Co-Op extension, which was accepted.
- Developed demonstrations for biosignal-based remote multi-sensor real-time shared-autonomy industrial robotic applications.

- Investigated multi-channel sEMG based hand movement classification for robotic control using deep learning (MLP, CNN).
- Utilized transfer learning approach for improving performance of sEMG based hand configuration classification from 91% to 96%.

Agile Resources Inc.   Peachtree City, GA
Audio DSP Engineer (Panasonic Automotive Systems of America)   Oct '19 – March '20
- Developed Qualcomm's Hexagon SDK for audio applications in Eclipse on Android framework development.
- Utilized Qualcomm tools to evaluate audio modules such as Bass Mid Treble, Parametric Equalizer, Fade & Balance, etc.

Bose Corporation   Stow, MA
Active Noise Control Engineering Intern (Automotive Systems Division)   May '19 – Oct '19
- Designed sound synthesis framework for electric vehicles and implemented processor-optimized signal processing algorithms.
- Devised a physical car sound simulation system using Logitech pedals to evaluate models and reduce testing time.

Georgia Institute of Technology (Georgia Tech)   Atlanta, GA
Research Assistant (Robotic Musicianship Lab)   Aug '17 – May '19
- Lead the ML based ultrasound gesture classification project from Aug '18 – May '19. Robot and code featured in The Age of A.I.
- Utilized ultrasound data from the forearm to classify hand grasping configurations for controlling a soft robotic gripper. Paper Link.
- Investigated a combination of Ultrasound & EMG data using supervised learning algorithms to enhance assistive robot control.
- Translated Piano playing to robots using a single DOF system and designed a robotic hand with one DOF per finger. Link.
- Created an ultrasound in the loop tendon-based wearable exoskeleton for upper extremity rehabilitation of stroke survivors. Link.
- Taught Computer-Aided Design (CAD), Fusion 360, 3D printing, and Mechatronics for Project Studio Course. Link, Link.

IIT Delhi   New Delhi, India
Research Intern (Autonomous Robotics Lab)   Jan '16 – Aug '16
- Conceptualized and programmed the system framework for two KUKA KR-5 robotic arms to collaboratively play a guitar. Link.
- Improved performance of a 6 DOF motion platform at Simulator Development Division, Secunderabad, India. Link.
- Developed a teach pendant and a control module to control virtual robots in RoboAnalyzer software. Link.
- Modified the mechanical and electrical design of Tulsi Bead making device under the rural development initiative of IIT Delhi.

Research Interests

Human-Machine Interaction: Human-machine interfaces & robotics applications; AI-enabled robotics & medical image processing; Gesture & pose classification, estimation, & detection;

Machine Learning: Deep learning; Multi-modal data processing; Transfer Learning; Generative AI; Deep learning model optimization; Model compression; Data compression; Online learning; End-to-end deep learning pipelines;

Robotics: Wearable robotics & wearable sensor systems; Design & development of robots for human-robot interaction; Computer vision; Industrial robotics & automation; Robot teleoperation;

Medical Robotics: New technologies & methodologies in medical robotics; Ultrasound image processing; IoT (Internet of Things); Device development; Surgical robotics;

SKILLS

Software Skills	Python, TensorFlow, PyTorch, ROS, Linux, NumPy, MATLAB, OpenCV, C++
Deep Learning Model Experience	1D, 2D and 3D CNN, Vision Transformer, GPT-x, Enc-Dec, ResNet, MLP
3D Design/3D printing	SolidWorks, Autodesk Inventor, Autodesk Fusion 360, Unity, TinkerCAD, Cura
Electrical/Electronic skills	Arduino, Raspberry Pi, Motors, Actuators, Hardware & software interfacing
Programming Frameworks	Shell Scripting, Git, Visual Studio Code, PyCharm, Version Control

ACADEMIC PROJECTS

Ultrasound based Gesture Recognition on Edge (WPI, On Device Deep Learning)   Fall '23
- Developed an edge solution for ultrasound based gesture classification by deploying a pre-trained CNN on a Raspberry Pi.
- Utilized Float16 quantization to reduce latency by 10 ms while achieving the same train and test accuracy.

Analyzing the performance of a cart pole system for different parameters for RL (WPI, Artificial Intelligence)   Spring '23
- Implemented a Reinforcement Learning framework in PyTorch using OpenAI Gym where the goal is to keep a pole upright,
- Analyzed the performance of the system for Deep Q-Networks (DQN) and Q-Learning scenarios for various system parameters.

Comparing low & high-dimensional forearm ultrasound-based hand state classification (WPI, Machine Learning)   Spring '22

- Investigated the feasibility of using image compression techniques for extracting the latent structure of ultrasound images. Link.
- Designed a real-time ML pipeline for training and testing models for hand motion classification based on forearm ultrasound.

Navigation of a Raspberry-Pi-based Robot using camera and Lidar data (Georgia Tech, Intro. To Robotics Research)   Fall '18
- Used camera data to find the center of a ball and tracked it using Dynamixel actuators attached to a mobile robot.
- Used Lidar data to avoid obstacles and maintaining a specific distance from them while moving towards a goal (waypoint classification using SVM).

Design of an ultrasound-guided vein cannulation robot (Georgia Tech, Medical Robotics)   Spring '18
- Oversaw a 5-person multi-discipline team to develop a medical robot that can hold an ultrasound probe to detect jugular vein. Link.
- Designed and programmed a PRRRP configuration robot for its end effector to reach specific positions in the robot workspace.

LEADERSHIP

Leadership Experience at WPI   Fall '20 – now
- Mentored high school and undergraduate students towards ongoing research projects through Massachusetts Life Sciences Center (MLSC) High School Apprenticeship Program, Major Qualifying Projects (MQP), & Research Experience for Undergrads (REU).
- Senator and representative of the Robotics Department for the Graduate Student Government for academic year '21- '22.
- Member of the Rho Beta Epsilon Robotics Engineering society. Co-hosted a C++ workshop for beginners.
- Graduate Student Officer at The Alliance: the social, educational, & professional support network of LGBT+ students.

Vertically Integrated Projects (VIP) Instructor at Robotic Musicianship Lab at Georgia Tech   Fall '17 – Spring '19
- Lead teams of undergraduates in robotics and mechatronics research. Assisted with continual mentorship and guidance.

HONORS & AWARDS

- Won PhD Backlin Scholarship to cover tuition and health insurance through WPI.   Sept. '24
- Won IEEE EMBC NextGen Scholar Award.   May '24
- Funded through Amazon Robotics GBTI Award for the 2023-2024 academic year (Tuition support & yearly award)   August '23
- Selected for the 2021B cohort of Google Research's CSRMP. The first person at WPI to have ever been selected.   Sept. '21
- Awarded PhD positions at WPI & Georgia Tech. Accepted the WPI offer. (Tuition support & $31824 yearly award).   March '20
- Selected to be Diversity and Inclusion Fellow by Georgia Tech Institute Diversity ($1000 award).   February '19
- Selected as NSF-NRT ARMS (Accessibility, Rehabilitation, & Movement Science) Trainee ($1500 award).   August '18
- Scholarship to pursue master's at Georgia Tech (Tuition support & $14100 yearly award).   August '17
- Awarded merit scholarships and grants totaling INR 336,000 at Thapar University.   June '17

JOURNAL PUBLICATIONS

Published
[1]   **Bimbraw, K.**, Nycz, C. J., Schueler, M., Zhang, Z., & Zhang, H. K. (2023). Simultaneous estimation of hand configurations and finger joint angles using forearm ultrasound. *IEEE Transactions on Medical Robotics and Bionics, 5(1)*, 120-132. Paper.
[2]   Tsumura, R., Hardin, J.W., **Bimbraw, K.**, Grossestreuer, A.V., Odusanya, O.S., Zheng, Y., Hill, J.C., Hoffmann, B., Soboyejo, W. and Zhang, H.K., 2021. Tele-Operative Low-Cost Robotic Lung Ultrasound Scanning Platform for Triage of COVID-19 Patients. *IEEE Robotics and Automation Letters, 6*(3), pp.4664-4671. Paper. Video.

Awaiting Review
[1]   **Bimbraw, K.**, Wang, Y., Liu, J., & Koike-Akino, T. (2024, October). GPT Sonograpy: Hand Gesture Decoding from Forearm Ultrasound Images via VLM. *IEEE Journal of Biomedical and Health Informatics*. Paper.
[2]   **Bimbraw, K.**, Tang, Y., & Zhang, H. K. (2024, September). Acoustic Reflector based Forearm Ultrasound for Hand Gesture Classification. *IEEE Transactions on Medical Robotics and Bionics*.

In Preparation
[1]   **Bimbraw, K.**, Nekkanti, S., Tiller, D., Deshmukh, M., Calli, B., Howe, R. D., & Zhang, H. K. (2024, December). Simultaneous Estimation of Manipulation Skill and Hand Grasp Force from Forearm Ultrasound Images. *Cyborg and Bionic Systems, a Science journal*.
[2]   Lin F., **Bimbraw, K.**, Hou, S., Gao, S., Zhang, Z., and Zhang, H. K. (2024, December). Ultrasound-Based Hand Gesture Recognition with Cross-User Reproducibility through Deep Metric Learning with Triplet Network. *IEEE Robotics and Automation Letters*.

CONFERENCE PUBLICATIONS

[1]   **Bimbraw, K.**, Zhang, H. K., & Islam, B. (2024, September). Forearm Ultrasound based Gesture Recognition on Edge. In *2024 IEEE Body Sensor Networks Conference*. Paper.

[2]   **Bimbraw, K.**, Talele, A., & Zhang, H. K. (2024, September). Hand Gesture Classification based on Forearm Ultrasound Video Snippets Using 3D Convolutional Neural Networks. In *2024 IEEE International Ultrasonics Symposium (IUS)* (pp. 1-4). IEEE. Paper.

[3]   **Bimbraw, K.**, Rothenberg, J., & Zhang, H. K. (2024, September). Improving Intersession Reproducibility for Forearm Ultrasound based Hand Gesture Classification through an Incremental Learning Approach. In *2024 IEEE International Ultrasonics Symposium (IUS)* (pp. 1-4). IEEE. Paper.

[4]   **Bimbraw, K.**, Liu, J., Wang, Y., & Koike-Akino, T. (2024, July). Random Channel Ablation for Robust Hand Gesture Classification with Multimodal Biosignals. In *2024 IEEE Engineering in Medicine and Biology Conference (EMBC)* (pp. 1-6). IEEE. Paper.

[5]   **Bimbraw, K.**, & Zhang, H. K. (2024, April). Mirror-based Ultrasound System for Exploring Hand Gesture Classification through Convolutional Neural Network and Vision Transformer. In *Medical Imaging 2024: Ultrasonic Imaging and Tomography* (Vol. 12932, pp. 218-222). SPIE. Paper and Video.

[6]   **Bimbraw, K.**, Rothenberg, J., & Zhang, H. K. (2023, October). Leveraging Ultrasound Sensing for Virtual Object Manipulation in Immersive Environments. In *2023 IEEE 19th International Conference on Body Sensor Networks (BSN)* (pp. 1-4). IEEE. Paper. Video.

[7]   **Bimbraw, K.**, & Zhang, H. K. (2023, September). Estimating Force Exerted by the Fingers Based on Forearm Ultrasound. In *2023 IEEE International Ultrasonics Symposium (IUS)*. (pp. 1-4). Paper. Video.

[8]   **Bimbraw, K.**, & Zheng, M. (2023, January). Towards The Development of a Low-Latency, Biosignal-Controlled Human-Machine Interaction System. In *2023 IEEE/SICE International Symposium on System Integration (SII)* (pp. 1-7). Paper. Video.

[9]   **Bimbraw, K.**, Nycz, C. J., Schueler, M. J., Zhang, Z., & Zhang, H. K. (2022, May). Prediction of Metacarpophalangeal joint angles and Classification of Hand configurations based on Ultrasound Imaging of the Forearm. In: *2022 International Conference on Robotics and Automation (ICRA)* (pp. 91-97). IEEE. Paper. Video.

[10]   **Bimbraw, K.**, Ma, X., Zhang, Z., Zhang, H. (2020). Augmented Reality-Based Lung Ultrasound Scanning Guidance. In: *Medical Ultrasound, and Preterm, Perinatal and Paediatric Image Analysis. ASMUS 2020, PIPPI 2020*. Lecture Notes in Computer Science, vol 12437. Springer, Cham. doi.org/10.1007/978-3-030-60334-2_11. Paper. Video.

[11]   **Bimbraw, K.**, Fox, E., Weinberg, G. and Hammond, F. L. (2020). Towards Sonomyography-Based Real-Time Control of Powered Prosthesis Grasp Synergies. In: *2020 42nd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC)*, Montreal, QC, Canada, 2020, pp. 4753-4757, doi: 10.1109/EMBC44109.2020.9176483. Paper. Video.

[12]   Mehta, I., **Bimbraw, K.**, Chittawadigi, R. G., & Saha, S. K. (2016). A teach pendant to control virtual robots in Roboanalyzer. In: *2016 Int. Conference on Robotics and Automation for Humanitarian Applications (RAHA)* (pp. 1-6). IEEE. Paper.

[13]   **Bimbraw, K.**, Mehta, I., Venkatesan, V., Joshi, U., Sabherwal, G. S., & Saha, S. K. (2016). Performance improvements of a 6-DOF motion platform. In: *2016 Int. Conference on Robotics & Automation for Humanitarian App. (RAHA)* (pp. 1-5). IEEE. Paper.

[14]   Kaur, M., Singh, G., **Bimbraw, K.**, & Uniyal, P. (2015). Study of phase transformation and microstructure of alcohol washed titania nanoparticles for thermal stability. In: *AIP Conference Proceedings* (Vol. 1675, No. 1, p. 030049). AIP Publishing. Paper.

[15]   **Bimbraw, K.** (2015). Autonomous cars: Past, present, and future. In: *2015 12th International Conference on Informatics in Control, Automation and Robotics (ICINCO)* (Vol. 1, pp. 191-198). IEEE. Paper.

PRESENTATIONS AND POSTERS

[1]   **Bimbraw, K.**, Wang, Y., Liu, J., & Koike-Akino, T. (2024, July). GPT Sonograpy: Hand Gesture Decoding from Forearm Ultrasound Images via VLM. *AIM-FM: Advancements in Medical Foundation Models: Explainability, Robustness, Security, and Beyond at Neural Information Processing Systems (NeurIPS 2024)*.

[2]   Murphy, A., **Bimbraw, K.**, Vostrikov, S., Enyedy, A., Cossettini, A., & Zhang, H. K. (2024). Towards Wearable Forearm Ultrasound Based Gesture Recognition for Human-Robot Interfacing. *Biomedical Engineering Society Meeting (BMES 2024)*.

[3]   **Bimbraw, K.**, Tang, Y., & Zhang, H. K. (2024). Acoustic Reflector based Forearm Ultrasound for Hand Gesture Classification. *Northeast Robotics Colloquium (NERC 2024)*.

[4]   **Bimbraw, K.**, & Zhang, H. K. (2024). Towards Forearm Ultrasound based Hand Gesture Classification and Finger Force Estimation using Deep Learning. *New England Manipulation Symposium (NEMS 2024)*.

[5]   Garza, J., **Bimbraw, K.**, Tang, Y., & Zhang, H. K. (2023). Integrating Vibrational Haptic Feedback on Sonomyography Hand Configuration Estimation. *2023 BMES Annual Conference*.

[6]   **Bimbraw, K.**, Rothenberg, J., & Zhang, H. K. (2022). Forearm Ultrasound Images can be Classified to Predict Static American Sign Language Letters. In: *2022 International Conference on Robotics and Automation Workshop on Human-centered Autonomy in Medical Robotics (IEEE ICRA)*. Poster. Abstract.

[7]   **Bimbraw, K.**, Fox, E., Weinberg, G. & Hammond, F. L. (2019). Sonomyography based real-time hand grasp configuration identification via supervised learning to control a soft robotic gripper. In: *2019 Spring School on Medical Robotics (SSMR) and 2019 International Symposium on Medical Robotics (ISMR)*, Atlanta, GA, USA. Poster.

[8]   **Bimbraw, K.** (2018). Imparting expressivity and dynamics to percussive musical robot Shimon. In: Three Minute Thesis (3MT™) at Georgia Tech. Link.

[9]   Rosa, L., **Bimbraw, K.**, Hammond, F. L. & Weinberg, G. (2018). Comparison and Integration of SMG and EMG. In: *BMES 2018 Annual Meeting*. Atlanta, GA, USA. Poster.

PROFESSIONAL AFFILIATIONS

- Institute of Electrical and Electronics Engineers (IEEE)
- IEEE Robotics & Automation Systems (RAS)
- Biomedical Engineering Society (BMES)
- Association for Computing Machinery (ACM)

REVIEWING

- IEEE Robotics and Automation Letters (IEEE RA-L)
- Medical Image Computing and Computer Assisted Interventions (MICCAI) Advances in Simplifying Medical UltraSound (ASMUS)
- IEEE International Conference on Robotics and Automation (ICRA)

REFERENCES (Contact information available upon request)

Haichong K. Zhang Assistant Professor, Robotics Engineering Worcester Polytechnic Institute	Toshiaki Koike-Akino Distinguished Research Scientist Mitsubishi Electric Research Laboratories
Ziming Zhang Assistant Professor, Electrical & Computer Engineering Worcester Polytechnic Institute	Jing Liu Visiting Research Scientist Mitsubishi Electric Research Laboratories
Frank L. Hammond III Assistant Professor, Mechanical Engineering Georgia Institute of Technology	Mingde (Jack) Zheng Principal Scientist, Augmented Human Sensing, Nokia Bell Labs
Ayanna Howard Dean of Engineering, Monte Ahuja Endowed Dean's Chair College of Engineering, The Ohio State University	Michael Eggleston Data & Devices Group Leader, Nokia Bell Labs

MENTEES

Matthew Hunter Mentored At: Georgia Tech (VIP) Current Affiliation: Stanford University	Catherine Pollard Mentored At: Worcester Polytechnic Institute (MLSC) Current Affiliation: John Hopkins University
Kevin Greene Mentored At: Worcester Polytechnic Institute (MLSC) Current Affiliation: Worcester Polytechnic Institute	Matthew Garza Mentored At: Worcester Polytechnic Institute (REU) Current Affiliation: University of Texas