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-Computer Interaction   *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

Mitsubishi Electric Research Laboratories   Cambridge, MA

Research Intern (Connected Interfaces Group, Mentor: Toshiaki Koike-Akino)   May '23 – Aug '23; June '24 – now

- Working on exciting research directions focusing on Generative AI and Vision Language Models (VLMs) like GPT-4o. Paper.
- 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 randomized channel ablation to optimize the performance of multi-modal biosignal modalities (IEEE EMBC 2024).

Worcester Polytechnic Institute (WPI)   Worcester, MA

Research Assistant (Medical FUSION Lab)   March '20 – now

- Funded by Amazon GBTI grant 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 an innovative mirror-based ultrasound system for gesture classification, utilizing Convolutional Neural Networks (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.

Nokia Bell Labs   New Providence, NJ

Augmented Human Sensing Co-Op (Data and Devices Group, AI Research Lab)   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 for improving performance of sEMG based hand configuration classification from 91% to 96%.

Agile Resources Inc.   Alpharetta/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.

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.
- Investigated a combination of Ultrasound & EMG data using supervised learning algorithms to enhance assistive robot control.
- 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.

SKILLS

Software Skills	Python, TensorFlow, PyTorch, ROS, Linux, NumPy, MATLAB, OpenCV, C++
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

RECENT ACADEMIC PROJECTS

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.

LEADERSHIP

- Mentored high school & undergraduate students towards ongoing projects through MLSC, MQP & REU (WPI), & VIP (GT).
- Senator and representative of the Robotics Department for the Graduate Student Government for academic year '21 - '22.

HONORS & AWARDS

- 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 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

SELECTED FIRST-AUTHOR PUBLICATIONS (Full list: CV)

[1] **Bimbraw, K.**, Wang, Y., Liu, J., & Koike-Akino, T. (2024, July). GPT Sonograpy: Hand Gesture Decoding from Forearm Ultrasound Images via VLM. In arXiv:2407.10870. Paper.

[2] **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.

[3] **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* (Vol. 12932, pp. 218-222). SPIE. Paper and Video.

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

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

[6] **Bimbraw, K.**, 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). IEEE. Paper. Video.

[7] **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 Link. Video. *Journal Paper published in IEEE Transactions on Medical Robotics and Bionics.*

[8] **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*. Paper Link. Video.

[9] **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 Link. Video.