Blair H. Hu

Shirley Ryan AbilityLab
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Education

Ph.D. Candidate in Biomedical Engineering, Northwestern University, Chicago, IL
Expected graduation: August 2019, M.S. degree awarded in 2018 (4.0/4.0 GPA)
Thesis: "Exploiting human movement and machine learning for robust control of lower-limb assistive devices"
Advisor: Levi Hargrove, Ph.D.

B.S. in Biomedical Engineering, **Highest Distinction**, University of Virginia, Charlottesville, VA
Graduation: May 2013 (3.9/4.0 GPA)
Thesis: "Novel EMG-based rehabilitation gaming: A customizable biofeedback device for improving muscle strength and control"

Skills and Strengths

Programming: Python (NumPy, SciPy, scikit-learn, pandas, matplotlib, Tensorflow/Keras), MATLAB, familiar with SQL/R/C/C++
Other tools: Jupyter notebooks, Git, Command line, familiar with Mac OS/Linux
Data science: Machine learning (classification, regression, Bayesian networks, deep neural networks), algorithm validation, data wrangling, data visualization, feature extraction, dimensionality reduction, data augmentation, regularization techniques, sampling methods, statistical modeling, hypothesis testing
Expertise: Predictive models, generative models, signal processing, time series data, wearable sensors

Experience

Graduate Research Assistant, Center for Bionic Medicine (Shirley Ryan AbilityLab, Northwestern University), Chicago, IL

Applied deep learning to improve generalizability of activity prediction for assistive devices Jan 2018-Present

- Surveyed state of the art techniques in deep learning developed for other domains and data types to creatively formulate machine learning problems to improve activity prediction for controlling a powered leg prosthesis
- Developed a data processing workflow to consolidate and standardize unstructured time series data (17 channels, 1 kHz sampling rate) previously acquired from four amputee subjects across four separate experimental sessions by clinical and research teams
- Integrated Github repositories with personal code to implement and validate a semi-supervised adversarial autoencoder model in Keras/Tensorflow (Jupyter notebook) to simultaneously predict locomotor activities and artificially synthesize multivariate time series sensor data in order to improve classifier generalizability to unseen human movement variability and devices
- Implemented data augmentation techniques to amplify number of training examples to train a deep neural network with hundreds of empirical examples and used data visualization tools with qualitative and quantitative outcome measures to debug and tune neural network parameters for stable convergence and practical and clinical benefit according to the problem formulation

Scalable data-driven intent recognition infrastructure for controlling exoskeletons Sept 2016-June 2018

- Developed and completed an instrumentation setup and experimental protocol to collect labeled training data of natural transitions between seven locomotor activities (e.g. walking, ramps, stairs) from ten able-bodied human subjects
- Constructed an end-to-end data processing pipeline including signal conditioning, segmentation and windowing, feature extraction, dimensionality reduction, and classification in Python (Jupyter notebook)
- Built a graphical user interface with data visualization in MATLAB to enable immediate quantitative assessment of design choices for the processing pipeline to elucidate tradeoffs in accuracy, delay, and robustness to noise for personal and population models
- Thoroughly analyzed effects of choices for sensor data composition and classifier (linear discriminant analysis, support vector machine, and neural network) on performance and practicality to achieve best overall activity prediction accuracy of 99%
- Self-managed execution of overall project goals and deliverables, and communicated main findings through monthly updates, semi-annual presentations, and a final report to an industrial partner and the funding agency to accelerate implementation of real-time intent recognition for an ankle exoskeleton prototype for recreational and military applications

Open access benchmark dataset of human movement data for activity prediction Jan 2017-Jan 2018

- Cleaned 20 GB of unstructured human movement time series data (52 channels,1 kHz sampling rate) from ten experimental subjects to improve dataset accessibility and usefulness for activity prediction-related applications
- Established dataset validity by rigorous comparison of post-processed empirical kinematic and electromyographic data with reported values for several locomotor activities aggregated from studies found in previous literature
- Extracted metadata and assembled a comprehensive user guide to enhance transparency and reproducibility of experimental protocol and classification results and managed content on an open access repository (Figshare)
- Providing ongoing support to dataset users (2,000 total views and 200 total downloads internationally to date)

Publications and Presentations

1. **Hu, B.**, Hargrove, L. "Style transfer using deep neural networks to synthesize realistic sensor data for analogous assistive devices." *In preparation.*
2. **Hu, B.**, Hargrove, L. "Encoding variability within deep neural networks to improve stability and generalizability of intent recognition for a powered leg prosthesis." *In preparation.*
3. **Hu, B.**, Rouse, E., Hargrove, L. (2018). "Benchmark datasets for bilateral lower-limb neuromechanical signals from wearable sensors during unassisted locomotion in able-bodied individuals." Frontiers in Robotics and AI, 5 (14). https://doi.org/10.3389/frobt.2018.00014
4. **Hu, B.**, Rouse, E., Hargrove, L. (2018). "Fusion of bilateral lower-limb neuromechanical signals improves prediction of locomotor activities." Frontiers in Robotics and AI, 5(78). https://doi.org/10.3389/frobt.2018.00078
5. **Hu, B.**, Krausz, N., Hargrove, L. (2018). "A novel method for bilateral gait segmentation using a single thigh-mounted depth sensor and IMU." 7th IEEE International Conference on Biomedical Robotics and Biomechatronics, Enschede, Netherlands. (*Oral presentation*)
6. **Hu, B.**, Rouse, E., Hargrove, L. (2017). "Using bilateral lower limb kinematic and myoelectric signals to predict locomotor activities: A pilot study." 8th IEEE/EMBS International Conference on Neural Engineering and Rehabilitation, Shanghai, China. (*Poster presentation*)

Leadership and Teaching

Team Lead for Student Academic Group (Center for Bionic Medicine, Shirley Ryan AbilityLab) Jan 2017-Jan 2018

- Provided organizational leadership of scholarly activities for 10+ graduate students/post-docs by coordinating weekly meetings to discuss relevant papers in the field and give constructive criticism on research methodology, manuscripts, and presentations
- Led six informal hour-long lessons on machine learning, optimization, Git, control systems for assistive devices, general research methods, and career planning and professional development

Teaching Assistant (BME 307 Quantitative Experimentation and Design, Northwestern University) Spring 2017

Oversaw lab course for 45 undergraduate students, provided strategies to understand difficult course concepts, and used course assessments and small group meetings to provide feedback on improving data analysis and written communication (median score of 5 out of 6 on categories of preparation, helpfulness, and communication on teaching assistant course evaluation)

Small Group Leader (Park Community Church, Rogers Park) Fall 2015-Present

Provided organizational and spiritual leadership to cultivate personal growth and maturity in 10+ men by facilitating weekly discussions, fostering community, and establishing one-on-one relationships to mutually encourage and challenge members

Community Outreach

Deacon (Park Community Church, Rogers Park) July 2016-Present

Serve local congregation of 250+ by coordinating and providing care for the physical, emotional, and spiritual needs of members of the Rogers Park congregation and neighboring community

Non-Profit Development Staff (International English Center, Yogyakarta, Indonesia) June 2013-June 2014

- Raised $13k in support and sent out detailed monthly newsletters to financial sponsors
- Established local partnerships and networked with over 200 new members to plan, promote, and pioneer grand opening of the center
- Achieved Indonesian language proficiency (150 class hours), started and led more than 10 English conversation groups