PAUL GHANEM

Contact details Email: ghanem.p@northeastern.edu - Tel: + 001 240 302 7407 - Address: 587 E Broadway, apt 3, Boston, MA
Github: https://github.com/paulghanem **-** Private repos can be accessed upon request
Scholar: https://scholar.google.com/citations?user=N0wCoH8AAAAJ&hl=en
Website: https://paulghanem.github.io/

EDUCATION

2020-present	**Northeastern University** PhD student-Electrical Engineering	**USA**
2017-2019	**University of Maryland College Park - A. James Clark School of Engineering** Master of Science inRobotics	**USA**
2011 - 2016	**Lebanese American University** Bachelor of Engineering in Electrical Engineering	**Lebanon**

PROGRAMMING TOOLS

Python, PyTorch, Jax, CUDA,TensorFlow, Keras NumPy, Matlab, Modern C++17, ROS, OpenCV, Simulink Real-time, Linux

PUBLICATIONS (Machine learning and Controls)

1. **P. Ghanem**, O.Howell,M. Potter, D. Erdogmus. "Recursive Deep Inverse Reinforcement learning" Submitted to Neurips, 2025. **(Neurips).**
2. **P. Ghanem**, A. Demirkaya, A. Ramezani, Z. Danziger, T. Imbiriba, D. Erdogmus. "Learning Physics Informed Neural ODEs With Partial Measurements." Accepted in AAAI 2025. **(AAAI)**.
3. **Paul Ghanem**, Yunus Bicer, Deniz Erdogmus, Alireza Ramezani. "Efficient Modeling of Morphing Wing Flight Using Neural Networks and Cubature Rules." IEEE 62nd Conference on Decision and Control, 2023. **(CDC)**
4. Gaurav Singh, **Paul Ghanem**, Taskin Padir. "Sporadic Audio-Visual Embodied Assistive Robot Navigation for Human Tracking." Proceedings of the 16th International Conference on Pervasive Technologies Related to Assistive Environments,2023. **(PETRA)**
5. E Sihite, **P Ghanem**, A Salagame, A Ramezani, "Unsteady aerodynamic modeling of Aerobat using lifting line theory and Wagner's function." IEEE/RSJ International Conference on Intelligent Robots and Systems, 2022. **(IROS)**
6. E Sihite, B Mottis, **P Ghanem**, A Ramezani, M Gharib. "Efficient Path Planning and Tracking for Multi-Modal Legged-Aerial Locomotion Using Integrated Probabilistic Road Maps (PRM) and Reference Governors (RG)." IEEE 61st Conference on Decision and Control, 2022. **(CDC)**
7. Bibek Gupta, Adarsh Salagame, **Paul ghanem**, Eric Sihite, Alireza Ramezani, "Hovering Control of Flapping Wings in Tandem with Multi-Rotors", IEEE/RSJ International Conference on Intelligent Robots and Systems ,2023. **(IROS)**
8. D. A. Paley, A. A. Thompson, A. Wolek, and **P. Ghanem**. "Planar formation control of a school of robotic fish: Theory and experiments." Frontiers in Control Engineering, 2021.
9. **P. Ghanem**, A. Wolek, and D. A. Paley. "Parallel and Circular Formation Control of a School of RoboticFish." In proceedings of the American Control Conference, 2020. **(ACC)**
10. S. S. Saab and **P. Ghanem**, "A multivariable stochastic tracking controller for robot manipulators without joint velocities," *IEEE Transactions on Automatic Control ,2018.* ***(TAC)***

WORK EXPERIENCE

2024 **Bose Corporation** **USA**
Research Intern, Machine Learning (Python, TensorFlow,CUDA,Transformer,CNN)

- Developed a **Kalman filter-integrated deep neural network** for **real-time road noise cancellation** via active sound control using vehicle speakers.
- Processed and modeled **multi-gigabyte multimodal time-series data** from vehicle-mounted acoustic and vibration sensors to predict **cabin noise levels** at the driver's ears.
- Designed, trained, and deployed a **multimodal deep residual neural network**, robust to driver head pose variation, for personalized noise sequential **prediction** and cancellation.
- Integrated the trained model within a **Kalman filtering framework**, leveraging real-time **residual error** signals from cabin microphones for adaptive feedback control.
- Collaborated with **hardware, acoustics, and embedded software teams** to co-design and deploy **production-ready ML pipelines**.
- Delivered **production-level, testable Python code** used in internal prototype systems under a **fast-paced, agile development cycle**

2020 - present **Northeastern University** **USA**
Research Assistant in Machine Learning – Inverse Reinforcement learning for motion prediction (MPC, MPPI, IRL, Python, Jax,CUDA, Pytorch,RNN)

- Developed end-to-end planning algorithms for real-time navigation and trajectory forecasting in autonomous robotics and vehicle-like systems that reason online under uncertainty
- Designed and MPC algorithm that for multi agent aerial vehicles motion planning to escape mobile radars by maximizing the radar's Fisher Information Matrix (FIM)
- Designed an inverse reinforcement learning algorithm, by merging Maximum Entropy **Inverse Reinforcement Learning** with MPPI, to learn moving radar's cost functions and policies using radars position and velocity measurements.
- Successfully learned radars cost function and used the learned function to escape the radars using MPPI, then submitted the results to **NeurIPS.**
- Developed and validated algorithms in OpenAI gym simulation environment (ROS, OpenAI Gym) for

trajectory and end-to-end policy learning

2020 - present **Northeastern University** **USA**
Research Assistant in Machine Learning - Biomechanistic Learning Augmentation of Deep Differential Equation Representations (MATLAB, Python, TensorFlow, Pytorch,RNN)

- My research is focused on developing machine learning algorithms to learn the hidden dynamics governing the neuromodulation signal activity in lower urinary tracts with multiple sources of real datasets without access to neuromodulation data.
- Developed a recursive 2nd order newton method algorithm that learns Neural Ordinary Differential Equations (NODE) when parts of the ODEs are not observed and submitted to **NeurIPS.**
- I applied my resulting method to learn hidden peripheral neuromodulation inside the lower urinary tract (LUT) of animals to treat LUT disfunction when the neuromodulation signal is not available in training.
- Developed a companion method that learns the neuromodulation signal dynamics from data coming from different animals in a parallelized training fashion.
- Successfully used my first and second proposed methods to learn hidden neuromodulation signal from experimental data coming from single and different animals respectively.
- Preparing my second submission with the experimental dataset to be submitted to **NATURE.**

2022 - 2023 **Northeastern University** **USA**
Research Assistant in Machine Learning, Target Tracking and Sensor fusion (OpenCV, Python, Modern C++17, ROS, Linux, git,CNN)

- Lead the Human state estimation submodule in an interdisciplinary project funded by **Verizon** to deploy an aging in place robot to help the elderly. The robot includes speech recognition, computer vision, Human computer Interface and body pose estimation modules.
- Developed production-grade modules in C++ and Python for real-world robotics applications
- Designed face recognition algorithm to match face descriptors using **python** and Intel Open Vino pretrained Deep Neural Networks Library.
- Implemented a person re-ID algorithm using **C++17** and a Deep Neural Net from Intel Open Vino pre trained Library.
- Implemented a leg-tracking algorithm using lidar data and **python.**
- **Integrated** the above three algorithm in a Kalman filter in **ROS** and assigned different uncertainties to each method depending on the scenario, which enabled excellent tracking for target person.
- Led the Implementation of the integrated algorithm on the stretch robot from Hello robot in **ROS** and published my finding in **PETRA.**
- Actively maintained my module using **Git** and did version control and synchronization with project lead on a regular basis.

2020 - present **Northeastern University** **USA**
Research Assistant in Machine learning and Control Theory (Matlab, python, TensorFlow, Keras)

- Developed a machine learning approach that consists of online training deep Neural Networks using diverse types of Kalman filters (EKF, CKF).
- Designed a hybrid model for our lab's flapping wing robot by modeling the fluidic-structure interactions acting on the bat as a physics-informed neural network.
- Used my proposed online machine learning approach and my deep neural network hybrid model to learn unknown aerodynamic forces acting on our lab's flapping wing robot and published my findings in **CDC.**
- Modeled the Aerodynamic forces acting on the robotic bat wing using unsteady lifting line theory and Wagner functions.
- Validated my findings with experimental data and published my finding **IROS.**
- Assisted in the design of an observer-based controller for the robotic bat, with an actuated spherical guard that acts as a roll pitch and yaw compensator.
- Validated the above controller in real-time experiment and published my finding in **IROS**

2021–2022 **Northeastern University** **USA**
Teaching Assistant in Machine Learning (MATLAB, Python)

- Designed the assignments of the Introduction to Machine Learning Course (EECE 5644) using python and MATLAB.
- Covered fundamental machine learning topics such as Probability, Linear algebra, Bayesian Classification, Gaussian mixture models, Maximum Likelihood and Maximum-a-Posteriori (MAP) parameters estimation, Expectation Maximization, PCA, LDA, SVM, stochastic Gradient descent etc.
- Taught three lectures introduced students to my current research in training MLP's with Kalman filters and second order methods.
- Held weekly office hours and answered students' questions on the topics covered.

2019 –2020 **Airgility.co** **USA**
Controls Software Engineer (C, MATLAB, Linux)

- Worked on the implementation of controls algorithms on a novel Bi-copter drone design, in a project that is funded by Department of Homeland security.
- Implemented Madgwick filter to estimate yaw pitch and roll of the Bi-copter using 9dof IMU of a light-weight inertial navigation system (ELKA) and **C** language.
- Designed ayaw, pitch, roll and altitude PID controller for the drone using MATLAB.
- Implemented the PID Controller using C on the ELKA board mounted on the bi-copter to control yaw,

pitch and roll of the bi-copter.

2018 – 2019 **University of Maryland College Park** **USA**
Research Assistant – Control Theory (MATLAB)

- Developed a Multi-agent control that Synchronizes the heading and tail flapping frequency of a collection of underwater fish robots (AUV) having nonlinear dynamics and nonholonomic constraints using a decentralized controller with limited communication between the fish by merging Lyapunov Control and Graph Theory.
- Achieved parallel formation and symmetric circular formation for a collection of N underwater fish robots with nonlinear dynamics and nonholonomic constraints using a novel decentralized multi-agent control with limited communication between all the fish by merging Lyapunov and Graph Theory.
- Published my theoretical findings and the novel multi-agent control designs to the **American Control Conference (ACC)**
- Experimental validation was conducted later, and results were published in **Frontiers in Control Engineering Journal**

2016 – 2017 **Lebanese American University** **Lebanon**
Research Assistant - Control theory (MATLAB, Real-time Simulink, optimal control)

- Developed a model (Inertia, Gravity and friction matrices) for the Barrett 7DOF robotic arm Kinematics using Euler-Lagrange formulation. I went through transformation matrices, DH parameters, Kinematics and Euler-Lagrange formulation with no undergraduate or graduate course given at LAU
- Developed a PD controller with optimal gains calculated recursively based on a Bayesian probability theory
- Adapted the proposed approach to deal with missing velocity measurement by cheating the controller using a fictious measurement for joint velocities instead of the true measurement. We increase the uncertainty associated with joint velocities in state and measurement covariances to achieve desired performance.
- For experimental validation, I designed an interface and message instructions to operate the Barrett Whole arm 7Dof Manipulator via Real-Time Simulink using Controller Area Network (CAN) bus and xPC target.
- Implemented the proposed approach on the Barret Whole arm manipulator and Published results in **IEEE Transactions on Automatic Control (TAC)**

SELECTED COURSE PROJECTS

2020 **Reinforcement learning (Python):** **USA**

- Designed a deep deterministic policy gradient algorithm (DDPG), and a deep Q Network (DQN) to balance a legged robot starting from scratch
- Applied the above algorithms to the **OpenAI Gym** bipedal robot environment in **python** and comparedtheir performance
- Updated the reward function one the biped of the OpenAI gym and modified the punishment of the hull angle in a way that is less frequent but more severe which yielded better results than the previous rewardfunction in both RL algorithms
- Compared our results to classical nonlinear control theory approaches.