Richard (Han) Hu

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Experiences

PX Robotics *Jan. 2022 - Present*

Senior Machine Learning Engineer, Motion Control Center

- **Innovation** Spearheaded reinforcement learning based biomimetic gait controllers projects by improving on SOTA algorithms. Exceeded SOTA methods on all metrics. Achieving 1.5x better disturbance rejection, doubling maximum velocity, and generalization to unseen rough terrains and tasks. Current have 2 patents pending.
- **Locomotion** Engineered a locomotion controller for quadruped robots by integrating reinforcement learning with model-based control to enhance disturbance rejection. Achieved state of the art disturbance rejection.
- **Process Optimization** Formulated an analytical approach to reinforcement learning training, slashing model iterations by up to 70%.
- **Infrastructure** Revamped the reinforcement learning pipeline using a modular design; led the development of MLOps tools, including cloud model sharing, test automation, and data collection and analysis, reducing manual tasks by 80%.
- **Strategy** Analyzed SOTA machine learning methods for quadruped control, large language models, manipulators, and embodied AI, provides insight on departmental product strategy.

Autonomous System and Biomechatronics Lab *Sep. 2018 - Aug. 2021*

Developer, Master Thesis

- **Deep Learning** Led the development and **published** a novel sim-to-real pipeline for end-to-end reinforcement learning rough terrain navigation policy in Pytorch. Achieved 87% real world success rate, 90% simulation success rate; 72% increase against benchmarks.
- **Development** Developed a distributed software and hardware robot system using ROS, C++, Python, and SolidWorks. System included simulator, LiDAR and VIO SLAM, position controller, hardware driver, reinforcement learning training and deployment framework, 3D reconstruction module, sensor interfaces, and teleoperation.
- **Analysis** Led real-world navigation, comparison, and ablation experiments to demonstrate that the pipeline achieved 87% real world success rate given a 90% simulation success rate; up to 72% increase against existing methods
- **Publication** Published in 1) IEEE Robotics and Automation Letters 2021 and 2) IROS 2021 Conference.

Huawei Noah's Ark Lab *May. 2020 - Jan 2021*

Developer, Autonomous Driving Division

- **Path Planning** Developed, **published**, and **patented** a novel Delaunay Triangulation based spatial constraint generation algorithm for mapless autonomous vehicle navigation in a dynamic environment. Achieved 18% increase in navigation success rate and 28% increase in valid plans compared to existing methods.
- **Simulation** Engaged in simulator development using CARLA by automating map generation process from real-world datasets.
- **Publications** Published in 1) IROS 2021 Conference and 2) US Patent Application No. 17/515,522.

Projects

Parallel Proximal Policy Gradient in Pytorch *Nov. 2019*

Personal Project

- **Development** Implemented parallel agent for faster experience collection and training for proximal policy gradient in Pytorch

Apprenticeship Learning with Inverse Reinforcement Learning Implementation *Mar. 2019*

Developer, Course Project

- **Development** Implemented the Apprenticeship Learning algorithm using traditional Q-Learning algorithm in Python
- **Lecture** Lectured students on the algorithm using a version implemented in Google Colab

aUToronto - SAE AutoDrive Challenge (Winner 2018-19) *Sep. 2018 - Oct. 2019*

Planning and Control Team Member, University of Toronto Team

- **Collaboration** Aim to develop a level 4 autonomous vehicle using ROS and C++ in a team of 30+ students
- **Localization** Implemented real-time kinematics GPS using NovAtel's SPAN for centermeter level localization
- **Mapping** Automated the semantic map layer's lane to centerline association process using Python, QGIS, and Open Street Map

Toward Smart Cities: Road Accident Prevention *Sep. 2018 - Dec. 2018*

Developer, Course Project

- **Collaboration** Data-driven accident prediction using Scikit-learn in Python; within a team of 5 students
- **Data Engineering** Data collection, visualization, feature engineering, and negative sampling
- **Machine Learning** Trained and benchmarked 3 supervised learning models: Random Forest, SVM, and MLP Network

Autonomous Turtlebot *Jan. 2018 - Sep. 2018*

Developer, Course Project

- **Path Planning** Developed robot coverage and exploration algorithm using ROS and C++
- **Computer Vision** Object detection and identification using OpenCV library
- **Control** Implemented person-following and emotional model for human-robot interaction

Autonomous Maze Navigation Rover Design *Sep. 2017 - Dec. 2017*

Developer, Course Project

- **Development** Designed the software and hardware architecture for autonomous payload pick-up and delivery robot in a maze
- **Path Planning** Designed and implemented localization, collision avoidance, and path planning algorithm in MATLAB and Arduino

Publications

A Sim-to-Real Pipeline for Deep Reinforcement Learning Autonomous Navigation in Cluttered Rough Terrain

Hu. H, Kaicheng Zhang, Aaron Hao Tan, Michael Ruan, Christopher Agia, and Goldie Nejat *RAL and IROS2021*

- Proposed a pipeline to transfer challenging rough terrain navigation policy from simulation to the real-world using high fidelity simulation, abstract observation space, and domain randomization.
- The pipeline acheived a 87% real world navigation success rate given a 90% simulation success rate.
- The pipline has up to 72% increase in navigation success along with a faster travel time and shorter distance against existing methods.

Spatial Constraint Generation for Motion Planning in Dynamic Environments

Hu. H, Peyman Yadmellat *Patent and IROS2021*

- Proposed to generate spatial constraint using triangulation mesh for long-term mapless path planning in a dynamic environment.
- Overcame the static triangulation mesh assumption and the object masking issue that existing methods have.
- Achieved up to 18% increase in navigation success rate and up to 28% increase in valid plans compared to existing methods.
- Patent pending .

Optimization and System Identification of a Variable Pico-Scale Hydro Turbine for Pressure Regulation

Yu. SM, Ko. Y, **Hu. H**, Seo. J, and Bilton. AM *ASME*

- Engaged in the design and prototyping of the turbine and its experiment rig using SolidWorks, machining, and 3D printing.

Education

University of Toronto *Toronto, Canada*

Master of Applied Science, Mechanical Engineering *Sep. 2018 - Aug. 2021*

- **Specialization** Deep Reinforcement Learning, Machine Learning, Mobile Robotics; GPA (4.00/4.00)

University of Toronto *Toronto, Canada*

Bachelor of Applied Science, Mechanical Engineering *Sep. 2013 - Apr. 2018*

- **Specialization** Robotics and Mechatronics Minor; Dean's Honor List for all terms; GPA (3.81/4.00)

Honors & Awards

2019-20	**MIE Teaching Assistant Award**, University of Toronto	*Toronto, Ontario*
2013-18	**Dean's Honor List**, University of Toronto	*Toronto, Ontario*
2018	**Best Undergraduate Poster Presentation**, CFD Society of Canada Conference	*Winnipeg, Manitoba*
2015	**University of Toronto Excellence Award**, University of Toronto	*Toronto, Ontario*
2015	**Shell Canada Limited Engineering Scholarship**, University of Toronto	*Toronto, Ontario*
2015	**Best Innovation Award and Best Prototype Award**, U of T Engineering Competition Junior Design	*Toronto, Ontario*