

# Richard (Han) Hu

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## Experiences

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### Autonomous System and Biomechatronics Lab

Sep. 2018 - Aug. 2021

Researcher, Master Thesis

- **Deep Learning** Led the development and **published** a novel sim-to-real transfer pipeline for rough terrain navigation in Pytorch
- **Sim-to-Real** Researched, designed, and implemented a high fidelity Gazebo simulator and domain randomization
- **Development** Developed a decentralized software and hardware robot architecture using ROS, C++, and Python
- **Localization** Implemented LiDAR and visual SLAM on a mobile robot for real time pose estimation
- **Control** Designed and optimized a cascade PID controller for global position and wheel control in rough terrain
- **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
- **Hardware** Enhanced a robot with auxilliary computing units and sensors with components designed using SolidWorks

### Huawei Noah's Ark Lab

May. 2020 - Jan 2021

Support Researcher, Autonomous Driving Division

- **Path Planning** Developed, **published**, and **patented** a Delaunay Triangulation based spatial constraint generation algorithm for mapless autonomous vehicle navigation in a dynamic environment
- **Development** Implemented a Python based path planning simulator and the algorithm's modules for fast development iterations
- **Algorithms** Implemented Hybrid A\* and Funnel algorithm for path planning in triangulation mesh
- **Simulation** Engaged in CARLA simulator development by automating map generation process from real-world datasets

### MIE443 Mechatronics Systems: Design & Integration

Jan. 2018 - Apr. 2020

Head Teaching Assistant

- **Lecture** Lectured 4th year engineering students on ROS based robot navigation and SLAM methods
- **Mentorship** Guided students on ROS based autonomous robot algorithm development, vision sensor, and OpenCV

### Water and Energy Research Laboratory

Jan. 2018 - Sep. 2018

Researcher, Pico-Scale Hydro Turbine Design

- **Mechanical** Designed and published a variable guide vane for pico-scale hydro turbine using SolidWorks
- **Analysis** Evaluated the guide vane failure mode with fluid pressure test, mechanical stress test, and finite element analysis
- **Development** Prototyped the turbine and an experiment pipeline using Arduino, SLA 3D printing and machining techniques

### Conavi Medical

May. 2016 - Aug. 2017

Mechanical Engineer Intern, Novasight Hybrid System

- **Analysis** Investigated potential design hazards and risks of catheter rotary assembly
- **Manufacturing** Streamlined an efficient assembly and calibration work instruction for intravascular catheter
- **Organization** Established an inventory system with full traceability for FDA 510k submission validation
- **Management** Directed technical design reviews with senior leadership, accelerated the exit of the project phase
- **Mechanical** Designed imaging and rotary assembly for a intravascular catheter using MATLAB and SolidWorks

### Multiphase Flow and Spray Systems Lab

Jun. 2015 - Sep. 2015

Researcher

- **Development** Developed Arduino based camera to fluid pipeline synchronization system to speed up data collection by 85%
- **Analysis** Classified 13 novel air-fluid impingement shatter pattern using statistical analysis

## Projects

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### 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 centimeter 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

## Open Architecture Quadcopter Design

Sep. 2017 - Apr. 2018

Mechanical Designer

- **Mechanical** Designed mechanical features of quadcopter using SolidWorks and prototyped using 3D printer
- **Analysis** Evaluated failure mode of designed components using ANSYS Explicit Dynamics Analysis

## Publications

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### A Sim-to-Real Pipeline for Deep Reinforcement Learning Autonomous Navigation in Cluttered Rough Terrain (RAL, IROS2021)

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

- 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 achieved a 87% real world navigation success rate given a 90% simulation success rate
- The pipeline 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 (IROS2021, Huawei Patent)

Hu. H, Peyman Yadmellat

- 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

### Optimization and System Identification of a Variable Pico-Scale Hydro Turbine for Pressure Regulation (ASME2021)

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

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

## Education

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### 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

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