Neel **Bhatt**

PhD · Mechatronic Vehicle Systems Lab · NODE Lab

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Research Interests

Reinforcement Learning, Computer Vision, Autonomous Driving, Joint Agent Perception & Prediction, State Estimation, Intelligent Decision-Making.

Education

University of Waterloo *Sept 2018 - Present*

Doctor of Philosophy (PhD) - Mechatronics Engineering (Supervisors: A Khajepour and E Hashemi) *Waterloo, ON - Canada*

- Research focus: Spatially-aware multi-agent object motion prediction for autonomous driving using RL and potential fields
- Project Lead: WATonoBus: First Canadian all weather autonomous shuttle in operation on public roads
- Head Course TA for ME780: Autonomous Driving
- **Courses:** RL, DL, ML, Autonomous Driving, Adaptive Control, Robotics, Tools for Software Eng., Mechatronics System Integration

University of Toronto *Sept 2014 - June 2018*

Bachelor of Applied Science (BASc) with High Honours - Mechanical Eng. - Robotics Minor - GPA: 3.97/4 *Toronto, ON - Canada*

- Among the top 3 winners for the capstone design project competition across the department
- Ranked in the top 5% of all students in the department
- **Courses:** Robotics, Mechatronics Principles, Mechatronics Systems: Design and Integration, Control Systems

Experience

University of Waterloo *Sept 2018 - Present*

Lead Research Scientist, WATonoBus Autonomous Shuttle *Waterloo, ON - Canada*

- Developed and implemented hardware and software architecture for Perception, Prediction, and Decision-Making including auto startup launch scripts, custom packages and drivers (Python/C++), multi-sensor fusion, system integration (ROS), and visualization.
- Led a team of several graduate students achieving permit for daily operation and testing on public roads as part of ministry's pilot program.

University of Alberta *Jan 2021 - Present*

Visiting Research Scholar, NODE Lab *Edmonton, AB - Canada*

- Worked with Professor Ehsan Hashemi on several research projects covering RL-based decision making for human-autonomous system handover, visual and interial odometry, SLAM, object detection, cooperative perception, and supervised several graduate students.
- Developed and implemented hardware and software architecture for NODE Lab's autonomous vehicle.

General Motors R&D *May 2019 - Sept 2019*

AV Software Engineering Intern *Detroit, MI - USA*

- Designed and implemented a novel real-time supervisory DL framework for vehicle velocity estimation consisting of a LSTM-based network architecture achieving > 95% accuracy on a large test set (Python, PyTorch) – ROI for patent submitted.
- Automated data generation and augmentation to ensure class balance and generalizability.

WATonomous Self-Driving Vehicle *May 2018 - Aug 2019*

Perception Team Core Member *Waterloo, ON - Canada*

- Worked on the GM AutoDrive Competition training TensorFlow based object detection models with data augmentation to classify traffic lights and achieved higher accuracy on test images specific to application.

Clearpath Robotics *May 2017 - Sept 2017*

Applications Engineering Intern *Waterloo, ON - Canada*

- Conducted robot simulations with Gazebo and ROS for line/person following demos presented at IROS 2017.
- Design focused on addressing needs of robot autonomy team for effective image processing, recognition, and control.

University of Toronto *May 2016 - Sept 2016*

Research Intern *Toronto, ON - Canada*

- Worked with Professor Yu Sun at the Robotics Institute, specifically at the Advanced Micro and Nanosystems Lab.
- Designed and fabricated an easy to use and maintain system for vibration and acoustic isolation of one of a kind Atomic Force Microscope (AFM) with resolution better than 0.05 nm.

University of Toronto *May 2015 - Sept 2015*

Research Intern *Toronto, ON - Canada*

- Worked with Professor Chul B. Park and analyzed discrete event procedures and algorithms, studied mathematical structures behind, and designed experiments toward parametric study and simulation of relevant parameters that govern the geometry of cellular plastic structures.

Publications

Journal Articles

[J1] MPC-PF: Socially and Spatially Aware Object Trajectory Prediction for Autonomous Driving Systems Using Potential Fields
Neel P. Bhatt, Amir Khajepour, Ehsan Hashemi
IEEE Transactions on Intelligent Transportation Systems (T-ITS), 2023

[J2] Integrated Inertial-LIDAR based Map Matching Localization for Varying Environments
Xin Xia, **Neel P. Bhatt**, Ehsan Hashemi
IEEE Transactions on Intelligent Vehicles (T-IV), 2023

[J3] Infrastructure-Aided Localization and State Estimation for Autonomous Mobile Robots
Daniel Flögel, **Neel P. Bhatt**, Ehsan Hashemi
Robotics, 2022

Conference Papers

[C1] DynaStreet-SVO: Efficient Stereo Visual Odometry Using Dynamic Union Masking
Marcelo Cabrera, **Neel P. Bhatt**, Ehsan Hashemi
IEEE Intelligent Transportation Systems Conference (ITSC), Bizkaia, Spain, 2023

[C2] MPC-PF: Social Interaction Aware Trajectory Prediction of Dynamic Objects for Autonomous Driving Using Potential Fields
Neel P. Bhatt, Amir Khajepour, Ehsan Hashemi
IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2022, Kyoto, Japan

[C3] Augmented Visual Localization Using a Monocular Camera for Autonomous Mobile Robots
Ali Salimzadeh, **Neel P. Bhatt**, Ehsan Hashemi
IEEE International Conference on Automation Science and Engineering (CASE), 2022, Mexico City, Mexico

[C4] Real-time Pedestrian Localization and State Estimation Using Moving Horizon Estimation
Ehsan Mohammadbagher*, **Neel P. Bhatt***, Ehsan Hashemi, Baris Fidan, Amir Khajepour
IEEE Intelligent Transportation Systems Conference (ITSC), 2020, Rhodes, Greece

Manuscripts

[M1] Human-Autonomous System Handover Using Reinforcement Learning For Safe Decision Making in Autonomous Driving
Calarina Muslimani, Arunava Banerjee, **Neel P. Bhatt**, Mohammad Afshari, Matthew E. Taylor, Ehsan Hashemi
To be submitted to ICRA, 2023

[M2] Real Time Static and Dynamic Object Identification for Autonomous Vehicles Using Stereo Vision and Inertial Measurements
Neel P. Bhatt, Ali Salimzadeh, Ehsan Hashemi
To be submitted to T-ITS, 2023

[M3] Danger-Triggered Distributed Control for Connected Automated Driving Using Road-Side Networks
Mohammad H. Mamduhi, **Neel P. Bhatt**, Ehsan Hashemi
To be submitted to T-ITS, 2023

[M4] Reliable Slip Estimation for Autonomous Driving in GPS-Denied Environments
Arunava Banerjee, **Neel P. Bhatt**, Ehsan Hashemi
Submitted to IoT Journal, 2023

[M5] Soft Constrained Autonomous Vehicle Navigation using Gaussian Processes and Instance Segmentation
Bruno H. Groenner Barbosa, **Neel P. Bhatt**, Amir Khajepour, Ehsan Hashemi
arXiv preprint - arXiv:2101.06901, 2021

Thesis

[T1] Socially and Spatially Aware Motion Prediction of Dynamic Objects for Autonomous Driving
Neel P. Bhatt
University of Waterloo, 2023

Invited Talks

Reliable State Estimation and Distributed Controls in Intelligent Vehicular Networks
Tutorial Presenter and Organizer for IEEE Intelligent Vehicles (IV), 2023

WATonoBus - Algorithms and Software Structure for an All Weather Shuttle
Guest Lecture for ECE495 at University of Waterloo, 2023

Object Detection with ROS and OpenCV, Multi-Modal Data Acquisition, and Visualization
Guest Lecture for MECE788 at University of Alberta, 2023

An Overview of the WATonoBus - Canada's First Autonomous 5G Shuttle
Guest Lecture at University of Waterloo, 2022

Awards

Queen Elizabeth II Graduate Scholarship in Science and Technology (QEII-GSST) *2022 - 2023 & 2019 - 2020*
Government of Ontario *Waterloo, ON - Canada*
QEII-GSST is a merit-based scholarship program based on academic excellence, research ability and potential in program of study, and communication and leadership abilities targeted specifically towards students in a research-based graduate program in STEM disciplines.

Ontario Graduate Scholarship (OGS) *2021 - 2022 & 2020 - 2021*
Government of Ontario *Waterloo, ON - Canada*
OGS is a merit-based scholarship program for Ontario's best graduate students in all disciplines of academic study.

Engineering Excellence Doctoral Fellowship (EEDF) *2020 - 2021*
University of Waterloo *Waterloo, ON - Canada*
EEDF is awarded to student researchers who were admitted directly to the PhD program from a Bachelor's degree.

NSERC Industrial Experience Award *May 2017 - Sept 2017*
National Sciences and Engineering Research Council (NSERC) *Waterloo, ON - Canada*
Received for conducting R&D at Clearpath Robotics as part of an internship.

NSERC Undergraduate Research Award *May 2016 - Sept 2016*
National Sciences and Engineering Research Council (NSERC) *Toronto, ON - Canada*
Received for conducting research with Professor Yu Sun during undergradute studies.

President's Scholar Award *2014 - 2015*
University of Toronto *Toronto, ON - Canada*
Received for being one of the top 150 highly qualified students applying to first year of direct-entry undergraduate studies.

Service

Reviewing	**T-ITS** (2020,2021,2022,2023), **IROS** (2022), **ICRA** (2021,2022) **ITSC** (2020,2023,2024), **IV** (2020,2021,2023), **ICORR** (2022), **SMCS** (2022,2023), **MSSP** (2023)
Committee	**ITSC** (2024)
Fellowships	**MITACS Accelerate** (2021-2022)
Tutorials	**Reliable State Estimation and Distributed Controls in Intelligent Vehicular Networks** (ITSC 2023)

Patents

Monocular Camera System Performing Depth Estimation of Objects Surrounding a Vehicle
US Patent Application No.: P104140-PRI-NP-US01, Filing Date: March 29, 2023

Deep Learning Supervisory Framework for Vehicle State Estimation
Patent Application Pending, ROI Filing Date: September 1, 2019

Skills

Machine Learning	Pytorch, TensorFlow, Keras, OpenCV, scikit-learn.
Programming	Python, C++, ROS, CUDA, Linux, Shell (Bash/Zsh), LaTeX, Markdown, Firebase, Git.
Simulation and Design	OpenAI Gym, CARLA, Gazebo, Simulink, SolidWorks, MasterCAM.
Hardware Interfacing	LIDARs, Cameras, RADARs, GNSS, IMU, Embedded Computing (NVIDIA Jetsons), Time Sync., CAN Bus, Arduino.