# Connor Holmes

*PhD Candidate*

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*Canadian Citizen*
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## Core Competencies

**State-Estimation**
Significant experience with SLAM, Localization, Classical and Learning-based Perception Algorithms.

**Control Systems**
Significant experience with Control System Architecture Design and Tuning, System Identification, Manipulator Dynamics and Kinematics, Dynamics Simulators, and Systems Engineering.

**Optimization**
Significant experience with Optimization Theory as well as Mosek, Gurobi, and CVXPY.

**Programming**
Proficient in Python, PyTorch, Matlab, and Simulink.

Experience with C++, Fortran, ROS2.

Github: Personal, Research Group

## Objective

Seeking a research internship to develop real-world, cutting-edge robotics and embodied AI solutions. Passionate about combining classical methods with state-of-the-art machine learning architectures to solve complex challenges in state estimation, optimization, and control in order to develop autonomous systems that are both scalable and robust.

## Education

**2021–present** **PhD. Aerospace Science and Engineering**, *University of Toronto*, Robotics Institute.
Collaborative Specialization in Robotics
**Supervisor**: Timothy D. Barfoot (Autonomous Space Robotics Laboratory)
**Thesis**: "*Convex Relaxations for State-Estimation Problems in Robotics*". Developed *certifiable algorithms* for robotic state-estimation problems that either are *initialization-free* or *certify correctness* of solutions.
**Coursework**: State Estimation for Robotics, Control for Robotics, Perception for Robotics, Stochastic Programming and Robust Optimization

**2014–2016** **MASc. Electrical and Computer Engineering**, *University of Toronto*.
**Supervisor**: Mireille Broucke (Systems Control Group)
**Thesis**: "*Patterned Linear Control Systems*". Developed a methodology for control law design that preserves the structure of large-scale, patterned systems.
**Coursework**: Linear Geometric Control, Nonlinear Control, Convex Optimization, Discrete-Event Systems, Kernel Methods and Support Vector Machines

**2009–2014** **BASc. Engineering Science**, *University of Toronto*.
Specialized in Electrical and Computer Engineering (GPA: 3.42)
**Dean's Honour List**, Engineering Business Certificate
**Supervisor**: Peter Lehn
**Thesis**:"*Dynamic State-Space Modeling of a New Class of Modular Multilevel Bidirectional DC/DC Converters for HVDC Applications*". Developed state-space models for a novel, high-voltage converter topology.

## Professional Experience

**2016–2021** **Member of Technical Staff (Engineer)**, *MacDonald, Dettwiler and Associates*, Brampton, ON, Canada.

Performed systems and controls engineering tasks on teams of over 50 engineers for robotic manipulator systems including control system design (architecture and subsystems), requirements generation, system identification, control system tuning and stability analysis, simulation, and hardware testing.

- Developed detailed systems requirements for an on-orbit, robotic servicing systems for commercial (Skymaker, SPIDER) and government (Canadarm3) applications.
- Designed and simulated actuator control system for an on-orbit, satellite-servicing manipulator (SPIDER Manipulator for OSAM-1 Mission). Validated and verified control system performance on hardware.
- Expedited controls engineering workflow by developing an in-house control system optimization tool (in MATLAB) that maximized performance while conforming to stability and system requirements.
- Guided junior-level controls engineers and wrote key technical specifications and guidelines for control systems development. Documented methodologies and hardware experiments.

**2012–2013** **Electrical Engineering Intern**, *Vale Canada*, Sudbury, ON, Canada.

Installed and improved existing industrial automation systems in smelter, mill, railway, and mining environments. Amended standards, guidelines and technical specifications. Designed and executed integration of system components into power generation stations.

## Professional Development

**Summer 2024** **Workshop on The Frontiers of Optimization for Robotics**, *Robotics: Science and Systems (TU Delft)*, Organizer.

As a co-organizer, promoted an exchange of ideas and established future directions for optimization in robotics. Responsible for designing workshop, recruiting speakers, guiding discussions during event (Workshop Link).

**2022–2023** **Robotics Leadership Program**, *University of Toronto Robotics Institute*.

Gained professional communication and key leadership skills through team-building workshops culminating in several outreach activities. Activities involved engagement with grade-school educators to encourage robotics-based learning as well as hosting classes of students at the Robotics Institute.

## Service

### Community Involvement

**2022 – Present** **Robotics in Schools**, *Organizer*.

Encourage the use of robotics as a teaching tool throughout Ontario classrooms by hosting classes at the Robotics Institute, presenting at math teaching conferences (2023 OAME EmpowerMe Conference), and presenting workshops to teachers ("Why you should use Robotics to teach coding" in the 2024 TEAMS Speaker Series).

Engaged 50+ teachers and 170+ students in grades 6-12.

**2022 – Present** **Canadian Robotics Council**, *Member and Participant*.

Broadened my understanding of the Canadian robotics ecosystem and the impact of robotics in society by participating in the Canadian Robotics Council Symposium in 2022 and 2024.

Contributed to addressing Canada's robotics talent needs as a participant in roundtable discussion: "Filling the gap in the Canadian robotics talent pipeline through service leadership and outreach" (Report).

**2024 – Present** **Robotics Institute Reading Group**, *Organizer*.

Established and organize by-weekly reading group meetings to keep 90+ robotics graduate students up-to-date on new and interesting robotics and AI research.

### Professional Service

**Journal reviewer** **IJRR**: International Journal of Robotics Research, **T-RO**: Transactions on Robotics, **RA-L**: Robotics and Automation Letters

**Conference reviewer** **ICRA**: IEEE International Conference on Robotics and Automation, **IROS**: IEEE/RSJ International Conference on Intelligent Robots and Systems, **RSS**: Robotics: Science and Systems

## Publications

### Peer-Reviewed

[R1] Frederike Dümbgen, **Connor Holmes**, Ben Agro, and Timothy Barfoot. Toward Globally Optimal State Estimation Using Automatically Tightened Semidefinite Relaxations. *IEEE Transactions on Robotics*, 40:4338–4358, 2024.

[R2] **Connor Holmes**, Frederike Dümbgen, and Timothy Barfoot. On Semidefinite Relaxations for Matrix-Weighted State-Estimation Problems in Robotics. *IEEE Transactions on Robotics*, 40:4805–4824, 2024.

[R3] **Connor Holmes** and Timothy D. Barfoot. An Efficient Global Optimality Certificate for Landmark-Based SLAM. *IEEE Robot. Autom. Lett.*, 8(3):1539–1546, March 2023.

[R4] Timothy D. Barfoot, **Connor Holmes**, and Frederike Dümbgen. Certifiably optimal rotation and pose estimation based on the Cayley map. *The International Journal of Robotics Research*, page 02783649241269337, September 2024.

[R5] Frederike Dümbgen, **Connor Holmes**, and Timothy D. Barfoot. Safe and Smooth: Certified Continuous-Time Range-Only Localization. *IEEE Robotics and Automation Letters*, 8(2):1117–1124, February 2023.

[R6] Daniil Lisus, **Connor Holmes**, and Steven Waslander. Towards open world nerf-based slam. In *2023 20th Conference on Robots and Vision (CRV)*, pages 37–44. IEEE, 2023.

[R7] **Connor Holmes**. Practical Design Considerations for Performance and Robustness in the Face of Uncertain Flexible Dynamics in Space Manipulators. *Frontiers in Robotics and AI*, 8, 2021.

[R8] **Connor Holmes** and Mireille E. Broucke. Pattern preserving pole placement and stabilization for linear systems. In *2016 American Control Conference (ACC)*, pages 5181–5186, July 2016.

[R9] Gregory J. Kish, **Connor Holmes**, and Peter W. Lehn. Dynamic modeling of modular multilevel DC/DC converters for HVDC systems. In *2014 IEEE 15th Workshop on Control and Modeling for Power Electronics (COMPEL)*, pages 1–7, June 2014.

### Pre-Prints and Reports

[P1] Frederike Dümbgen, **Connor Holmes**, and Timothy D. Barfoot. Exploiting Chordal Sparsity for Fast Global Optimality with Application to Localization. *arXiv:2406.02365*, June 2024. (*Presented at at WAFR 2024*)

[P2] **Connor Holmes**, Frederike Dümbgen, and Timothy D. Barfoot. SDPRLayers: Certifiable Backpropagation Through Polynomial Optimization Problems in Robotics. *arXiv:2405.19309*, May 2024. (*Submitted to T-RO*)

## Teaching Experience

### Course Instructor

Fall 2023 **ROB310 – Mathematics for Robotics**, *University of Toronto*.
Created course content, delivered lectures, designed and administered homework and examinations (enrollment: 80+ students).
Course Description: An introduction to the advanced mathematical concepts particularly relevant for robotics. The mathematical tools covered in this course are fundamental for understanding, analyzing, and designing robotics algorithms that solve tasks such as robot path planning, robot vision, robot control and robot learning. Topics included optimization techniques, signals and filtering, advanced probability theory, and numerical methods.

### Teaching Assistant

Fall 2024 **AER1513 – State Estimation for Robotics**, *University of Toronto*.
Marked all assignments.

Fall 2022 **ROB310 – Mathematics for Robotics**, *University of Toronto*.
Delivered lectures (2), marked assignments and exams.

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| Spring 2021 | **ROB498 – Robotics Capstone**, *University of Toronto*. <br> Guided and assessed students' fourth year culminating design project. |
| Fall 2015 | **ECE470 – Robotic Modeling and Control**, *University of Toronto*. <br> Guided laboratories, marked laboratory reports and examinations. |
| Spring 2015 | **ECE311 – Dynamic Systems and Control**, *University of Toronto*. <br> Guided laboratories, marked laboratory reports. |
| Fall 2014 | **MAT188 – Linear Algebra**, *University of Toronto*. <br> Guided laboratories, marked laboratory reports. |

## Awards

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| 2022–2023 | Ontario Graduate Scholarship |
| 2023 | Robotics Leadership Award (Honourable Mention) |
| 2023–2024 | Ontario Graduate Scholarship |
| 2014 | Summer Studentship |