Tyler Toner

Homepage: twtoner.github.io || Email: twtoner@umich.edu || LinkedIn: linkedin.com/in/twtoner

EDUCATION

University of Michigan *September 2019 - August 2024* (expected)
Ph.D. in Mechanical Engineering GPA: 3.98
Topic: Learning-based robot control in data-limited environments.
National Science Foundation Graduate Research Fellowship (16% acceptance rate)

Auburn University *August 2015 - May 2019*
Bachelor of Mechanical Engineering GPA: 4.00
Minor in Computer Science

RESEARCH AND PROFESSIONAL EXPERIENCE

Barton Research Group September 2019 - Present
Graduate Research Fellow | Supervisors: Prof. Kira Barton and Prof. Dawn Tilbury *Ann Arbor, MI*

· Conducted dissertation research in (1) **data-driven automated robot programming**; (2) **coordinated control of mobile robots for economic, on-demand sensing**; (3) **robotic wire harness installation**
· Led robot program development and integration within our Smart Manufacturing Laboratory: an industry-university collaboration for Digital Twin and Industry 4.0 research
· Routinely presented robot hardware demonstrations to industry stakeholders to communicate research results
· Actively mentored and managed the independent research projects of **20+** undergraduate and master's students

General Motors R&D: Manufacturing Automation May 2022 - August 2022 | May 2023 - August 2023
Research Intern | Supervisor: Dr. Miguel Saez *Warren, MI*

· Built a physical testbed and software framework for robotic installation of automotive wire harnesses
· Developed algorithms for harness installation based on **reinforcement learning** and **model predictive control**
· Communicated results through regular team meetings, live demonstrations, and conference presentations

Nonlinear Dynamics Laboratory January 2019 - May 2019
Undergraduate Research Assistant | Supervisor: Prof. Edmon Perkins *Auburn, AL*

· Developed an experimental setup for computer vision-based tracking of an insect colony towards the development of novel, biologically-inspired optimization algorithms

Naval Surface Warfare Center: Unmanned Systems Branch May 2018 - July 2018 | May 2019 - July 2019
Mechanical Engineer (intern) | Supervisor: Dr. Drew Lucas *Panama City, FL*

· Worked with a team to design and manufacture a speed sensor for an experimental unmanned underwater vehicle
· Integrated sensor with a microcontroller for improved state estimation of the onboard ROS-based controller
· Researched optimal thruster control design in an overactuated underwater vehicle

GPS and Vehicle Dynamics Laboratory October 2017 - December 2018
Undergraduate Research Assistant | Supervisor: Prof. David Bevly *Auburn, AL*

· Performed analysis of autonomous vehicle platooning algorithms using CarSim and Simulink
· Implemented preprocessing algorithms for raw fuel data of real vehicle platoons

PUBLICATIONS

T. Toner, D. M. Tilbury, and K. Barton, "Leveraging existing robot programs to enable high-level programming for novel tasks." Under review, 2024

H. Lee, **T. Toner**, D. M. Tilbury, and K. Barton, "Graspmixer: Hybrid of contact surface sampling and grasp feature mixing for grasp synthesis." Under review, 2024

T. Toner, V. Molazadeh, M. Saez, D. M. Tilbury, and K. Barton, "Sequential manipulation of deformable linear object networks with endpoint pose measurements using adaptive model predictive control." Accepted to *2024 IEEE International Conference on Robotics and Automation*. Preprint at `https://arxiv.org/abs/2402.10372`. Project website: `https://sites.google.com/view/robo-harness`, 2024

M. van de Vosse, **T. W. Toner**, M. J. Wu, D. M. Tilbury, and K. L. Barton, "Using economic iterative learning control for time-optimal control of a redundant manipulator," in *2023 IEEE 19th International Conference on Automation Science and Engineering (CASE)*, pp. 1–7, 2023. `https://ieeexplore.ieee.org/abstract/document/10260418`

T. Toner, M. Saez, D. M. Tilbury, and K. Barton, "Opportunities and challenges in applying reinforcement learning to robotic manipulation: An industrial case study," *Manufacturing Letters*, vol. 35, pp. 1019–1030, 2023. Presented at 51st SME North American Manufacturing Research Conference (NAMRC 51). `https://www.sciencedirect.com/science/article/pii/S2213846323001128`

H. Lee, **T. Toner**, D. Tilbury, and K. Barton, "Multi-sensor aided deep pose tracking," *IFAC-PapersOnLine*, vol. 55, no. 37, pp. 326–332, 2022. `https://www.sciencedirect.com/science/article/pii/S2405896322028488`

T. Toner, D. M. Tilbury, and K. Barton, "Probabilistically safe mobile manipulation in an unmodeled environment with automated feedback tuning," in *2022 American Control Conference (ACC)*, pp. 1214–1221, 2022. `https://ieeexplore.ieee.org/abstract/document/9867877`

SKILLS

Leadership	Personal and supervisory project management, Robotics PhD Leadership Development Program
Control Systems	Classical control, Linear control, Optimal estimation, Hybrid control Iterative learning control, Sliding mode control, Model predictive control Optimal control, Adaptive control, Reinforcement learning
Simulation and Analysis	Pybullet, Gazebo, MATLAB, Simulink
Software Development	Python, Java, C++, Object-oriented programming, UML-based design
Robotics	Robot Operating System (ROS), Manipulation planning, Motion planning, Visual servoing, AprilTag pose tracking,
Robot Platforms	Kuka KMR iiwa: mobile manipulator (Kuka Sunrise OS, ROS), Universal Robots UR5: manipulator (UR Script, ROS), Toyota Human Support Robot: mobile manipulator (ROS), Kawasaki RS007L: manipulator (ROS)
Machine Learning	Deep reinforcement learning, Supervised learning, Pytorch, Learning from demonstration
Mechatronics	Digital electronics, Circuit analysis, LabVIEW, NI DAQ , Arduino
Computer-Aided Design	SolidWorks, 3ds Max, Inventor

PRESENTATIONS

T. Toner, "Adaptive mpc for automotive wire harness installation." To be presented at the Midwest Robotics Workshop (MWRW) in Chicago, IL, April 2024

T. Toner, "Robotic wire harness installation." Presented at the NSF IUCRC Digital Twins in Manufacturing Industry Workshop in Ann Arbor, MI, January 2024

T. Toner, "Sequential manipulation of deformable linear object networks with endpoint pose measurements using adaptive model predictive control." Presented at General Motors Research & Development in Warren, MI, October 2023

T. Toner, "Data-driven robot learning for unstructured task automation: Application to wire harness instalation." Presented at General Motors Research & Development in Warren, MI, August 2022

H. Lee and **T. Toner**, "Multi sensor aided deep pose tracking." Presented at Toyota HSR Community in North America Meeting 3, May 2022

T. **Toner**, "Temporary sensing for economic robot reprogramming." Presented at University of Michigan Mechanical Engineering Department Seminar, March 2022

T. Toner, "Skill learning and heterogeneous robot teaming." Presented at Toyota HSR Community in North America Meeting 2, November 2021

T. Toner, "Learning and reusing skills from existing robot programs." Presented at Toyota HSR Community in North America Meeting 1, May 2021

FELLOWSHIPS

National Science Foundation Graduate Research Fellowship
National Science Foundation, 2021-Present

Mechanical Engineering Departmental Fellowship
University of Michigan, 2019-2020

SELECTED PROJECTS

Adaptive Model Predictive Control for Wire Harness Installation
Developed a novel adaptive model predictive control strategy for single-arm robotic installation of a wire harness with limited sensing and no pretraining. Validated in simulation and on a physical wire harness testbed. To be presented at ICRA 2024. **Project website**: `https://sites.google.com/view/robo-harness`.

Reinforcement Learning for Collision-Free Manipulation
Developed a reinforcement learning approach for safe goal reaching in the presence of point cloud obstacles. Efforts focused on developing a compact and expressive representation of the state and action spaces for a redundant manipulator.

Program Reuse Framework for Automated Robot Programming
Developed a methodology for systematically learning semantically meaningful skills from historical data generated by existing robot programs. Given a novel task description, skill sequences are automatically selected and parameterized to generate robot program trajectories that realize the task.

Model Predictive Control for Collision-Free Manipulation
Extended prior research on iterative feedback tuning for manipulator obstacle avoidance by replacing an explicit control law with a nonlinear model predictive controller. Implemented for both joint tracking and end-effector pose tracking with support for moving goals and obstacles.

Iterative Feedback Tuning for Probabilistically Safe Mobile Manipulation
Designed an optimal nonlinear feedback controller for simultaneous visual servoing and obstacle avoidance with a redundant mobile manipulator. Explicitly modeled the uncertainty generated by repetitive task iterations to guarantee open-loop task safety in iterations without available sensor feedback.

Inverted pendulum system controller
Developed a controller for regulation of a double-link inverted pendulum system using both classical frequency methods and optimal control methods for full state feedback. Implemented in hardware using a National Instruments myRIO FPGA commanding a DC motor.

Automated epoxy dispenser system
Worked with a team to design, fabricate, and implement an automated epoxy dispenser intended to improve uniformity of cured epoxy strips used in the CAVE3 research laboratory. This was accomplished by integrating a syringe and linear actuator with a modified 3D printer. Primary responsibility was development of a graphical Python program on a Raspberry Pi for real-time G-code streaming.

Ball-on-beam controller
Designed a cascaded control scheme for a ball's position on a rotating beam using a DC motor for rotation. A classical state space feedback controller was used for the outer loop and a nonlinear sliding mode controller was used for the inner loop.

Loudspeaker frequency response control
Attempted to normalize the frequency response of a typical loudspeaker using model inversion and feedback control. System identification was performed in MATLAB and a digital filter was designed to approximate the inverse of the loudspeaker's plant. Feedback was performed in Simulink using real-time measurements from a calibrated microphone.

Lateral vehicle tracking
Designed a three-term lateral lane position controller for a passenger car, which was successfully evaluated using CarSim, a high fidelity, nonlinear vehicle dynamics simulator.

OUTREACH AND SERVICE

Volunteer, International Conference on Intelligent Robots and Systems (IROS 2023)   *October 2023*
Detroit, MI

· Assisted with smoothly checking in participants and directing attendees to presentation locations.
· Provided technical support of presentations during oral sessions.

Mechanical Engineering Graduate Council
University of Michigan
<div align="right">*September 2021 - present*</div>

· As co-chair of the workshop committee: responsible for organizing, advertising, and hosting professional and academic workshops for ME graduate students, delivered by industry professionals or fellow students.
· As co-chair of the mentorship committee: organized peer practice sessions for doctoral students preparing for oral preliminary exams each semester.

Detroit Area Pre-College Engineering Program
University of Michigan
<div align="right">*February - March 2020, 2021, 2022*</div>

· DAPCEP seeks to engage underrepresented middle- and high-school students in STEM through hands-on experiences at local universities.
· Programmed a mobile home-assistant robot and designed graphical interface for interactive human-robot collaborative pick-and-place activity. Students learned the importance of human-friendly and cooperative robotics.

Engineering as Art Exhibition
Auburn University
<div align="right">*April 2019*</div>

· The purpose of the event is to demonstrate the ways in which engineering endeavours can be viewed from an artistic perspective by showcasing pieces from engineering students and faculty.
· Submitted *1088 hours*, constructed from machining projects contributed by mechanical engineering undergraduates.

STUDENTS MENTORED

The following students were closely mentored through regular meetings during the completion of their projects.

Independent research projects
· John Zhang (MS, ROB) *January 2024 - Present*
  – Digital twins for logical state estimation and task planning in a smart manufacturing system.
· Pannaga Sudarshan (MS, ROB) *January 2024 - Present*
  – Part pose estimation in a smart manufacturing system.
· Xiujin Liu (MS, ROB) *January 2024 - Present*
  – Part pose estimation in a smart manufacturing system.
· Rhea Uppal (BS, CS) *May 2023 - August 2023*
  – System level control of a smart manufacturing system.
· Julius Stuhec (BS, ROB) *May 2023 - Present*
  – Perception of part flow through a smart manufacturing system.
· Ephrem Lemma (BS, ME) *May 2023 - Present*
  – Automated planning for heterogeneous assets in smart manufacturing.
· Jose Galvan (BS, ROB) *May 2023 - Present*
  – Product flow design for a smart manufacturing testbed.
· Siddharth Anilkumar Bhurat (MS, ROB) *January 2023 - Present*
  – Heterogeneous multi-robot networking and collaboration.
· Leo Bringer (MS, ME) *September 2022 - May 2023*
  – Vision-based human pose estimation for human-robot collaboration.
  – Point cloud transformer based autoencoder for robot grasping.
  – Vision-based human intent prediction for human-robot collaboration.
· Eric Kam (MS, ROB) *September 2022 - December 2022*
  – Integration and networking of heterogeneous robots in ROS.
· Christopher Wong (MS, ROB) *January 2021 - September 2021*
  – Multi-modal automated robot motion decomposition for learning from demonstration.
· Kaiduo Fang (MS, ME & ECE) *September 2020 - December 2020*
  – Point cloud-based unknown object manipulation and sorting with a mobile manipulator.

Visiting scholars
· Matthijs van de Vosse (MS, ME *Eindhoven University of Technology*) *November 2022 - March 2023*
  – Economic ILC for constrained time-optimal manipulator goal reaching (**published, CASE 2023**).

Mutidisciplinary Design Program

MDP brings students from various technical backgrounds together to work on research projects supervised by faculty and graduate students.

· Sairub Naaz (MS, ROB) *January 2022 - December 2022*
  – Vision-based multi-robot relative pose estimation for teaming.
· Vatsala Prasad (MS, ROB) *January 2022 - December 2022*
  – Robot skill learning from demonstration and automated improvement with reinforcement learning.
· Yuhang Ning (BS, CE) *January 2022 - December 2022*
  – Autonomous environment mapping for periodically reconfigured manufacturing environments.
· Adam Cheng (BS, CE) *January 2022 - December 2022*
  – Vision sensor integration and optimal placement for an industrial manipulator.
· Aron Choo (BS, ME) *September 2021 - December 2021*
  – Optimal placement and automatic reconfiguration for external vision sensor on a manipulator.
· Stefan Heng (BS, CS) *September 2021 - December 2021*
  – Multi-mobile robot relative pose estimation for mobile sensing and precise interaction.
· Hojun Lee (MS, ME) *January 2021 - May 2023*
  – CNN-based RGB-D object recognition and pose estimation for manipulation (**published, MECC 2022**).
  – Fast offline model-based grasp sampling.
  – Learning-based grasp quality classifier (**journal paper under review**).
· Ziwen Jia (MS, ECE) *January 2021 - December 2021*
  – Visual servo control design for a mobile manipulator.
· Yuchen Wu (BS, ECE) *January 2021 - December 2021*
  – Agile mobile robot path planning in a dynamic environment.
· Nikhil Khosla (BS, CS) *January 2020 - December 2020*
  – Object segmentation and pose estimation.
· Yiming Fan (MS, ME) *December 2019 - January 2020*
  – Autonomous mobile manipulator debris cleanup in an unstructured environment.

OTHER HONORS AND AWARDS

Awarded **Spirit of Auburn Founder's Scholarship**, Merit-based full tuition scholarship
Auburn University, 2015-2019

Awarded **O'Neal Austin Best Student Award**, System Dynamic & Controls
Auburn University, 2018

Awarded **O'Neal Austin Best Student Award**, Heat Transfer
Auburn University, 2018

Awarded **O'Neal Austin Best Student Award**, Mechanics of Materials
Auburn University, 2018

Awarded **American Cast Iron Pipe Company Annual Scholarship**
Auburn University, 2017

Member of **Pi Tau Sigma** Mechanical Engineering Honor Society
Auburn University, 2017 - 2019

Awarded **Huan D. Nguyen Annual Scholarship**
Auburn University, 2017

Awarded **O'Neal Austin Best Student Award**, Thermodynamics II
Auburn University, 2017

Awarded **Hugensmith Endowed Scholarship**
Auburn University, 2016

Awarded **AU Board of Trustees Endowed Scholarship**
Auburn University, 2016-2019