

# Patrick Musau

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## Education

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### Vanderbilt University

Nashville, TN

PH.D. IN ELECTRICAL ENGINEERING, M.S IN ELECTRICAL ENGINEERING

May 2022

- **Dissertation:** "Safety Assurance Of Autonomous Learning-Enabled Cyber Physical Systems"
- **Committee:** Taylor Johnson (Adviser), Alan Peters, Gabor Karsai, Janos Sztipanovits, Stanley Bak

### Vanderbilt University

Nashville, TN

M.S IN ELECTRICAL ENGINEERING

May 2020

### Furman University

Greenville, SC

B.S. IN PHYSICS, AND COMPUTING AND APPLIED MATHEMATICS

May 2017

## Research Experience

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### Graduate Research Assistant

Nashville, TN

THE VERIFICATION AND VALIDATION FOR INTELLIGENT AND TRUSTWORTHY AUTONOMY LABORATORY, VANDERBILT UNIVERSITY

July 2017- PRESENT

- Conducted research centering on problems related to the safety and reliability of machine learning enabled autonomous systems in connection with the DARPA Assured Autonomy project.
- Demonstrated work on unmanned underwater vehicles, a 1/10 scale autonomous race car, and unmanned aerial vehicles.
- Learned effective technical writing skills demonstrated by over 19 publications in top conferences and journals.
- Built a 1/10 scale autonomous car platform, equipped with LIDAR and stereoscopic cameras, for designing and testing experimental AI controllers as well as competing in multiple racing competitions with my team.
- Developed a translation tool for neural network models into the Open Neural Network Exchange format (<https://onnx.ai/>) to assist verification researchers in translating between the various input formats for state of the art neural network verification tools.
- Developed hands-on experience with vehicle systems in design, development, and testing of ML-trained controllers; published in ICAA 2022.
- Gained experience with quantitative and qualitative research methods.
- Developed and maintained collaborations with external research groups.
- Supervisor: Dr. Taylor Johnson

### Undergraduate Research Mentor

Nashville, TN

VANDERBILT UNIVERSITY INSTITUTE FOR SOFTWARE INTEGRATED SYSTEMS

Summer 2017- 2020

- Mentored and coached undergraduate students on research primarily focused on the verification of artificial neural networks and AI inspired autonomous applications
- Helped students design, conduct, and analyze experiments.
- Trained the next generation of graduate students and scientists by providing advice, making observations, and giving feedback.

### Chemistry Research Fellow

Greenville, SC

UNDERGRADUATE RESEARCH, FURMAN UNIVERSITY

May 2017

- Created a web application that stored highly detailed quantum mechanical calculations of molecular cluster energies and geometry calculations modeled after The Benchmark Energy and Geometry Database ([begdb.com](http://begdb.com))
- Goal was to promote efficient storing and access of molecular cluster data for computational chemists
- Website can be viewed here: <http://marcy.furman.edu/pmusau/>
- Supervisors: Dr. Berhane Temelso, Dr. George Fields

### Computer Science Research Fellow

Greenville, SC

UNDERGRADUATE RESEARCH, FURMAN UNIVERSITY

May 2016-December 2016

- Designed a web-based dietary self-monitoring application modeled after the United States Department of Agriculture's MyPlate food recommendations and guidelines
- System was designed for a long-term interdisciplinary study of the effectiveness and usability of self-monitoring systems in facilitating weight loss.
- Supervisor: Dr. Andrea Tartaro

## Experience

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### Open Robotics, ROS2 Technical Steering Committee (TSC)

Remote

COMMUNITY REPRESENTATIVE

October 2021 -PRESENT

- Elected as a community representative for the Open Source Robotics Foundation's ROS2 Project Technical Steering Committee, Service Term will begin January 2022
- Provide advice, ensure delivery of the ROS2 project outputs and the achievement of ROS2 goals/

## Software Engineering Intern

Remote

OPEN ROBOTICS

May 2021 - Aug 2021

- Assisted with the ongoing ROS2 Migration and maintenance of ROS Perception pipeline packages.
- Ported Alvar AR Tracking library to ROS2.
- Helped design ROS2 shell architecture demo for the U.S.DOT CARMA Platform ROS2 Migration.

## Data Science Fellow

Remote

CORRELATION ONE, DATA SCIENCE FOR ALL (DS4A) FELLOW

October 2020 - Feb 2020

- Partook in a competitive, merit-based immersive 13-week program led by Natesh Pillai of Harvard University. The curriculum teaches data skills through real business cases, using actual datasets. The program is defined by a diverse network of professional mentors and highly talented peers.
- Capstone Project centered around an analysis of rates of crime and the prevalence of social services.
- Program Partners include Soft Bank Group, Citadel Securities, Point72, Two Sigma, IHS Markit, Gilead, BlackRock, Accenture, and Marshall Wace

## Library Student Assistant

Greenville, SC

JAMES B. DUKE LIBRARY, FURMAN UNIVERSITY

Aug 2015 - May 2017

- Assisted patrons with general needs such as locating books, checking out books, and other inquiries.
- Re-shelved and took inventory of books.

## Resident Assistant

Greenville, SC

FURMAN UNIVERSITY HOUSING AND RESIDENTIAL LIFE

Aug. 2016 - May 2017

- Served as a liaison between residents and other institutional areas (i.e. Counseling Center, Division of Student Life, University Police, Student Health Services, and University Chaplain)
- Responsible for building and fostering community among 96 residents by planning monthly events that encourage thoughtful discussion of topics such as academic achievement, diversity, and health and wellness
- Made referrals to appropriate campus resources as needed

## Tutor and Lab Assistant

Greenville, SC

FURMAN UNIVERSITY PHYSICS DEPARTMENT

Aug. 2015 - May 2017

- Assisted Physics Students with assignments and laboratory experiments.
- Held group study sessions to help students prepare for exams.
- Sessions held once a week for two hours.

## Furman University Center for Academic Success, Housing and Residential Life

Greenville, SC

FIRST-YEAR AND FRESHMAN ADVISOR

Aug 2014 - May 2016

- Served as a role model for new students and mentor them in areas, which encouraged and supported academic.
- Implemented monthly programs aimed at aiding first year students in their transition to the University experience.
- Served as a liaison between students and institutional academic resources.

## Publications

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### Refereed Journal Articles

[J1] Hoang-Dung Tran, Neelanjana Pal, Diego Manzananas Lopez, [Patrick Musau](#), Xiaodong Yang, Luan Viet Nguyen, Weiming Xiang, Stanley Bak, Taylor T Johnson, "Verification of piecewise deep neural networks: a star set approach with zonotope pre-filter," In Formal Aspects of Computing, Volume 33, Issue 4-5, pp. 519-545, 2021 August.

[J2] Hoang-Dung Tran, Feiyang Cai, Diego Manzananas Lopez, [Patrick Musau](#), Taylor T. Johnson and Xenofon Koutsoukos, "Safety Verification of Cyber-Physical Systems with Reinforcement Learning Control," In ACM Transactions on Embedded Computing Systems, Volume 18, Issue No. 5s, Article 105, 2019, October.

[J3] Weiming Xiang, Diego Manzananas Lopez, [Patrick Musau](#), Taylor T. Johnson, "Reachable Set Estimation and Verification for Neural Network Models of Nonlinear Dynamic Systems", In (Huafeng Yu, Xin Li, Richard M. Murray, S. Ramesh, Claire J. Tomlin, eds.), Springer International Publishing, pp. 123-144, 2019

### Refereed Highly-selective Conference Proceedings Papers

[C1] [Patrick Musau](#), Nathaniel Hamilton, Diego Manzananas Lopez, Preston Robinette, Taylor Johnson, "On Using Real-Time Reachability for the Safety Assurance of Machine Learning Controllers," In IEEE International Conference on Assured Autonomy (ICAA), 2022, March.

[C2] Nathaniel Hamilton, [Patrick Musau](#), Diego Manzananas Lopez, Taylor Johnson, "Zero-Shot Policy Transfer in Autonomous Racing: Reinforcement Learning vs Imitation Learning," In IEEE International Conference on Assured Autonomy (ICAA), 2022, March.

[C3] Hoang-Dung Tran, Neelanjana Pal, [Patrick Musau](#), Diego Manzananas Lopez, Nathaniel Hamilton, Xiaodong Yang, Stanley Bak, Taylor T. Johnson, "Robustness Verification of Semantic Segmentation Neural Networks Using Relaxed Reachability," In 33rd International Conference (CAV), 2021 July.

[C4] Hoang-Dung Tran, Xiaodong Yang, Diego Manzananas Lopez, [Patrick Musau](#), Luan Viet Nguyen, Weiming Xiang, Stanley Bak, Taylor T. Johnson, "NNV: The Neural Network Verification Tool for Deep Neural Networks and Learning-Enabled Cyber-Physical Systems," In 32nd International Conference on Computer-Aided Verification (CAV), 2020, July.

[C4] Hoang-Dung Tran, Diego Manzananas Lopez, [Patrick Musau](#), Xiaodong Yang, Luan Viet Nguyen, Weiming Xiang, and Taylor T. Johnson, “Star-Based Reachability Analysis for Deep Neural Networks”, In 23rd International Symposium on Formal Methods (FM’19) (, ed.), Springer International Publishing, 2019, October

[C5] Hoang-Dung Tran, Luan Viet Nguyen, [Patrick Musau](#), Weiming Xiang, Taylor T. Johnson, “Decentralized Real-Time Safety Verification for Distributed Cyber-Physical Systems”, In Formal Techniques for Distributed Objects, Components, and Systems (FORTE’19) (Jorge A. Pérez, Nobuko Yoshida, eds.), Springer International Publishing, Cham, pp. 261–277, 2019, June.

[C6] Hoang-Dung Tran, [Patrick Musau](#), Diego Manzananas Lopez, Xiaodong Yang, Luan Viet Nguyen, Weiming Xiang, Taylor T. Johnson, “Parallelizable Reachability Analysis Algorithms for Feed-forward Neural Networks”, In Proceedings of the 7th International Workshop on Formal Methods in Software Engineering (FormalISE’19), IEEE Press, Piscataway, NJ, USA, pp. 31–40, 2019, May.

### **Refereed Workshop Proceedings Papers**

[W1] Taylor T. Johnson, Diego Manzananas Lopez, [Patrick Musau](#), Hoang-Dung Tran, Elena Botoeva, Francesco Leofante, Amir Maleki, Chelsea Sidrane, Jiameng Fan, Chao Huang, “ARCH-COMP20 Category Report: Artificial Intelligence and Neural Network Control Systems (AINNCS) for Continuous and Hybrid Systems Plants,” In ARCH20. 7th International Workshop on Applied Verification of Continuous and Hybrid Systems (Goran Frehse, Matthias Althoff, eds.), EasyChair, vol. 74, pp. 107–139, 2020, September.

[W2] Diego Manzananas Lopez, [Patrick Musau](#), Nathaniel Hamilton, Hoang-Dung Tran, Taylor T. Johnson, “Case Study: Safety Verification of an Unmanned Underwater Vehicle,” In 2020 IEEE Security and Privacy Workshops (SPW) 2020, May.

[W3] Hoang-Dung Tran, Diego Manzananas Lopez, Xiaodong Yang, [Patrick Musau](#), Luan Viet Nguyen, Weiming Xiang, Stanley Bak, Taylor T. Johnson, “Demo: The Neural Network Verification (NNV) Tool”, In 2020 IEEE Workshop on Design Automation for CPS and IoT (DESTION) 2020, April.

[W4] Diego Manzananas Lopez, [Patrick Musau](#), Hoang-Dung Tran, Taylor T. Johnson, “Verification of Closed-loop Systems with Neural Network Controllers,” In ARCH19. 6th International Workshop on Applied Verification of Continuous and Hybrid Systems (Goran Frehse, Matthias Althoff, eds.), EasyChair, vol. 61, pp. 201–210, 2019, April.

[W5] Diego Manzananas Lopez, [Patrick Musau](#), Hoang-Dung Tran, Souradeep Dutta, Taylor J. Carpenter, Radoslav Ivanov, Taylor T. Johnson, “ARCH-COMP19 Category Report: Artificial Intelligence and Neural Network Control Systems (AINNCS) for Continuous and Hybrid Systems Plants,” In ARCH19. 6th International Workshop on Applied Verification of Continuous and Hybrid Systems (Goran Frehse, Matthias Althoff, eds.), EasyChair, vol. 61, pp. 103–119, 2019, April.

[W6] [Patrick Musau](#), Diego Manzananas Lopez, Hoang-Dung Tran, and Taylor T. Johnson, “Linear Differential-Algebraic Equations (Benchmark Proposal),” in 5th International Workshop on Applied Verification of Continuous and Hybrid Systems (ARCH 2018), Co-located with IFAC Conference on Analysis and Design of Hybrid Systems (ADHS) 2018, Oxford, UK, July 2018

[W7] [Patrick Musau](#), Taylor T. Johnson, “Continuous-Time Recurrent Neural Networks (CTRNNs) (Benchmark Proposal),” In 5th Applied Verification for Continuous and Hybrid Systems Workshop (ARCH), Oxford, UK, 2018, July.

### **Surveys**

[S1] Weiming Xiang, [Patrick Musau](#), Ayana A. Wild, Diego Manzananas Lopez, Nathaniel Hamilton, Xiaodong Yang, Joel Rosenfeld, Taylor T. Johnson “Verification for Machine Learning, Autonomy, and Neural Networks Survey,” ArXiv, 2018, October.

### **Papers Submitted And Pending Review Decisions**

[R1] [Patrick Musau](#), Nathaniel Hamilton, Diego Manzananas Lopez, Preston Robinette, and Taylor T. Johnson, “An Empirical Analysis of the Use of Real-Time Reachability for the Safety Assurance of Autonomous Vehicles,” Submitted for review to Artificial Intelligence Journal Special Issue on Risk-aware Autonomous Systems: Theory and Practice. 2022 May

[R2] Paulius Stankaitis, [Patrick Musau](#), Diego Manzananas Lopez, Sergiy Bogomolov, Taylor T. Johnson, “Integrating Online Reachability Analysis with Model-Predictive Control for Dynamic Obstacle Avoidance,” Submitted for Review to the ACM SIGBED International Conference on Embedded Systems (EMSOFT) at ESWeek 2022.

## **Presentations**

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[P1] Presented paper [C1], “On using Real-Time Reachability for the Safety Assurance of Machine Learning Controllers,” at the 2022 IEEE Conference on Assured Autonomy (ICAA), Virtual Presentation, March 22, 2022.

[P2] Presented paper [C2], “Zero-Shot Policy Transfer in Autonomous Racing: Reinforcement Learning vs Imitation Learning,” at the 2022 IEEE Conference on Assured Autonomy (ICAA), Virtual Presentation, March 22, 2022.

[P3] Presented “Towards Assured Autonomy with ROS,” at ROS World 2021, Virtual Presentation, October 21, 2021.

# Software Tools and Artifacts

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## Rtreach

SOFTWARE TOOL, ([GITHUB.COM/PMUSAU17/RTREACH\\_F1TENTH](https://github.com/PMUSAU17/RTREACH_F1TENTH))

- Real-time reachability algorithms for hybrid systems with linear and nonlinear dynamics: This software implements reachability analysis algorithms based on face-lifting that have worst-case execution time (WCET) guarantees
- Related papers include: [C1,C2,C5,R1,R2]
- Development timeframe: 2019-present

## Neural Network Verification Model Translation Tool

SOFTWARE TOOL, ([GITHUB.COM/VERIVITAL/NNVMT](https://github.com/VERIVITAL/NNVMT))

- Purpose of this tool was to address the lack of neural network model standardization among the various verification research software artifacts
- Tool allows for interchange between neural network verification tools and related software, such as ONNX, PyTorch, Keras, Tensorflow
- Related papers include: [C3,C4,C5,C6,W1,W3, W4,W5]
- Development timeframe: 2018-2022

## F1Tenth Simulation and Hardware Artifacts

SOFTWARE PACKAGES, ([GITHUB.COM/PMUSAU17/PLATOONING-F1TENTH](https://github.com/PMUSAU17/PLATOONING-F1TENTH))

- Simulation package containing all source code and experimental artifacts for disseration research
- The package contains a host of Robot Operating System (ROS) packages designed for both simulation and the F1Tenth hardware platform.
- Related papers include: [C1,C2,C5,C6,R1,R2]
- Repeatability packages for conference papers also available at: [zenodo.org/record/6418817](https://zenodo.org/record/6418817), [zenodo.org/record/5879654](https://zenodo.org/record/5879654), [zenodo.org/record/5879646](https://zenodo.org/record/5879646)
- Development timeframe: 2018-2022

# Projects

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## Run-time Assurance for Autonomous Systems

RESEARCH PROJECT ([GITHUB.COM/PMUSAU17/PLATOONING-F1TENTH](https://github.com/PMUSAU17/PLATOONING-F1TENTH))

- Created a runtime assurance architecture for autonomous systems using real-time reachability techniques and a simplex regime.
- Platforms Considered: 1/10 scale embedded autonomous racecar, unmanned underwater vehicles (BlueRoV)
- <https://youtu.be/tTnGUFv3HmU>
- This regime ensures that a system will not collide with objects within its environment whilst utilizing a controller synthesized using AI and Machine Learning techniques
- Funded through the Assured Autonomy(AA) Project, Defense Advanced Research Projects Agency (DARPA)
- Framework's used: Robotic Operating System, Python, MATLAB, C, C++

## Model Predictive Control Leveraging Reachability

RESEARCH PROJECT ([GITHUB.COM/PMUSAU17/PLATOONING-F1TENTH](https://github.com/PMUSAU17/PLATOONING-F1TENTH))

- Created an optimisation based approach for static and dynamic obstacle avoidance problem within an autonomous vehicle racing context.
- Our control regime leverages online reachability analysis and model predictive control.
- Funded through the Assured Autonomy(AA) Project, Defense Advanced Research Projects Agency (DARPA)
- Framework's used: Robotic Operating System, Python, MATLAB, C, C++, do-mpc

## Learning-Enabled Autonomous Racing

RESEARCH PROJECT ([GITHUB.COM/PMUSAU17/PLATOONING-F1TENTH](https://github.com/PMUSAU17/PLATOONING-F1TENTH))

- Evaluated the use of a diverse set of machine learning techniques for the machine learning task
- Each approach was evaluated on a 1/10 scale autonomous racing platform known as the F1tenth both in simulation and on an embedded hardware platform
- Conducted analysis of each regime's efficacy at zero-shot policy transfer and studied their performance when transferred from simulation to the real world.
- Funded through the Assured Autonomy(AA) Project, Defense Advanced Research Projects Agency (DARPA)
- Framework's used: Robotic Operating System, Python, MATLAB, C, C++

## DARPA Assured Autonomy

RESEARCH PROJECT ([GITHUB.COM/PMUSAU17/RTREACH\\_F1TENTH](https://github.com/PMUSAU17/RTREACH_F1TENTH))

- Goal of the Assured Autonomy program is to create technology for continual assurance of Learning-Enabled, Cyber Physical Systems
- Utilizing formal methods and other methods the project seeks to advance the ways ML/AI systems can learn and evolve to better manage variations in the environment
- Working on formally reasoning about neural network classification and semantic segmentation robustness and safety properties
- Funded Assured Autonomy(AA), Defense Advanced Research Projects Agency (DARPA)
- Framework's used: Robotic Operating System, Python, MATLAB, NNV ([github.com/verivital/nnv](https://github.com/verivital/nnv))

## F1/10 Autonomous Racing Competition

RESEARCH PROJECT, ([HTTPS://GITHUB.COM/PMUSAU17/PLATOONING-F1TENTH](https://github.com/PMUSAU17/PLATOONING-F1TENTH))

- Built a 1/10 scale autonomous vehicle testbed equipped with a LIDAR, stereo camera, and inertial sensors
- The testbed's sensors mimic full scale solutions and allow us to pursue research in perception, planning, control, and networking
- <https://youtu.be/fevOWW0qbu8>
- Competed at CPS-IoT Week in Montreal Canada and at Columbia University using a potential field control strategy
- Pursuing strategies involving Simultaneous Localization and Mapping, Path Planning, Reinforcement Learning, and End to End Learning
- Languages and Framework's used: Robotic Operating System, Python, C++

## National Science Foundation CPS Challenge

RESEARCH PROJECT, ([GITHUB.COM/VERIVITAL/VANDYCPS](https://github.com/VERIVITAL/VANDYCPS))

- Programmed a quadrotor aircraft with downward facing camera, and other sensors, to scan an area for a lost aircraft, and recover it safely back to base
- ([https://youtu.be/D0zkDO46w\\_A](https://youtu.be/D0zkDO46w_A))
- Platform used: the Intel® Aero Ready to Fly Drone
- Languages and Framework's used: Robotic Operating System, Python, OpenCV, C++

## City Budgeting and Rates of Crime

RESEARCH PROJECT, ([GITHUB.COM/PMUSAU17/TEAM7](https://github.com/PMUSAU17/TEAM7))

- Conducted analysis investigating the relationship between the rate of crime and the amount of social service spending in major cities in the United States.
- Datasets that we leveraged included the FISC Dataset as well as the FBI's UCR data. Demographic data came from the Census American Community Survey
- Final Analysis was awarded People's Choice award during 2020 Data Science For All Cohort
- Formulated strategies aimed at lowering rates of crime in major metropolitan areas.
- Frameworks Leveraged: Plotly, Python, Bokeh, Heroku,

## Honors & Awards

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2021	<b>DS4A Two Sigma Distinguished Scholar</b> , Correlation One	<i>Nashville, TN</i>
2020	<b>2020 36 86 Student Entrepreneurship Competition Winner (\$ 25,000)</b> , Launch Tennessee	<i>Nashville, TN</i>
2020	<b>NSF MCommercialization Microgrant Winner (\$2300)</b> , Vanderbilt University Innovation Center	<i>Nashville, TN</i>
2019	<b>International Conference on Computer-Aided Verification Week Travel Award</b> , Loris D'Antoni	<i>New York, NY</i>
2019	<b>CPS-IOT Week Travel Award</b> , ACM SIGBED	<i>Montreal, Québec</i>
2017	<b>Computer Science-Mathematics Award for Excellence</b> , Furman University Computer Science Department	<i>Greenville, SC</i>
2017	<b>Member of Quaternion Club</b> , Furman University	<i>Greenville, SC</i>
2017	<b>Pi Mu Epsilon</b> , (Mathematics)	<i>Greenville, SC</i>
2017	<b>Upsilon Pi Epsilon</b> , (Computer Science)	<i>Greenville, SC</i>
2017	<b>Sigma Pi Sigma</b> , (Physics)	<i>Greenville, SC</i>
2016	<b>Phi Beta Kappa</b> , Furman University	<i>Greenville, SC</i>
2013	<b>Goodwill Tuition Scholarship</b> , Furman University	<i>Greenville, SC</i>

## Reviewing and Scholarly Community Service

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### Journal Reviewer

[Elsevier JSS] **Journal of Systems and Software**, 2021

### Conference Reviewer

[CAV' 2022] **34th International Conference on Computer Aided Verification**, 2022

[HSCC' 22] **ACM International Conference on Hybrid Systems: Computation and Control**, 2022

[ICCPs' 22] **ACM/IEEE International Conference on Cyber-Physical Systems**, 2022

[CVPR' 22] **IEEE / CVF Computer Vision and Pattern Recognition Conference**, 2022

[ICCV' 2021] **IEEE/CVF International Conference on Computer Vision**, 2021

[ADHS' 2021] **IFAC Conference on Analysis and Design of Hybrid Systems**, 2021

[IROS' 21] **IEEE/RSJ International Conference on Intelligent Robots and Systems**, 2021

[ICRA' 21] **IEEE International Conference on Robotics and Automation**, 2021

[CAV' 2021] **33rd International Conference on Computer Aided Verification**, 2021

[HSCC' 21] **ACM International Conference on Hybrid Systems: Computation and Control**, 2021

[ICCPs' 21] **ACM/IEEE International Conference on Cyber-Physical Systems**, 2021

[AAAI' 21] **35th AAAI Conference on Artificial Intelligence**, 2021

[ICRA' 20] **IEEE International Conference on Robotics and Automation**, 2020

[HSCC' 20] **ACM International Conference on Hybrid Systems: Computation and Control**, 2020

[ICCCPS' 20] **ACM/IEEE International Conference on Cyber-Physical Systems**, 2020

[HSCC' 19] **ACM International Conference on Hybrid Systems: Computation and Control**, 2019

[ICCCPS' 19] **ACM/IEEE International Conference on Cyber-Physical Systems**, 2019

[ICCCPS' 18] **ACM/IEEE International Conference on Cyber-Physical Systems**, 2018

## Technical Skills

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**Programming** Python, C, C++, MATLAB

**Frameworks** NumPy, Pandas, OpenCV, Tensorflow, Keras

**Systems** Linux, Docker, Robotics Operating System (ROS), ROS2, AWS (basic knowledge)

**AI Background** Behavior Cloning, Deep Learning, Imitation Learning, Machine Learning, Neural Network Control

**Research Interests** AI Safety, Formal Methods, Deep Learning, Intelligent Control, Cyber-Physical Systems, Internet of Things, Big Data

**Languages** English, Swahili, French

## Extracurricular Activities

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### Nashville Rugby

CAPTAIN AND MEMBER

- Captain 2019-2020 Season
- 2019 True South Championship Runners-Up.

*Greenville, SC*

*January 2018- Present*

### Furman Club Rugby

CAPTAIN

- 2016 USA Rugby Men's DII National Championship Runners-Up.
- Honored by South Carolina's House of Representatives April 2017.

*Greenville, SC*

*May 2015- May 2017*

### East African Model United Nations

DELEGATE

- Proposed and debated resolutions in a format that simulated the United Nations General Assembly
- Recognized as best speaker in the Political committee which deals with issues that require political cooperation or seek to resolve political conflict.

*(UNON), Nairobi, Kenya*

*Aug 2012-March 2013*

## References

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### Dr. Taylor Johnson, Vanderbilt University

ASSOCIATE PROFESSOR OF COMPUTER ENGINEERING, COMPUTER SCIENCE, AND ELECTRICAL ENGINEERING

*1025 16th Ave S, Nashville, TN 37212*

### Dr. Joel A. Rosenfeld, University of South Florida

ASSISTANT PROFESSOR MATHEMATICS AND STATISTICS

*4202 E Fowler Ave, Tampa, FL 33620*