Patrick **Musau**

Graduate Research Assistant · Institute of Software Integrated Systems

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Education

Vanderbilt University

2201 West End Ave, Nashville, TN

Ph.D. in Electrical Engineering (3.90 / 4.0) *2017-Present*

- Machine Learning (Certificate), Coursera Inc. 2019
- Deep Learning Specialization (Certificate), Coursera Inc. 2019

Furman University

3300 Poinsett Hwy, Greenville, SC

B.S. in Physics, and Computing and Applied Mathematics, Summa Cum Laude (3.991 / 4.00) *2013-2017*

Skills

Programming	Python, Java, MATLAB, Simulink, Racket, Mathematica LaTeX
Frameworks	NumPy, Pandas, OpenCV, Tensorflow, Keras, PyTorch, ONNX
Web	SQL, JQuery, HTML5, Basic Bootstrap, Javascript, and CSS
Systems	Linux, AWS, Docker, Robotics Operating System
Research Interests	AI Safety, Formal Methods, Deep Learning, Intelligent Control, Cyber-Physical Systems, Internet of Things, Big Data
Languages	English, Swahili, French

Projects

Neural Network Verification Model Translation Tool

Software Tool, (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
- Development timeframe: 2018-present
- Written in Python 3

F1/10 Autonomous Racing Competition

Research Project, (github.com/verivital/F1TenthVanderbilt)

- 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
- Competed at CPS-IoT Week in Montreal Canda using a potential field control strategy
- Pursuing strategies involving Simultaneous Localization and Mapping, Path Planning, Reinforcement Learning, and End to End Learning
- Development timeframe: March 2019-present
- Languages and Framework's used: Robotic Operating System, Python, C++

National Science Foundation CPS Challenge

Research Project, (github.com/verivital/VandyCPS)

- Goal of this challenge is to use 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
- Platform used: the Intel® Aero Ready to Fly Drone
- Achieved a 3rd place ranking after one week of development in 2017
- Development timeframe: 2017-Present
- Languages and Framework's used: Robotic Operating System, Python, OpenCV, C++

DARPA Assured Autonomy

Research Project (github.com/verivital/nnv)

- 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
- Our focus has been on the autonomous vehicle space, although the technology and techniques being designed are to be transferable to other autonomous systems with minimal modifications
- Funded Assured Autonomy(AA), Defense Advanced Research Projects Agency (DARPA)
- Framework's used: Robotic Operating System, Python, MATLAB, NNV (github.com/verivital/nnv)

Experience

The Verification and Validation for Intelligent and Trustworthy Autonomy Laboratory

Nashville, TN

Graduate Research Assistant

July 2017- PRESENT

- Research is primarily focused on the verification of artificial neural networks and AI inspired autonomous applications
- Developing 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.
- Involved in DARPA's Assured Autonomy project, that seeks to assure Learning enabled components in Autonomous Cyber-physical systems
- Participant in the F1Tenth Autonomous Racing Competition (f1tenth.org). Competed at CPS IOT Week in Montreal, Canada in April of 2019
- Participated twice in the 2018 and 2019 edition of the NSF CPS Challenge focused on autonomous drone applications

Undergraduate Research, Furman University

Greenville, SC

Chemistry Research Fellow

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)
- 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

Undergraduate Research, Furman University

Greenville, SC

Computer Science Research Fellow

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

Publications

Journal Articles

[J1] Weiming Xiang, Diego Manzanas 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

Conference Papers

[C1] Hoang-Dung Tran, Diego Manzanas Lopez, Patrick Musau, Xiaodong Yang, Luan Viet Nguyen, Weiming Xiang, and Taylor T. Johnson, "Star-Based Reachability Analsysis for Deep Neural Networks", In 23rd International Symposisum on Formal Methods (FM'19) (, ed.), Springer International Publishing, 2019, October

[C2] 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.

Refereed Workshop Proceedings Papers

[W1] Hoang-Dung Tran, Patrick Musau, Diego Manzanas 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.

[W2] Diego Manzanas 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.

[W3] Diego Manzanas 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.

[W4] Patrick Musau, and Taylor T. Johnson, "Verification of Continuous Time Recurrent Neural Networks (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

[W5] Patrick Musau, Diego Manzanas 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