






Diego MANZANAS LOPEZ

Graduate Research Assistant

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EDUCATION

- 2017-2022 **PhD in Electrical Engineering**, Vanderbilt University
- Dissertation : "Learning and Verification of Dynamical Systems with Neural Network Components"
- Committee : Taylor T. Johnson (adviser), Gautam Biswas, Radu Grosu, Yuankai Huo, Janos Sztivanopits
- 2017-2020 **M.S. in Electrical Engineering**, Vanderbilt University
- 2013-2017 **Bachelor of Science in Physics**, Presbyterian College

SKILLS

- Prog. Languages** Python, MATLAB, C++
- Frameworks & Tools** Docker, Git, Simulink, PyTorch, Tensorflow, Keras, ONNX, Pandas, WebGME
- Systems** Linux, Windows 10, AWS, Robotic Operating System (ROS)
- Research** Machine Learning, Deep Learning, Cyber-Physical Systems (CPS), Formal Methods, Safe AI
- Languages** Spanish, English

EXPERIENCE

- August 2022 **Graduate Research Assistant | Institute for Software Integrated Systems, VANDERBILT UNIVERSITY, Nashville, TN, US**
- August 2017 Research in the intersection of three main areas : Formal Methods, Deep Learning and Cyber-Physical Systems under the supervision of Taylor T. Johnson (VeriVITAL),.
- Collaborate in a DARPA project for assured autonomy, where my work focuses on the identification of system dynamics and the verification of autonomous systems.
 - Collaborate in various team projects regarding the forward reachability analysis and verification of neural networks.
 - Develop a verification tool for feedforward neural networks and closed-loop systems with linear, non-linear and hybrid dynamics with other members of VeriVITAL (NNV).
 - Lead the development of a neural network transformation tool for several feedforward and convolutional neural network verification tools as well as some well-known deep learning frameworks such as TensorFlow.
 - Develop a verification framework for the verification of neural ordinary differential equations using reachability analysis.
- May 2021 **Machine Learning Engineer, INTELLIGENT SYSTEMS LLC, Nashville, TN, US**
- December 2021 Responsible for providing more intelligence to the facility management industry, and in particular indoor air quality (IAQ), occupant comfort, and mechanical system health.
- Data inspection, cleaning, and preprocessing in time-series data.
 - Design and implement autoencoders and variational autoencoders for fault detection of HVAC systems.
 - Design and implement multiple neural network prediction models for indoor air quality and occupant comfort
- August 2020 **Mentor | VU-ISIS Summer 2020 Internship Program, VANDERBILT UNIVERSITY, Nashville, TN, US**
- May 2020
- Introduce undergraduate interns to the machine learning verification topic.
 - Help and guide interns to perform individual research in the topics of adversarial attacks and generative adversarial networks (GAN).
 - An increase on the number, diversity and quality of case studies to evaluate using NNV was achieved by the students.

December 2016 January 2016	Undergraduate Research Assistant Physics Department, PRESBYTERIAN COLLEGE, Clinton, SC, US Worked under the supervision of Chad Rodekohr <ul style="list-style-type: none"> › Studying the mathematical analysis of rope braiding › Goal is to develop rope braiding as a science and reduce waste and money on braiding production. › Main contribution is the formulation of the initial angle the yarns make with each other at the braiding formation point.
May 2017 February 2016	Academic Tutor Athletics Department, PRESBYTERIAN COLLEGE, Clinton, SC, US Physics and Math Individual Sessions <ul style="list-style-type: none"> › Provided individual academic support and guidance to fellow students in introductory courses. › Developed personalised explanations of material to help improve comprehension where difficulty exists. Math Help Sessions <ul style="list-style-type: none"> › Organized 2-hour sessions to help improve comprehension by doing examples of material covered in class. › One-to-one help after to help students with their individual questions.
Summers '15-'17 Dec '13-'16	Tennis Coach, ESTUDIO TENIS COUDER, Spain <ul style="list-style-type: none"> › Overnight Tennis Camp Counselor and Tennis Coach (Villoria de Orbigo, Leon, Spain). › Adult and Kids Tennis Coach (Madrid, Spain)

PROJECTS

DARPA ASSURED AUTONOMY

RESEARCH PROJECT

 [DARPA AA project](#)

The overall goal of this project is to create technology and techniques for the assurance of learning enabled CPS, meaning any CPS that has any ML/AI components as part of the CPS. The focus of the projects is on the autonomous vehicle space, although the technology and techniques are anticipated to be transferable to other autonomous systems under minimal modifications. Both of the next two projects are funded by DARPA under the Assured Autonomy program.

CPS System Identification Deep Learning Safe AI

F1/10 AUTONOMOUS CAR

COMPETITION & TOOL

 [F1tenth](#)  github.com/verivital/F1TenthVanderbilt

We built a 1/10 scale autonomous vehicle equipped with a LIDAR, stereo camera, and inertial sensors to compete in the F1/10 Competition at CPSWeek in April 2018 at Montreal for the first time in school's history. Designed several path planning and reactive algorithms based on sensors and track environment. Placed 1st at IROS 2020 virtual competition timed trials. These are also used as part of our daily research tasks to verify the safety of the autonomous car in a simulator and in the hardware platform using reachability analysis techniques.

ROS Python C++

NNV

SOFTWARE TOOL

 [nnv description](#)  github.com/verivital/nnv

NNV is a software verification tool whose ultimate goal is to develop several neural network (NN) verification techniques. The first one is the verification of control systems with feedforward NN as controllers at Design Time as well as Run-time verification. Another area is the verification and robustness evaluation of convolutional neural networks (CNN), implemented in the VGG-16 and VGG-19 models, and of Recurrent Neural Networks (RNN).

MATLAB Deep Learning Toolbox

NNVMT

SOFTWARE TOOL

 github.com/verivital/nnvmt

NNVMT is a software tool built in Python whose main goal is to translate neural networks (FNN and CNN) across multiple formats and frameworks such as MATLAB and Keras. With a special emphasis on neural network verification tools, we also support input formats of other research software such as Marabou, Sherlock, and more. As an ongoing project, we would like to include size reduction techniques of neural networks whose goal is the deployment in physical devices for faster computation while preserving the accuracy of the model.

Python TensorFlow PyTorch ONNX Keras

[CPS Challenge](#) github.com/verivital/VandyCPS

This is a competition funded by the NSF whose goal is to promote research in the area of autonomous drones. Specifically, the goal of this competition is to *autonomously* find a "lost" object in the desert of Tucson, AZ, pick the object up, drop it at the desired destination and land at the starting point. In this project, we used a commercial platform : Intel Aero Ready to Fly Drone, finishing in 3rd place.

ROS Python C++ OpenCV

PUBLICATIONS

PAPERS SUBMITTED AND PENDING REVIEW DECISIONS

- [U2] **Diego Manzananas Lopez**, Stanley Bak, Hoang-Dung Tran, Taylor T. Johnson, Kerianne L. Hobbs, "Evaluation of Neural Network Verification Methods for Air to Air Collision Avoidance", under review for the AIAA Journal of Air Transportation, May 2021.

REFEREED JOURNAL PAPERS

- [J3] 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**, Taylor T. Johnson, Xenofon Koutsoukos, "Safety Verification of Cyber-Physical Systems with Reinforcement Learning Control," ACM Transactions on Embedded Computing Systems (TECS), Special Issue from EMSOFT'19, 2019.
- [J1] Weiming Xiang, **Diego Manzananas Lopez**, Patrick Musau, Taylor T. Johnson, "Reachable Set Estimation and Verification for Neural Network Models of Nonlinear Dynamic Systems", In (Hua-feng Yu, Xin Li, Richard M. Murray, S. Ramesh, Claire J. Tomlin, eds.), Springer International Publishing, pp. 123-144, 2019. [\[pdf\]](#)

REFEREED CONFERENCE PROCEEDINGS PAPERS

- [C8] **Diego Manzananas Lopez**, Patrick Musau, Nathaniel Hamilton and Taylor T. Johnson, Reachability Analysis of a General Class of Neural Ordinary Differential Equations, In 20th International Conference on Formal Modeling and Analysis of Timed Systems (FORMATS), September 2022
- [C7] 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), March 2022
- [C6] 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), March 2022
- [C5] Hoang-Dung Tran, Neelanjana Pal, Patrick Musau, Xiaodong Yang, Nathaniel P. Hamilton, **Diego Manzananas Lopez**, Stanley Bak, Taylor T. Johnson, Robustness Verification of Semantic Segmentation Neural Networks using Relaxed Reachability, In 33rd International Conference on Computer-Aided Verification (CAV), Springer, 2021, July
- [C4] **Diego Manzananas Lopez**, Taylor T. Johnson, Hoang-Dung Tran, Stanley Bak, Xin Chen, Kerianne Hobbs, Verification of Neural Network Compression of ACAS Xu Lookup Tables with Star Set Reachability, In AIAA Scitech 2021 Forum, AIAA, 2021, January.
- [C3] 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. [\[pdf\]](#)
- [C2] Hoang-Dung Tran, Patrick Musau, **Diego Manzananas Lopez**, Xiaodong Yang, Luan Viet Nguyen, Weiming Xiang, 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. [\[pdf\]](#)
- [C1] Hoang-Dung Tran, Feiyang Cai, **Diego Manzananas Lopez**, Taylor T. Johnson, Xenofon Koutsoukos, "Safety Verification of Cyber-Physical Systems with Reinforcement Learning Control", In ACM SIGBED International Conference on Embedded Software (EMSOFT'19), ACM, 2019, October. [\[pdf\]](#)

- [W9] Taylor T. Johnson, **Diego Manzananas Lopez**, Luis Benet, Marcelo Forets, Sebasti  n Guadalupe, Christian Schilling, Radoslav Ivanov, Taylor J. Carpenter, James Weimer and Insup Lee, ARCH-COMP21 Category Report : Artificial Intelligence and Neural Network Control Systems (AINNCS) for Continuous and Hybrid Systems Plants In Goran Frehse and Matthias Althoff (editors). 8th International Workshop on Applied Verification of Continuous and Hybrid Systems (ARCH21), vol 80, pages 90–119. December 2021.
- [W8] 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
- [W7] **Diego Manzananas Lopez**, Patrick Musau, Nathaniel Hamilton, , Hoang-Dung Tran, Taylor T. Johnson, "Case Study : Safety Verification of an Unmanned Underwater Vehicle", IEEE Workshop on Assured Autonomous Systems (WAAS'20), Co-located with the 41st IEEE Symposium on Security and Privacy (Oakland), 2020.
- [W6] **Diego Manzananas Lopez**, Patrick Musau, Taylor T. Johnson, "On the Effectiveness of L_1 -Norm Based Channel Pruning for Convolutional Neural Network Verification", Workshop on Verification of Neural Networks (VNN20), co-located with the 32nd International Conference on Computer-Aided Verification (CAV 2020), July, 2020, Los Angeles, US.
- [W5] Hoang-Dung Tran, Feiyang Cai, **Diego Manzananas Lopez**, Patrick Musau, Taylor T. Johnson, Xenofon Koutsoukos, "Safety Verification in Reinforcement Learning Control," 2nd Workshop on Formal Methods for ML-Enables Autonomous Systems (FoMLAS'19),2019
- [W4] 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. *[pdf]*
- [W3] **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. *[pdf]*
- [W2] **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. *[pdf]*
- [W1] Patrick Musau, **Diego Manzananas Lopez**, Hoang-Dung Tran, Taylor T. Johnson, "Differential Algebraic Equations (DAEs) with Varying Index (Benchmark Proposal)", In 5th Applied Verification for Continuous and Hybrid Systems Workshop (ARCH), Oxford, UK, 2018, July. *[pdf]*

DEMOS, POSTERS, and OTHERS

- [O4] Diego Manzananas Lopez, Patrick Musau, Nathaniel Hamilton, Taylor T. Johnson, "Verification of Neural Ordinary Differential Equations using Reachability Analysis", Workshop on Formal Verification of Machine Learning (WFMV), Co-located with ICML, 2022 July.
- [O3] 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", arXiv, May 2022
- [O2] 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", Workshop on Design Automation for CPS and IoT (DESTION), CPS-IoT Week 2020, April, Sydney, Australia.
- [O1] 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.

● HONORS, AWARDS AND PROFESSIONAL ACTIVITIES

- 2022 Subreviewer at International Conference on Computer Aided Verification (CAV), 2022
- 2022 Repeatability Evaluation Reviewer at ACM International Conference on Hybrid Systems : Computation and Control (HSCC), 2022
- 2022 Subreviewer at ACM International Conference on Hybrid Systems : Computation and Control (HSCC), 2022
- 2021 Subreviewer at AAAI Conference on Artificial Intelligence, 2022
- 2021 Venture Well E-Teams Stage 2 grant - \$20000, Intelligent Systems LLC
- 2021 Subreviewer at IEEE Transactions on Software Engineering
- 2020 Subreviewer at ACM International Conference on Hybrid Systems : Computation and Control (HSCC), 2020
- 2019 Subreviewer at ACM/IEEE International Conference on Cyber-Physical Systems (ICCPS), 2020
- 2019 Subreviewer at ACM International Conference on Hybrid Systems : Computation and Control (HSCC), 2019
- 2019 Wond'ry Prelaunch Entrepreneur Program - \$2300 Microgrant Winner
- 2019 *International Conference on Computer-Aided Verification Week Travel Award*, Loris D'Antoni, New York, NY
- 2018 Subreviewer at ACM/IEEE International Conference on Cyber-Physical Systems (ICCPS), 2019
- 2017 Subreviewer at ACM/IEEE International Conference on Cyber-Physical Systems (ICCPS), 2018
- 2017 *Pi Mu Epsilon* (Mathematics), Presbyterian College, Clinton, SC
- 2017 *Society of Physics Students*, Presbyterian College, Clinton, SC
- 2016, 2017 *Scholar Athlete of the Year*, Big South Conference, Clinton, SC
- 2014 *Freshman of the Year*, Big South Conference, Clinton, SC
- 2012 *America International Student Scholarship*, America International, Madrid, Spain - \$4000

“ REFERENCES

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