Zachariah Carmichael

zcarmich@nd.edu | +1.860.853.0228 | zcarmichael.com

Education

University of Notre Dame

Ph.D. in Computer Science & Engineering
Exp. May 2024 | Notre Dame, IN
GPA: 4.0

Rochester Institute of Technology

M.S. in Computer Engineering
May 2019 | Rochester, NY
GPA: 4.0 | *magna cum laude*

B.S. in Computer Engineering
May 2019 | Rochester, NY
GPA: 3.7 | *magna cum laude*

Skills

AI & ML

Explainable AI • Trustworthy AI • Responsible AI • Interpretable ML • Convolutional Neural Networks (CNNs) • Deep Neural Networks (DNNs) • Large Language Models (LLMs) • Generative AI • Transformers • Deep Learning • Machine Learning

Programming

Python • C/C++ • LaTeX • Bash/Shell • Julia • Java • Verilog • VHDL • JS/HTML/CSS

Software

PyTorch • TensorFlow • Keras • scikit-learn • OpenCV • SymPy • Git • SVN • Docker • Singularity • Matplotlib/Seaborn • MATLAB • ray • Django • ROS • SQL • Azure • AWS

OS

Arch Linux • Ubuntu/Debian • CentOS • NixOS • Linux • Windows

Other

System admin • Project management • Web dev • Drumming • Tennis

Links

GitHub | @craymichael
StackOverflow | @craymichael
LinkedIn | @craymichael
Google Scholar

Service

- Computer Vision Foundation (CVF)

Research Experience

University of Notre Dame Computer Vision Research Lab | Graduate Research Assistant

Aug 2019 - Now | Notre Dame, IN

- Engaged in research on opening the AI black box via intrinsically interpretable neural networks, e.g., the prototypical part neural networks and neuro-symbolic explainable AI (XAI) methods for vision, language, and tabular data
- Conducted research demonstrating the infidelity of post hoc explanation methods for black box interpretation
- Developed an open-source symbolic framework that enables researchers to study feature attribution, interaction effects, & explanations of arbitrarily complex models
- Proposed a highly effective defense for explainers against adversarial attacks to identify malicious auditees and recover faithful explanations

Hewlett Packard Enterprise (HPE) Labs | Research Associate Intern

May 2023 - Now | Milpitas/San Jose, CA

- Developed methods for the evaluation and enhancement of natural and adversarial robustness in neural networks
- Developed a neural surrogate for a computational fluid dynamics solver to improve data center sustainability, achieving 2,000× speedup. The surrogate is combined with online reinforcement learning for the optimization of carbon footprint in data centers

Mitsubishi Electric Research Lab (MERL) | PhD Research Intern

Jun 2022 - Sep 2022 | Boston, MA

- Conducted original research on intrinsically human-interpretable AI for vision tasks (prototypical part neural networks) under supervision of Dr. Mike Jones
- Uncovered and mitigated a fundamental shortcoming of prototypical part neural networks that can produce highly misleading explanations – my solution (which led to a patent application that I helped author) quantitatively improves interpretability for this model which is often applied in high-stakes domains including biomedical imaging
- Helped run a reading group for the state-of-the-art in computer vision

Lawrence Livermore National Lab (LLNL) | Graduate Student Intern

May 2021 - Aug 2021 | Remote

- Proposed a novel algorithm (XNAS) for the optimization of both accuracy and interpretability via multi-objective neural architecture search (NAS)
- Scaled XNAS to a cluster of >100 nodes using `Ray` and asynchronous algorithm design
- Employed a deep learning object detection pipeline for asteroids in Zwicky Transient Facility (ZTF) difference image data with detection accuracy $>90\%$

Neuromorphic AI Lab | Research Fellow

Aug 2019 - May 2021 | University of Texas at San Antonio, San Antonio, TX
Jan 2018 - Aug 2019 | Rochester Institute of Technology, Rochester, NY

- Collaborated with epidemiologists & demographers in the modeling of COVID-19 infectious spread. Developed a live online dashboard for Texas state showcasing case data & forecasts
- Researched the accuracy-energy-latency trade-off of network compression via low-precision arithmetic & custom hardware architecture
- Improved efficiency of neural networks for time series forecasting upwards of 95% in size & training speed using randomness & compression for resource-constrained devices

Publications

H-Index: 9 | I10-Index: 9 | Citations: 331

†Paper | §Oral Presentation | ‡Poster Presentation

Z. Carmichael, S. Lohit, A. Cheerian, M. Jones, W. J. Scheirer. "**Pixel-Grounded Prototypical Part Networks**." *Preprint* (Under Review), –, 2023. arXiv

†§‡ **Z. Carmichael**, W. J. Scheirer. "**Unfooling Perturbation-Based Post Hoc Explainers**." In *Proceedings of the AAAI Conference on Artificial Intelligence*, Washington D.C., USA, 2023. AAAI Press | arXiv

- NeurIPS
- WACV
- IEEE Access
- IEEE Transactions on Computers
- Czech Science Foundation
- IEEE TNNLS

Z. Carmichael, W. J. Scheirer. "**How Well Do Feature-Additive Explainers Explain Feature-Additive Predictors?**." *Preprint* (Under Review), –, 2023. arXiv

S. Sarkar, A. Naug, **Z. Carmichael**, A Guillen, V. Gundecha, R. Luna, L. D. Kashyap, S. Ghorbanpour, D. Markovikj, S. Mousavi, A. Ramesh-Babu. "**CFD Surrogates for Data Center Sustainability Using 3D Convolutional Models**." *Preprint* (Under Review), –, 2023. arXiv

†§‡ **Z. Carmichael**, T. Moon, S. A. Jacobs. "**Learning Debuggable Models Through Multi-Objective Neural Architecture Search**." *International Conference on Automated Machine Learning (AutoML) Workshop*, Potsdam/Berlin, Germany, 2023. arXiv

S. J. Abraham, K. D. G. Maduranga, J. Kinnison, **Z. Carmichael**, J. D. Hauenstein, W. J. Scheirer. "**HomOpt: A Homotopy-Based Hyperparameter Optimization Method**." *Preprint* (Under Review), –, 2023. arXiv

†§‡ W. Theisen, D. Gonzalez, **Z. Carmichael**, T. Weninger, W. J. Scheirer. "**Motif Mining: Finding and Summarizing Remixed Image Content**." In *Proceedings of the IEEE/CVF Winter Conference on Applications of Computer Vision (WACV)*, Waikoloa, Hawaii, USA, 2023. arXiv

†‡ J. Takeshita, **Z. Carmichael**, R. Karl, T. Jung. "**TERSE: Tiny Encryptions and Really Speedy Execution for Post-Quantum Private Stream Aggregation**." In *EAI International Conference on Security and Privacy in Communication Networks (SecureComm)*, Kansas City, USA, 2022. IACR Cryptology ePrint Archive

†§ S. Abraham, **Z. Carmichael**, S. Banerjee, R. VidalMata, A. Agrawal, M. N. Al Islam, W. Scheirer, J. Cleland-Huang. "**Adaptive Autonomy in Human-on-the-Loop Vision-Based Robotics Systems**." In *1st Workshop on AI Engineering – Software Engineering for AI (WAIN'21)*, Remote, 2021. arXiv

†‡ H. Langroudi, V. Karia, **Z. Carmichael**, A. Zyarah, T. Pandit, J. L. Gustafson, D. Kudithipudi. "**ALPS: Adaptive Quantization of Deep Neural Networks With GeneraLized PositS**." In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition Workshops*, Remote, 2021. CVF Open Access

† N. Soures, D. Chambers, **Z. Carmichael**, A. Daram, D. P. Shah, K. Clark, L. Potter, D. Kudithipudi. "**SIRNet: Understanding Social Distancing Measures with Hybrid Neural Network Model for COVID-19 Infectious Spread**." In *Proceedings of the International Joint Conference on Artificial Intelligence (IJCAI) Disease Computational Modeling Workshop*, Remote, 2020. IJCAI DCM | arXiv (out-of-date)

‡ —. "**—**." In *Proceedings of the International Conference on Machine Learning (ICML) Machine Learning for Global Health Workshop*, Remote, 2020. Poster

†§ **Z. Carmichael**, D. Kudithipudi. "**Stochastic Tucker-Decomposed Recurrent Neural Networks for Forecasting**." In *IEEE Global Conference on Signal and Information Processing (GlobalSIP 2019)*, Ottawa, Canada, 2019. IEEE Xplore®

†§ **Z. Carmichael**. "**Towards Lightweight AI: Leveraging Stochasticity, Quantization, and Tensorization for Forecasting**." Master's Thesis (*Won the 2019 RIT Outstanding Master's Thesis Award*), Department of Computer Engineering, Rochester Institute of Technology, 2019. RIT Scholar Works

†§ **Z. Carmichael**, H. F. Langroudi, C. Khazanov, J. Lillie, J. L. Gustafson, D. Kudithipudi. "**Deep Positron: A Deep Neural Network Using the Posit Number System**." In *Proceedings of the IEEE Conference and Exhibition on Design, Automation and Test in Europe (DATE)*, Florence, Italy, March 25-29, 2019. IEEE, 1421–1426. IEEE Xplore® | arXiv

†§ **Z. Carmichael**, H. F. Langroudi, C. Khazanov, J. Lillie, J. L. Gustafson, D. Kudithipudi. "**Performance-Efficiency Trade-off of Low-Precision Numerical Formats in Deep Neural Networks**." In *Proceedings of the ACM Conference for Next Generation Arithmetic (CoNGA)*, Singapore, 2019. ACM DL | arXiv

H. F. Langroudi, **Z. Carmichael**, J. L. Gustafson, D. Kudithipudi. "***Cheetah*: Mixed Low-Precision Hardware & Software Co-Design Framework for DNNs on the Edge**." *arXiv*, Preprint, 2019. arXiv

†§ H. F. Langroudi, **Z. Carmichael**, J. L. Gustafson, D. Kudithipudi. "**PositNN Framework: Tapered Precision Deep Learning Inference for the Edge**." In *Proceedings of the Twelfth IEEE Space Computing Conference (SCC 2019)*, Pasadena, CA, July 30-August 1, 2019. IEEE, 53–59. IEEE Xplore®

†§ **Z. Carmichael**, H. Syed, D. Kudithipudi. "**Analysis of Wide and Deep Echo State Networks for Multiscale Spatiotemporal Time Series Forecasting**." In *ACM International Conference Proceedings*

Series (ICPS) of the Neuro Inspired Computational Elements (NICE) Workshop, Albany, NY, 2019. ACM DL | arXiv

†§ **Z. Carmichael**, B. Glasstone, F. Cwitkowitz, K. Alexopoulos, R. Relyea, R. Ptucha. "**Autonomous Navigation Using Localization Priors, Sensor Fusion, and Terrain Classification**." In *Proceedings of IS&T International Symposium on Electronic Imaging: Autonomous Vehicles and Machines*, San Francisco, CA, 2019. Ingenta Connect

†‡ **Z. Carmichael**, H. Syed, S. Burtner, D. Kudithipudi. "**Mod-DeepESN: Modular Deep Echo State Network**." In *Annual Conference on Cognitive Computational Neuroscience*, Philadelphia, PA, 2018. CCN (out-of-date) | arXiv

Other Publications

Z. Carmichael. "**Demystifying ChatGPT and Other Large Language Models**." *Digital Spirits Substack*, Online, 2023. DigitalSpirits

Z. Carmichael. "**Noncompliance in Algorithmic Audits and Defending Auditors**." *Medium*, Online, 2023. Medium

Grants & Fellowships

NSF Graduate Fellowships Research Program (GRFP) Honorable Mention 2020

University of Notre Dame Jack and Mary Ann Remick Fellowship in Engineering 2019-2024

University of Notre Dame Kilgallon Family Graduate Fellowship 2019-2024

Honors & Awards

RIT Outstanding M.S. Thesis Award 2019
Thesis: "Towards Lightweight AI: Leveraging Stochasticity, Quantization, and Tensorization for Forecasting"

UTSA Best Poster: Fundamental Research in AI (Ph.D.) 2019
Poster: "Cheetah: Mixed Low-Precision Hardware & Software Co-Design Framework for DNNs on the Edge"

RIT KGCOE Dean's List 2014-2019

RIT Presidential Scholarship 2014-2019

RIT BS/MS Tuition Award 2014-2019

RIT Excellence in Computing 2014

Projects

NFL Betting App with Betting AI Oct 2020

CNNs for Loop-Closure Detection in vSLAM Systems 2018-2019

Autonomous Golf Cart – "Tiger Taxi" 2018

Segmentation of Histopathological Images Using U-Net 2018

Experience

Computer Vision Foundation (CVF) | Web Manager
Sep 2019 - Now | Remote

- Position funds my PhD
- Rewrote, audited, & actively maintain CVF Open Access to better serve papers, talks, posters, & other open content from the CVPR, ICCV, ECCV, & WACV conferences to *500,000+* monthly visitors
- Automated synchronization of CVF COVE computer vision datasets & arXiv erratum retrieval with Open Access

- Discovered & mitigated several SQL security vulnerabilities

University of Notre Dame | Graduate Teaching Assistant
Aug 2019 - May 2020 | Notre Dame, IN

- Courses: *Advanced Topics in Machine Learning (ML)* (20+ students | Graduate CS); *Theory of Computing* (30+ students | Upper-level undergraduate CS)
- Taught students core CS & ML concepts in office hours, scoped assignments, held review sessions, & graded exams

Plexus Corp. | Digital Engineering Intern
Jun 2017 - Aug 2017 | Raleigh, NC

- Carried out RTL design of FPGA-agnostic module for evaluation of FPGA cooling systems, validated all test cases with digital engineering team
- Developed embedded software for a battery testing unit using the FRDM-K64F dev board, validated design & integration with mechanical, electrical, & software teams

CUBRC, Inc. | Research/Software Engineering Intern
Jun 2016 - Dec 2016 | Cheektowaga, NY

- Developed a machine learning framework to model surgery risk, patient mortality, & other analytics using `TensorFlow` & `scikit-learn` with automatic model search & hyperparameter optimization
- Worked with customers in the design of electronic health record-unifying database & interface

Membership

Institute of Electrical and Electronics Engineers (IEEE) Student Oct 2018 - Now

Tau Beta Pi – The Engineering Honor Society (TBΠ) Oct 2018 - Now

The National Society of Leadership and Success (ΣAΠ) Oct 2018 - Now

Sigma Xi Nomination (ΣΞ) Jun 2020