AIDAN JOHN FURLONG

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EDUCATION

North Carolina State University, Raleigh, NC — Expected: Dec 2026
Ph.D. in Nuclear Engineering

North Carolina State University, Raleigh, NC — May 2024
M.Sc. in Nuclear Engineering
Thesis: "Prediction of CIPS Susceptibility in PWR Assemblies Using 3D Convolutional Neural Networks"

University of Florida, Gainesville, FL — May 2022
B.Sc. in Nuclear Engineering
Honors: *Cum Laude*

RESEARCH AFFILIATIONS

Artificial Intelligence for the Simulation of Advanced Nuclear Systems Group — Raleigh, NC
Graduate Research Assistant — Jan. 2023 - Present

- Major areas: Convolutional Neural Networks (CNNs), Uncertainty Quantification (UQ), Transfer Learning (TL).
- Advisor: Dr. Xu Wu.

Florida Multiphysics Modeling and Simulation Group — Gainesville, FL
Undergraduate Research Assistant — Sep. 2020 - Apr. 2023

- Major areas: Deep Neural Networks (DNNs), Convolutional Neural Networks (CNNs), Reactor Physics.
- Advisor: Dr. Justin Watson.

PROFESSIONAL EXPERIENCE

Oak Ridge National Laboratory — Oak Ridge, TN
Machine Learning Intern — June 2024 - Aug. 2024

- Compared physics-based hybrid modeling with pure machine learning techniques in the prediction of critical heat flux for dryout conditions.
- The performance benefits of hybrid approaches were confirmed in scenarios of extremely scarce data, with a high resistance to noise.
- Secondary investigation focused on quantifying the uncertainty in these models' predictions using ensembling and Bayesian neural networks.

Westinghouse Electric Company — Cranberry Township, PA
Radiation Engineering & Analysis Intern — May 2023 - Aug. 2023

- Transitioned pressure vessel fluence validation benchmarks to the current discrete ordinates methodology.
- Overhauled in-house SERPENT/MCNP interface script to add enhancements and optimize resource use in support of the eVinci platform's shielding analysis.
- Modeled as-built Vogtle Unit 4 hatches in MCNP to provide updated radiation field estimates.

Palo Verde Nuclear Generating Station — Tonopah, AZ
Nuclear Analysis Intern — May 2022 – Jul. 2022

- Investigated the use of a fresh center assembly as a replacement option instead of a typical twice-burnt assembly.
- Produced a viable design for surviving three consecutive cycles using SIMULATE, with a technical report of findings accepted for use by PVNGS.
- Performed control rod lifetime calculations for the upcoming reload campaign.

Inyo Pool Products — Longwood, FL
Customer Service Representative — May 2019 – Aug. 2020

- Placed orders, coordinated with vendors, and regularly contributed to the technical Q&A thread.
- Achieved the highest customer satisfaction rating with the highest volume of interactions in a department of 15.

PROJECTS

Critical Heat Flux Predictions — Raleigh, NC
Modern Nuclear I&C Group, Oak Ridge National Laboratory — Feb. 2024 - Present

- Implemented and investigated a transfer learning scheme to predict CHF in rectangular channels by leveraging knowledge of the public cylindrical CHF database extracted with deep neural networks (DNNs).
- Found that transfer learning can be a powerful tool to increase DNN performance in situations of scarce data, with plans of extending these methods to other domains and problems.

- Separately, compared DNN performance to that of conditional variational autoencoders geared towards synthetic data generation, concluding that they are comparable in large-data scenarios.

Prediction of Crud-Induced Power Shift Raleigh, NC
Artificial Intelligence for the Simulation of Advanced Nuclear Systems Group Jan. 2023 - May 2024

- Developed a 3D CNN-based framework to quickly and accurately predict the CIPS susceptibility of a modeled core's fuel assemblies.
- Trained using a combination of calculated and measured data from the Catawba Nuclear Station, the model can predict CIPS instances for a complete cycle with an accuracy of 92% in under 17 milliseconds.
- Extensive Uncertainty Quantification was performed using Monte Carlo Dropout (MCD) to assess the model's prediction confidence.

PWR Neutronics Predictions using Neural Networks Gainesville, FL
Florida Advanced Multiphysics and Simulation Group Sep. 2020 - Apr. 2023

- Investigated the use of neural networks in the prediction of neutronics features such as pin powers and k-eigenvalues.
- Using the in-house CNN framework, single-assembly pin power and multiplication factors predictions can be made within 0.5% deviation from OpenMC-calculated values while using a tenth of the computational expense.
- This work was geared towards developing methods for the acceleration of conventional neutronics codes.

Neutronics of a SMR Core for Puerto Rican Deployment Gainesville, FL
Coursework - Senior Design Nov. 2021 - May 2022

- Made design decisions for core geometry, loading pattern, and reactivity control for a small modular paper reactor.
- Found a viable 22-month equilibrium cycle using CASMO/SIMULATE while adhering to all safety and performance limits.
- Thermal hydraulic, safety, and balance-of-plant analyses performed with other team members.

Fast Flux Test Facility Isotopic Modeling Gainesville, FL
Florida Advanced Multiphysics and Simulation Group Feb. 2021 - Apr. 2022

- In support of a graduate student, modeled radial concentrations of various nuclides in generic assemblies using Serpent.
- Compared calculations with experimental data to estimate assembly-specific as-operated power histories.

Modeling Historical PWRs with OpenMC Gainesville, FL
Coursework - Nuclear Materials Feb. 2021 - Apr. 2021

- Simulated core from the early-era modular PM-3A "Antarctica Reactor" using OpenMC.
- Validated model accuracy using historical technical reports and measurements.
- Investigated the use of modernized corrosion-resistant materials on neutronics parameters.

SKILLS

- **Relevant Coursework:** Mathematical Modeling, Nuclear Reactor Design Calculations, Nuclear Fuel Performance, Scientific Machine Learning, Uncertainty Quantification.
- **Languages:** Python, MATLAB, Fortran, C++, Linux, LaTeX.
- **Nuclear Codes:** CASMO/SIMULATE, DOORS, MCNP, MOOSE, OpenMC, Serpent.
- **Python Packages:** Matplotlib, NumPy, Pandas, PyTorch, scikit-learn, seaborn, TensorFlow.
- **Software:** Excel, Word.

SERVICE

- American Nuclear Society (ANS).
- Reviewer for Nuclear Engineering and Design.
- Reviewer for Nuclear Engineering and Technology.
- Reviewer for Scientific Reports.

PUBLICATIONS

1. **Furlong, A.**, Zhao, X., Salko, R. (2025). Physics-based Hybrid Machine Learning for Critical Heat Flux Prediction: Development, Uncertainty Quantification, and Deployment in the CTF Thermal Hydraulics Code. (*in preparation for Applied Thermal Engineering*)
2. **Furlong, A.**, Zhao, X., Salko, R. (2025). Uncertainty Quantification Approaches of Knowledge-based Hybrid Machine Learning Models. (*in preparation for the International Topical Meeting on Nuclear Reactor Thermal Hydraulics - NURETH 2025*)
3. Alsafadi, F., **Furlong, A.**, Wu, X. (2024). Critical Heat Flux Data Augmentation using Conditional Variational Autoencoders. (*in preparation for Nuclear Engineering and Design*)
4. **Furlong, A.**, Alsafadi, F., Palmtag, S., Godfrey, A., Hayes, S., and Wu, X. (2024). The Prediction of Crud-Induced Power Shift Susceptibility in PWR Fuel Assemblies using Convolutional Neural Networks. (*under review, Energy*)

5. **Furlong, A.**, Zhao, X., Salko, R. (2024). Behavior of Hybrid Physics-based and Pure Machine Learning Models in Limited Data Scenarios. (*accepted for the American Nuclear Society 2024 Winter Meeting*)
6. **Furlong, A.**, Wu, X. (2024). The Use of Transfer Learning to Extend Critical Heat Flux Predictions. (*accepted for the Advances in Thermal Hydraulics 2024 Meeting*)
7. Alsafadi, F., **Furlong, A.**, Wu, X. (2024). Comparative Analysis and Uncertainty Quantification in Critical Heat Flux Prediction via Generative Conditional Variational Autoencoders and Deep Neural Networks. (*accepted for the Advances in Thermal Hydraulics 2024 Meeting*)
8. **Furlong, A.**, Alsafadi, F., Palmtag, S., Godfrey, A., Hayes, S., and Wu, X. (2024). Predicting PWR Fuel Assembly CIPS Susceptibility with Convolutional Neural Networks: Performance and Uncertainty Quantification. In *Proceedings of the International Conference on Physics of Reactors - PHYSOR 2024*. San Francisco, CA, USA, April 21-25, 2024.
9. Akins, A., **Furlong, A.**, Kohler, L., Clifford, J., Brady, C., Alsafadi, F., and Wu, X. (2024). ARTISANS - Artificial Intelligence for Simulation of Advanced Nuclear Systems for Nuclear Fission Technology. *Nuclear Engineering and Design*. 423:113170.
10. **Furlong, A.**, and Watson, J. (2024). Analysis of the LatticeNet neural network framework's performance using prediction-calculated temperature coefficients in PWR assemblies. *Annals of Nuclear Energy*. 203:110498.
11. **Furlong, A.**, Alsafadi, F., Kohler, L., Wu, X., Palmtag, S., Godfrey, A., and Hayes, S. (2023). Machine Learning-based Prediction of Crud Buildup Locations in Pressurized Water Reactors. In Transactions of the American Nuclear Society. Washington, D.C., USA, November 12-15, 2023.
12. **Furlong, A.**, Watson, J. and Shriver, F. (2023). Investigation of Monte Carlo-trained CNNs for neutronics predictions of typical and atypical PWR assemblies. *Progress in Nuclear Energy*. 166:104961.
13. **Furlong, A.**, Shriver, F., and Watson, J. (2022). Using neural networks to predict pin powers in reflective PWR fuel assemblies with varying pin size. In *Proceedings of the International Conference on Physics of Reactors - PHYSOR 2022*. Pittsburgh, PA, USA, May 15–20, 2022.