TYLER W. HUGHES

Computational Physicist

ABOUT

I am a computational physicist working at the intersection of photonics, machine learning, and scientific software. My work focuses on differentiable electromagnetic simulation, adjoint-based optimization, and wave-based machine learning. I design and implement large-scale simulation systems (GPU-accelerated FDTD/FDFD), develop numerical optimization methods, and build software frameworks enabling gradient-based design of photonic structures.

EDUCATION

PhD and MS, Applied Physics — Sept 2014 – Aug 2019
Stanford University
Thesis: *Adjoint-Based Optimization and Inverse Design of Photonic Devices*
Advisor: Prof. Shanhui Fan

Bachelor of Science, Physics (With Distinction and Highest Honors) — Sept 2009 – May 2013
University of Michigan
Thesis: *Wafer Reuse for Low Cost, Fhin Film III-V Photovoltaic Devices*
Advisor: Prof. Stephen Forrest

SELECTED WORK EXPERIENCE

Research Scientist → Principal Scientist → Head of Photonics — Sept 2019 – present
Flexcompute Inc — *flexcompute.com*

- Technical lead for large-scale electromagnetic simulation systems, including GPU-accelerated solvers, distributed compute infrastructure, and differentiable simulation frameworks.
- Architected the Tidy3D API and Python client, defining abstractions for simulation setup, data flow, parallel execution, and cloud/HPC integration.
- Designed the automatic-differentiation stack enabling high-dimensional inverse design and gradient-based optimization of photonic devices.
- Developed adjoint formulations, numerical methods, and optimization techniques used across industry and academia for differentiable EM simulations.
- Collaborated closely with research, engineering, and product teams to translate advances in computational electromagnetics into scalable, production-ready tools.

Graduate Research Assistant — Sept 2014 – Aug 2019
Stanford University Shanhui Fan Group — *web.stanford.edu/group/fan*

- Invented approaches for analog machine learning with photonic hardware, including optical backpropagation, analog recurrent neural networks, and nonlinear optical activation functions.
- Developed extensions to the adjoint method for photonic device optimization; released open-source tools demonstrating differentiable simulation for photonics.

Machine Learning Intern — Jun 2018 – Sept 2018
Rasa Technologies — *rasa.com*

- Researched text understanding via named-entity recognition. Implemented a major open-source feature enabling lookup table matching.

Junior Software Engineer — Jan 2014 – Aug 2014
GudTech Inc. — *gudtech.com*

- Full-stack development for commercial inventory management systems; implemented multidimensional data analysis tools.

SELECTED PUBLICATIONS

Pai, S., Sun, Z., **Hughes, T.** et al. *Experimentally realized in situ backpropagation for deep learning in nanophotonic neural networks.* Science (2023).
Yamilov, A., Skipetrov, S.E., **Hughes, T.** et al. *Anderson localization of electromagnetic waves in three dimensions.* Nature Physics (2023).
Hughes, T. et al. *Training of photonic neural networks through in situ backpropagation.* Optica (2018).
Hughes, T. et al. *Wave physics as an analog recurrent neural network.* Science Advances (2019).
Hughes, T. et al. *Forward-mode differentiation of Maxwells equations.* ACS Photonics (2019).
Hughes, T. et al. *Adjoint method and inverse design for nonlinear nanophotonic devices.* ACS Photonics (2018).
Hughes, T. et al. *A perspective on the pathway toward full-wave simulation of large-area metalenses.* APL (2021).
Hughes, T., Fan, S. *Plasmonic circuit theory for multiresonant light funneling.* Nano Letters (2016).
Hughes, T. et al. *Reconfigurable photonic circuit for controlled power delivery to DLAs.* Physical Review Applied (2019).
Hughes, T. et al. *On-chip laser power delivery for dielectric laser accelerators.* Physical Review Applied (2018).

SELECTED PATENTS

- *Efficient Analog Backpropagation Training Architecture for Photonic Neural Networks* (2023).
- *Simultaneous Measurements of Gradients in Optical Networks* (2022).
- *Training Wave-Based Physical Systems as Recurrent Neural Networks* (2022).
- *Systems and Methods for Activation Functions for Photonic Neural Networks* (2022).
- *Training of Photonic Neural Networks Through In Situ Backpropagation* (2021).

SKILLS

Programming	Python, C/C++, Julia.
Frameworks	JAX, PyTorch, Autograd, Scientific Python (NumPy, SciPy, xarray).
Domains	Electromagnetic simulation (FDTD/FDFD), differentiable physics, inverse design, optimization.

OPEN SOURCE PROJECTS

Tidy3D	GPU-accelerated Maxwell's Equations solver.	link
Ceviche	Differentiable frequency-domain electromagnetic simulation.	link
Wavetorch	Wave-based analog RNN simulator and trainer.	link
Angler	Inverse-design tool for nonlinear optics.	link
Symbolic Regression	ML tool for discovering analytic expressions.	link
Neuroptica	Optical neural network hardware modeling framework.	link
Rasa	ML framework for natural language understanding.	link

SELECTED INVITED TALKS

- **Training of photonic neural networks through in situ backpropagation** CLEO (2019).
- **Hardware-accelerated FDTD for large-scale electrodynamics** UW Madison Computing in Engineering Forum (2022).
- **Building the future of photonic design with machine learning** Visionary Speaker, Frontiers in Optics (2025).

LINKS

Personal Website	twhughes.github.io
Google Scholar	scholar.google.com/citations?user=-AHhToYAAAAJ
Github	github.com/twhughes
LinkedIn	linkedin.com/in/tylerwhughes