Colin McDonald

Education

Carnegie Mellon University   Pittsburgh, Pennsylvania
Doctor of Philosophy, Computer Science   August 2023 - Current
University of Notre Dame   Notre Dame, Indiana
Bachelor of Arts, summa cum laude, Computer Science and Philosophy   Class of 2023

Publications

Spork: An Intermediate Representation for Parallelism Management. McDonald, Westrick, Fluet, Acar. *In submission.* 2025.

GraFeyn: Efficient Parallel Sparse Simulation of Quantum Circuits. Westrick, Liu, Kang, McDonald, Rainey, Xu, Arora, Ding, Acar. In *Proc. of the IEEE International Conference on Quantum Computing and Engineering*. 2024.

Exact Recursive Probabilistic Computing. Chiang, McDonald, Shan. In *Proc. of the ACM on Programming Languages*. 2023.

Syntax-Based Attention Masking for Neural Machine Translation. McDonald and Chiang. In *Proc. NAACL Student Research Workshop*. 2021.

Strong Functional Pearl: Harper's Regular-Expression Matcher in Cedille. Stump, Jenkins, Spahn, McDonald. In *Proc. of the ACM on Programming Languages*. 2020.

Experience

Parallel Compilers Research   Carnegie Mellon University
Graduate Researcher   August 2023 - Current

- Designed and implemented parallelism primitives in a state-of-the-art optimizing compiler
- Developed novel encoding for grain-free parallel loops with low sequential overhead while remaining fully parallelizable.
- Averaged 28x speedup on 80 cores and <70% overhead on a single core, while automatically managing granularity control.

Probabilistic Compilers Research   University of Notre Dame
Undergraduate Research Assistant   April 2021 - May 2023

- Designed probabilistic programming language PERPL based on linear lambda calculus with algebraic datatypes
- Wrote compiler from PERPL to a differentiable graph-generating grammar for use in training machine learning models
- Implemented numerous code transformation algorithms to preprocess and optimize PERPL code

Amazon Managed Service for Prometheus   AWS Open Source Observability
Software Development Engineer Intern   May 2022 - August 2022

- Designed and implemented bot to monitor automated trouble tickets, improving efficiency in resolving high-severity issues
- Integrated numerous AWS services and tools, enabling bot to determine the root cause of each ticket, find relevant error logs, plot recent error metrics, and run specialized CloudWatch queries based off that information
- Reduced customer-impacting tickets' average time to resolution by 10 minutes, also saving the on-call engineer 2+ hours/week

Quantum Computing Research   Center for Research Computing, University of Notre Dame
Quantum Computing Lab Intern   December 2020 - April 2021

- Executed quantum circuits on real quantum devices using IBM Quantum Experience with IBM Qiskit
- Developed quantum circuit error estimation algorithm, producing more accurate error estimates than Qiskit's noisy simulator
- Assisted implementation of parameterized quantum circuits, enabling accelerated machine learning

Natural Language Processing Research   University of Notre Dame
Undergraduate Research Assistant   August 2019 - November 2020

- Adapted custom Transformer implementation for tree-to-sequence translation tasks, with novel self-attention mechanism
- Designed model to automatically generate javadocs/docstrings for functions by parsing source code
- Optimized model for GPU use in high-performace computing environment, training models 2x-6x faster
- Created data processing tools to parse and standardize millions of Java and Python functions along with their javadocs/docstrings

Type Theory Research University of Iowa

Pre-Undergraduate Research Assistant May 2017 - August 2019

- Developed dependently-typed functional programming language *Cedille* with lab of grad students, post-docs, and professors
- Primary contributor to Cedille's 15,000-line code base, also writing compact core type checker in fewer than 1000 lines
- Implemented an elaborating transpiler from full language to core language, eliminating algebraic datatypes

Awards and Honors

2023 NDSEG Fellow
2023 NSF GRFP Awardee (declined, chose NDSEG)
2023 Phi Beta Kappa Inductee
2020 Gilman Scholar Awardee (declined, COVID-19)
2019 U.S. Presidential Scholar