

Paddy Ó Conbhuí

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SOFTWARE DEVELOPMENT

My preferred language is C++, and my preferred application domain is anything I haven't done yet. Ideally, something that's never been done. I have a great interest in high performance computing, computational physics, and build systems. I like to keep up to date with modern programming techniques and paradigms whenever possible.

All the technologies listed here I have used extensively in personal projects, or in a professional context.

Expertise:

Bash, C, C++, Fortran 90, Python,
MPI, OpenMP, CUDA C/C++, CUDA Fortran, OpenACC, UPC, Coarray Fortran,
CMake, Autotools, GCC, Clang, MSVC, PGI, ELF/Mach-O linkers & loaders,
SWIG, FEniCS, CGAL, VTK, ParaView, Mathematica, MATLAB, Zemax, Gnuplot, LaTeX,
PulseAudio, GStreamer, SBC, Bluetooth,
HTML/CSS, JavaScript, PHP, Ruby, Ruby On Rails, Node.js, jQuery,
SQL, CouchDB, MongoDB, Redis, Neo4j

EXPERIENCE

Irish Centre for High-End Computing (ICHEC)

Acting Oil & Gas Programme Manager

Dublin, Ireland

2018 - Present

Leading a research software engineering team of 9 post-docs with 1 PhD student with a focus on the oil & gas domain, leading a long-term consultancy oil & gas team of 5, and founded & leading a consultancy Financial software optimization team of 3. Lead and executed several bespoke AI performance optimization projects for Irish SMEs.

- Managed the smooth transition of the duties and consultancy development work of departing Oil & Gas Programme Manager to myself and the current consultancy oil & gas team with limited disruption to our clients. Expanded and still expanding our capability and capacity to service oil & gas clients.
- Founded a consultancy financial software optimization team. Won a highly competitive contract (competing with 4 other UK-based HPC consultancy firms) with a large financial software company for a (now completed) proof-of-concept consultancy optimization project. Further work with the client expected to begin in the next few months.
- Overseeing and contributing to the transition of the ExSeisDat project to its second phase focusing on hardware-level I/O optimization and exascale storage systems, securing ICHEC's partnerships with LERO and DDN to the end of the current funding cycle.
- Lead and contributed to an AI optimization & predictive performance modelling project in the Machine Translation domain.
- Assessing and implementing internal policies and procedures to foster and develop critical skills and experience for our computational scientists.
- Developing best-practice guidelines, FAQs, and teaching material for software development within the centre.
- Developing capability within ICHEC to develop and present Nvidia GPU training material and workshops. Mentoring in Nvidia-sponsored OpenACC hackathons.

Irish Centre for High-End Computing (ICHEC)

Computational Scientist

Dublin, Ireland

2017 - 2018

Contributed to the development of academic and enterprise software, primarily in the context of oil & gas. Ported and optimized software for clients to leverage GPU accelerators, primarily for AI codes.

- Contributed to the ExSeisDat library, focusing on parallel I/O and I/O optimization for oil & gas data formats and workflows. Introduced a number of common best-practices, including using CMake, eliminating compiler warnings, using static analysis, automatic code formatting, and continuous integration using multiple compilers and dependency versions / implementations.
- Contributed to the development of consultancy oil & gas software.
- Ported an oil & gas code (Kirchhoff Depth Migration) to run on Microsoft Azure cloud platform, leveraging Nvidia GPU acceleration for a multi-national oil & gas company.

- Analyzed and ported AI software stack in the Natural Language Processing domain to leverage GPU acceleration for Opening.io.
- Participated in numerous workshops (primarily with PRACE), further developing skills in high performance C++, parallel I/O, seismic data processing, FPGA programming, performance analysis tools, and modern parallel programming models for exascale systems.
- Received professional certification as Certified Scrum Master (CSM) from Scrum Alliance.

University Of Edinburgh
PhD Student

Edinburgh, Scotland
2013 - 2017

Investigated numerical techniques for understanding how rocks record changes in the earth's magnetic field. This was done primarily through the lens of micromagnetic modelling, using high-performance finite element analysis, C++ and Fortran.

- Developed theory and computational techniques for including magnetostrictive effects in non-uniformly-magnetized 3d finite-element micromagnetic models with free boundaries. This was implemented in our group's micromagnetics code, MERRILL, with results presented at conferences, and published in a thesis.
- Developed a meshing application, MESHRRILL, leveraging the CGAL library to generate unstructured meshes for micromagnetic simulations. The application generates a number of pre-defined shapes, typical for ferromagnetic crystals, but also generates reconstructions of geometries from tomography images. Data generated by this software has been used in publications.
- Developed software, HoloMag, to produce simulated electron holography data from our micromagnetic models. This is provided as a ParaView plugin and has been optimized to produce holography results in near real-time, allowing researchers to develop an intuition for how 3d magnetizations effect the 2d holography images. Data generated by this software has been used in publications.
- Developed workflows for compiling software for reliable distribution. This included building as-static-as-possible versions of programs like MERRILL, along with shared-library version of MESHRRILL with all dependencies installed in a subfolder and RPATHs set appropriately, so it could easily be used and linked as a C++ library to mesh complex user-defined geometries. HoloMag was also compiled to be ABI-compatible with ParaView binaries downloaded from the ParaView website.

Dublin Web Summit Limited
Technical Analyst

Dublin, Ireland
Summer 2012

Evaluated new technologies for use in projects. Built and maintained applications for internal and external use. Analyzed and modified applications to handle higher user loads as necessary.

- Developed browser based app leveraging Facebook's JavaScript API and FBQL API to display a user's mutual friends with attendees of an event. Handled events with thousands of attendees within seconds.
- Analyzed ticketing system used for event, identified features causing the system to slow to an unacceptable pace when the user base grew large enough and presented solutions.
- Implemented caching and distribution of content through a CDN for events sites when hosting servers began straining under high traffic.
- Researched and made recommendations on IaaS platforms, deployments in cloud environments and NoSQL database systems for use with apps and services being developed in-house.

LULI, École Polytechnique
Intern

Palaiseau, France
Summer 2011

Investigated alignment errors encountered by experiments using ellipsoidal plasma mirrors (EPM) for focusing lasers.

- Participated in a laser-plasma ion acceleration experiment.
- Developed numerical model of an experimental setup probing EPM alignment errors using the Zemax optics software.
- Investigated alignment errors due to geometric effects using ray tracing models, and compared them to diffractive errors by using wave front propagation models.
- Set up an equivalent physical model of the experimental setup using a Helium-Neon laser to experimentally replicate the predictions of the model.
- Demonstrated the classes of alignment errors the EPM was and was not sensitive to, informing alignment procedures in future experiments.

University Of Edinburgh

PhD, Geophysics

Edinburgh, Scotland

2013 to 2017

Trained as a researcher in Geophysics, primarily in computational paleomagnetism.

Thesis: *Micromagnetic Modelling of Imperfect Crystals*

Developed the theory needed to simulate non-uniformly-magnetized, multi-phase, ferromagnetic crystals including magnetostriction and crystal defects, with free boundary conditions. Presented implementations and results.

University Of Edinburgh

MSc, High Performance Computing – With Distinction

Edinburgh, Scotland

2012 to 2013

The course centred around building high performance applications, primarily through parallelism, and through deep understanding of the underlying architecture of a given system and language.

Subjects: Message Passing Programming, Threaded Programming, Parallel Numerical Algorithms, Parallel Programming Languages, HPC Architectures, HPC Ecosystems, Performance Programming, Software Development, Advanced Parallel Programming, Parallel Design Patterns.

Dissertation: *Towards Exascale Molecular Dynamics*

Compared replicated data and systolic loop schemes for molecular dynamics simulations, and presented a novel hybrid replicated systolic scheme with impressive scaling properties.

Trinity College, Dublin

BA Mod, Theoretical Physics – II-1

Dublin, Ireland

2008 to 2012

The course taught practical problem solving skills and analytical thinking in the fields of Mathematics and Physics.

Subjects: Computer Simulation, GPU Programming, Experimental Labs, Classical Mechanics, Quantum Mechanics, Classical Field Theory, Quantum Field Theory, Special Relativity, General Relativity, Classical Statistical Mechanics, Quantum Statistical Mechanics, Condensed Matter Physics, Spectroscopy, Optics, Electromagnetism, Magnetism, Thermodynamics, Electronics, Chaos and Complexity, Linear Algebra, Analysis, Topology.

Dissertation: *Computing Two Point Correlators For A Lattice QCD Theory On Graphics Processing Units*

Wrote complex-valued matrix multiplications routines in CUDA C which beat cuBLAS (at the time) by 20%. Re-cast the full set of matrix multiply-traces needed to compute the correlator matrix into a large matrix-matrix multiplication, providing up to 20x performance improvement over independent multiply-trace operations.

PUBLICATIONS

Fisher, M. A., Conbhuí, P. Ó., ... & Short, R. (2018). ExSeisDat: A set of parallel I/O and workflow libraries for petroleum seismology. *Oil & Gas Science and Technology–Revue d'IFP Energies nouvelles*, 73, 74.

Ó Conbhuí, P. (2018). Micromagnetic modelling of imperfect crystals, PhD Thesis, University of Edinburgh.

Conbhuí, P. Ó., Williams, W., Fabian, K., Ridley, P., Nagy, L., & Muxworthy, A. R. (2018). MERRILL: Micromagnetic earth related robust interpreted language laboratory. *Geochemistry, Geophysics, Geosystems*, 19(4), 1080-1106.

Valdez-Grijalva, M. A., Muxworthy, A. R., Williams, W., Conbhuí, P. Ó., Nagy, L., Roberts, A. P., & Heslop, D. (2018). Magnetic vortex effects on first-order reversal curve (FORC) diagrams for greigite dispersions. *Earth and Planetary Science Letters*, 501, 103-111.

Nagy, L., Williams, W., Muxworthy, A. R., Fabian, K., Almeida, T. P., Conbhuí, P. Ó., & Shcherbakov, V. P. (2017). Stability of equidimensional pseudo-single-domain magnetite over billion-year timescales. *Proceedings of the National Academy of Sciences*, 114(39), 10356-10360.

Almeida, T. P., Muxworthy, A. R., Kovács, A., Williams, W., Nagy, L., Conbhuí, P. Ó., ... & Dunin-Borkowski, R. E. (2016). Direct observation of the thermal demagnetization of magnetic vortex structures in nonideal magnetite recorders. *Geophysical Research Letters*, 43(16), 8426-8434.

Einsle, J. F., Harrison, R. J., Kasama, T., Conbhuí, P. Ó., Fabian, K., Williams, W., ... & Midgley, P. A. (2016). Multi-scale three-dimensional characterization of iron particles in dusty olivine: Implications for paleomagnetism of chondritic meteorites. *American Mineralogist*, 101(9), 2070-2084.

Einsle, J. F., Fu, R. R., Weiss, B. P., Kasama, T., Fabian, K., Conbhuí, P. Ó., ... & Harrison, R. J. (2015). Focused ion beam nanotomography of chondritic meteorites: Closing the mesoscale length gap in paleomagnetic studies. *Microscopy and Microanalysis*, 21(S3), 2261-2262.