Curriculum Vitae for Mats K. Brun

Personal information

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Born:	19.04.1988	Nationality:	Norwegian

Summary

I hold a PhD in Applied and Computational Mathematics, and have several years of experience with mathematical modeling and scientific programming. Through my work as a researcher both at the University of Bergen and at the University of Oslo, I have gained a good understanding of mathematical modeling and numerical simulation of diverse real-world systems, ranging from geothermal energy storage to evolutionary biology.

Technical skills

Frameworks	NumPy, SciPy, FEniCS, Pandas, MatPlotLib, Keras
Languages	Python, Java, MatLab, Haskell
Numerical methods	(Mixed) Finite Element Method, Finite Volume Method
Tools	Git, LaTeX, Microsoft Office

Education

2012	BSc in Physics, Department of Physics and Technology, University of Bergen
2013 – 2015	MSc in Applid and Computational Mathematics, Department of Mathematics, University of Bergen. Thesis title: 'Wave breaking in long wave models and undular bores'
2016 – 2019	PhD in Applied and Computational Mathematics, Department of Mathematics, University of Bergen. Thesis title: 'Upscaling, analysis, and iterative numerical solution schemes for thermo-poroelasticity'. Main supervisor: Florin Radu. Co-supervisors: Inga Berre and Jan M. Nordbotten

Professional experience

2008 – 2011	Part-time employee at Dolly Dimple's Torgallmenningen, Bergen
2014	Teaching assistant in Calculus II (MAT112) at the University of Bergen
2011 – 2016	Part-time Team Leader at ADAM 2326
2016	Substitute teacher (with varying hours) in mathematics and physics at Bergen Katedralskole
2016 – 2019	PhD Research Fellow aff. with the Porous Media Group, Department of Mathematics, University of Bergen
2018	Visiting researcher, Institute of Applied Mathematics, Leibniz Universität Hannover, Germany
2019	Co-supervisor for a MSc student aff. with the Porous Media Group
2019	Analyst at Frende Insurance, Bergen
2020 – 2021	Postdoctoral Fellow at CEES - Centre for Ecological and Evolutionary Synthesis, Department of Biosciences, University of Oslo
2021	Part-time position (20%) as teacher in mathematics (S2) at Sonans, Oslo
2021 –	IT-Consultant at Expert Analytics

Languages

English	Fluent (written and spoken)
Norwegian	Native language

Personal skills

Analytical	Through many years of technical education I have gained a good ability to think logically and analytically, and am not afraid to confront challenging problems.
Communication and teaching	Several teaching experiences both at the high-school and university levels has augmented my ability to internalize and communicate difficult concepts.
Creative	Extensive experience in creative thinking, both in terms of creative solutions to academic and technical problems, and in terms of music performance and production.
Modeling and scientific programming	Extensive experience with mathematical modeling of real-world systems, and design and implementation of numerical algorithms.
Problem solving	Always up for a new challenge, and always eager to learn new skills and explore new technology.

Some interests and hobbies

Music	Guitar, Piano, Music production
Personal	Personal development, Traveling, Live music, Reading
Sports	Weightlifting, Running, Hiking, Skiing

Extended descriptions of selected projects

Activity	Drivers of evolutionary change: Understanding stasis and non-stasis through integration of micro- and macroevolution
Period	2020 – 2021
Role	Researcher
Staffing	Team of 4
Volume	Full-time
Description	As a postdoctoral researcher in biomathematics, I was part of a research team led by Prof. Nils Chr. Stenseth and Prof. Jan Martin Nordbotten, devoted to developing a mathematical framework for eco-evolutionary modeling. In particular, to connect evolutionary models at different scales in a unified mathematical framework. E.g., one may consider a population as a system of interacting species, or, one may consider the population as distinct individuals without imposing the category of species upon them. A multi-scale description of an eco-evolutionary system can therefore give new insight into phenomena such as speciation. My role in this project was two-fold: To extend the existing mathematical framework in a more mathematically rigorous direction, and to apply this framework to a real-world eco-evolutionary system using biological data.
Tools	Mathematical modeling and analysis, Mathematical biology, Finite Volume Method, MatLab, Latex

Activity	An iterative staggered scheme for phase field brittle fracture propagation with stabilizing parameters
Period	2018
Role	Researcher
Staffing	Team of 5
Volume	Full-time
Description	During my doctoral work I spent some time at the Leibniz Universität Hannover, Germany, as a visiting researcher, where I collaborated with Prof. Thomas Wick. The purpose of this collaboration was to work on numerical solution algorithms for fracture propagation in brittle materials, where the fracture surface is represented by a phase-field variable. Our strategy was to decouple the mechanics from the phase-field and solve each linearized subproblem separately, while iteratively updating coupling terms. Analysis of the proposed algorithm revealed bounds on the elastic strain and the thickness of the phase-field surface for which convergence is guaranteed. Moreover, stabilizing parameters were introduced and tailored specifically to each subproblem. The resulting algorithm is a stable and efficient solution procedure for the notoriously difficult phase-field brittle fracture propagation problems, including conditions for guaranteed convergence.
Tools	Mechanics, Finite Element Method, Latyex, Deal II

Activity	Upscaling, analysis, and iterative numerical solution schemes for thermo-poroelasticity
Period	2016 – 2019
Role	Researcher
Staffing	Team of 5
Volume	Full-time
Description	The main objectives of my doctoral research was to provide part of the mathematical models and simulation technology required to assess large-scale deployment of thermo-mechanical subsurface energy storage in the context of intermittent renewable energy. The relevant physical processes for this application is the coupling of geomechenics, flow, and heat transfer within a porous material, i.e., thermo-poroelasticity. Thus, together with my supervisors; Prof. Florin Radu, Prof. Inga Berre, and Prof. Jan Martin Nordbotten, we focused on different aspects of thermo-poroelasticity, relevant for the previously mentioned application, and under the technical umbrella of mathematical modeling and analysis. In particular, the research was separated into three parts; (1) modeling, (2) analysis, and (3) implementation.
Tools	Mathematical modeling and analysis, Finite Element Method, Python, Numpy, SciPy, Latex

Publications

Journal	Computers & Mathematics with Applications
Date	2020
Authors	Brun, Mats Kirkesæther and Ahmed, Elyes and Berre, Inga and Nordbotten, Jan Martin and Radu, Florin Adrian
Title	Monolithic and splitting solution schemes for fully coupled quasi-static thermo-poroelasticity with nonlinear convective transport
Summary	This paper concerns monolithic and splitting-based iterative procedures for the coupled nonlinear thermo-poroelasticity model problem. The thermo-poroelastic model problem we consider is formulated as a three-field system of PDE's, consisting of an energy balance equation, a mass balance equation and a momentum balance equation, where the primary variables are temperature, fluid pressure, and elastic displacement. Due to the presence of a nonlinear convective transport term in the energy balance equation, it is convenient to have access to both the pressure and temperature gradients. Hence, we introduce these as two additional variables and extend the original three-field model to a five-field model. For the numerical solution of this five-field formulation, we compare six approaches that differ by how we treat the coupling/decoupling between the flow and/from heat and/from the mechanics, suitable for varying coupling strength between the three physical processes. We provide a convergence proof for the derived algorithms, and demonstrate their performance through several numerical examples investigating different strengths of the coupling between the different processes.
DOI	https://doi.org/10.1016/j.camwa.2020.08.022

Journal	Computer Methods in Applied Mechanics and Engineering
Date	2020
Authors	Brun, Mats Kirkesæther and Wick, Thomas and Berre, Inga and Nordbotten, Jan Martin and Radu, Florin Adrian
Title	An iterative staggered scheme for phase field brittle fracture propagation with stabilizing parameters
Summary	This paper concerns the analysis and implementation of a novel iterative staggered scheme for quasi-static brittle fracture propagation models, where the fracture evolution is tracked by a phase field variable. The model we consider is a two-field variational inequality system, with the phase field function and the elastic displacements of the solid material as independent variables. Using a penalization strategy, this variational inequality system is transformed into a variational equality system, which is the formulation we take as the starting point for our algorithmic developments. The proposed scheme involves a partitioning of this model into two subproblems; phase field and mechanics, with added stabilization terms to both subproblems for improved efficiency and robustness. We analyze the convergence of the proposed scheme using a fixed point argument, and find that under a natural condition, the elastic mechanical energy remains bounded, and, if the diffusive zone around crack surfaces is sufficiently thick, monotonic convergence is achieved. Finally, the proposed scheme is validated numerically with several bench-mark problems.
DOI	https://doi.org/10.1016/j.cma.2019.112752

Journal	Journal of Mathematical Analysis and Applications
Date	2019
Authors	Brun, Mats Kirkesæther and Ahmed, Elyes and Nordbotten, Jan Martin and Radu, Florin Adrian
Title	Well-posedness of the fully coupled quasi-static thermo-poroelastic equations with nonlinear convective transport
Summary	This paper is concerned with the analysis of the quasi-static thermo-poroelastic model. This model is nonlinear and includes thermal effects compared to the classical quasi-static poroelastic model (also known as Biot's model). It consists of a momentum balance equation, a mass balance equation, and an energy balance equation, fully coupled and nonlinear due to a convective transport term in the energy balance equation. The aim of this article is to investigate, in the context of mixed formulations, the existence and uniqueness of a weak solution to this model problem. The primary variables in these formulations are the fluid pressure, temperature and elastic displacement as well as the Darcy flux, heat flux and total stress. The well-posedness of a linearized formulation is addressed first through the use of a Galerkin method and suitable a priori estimates. This is used next to study the well-posedness of an iterative solution procedure for the full nonlinear problem. A convergence proof for this algorithm is then inferred by a contraction of successive difference functions of the iterates using suitable norms.
DOI	https://doi.org/10.1016/j.jmaa.2018.10.074