Mikhail Malovichko

PhD in Technical Sciences (Geophysics)
Senior Geophysicist at Aramco Innovations
Languages: Russian, English

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Summary

My areas of expertise are mathematical modelling, high-performance computing, inverse problems, and software development with applications to geophysics, including:

- geophysical modelling/inverse problems/imaging: acoustic/elastic/fluid-solid seismic simulation, elastic FWI, elastic RTM, LS-RTM, Hessian approximations, borehole sonic logging, electromagnetic modelling and inversion, multi-physics inversion, potential fields;
- multidimensional PDE-based inverse problems, optimal control, imaging;
- high-performance computing, MPI, OpenMP, CUDA;
- numerical methods for PDEs (FEM, mixed FEM, Discontinuous Galerkin, spectral elements, finite volume method, finite differences, multigrid, etc);
- computational linear algebra, Krylov solvers, saddle-point problems, preconditioning,multigrid, non-linear problems, optimization;

Education

- 2014 PhD in Technical Sciences from M.V. Lomonosov Moscow State University, Russia.
- 2006 M.S. in Geophysics from St.-Petersburg State University, Russia.
- 2004 B.S. in Geophysics from St.-Petersburg State University, Russia.

Employment

•Aramco Innovations *05.2024-present*
Full-time Senior Geophysicist Moscow, Russia

– Technical Thrust Champion (teamlead) at High-Performance Computatations team
– Software development for geophysical modeling and inverse problems.
– Project supervising

•Moscow Institute of Physics and Technology *11.2021-05.2024*
Full-time Associate Professor (Docent) at Dept. of Computational Physics Dolgoprudny, Russia

– Academic research in inverse problems and imaging targeting geophysics.
– Software development for industrial partners
– Student supervision

•Aramco Innovations *02.2022-05.2024*
Contractor Moscow, Russia

– Principal software developer for CUDA-based elastic reverse-time migration with the spectral-element method.
– Principal software developer for CPU/GPU based frequency-domain seismic modelling.

•Skolkovo Institute of Science and Technology *03.2022–01.2023*
Contractor Moscow, Russia

– Consultant on solving PDEs for seismic modelling in a quantum computing project.

•Skolkovo Institute of Science and Technology *11.2019–11.2021*
Full-time Research Scientist at Center for Data-Intensive Science and Engineering, HPC Lab Moscow, Russia

– Academic research in medical imaging and inverse problems.
– Software development for FEM-based inversion of EEG and MEG data.

•Moscow Institute of Physics and Technology *11.2019–11.2021*
Part-time Senior Research Scientist at Applied Computational Geophysics Lab Dolgoprudny, Russia

– Academic research in geophysical inverse problems
– Teaching, student supervision

•Moscow Institute of Physics and Technology *09.2014–11.2019*
Full-time Senior Research Scientist at Applied Computational Geophysics Lab (Prof. M. Zhdanov) Dolgoprudny, Russia

– Academic research in geophysical inverse problems

– Software development for industrial partners
– Teaching, student supervision

•Seabed Geosolutions S.A. *06.2014–08.2014*
Full-time Geophysics Operator the Netherlands

– QC of marine seismic data

•EMMET JSC (a subsidiary of Fugro NV) *04.2011–05.2014*
Full-time Chief of Software and Data Processing Team Moscow, Russia

– Software development, algorithm design, processing of industrial geophysical data

•EMMET LLC *01.2008–04.2011*
Full-time Scientific Researcher Moscow, Russia

– Software development, industrial R&D

Selected industrial projects

•Seismic reverse-time migration

– Project customer: Aramco
– Scope: software development for 3D elastic RTM based on the spectral-element method
– Technology: C++/CUDA
– Role: Principal Developer

•Seismic modelling in the frequency domain

– Project customer: Aramco
– Scope: software development for 3D acoustic modelling (Helmholtz's equation) based on the FEM with a preconditioned iterative solver targeting distributed-memory GPU clusters
– Technology: C++/CUDA/OpenMP/MPI
– Role: Project Lead

•Geophysical 3D electromagnetic inversion

– Project customer: a software vendor
– Scope: software development for 3D modelling and inversion of controlled-source electromagnetic geophysical data with the FEM on unstructured meshes targeting shared-memory systems
– Technology: C++/OpenMP
– Role: Project Lead

•Optimal-transport proximity measure for seismic FWI

– Project customer: Aramco
– Scope: Software development for calculating proximity measures between measured and observed seismograms using the Optimal Transport approach, based on the Simultaneous Directions Method of Multipliers (SDMM); a critical element is the application of a GPU-based full multigrid method.
– Technology: C/CUDA
– Role: Project Lead

•GPU-based finite-difference elastic simulation

– Project customer: Aramco
– Scope: Software development of high-throughput CUDA kernels for modeling elastic wave propagation using the 8th order finite-difference method on staggered grids.
– Technology: C++/CUDA
– Role: Principal Developer

Research grants

2019-2023 $280K **Russian Science Foundation** (Key Personnel) *Development of novel methods for 3D numerical modeling of harmonic fields in problems of exploration geophysics*

2018-2019 $92K **Russian Foundation for Basic Research** (Key Personnel) *Development of method of characteristics for modeling the propagation of dynamic waves in heterogeneous media at different scales*

2018-2020 $32K **Russian Foundation for Basic Research** (PI) *Solution of the inverse three-dimensional problem of acoustics in the frequency domain based on effective preconditioning of the finite difference matrix.*

2016-2020 $460K **Russian Science Foundation** (Key Personnel) *Development of mathematical methods for three-dimensional interpretation of geophysical data based on a joint solution of direct and inverse problems*

2016-2018 $96K **Russian Foundation for Basic Research** (Key Personnel) *Development of a novel numerical method for the joint inversion of seismic and electromagnetic data, including nonlinear inversion, and a software package based on it*

2016-2017 $15K **Russian Foundation for Basic Research** (PI)*Development of an algorithm for joint inversion of acoustic and electromagnetic fields based on an approximate solution of the Lippmann-Schwinger equation on a high-performance computer system*

2016 $7K **Russian Foundation for Basic Research** (Key Personnel) *Development of an algorithm for inversion of electromagnetic geophysical data in the frequency domain based on effective preconditioning of a finite difference matrix*

2014-2016 $470K **Russian Ministry of Education** (Key Personnel) *Development of accurate computational methods and an integrated software-algorithmic system for prospecting and exploration of mineral deposits using seismic and electromagnetic methods on Arctic shelf*

Journal articles

- **Malovichko** , Sabitov, Dmitriev, Zharnikov *Towards the shear-wave sonic reverse time migration with the spectral element method*, J. Appl. Geoph., 2025
- **Malovichko** , Orazbayev, Khokhlov, Petrov *Iterative PDE-constrained optimization for seismic full-waveform inversion*, Comput. Math. & Math. Phys., 2024
- **Malovichko** , Yavich, Razorenova, Golubev, Koshev, *PDE-constrained optimization for electroencephalographic source reconstruction*, Lobachevskii J. of Mathematics, 2024
- Skidchenko, Butorina, Ostras, Vetoshko, Kuzmichev, Yavich, **Malovichko** , Koshev, *Yttrium-iron garnet magnetometer in MEG: Advance towards multi-channel arrays*, Sensors, 2023
- Golubev, Shevchenko, Khokhlov, Petrov, **Malovichko** , *Compact grid-characteristic scheme for the acoustic system with the piece-wise constant coefficients*, Int. J. of Applied Mechanics, 2022
- **Malovichko** , Tarasov, Yavich, Titov, *Application of optimal control to inversion of self-potential data: theory and synthetic examples*, IEEE Trans. on Geoscience and Remote Sensing, 2021
- Yavich, Koshev, **Malovichko** , Razorenova, Fedorov, *Conservative Finite Element Modeling of EEG and MEG on Unstructured Grids*, IEEE Trans. on Medical Imaging, 2021
- Yavich, Khokhlov, **Malovichko** , Zhdanov, *Contraction operator transformation for the complex heterogeneous Helmholtz equation*, Computers & Mathematics with Applications, 2021
- **Malovichko** , Koshev, Yavich, Razorenova, Fedorov, *Electroencephalographic source reconstruction by the finite-element approximation of the elliptic Cauchy problem*, IEEE Trans. on Biomedical Engineering, 2021
- **Malovichko** , Khokhlov, Yavich, Zhdanov, *Incorporating known petrophysical model in the seismic full-waveform inversion using the Gramian constraint*, Geophys. Prospecting, 2020
- Yavich, **Malovichko** , Shlykov, *Parallel simulation of audio-and radio-magnetotelluric data*, Minerals, 2020
- Koshev, Yavich, **Malovichko** , E. Skidchenko, Fedorov, *FEM-based Scalp-to-Cortex EEG data mapping via the solution of the Cauchy problem*, J. of Inverse and Ill-Posed Problems, 2020
- **Malovichko** , Tarasov, Yavich, Zhdanov, *Mineral exploration with 3-D controlled-source electromagnetic method: a synthetic study of Sukhoi Log gold deposit*, Geophys. J. Int., 2019
- **Malovichko** , Khokhlov, Yavich, Zhdanov, *Acoustic 3D modeling by the method of integral equations*, Computers and Geosciences, 2018
- **Malovichko** , Khokhlov, Yavich, Zhdanov, *Approximate solutions of acoustic 3D integral equation and their application to seismic modeling and full-waveform inversion*, J. of Comput. Phys., 2017

Preprints/Manuscripts under review

- **Malovichko** , Shevchenko, Kim, Dmitriev, Sabitov, Salim *Iterative spectral-element modeling of the Helmholtz equation in seismic applications*, 2024, (under review in Geoph. J. Int)
- **Malovichko** , Shevchenko, Golubev, *On imaging conditions for elastic reverse-time migration*, Technical Report 2022 ResearchGateLink

Recent conference proceedings

- **Malovichko** et al., *On reconstruction of the coefficient in complex Helmholtz's equation*, IOP Conference Series 2021
- **Malovichko** et al., *Novel Approach to Newtonian Full-Waveform Inversion*, EAGE Geomodel 2021
- **Malovichko** et al., *Fast Finite-difference Audiomagnetotelluric Simulation*, EAGE Near-Surface Geosciences 2020
- Gordov, Khokhlov, **Malovichko** , *GPU-accelerated integral-equation seismic simulation*, Russian Supercomputer Days 2020
- Razorenova, Yavich, **Malovichko** , Fedorov, Koshev, Dylov, *Deep Learning for Non-Invasive Cortical Potential Imaging*, Machine Learning in Clinical Neuroimaging and Radiogenomics in Neuro-oncology 2020.
- Yavich, **Malovichko** , Zhdanov, *Towards efficient finite-element EM modeling on hexahedral grids*, EAGE Conference and Exhibition 2019
- **Malovichko** et al., *Comparing the effectiveness of CSEM, CSAMT, and DC methods on a 3D model of gold deposit*, EAGE Conference and Exhibition 2019
- **Malovichko** et al., *On the optimal strategy of three-dimensional inversion of low-frequency electromagnetic data*, EAGE Conference on Geophysics for Mineral Exploration and Mining 2018
- **Malovichko** et al., *The Gramian constraint for incorporating a priori geoelectrical model into seismic full-waveform inversion*, EAGE Conference on Geophysics for Mineral Exploration and Mining 2018
- Yavich, **Malovichko** , Khokhlov, Zhdanov, *Preconditioning the time-harmonic acoustic wave equation based on a special contraction operator transformation*, EAGE Conference on Geophysics for Mineral Exploration and Mining 2018

Teaching experience

- *Computational Math* (Instructor, 5 years). It is a two-semester undergraduate course dedicated to numerical methods for PDEs (finite differences, FEM, finite volumes, Riemann solvers, etc.), ODEs (Runge-Kutta, BDF, stiff systems, etc.), numerical linear algebra (direct solvers, Krylov space solvers, preconditioning, etc.), and optimization (gradient methods, Newton's method, BFGS, methods for saddle-point problems etc.).
- *Numerical solution of PDEs* (Lecturer, 2 years). It is a one-semester graduate course about numerical methods for mathematical modelling with PDEs, emphasising the finite element method (FEM). The course covers fundamentals of the FEM, properties of solutions, error estimates and software implementation, as well as the application of the FEM to elliptic and hyperbolic PDEs.

Technical skills

- Extensive knowledge of modern numerical methods (finite elements, finite volumes, spectral elements, finite differences, Riemann solvers, integral equations etc.)
- Expert in C++ (including NVCC), proficient in C and Matlab, working knowledge of Python, basic knowledge of FORTRAN.
- Extensive working knowledge of parallelization techniques (MPI, OpenMP, CUDA)
- Strong familiarity with industrial packages for math modelling and linear algebra: MFEM, FEniCS, HYPRE, PETSc, MUMPS, SuiteSparse etc.
- Linux/git/make/cmake/bash/SLURM/PBS.