

Bogdan Toader

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Research interests

I am an applied mathematician interested in the broad fields of machine learning, optimisation, inverse problems and data science, and their application to imaging problems. My current focus is on algorithms used in cryo-electron microscopy (cryo-EM) and cryo-electron tomography (cryo-ET), including both traditional iterative algorithms and approaches based on deep learning. Previously, I worked on algorithms for deconvolution with spatially varying point spread function arising in light-sheet microscopy and developed theory for the stability of the super-resolution problem with non-negative measures.

Professional experience

- Jan 2024 - present **Postdoctoral Scientist, Marie Skłodowska-Curie (MSCA) Postdoctoral Fellow**
MRC Laboratory of Molecular Biology, UK
Structural Studies Division
Research topic: image processing algorithms for cryo-ET
Group leaders: Dr Sjors Scheres and Dr Tanmay Bharat
- Sep 2021 - Dec 2023 **Postdoctoral Research Associate, Yale University, US**
Department of Statistics and Data Science and Quantitative Biology Institute
Research topic: analysis of cryo-EM methods
Group Leader: Prof Roy Lederman
- Sep - Dec 2022 **Visiting Researcher, University of California, Los Angeles, US**
Institute for Pure and Applied Mathematics (IPAM)
Core participant of the IPAM Long Program on Computational Microscopy.
- Aug 2019 - July 2021 **Postdoctoral Research Associate, University of Cambridge, UK**
Cambridge Advanced Imaging Centre (CAIC)
Research topic: deconvolution algorithms for light-sheet microscopy
Group leader: Dr Leila Muresan
- Aug 2013 - Sep 2015 **Technology Associate, Morgan Stanley, UK**
Jul 2011 - May 2012 Development of financial software for quantitative researchers and traders

Education

- Oct 2018 – Mar 2019 **Enrichment Placement, Alan Turing Institute, UK**
6-month placement at UK's national institute for data science and artificial intelligence.
- Oct 2015 – Jan 2020 **PhD in Mathematics, University of Oxford, UK**
Industrially Focused Mathematical Modelling (EPSRC Centre for Doctoral Training) in collaboration with the National Physical Laboratory (NPL).
Thesis title: Stability and perturbation analysis of non-negative super-resolution
Advisors: Prof Jared Tanner, Dr Andrew Thompson
- Oct 2009 – June 2013 **BSc (Hons) Computer Science and Mathematics with Industrial Experience**
University of Manchester, UK

Peer-reviewed publications

I publish in multiple fields, with different standards for ordering authors, some ordering by contributions and others ordering alphabetically. In the list below, **first authors are indicated in bold when authors are ordered by contribution; the symbol “=” indicates a manuscript with alphabetically ordered authors.**

- [1] Efficient high-resolution refinement in cryo-EM with stochastic gradient descent
B. Toader, M. A. Brubaker, R. R. Lederman
Acta Crystallographica Section D, 2025
DOI: <https://doi.org/10.1107/S205979832500511X>. Open access: <https://arxiv.org/abs/2311.16100>
- [2] An image processing pipeline for electron cryo-tomography in RELION-5
A. Burt, B. Toader, R. Warshamanage, A. von Kügelgen, E. Pyle, J. Zivanov, D. Kimanius, T.A.M. Bharat, S.H.W. Scheres
Febs Open Bio, 2024
Open access DOI: <https://doi.org/10.1002/2211-5463.13873>
- [3] On manifold learning in Plato's cave: remarks on manifold learning and physical phenomena
= R. R. Lederman, **B. Toader**
Proceedings of the International Conference on Sampling Theory and Applications (SampTA), 2023
DOI: <https://doi.org/10.1109/SampTA59647.2023.10301403>. Open access: <https://arxiv.org/abs/2304.14248>
- [4] Methods for cryo-EM single particle reconstruction of macromolecules having continuous heterogeneity
B. Toader, F. J. Sigworth, R. R. Lederman
Journal of Molecular Biology, 2023
DOI: <https://doi.org/10.1016/j.jmb.2023.168020>. Open access: <https://arxiv.org/abs/2211.10744>
- [5] Integrating molecular models into cryo-EM heterogeneity analysis using scalable high-resolution deep Gaussian mixture models
M. Chen, B. Toader, R. R. Lederman
Journal of Molecular Biology, 2023
DOI: <https://doi.org/10.1016/j.jmb.2023.168014>. Open access: <https://arxiv.org/abs/2211.10518>
- [6] Image reconstruction in light-sheet microscopy: spatially varying deconvolution and mixed noise
B. Toader, J. Boulanger, Y. Korolev, M. O. Lenz, J. Manton, C.-B. Schönlieb, L. Mureşan
Journal of Mathematical Imaging and Vision, 2022
Open access DOI: <https://doi.org/10.1007/s10851-022-01100-3>
- [7] Sparse non-negative super-resolution – simplified and stabilised
= A. Eftekhar, J. Tanner, A. Thompson, **B. Toader**, H. Tyagi
Applied and Computational Harmonic Analysis, 2021
DOI: <https://doi.org/10.1016/j.acha.2019.08.004>. Open access: <https://arxiv.org/abs/1804.01490>
- [8] The dual approach to non-negative super-resolution: impact on primal reconstruction accuracy
= S. Chrétien, A. Thompson, **B. Toader**
Proceedings of the International conference on Sampling Theory and Applications (SampTA), 2019
DOI: [10.1109/SampTA45681.2019.9030883](https://doi.org/10.1109/SampTA45681.2019.9030883). Open access: <https://arxiv.org/abs/1904.01926>
- [9] Global air transport complex network: multi-scale analysis
W. Guo, B. Toader, R. Feier, G. Mosquera, F. Ying, S. Oh, M. Williams, A. Krupp
Springer Nature Applied Sciences (SNAS), 2019
Open access DOI: <https://doi.org/10.1007/s42452-019-0702-2>
- [10] Non-negative super-resolution is stable
= A. Eftekhar, J. Tanner, A. Thompson, **B. Toader**, H. Tyagi
Proceedings of the 2018 IEEE Data Science Workshop (DSW), 2018
DOI: [10.1109/DSW.2018.8439120](https://doi.org/10.1109/DSW.2018.8439120)

Preprints and reports

- [1] White paper: Computational Microscopy
White paper, 2022.
Link: <https://www.ipam.ucla.edu/wp-content/uploads/2023/01/CMS2022-White-Paper.pdf>
- [2] The dual approach to non-negative super-resolution: perturbation analysis
= S. Chrétien, A. Thompson, B. Toader
Preprint, 2020 <https://arxiv.org/abs/2007.02708>
- [3] Data Study Group Final Report: DSTL – Bright-field image segmentation
Technical report, 2019. DOI: <https://doi.org/10.5281/zenodo.4452761>

Prizes and awards

- 2025 - 2027 **Marie Skłodowska-Curie Actions (MSCA) Postdoctoral Fellowship**
- 2022 **IPAM Long Program Housing and Travel Grant**
University of California, Los Angeles (UCLA), US
- 2018 **Enrichment Scheme Placement Award**, *Alan Turing Institute, UK*
- 2018 **Travel Award** to attend the SIAM UKIE Annual Meeting
Society for Industrial and Applied Mathematics, UK
- 2016 **IMA Best Team Performance Prize**
InFoMM Graduate Modelling Camp, UK
- 2015 - 2019 **EPSRC InFoMM Centre for Doctoral Training Studentship**, Oxford, UK
- 2010 **Golden Anniversary Prize** for excellence in year 1 studies, *University of Manchester, UK*
- 2007 - 2009 **Bronze Medal at the National Mathematical Olympiad**, Romania (in 2007, 2008, 2009)

Invited presentations

- Mar 2025 *Image Reconstruction at Scale: Challenges and Collaboration (ExCALIBUR Workshop)*
University of Cambridge, UK
- Nov 2024 *Machine Learning and Data Science Seminar*, Mathematical Institute
University of Oxford, UK
- Sep 2023 *11th Applied Inverse Problems Conference*, mini-symposium presentation
Göttingen, Germany
- Feb 2023 *SIAM Conference on Computational Science and Engineering*, mini-symposium presentation
Amsterdam, The Netherlands
- Nov 2022 *Institute for Pure and Applied Mathematics Seminar*, UCLA
Los Angeles, US
- May 2022 *PIMS Workshop on Mathematical and Computational Challenges in Cryo-EM*
Vancouver, Canada
- Jun 2018 *6th IMA Conference on Numerical Linear Algebra and Optimization*, mini-symposium pres.
Birmingham, UK

Conference and seminar presentations

Jun 2024	<i>MRC LMB Tomography Seminar</i> , Cambridge, UK – oral presentation
Apr 2024	<i>CCP-EM Spring Symposium 2024</i> , Nottingham, UK – poster
Oct 2023	<i>The 10th New England Cryo-EM Symposium</i> , Yale University, US – oral presentation
Jul 2023	International Conference on Sampling Theory and Applications (SampTA 2023) Yale University, US – oral presentation
Jun 2023	<i>CryoEM Summer Workshop</i> , Flatiron Institute, New York, US – poster
Sep 2022	<i>SIAM Conference on Mathematics of Data Science (MDS22)</i> , San Diego, US – poster
Mar 2021	<i>Focus on Microscopy 2021 Online Conference</i> – oral presentation
Sep 2020	<i>Virtual 12th Light Sheet Fluorescence Microscopy Conference 2020</i> – oral presentation
Jul 2020	<i>SIAM Conference on Imaging Science (IS20)</i> , online – poster
Jan 2020	<i>Quantitative BioImaging Conference (QBI 2020)</i> , Oxford, UK – poster
Aug 2019	<i>International Conference on Continuous Optimization (ICCOPT)</i> , Berlin, Germany –oral presentation
Jul 2019	<i>13th International Conference on Sampling Theory and Applications (SampTA)</i> , Bordeaux, France – oral presentation
Jul 2018	<i>Curves and Surfaces Conference</i> , Arcachon, France – oral presentation
Jun 2018	<i>IEEE Data Science Workshop (DSW)</i> , Lausanne, Switzerland – poster
Mar 2018	<i>Numerical Analysis Seminar</i> , Oxford, UK – oral presentation
Feb 2018	<i>Research Workshop on Optimization and Big Data</i> , KAUST, Saudi Arabia – poster
Jan 2018	<i>SIAM UKIE Annual Meeting</i> , Southampton, UK – poster

Participation in industrial innovation

Dec 2019	<i>Data Study Group</i> , Alan Turing Institute, London, UK Implemented deep learning solution for image segmentation of bright-field microscopy data.
Jun 2019	<i>Mathematics in Industry New Zealand Workshop</i> , Auckland, New Zealand Implemented optimal transport solution for decomposing the spectrum of cheese samples into different components (fat, protein, etc).
Jun 2018	<i>142nd European Study Group with Industry</i> , Palanga, Lithuania Predicting the sustainable income of loan applicants according to central bank rules.
Dec 2016	<i>Data Study Group</i> , Alan Turing Institute, London, UK Implemented network model to solve an air traffic prediction problem proposed by Airbus.
Jul - Sep 2016	<i>Deflating Magnetic Oscillations</i> , Culham Centre for Fusion Energy, Abingdon, UK Used deflation to find periodic solutions to a system of ODEs describing plasma behaviour. In collaboration with Dr Wayne Arter (CCFE) and Prof Patrick Farrell (Oxford).
May – Jul 2016	<i>Source Reconstruction from Hydrophone Data</i> , National Physical Laboratory, London, UK Analysed how compressed sensing can be applied to the problem of ship localisation from measurements of the sound in the shipping lane. In collaboration with Dr Peter Harris (NPL), Dr Stéphane Chrétien (NPL), Prof Jared Tanner (Oxford) and Dr. Andrew Thompson (Oxford).
May 2016	<i>116th European Study Group with Industry</i> , Durham, UK Implemented mixed integer programming solution to field trials scheduling problem proposed by Syngenta.

Teaching and supervision

- Sep 2025 **EMBO Practical Course**, Image Processing for Cryo-Electron Microscopy, *London*
Practical session on subtomogram averaging with RELION 5
- Jun 2024 **Dutch Cryo-EM School**, *TU Delft*
Invited to deliver a lecture on *Introduction to subtomogram averaging* and a demo of the subtomogram averaging pipeline in the RELION 5 software to a group of 20 students selected to participate in the week-long programme.
- Jun - Aug 2022 Mentor for *Yale Summer Undergraduate Research Fellowship Program*
- Mar 2021 **UK Graduate Modelling Camp**, *Newton Gateway to Mathematics*, Cambridge, UK.
Week-long programme where I proposed a mathematical modelling and computational problem and mentored a group of 6 PhD students on reaching a solution as a team.
- 2020 - 2021 Supervisor: **Numerical Analysis** (3rd year undergraduate), *University of Cambridge*
Responsible with marking and running fortnightly supervisions for pairs of students from Cambridge colleges.
- 2016 - 2018 Teaching assistant: **Continuous Optimisation** (4th year undergraduate),
Integer Programming (3rd year undergraduate), *University of Oxford*
Responsible with marking weekly assignments and leading problem-solving classes for groups of up to 15 students. Ran revision classes independently to groups of 30 students.
- 2016 - 2017 Lab demonstrator: **Computational Mathematics** (1st year undergraduate), *Univ. of Oxford*
Presented new material in the form of live computer demo to groups of up to 20 students.

Outreach

- 2017 - 2018 *Lord Williams's School*, Thame, Oxfordshire, UK.
Organised and lead two outreach sessions (in 2017 and 2018) for high-school students about doing research in applied mathematics.
Presented material on the mathematics of machine learning.

Peer review

- 2017 - present Acted as a reviewer for the following journals:
- *Applied and Computational Harmonic Analysis*
 - *SIAM Journal on Imaging Sciences*
 - *Information and Inference: a Journal of the IMA*
 - *Structure*