Bogdan Toader

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Research Interests

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

Employment

Sep 2021 – present **Postdoctoral Research Associate**, *Yale University*, New Haven, Connecticut, USA.
Department of Statistics and Data Science and the Quantitative Biology Institute (QBio).
Research on **algorithms for cryo-EM reconstruction.**

Sep 2022 –Dec 2022 **Visiting Researcher**, *UCLA*, Los Angeles, California, USA.
Institute for Pure and Applied Mathematics.
Core participant of the IPAM Long Program on **Computational Microscopy**.

Jul 2019 – Jul 2021 **Postdoctoral Research Associate**, *University of Cambridge*, Cambridge, UK.
Cambridge Advanced Imaging Centre (CAIC).
Research on **deconvolution algorithms for light-sheet microscopy**, a project in collaboration with the Cambridge Image Analysis Group in the Department of Applied Mathematics and Theoretical Physics and MRC Laboratory of Molecular Biology.

Education

Oct 2018 – Mar 2019 **Enrichment Student**, *Alan Turing Institute*, London, UK.
Six months placement at UK's national institute for data science and artificial intelligence.

2015 – 2020 **PhD in Mathematics**, *University of Oxford*, 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

2009 – 2013 **BSc (Hons) Computer Science and Mathematics with Industrial Experience**, *University of Manchester*, Manchester, UK.
First class degree with final grade above 80%.

2005 – 2009 **Romanian Baccalaureate**, *"Gheorghe Munteanu Murgoci" National College*, Braila, Romania.
Final grade of 9.91 (out of a maximum of 10).

Publications

1. **Methods for cryo-EM single particle reconstruction of macromolecules having continuous heterogeneity**
   B. Toader, F. J. Sigworth, R. R. Lederman
   submitted, arXiv:2211.10744, 2022

2. **Integrating molecular models into CryoEM heterogeneity analysis using scalable high-resolution deep Gaussian mixture models**
   M. Chen, B. Toader, R. R. Lederman
   submitted, arXiv:2211.10518, 2022

3. **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, vol. 64, pp. 968-992, 2022

4. **Sparse non-negative super-resolution – simplified and stabilised**
   A. Eftekhari, J. Tanner, A. Thompson, B. Toader, H. Tyagi
   Applied and Computational Harmonic Analysis, vol. 50, pp. 216-280, 2021

5. **The dual approach to non-negative super-resolution: perturbation analysis**
   S. Chrétien, A. Thompson, B. Toader
   submitted, arXiv:2007.02708, 2020

6. **The dual approach to non-negative super-resolution: impact on primal reconstruction accuracy**
S. Chrétien, A. Thompson, B. Toader
2019 13th International conference on Sampling Theory and Applications (SampTA) proceedings pages 1-4, 2019

7. **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), vol. 1(7), 2019

8. **Non-negative super-resolution is stable**
A. Eftekhari, J. Tanner, A. Thompson, B. Toader, H. Tyagi
2018 IEEE Data Science Workshop, DSW 2018, proceedings pp. 100-104, 2018

9. **Remarks on manifold learning and physical phenomena**
B. Toader, R. R. Lederman
In preparation, 2022

Other Research Experience

Jul – Sep 2016 **Deflating Magnetic Oscillations**, *Culham Centre for Fusion Energy*, Abingdon, UK.
Used deflation to find multiple periodic solutions to a system of ODEs that describes the behaviour of plasma. In collaboration with Culham Centre for Fusion Energy.
Supervisors Prof Patrick Farrell (Oxford), Dr Wayne Arter (CCFE)

May – Jul 2016 **Improved Source Reconstruction from Hydrophone Data**, *National Physical Laboratory*, London, UK.
Analysed how compressed sensing can be applied to a problem on ship localisation from measurements of the sound in the shipping lane, proposed by the National Physical Laboratory. An extension of this work to grid-free compressed sensing applied to the same problem has been the focus of my PhD project for the following three years.
Supervisors Prof Jared Tanner (Oxford), Dr. Andrew Thompson (Oxford), Dr Peter Harris (NPL), Dr Stéphane Chrétien (NPL)

2012 – 2013 **Formal Verification of Dynamical System**, *University of Manchester*, UK.
Final year undergraduate thesis on using the automatic theorem prover MetiTarski to analyse equilibrium and stability properties of dynamical systems.
Supervisor Dr Eva Navarro-López

Presentations

Nov 2022 *IPAM Seminar*, UCLA, Los Angeles, US – oral presentation
Sep 2022 *SIAM Conference on Mathematics of Data Science (MDS22)*, San Diego, US – poster presentation
May 2022 *PIMS Workshop on Mathematical and Computational Challenges in Cryo-EM*, Vancouver, Canada – invited presentation
March 2021 *Focus on Microscopy 2021 Online Conference* – oral presentation
Sep 2020 *Virtual 12th Light Sheet Fluorescence Microscopy Conference 2020* – oral presentation
Jul 2020 *SIAM Conference on Imaging Science (IS20)*, online – poster presentation
Jan 2020 *Quantitative BioImaging Conference (QBI 2020)*, Oxford, UK – poster presentation
Aug 2019 *International Conference on Continuous Optimization (ICCOPT 2019)*, Berlin, Germany – oral presentation
Jul 2019 *13th International Conference on Sampling Theory and Applications (SampTA 2019)*, Bordeaux, France – oral presentation
Mar 2019 *InFoMM Annual Meeting*, Oxford, UK – oral presentation
Feb 2019 *InFoMM Group Meeting*, Oxford, UK – oral presentation
Jul 2018 *Curves and Surfaces Conference*, Arcachon, France – oral presentation
Jun 2018 *6th IMA Conference on Numerical Linear Algebra and Optimization*, Birmingham, UK – oral presentation
Jun 2018 *2018 IEEE Data Science Workshop (DSW 2018)*, Lausanne, Switzerland – poster presentation
Mar 2018 *InFoMM Annual Meeting 2018*, Oxford, UK – oral presentation
Mar 2018 *Numerical Analysis Seminar*, Oxford, UK – oral presentation
Feb 2018 *Research Workshop on Optimization and Big Data*, KAUST, Saudi Arabia – poster presentation
Jan 2018 *SIAM UKIE Annual Meeting*, Southampton, UK – poster presentation
May 2017 *InFoMM Group Meeting*, Oxford, UK – oral presentation

Mar 2017 *InFoMM Annual Meeting 2017*, Oxford, UK – poster presentation

Other Academic Events

March 2021 *UK Graduate Modelling Camp*, Newton Gateway to Mathematics, Cambridge, UK
Proposed a modelling and computational problem and mentored a group of six PhD students on reaching a solution as a team.

Dec 2019 *Data Study Group*, Alan Turing Institute, London, UK
Implemented deep learning based solution for image segmentation applied to brighfield microscopy data.

Jun 2019 *Mathematics in Industry New Zealand Workshop*, Auckland, New Zealand
Implemented optimal transport based solution for decomposing spectrum of cheese samples into different components (fat, protein etc.).

Jan 2019 *Mathematics of Imaging CIRM Winter School*, Marseille, France

Jun 2018 *142nd European Study Group with Industry*, Palanga, Lithuania
Worked on predicting the sustainable income of loan applicants according to rules from the central bank.

Jun 2017 *Summer School on Structured Regularization for High-Dimensional Data Analysis*,
Henri Poincare Institute, Paris, France

Dec 2016 *Data Study Group*, Alan Turing Institute, London, UK
Implemented network model to solve an air traffic prediction problem proposed by Airbus.

May 2016 *116th European Study Group With Industry*, Durham, UK
Implemented mixed integer programming solution to problem on scheduling field trials proposed by Syngenta.

Mar 2016 *InFoMM Graduate Modelling Camp*, Oxford, UK
Worked on calculating trajectory of footballs. Won IMA Best Team Performance prize.

Awards

2018 *Travel Award*, SIAM UKIE Annual Meeting, Southampton, UK

2016 *IMA Best Team Performance Prize*, InFoMM Graduate Modelling Camp, Oxford, UK

2015 *EPSRC InFoMM CDT Studentship*, Oxford, UK

2010 *Golden Anniversary Prize*, University of Manchester, UK
For excellence in first year studies, awarded to the students with the first five highest grades in the first year.

2006–2009 *Bronze Medal at the National Mathematical Olympiad*, Romania in 2007, 2008 and 2009
Won various prizes at other national and regional mathematics contests, including the national contest organised by the editors of the Romanian mathematical journal "Gazeta Matematica" for students who regularly send solutions to the problems published in the journal.

Teaching Experience

2020 – 2021 **Numerical Analysis**, *University of Cambridge*.
Supervisor for third year undergraduate students. Responsible with marking and running fortnightly supervisions for pairs of students from a number of Cambridge colleges.

2016 – 2018 **Continuous Optimisation**, *University of Oxford*.
Teaching assistant for fourth year undergraduate course. Responsible with marking weekly assignments and solving problems on the board during classes, to groups of up to 15 students. Ran revision classes independently to groups of 30 students.

2016–2018 **Integer Programming**, *University of Oxford*.
Teaching assistant for third year undergraduate course. Responsible with marking weekly assignments and solving problems on the board during classes, to groups of up to 15 students. Ran revision classes independently to groups of 30 students.

2016 – 2017 **Computational Mathematics**, *University of Oxford*.
Lab demonstrator for first year undergraduate Matlab classes. Presented new material in the form of live computer demo to groups of up to 20 students.

2010 – 2011 **Peer Assisted Study Sessions Leader**, *University of Manchester*.
Weekly sessions with first year undergraduate students, in groups of around 6, assisting them with basic mathematics and programming.

Industry Experience

2013 – 2015 **Technology Associate**, *Morgan Stanley*, London, UK.
Worked in the Pricing Technology team for the Interest Rate Derivatives business, where I used Scala and Perl to build and improve the pricing tools used by quantitative analysts and traders.

Jun – Jul 2012 **Summer Intership, Technology**, *Credit Suisse*, London, UK.
Part of the team that maintains the Unix servers in the EMEA region. On top of handling daily requests from users, I improved my shell scripting skills.

2011 – 2012 **Industrial Placement, Technology**, *Morgan Stanley*, London, UK.
Worked as part of the Institutional Securities Group Technology division in one of the teams developing and supporting the equities trading systems. Acquired experience of working with large sets of data.

Outreach

2017 – 2018 **Lord Williams's School**, *Thame, Oxfordshire, UK.*
Ran two outreach sessions (in 2017 and in 2018 respectively) aimed at pre-final year students about doing research in applied mathematics. Presented material on the mathematics of machine learning.

Other

Languages Romanian (native), English (fluent)

Hobbies Climbing, running, gliding, hiking, skiing, guitar