Alex Townsend
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Research resume

Numerical analysis and scientific computing. My research focuses on spectral methods, low rank approximation, fast transforms, and polynomial system solving.

Education

DPhil in Numerical Analysis University of Oxford Oct 2010 – July 2014
Supervised by Prof. L. N. Trefethen FRS
Thesis title: *Computing with functions in two dimensions*

MMath Mathematics University of Oxford Oct 2006 – July 2010
Awarded 1st class degree (ranked 2nd in the year)

Professional experience

Assistant Professor Cornell University July 2016 – Present
Taught MATH 4250: Numerical analysis and ODEs
MATH 6140: Top-ten algorithms of the 20th century
MATH 2220: Multivariable calculus

Applied Math Instructor MIT Aug 2014 – June 2016
Taught 18.336: Fast Numerical methods for PDEs
18.085: Computational Science and Engineering
18.06: Linear Algebra

Adjunct Instructor Courant Institute Sept 2013 – Oct 2013
Tutored: Approximation Theory and Approximation Practice

New College graduate assistant University of Oxford Oct 2012 – June 2013
Tutored: Constructive mathematics, Multivariable calculus, Probability, Statistics

Class tutor University of Oxford Oct 2010 – June 2013
Tutored: Approximation Theory, Numerical Analysis, Numerical Linear Algebra, Perturbation Methods

Honors and prizes

- The SIAM Activity Group on Linear Algebra Early Career Prize in 2018.
- Leslie Fox prize (1st place) for work on the discrete Hankel transform in 2015
- SIAM UKIE certificate of recognition for talk in 2013
- Leslie Fox prize (2nd place) for work on the ultraspherical spectral method in 2013
- SIAM UKIE prize for the best student talk in 2011
- Junior Mathematics Prize in 2008 and 2009, and IMA prize in 2009 and 2010. Awarded by the University of Oxford for top undergraduate examination results

Research grants and travel award

- National Science Foundation grant (as the principal investigator), worth $144,797
- University of Sydney, School of Mathematics and Statistics, travel award, worth $6000
- SIAM travel award in March 2015, worth $600

Supervised graduate students

Elizabeth Wesson (Center for Applied Mathematics, postdoc)

Supervised graduate students

Dan Fortunato (Harvard graduate student, joint with Chris Rycroft)
Marc Gilles (CAM graduate student)
Andrew Horning (CAM graduate student)
Tianyi Shi (CAM graduate student)
Heather Wilber (CAM graduate student, awarded a NSF graduate fellowship in 2016)

Undergraduate students and other mentees

Nicolas Boulle (MSc student from ENS de Rennes)
David Darrow (MIT PRIMES student)
Sujit Rao (Cornell undergraduate, top-200 in Putnam exam in 2016)

Past students

Diego Antolin–Ruiz (2016 summer PhD student)
Aaron Yeiser (MIT PRIMES student, a 2nd place Regeneron STS 2017 Finalist)

Journal publications

[20] A. Townsend and H. Wilber, *On the singular values of matrices with high displacement rank*, to appear in Linear Alg. Appl., 2017.

[19] D. Antoln–Ruiz and A. Townsend, *A nonuniform fast Fourier transform based on low rank approximation*, to appear in SISC, 2017.

[18] B. Beckermann and A. Townsend, *On the singular values of matrices with displacement structure*, SIAM J. Mat. Anal. Appl., 38 (2017), pp. 1227–1248.

[17] A. Townsend, M. Webb, and S. Olver, *Fast polynomial transforms based on Toeplitz and Hankel matrices*, to appear in Math. Comp., 2017.

[16] A. Townsend, H. Wilber, and G. B. Wright, *Computing with functions in spherical and polar geometries II. The disk*, SIAM J. Sci. Comput., 39 (2017), C238–C262.

[15] V. Noferini, Y. Nakatsukasa, and A. Townsend, *Vector spaces of linearizations for matrix polynomials: A bivariate polynomial approach*, SIAM J. Mat. Anal. Appl., 38 (2016), pp. 1–29.

[14] N. Hale and A. Townsend, *A fast FFT-based discrete Legendre transform*, IMA Numer. Anal., 36 (2016), pp. 1670–1684.

[13] A. Townsend, H. Wilber, and G. B. Wright, *Computing with functions in spherical and polar geometries I. The sphere*, SIAM J. Sci. Comput., 38 (2016), C403–C425.

[12] V. Noferini and A. Townsend, *Numerical instability of resultant methods for multidimensional rootfinding*, SIAM J. Numer. Anal., 54 (2016), pp. 719–743.

[11] A. Townsend, T. Trogdon, and S. Olver, *Fast computation of Gauss quadrature nodes and weights on the whole real line*, IMA Numer. Anal., 36 (2016), pp. 337–358.

[10] A. Townsend and S. Olver, *The automatic solution of partial differential equations using a global spectral method*, J. Comp. Phys., 299 (2015), pp. 106–123.

[9] A. Townsend, *A fast analysis-based discrete Hankel transform using asymptotic formulas*, SIAM J. Numer. Anal., 53 (2015), pp. 1897–1917.

[8] Y. Nakatsukasa, V. Noferini, and A. Townsend, *Computing the common zeros of two bivariate functions via Bézout resultants*, Numer. Math., 129 (2015), pp. 181–209.

[7] A. Townsend and L. N. Trefethen, *Continuous analogues of matrix factorizations*, Proc. Roy. Soc. A., 471 (2015).

[6] N. Hale and A. Townsend, *An algorithm for the convolution of Legendre series*, SIAM J. Sci. Comput., 36 (2014), A1207–A1220.

[5] N. Hale and A. Townsend, *A fast, simple, and stable Chebyshev–Legendre transform using an asymptotic formula*, SIAM J. Sci. Comput., 36 (2014), A148–A167.

[4] A. Townsend and L. N. Trefethen, *An extension of Chebfun to two dimensions*, SIAM J. Sci. Comput., 35 (2013), C495–C518.

[3] N. Hale and A. Townsend, *Fast and accurate computation of Gauss–Legendre and Gauss–Jacobi quadrature nodes and weights*, SIAM J. Sci. Comput., 35 (2013), A652–A672.

[2] S. Olver and A. Townsend, *A fast and well-conditioned spectral method*, SIAM Review, 55 (2013), pp. 462–489.

[1] A. Townsend and H. Wendland, *Multiscale analysis in Sobolev spaces on bounded domains with zero boundary values*, IMA J. Numer. Anal., 33 (2013), pp. 1095–1114.

Submitted papers, conference proceedings, and technical reports

S. Olver, A. Townsend, and G. M. Vasil, Recurrence relations for a family of orthogonal polynomials on a triangle, submitted to SIGMA, 2017.

D. Fortunato and A. Townsend, *Fast Poisson solvers for spectral methods*, submitted to SISC, 2017.

J. Słomka, A. Townsend, and J. Dunkel, *Stokes II problem and Einstein-de Haas effect in active fluids*, submitted to Phys. Rev. Let. E, 2017.

M. Udell and A. Townsend, *Nice latent variable models have log-rank*, submitted, 2017.

L. Demanet and A. Townsend, *Stable extrapolation of analytic functions*, submitted to Math. Comp., 2017.

S. Olver and A. Townsend, *A practical framework for infinite-dimensional linear algebra*, First Workshop for High Performance Technical Computing in Dynamic Languages, in IEEE conference proceedings, 2014.

Other articles

A. Townsend, *A review of "Orthogonal Polynomials in MATLAB" by Gautschi*, SIAM Review, 59 (2017), pp. 463–464.

A. Townsend, *A review of "A Graduate Introduction to Numerical Methods" by Corless and Fillion*, SIAM Review, 58 (2016), pp. 795–798.

A. Townsend, *The race for high order Gauss–Legendre quadrature*, SIAM News, March 2015.

A. Townsend and L. N. Trefethen, *Gaussian elimination as an iterative algorithm*, SIAM News, March 2013.

Presentations at conferences and workshops

Algebra meets numerics: conditioning and complexity in TU Berlin	Nov 2017
27th Biennial Numerical Analysis conference in Strathclyde	June 2017
SIAM CSE 2017 conference in Atlanta	March 2017
Workshop on Fast Direct Solvers, Purdue	November 2016
SIAM Annual Meeting in Boston	July 2016
15th International Conference on Approximation theory in San Antonio	May 2016
26th Biennial Numerical Analysis conference in Strathclyde	June 2015
SIAM OPSFA 2015 in Maryland	April 2015
SIAM CSE 2015 Conference in Utah	March 2015
CBMS-NSF Fast Direct Solvers for PDEs in Dartmouth College	June 2014
SIAM Annual Meeting in San Diego	July 2013
25th Biennial Numerical Analysis conference in Strathclyde	June 2013
Advances in Matrix Functions and Matrix Equations in Manchester	April 2013
Nonlinear Waves: Theory and Application in Athens, Georgia	March 2013
Chebfun and Beyond workshop in Oxford	Sept 2012
24th Biennial Numerical Analysis conference in Strathclyde	June 2011

Invited presentations

University of Maryland, Colloquium (invited by Howard Elman)	Nov 2017
Temple University, Colloquium (invited by Daniel Szyld)	Nov 2017
KU Leuven, Numerical seminar talk (invited by Daan Huybrechs)	Nov 2017
NJIT, Colloquium (invited by Michael Booty)	Sept 2017
Plenary lecture at Householder conference	June 2017
NCAR workshop on multiscale geoscience (invited by Natasha Flyer)	May 2017
Ithaca College, Colloquium (invited by Vera Babenko)	October 2016
Dartmouth University, Colloquium (invited by Alex Barnett)	October 2016
Cornell University, Colloquium (invited by Reyer Sjamaar)	October 2016
Purdue University (invited by Jie Shen)	April 2016
University of California Irvine (invited by Leonardo Zepeda)	April 2016
Harvard SEAS (invited by Chris Rycroft)	April 2016

John Hopkins University (invited by J. Tilak Ratnanather)	March 2016
University of New South Wales (invited by Quoc Thong Le Gia)	Feb 2016
University of Sydney, Colloquium (invited by Sheehan Olver)	Feb 2016
Boise State University (invited by Grady Wright)	Feb 2016
University of Delaware (invited by Francisco–Javier Sayas)	Nov 2015
Strathclyde University (invited by the Leslie Fox prize committee)	June 2015
University of Massachusetts Dartmouth (invited by Akil Narayan)	April 2015
Courant Institute for NASC seminar	March 2015
Cornell University (invited by Alex Vladimirsky)	Dec 2014
Courant Institute (invited by Tom Trogdon)	Oct 2014
Manchester University (invited by Vanni Noferini)	May 2014
Toyko University (invited by Yuji Nakatsukasa)	Feb 2014
KAUST (invited by David Keyes)	Jan 2014
Cambridge University (invited by Marcus Webb)	Oct 2013
Courant Institute (invited by Michael Overton)	Sept 2013
Colorado State University (invited by Dan Bates)	Sept 2013
Edinburgh University (invited by the Leslie Fox prize committee)	June 2013
École Polytechnique Fédérale de Lausanne (invited by Daniel Kressner)	May 2013
Leuven University (invited by Daan Huybrechs)	March 2013
University of Sydney (invited by Sheehan Olver)	July 2012

Professional activities

Referee for BIT Numerical Mathematics, IMA Journal of Numerical Analysis, Journal of Computational Physics, Numerische Mathematik, SIAM Journal on Numerical Analysis, SIAM Journal on Matrix Analysis and Applications, SIAM Journal of Scientific Computing, SIAM Review, and many others. Also referee for SIAM Books and Cambridge University Press.

Panelist for National Science Foundation grant proposals in 2016 and 2017.

Co-organize an undergraduate math modeling competition in Cornell with engagement from the local community and businesses.

Math consultant for the two episodes of PBS infinite series "Why Computers are Bad at Algebra" and "How to Generate Pseudorandom Numbers".

Co-organizer for the "New Directions in Numerical Computing" in 2015 conference and the Numerical linear algebra workshop in "Foundations of Computational Mathematics: Numerical Linear Algebra" in 2017.