Nicolas Charon

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A. Biographical information

Education

- Ph.D in applied mathematics, ENS Cachan, 2013
  - *Title :* Analysis of geometric and functional shapes with extensions of currents. Applications to registration and atlas estimation.
  - *Advisor:* Pr. Alain Trouvé, ENS Cachan.
- Agrégation de Mathématiques, 2009 : Received (rank 24)
- M.S in applied mathematics (specialization in computer vision), ENS Cachan 2008.
  - *Thesis title :* Target detection in radar images based on geometric averages of covariance matrices.
  - *Advisor:* Dr. Frederic Barbaresco, Thales Air Systems.
- B.S in Mathematics, ENS Cachan & Université Paris 7, 2007.

Academic and other research positions

- Assistant Professor, University of Houston, September 2023-present.
- Assistant Professor, The Johns Hopkins University, Department of Applied Mathematics and Statistics, January 2015-August 2023.
- Visiting professor, Institut Henri Poincaré, Paris, October 2022.
- Post-doctoral research fellow, University of Copenhagen, Department of Computer Science, January 2014- December 2014.
- Research assistant at Thales Air Systems (France), April 2008 - August 2008.

Current affiliations

- Department of Mathematics, University of Houston.

B. Research activities

Journal Publications

1. E. Hartman, E. Pierson, M. Bauer, M. Daoudi and N. Charon. Basis restricted elastic shape analysis on the space of unregistered surfaces. *International Journal of Computer Vision.* vol 133(4), pp 1999-2024, 2025.
2. M. Yin, N. Charon, R. Brody, L. Lu, N. Trayanova and M. Maggioni. A scalable framework for learning the geometry-dependent solution operators of partial differential equations. *Nature Computational Science.* vol 4(12), pp 928-940, 2024.

3. M. Bauer, N. Charon, E. Klassen, S. Kurtek, T. Needham and T. Pierron **(authors in alphabetical order)**. Elastic Metrics on Spaces of Euclidean Curves: Theory and Algorithms. *Journal of Nonlinear Science*. vol 34(56), 2024.

4. E. Hartman, Y. Sukurdeep, E. Klassen, N. Charon and M. Bauer. A numerical framework for elastic shape analysis of surfaces. *International Journal of Computer vision*. vol 131, pp 1183–1209, 2023.

5. R. Shankar, H-W. Hsieh, N. Charon and A. Venkataraman. A Diffeomorphic Flow-based Variational Framework for Multi-speaker Emotion Conversion. *IEEE/ACM Transactions on Audio, Speech, and Language Processing*. 2022.

6. H-W. Hsieh and N. Charon. Weight metamorphosis of varifolds and the LDDMM-Fisher-Rao metric. *Calculus of Variations and Partial Differential equations*. vol 61(5),pp 1-41, 2022.

7. Y. Sukurdeep, M. Bauer and N. Charon. A new variational model for the analysis of shape graphs with partial matching constraints. *SIAM journal on Imaging Sciences*, vol 15(1),pp 261-292, 2022.

8. D-N. Hsieh, S. Arguillère, N. Charon, L. Younes. Diffeomorphic shape evolution coupled with a reaction-diffusion PDE on a growth potential. *Quarterly of Applied Mathematics*, vol 80, pp 23-52, 2022.

9. D-N. Hsieh, S. Arguillère, N. Charon, L. Younes. Mechanistic Modeling of Longitudinal Shape Changes: equations of motion and inverse problems. *SIAM journal on Applied Dynamical Systems*, vol 21(1), pp 80-101, 2022.

10. N. Charon, A. Islam and W. Zbijewski. Landmark-free morphometric analysis of knee osteoarthritis using joint statistical models of bone shape and articular space variability. *Journal of Medical Imaging*, vol 8(4), pp 044001, 2021.

11. N. Charon and T. Pierron. On length measures of planar closed curves and the comparison of convex shapes. *Annals of Global Analysis and Geometry*, vol 60(4), pp 863-901. 2021.

12. M. Bauer, N. Charon, P. Harms and H-W. Hsieh **(authors in alphabetical order)**. A numerical framework for elastic surface matching, comparison, and interpolation. *International Journal of Computer Vision*, vol 129(8), pp 2425-2444, 2021.

13. H-W. Hsieh and N. Charon. Metrics, quantization and registration in varifold spaces. *Journal of Foundations of Computational Mathematics*, vol 21(5), pp 1317-1361, 2021.

14. G. Li, M. Tang, N. Charon and C. Priebe. Central limit theorems for classical multidimensional scaling. *Electronic Journal of Statistics*, vol 14(1), pp 2362-2394, 2020.

15. H-W. Hsieh and N. Charon. Diffeomorphic registration of discrete geometric distributions. *Mathematics of shapes and applications, Lecture Notes Series, Institute for Mathematical Sciences, National University of Singapore*, vol 37, pp 45-74, 2020.

16. E. Schwab, B. Haeffele, R. Vidal and N. Charon. Global Optimality in Separable Dictionary Learning with Applications to the Analysis of Diffusion MRI. *SIAM journal on Imaging Sciences*, vol 12(4), pp 1967-2008, 2019.

17. M. Bauer, M. Bruveris, N. Charon and J. Moeller-Andersen **(authors in alphabetical order)**. A relaxed approach for curve matching with elastic metrics. *ESAIM: Control, Optimization and Calculus of Variations*, vol 25, 2019.

18. E. Schwab, R. Vidal and N. Charon. Joint Spatial-Angular Sparse Coding for dMRI with Separable Dictionaries. *Medical Image Analysis*, vol 48, pp 25-42, 2018.

19. N. Charon, B. Charlier and A. Trouvé. Metamorphoses of functional shapes in Sobolev spaces. *Journal of Foundations of Computational Mathematics*, vol 18(6), pp 1535-1596, 2018.

20. S. Lee, M.L. Heisler, K. Popuri, N. Charon, B. Charlier, A. Trouvé, P.J Mackenzie, M. Sarunic and M.F. Beg. Age and Glaucoma-Related Characteristics in Retinal Nerve Fiber Layer and Choroid: Localized Morphometrics and Visualization Using Functional Shapes Registration. *Frontiers of Neuroscience*, vol 11, pp 381, 2017.

21. C. Ragni, N. Diguet, J-F. Le Garrec, M. Novotna, T. Resende, S. Pop, N. Charon, L. Guillemot, L. Kitasato, C. Badouel, A. Dufour, J-C. Olivo-Marin, A. Trouvé, H. McNeill and S. Meilhac. Amotl1 mediates non-canonical Hippo signalling downstream of Fat4 to restrict heart growth. *Nature communications*, vol 8(1), pp 1-11, 2017.

22. S. Lee, N. Charon, B. Charlier, K. Popuri, E. Lebed, M. Sarunic, A. Trouvé and M.F. Beg. Atlas-based Shape Analysis and Classification of Retinal Optical Coherence Tomography Images using the Functional Shape (fshape) Framework. *Medical Image Analysis*, vol. 35, pp 570-581, 2017.

23. N. Charon, B. Charlier and A. Trouvé. The fshape framework for the variability analysis of functional shapes, *Journal of Foundations of Computational Mathematics*, vol 17, pp 287-357, 2017.

24. S. Durrleman, M. Prastawa, N. Charon, J.R. Korenberg, S. Joshi, G. Gerig and A. Trouvé. Morphometry of anatomical shape complexes with dense deformations and sparse parameters. *Neuroimage*, vol 101, pp. 35-49, 2014.

25. N. Charon and A. Trouvé. Functional currents : a new mathematical tool to model and analyse functional shapes. *Journal of Mathematical Imaging and Vision*, vol 48(3), pp 413-431, 2014.

26. N. Charon and A. Trouvé. The varifold representation of non-oriented shapes for diffeomorphic registration. *SIAM journal on Imaging Science*, vol 6(4), pp 2547–2580, 2013.

27. N. Charon and F. Barbaresco. A new approach for target detection in radar images based on geometric properties of covariance matrices' spaces. *Traitement du signal*, vol 26, pp 269-278, 2009.

Conference and proceedings articles

1. E. Hartman, E. Pierson, M. Bauer, N. Charon and M. Daoudi. BaRe-ESA: A Riemannian Framework for Unregistered Human Body Shapes. *Proceedings of the International Conference of Computer Vision*, pp 14181-14191, 2023.

2. H. Li, G. Shi, L. Meckel, D. Cunningham, D.J. Wescott, A.D. Sylvester, N. Charon, W. Zbijewski. Body Mass Classification from Skeletal Elements Using Landmark-Free Morphological Atlas Estimation with Diffeomorphic Shape Mapping. *Proceedings of the SPIE conference on Medical Imaging*, 2023.

3. E. Hartman, Y. Sukurdeep, N. Charon, E. Klassen and M. Bauer. Supervised Deep Learning of Elastic SRV Distances on the Shape Space of Curves. *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, pp 4425-4433, 2021.

4. H-W. Hsieh and N. Charon. Diffeomorphic Registration with Density Changes for the Analysis of Imbalanced Shapes. *International Conference on Information Processing in Medical Imaging*, pp 31-42, 2021.

5. D. Poinapen, T. Yoshizawa, Y. Zhou, N. Charon, S. Mou, K. Oshima, L. Wood, R. H. Hruban, W. Zbijewski. Three-dimensional shape and topology analysis of tissue-cleared tumor samples. *Proceedings of the SPIE conference on Medical Imaging*, vol 11603, pp 309-314. 2021.

6. R. Shankar, H-W. Hsieh, N. Charon and A. Venkataraman. Multi-speaker Emotion Conversion via Latent Variable Regularization and a Chained Encoder-Decoder-Predictor Network. *Proc. Interspeech.* 2020.

7. Y. Sukurdeep, M. Bauer and N. Charon. An inexact matching approach for the comparison of plane curves with general elastic metrics. *Proceedings of ASILOMAR conference on Signals, Systems & Computers*, pp 512-516, 2019.

8. M. Bauer, N. Charon and P. Harms. Inexact elastic shape matching in the square root normal field framework. *Geometric Science of Information*, pp 13-20, 2019.

9. R. Shankar, H-W. Hsieh, N. Charon and A. Venkataraman. Automated Emotion Morphing in Speech Based on Diffeomorphic Curve Registration and Highway Networks. *Proc. Interspeech* 4499-4503, 2019.

10. D-N. Hsieh, S. Arguillère, N. Charon, M.I. Miller, L. Younes. A Model for Elastic Evolution on Foliated Shapes. *International Conference on Information Processing in Medical Imaging*, pp 644-655, 2019.

11. E. Schwab, R. Vidal and N. Charon. (k,q)-Compressed Sensing for HARDI with Joint Spatial-Angular Sparsity. *Computational Diffusion MRI*, pp 21-35, 2018.

12. M. Bauer, M. Bruveris, N. Charon and J. Moeller-Andersen. Varifold-based matching of curves via Sobolev-type Riemannian metrics. *Graphs in Biomedical Image Analysis, Computational Anatomy and Imaging Genetics*, pp 152-163, 2017.

13. K. Kutten, N. Charon, M.I. Miller, J.T. Ratnanather, J. Matelsky, A.D. Baden, K. Lillaney, K. Deisseroth, L. Ye and J. Vogelstein. A Large Deformation Diffeomorphic Approach to Registration of CLARITY Images via Mutual Information. *International Conference on Medical Image Computing and Computer-Assisted Intervention*, pp 275-282, 2017.

14. I. Kaltenmark, B. Charlier and N. Charon. A general framework for curve and surface comparison and registration with oriented varifolds. *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, pp 3346-3355, 2017.

15. E. Schwab, N. Charon and R. Vidal. Spatial-Angular Sparse Coding for HARDI. *International Conference on Medical Image Computing and Computer-Assisted Intervention*, pp 475-483, 2016.

16. K. Kutten, J. Vogelstein, N. Charon, L. Ye, K. Deisseroth and M.I. Miller. Comparison of methods for annotating CLARITY mouse brain images. *Optics, Photonics and Digital Technologies for Imaging Applications*, 2016.

Book Chapters

1. N. Charon and L. Younes. Shape spaces: From geometry to biological plausibility. *Handbook of Mathematical Models and Algorithms in Computer Vision and Imaging*, pp 1929-1958, 2023.

2. M. Bauer, N. Charon, E. Klassen and A. Le Brigant **(authors in alphabetical order)**. Intrinsic Riemannian metrics on spaces of curves: theory and computation. *Handbook of Mathematical Models and Algorithms in Computer Vision and Imaging*, pp 1-35, 2021.

3. N. Charon, B. Charlier, J. Glaunès, P. Gori and P. Roussillon. Fidelity metrics between curves and surfaces: currents, varifolds and normal cycles. *Riemannian Geometric Statistics in Medical Image Analysis*, pp 441-477, 2020.

4. M. Bauer, N. Charon and L. Younes **(authors in alphabetical order)**. Metric Registration of Curves and Surfaces using Optimal Control. *Handbook of Numerical Analysis*, vol 20, pp 613-646, 2019.

Preprints and papers in preparation

1. M. Bauer, N. Charon, T. Needham, M. Nishino **(authors in alphabetical order)**. Path constrained unbalanced optimal transport. *Under revision in Nonlinearity.*

2. E. Hartman, N. Charon, M. Bauer. Self Supervised Networks for Learning Latent Space Representations of Human Body Scans and Motions. *Submitted to SIAM journal of Mathematics of Data Science.*

3. B. Brindle, T. Derrick, M. Malgaroli and N. Charon. VISTA-SSM: Varying and Irregular Sampling Time-series Analysis via State Space Models. *Under revision in Psychological Methods.*

4. Z. Ahmad, S. Chen, M. Yin, A. Kumar, N. Charon, N. Trayanova, M. Maggioni. Diffeomorphic Latent Neural Operator Learning for Data-Efficient Predictions of Solutions to Partial Differential Equations. *Submitted to AI2ASE 2025*.

Softwares

- Elastic weighted shape graph matching (ShapeGraph_H2match), co-developer. Website: https://github.com/charoncode/ShapeGraph_H2match. 2021.
- Diffeomorphic registration of varifold (Var-LDDMM), co-developer. Website: https://github.com/charoncode/Var_LDDMM. 2020.
- Square root normal field elastic shape analysis of surfaces (SRNFmatch), co-developer. Website: https://github.com/SRNFmatch/SRNFmatch_code. 2020.
- Riemannian shape analysis with second order Sobolev metrics (H2metrics), co-developer. Website: http://github.com/h2metrics/h2metrics. 2018.
- Functional Shapes Toolkit (FshapesTk), co-developer. Website: https://github.com/fshapes/fshapesTk. 2014 (latest version 2017).

C. Scholarly presentations

Invited conference and seminar talks

- SIAM conference on Mathematics of Data Science, Atlanta (October 2024).
- "Maths in Maine" workshop, Andover, Maine (August 2024).
- Shape seminar, session on "Optimization in shape analysis", Sorbonne Université (July 2024).
- Workshop "Geometric Sciences in Action: from geometric statistics to shape analysis", CIRM Marseille (May 2024).
- Workshop "Special Session on Advances in Shape and Topological Data Analysis", AMS 2024 Spring Southeastern Sectional Meeting, Florida State University (March 2024).
- Workshop "Mathematical Methods for Exploring and Analyzing Morphological Shapes across Biological Scales", Banff International Research Station (September 2023).
- ACMD seminar, National Institute of Standards and Technology (May 2023).
- Maths colloquium, Florida State University (January 2023).
- Maths department seminar, University of Houston (January 2023).
- Séminaire équipe CRIStAL, Université de Lille (October 2022).
- Workshop "Geometry and Statistics in Data Sciences", Institut Henri Poincaré (October 2022).
- Maths on Long Island workshop, Denmark (July 2022).
- Center for Functional Anatomy and Evolution seminar, Johns Hopkins University (May 2022).
- CIS/MINDS seminar, Johns Hopkins University (April 2022).
- SIAM conference on Imaging Sciences (IS22), held remotely (March 2022).
- Information Processing in Medical Imaging (IPMI), held remotely (June 2021).
- SIAM conference on Mathematics of Data Science, held remotely (June 2020).
- Applied Mathematics and Statistics department seminar, Johns Hopkins University (January 2020).
- ASILOMAR conference on Signals, Systems, and Computers, Pacific Grove (November 2019).
- Geometric Science of Information, Toulouse, France (August 2019).
- Maths in the Desert, Utah (May 2019).
- Mathematics colloqium, Florida State University (April 2019).

- AMS Joint Mathematics Meeting, session on Statistical, Variational, and Learning Techniques in Image Analysis, Baltimore (January 2019).
- Shape Analysis, Stochastic Mechanics and Optimal Transport workshop, Banff, Canada (December 2018).
- Maths in the black forest: workshop on new directions in shape analysis , Germany (July 2018).
- SIAM conference on Imaging Sciences, Bologna, Italy (June 2018).
- Journée de l'équipe Modélisation Mathématique et Calcul Scientifique, Lyon, France (December 2017).
- MINDS institute inaugural symposium, Baltimore (November 2017).
- Workshop on "Applications-Driven Geometric Functional Data Analysis", Tallahassee (October 2017).
- Medical Imaging and Computer Assisted Intervention (MICCAI), Quebec, Canada (September 2017).
- Computer Vision and Pattern Recognition (CVPR), Honolulu (July 2017).
- SIAM annual meeting, Pittsburgh (July 2017).
- AMS Sectional Meeting symposium on "Geometry and Topology in Image and Shape Analysis", Raleigh (November 2016).
- IMS Shapes and Application seminar, Singapore (July 2016).
- SIAM conference on Imaging Sciences, Albuquerque (May 2016).
- 8th International Congress on Industrial and Applied Mathematics, minisymposium 'Regularization methods for biomedical image analysis on manifolds', Beijing, China (2015).
- 8th International Congress on Industrial and Applied Mathematics, minisymposium 'Theoretical and computational aspects of geometric shape analysis', Beijing, China (2015).
- Applied Maths. Department seminar, Johns Hopkins University (2015).
- Congrès franco-roumain des Mathématiques appliquées, Université de Lyon, France (2014).
- SIAM conference of Imaging Sciences, Hong-Kong (2014).
- Presentation to the CIS seminar, Johns Hopkins University, Baltimore (2014).
- Presentation to the image group seminar in DIKU, University of Copenhagen, Denmark (2013).
- Presentation to MAP5 seminar, Université Paris Descartes, France (2013).
- Shape FRG meeting, Johns Hopkins University, Baltimore (2013).
- Presentation to the image seminar , Université Paris-Dauphine, Paris, France (2013).
- Workshop SIGMA'2012 , CIRM Marseille, France (2012).
- International Conference on Mathematical Methods for Curves and Surfaces , Oslo, Norway (2012).
- Séminaire Landau , Université Rennes 1, France (2012).
- Shape FRG meeting, ENS Cachan, Paris, France (2012).
- SMAI poster session, Guidel, France (2011). Awarded best poster prize.
- Shape FRG meeting, Imperial College, London, UK (2011).

D. Grants and funding

Awarded

- Collaborative Research: 4D Human Shape Analysis and Synthesis. Institute: ANR/NSF. Role: PI. Amount: $\$91,905$. Start date: 11/01/2024. End date: 10/31/2027.
- Collaborative Research: Data-Driven Elastic Shape Analysis with Topological Inconsistencies and Partial Matching Constraints. Institute: NSF. Role: PI. Amount: $\$149,998$. Start date: 09/01/2020. End date: 08/31/2025.
- CAREER: Shape analysis in submanifold spaces: new directions for theory and algorithms. Institute: NSF. Role: PI. Amount: $\$451,186$. Start date: 02/01/2020. End date: 01/31/2026.
- Individualized spatial topology in functional neuroimaging. Institute: NIH (R01). Role: co-I. Amount: $\$673,914$. Start date: 07/18/2018. End date: 03/31/2022.
- A general and efficient framework for computational shape analysis through geometric distributions. Institute: NSF. Role: PI. Amount: $\$217,969$. Start date: 07/01/2018. End date: 06/30/2020.

Pending

- Collaborative Research: CIF: Small: Generalized Optimal Transport Models: Theory and Computation. Institute: NSF. Role: PI. Amount: $221,970.
- Fast clustering on Riemannian manifolds using Frechet mappings. Institute: NSF. Role: co-PI. Amount: $489,259.

E. Research advising and student mentoring

PhD students

Current:

1. Samundra Regmi. PhD candidate in Mathematics, University of Houston. Fall 2024-present.
2. Murad Hossein. PhD candidate in Mathematics, University of Houston. Summer 2024-present.
3. Benjamin Brindle. PhD candidate in Applied Mathematics and Statistics, Johns Hopkins University. Spring 2022-present.

Graduated:

1. Dr. Yashil Sukurdeep. Ph.D in Applied Mathematics and Statistics. Fall 2018-2023.
   Thesis title: Elastic shape analysis of geometric objects with complex structures and partial correspondences.
   Defense date: 03/03/2023.
2. Dr. Hsi-Wei Hsieh. Ph.D in Applied Mathematics and Statistics. Fall 2016-2021.
   Thesis title: Analysis of Geometric Shapes with Varifold Representation.
   Defense date: 06/21/2021.
3. Dr. Dai-Ni Hsieh. PhD in Applied Mathematics and Statistics (co-advised with Pr. Laurent Younes). Fall 2017-2021.
   Thesis title: On model-based diffeomorphic shape evolution and diffeomorphic shape registration.
4. Dr. Evan Schwab. Ph.D in Electrical and Computer Engineering (co-advised with Pr. Rene Vidal). Fall 2015-2017.
   Thesis title: Joint Spatial-Angular Sparse Coding, Compressed Sensing, and Dictionary Learning for Diffusion MRI.
   Defense date: 10/19/2017.

Thesis defense committee member:

1. Dr. Xiyuan Wang: PhD in Mathematics.
   Thesis title: Topics in Galois representations
   Defense date: 05/06/2021.
2. Dr. Jingyi Zhu. PhD in Applied Mathematics and Statistics.
   Thesis title: Error bounds and applications for stochastic approximation with non-decaying gain
   Defense date: 02/17/2020.
3. Dr. Zachary Lubberts. PhD in Applied Mathematics and Statistics.
   Thesis title: Generating tight wavelet frames from sums of squares representations.
   Defense date: 03/13/2019.
4. Dr. Mingyue Gao. PhD in Applied Mathematics and Statistics.
   Thesis title: On Manifold Learning Subsequent Inference.
   Defense date: 03/04/2019.

5. Dr. Theodore Drivas. PhD in Applied Mathematics and Statistics.
   Thesis title: Anomalous Dissipation, Spontaneous Stochasticity and Onsager's Conjecture.
   Defense date: 04/27/2017.

6. Dr. Kwame Kutten. PhD in Biomedical Engineering.
   Thesis title: A Large Deformation Diffeomorphic Approach to Inter-modality Registration of Microscopy Image Volumes with Mutual Information Matching.
   Defense date: 01/31/2017.

7. Dr. Graham Beck. PhD in Applied Mathematics and Statistics.
   Thesis title: Planar Homography Estimation from Traffic Streams via Energy Functional Minimization.
   Defense date: 02/05/2016.

Graduate students

Supervised summer research for several masters and visiting PhD students:

1. Giacomo Cristinelli. Ph.D candidate at University of Twente. Summer 2025.

2. David Pierucci. M.S student in mathematics from Ecole Normale Supérieure Paris-Saclay. Summer 2024.

3. Thomas Besnier. Ph.D candidate at Université de Lille. Summer 2023.

4. Mao Nishino. Ph.D candidate at Florida State University. Summer 2023.

5. Junchao Zhou. M.S in Data Science at Johns Hopkins University. Spring 2022.

6. Yanzong Yu. M.S in Data Science at Johns Hopkins University. Summer 2021.

7. Thomas Pierron. M.S student in mathematics from Ecole Normale Supérieure de Cachan. Summer 2020 and 2021.

8. Mathilde Bateson. M.S student in mathematics, vision and learning from Ecole Normale Supérieure de Cachan. Summer 2017.

9. Vianney Debavelaere. M.S student in mathematics from Ecole Normale Supérieure de Cachan. Summer 2016.

Undergraduate students

1. Jose Jaramillo (co-advised with Charles Puelz). B.S student in Mathematics, University of Houston. 2025-present.

2. Asef Islam (co-advised with Wojtek Zbijewski). B.S student in Biomedical engineering, Johns Hopkins University. 2018-2019.

High school students

1. Mentored and supervised a research project for Ananya Gottumukkala, during her junior and sophomore year at Thomas Jefferson High School. (Summer and Fall 2021, Spring 2022).

F. Courses taught

At University of Houston:

1. MATH2318: Linear Algebra. Spring 2025. (59 students)
   Systems of linear equations. Vectors, linear combinations and linear independence. Matrices, matrix operations, inverse of a matrix. Determinants. Vector subspaces, bases and dimension. Rank of a matrix. Characteristic polynomials, eigenvalues, eigenspaces and diagonalization. Inner product, orthogonality and projections. Numerical complexity of matrix operations, matrix reductions... Illustration of linear algebra concepts and tools in MATLAB. Applications of linear algebra to least squares problems, neural networks and geometry.

2. MATH6366: Optimization Theory. Fall 2024. (30 students)
   Convex sets and convex functions. Unconstrained minimization: gradient descent, steepest descent, Newton's method and convergence bounds. Convex optimization problems: linear, quadratic programs, generalized inequality problems. Lagrange duality and KKT optimality conditions. Numerical methods for convex equality and inequality constrained minimization problems.

3. MATH6397: Spectral and variational methods in image processing. Spring 2024. (11 students)
   Images as functions in Sobolev and bounded variation spaces. Continuous and Discrete Fourier transform, applications to linear filtering and image compression. Direct method of calculus of variation. Variational formulations of image denoising and image restoration. Proximal optimization methods for total variation image restoration. Image segmentation: the Chan-Vese model and its variants. Introduction to wavelets and wavelet transforms.

4. MATH2318: Linear Algebra. Fall 2023. (29 students)
   Systems of linear equations. Vectors and linear independence. Matrices, matrix operations and matrix inverse. Determinants. Vector subspaces, bases and dimension. Rank of a matrix. Characteristic polynomials, eigenvalues, eigenspaces and diagonalization. Inner product, orthogonality and projections.

At Johns Hopkins University:

1. EN.553.291: Linear Algebra and Differential Equations. Fall 2019, 2020.
   Systems of linear equations. Matrices and matrix operations. Linear Independence. Nonsigular matrices and matrix inversion. Subspaces, span, bases, nullspace and range. Orthogonality, projection and Gram-Schmidt procedure. Characteristic polynomials, eigenvalues and eigenspaces. Diagonalization of real symmetric matrices.
   Differential equations: separable and linear first-order DEs. Slope fields, Euler's method. 2nd and higher order linear DEs. Method of undetermined coefficients and variation of parameters. Systems of DEs: resolution by matrix exponentials and Laplace transforms.

2. EN 553.701: Real Analysis: Preparation for the Ph.D. Introductory Examination. Fall 2018.
   Topology of the real line: sequences, series, convergence and completeness. Topology of metric spaces: complete sets, connected sets, compact sets. Functions on metric spaces: continuity, uniform continuity, fixed point theorems. Sequences and series of functions: pointwise, uniform convergence, Stone-Weierstrass and Ascoli theorems, power series. Differentiability and integration of multivariate functions. Fourier series and Fourier transform.

3. EN 553.797: Introduction to control theory and optimal control. Springs 2018-2022.
   General ordinary differential equations: existence, uniqueness of local and global solutions. Controllability of linear control systems: Kalman rank condition, constrained and time-dependent systems. Optimal control for linear systems: time optimality and linear-quadratic problems. Non-linear optimal control problems: weak and strong Pontryagin maximum principle, Hamilton-Jacobi-Bellman equations. Numerical methods for optimal control: direct, shooting and dynamic programming methods.

4. EN 550.681: Numerical Analysis. Fall 2016, 2017.
   Computer arithmetics and numerical instability. Numerical solutions to nonlinear systems of equations:

fixed point, Newton, quasi-Newton methods, Laguerre method. Matrix linear algebra for linear systems of equations and eigenvalue problems. Interpolation and approximation of functions. Numerical PDEs: finite difference and finite element methods.

5. EN 550.493/693: Mathematical Image Analysis. Spring 2015, 2016, 2017.
Digital images acquisition and modeling. Continuous and Discrete Fourier transform, applications to linear filtering and image compression. Variational methods for image denoising and deblurring. Image segmentation: thresholding methods, Chan-Vese model and variants.

At Institut Henri Poincaré:

1. Mini course (4h) on "Applications of geometric measure theory to shape analysis". September 2022.

At University of Copenhagen:

1. Signal and image processing (computer science masters program). Fall 2014. Co-taught with Jon Sporring.

At Ecole Normale Supérieure de Cachan:

1. Numerical analysis (masters level). Fall 2010. Co-taught with Frédéric Pascal.
Matrix linear algebra: exact and iterative methods for linear systems, eigenvalue problems. Polynomial interpolation and approximation.

2. Complex analysis (senior undergraduate level). Spring 2011, 2012.
Complex differentiable functions and Cauchy-Riemann equations. Path integrals of complex functions: index, homotopy, Cauchy theorem. Properties of holomorphic functions: analyticity, isolated zeros, maximum principle. Meromorphic functions and the residue theorem. Riemann theorem for simply connected sets of the complex plane.

3. Differential calculus (undergraduate level), Fall 2010, 2011, 2012. Co-taught with Frederic Pascal.
Multivariate functions: differential map, partial derivatives, fixed point theorems, inverse function theorem. Notions on general ODEs: Cauchy-Lipschitz theorem, explosion theorem. Introduction to submanifolds and optimization on submanifolds.

G. Professional service

Seminar and workshop organization

- Co-organizer of the upcoming "AfterShape workshop" at ENS Paris-Saclay (July 2025).
- Main organizer of the retreat workshop "Maths in the Appalacheans" in Maine (August 2024).
- Organizer of the Center of Imaging Science 25th anniversary (May 2023).
- Organizer (with Pr. Younes) of a weekly group meeting on shape analysis (April-June 2022).
- Organizer of the minisymposium "Shape Matching, Shape Analysis, and Morphometry: Theory, Numerics, and Applications" at the SIAM conference of Imaging Sciences (2022).
- Chair of the "Registration" session at the Information Processing in Medical Imaging conference (2021).
- Co-organizer and chair of the "Shape space" session at Geometric Science of Information conference (2019).
- Organizer of the minisymposium on "Geometric methods for shape analysis with applications to biomedical imaging and computational anatomy" at SIAM conference of Imaging Sciences (2018).

- Organizer of the minisymposium on "Recent advances in theoretical and computational shape analysis, applications to biomedical imaging" at SIAM annual meeting (2017).
- Organizer of the minisymposium on "Computational methods for the processing of diffusion MRI data and the analysis of brain connectivity" at SIAM conference of Imaging Sciences (2016).

Reviewing activities

For journals and conferences:

- SIAM journal of Imaging Science (SIIMS).
- Transactions of Pattern Analysis and Machine Intelligence (TPAMI).
- International Journal of Computer Vision (IJCV).
- Discrete and Continuous Dynamical Systems (DCDS).
- Journal of Foundations of Computational Mathematics (JFoCM).
- Journal of Computational Geometry (JoCG).
- Journal of Mathematical Imaging and Vision (JMIV).
- ESAIM: Mathematical Modelling and Numerical Analysis (ESAIM: M2AN).
- Annals of Global Analysis and Geometry (AGAG).
- Bulletin of the London Mathematical Society.
- Journal of Computational Physics (JCOMP).
- Proceedings of the Royal Society A (RSPA).
- Research in the Mathematical Sciences (RMSB).
- Journal of the American Statistical Association (JASA).
- IEEE Transactions on Image Processing (TIP).
- Astronomy and Computing (ASCOM).
- Computer Vision and Pattern Recognition (CVPR).
- Geometric Science of Information (GSI).

For grants institutes:

- National Science Foundation (NSF).
- Swiss National Science Foundation (SNSF).
- US Army research office (ARO).

University and department service

- Co-creator of the research group on "High-dimensional data analysis" within the department of Mathematics at the University of Houston, runs biweekly meetings for the group.
- Exam writer (Algebra I) for the University of Houston 2025 Maths contest.
- Department graduate studies committee, University of Houston. Fall 2024 to present.
- Department colloquium organization committee, University of Houston. Fall 2024.
- Department communication committee member, Johns Hopkins University, 2019-2021.
- Department graduate admissions' committee member, Johns Hopkins University, 2015-2019 and 2021-2022.
- Faculty search committee member, Johns Hopkins University, 2016-2017 and 2020.
- Graduate Board Oral (GBO) or Annual Performance Review (APR) committee member for:

1. Sajjadul Bari (PhD candidate in Mathematics, UH), 2024.
2. Augustin Castellano (PhD candidate in Electrical and Computer Engineering, JHU), 2024.
3. Dayeon Kim (PhD candidate in Computer Science, JHU), 2022.
4. Kaitlin Stouffer (PhD candidate in Biomedical Engineering, JHU), 2021.
5. Dai-Ni Hsieh (PhD candidate in Applied Mathematics and Statistics, JHU), 2020.
6. Ran Liu (PhD candidate in Biomedical Engineering, JHU), 2019.
7. Michelle Lohr (PhD candidate in Applied Mathematics and Statistics), 2019.
8. Vikram Chandrashekhar (PhD candidate in Biomedical Engineering, JHU), 2019.
9. Jingyi Zhu (PhD candidate in Applied Mathematics and Statistics, JHU), 2017.
10. Zachary Lubberts (PhD candidate in Applied Mathematics and Statistics, JHU), 2016.

Other

- Participant in the Universities for Ukraine (U4U) initiative.
- Participant in the 2018 USA Science & Engineering Festival.
- National judge in the finals of the 2017 Siemens Competition in Math, Science and Technology.